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Voices of First Responders—Nationwide Public Safety Communication Survey Findings:

Mobile Devices, Applications, and Futuristic Technology
Phase 2, Volume 2

Shaneé Dawkins
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Shaneé Dawkins
Kristen K. Greene
Information Access Division
Information Technology Laboratory

Sandra Spickard Prettyman
Culture Catalyst, LLC

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Voices of First Responders Series

This report is a part of a series of publications amplifying the voices of first responders (VoFR) in four public safety disciplines: Communication Center & 9-1-1 Services (COMMS); Emergency Medical Services (EMS); Fire Service (FF); and Law Enforcement (LE). The VoFR series reports on the experiences of first responders with communication technology, including their needs for, and problems with, communication technology. Publications in this series are primarily intended for designers, developers, vendors, and researchers of public safety communication technology, as well as for public safety administrators and decision-makers.

Published as a part of the VoFR series include NIST reports, conference papers, presentations, posters, articles and blog posts, a book chapter, and a web tool for disseminating the research results and data collected from the interviews with and survey of first responders. The reports from which all published materials are derived are listed below and can be accessed from the ***PSCR User Interface/ User Experience Publications*** webpage at: https://www.nist.gov/ctl/pscr/user-interface-user-experience-publications. The ***PSCR Usability Results Tool***, providing access to results of the large-scale survey and in-depth interviews with first responders across the U.S. about their communication technology use, can be accessed via https://publicsafety.nist.gov/. The datasets from this research project are available via https://doi.org/10.18434/mds2-2820.

Voices of First Responders

- How to Facilitate Adoption and Usage of Communication Technology: An Integrated Analysis of Qualitative and Quantitative Findings (NISTIR 8443) https://doi.org/10.6028/NIST.IR.8443
- COMMS (NIST SP 1286pt1) https://doi.org/10.6028/NIST.SP.1286pt1
- EMS (NIST SP 1286pt2) https://doi.org/10.6028/NIST.SP.1286pt2
- FF (NIST SP 1286pt3) https://doi.org/10.6028/NIST.SP.1286pt3
- LE (NIST SP 1286pt4) https://doi.org/10.6028/NIST.SP.1286pt4

Phase 1: Findings from User-Centered Interviews

- Volume 1 - *Identifying Public Safety Communication Problems* (NISTIR 8216) https://doi.org/10.6028/NIST.IR.8216
- Volume 2 - *Examining Public Safety Communication Problems and Requested Functionality* (NISTIR 8245) https://doi.org/10.6028/NIST.IR.8245
- Volume 3 - *Examining Public Safety Communication from the Rural Perspective* (NISTIR 8277) https://doi.org/10.6028/NIST.IR.8277
- Volume 4 - *Examining Public Safety Communication from the Perspective of 9-1-1 Call Takers and Dispatchers* (NISTIR 8295) https://doi.org/10.6028/NIST.IR.8295
- Volume 5 - *Applying Human Factors and Ergonomics Knowledge to Improve the Usability of Public Safety Communications Technology* (NISTIR 8340) https://doi.org/10.6028/NIST.IR.8340

Phase 2: Nationwide Survey

- Volume 1 - *Methodology: Development, Dissemination, and Demographics* (NISTIR 8288) https://doi.org/10.6028/NIST.IR.8288
- Volume 2 - *Mobile Devices, Applications, and Futuristic Technology* (NISTIR 8314) https://doi.org/10.6028/NIST.IR.8314
- Volume 3 - *Day-to-Day Technology* (NISTIR 8400) https://doi.org/10.6028/NIST.IR.8400
- Volume 4 - *Statistical Analysis Results* (NISTIR 8444) https://doi.org/10.6028/NIST.IR.8444

Abstract

With the newly created Nationwide Public Safety Broadband Network (NPSBN), the public safety community is in the process of supplementing the use of land mobile radios with the use of a broader spectrum of technologies. As these technologies are being developed, researchers and industry alike need to focus on the end users – the first responders – in order to ensure successful and usable systems. Understanding the user population of first responders is key to improved usability. The NIST Public Safety Communications Research (PSCR) Usability Team conducted a multi-phase, mixed methods research project in order to provide greater understanding of public safety users, their experiences, and their technology needs and problems. This report, Phase 2, Volume 2, is the second in a series of reports on the data from the Phase 2 large-scale, nationwide survey of 7 182 first responders. Three specific topics in the first responder communication technology space, drawing on data from both Phase 1 and Phase 2 of the project are presented: 1) mobile devices, apps, and software, 2) futuristic technology and virtual reality, and 3) technology used in large incidents.

Findings suggest that broader access to affordable devices, particularly work-issued smartphones, and data through smartphone apps, most essential being email and mapping/navigation, could fill significant gaps in the public safety technology space, making the NPSBN build-out so important for public safety. It is also important to understand that what many first responders want for the future of public safety is technology that already exists for the general public, it just is not yet widespread in the public safety domain, e.g., single sign-on (SSO). Lastly, researchers and developers in the public safety domain should focus on solving the problems that first responders have with technology used for daily incident response, as it will also help first responders during large events.

Key words

First responders; Communication technology; Public safety communication research; Survey research; Usability; User needs and requirements.

Audience

This report is primarily intended for designers, developers, vendors, researchers, and public safety administrators of public safety communication technology.

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Technology, nor does it imply that the products mentioned are necessarily the best available for the purpose.

Executive Summary

Background

With the newly created Nationwide Public Safety Broadband Network (NPSBN), the public safety community is continuing to look toward the communication technology of the future for incident response. As this technology is being developed, researchers and industry alike need to focus on the end users – the first responders – in order to ensure successful and usable systems. This means that communication technology must help first responders to achieve their goals and objectives with effectiveness, efficiency, and satisfaction in their specified contexts of use [19]. User interfaces and user experience (UI/UX) have been identified as critical components by the Public Safety Communications Research (PSCR) community [25]. Understanding the user population of first responders —911/Dispatch Communications (COMMS), Emergency Medical Services (EMS), Fire Service (FF), and Law Enforcement (LE)— is key to improved UI/UX. It is crucial to understand these 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.

The National Institute of Standards and Technology (NIST) PSCR Usability Team conducted a multi-phase, mixed methods research project in order to provide greater understanding of public safety users, their experiences, and their technology needs and problems. The goal was to understand what first responders believe is necessary to facilitate communication and that can best address their technology needs. Phase 1 of the project was a qualitative examination of first responder contexts of work, focusing on communication technology. The first phase included interviews with 193 first responders across the country, from 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 in order to provide a more comprehensive view of communication technology in the first responder community.

Results

A series of reports from Phase 1 highlight both general and specific analyses of the interview data [5][9][18][28]. This report is the second in a series of reports on the Phase 2 survey data – results from 7 182 first responders who completed the survey. The Phase 2, Volume 1 report provides specifics about survey methodology and demographics [17]. This report, Phase 2, Volume 2, focuses on data from three specific topics in the first responder communication technology space, drawing on data from both Phase 1 and Phase 2 of the project. First, mobile devices (i.e., smartphones and tablets) and applications/software used by first responders are discussed. Second, data related to futuristic technology for first responders, including the use of virtual reality (VR) is presented. The third topic is the type of technology first responders have, and think would be helpful in a major disaster or large planned event. The technologies presented in this report are by no means exhaustive, and were selected to look toward the future of public safety and the NPSBN. Additional devices and survey data will be examined in future volumes of the Phase 2 series of reports.

When considering the many devices first responders currently utilize, a great deal of consideration needs to be given to those devices that are expected to significantly increase in public safety use in the coming years: mobile devices. Presently, twice as many first responders use personal smartphones for their everyday public safety work than work-issued smartphones. Additionally, the first responders who experienced problems with the cost of mobile devices outnumbered all other problems experienced by a factor of 2-to-1. It is often the ongoing expenses such as data plans, maintenance, upgrades, training, etc., that preclude many agencies from being able to afford new technology they would otherwise like to have. These findings suggest that broader access to affordable devices and data plans for the NPSBN, particularly for work-issued smartphones, could address these issues in the public safety technology space. The apps used by first responders on these devices also should garner much interest. In addition to public safety-specific applications like Computer-Aided Dispatch (CAD) and Records Management System (RMS), first responders largely use apps that are common to the general public, in particular email and mapping/navigation. These apps are often the reason first responders use their personal smartphones in their work; problems first responders often experience with outdated public safety mapping/navigation can lead them to prefer personal smartphone use in order to have the most up-to-date maps. The desire to have access to data through smartphone apps for first responders in the field is another reason that the NPSBN build-out is so important for public safety.

As the NPSBN build-out progresses, its support capabilities for forward-looking technology will expand. While first responders can envision the use of futuristic technology, the need is utility driven. VR, for example, is only seen by first responders as potentially useful for training purposes. Conversely, a solution many first responders across disciplines want is single sign-on; it addresses a universal pain point in public safety. SSO is widely used by the general public, but it is still uncommon in public safety—as with many technologies, in public safety, one login is still "futuristic" technology. In addition to seeing the utility in SSO, each of the four disciplines could envision their needs fulfilled in other discipline-specific technologies. In particular, automatic caller location for COMMS, and automatic transmission of patient vitals to hospitals for EMS. The use of drones was more common for futuristic technology envisioned by FF and LE. When considering futuristic technology, for COMMS, it goes beyond the technology itself to considering the unintended consequences of technology adoption and use. Consider the unintended consequences of removing the human voice element in text-to-911, or the unintended mental and emotional consequences—such as increased risk of post traumatic stress disorder (PTSD)—that may result from viewing inappropriate and/or graphic images and video with Next Generation 9-1-1 (NG 911). While it may be beneficial to adopt these futuristic technologies, it is also vital to weigh the potential negative impacts of their implementation.

In researching, designing, and creating futuristic technology, the direct benefit of its use by first responders must be considered. Designing communication technology for large events should follow this principle as well. The devices and applications/software that are most useful in day-to-day incident response are mostly the same as those used in large events—major disasters and large, planned events, alike. This makes it extremely important for technology researchers and developers in the public safety space to focus on solving the problems that first responders have with technology used for daily incident response, as it will also help them during large events.

In solving the communication technology problems first responders face, the overarching user-centered guidelines for developers, previously reported in Phase 1, Volume 1, remain important and applicable [5].

1. Improve current technology
2. Reduce unintended consequences
3. Recognize 'one size does not fit all'
4. Minimize "technology for technology's sake"
5. Lower product/service costs
6. Require usable technology

These six guidelines, initially identified in analysis of one-on-one interviews with first responders, were mirrored and amplified in the largescale nationwide survey data. The user-centered design guidelines can promote first responders' trust with technology, people, and organizations. Only by listening to the voices of first responders, and engaging actively with them, can new technology be designed and implemented such that it meets user needs and facilitates public safety incident response. It is necessary to recognize and address both the promise and peril of new technology so that its adoption will ultimately be as successful as possible.

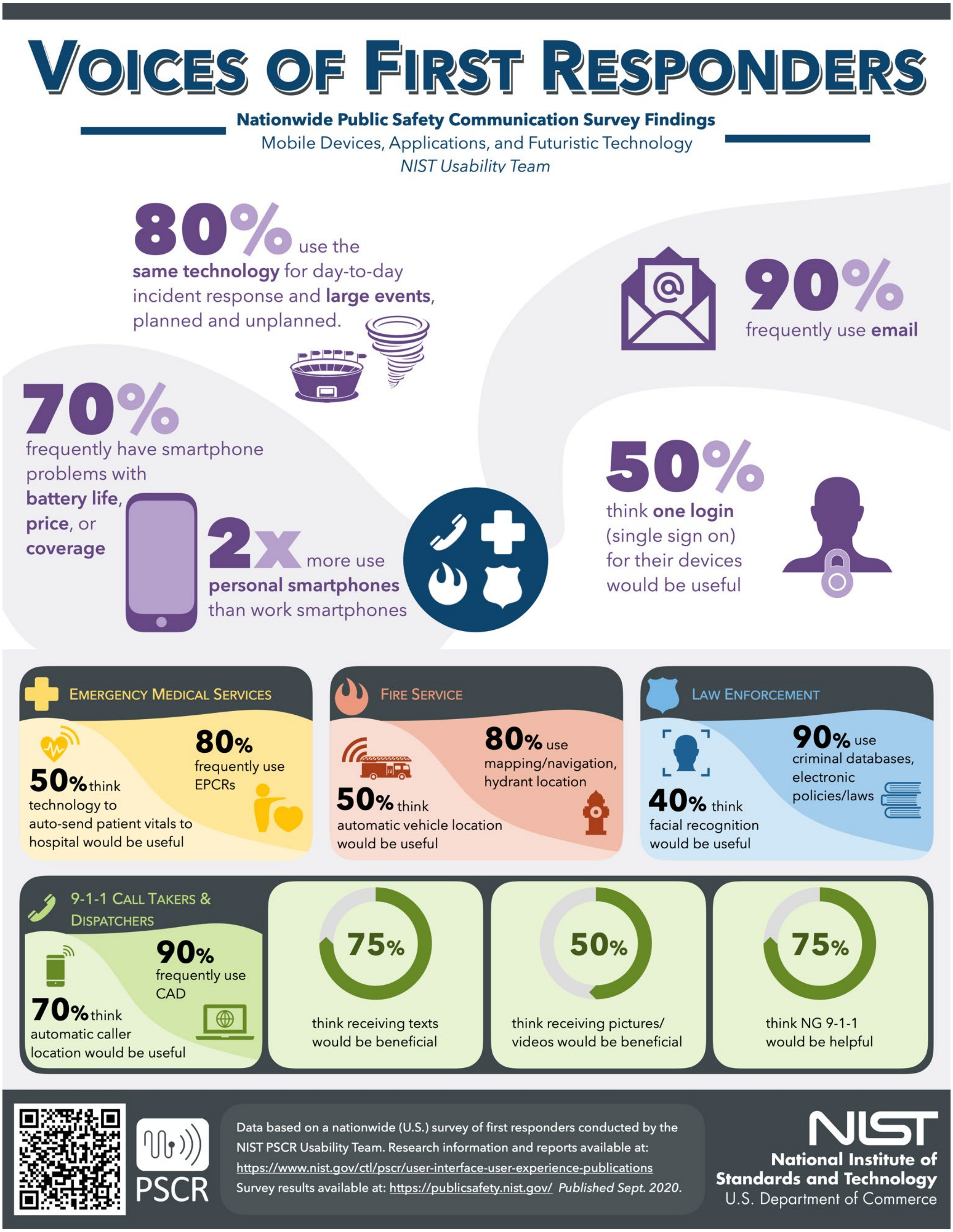
VOICES OF FIRST RESPONDERS
Nationwide Public Safety Communication Survey Findings
Mobile Devices, Applications, and Futuristic Technology
NIST Usability Team
80% use the same technology for day-to-day incident response and large events, planned and unplanned.
90% frequently use email
70% frequently have smartphone problems with battery life, price, or coverage
2x more use personal smartphones than work smartphones
50% think one login (single sign on) for their devices would be useful
EMERGENCY MEDICAL SERVICES
80% frequently use EPCRs
50% think technology to auto-send patient vitals to hospital would be useful
FIRE SERVICE
80% use mapping/navigation, hydrant location
50% think automatic vehicle location would be useful
LAW ENFORCEMENT
90% use criminal databases, electronic policies/laws
40% think facial recognition would be useful
9-1-1 CALL TAKERS & DISPATCHERS
90% frequently use CAD
70% think automatic caller location would be useful
75% think receiving texts would be beneficial
50% think receiving pictures/ videos would be beneficial
75% think NG 9-1-1 would be helpful
PSCR
Data based on a nationwide (U.S.) survey of first responders conducted by the NIST PSCR Usability Team. Research information and reports available at: https://www.nist.gov/ctl/pscr/user-interface-user-experience-publications
Survey results available at: https://publicsafety.nist.gov/ Published Sept. 2020.
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Table of Contents

List of Tables

List of Figures

List of Acronyms and Abbreviations

AED .... Automatic External Defibrillator
APCO .... Association of Public-Safety Communications Officials
Apps .... Applications
AR .... Augmented Reality
AVL .... Automatic Vehicle Location
CAD .... Computer-Aided Dispatch
CCIC .... Colorado Crime Information Center
COLTs .... Cell on Light Truck
COMMS .... Communications, 9-1-1/Dispatch
COWs .... Cell on Wheels
DB .... Database
D.C. .... District of Columbia
EMS .... Emergency Medical Services
ENS .... Emergency Notification System
EPCR .... Electronic Patient Care Reporting
ERG .... Emergency Response Guide
FCC .... Federal Communications Commission
FEMA .... Federal Emergency Management Agency
FF .... Fire Service, Fire Fighting
FR .... First Responder
GIS .... Geographic Information System
HazMat .... Hazardous Materials
HIPAA .... Health Insurance Portability and Accountability Act of 1996
HUDs .... Heads-Up Displays
IDACS .... Indiana Data and Communications System
LE .... Law Enforcement
LEADS .... Law Enforcement Automated Data System
LTE .... Long-Term Evolution
MCC .... Mobile Command Center
MCI .... Mass Casualty Incident
MDC .... Mobile Data Computer
MDT .... Mobile Data Terminal
MOU .... Memorandum of Understanding
NCIC .... National Crime Information Center
NG 911 .... Next Generation 9-1-1

NIST .... National Institute of Standards and Technology
NPSBN .... Nationwide Public Safety Broadband Network
PIA .... Private Internet Access
PSAP .... Public Safety Answering Point
PSCR .... Public Safety Communications Research
PTSD .... Post Traumatic Stress Disorder
RDS .... Remote Desktop Services
RMS .... Records Management System
SAT phone ..... Satellite Phone
SOP .... Standard Operating Procedure
TIC .... Thermal Imaging Camera
UI/UX .... User Interface/User Experience
USB .... Universal Serial Bus
VR .... Virtual Reality

1. Introduction

The Nationwide Public Safety Broadband Network (NPSBN) was created as a dedicated long-term evolution (LTE) network for public safety communication. The goal of this network is to improve public safety communication by providing an independent, interoperable communication platform for incident response. In addition, a wide range of new and improved communication tools are being developed to operate on the NPSBN. However, if advanced public safety communication technology is to be successful, it must focus on usability. This means that communication technology must help first responders[1] to achieve their goals and objectives with effectiveness, efficiency, and satisfaction in their specified contexts of use [19]. User interfaces and user experience (UI/UX) have been identified as critical components by the Public Safety Communications Research (PSCR) community [25][26]. However, understanding the first responder user population can be challenging given the great variation within the user group. For example, different first responder disciplines—911/Dispatch Communications (COMMS), Emergency Medical Services (EMS), Fire Service (FF), and Law Enforcement (LE)—use different types of tools and for different purposes. Different types of communication technology are needed, and different problems are experienced, partly based on where first responders are located—rural, suburban, or urban areas. 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.

The PSCR usability team conducted a multi-phase, mixed methods research project in order to provide greater understanding of public safety users, their experiences, and their technology needs and problems. The goal was to understand what first responders believe is necessary to facilitate communication and that can best address their technology needs. Phase 1 of the project was a qualitative examination of first responder contexts of work, focusing on communication technology. This phase included interviews with 193 first responders across the country, from 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 in order to provide a more comprehensive view of communication technology in the first responder community.

A series of reports from Phase 1 and Phase 2 highlight both general and specific analyses of the data. The Phase 1, Volume 1 report explores first responder contexts of use, as well as their beliefs and behaviors related to communication technology [5]. Phase 1, Volume 2 details the problems and requested functionality that first responders experience related to communication technology identified in the qualitative data [9]. Phase 1, Volume 3 presents findings from first responders in rural areas [18]; and Phase 1, Volume 4 presents findings from the COMMS data [28].

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[1] For the purposes of this report, the use of first responders refers to personnel who are actively involved in day-to-day incident response and operations or in supporting roles.

The Phase 2, Volume 1 report provides specifics about survey methodology and demographics [17]. This report, Phase 2, Volume 2, focuses on data from three specific topics in the first responder communication technology space, drawing on data from both Phase 1 and Phase 2 of the project. First, mobile devices (i.e., smartphones and tablets) and applications/software used by first responders are discussed. Second, data related to futuristic technology for first responders, including the use of virtual reality (VR) is presented. The third topic is the type of technology first responders have and think would be helpful in a major disaster or large planned event. Given the significant length of the document and many topics covered and results sub-sections, an orienting header can be found at the top right of every page. The technologies presented in this report are by no means exhaustive, and were selected to look toward the future of public safety and the NPSBN. Certainly, other devices besides smartphones and tablets can also be mobile (e.g., laptops, some mobile data terminals/mobile data computers (MDTs/MDCs), flip phones, and pagers), but are not within the scope of this report. Additional devices and survey data will be examined in future volumes of this series of reports.

2. Methodology

This study is based on a sequential, exploratory mixed methods design, which is often used when a measure or instrument is not currently available and the variables are not known (the technology needs and problems of first responders, for example) and when exploring a phenomenon (such as public safety communication). Phase 1 of the project included interviews with 193 first responders across the country [5]. The qualitative data from Phase 1 provided input for the construction of a quantitative survey used in Phase 2. The use of a large-scale, nationwide survey allowed for greater representation from more first responders across the country. This allowed for the ability to confirm, clarify, and/or expand on the findings from Phase 1 of the study, which identified first responder needs and problems related to communication technology [5][9][18][28].

Both phases of the project were approved by the NIST Research Protection Office and complied with all institutional human subjects requirements and processes. Full methodological details such as specifics related to study design, data collection, and data analysis can be found in Phase 1, Volume 1 (for the in-depth interviews) and Phase 2, Volume 1 (for the survey) [5][17]. Abbreviated summaries of the methodology from both Phase 1 interviews and Phase 2 survey are presented in Appendix A and Appendix B, respectively. However, given the importance of understanding the survey questions in interpreting the results, the question stems and response options are presented at the start of the results sections to which they pertain rather than in an appendix. The results sections all present analyses performed on unweighted survey data. Survey responses are representative of the first responders who participated; weighting of the data should be applied prior to making any generalizations about the results to the broader public safety population.

There was a total of 7 182 completed survey responses, including responses from all 50 states and the District of Columbia (D.C.). There was representation from the four public safety disciplines surveyed (COMMS, EMS, FF, and LE), as well as representation from agencies in urban, suburban, and rural areas. Other demographic variables of interest—such as jurisdictional level, years of service, and age—also showed good variability.

Data presented in this report relate specifically to mobile devices and applications/software, futuristic technology including VR, and technology used and desired for major disasters and large planned events. While the focus is on responses from the nationwide survey, the analysis also includes representation from the qualitative interviews, examining where the quantitative and qualitative data converge or diverge. Of particular interest are those findings where the qualitative interview data helps explain or provide relevant context around the quantitative survey data. Where appropriate, discipline-specific interview analyses for COMMS, EMS, FF, and LE are presented in addition to the overall findings.

As described in Appendix B, survey questions and response options were grounded in research from the previously collected empirical interview data from Phase 1 [5][9], as well as from content and survey expert reviews during survey development, and were tailored appropriately for each discipline. Additionally, 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. Therefore, data about certain communication devices and software were not collected across all four disciplines. Survey questions were tailored to each discipline, as well; for example, COMMS participants were not asked about their device or software problems or to rank their top devices, as they received additional questions about their call center and information problems instead.

For clarity of exposition, the different research phases will be referred to simply as "interview" and "survey" phases henceforth (for Phase 1 and Phase 2, respectively). The terms "participant" and "respondent" refer to either first responders interviewed or first responders who completed the survey, and are used interchangeably throughout the report.

3. Demographics

7 182 first responders participated in the nationwide survey, across COMMS, EMS, FF, and LE disciplines; 193 responders participated in in-depth interviews throughout the U.S. As this report is focused primarily on the survey data, additional details for the survey demographic data are provided. Demographic data from the interviews, and survey data on demographics across disciplines, are highlighted as well. Sec. 3.1 presents the demographic data from the survey; Sec. 3.2 from the interviews. Previously reported demographic information from the survey can be found in Appendix C [17]; detailed interview demographics can be found in previous volumes [5][9][18][28].

3.1. Survey Demographics

The demographics presented throughout this section represent the data from the 7 182 participants who completed the entire survey. However, since all survey questions were optional[2], the number of

[2] Only the discipline question required a response, in order to branch to the appropriate discipline-specific survey. If participants did not answer that question the survey would not allow them to move forward. They could choose to quit the survey at that, or any, point.

participant responses, *n*, per question varied (see Appendix B); the *n* for each response is given with the associated figure.

Of the 7 182 completed survey responses, 21.78 % were COMMS, 12.56 % were EMS, 36.44 % were FF, and 29.23 % were LE (see Fig. 1). All four disciplines had representation in each of the 10 Federal Emergency Management Agency (FEMA) regions (see Fig. 2) [14]. FEMA Region V had the most responses, 1 382, while FEMA Region X had the fewest, 307. The mean number of responses per FEMA Region was 712.30; the median was 544.00. The largest COMMS response was in FEMA Region IV (341); EMS in Region II (191); FF in Region V (575); and LE in Region V (433).

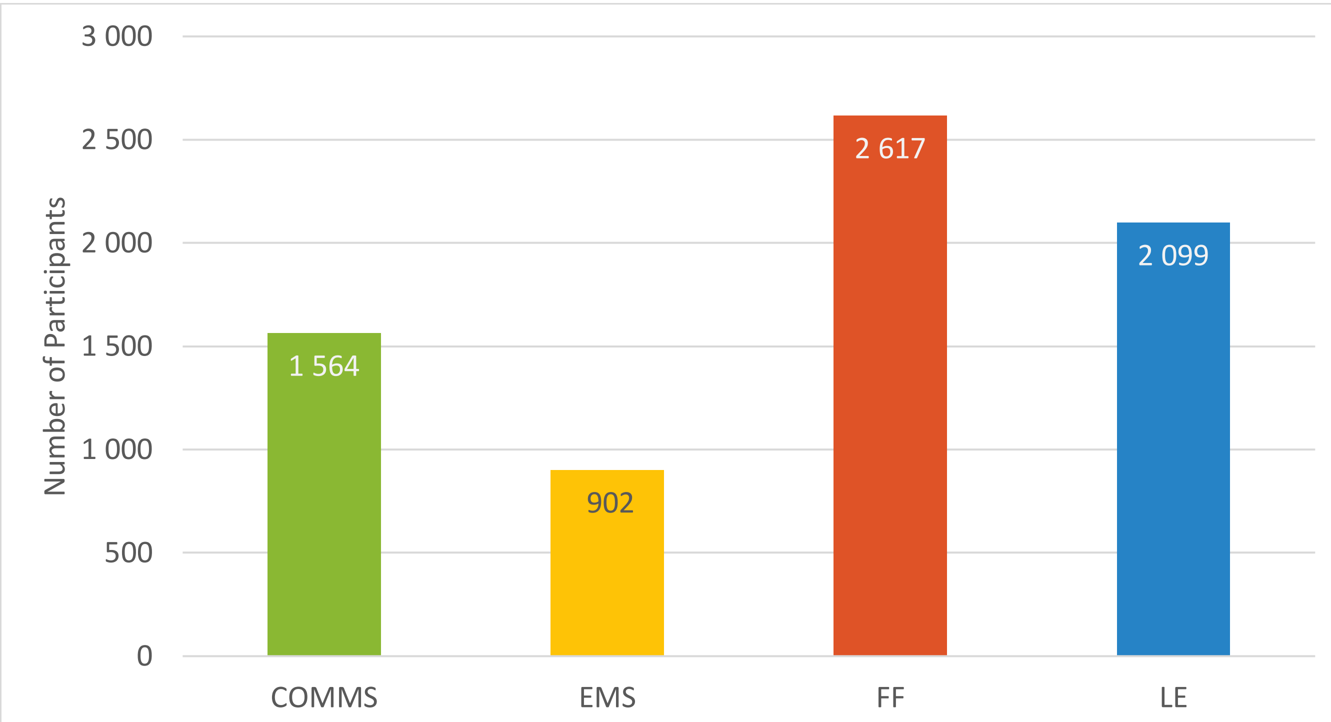

Fig. 1. Number of participants who completed the survey *(n=7 182)*

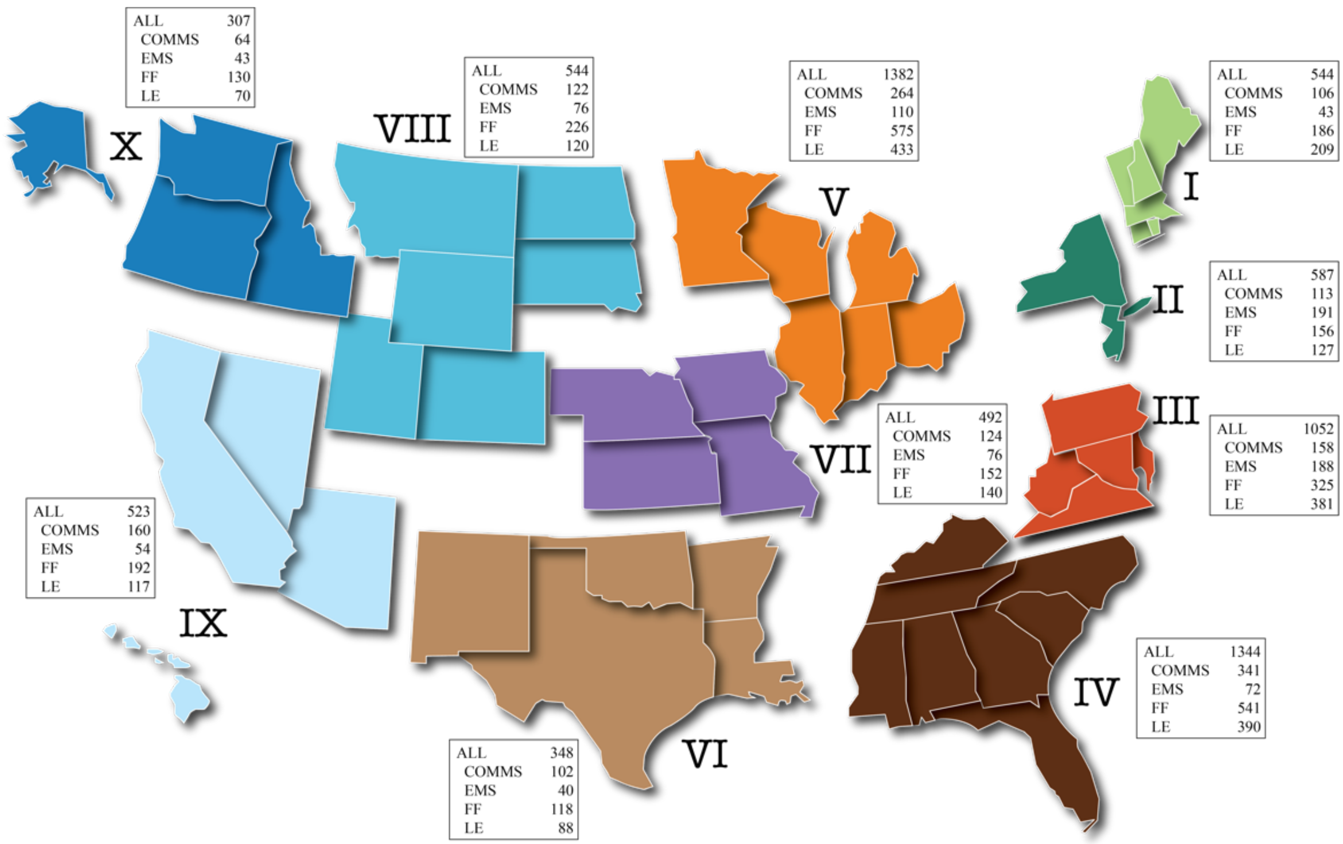

Fig. 2. Participants who completed the survey by discipline and FEMA Region *(n=7 123)*

In the sections that follow, overall nationwide survey demographics will be presented followed by discipline-specific survey demographics.

3.1.1. Nationwide Survey Demographics

The vast majority of respondents completed the survey on a desktop device, while the remaining respondents used mobile devices (see Fig. 3). Overall, most survey participants indicated they mainly work in suburban (38.68 %) or rural areas (37.68 %), while 23.25 % of participants indicated that their work was primarily in urban areas (see Fig. 4). The large majority, 63.20 % of survey participants, worked in public safety at the local level, while 31.87 % of respondents worked at the county level (see Fig. 5).

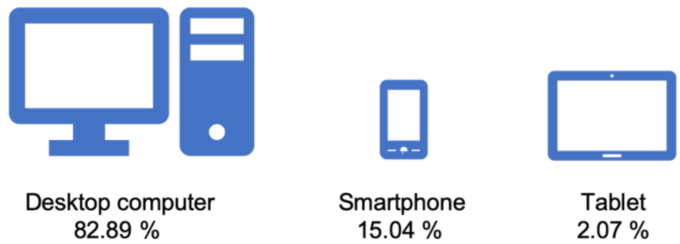

Fig. 3. Device types used by participants to complete the survey *(n=7 182)*

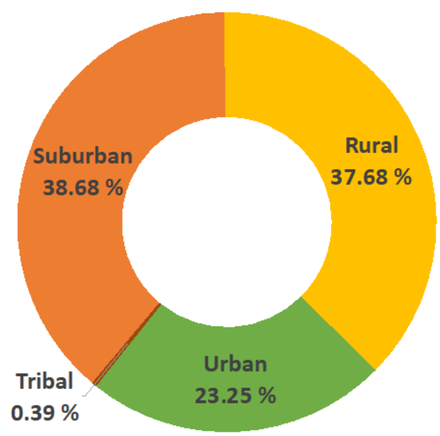

Fig. 4. Participants who completed the survey by area type *(n=7 161)*

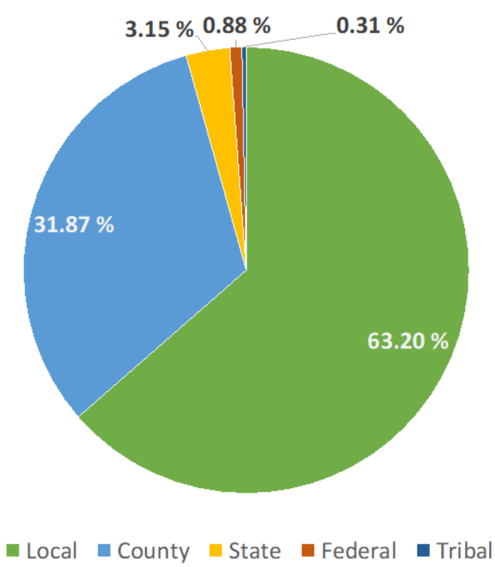

Fig. 5. Participants who completed the survey by jurisdiction *(n=7 139)*

Although tribal was a response option in the demographic section of the survey for area type and jurisdiction (see preceding figs. 4 and 5), there were no specific outreach efforts for tribal first responders aside from the larger sample outreach. As tribal responses were so few, meaningful analyses could not be completed with the limited sample size. Therefore, the tribal responses are only included in the nationwide data above, and in the nationwide analysis of the survey results; tribal demographics are not further broken down by discipline, FEMA region, sex, or other variables. Additional nationwide demographics—age, years of service, age by years of service, and sex—originally published in survey report Volume 1 [17], are presented in Appendix C.

3.1.2. Discipline-Specific Survey Demographics

This section presents per-discipline demographics, beginning with area and jurisdiction (Figs. 6 and 7, respectively). Age, experience, and gender demographic data follow (Figs. 8 through 10). The section ends with discipline-specific demographic data (Figs. 11 and 12). Greater granularity of the discipline-specific demographic data can be found in Appendix D. For consistency throughout this report, where discipline-specific data are presented together, the individual disciplines will be ordered alphabetically – COMMS, EMS, FF, LE – unless otherwise noted.

Figure 6 breaks down survey participants by area and discipline. As stated in the overview of the across discipline demographics, the majority of survey respondents were from suburban or rural areas; the area with the fewest respondents in each discipline was urban. Around 40 % of all FF and LE participants were suburban; just over 40 % of COMMS were rural, and over 50 % of EMS was from rural.

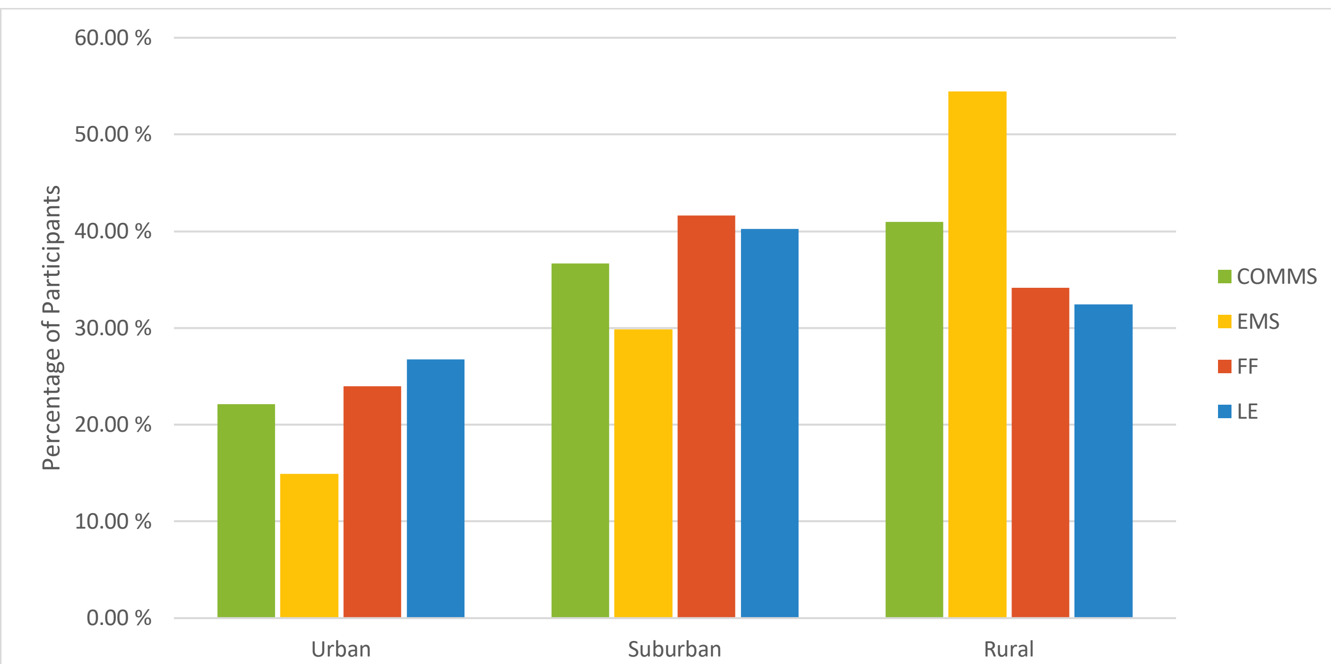

Fig. 6. Participants who completed the survey by area and discipline

As incident response usually starts at the local level, the focus on survey outreach was primarily on the local and county levels rather than the state or federal levels, as described in Appendix B, so it is not surprising that the majority of survey respondents were from local and county levels. The total number of participants, by discipline, from local and county jurisdictions is shown in Fig. 5. The majority of COMMS survey respondents were from jurisdictions at the county level; many of the 9-1-1 communication centers and public safety answering point (PSAPs) across the U.S. are responsible for a county (or counties) rather than individual towns. EMS, FF, and LE respondents were largely from local jurisdictions, each by a factor of approximately 2:1; more than two times as many EMS, FF, and LE were from local jurisdictions than those from county-level jurisdictions (more than three times as many for FF).

The discipline with the most respondents at the state level, by far, was EMS (9.20 %); each of the other disciplines accounted for less than 3 % of the respondents at the state level (2.38 % at the state level in COMMS; 1.88 % in FF; 2.78 % in LE). Less than 2 % of participants in each discipline were from the federal level: 0.64 % COMMS, 0.67 % EMS, 0.84 % FF, and 1.20 % LE. In the U.S., there are more federal law enforcement agencies than the other disciplines; federal representation in the study was much higher for LE than the other disciplines.

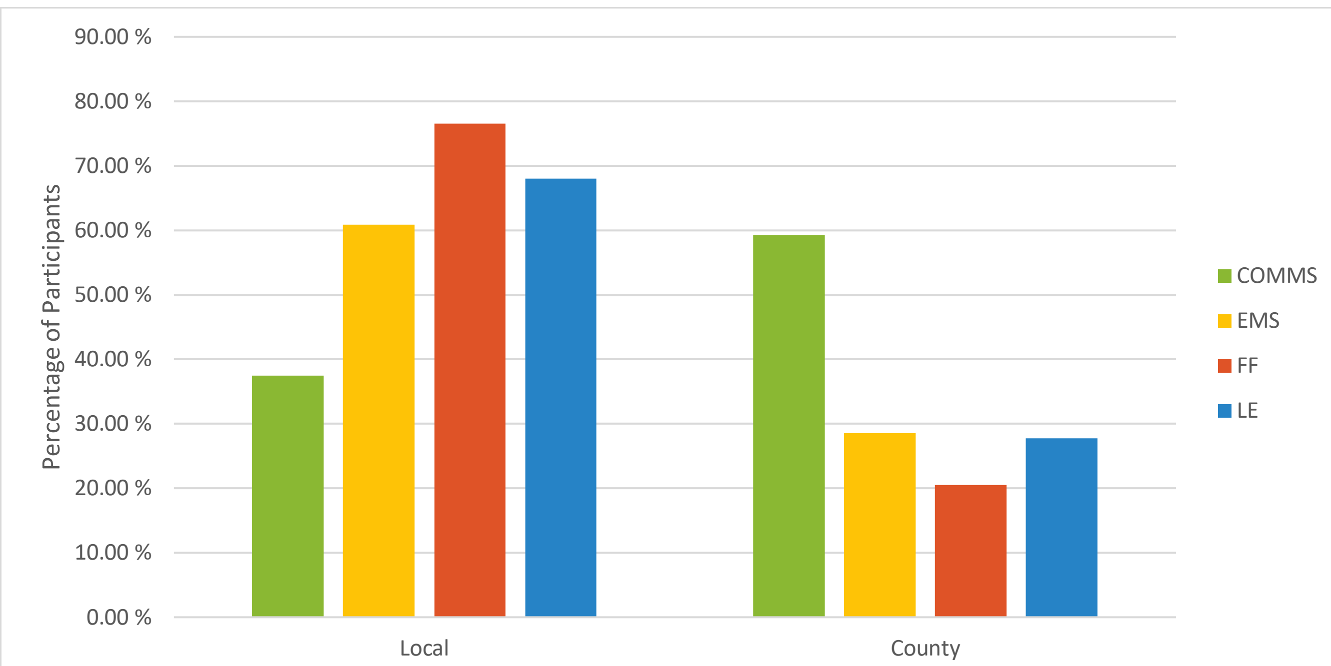

Fig. 7. Participants who completed the survey by jurisdiction and discipline

The distributions of age and total years of service were comparable across disciplines; means and standard deviations are shown in Table 1. Most participants in each discipline were between the ages of 46 and 55 years; age groups 18-25 and 66 and up had the fewest participants (see Fig. 8). The most COMMS, EMS, and LE participants had experience between 21 and 25 total years of service; the most in FF had 26-30 years of experience (see Fig. 9).

Table 1. Age and experience of participants who completed the survey

	AGE (YEARS)		TOTAL YEARS OF SERVICE	
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**
COMMS	44.92	10.79	18.90	10.58
EMS	47.53	12.84	22.17	12.25
FF	48.84	10.39	26.15	10.89
LE	47.97	9.76	23.42	10.09

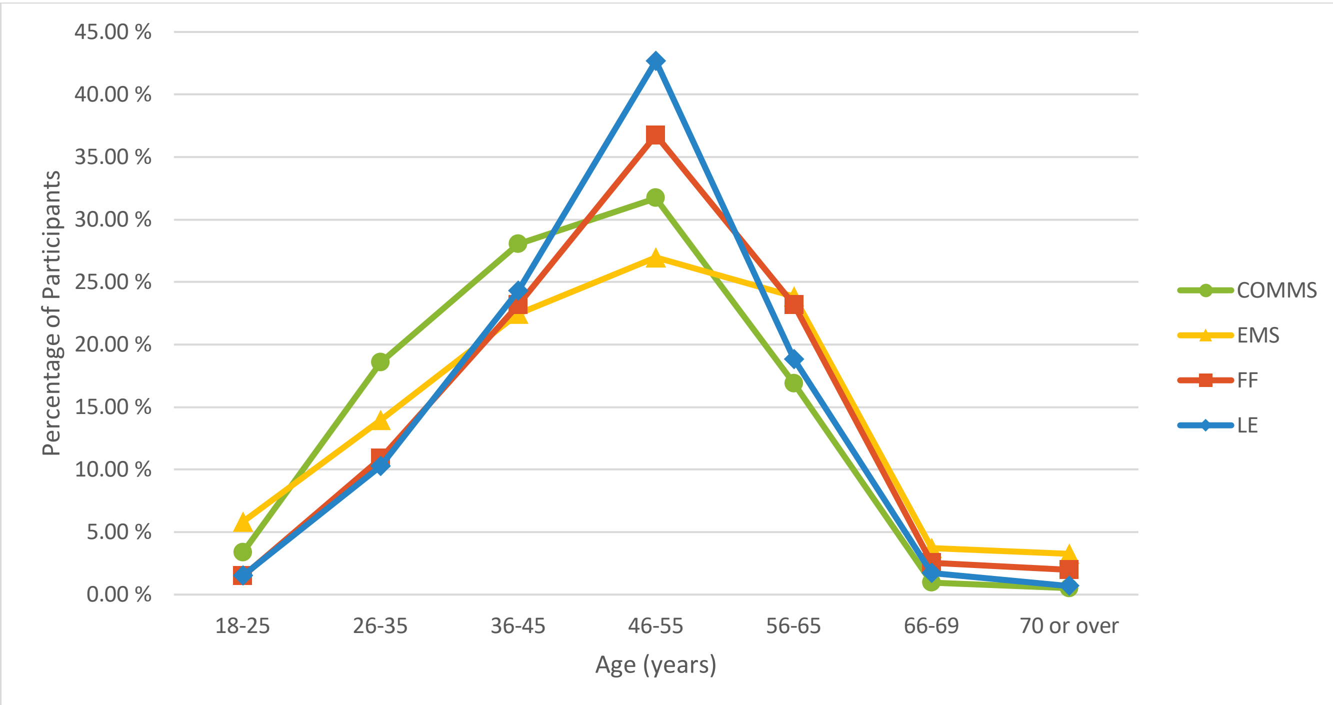

Fig. 8. Participants who completed the survey by age and discipline

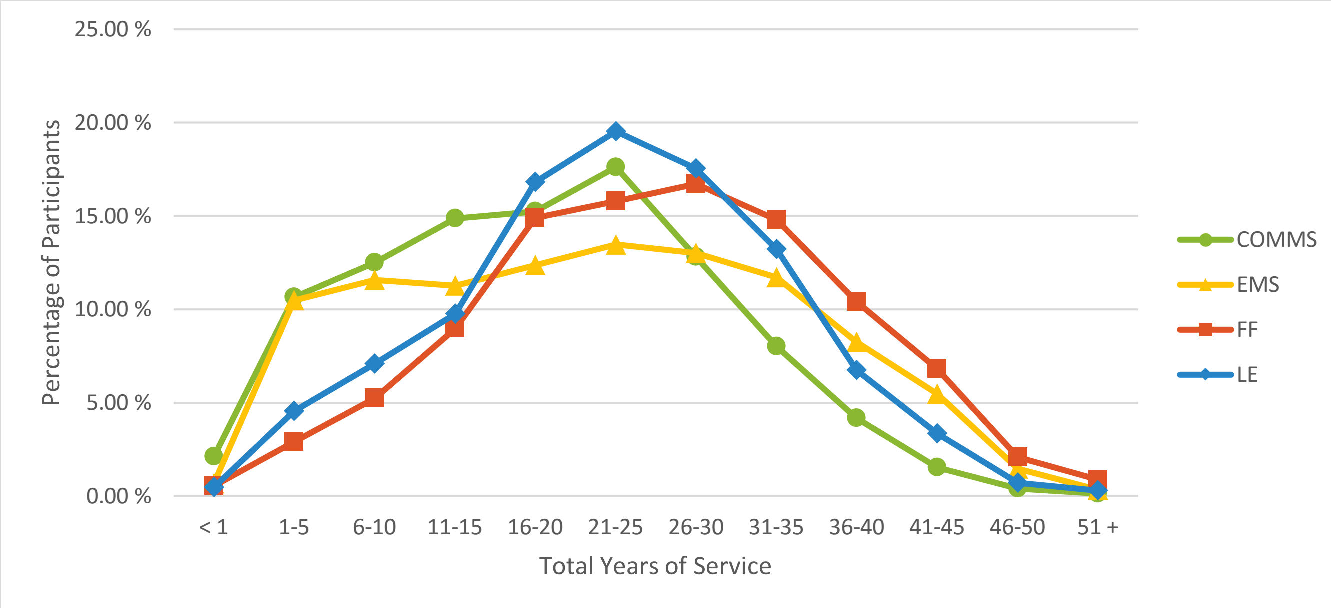

Fig. 9. Participants who completed the survey by total years of service and discipline

The percentages of men and women who completed the survey, by discipline, are shown in Fig. 10. As reported in survey volume 2, the percentages of male and female first responders were comparable to the nationwide population of first responders [17]. Not surprisingly, the percentage of females was much higher in the COMMS data than in the other three first responder disciplines, reflecting the higher number of women in COMMS nationwide, where approximately 55 % of dispatchers are women [8].

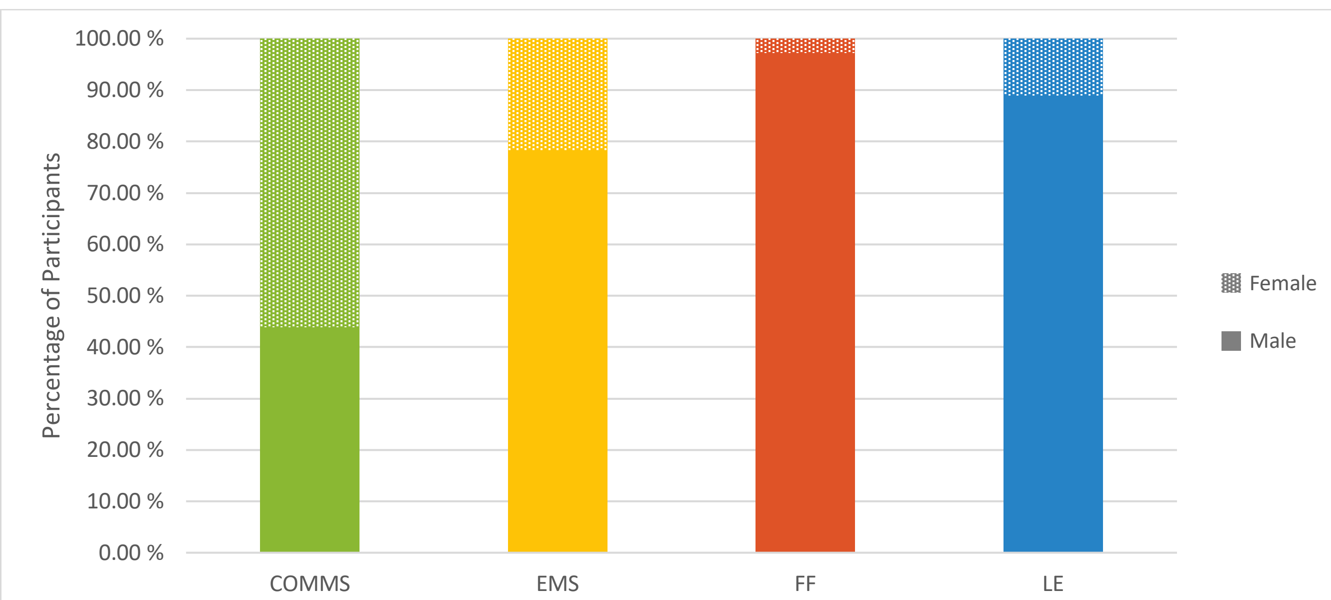

Fig. 10. Participants who completed the survey by sex and discipline

A discipline-specific demographics question was asked for three of the disciplines (see Fig. 11). COMMS were asked if they were civilian or deputized; 92.11 % of COMMS participants were civilian and 7.89 % were deputized. EMS participants were asked if they worked in the public or private sector; 67.04 % worked in the public sector and 32.96 % in the private sector. FF were asked if they were career or volunteer; 67.96 % were career and 32.04 % were volunteer.

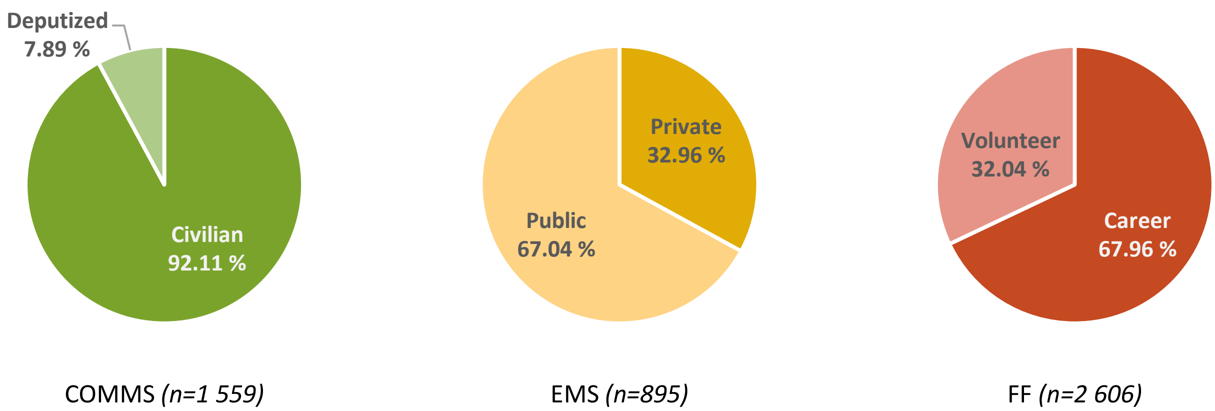

Fig. 11. Discipline-specific demographics for participants who completed the survey

As previously stated, the survey design, based on the interview data, was tailored to fit each discipline. For COMMS, a series of questions was asked about information related to the call center where they work (see Appendix B). The first question in the call center information section – who they dispatched for – is related to the discipline-specific demographics data, and therefore is being reported here. The question was presented as the following, with EMS, Fire, and Police as the response options:

> "What does your call center dispatch for? (Check all that apply.)"

A checkbox was provided for each response option; the COMMS participant was able to select as many or as few as were related to their environment. The vast majority of COMMS call centers dispatch for all three disciplines – EMS, FF, and LE (see Fig. 12). LE is the only discipline where a substantial number of call centers only dispatch for that discipline. Just over 10 % of COMMS call centers dispatch for two of the three disciplines.

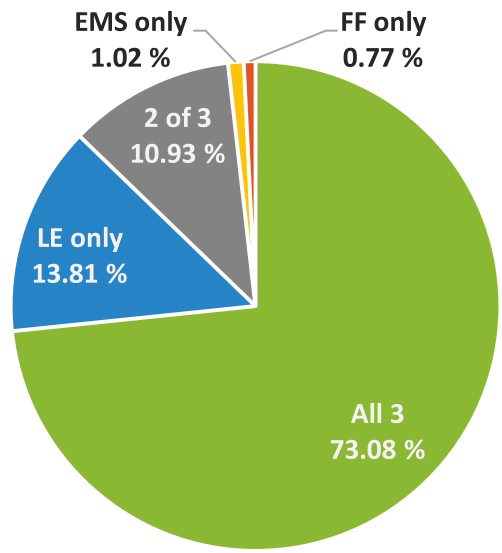

Fig. 12. COMMS call center dispatch responsibilities *(n = 1 558)*

3.2. Interview Demographics

A total of 193 first responders participated in the interviews (see Appendix A). Table 2 below shows a breakdown of interview participants by area type and discipline. Of the interviews conducted, 86 % were with male participants (see Fig. 13). The majority of participants were between 26 and 55 years of age; with 25 % from 26-35, 28 % from 36-45, and 35 % from 46-55. The interviews also included participants with varying levels of experience, divided into five-year intervals, representing the novice to the most experienced.

Table 2 Participants interviewed by area and discipline

	COMMS	EMS	FF	LE	*TOTAL*
Urban	4	13	28	32	*77*
Suburban	3	6	24	20	*53*
Rural	18	6	19	20	*63*
TOTAL	*25*	*25*	*71*	*72*	*193*

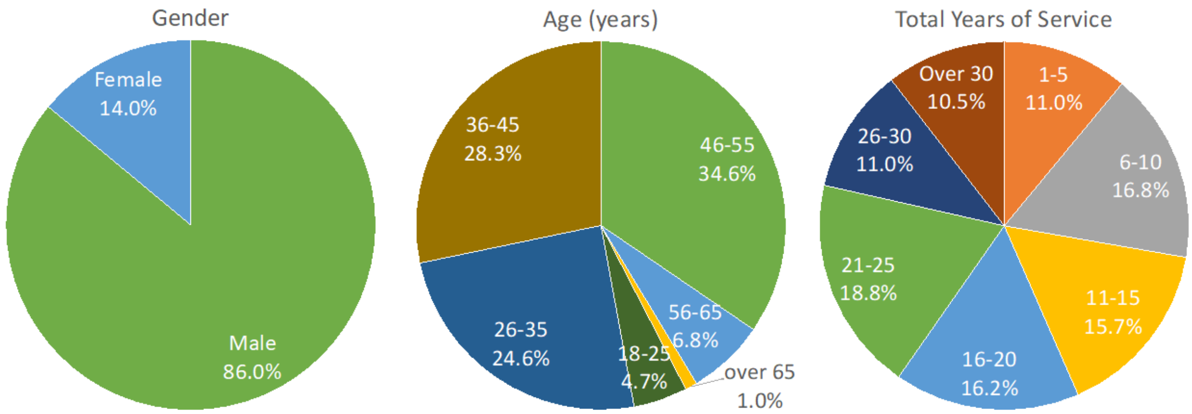

Fig. 13. Demographic data for participants interviewed

Full analysis and reporting of demographic data from the interviews can be found in previous volumes [5][9][18][28]; from the surveys, see Appendix C.

4. Results

The nationwide survey focused specifically on communication technology, especially on problems and requested functionality identified in the interviews with first responders [5][9], and on PSCR research priorities [25]. As described in Sec. 2, survey questions and response options were grounded in research from the previously collected empirical interview data [5][9], and were tailored appropriately for each discipline. There are two key aspects of the survey worth noting to gain an appropriate understanding of the results presented in this section.

First, for all four disciplines, lists of technologies were used for questions about first responders' day-to-day device use, day-to-day applications/software use, technology use during major disasters/large planned events, and envisioned use of futuristic technology (see Appendix B for detailed methodology). While certain technologies were common across disciplines—such as radios and smartphones—other technologies were discipline-specific. All lists used in the survey were the result of a thorough review of the problems and requested functionality identified in the interviews with first responders and the technologies first responders discussed as being important for their work [5][9]. Response item lists were also verified with content experts during the review phase of survey development. Where applicable, side-by-side comparisons and figures are presented for those questions and technologies common across disciplines in the following Results sections. Due to the breadth of data in this report, each Results section outlines the figures presented in that section prior to presenting the data. Throughout the Results sections, discipline-specific data are presented in the following order: COMMS, EMS, FF, and LE, unless otherwise noted.

Second, many survey sections included questions with open-ended responses (see Appendix B). Note that open-ended text boxes had no character limits. The open-ended responses were analyzed and are presented here where applicable. The responses quoted are provided as exemplars to convey participants' perspectives, and should not be viewed solely as the thoughts of a single participant. At the end of each quoted response is a notation that represents a particular survey response. The notation 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. For example, (FF:U:1234) represents the survey responses for record ID #1234, from a firefighter in an urban area.

All quotes in this report, including quotes from interview participants, are verbatim and are presented in blue, indented text. Interview quotes come directly from the first responders via the transcripts of the audio recorded interviews; their associated notations represent the source transcript from the interview quote. Interview quotes are distinguishable from survey quotes in their notations; "INT" precedes the original three-part notation for interview quotes. The three-parts of the original notations are: discipline, city type, and interview number. Thus, (INT-LE-U-006) refers to an LE interview, from an urban location, who is law enforcement interviewee number 006. These conventions provide assurances of the data's provenance and that the data can quickly and easily be located within the larger datasets when necessary. It is important to highlight that these notations are not connected to specific participants, as surveys were completed anonymously; any potentially identifiable information within the quotes have been redacted, with redacted text replaced with general terms in square brackets (e.g., [name redacted]). Throughout the subsequent Results sections, quotes from the interview data are presented where appropriate, along with relevant responses from the open-ended survey questions.

As discussed in Appendix B, since participation in the survey was voluntary, none of the questions on the survey required a response, with the exception of the discipline question since a response was necessary in order to branch to the appropriate discipline-specific survey. Therefore, participants could choose to skip any of the questions and continue to the next question, or they could choose to quit the survey at any point. While 7 182 participants completed the survey in its entirety, the number of participants who responded to a particular question varied. For ease of exposition, select figures and tables include the total number of responses, *n*, for the corresponding question where appropriate; the complete results and *n*'s for each survey question presented in this report are listed in Appendix D.

This section begins by presenting descriptive statistics for mobile device usage and problems first responders experience with those mobile devices. This is followed by descriptive statistics for applications/software usage and applications/software rankings[3]. The section concludes with descriptive data from three additional areas. First, data is provided on the types of futuristic technology first responders believe would be useful for day-to-day incident response. Second is the presentation on first responder technology usage in large events (major disasters or large planned events). Finally, data that specifically addresses the use of virtual reality (VR) for training and other purposes is presented. The order in which the results are presented mirrors the presentation of questions in the actual survey, unless otherwise noted (see Appendix B).

[3] While not in scope for this document, device rankings will be reported in future volumes, as discussed in Sec. 5.2.

4.1. Mobile Devices

This section presents per-discipline and cross-discipline data from the day-to-day device section of the survey. The list of technologies used in the day-to-day device questions was similar across disciplines (see Appendix B). The list included 10 to 14 devices depending on discipline, ranging from radios and MDTs to thermal imaging camera (TICs) (for firefighters) and body cameras (for law enforcement officers). The following sections present an analysis of the results for the subset of the list that are considered mobile devices for this report: personal smartphones, work-issued smartphones, and tablets.

4.1.1. Frequency of Use

The first question in the day-to-day device section asked participants how often they used certain devices. The survey question was framed as follows:

> "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 day-to-day work."

The survey question stem was:

> "Think about your **DAY-TO-DAY** work and your use of the following **devices**."

For each device listed, respondents then chose from the following frequency of use response options:

- Use a lot
- Use occasionally
- Have, but do not use
- Do not have

As described in Sec. 2, the survey items were based on the interview data. Given the nature of their environments and in order to adhere to the goal of keeping the survey short, the list of devices for COMMS participants did not include tablets (see Appendix B). A final open-ended text box was used to capture any other devices participants use in their day-to-day work. The instruction preceding the textbox was:

> "Other (please specify)"

This gave participants the opportunity to identify any communication devices not listed that they felt were useful in their work environments.

In this section, Figure 14 shows each of the participants' responses for the three mobile devices – personal smartphones, work-issued smartphones, tablets – across disciplines. Discipline-specific data for these devices are shown in Figs. 15 through 18. Appendix D lists the detailed frequency of use percentages for each mobile device, for each response option, by discipline. Relevant results from the open-ended survey responses are presented throughout the section.

Across disciplines, the most used mobile devices in participants' day-to-day work were personal smartphones (see Fig. 14). The number of participants who selected "Use a lot" for their personal smartphones was nearly double the number of who selected "Use a lot" for work-issued smartphones, and almost triple the number for tablets. Across disciplines, tablet use is more occasional than smartphone use. It is also interesting to note the small percentage of participants who selected "Have, but do not use" for each of the mobile devices. First responders either have smartphones or they do not, but those who have them use them frequently.

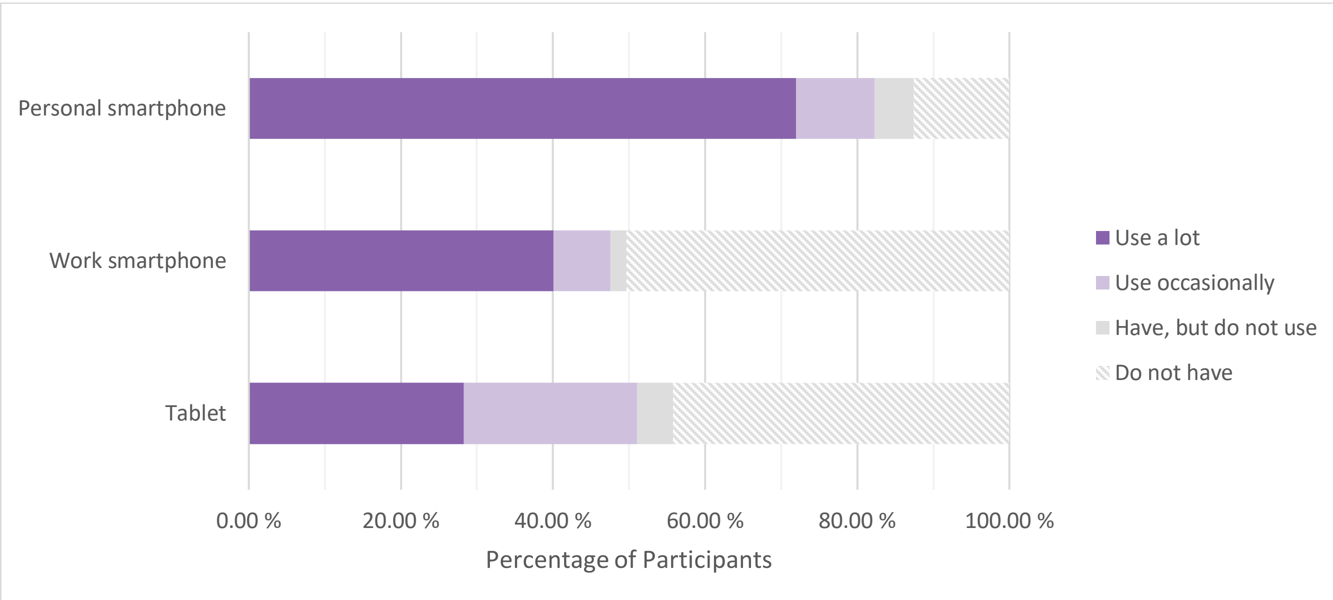

Fig. 14. Mobile device frequency of use, across disciplines

Table 3 provides more insight into the overall use (response options "Use a lot" and "Use occasionally" combined) of smartphones, both personal and work-issued, by discipline. Across disciplines, nearly two times the number of first responders use personal smartphones (82.26 %) than work-issued smartphones (47.56 %). As discussed later, the higher number for LE work-issued smartphones than the other disciplines may be due to the intended use of the devices. Some LE responders are issued smartphones for specific job-related tasks beyond making calls (e.g., "Body Worn Camera phone device" (LE:U:6943)).

Table 3. Participants who use smartphones

	Personal	Work-issued
COMMS	72.24 %	40.91 %
EMS	89.50 %	32.76 %
FF	87.63 %	45.88 %
LE	79.90 %	60.98 %

It is somewhat surprising that over 40 % of COMMS participants are issued smartphones for their work. COMMS environments are mostly stationary, with personnel primarily monitoring one or more communication systems from their workstation:

> Well, each one of our consoles has four computers. There's a what we call a console computer, which is your basic. We have our remote desktop for the town of [town redacted] with email. You get your calendar, all that kind of stuff, Outlook stuff. And then that computer also controls the CCIC [Colorado Crime Information Center] and NCIC [National Crime Information Center]. …. And that's about it on that one. It's just a regular computer. [The console computer] … that has two screens. So one for RDS [Remote Desktop Services] and one for CCIC. The next computer is our CAD computer. So it's got two screens as well, and these two are 24 inch, these are 27 inch, and they have our CAD database, and then there's also a CAD map, as well as our texts to 911 comes into that….And then, to the right, there's two more 24-inch monitors. Those are the radio phone on those two. And of course, then you have three keyboards, four mice. And then, on the side, we also monitor about 200 alarm accounts in the county. (INT-COMMS-R-002)

While not all COMMS environments have the exact same workstation configurations, the types of communication technology that COMMS personnel use are relatively similar [28]. It could be the case that many of the work-issued smartphone users who took the survey were COMMS supervisors:

> Dispatchers are not allowed to use their personal cells while on duty, supervisors are [the] only ones with department issued cell phones. (COMMS:R:4274)

> In my admin capacity… personal smartphone is not used for work related duties. If I was not issued a work smartphone, I can see a couple cases I might use personal. (COMMS:U:6905)

Those in COMMS administration often have access to work-issued smartphones when others do not. Many of them use both work-issued and personal smartphones.

Of the participants who use smartphones in their day-to-day work, just over one-third of participants (34.89%) use both personal and work-issued smartphones, across disciplines (see Table 4). This finding mirrors the interview data, where the functionality requested by many interview participants, like the LE participant below, were for all-in-one devices [9].

> [In the future,] I won't have to carry two phones… this is either my personal phone that does both or my city-issued phone that I can - whether it's a double SIM or something - I can still do-- because I mean, these phones are huge now, which is great. But I don't want two of them. So something like that would be-- it's the only thing that I just hope that we get there. I know we will someday. (INT-LE-U-006)

The high number of requests for all-in-one devices from the interview data may also be related to the way smartphones are used. Responses to the open-ended question in this survey section indicate that in LE, smartphones are often used for purposes not related to making calls.

> To clarify on the work issued smart phone; I have a work issued android, however, it only allows me to tag body camera videos. I cannot make phone calls, text message, or use the internet because it's not activated. It's only purpose is the body camera. That's why I said I do not have a work issued phone. It would be nice to have a work number to call complainants/suspects. (LE:S:7088)

As illustrated by this participant, an all-in-one smartphone device, combining the various uses of similar devices into one, may reduce the technological burdens on first responders.

Table 4. Participants who use both personal and work-issued smartphones

	% of Smartphone Users
COMMS *n = 1 288*	35.17 %
EMS *n = 865*	24.97 %
FF *n = 2 565*	33.37 %
LE *n = 2 041*	40.81 %

For tablets, LE use is far lower than in EMS and FF; around half of LE participants compared to EMS and FF use tablets (see Table 5). Of the open-ended responses related to mobile devices, 50.00 % of FF responses were about the use of tablets, likewise for LE. Only 16.67 % of EMS mobile device related open-ended responses were about tablets. As the COMMS device list did not include tablets, the most tablet-related open-ended responses were from COMMS (57.14 %).

Table 5. Participants who use tablets

	% of Participants
EMS	59.93 %
FF	63.59 %
LE	31.52 %

There were 277 total open-ended responses overall in this section of the survey. Across disciplines, 19.49 % of those simply listed mobile devices. Of these, 59.26 % listed tablets and 38.89 % listed smartphones. Table 6 shows the percentages of open-ended responses that listed mobile devices, by discipline; these percentages reflect the percentage of responses to the open-ended question, not the total number of survey responses in each discipline. For example, 32.43 % of all EMS open-ended responses listed mobile devices; it is not 32.43 % of the total number of EMS survey responses.

Table 6. Participants with responses to devices open-ended question: mobile devices listed

	% of Open-ended Responses
COMMS	13.73 %
EMS	32.43 %
FF	23.26 %
LE	15.38 %

Figures 15 through 18 show mobile device use by discipline. For COMMS (Fig. 15), almost twice as many participants *have* a personal smartphone than a work-issued smartphone (i.e., a selection of "Use a lot," "Use occasionally," or "Have, but do not use"). Notably, more participants "Have, but do not use" their personal smartphone in COMMS than in the other disciplines (16.38 %). As alluded to previously, this could be a result of the restrictions on the use of personal devices in the COMMS environment, as indicated by this first responder:

> Communicators are not allowed access to our smartphones on the floor (COMMS:U:3722)

The high number of "Have, but do not use" in COMMS is perhaps not surprising since PSAPs often have policies prohibiting or limiting personal smartphone use while on shift.

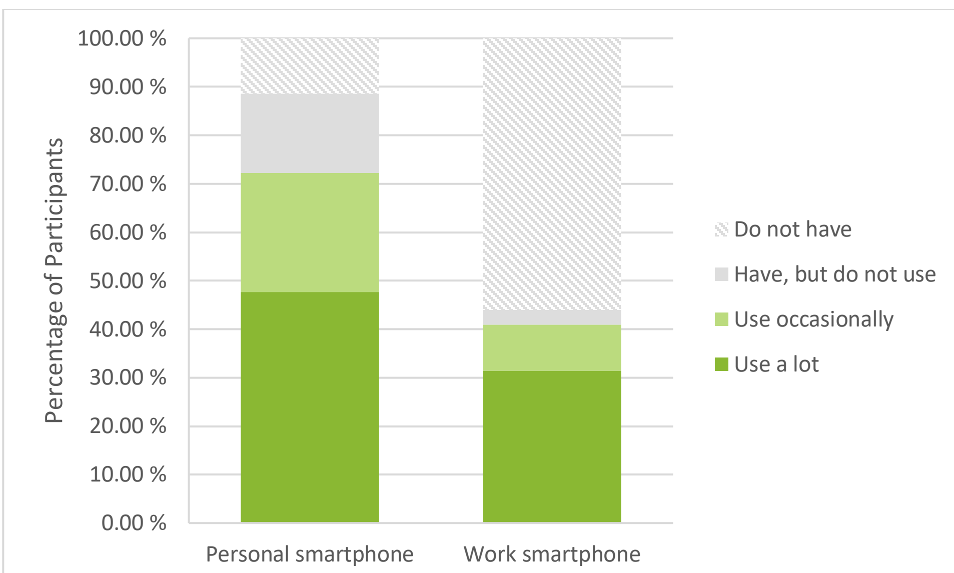

Fig. 15. Mobile device frequency of use for COMMS

The frequency of use data for EMS and FF participants are strikingly similar (see Figs. 16 and 17). While most EMS and FF participants have personal smartphones and most do not have work-issued smartphones, nearly all of the participants who have a smartphone use it a lot. Approximately two-thirds of EMS and FF participants have tablets; about half of those participants use their tablets a lot.

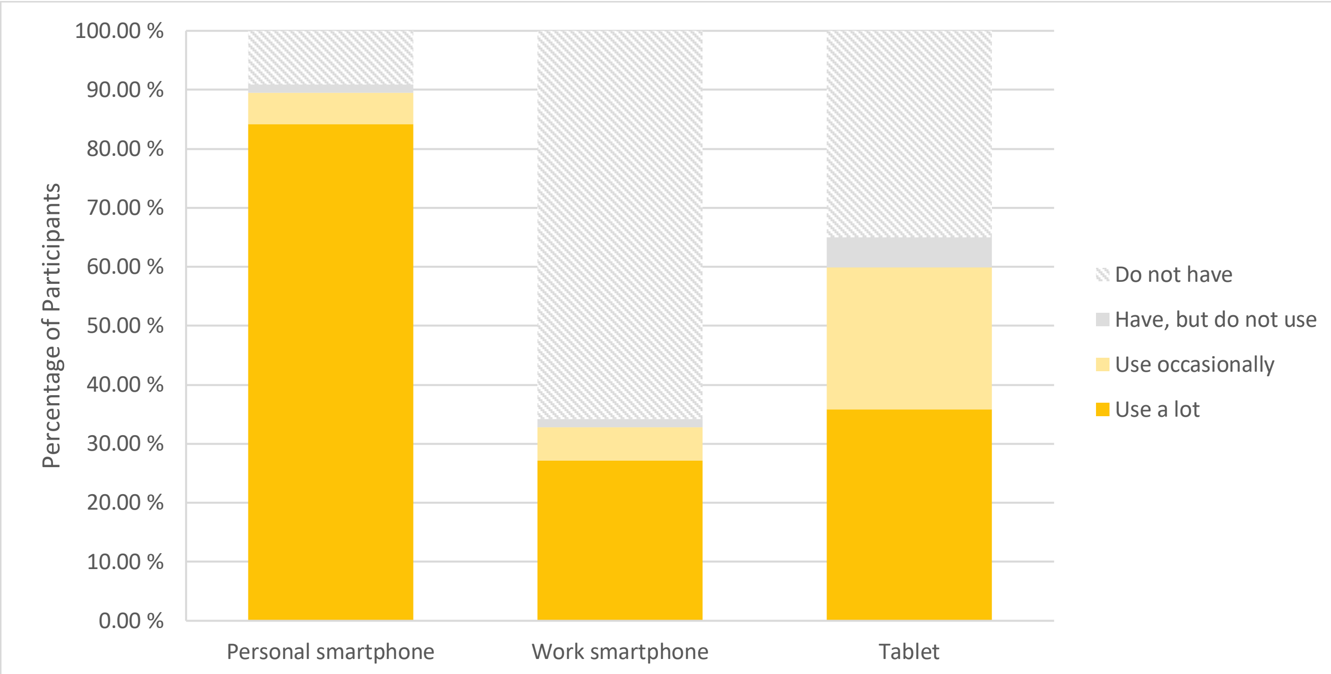

Fig. 16. Mobile device frequency of use for EMS

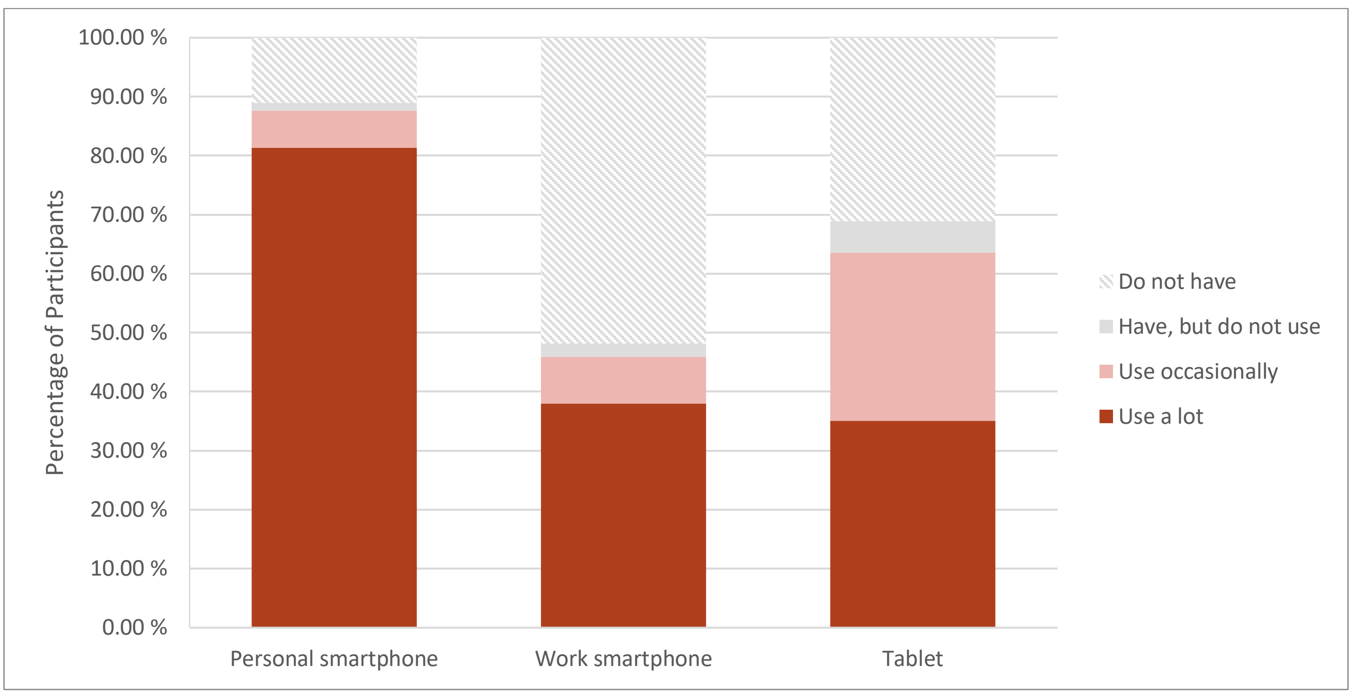

Fig. 17. Mobile device frequency of use for FF

While the LE data are similar to EMS and FF for personal smartphone use, they differ somewhat for work-issued smartphones and tablets. Like EMS and FF, most LE participants have personal smartphones, with 87.74 % of those using them a lot (see Fig. 18). Where they differ is that more than half of LE participants have a work-issued smartphone (62.49 %). As previously stated, the number of LE tablet users is about half that of EMS and FF; but like EMS and FF, half of those LE participants use them a lot.

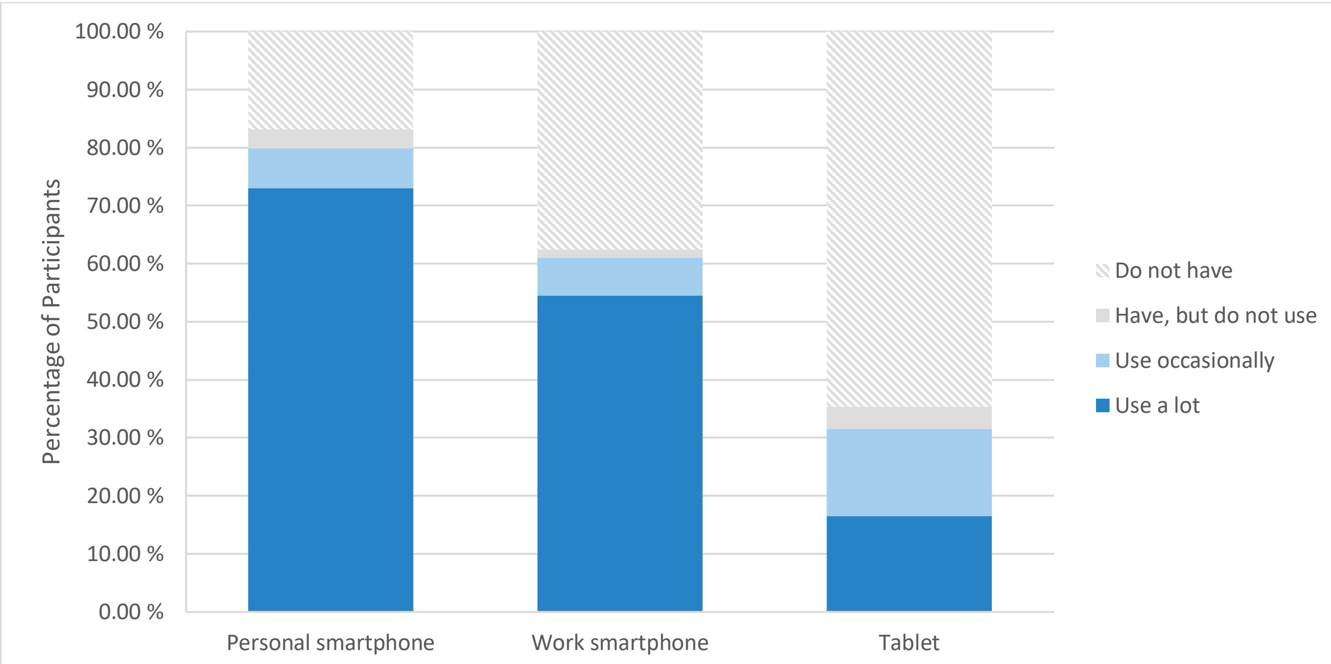

Fig. 18. Mobile device frequency of use for LE

By far, the single most important mobile device usage finding is the consistency of personal versus work-issued smartphone usage across disciplines. Across all four disciplines, larger numbers of first responders are using their personal smartphones than are using work-issued smartphones, consistent with the interview data. While the magnitude of the difference between personal and work-issued smartphone usage may be smaller for LE, the overall pattern of smartphone usage across disciplines is striking in its consistency, where personal devices are used more than work-issued devices.

4.1.2. Problems Experienced

The survey included questions about problems experienced for each of the devices listed in the frequency of use question (see Sec. 4.1.1). The framing page for the day-to-day technology problems section of the survey consisted of the following text:

> "For the next set of questions, think about problems you have experienced with the devices you previously ranked as most useful."

Each device and its associated problems were presented on a separate page, with a question stem tailored for each device (see Appendix B). The question stems for the mobile devices were:

> "With your **SMARTPHONE** (work-issued or personal), have you experienced problems with:"
>
> "With your **TABLET**, have you experienced problems with:"

The question stem was followed by a list of problems customized for that particular device. For each problem, participants selected from the following response options:

- Always
- Most of the time
- Sometimes
- Rarely
- Never
- Does not apply

Work-issued smartphone and personal smartphone variations were listed separately for the frequency of use question, but since the problems experienced by those variations were not unique, they were collapsed into a single instance for the problem section. Participants had the option to choose "Does not apply" for the few problems that were only meant for work-issued smartphones.

The final question for each device in the problems section was a yes/no question asking about other problems associated with the device. The mobile device questions were:

> Have you experienced other problems with your **SMARTPHONE** (work-issued or personal)?
>
> Have you experienced other problems with your **TABLET**?

A final open-ended text box was presented after this question with the instruction, "Please list."

As described in Appendix B, one of the guiding principles of the survey instrument design was to keep the survey short out of respect for first responders and their time, and to encourage survey completion. Therefore, participants were only asked about problems for up to three of the devices listed. A participant's responses to previous survey questions determined the device problems asked. Figure 19 shows the process logic for selecting these devices: participants were asked to rank the devices, by usefulness, that they had indicated they use, or that they have had but do not use, in the frequency of use question; problems were asked for their ***top three ranked devices***.

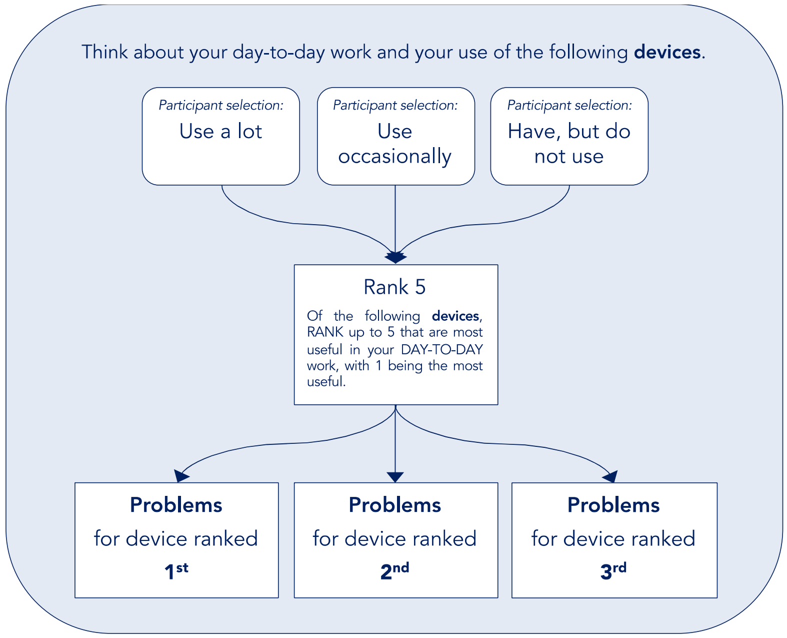

Fig. 19. Survey piping for day-to-day problems questions

This section presents the problems first responders experience with mobile devices. Across discipline and discipline-specific data from the smartphone and tablet problems questions are reported separately in the subsequent sections. As previously stated, a guiding principle of the survey was to keep the survey short; since COMMS participants were asked additional survey questions related to their problems with receiving and disseminating information, they were not asked questions in the day-to-day technology problems section.

Smartphone Problems, Across Disciplines

The list of problems associated with each technology were based on a thorough review of the findings from the interview data. Therefore, there was some variability in which problems were asked of a discipline. In the case of smartphones, problems with interoperability were only asked to EMS participants. The list of problems associated with smartphones, both work-issued and personal, for the survey question are listed below, in full as they appeared in the survey. Throughout Sec. 4.1.2, abbreviated versions of the problems with longer text will be used (e.g., “Subsidy for personal smartphone,” “Logging in”).

- Battery life
- Coverage/dead zones
- Data plans/data limits
- Dropped calls
- Durability
- Glare
- Logging in (PINS, passwords, usernames, etc.)

- Interoperability
- Outdated/old
- Permission/access to applications (apps)
- Policies about usage
- Price: too expensive
- Subpoena possibility for personal smartphone
- Subsidy for personal smartphone (insufficient or no subsidy)

3 831 participants across disciplines were asked if they experienced problems with using their smartphones (work-issued or personal). Table 7 shows the number of participants by discipline who were asked the question.

Table 7. Participants asked about smartphone problems

EMS	675
FF	1 804
LE	1 352
Total	*3 831*

In this section, to provide an overview of the smartphone problems most frequently experienced by first responders, percentages for individual problems where participants chose "Always" or "Most of the time," FF, EMS, and LE data are shown side-by-side in Fig. 20. A comparison of every response option, across disciplines, for each of the smartphone problems can be found in Fig. 21, ordered by most experienced problem to least (by a combined "Always," "Most of the time," and "Sometimes").

Overwhelmingly, the top smartphone problem participants face across disciplines is "Price: too expensive," where 43.28 % of participants experience the problem "Always" or "Most of the time" (see Fig. 20; problems in alphabetical order). The number of participants who often have problems with the cost of smartphones is nearly double the number of participants who have any other smartphone problem. Across disciplines, "Subsidy for personal smartphone" and smartphone "Battery life" are also among the top problems participants experience often.

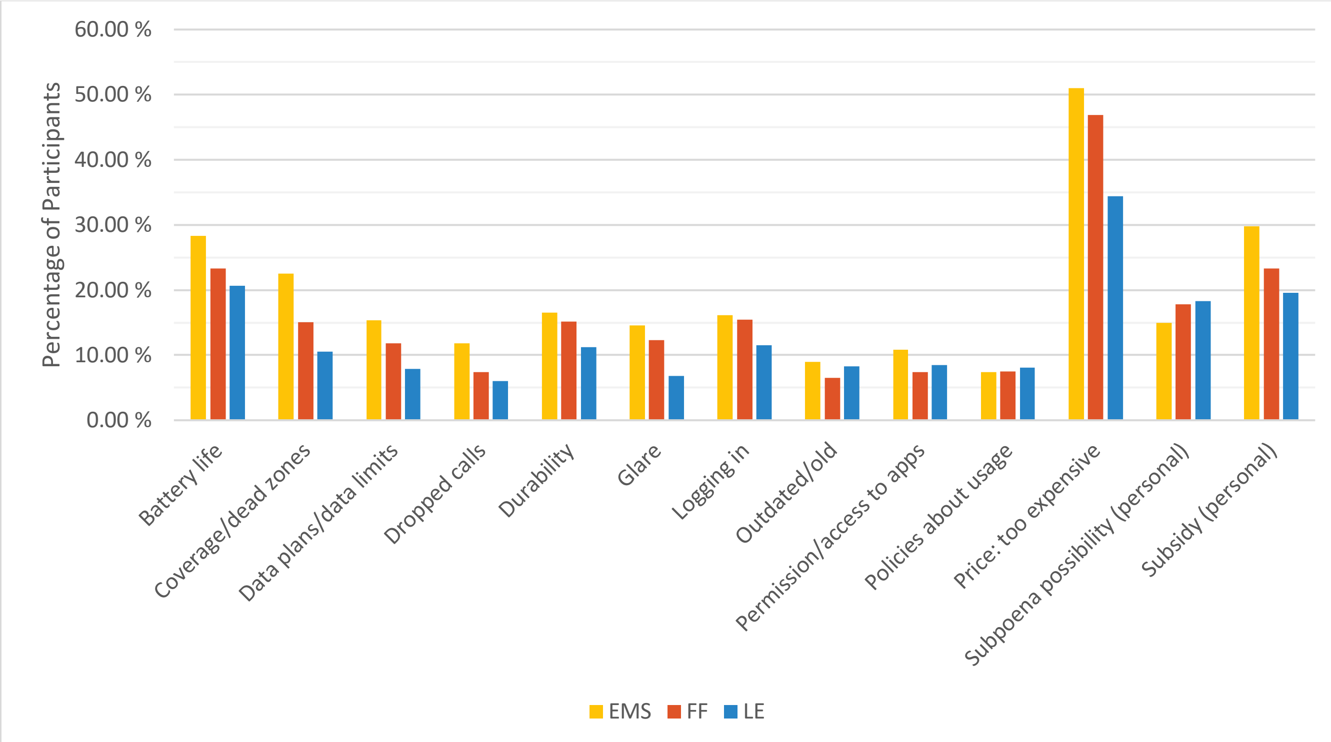

Fig. 20. Most frequently experienced smartphone problems, by discipline

It is imperative to know which smartphone problems participants experience most often in order to effectively improve their day-to-day technology use. However, in the work of first responders, problems that occur at times but not at others may cause even more of a burden on responders; technology that only works on occasion is dangerous because the user never knows when it will fail. Figure 21 shows the data for smartphone problems, across disciplines, ordered most to least by combined total of "Always," "Most of the time," and "Sometimes" response options. For many of the common smartphone problems, "Sometimes" was the response option chosen by most participants. Each of the problems listed were experienced by over ¼ of participants at least "Sometimes." The top smartphone problems participants across disciplines have at least "Sometimes" are listed below. "Price: too expensive" is a very frequently experienced issue even when considering "Sometimes" along with "Always" and "Most of the time."

- Battery life
- Price: too expensive
- Coverage/dead zones

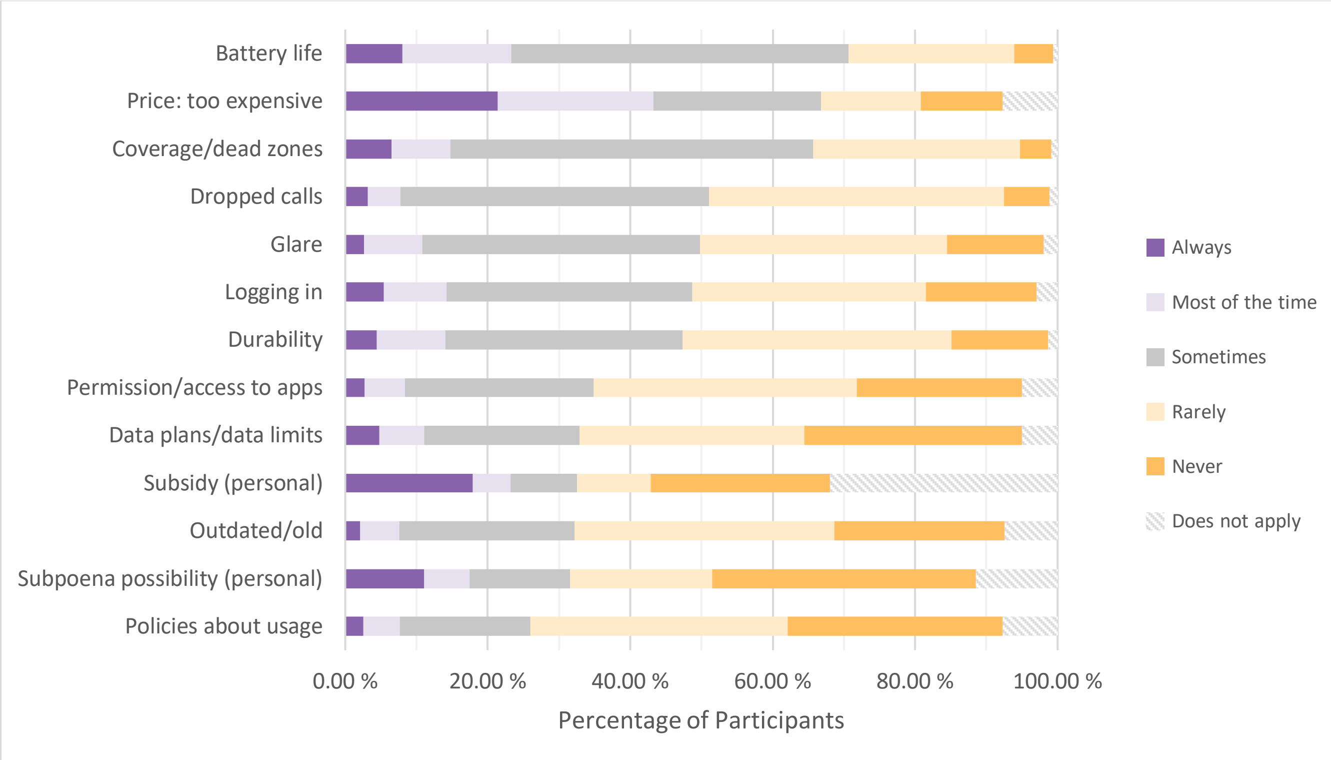

Fig. 21. Smartphone problems experienced, across EMS, FF, and LE

The open-ended question for other smartphone problems resulted in comments on wide-ranging topics, including the re-emphasis of those included in the common problems list. Of the 3 831 participants who were asked about their smartphone problems, only 274 (7.15 %) responded to this question with additional problems. Table 8 shows the total number of participants who responded to the open-ended question, by discipline. As participants rarely listed other problems with smartphones, the list of problems included in the survey design thoroughly captured the experiences of first responders in their day-to-day work.

Table 8. Participants with responses to smartphone problems open-ended question

	% of Participants
EMS	8.59 %
FF	7.32 %
LE	6.21 %

Interestingly, many of the open-ended responses were related, or identical, to a problem in the list of common smartphone problems. This redundancy is not uncommon in survey research, and could indicate that those problems resonated even more with some participants than others. Many of these were problems with coverage/dead zones, dropped calls, battery life, durability, outdated/old smartphones, and cost.

Many participants elaborated on the specific issues they experience with the cost of smartphones being too expensive. Cost is not solely the price of the smartphone itself; participants also voiced concern over the cost of the data plans and apps associated with smartphones as well as the cost of having both personal and work-issued smartphones.

> Cost of useful apps prevents us from [using the apps] that could really assist us… We carry pagers and our smart phones could take [their] place but cost is the issue. (FF:S:7583)

> My personal cell phone I want to keep personal and don't want it to be related to my work. The [work-] issued cell phone is not connected to a wireless plan, [it] is only used to access the body worn camera. (LE:S:7988)

> Would like to see the agency… save us some money on our personal cell bills since we use them for work. (EMS:T:8751[4])

> Simply having to use my cell phone for a reliable connection. They work better than our radios. Why should I have to use my data/minutes for work related communications. (EMS:S:3987)

Interview data showed more depth to the cost issue with carrying personal and work-issued smartphones:

> "People don't want to have to carry a work phone, a private phone, a NCIC capable secure device, you know what I mean? You just start adding them on and on and on… You're running out of pocket space. It's a waste of hardware… So, it starts adding on. So if we can reduce that number and… logins as well. That's the big one." (INT-COMMS-S-001)

Often, a burden of using smartphones is more than a financial cost, but a physical cost as well. As the interview data revealed, while certain technology may be useful for their work, first responders do not want to pile new technology on top of what they already use [9].

Related to the cost problem with smartphones are issues with subsidies for personal smartphones. The "Subsidy for personal smartphone"[5] item included in the common smartphone problems list resulted in responses unique from the other smartphone problems (see Fig. 21); "Does not apply" was selected by the most participants for the "Subsidy for personal smartphone" problem, by far, than for the other

---

[4] First responders in tribal areas were not specifically recruited for the survey. Although the percentage of tribal responses was low, it is important to include their data with the overall results.

[5] As previously noted, the full text used in the survey for this problem was "Subsidy for personal smartphone (insufficient or no subsidy)"

smartphone problems. It can be inferred from the open-ended responses that this may be due to no subsidy being available for these participants.

> Seems to be some hurdles still if using my own phone - no reimbursement from company & if I use my own then no way to access first responder discounts. (EMS:R:6478)

> Personal phones only- department does not provide any subsidy for phones and do not give us departmental phones. This severely hinders us from doing our jobs. (LE:S:7081)

> There are no work issued phones. We are expected to use our personal phones with zero reimbursement from the County. (LE:R:4768)

Also unique to the "Subsidy for personal smartphone" data is that although fewer participants across disciplines have this problem than the other smartphone problems (at least "Sometimes"), those that do almost always experience the problem: 41.77 % of participants who have a subsidy problem with their smartphones "Always" have the problem. For those who receive subsidies, the strength of opinions ranged from simply "insufficient" (LE:R:3069) to "vastly underfunded" (LE:U:6512).

The "Subsidy for personal smartphone" problem resulted in more contrasting "all or nothing" data than the other smartphone problems. This may be due to whether subsidies are policy or not depending on the department, as the participants above implied. In all, the initial cost of purchasing smartphones is only part of a bigger picture with the expense of smartphones (e.g., data plans and upgrades); the costs associated with using smartphones, both work-issued and personal, are burdensome as well.

For some participants, the burden of the many expenses associated with smartphones does not outweigh the usefulness of the device. Without a work-issued smartphone, and without a subsidy for their personal smartphone, participants still feel that the use of a smartphone is essential for their day-to-day work.

> I use my personal smartphone every day and more often than all the other electronic devices provide to me by the department. It maps better than the Engine laptop/MDT and I can always get CAD info and communicate with someone on it. (FF:S:5590)

> Our personal smartphones with a software we personally pay for is the most efficient way to receive 911 dispatches, turn by turn directions, and hydrant locations. Work provided means are outdated and lacking. (FF:S:3765)

> No work related phone, this is my personal… We use them for directions, to call certain [hospitals] because our radios don't have the right channels, and to look things up for the patient. A tablet would be best but still doesn't fix the phone call to the hospital part. (EMS:R:2208)

The interview data also revealed the use of personal smartphones when other technology is unreliable.

> So on the squad, our systems are so dated. So Google Maps doesn't really work and they're not precise, so we rely a lot on our phones. So a lot of firefighters-- if I'm driving the squad I'll have the person behind me go, 'Can you map this out and tell me directions over the headsets?' (INT-FF-U-011).

> We've got a $10 000 computer system in each of these apparatus, and all I can do is push a button, I'm on scene or I'm not. But if I wanted to get Google, and say, 'Okay. Well, what is this material that's in a hazmat [Hazardous Materials] event?' Well, now I've got to use my phone. That doesn't make sense. (INT-FF-R-008)

Participants understand the advantages and disadvantages of using certain devices for different tasks. They settle for using their personal smartphones in order to effectively do their jobs, despite the cost.

A risk often associated with the use of personal smartphones is the possibility of the smartphone being subpoenaed. Of the participants who experience problems with smartphones, after "Subsidy" and "Price," the next greatest number of participants "Always" had a problem with "Subpoena possibility (personal)" (see Fig. 21). Similar to the subsidy data but not as pronounced, experiences with subpoena problems are more infrequent overall, but those who do have the problem are concerned about it almost all of the time. These concerns were further expressed in the open-ended responses:

> Subpoena is always a possibility, personal or work. (FF:S:7583)

> The complete irony is that everyone tells you that using your personal cell phone is the worst possible idea; however, everybody uses their personal cell phone once every 10 minutes in law enforcement. It's a complete joke from the city legal department, the administration, all the way down to Prosecutor's are all hitting you on your cell phone all the time and yet telling you that it's going to be your downfall. (LE:U:3472)

> If we use our personal devices/equipment for on the job investigations they become subject to open records requests. For most, this severely limits our ability and willingness to use them. (LE:S:493)

Like the possibility of subpoena, there are other legal issues and considerations—such as Health Insurance Portability and Accountability Act (HIPAA)—that surround the use of smartphones. Expensive cost, insufficient subsidy, and subpoena possibility all play a large role in the problems that first responders experience in the use of smartphones for their day-to-day work.

Beyond cost and its associated problems, open-ended responses were grouped into four categories, listed below (ordered from most responses to least):

- Hardware issues
- Coverage and network infrastructure issues
- Software issues
- Other issues with personal phone

Few open-ended responses did not fit into one of these categories. As indicated above, most participants who responded to the open-ended question have problems with smartphone hardware and/or coverage and network infrastructure.

The hardware issues listed varied; however, over a third of those reemphasized problems with battery life and durability, often in a single response. Given their work environments, many first responders are also concerned about smartphone performance in extreme weather conditions and the lack of waterproofing of smartphones. Other hardware issues included insufficient memory and storage capabilities and size.

> Fell and cracked during a job. Battery is also an issue. (EMS:U:5155)
>
> Poor performance in below freezing cold weather (battery crashing, screen locking up). (LE:R:5774)
>
> It doesn't like to get wet. I tried a lifeproof case but no one could hear me. (FF:S:5094)
>
> We provide water rescue from a busy beach. Water intrusion in phones is a problem. (FF:U:2317)
>
> Not enough storage for personal apps and work apps. (LE:R:5717)
>
> Display size makes smartphones fairly useless for anything beyond voice calls and short texts. (EMS:R:824)

Of the coverage and network infrastructure issues, the overwhelming majority of the responses elaborated on problems participants face with coverage/dead zones (73.26 %). Some participants also pointed out issues with "poor coverage in rural areas" (EMS:R:1480). Dropped calls and problems with the network being overloaded during large incidents were also heavily discussed.

> You might get 3G coverage in most of the covered area, and 4G only in the corridor of the main highway; but there are dead spots everywhere regardless of carrier. (EMS:R:2434)
>
> Coverage is lacking. Dropped calls are problematic. (LE:R:2441)
>
> Often during wide spread emergency network access is difficult. (FF:R:3287)
>
> Lost network coverage with work issued smart phone. Required replacement of SIMS card to correct the issue. (LE:R:6928)
>
> Smart phones should never be considered a reliable alternative to the 2-way radio system. They do not work effectively during a big event such as a hurricane/ blizzard and I have found the service providers are not always forthcoming in a timely manner when there are service disruptions. Secondly, the agencies do not have the control and supervision of the cellular network as they do [with] their 2-way radio network. (FF:S:2551)

Consistent with the findings from the interview data, the use of smartphones in the work of first responders is often hindered by the unreliability of the devices and their communication networks.

> I'm on the outside. I'm just the person that uses [wireless technology]. I don't know the ins and outs but it seems as though when you're in a rural setting, that those things should be considered when they're choosing… when we're one of the more rural counties and we have all of these areas that we can't even get radio reception, we can't get cell phone reception then you need to recognize that some of these things are not going to work for us. (INT-EMS-R-019)

> In any type of critical incident, that is one of the first things that goes, is the communications on cell phones… we try to have the redundant systems in place, probably more so in public safety than any other profession; we try to have those redundant systems but it still doesn't mean that, you know, some of them haven't been utilized in years and we are not sure that they are going to continue to work if we need them to do so. (INT-LE-R-059)

As discussed in previous Volumes, reliability is one of the most important aspects of technology for first responders [9].

Finally, when smartphones are vital for the day-to-day work of first responders, seemingly typical disturbances in normal life can become major interruptions.

> Spam calls and texts. (FF:U:788)

> Unwanted calls often from phone numbers I know so I answer them only to find robocalls or unsolicited vendor calls. (EMS:R:7242)

> Telemarketers Very big problem. (LE:U:8154)

People across the country experience spam and telemarketers, but when first responders are trying to focus on their work, it can be more of a nuisance. Overall, this rings true for most of the categories of open-ended responses for smartphone problems: typical problems are exacerbated when used in the context of public safety and incident response.

Smartphone Problems, Discipline-specific

In this section, Figures 22 through 24 show the data for smartphone problems by discipline, ordered most to least by the combined total of "Always," "Most of the time," and "Sometimes" response options. The percentages above each column in the discipline-specific charts below represents the number of participants, combined, who selected "Always," "Most of the time," or "Sometimes." Appendix D lists the detailed percentages for each smartphone problem, for each response option, by discipline.

EMS, FF, and LE smartphone problem responses followed similar patterns. Unsurprisingly, given the overwhelming number of participants across disciplines who experienced them, the top three problems faced within each discipline were "Battery life," "Price," and "Coverage/dead zones," though the order varied for each discipline. By a large margin, these three problems impact the day-to-day work of first responders and should be the leading considerations for designers and developers in the public safety community. In each of the disciplines, after these top three problems, there is at least a 10 % drop to the problem experienced by the next highest number of participants.

After the top three problems, each discipline experiences the same set of problems with their smartphones: “Glare,” “Durability,” “Dropped calls,” and “Logging in.” Approximately half of participants in each discipline face these smartphone challenges, although the totals overall are slightly less for LE.

Specifically for EMS, more participants “Always” had problems with “Subsidy (personal)” than with the other disciplines. Subpoena concerns for their personal smartphones were faced “Always” more often for LE than the other two disciplines.

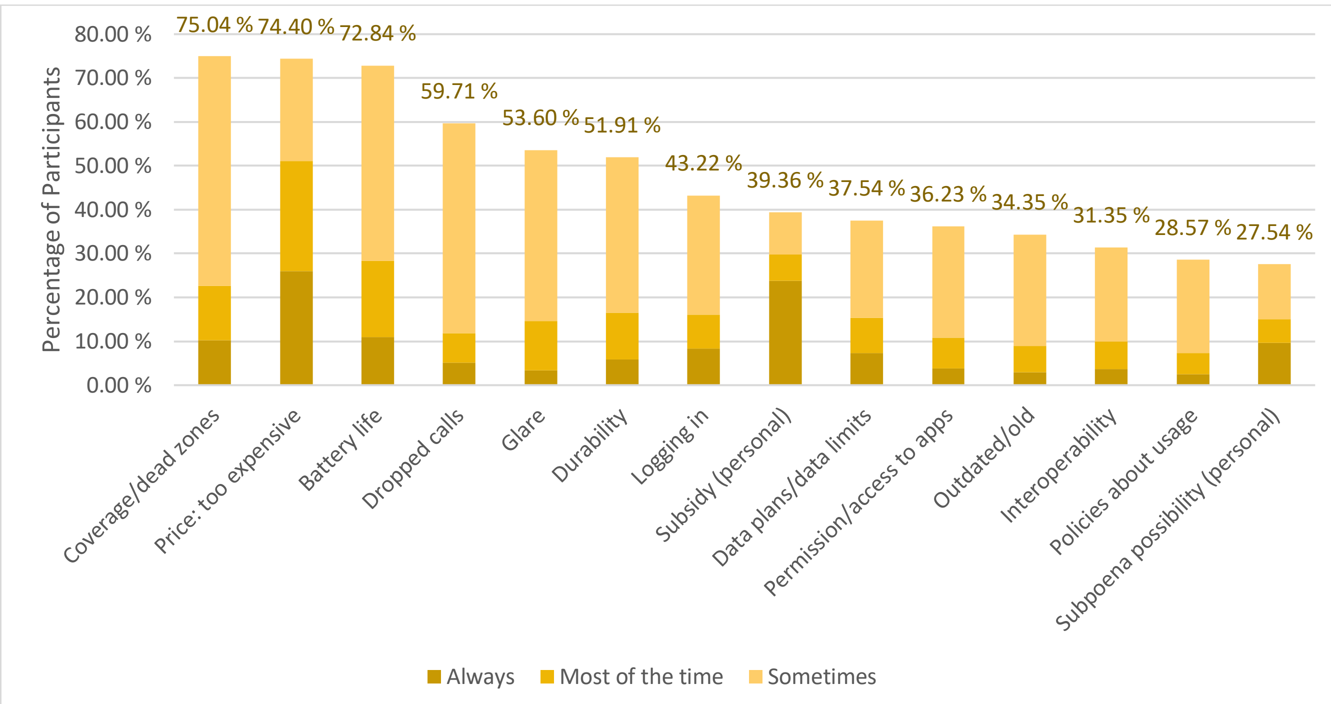

Fig. 22. Smartphone problems experienced for EMS

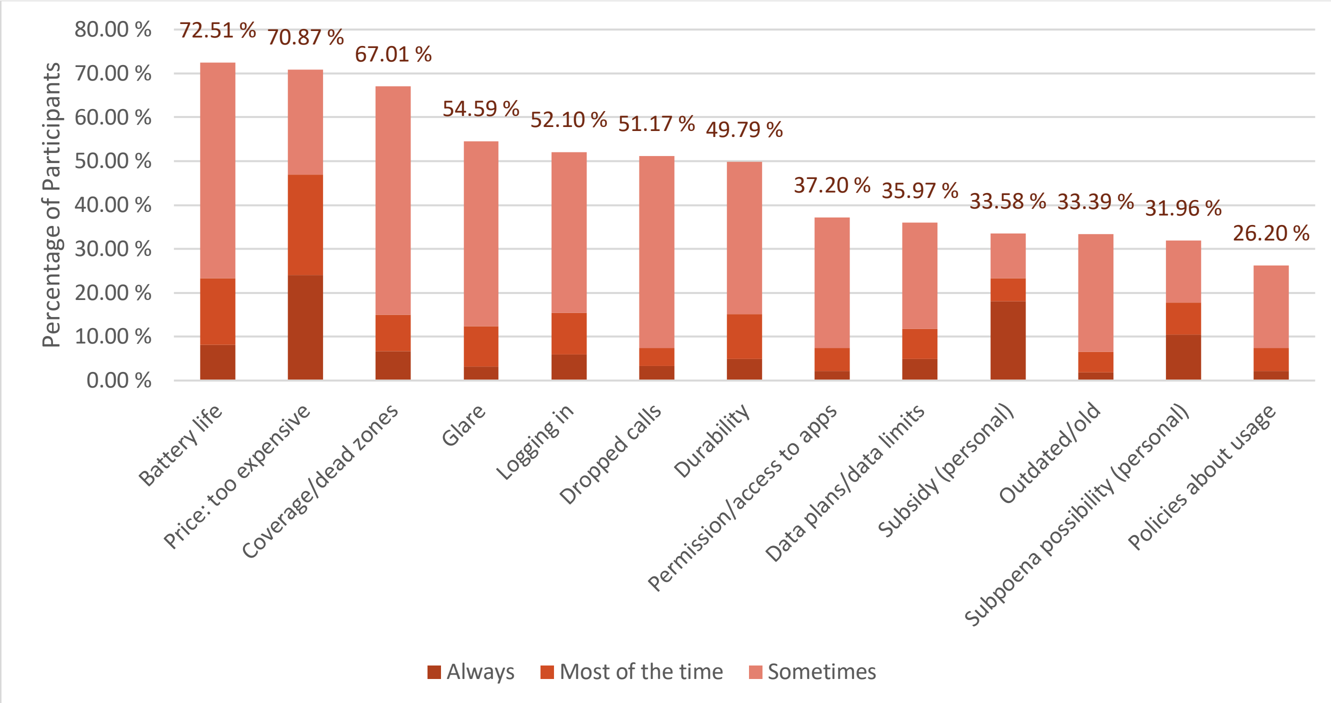

Fig. 23. Smartphone problems experienced for FF

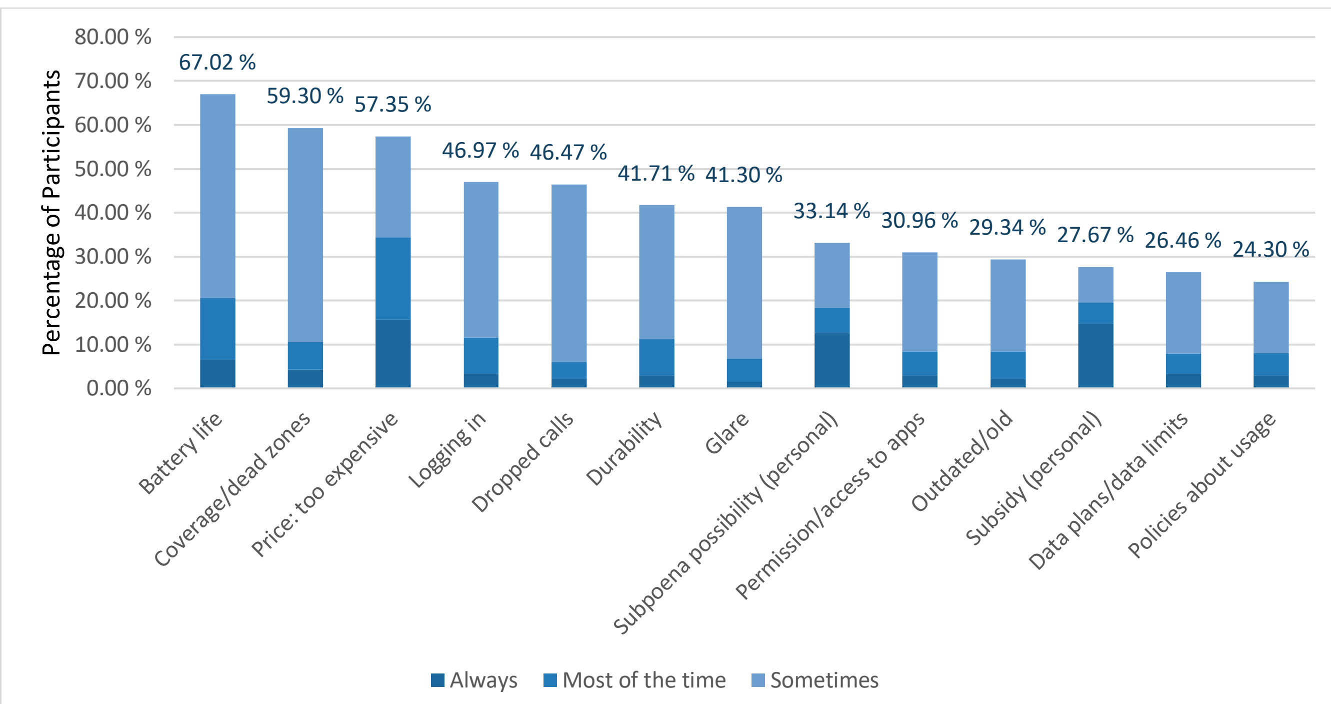

Fig. 24. Smartphone problems experienced for LE

Although there are some slight differences between disciplines in terms of the frequency with which first responders experience various smartphone problems, the similarities across disciplines are far more striking than the differences.

Tablet Problems, Across Disciplines

The list of problems for tablet computers was similar to the list of smartphone problems. Seven of the twelve items in the tablet problems list were also in the smartphone problems list. Like the list of smartphone problems, the items on the tablet problems list were based on the results and analysis of the interview data. This analysis showed that fewer people overall voiced concerns with using tablets, in part because their use was not widespread. Therefore, some variability existed in the tablet problem items asked to each discipline; "outdated/old" and "Price: too expensive" were only asked to LE participants. The full list of problems associated with tablets for this survey question were:

- Battery life
- Durability
- Glare
- Internet connection
- Interoperability
- Logins/passwords
- Outdated/old
- Price: too expensive
- Report writing
- Size/bulkiness
- Touchscreen
- Weight

As previously described, participants only saw problem questions for their top three ranked devices; as tablets were not frequently in participants' top three device selections, only 524 participants across disciplines were asked if they experienced problems using their tablets. Table 9 shows the number of participants by discipline who were asked this question.

Table 9. Participants asked about tablet problems

EMS	124
FF	302
LE	98
Total	*524*

In this section, to provide a high-level comparison of how each discipline experienced tablet problems, the results showing whether participants chose "Always" or "Most of the time" are shown in Fig. 25. A *summary of the across-discipline data, with each of the response options by problem can be found in Fig. 26.*

By comparison, more EMS participants expressed problems “Always” or “Most of the time” with their tablets overall than FF and LE participants (see Fig. 25; ordered alphabetically). Problems were experienced less frequently for LE (only “Logins/passwords” was more than 10 %).

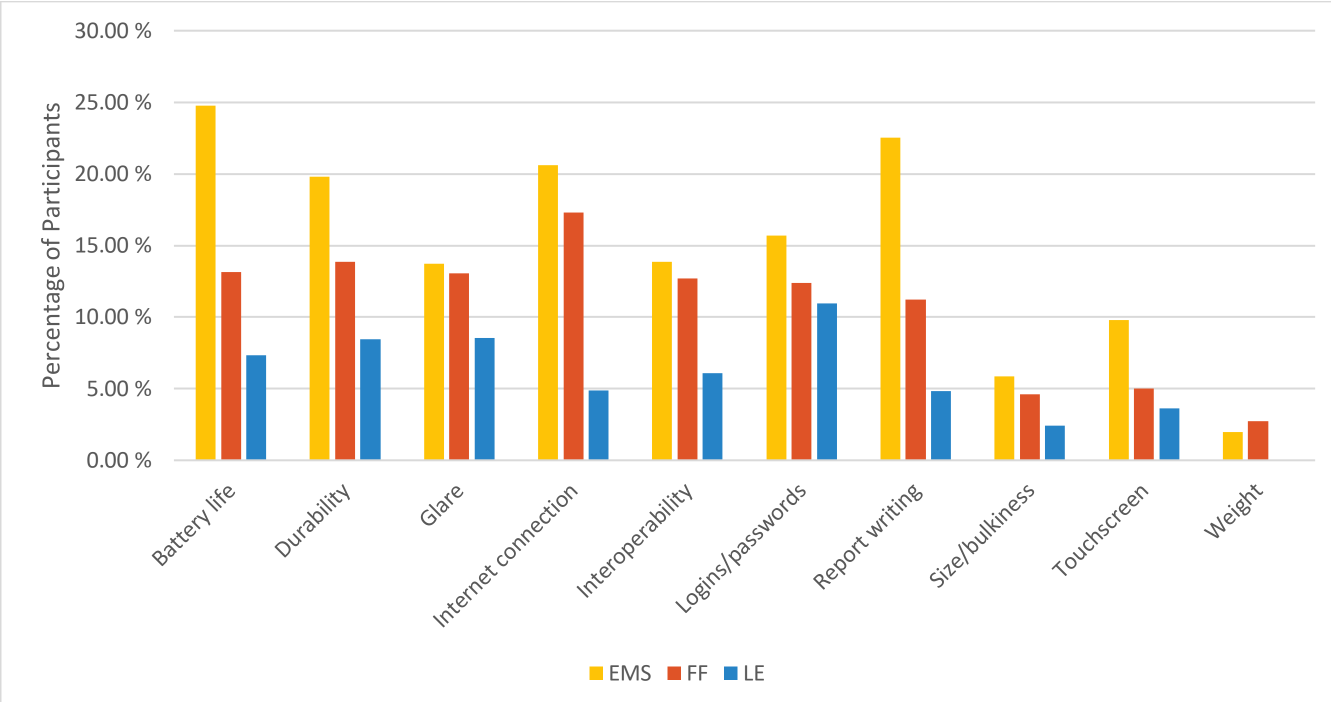

Fig. 25. Most frequently experienced tablet problems, by discipline

The data for tablet problems, across the three disciplines, ordered most to least by the combined total of “Always,” “Most of the time,” and “Sometimes” response options is shown in Fig. 26. Across disciplines, the problem most participants had “Always,” “Most of the time,” or “Sometimes” with their tablets was “Internet connection.” Over 30 % of participants experience eight of the ten tablet problems at least “Sometimes,” yet less than 10 % of participants across disciplines “Always” experience each of the tablet problems listed. The top tablet problems across disciplines, with over half of participants experiencing the problem at least “Sometimes,” were:

- Internet connection
- Glare
- Battery life

Notably, over 10 % of participants selected “Does not apply” for report writing issues on a tablet. It may be the case that participants who use tablets often do not use them to write reports, or that these participants do not write reports frequently, if at all.

The fewest tablet problems in each discipline were with “Touchscreen,” “Size/bulkiness,” and “Weight.” Although analysis of the interview data revealed weight as a problem, none of the survey participants “Always” thought it was an issue; LE participants only experienced problems with tablet weight, at most, “Sometimes.”

> “…when I'm on patrol, I carry 30 extra pounds of stuff, which doesn't count the two bags which are probably 30-pounds each of stuff that I keep in the car. So adding more stuff to all my stuff is more weight and redundant. So I think finding ways to use what we already carry… I think it's fairly mainstream that people have smartphones, and I think computers in the car is relatively mainstream. So adding technology or applications without adding something physical that I have to carry would be really nice.” (INT-LE-R-018)

As this LE interviewee voiced, weight is generally an issue for first responders. Responders expressed that they would be “better off” (INT-LE-S-016) if devices with similar functionality were combined into one. In the case of the survey, it may be that participants did not view weight as much of an issue when considering tablets in isolation. In contrast, when combined with the many other devices and extra equipment first responders are required to carry, weight can become a problem.

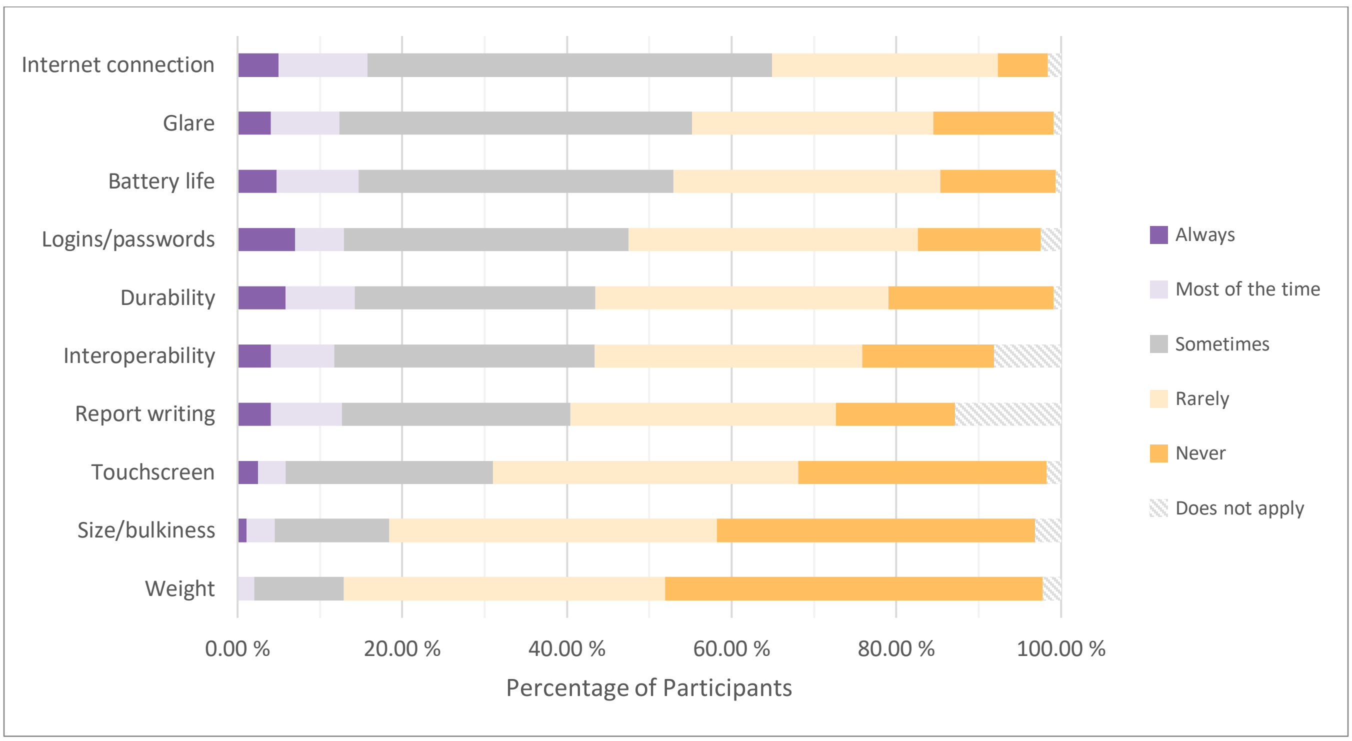

Fig. 26. Tablet problems experienced, across EMS, FF, and LE

Of the 524 participants who were asked whether they experienced problems using their tablet, 8.40 % (44 participants) responded to the open-ended question at the end of the section. Table 10 shows the number of participants who responded to the open-ended question, by discipline. Like the list of problems with smartphones, the designed list of problems experienced with tablets was extensive in order to capture the problems first responders face.

Table 10. Participants with responses to tablet problems open-ended question

	% of Participants
EMS	10.48 %
FF	7.95 %
LE	7.14 %

In their open-ended responses, participants across disciplines expressed problems related to a few key topics (ordered from most open-ended responses to least):

- Software issues
- Hardware issues, including battery life and durability
- Connectivity

A large majority of responses related to the device itself, or the apps that ran on the device. Within these topic categories, the tablet problems experienced by participants varied widely.

> Our EPCR system is tablet-based and while it works most of the time completing reports is more cumbersome than it should be and software issues causing charts to lock/freeze/crash are fairly frequent. (EMS:U:5306)

> Using an i-pad limits your productivity in the field; no ability to connect USB [universal serial bus]; tablet keypad not practical; department software awkward to maneuver around. (LE:U:305)

> Battery life, overheating, and durability are the biggest issues. (FF:R:1249)

> Freezing up on occasion, problem with connectivity with Wi-Fi and [LTE] . (FF:U:2455)

This is consistent with the interview data that showed participants have problems with tablets crashing and reliability:

> "The [MDC] tablets, they're not reliable… We were going to the tablet shop almost every day because the way that the bracket and the way it was mounted in there, the tablet would shake so much that essentially it'd just shake the thing to death and it would just crash. In the docking port, it would not get a charge because anytime you were moving, it wouldn't be able to keep the connection so it would just die all the time. That's across the board." (INT-FF-U-042)

As with the smartphone problems, open-ended responses were often more succinct, and participants simply responded with things like "expensive" (FF:R:5071), "memory" (FF:R:5516), "availability of apps" (FF:U:4224), or "application security" (LE:R:3983).

Tablet Problems, Discipline-specific

In this section, to better understand where participants had the most issues with tablet use, as with smartphone problems, figures 27, 28, and 29 show the tablet problems participants experienced "Always," "Most of the time," or "Sometimes," by discipline. The totals for these responses are shown above the column for each problem; problems are ordered by this combined total, from most to least.

As previously stated, "Price" was only asked to LE participants; it was the top problem in LE. After "Price," like EMS and FF, "Internet connection" was the top tablet problem experienced at least "Sometimes." For EMS, unlike FF and LE, there is a large margin between "Internet connection" and the second most experienced problem. Appendix D lists the detailed percentages for each tablet problem, for each response option, by discipline.

For EMS, tablet problems overall were experienced "Always" more than for FF and LE; although higher percentages of EMS and FF used tablets than those in LE (see Sec. 4.1.1). Additionally, EMS experienced tablet problems relatively uniformly across the board; between 45 % and 65 % of participants experienced most problems. Both FF and LE had gradual declines in the total number of problems experienced.

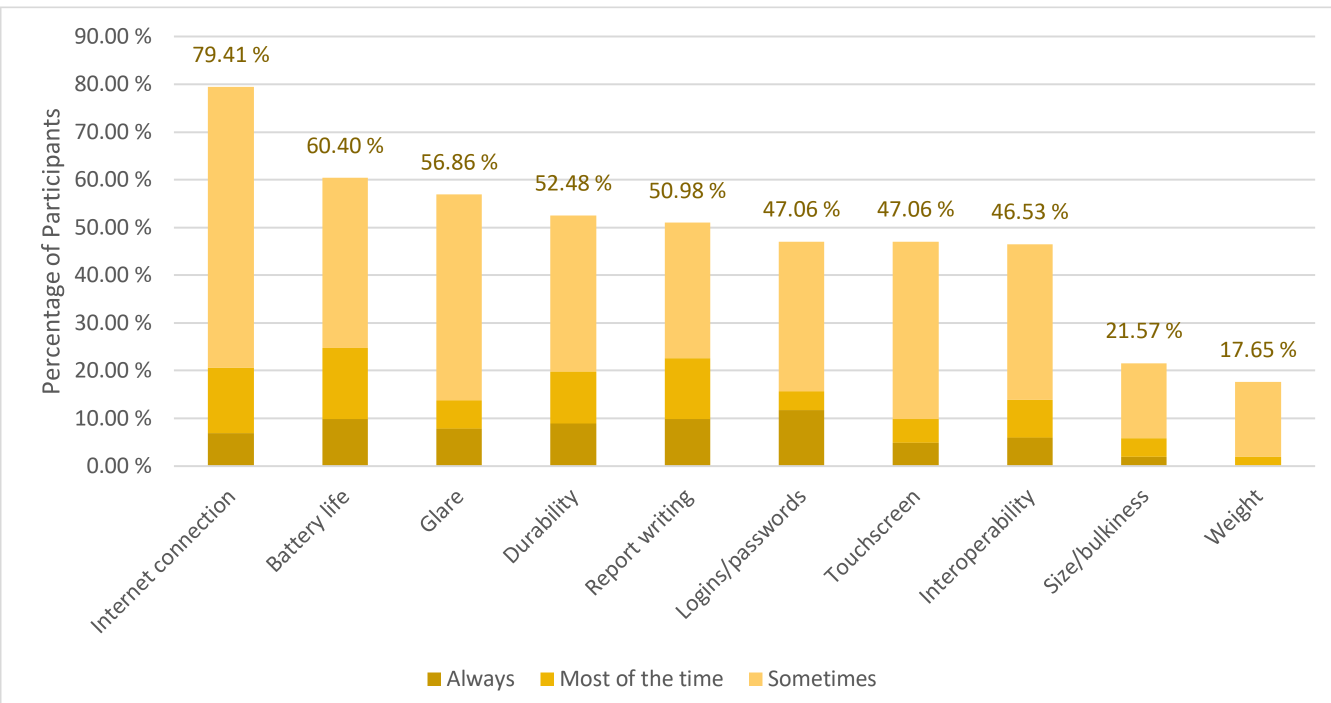

Fig. 27. Tablet problems experienced for EMS

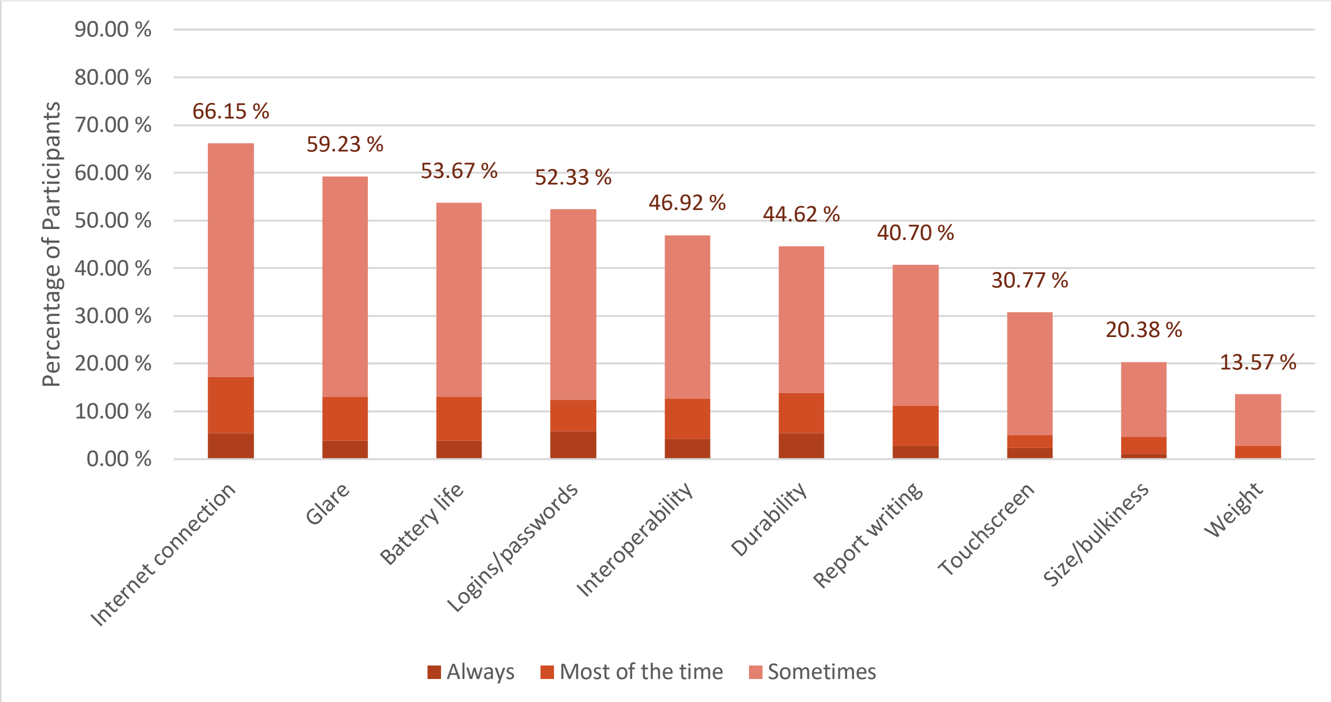

Fig. 28. Tablet problems experienced for FF

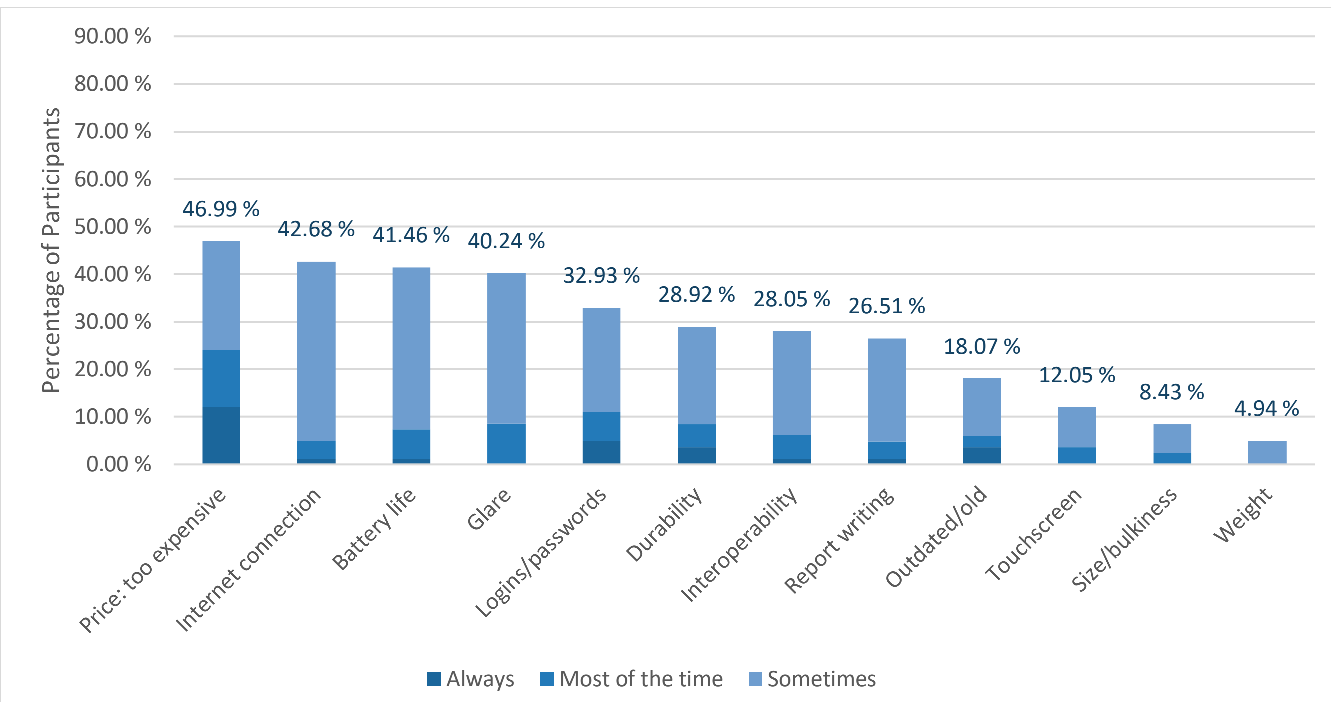

Fig. 29. Tablet problems experienced for LE

As with smartphones, while there are some slight differences between disciplines in terms of tablet problems experienced, the similarities across disciplines are far more striking than the differences.

4.2. Applications and Software

This section presents per-discipline and cross-discipline data from the applications/software questions in the day-to-day section of the survey (see Appendix B). The list of applications/software used in these questions included many discipline-specific applications/software. An analysis of the similarities and differences in the use of applications/software between and within disciplines are explored in this section.

4.2.1. Frequency of Use

This section presents per-discipline and cross-discipline data from the survey question stem:

> "Think about your **DAY-TO-DAY** work and your use of the following **applications/software**."

As previously mentioned, the lists of technologies throughout the survey were based on the findings from the interview data and were tailored appropriately for each discipline. For the applications/software section of the survey, several technologies were common across disciplines:

- CAD (computer-aided dispatch)
- Email
- Mapping/driving directions
- RMS (records management system)
- Traffic apps/software
- Weather apps/software

Additionally, the applications/software list for each discipline included the discipline-specific technologies listed in Table 11. Like the references to the device problems (see Sec. 4.1.2), abbreviated versions of the applications/software with longer text will be used throughout Sections 4.2.1 and 4.2.2 (e.g., “RMS,” “Criminal DBs”).

Table 11 Discipline-specific applications/software lists

COMMS	EMS	FF	LE
Criminal databases	AED (automatic external defibrillator) locator	EPCR (electronic patient care reporting)	Criminal databases (DBs)
Electronic policies/laws	EPCR (electronic patient care reporting)	ERG (emergency response guide)	Electronic policies/laws
Emergency notification system (for informing the public) (ENS)	ERG (emergency response guide)	Hazmat (guides or operating procedures)	First responder vehicle tracking
First responder vehicle tracking	First responder vehicle tracking	Hydrant location	Language translation
Language translation	Medication/drug identification or interaction	Language translation	Report writing software
	Report writing software (other than patient care reports)	Pre-plan software	
		Report writing software	

For each application/software listed, respondents then chose from the following frequency of use response options:

- Use a lot;
- Use occasionally;
- Have, but do not use;
- Do not have.

A final open-ended text box was used to capture any other applications/software participants use in their day-to-day work. The instruction preceding the textbox was:

> "Other (please specify)"

In this section, percentages from all frequency of use response options are shown in Figs. 30 through 33, for COMMS, EMS, FF, and LE, respectively. The most frequently used applications/software common across all four disciplines are presented in Figs. 34 and 35. Detailed frequency of use data for each of the applications/software can be found in Appendix D.

In each discipline, most applications/software listed were used by at least half of the survey respondents (where respondents selected "Use a lot" or "Use occasionally"). By far, the application/software used by most respondents across all four disciplines was “Email,” with over 98 % of respondents selecting “Use a lot” or “Use occasionally” (see Table 12) [6].

Table 12 Applications/software use, across disciplines

Email	98.83 %
CAD	80.21 %
Mapping/navigation	79.88 %
RMS	71.28 %
Weather	66.83 %
Traffic	36.94 %

It is extremely interesting to note both the consistencies, and the differences, across the four disciplines. Examining the top three applications/software as determined by the “Use a lot” rating, it is striking that “Email” is the most frequently used application/software for EMS, FF, and LE, while it is the second most frequently used application for COMMS, with “CAD” being first (see Figs. 30 – 33; ordered by “Use a lot” from most to least). It is also interesting to examine the frequency of use for the “Mapping/navigation” application/software in particular, as this is an excellent example of the type of cellular application usage envisioned for the NPSBN. For the most frequently used applications/software, “Mapping/navigation” is fifth for COMMS (Fig. 30), fourth for EMS (Fig. 31), third for FF (Fig. 32), but seventh for LE (Fig. 33). For LE, “Reporting writing,” “Electronic policies/laws,” and “Criminal DBs” are all used more frequently than are “Mapping/navigation.” While there was overwhelming consistency in the high frequency of use for certain applications/software (where respondents selected “Use a lot”), such as “Email” and “CAD”, there were other apps that tended to be more important for particular disciplines. This is not surprising, given the specialized nature of first responder work. For example, “EPCR” was the second most frequently used application/software for EMS, but sixth for FF, even though many firefighters are cross-trained.

It is also interesting to note the applications/software used by many of the participants (where respondents selected “Use a lot” or “Use occasionally”), although not necessarily used a lot. Around 70 % of EMS and FF use “ERGs,” while a much smaller percentage selected “Use a lot” (10.25 % of EMS; 3.44 % of FF). The data are similar for the use of “Hazmat SOPs” in FF (72.27 % use; 4.04 % “Use a lot”). Nearly 80 % of FF participants use the discipline-specific application/software “Hydrant location.” At least 80 % of COMMS participants use “Criminal DBs” and “Electronic policies/laws;” close to 90 % of LE participants use those applications/software as well. The similarities in applications/software use in COMMS and LE is not surprising, given the high number of COMMS that dispatch for LE; over 90 % of COMMS dispatch for LE (see Sec. 3.1.2).

[6] As previously noted, the names of some applications/software items have been abbreviated/modified for visual presentation.

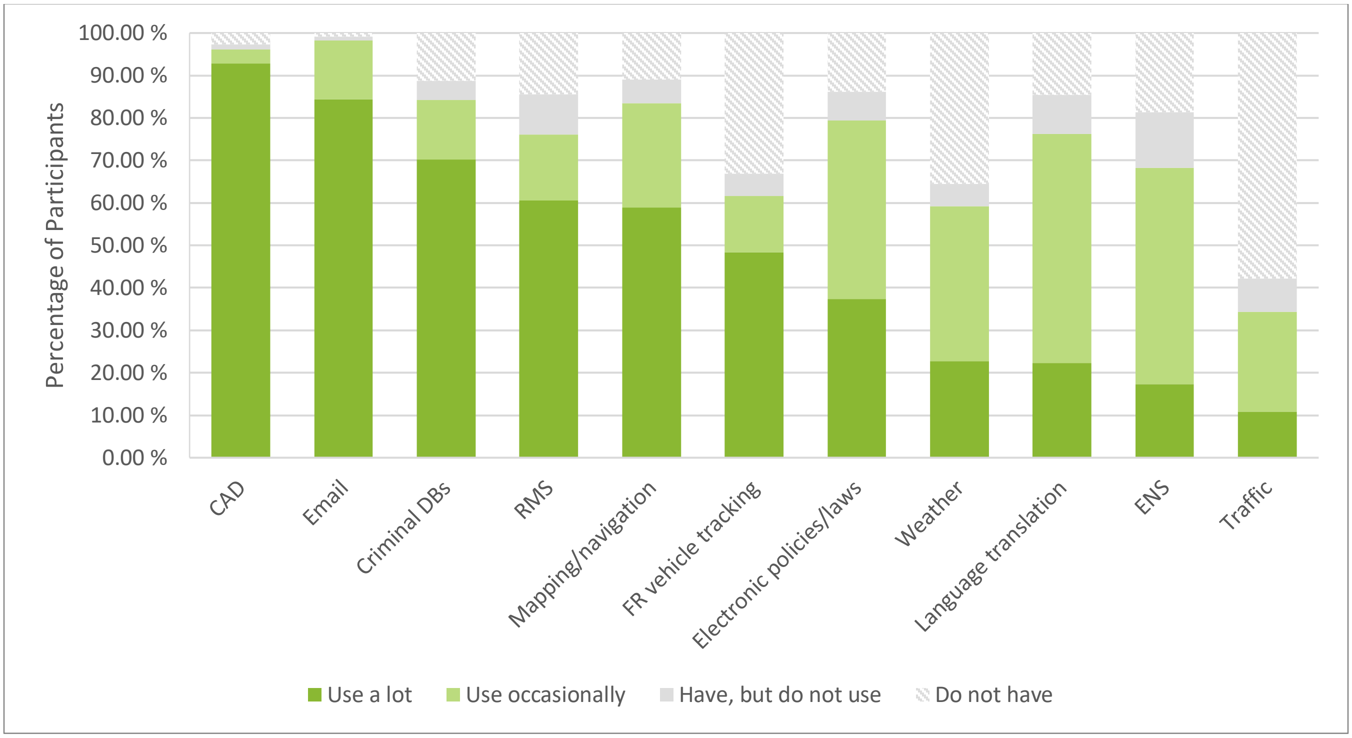

Fig. 30. Applications/software frequency of use for COMMS

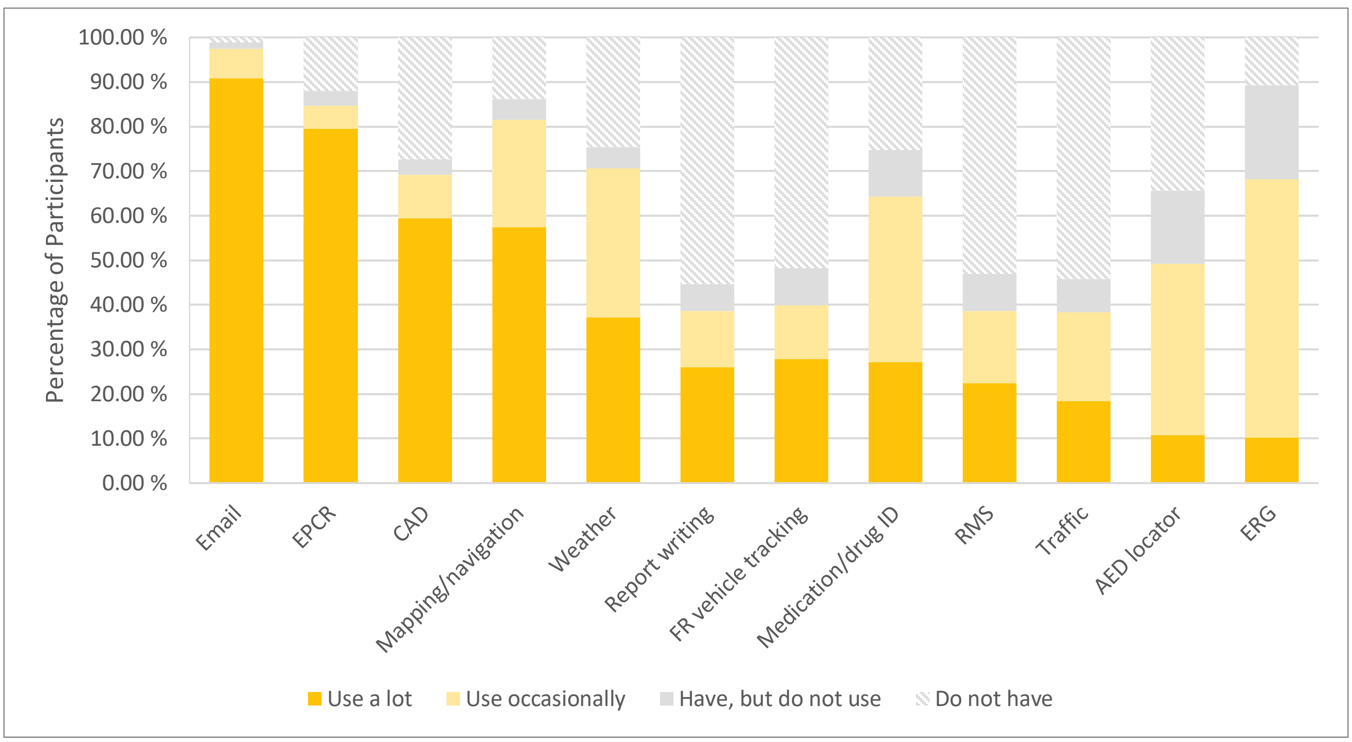

Fig. 31. Applications/software frequency of use for EMS

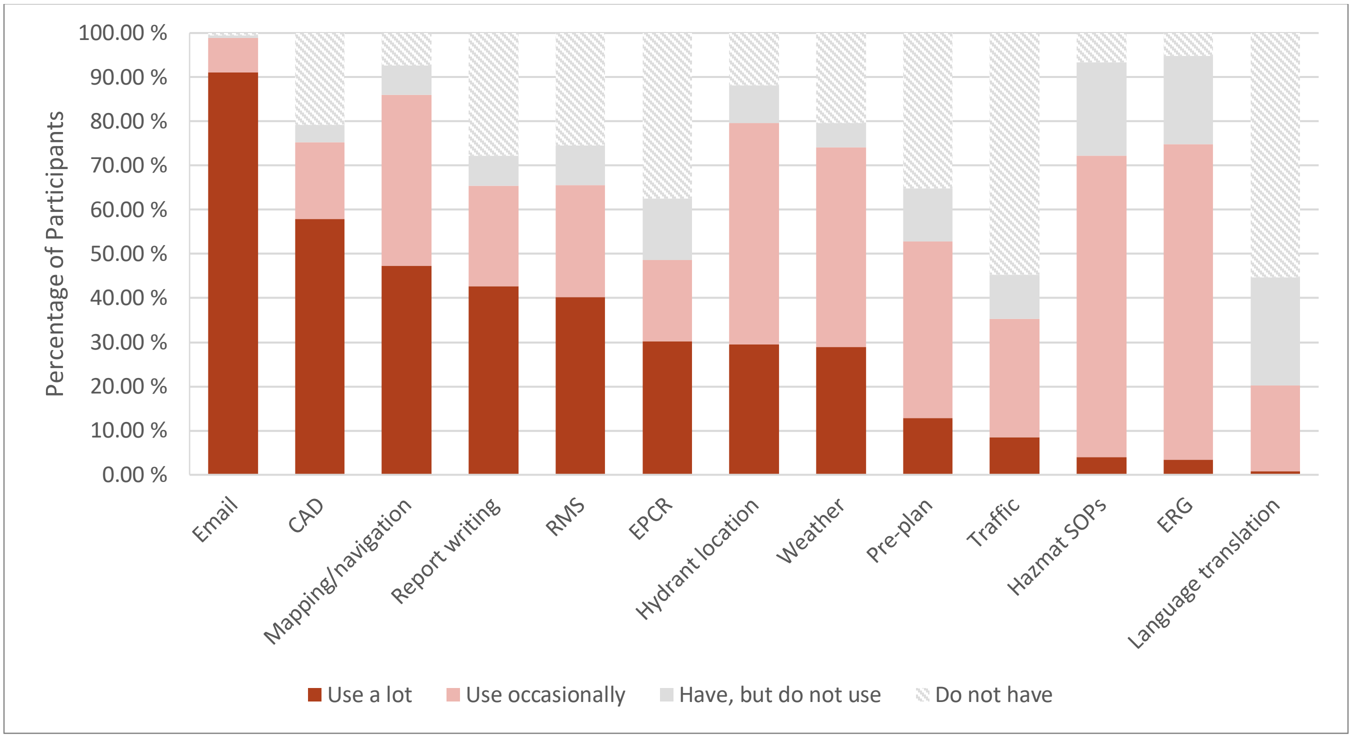

Fig. 32. Applications/software frequency of use for FF

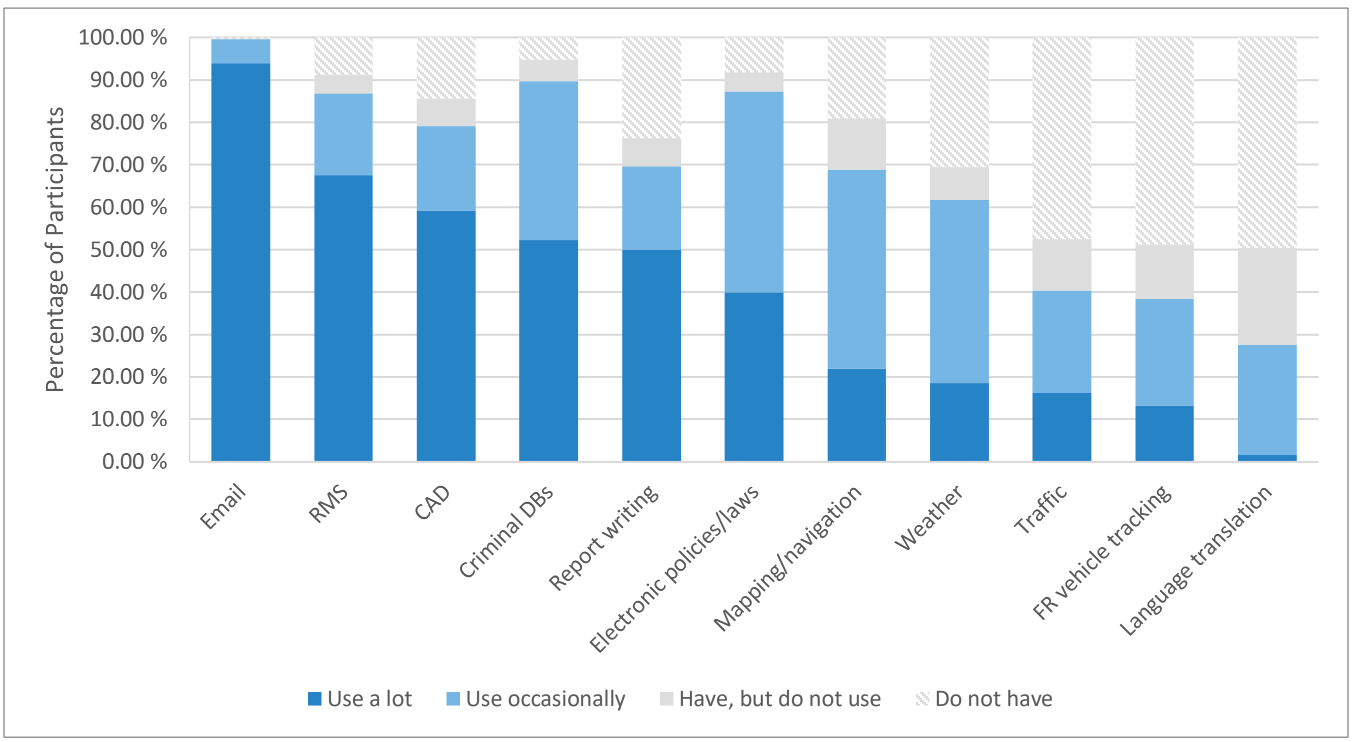

Fig. 33. Applications/software frequency of use for LE

As is clear from Fig. 34 (ordered by “Use a lot” from most to least), “Email” and “CAD” are by far the most frequently used applications/software across disciplines, followed by “RMS” and “Mapping/navigation,” then “Weather” and “Traffic”. Looking at the data across disciplines there is a steep drop-off between the top two most frequently used devices (approximately 20 % between “Email” and “CAD”).

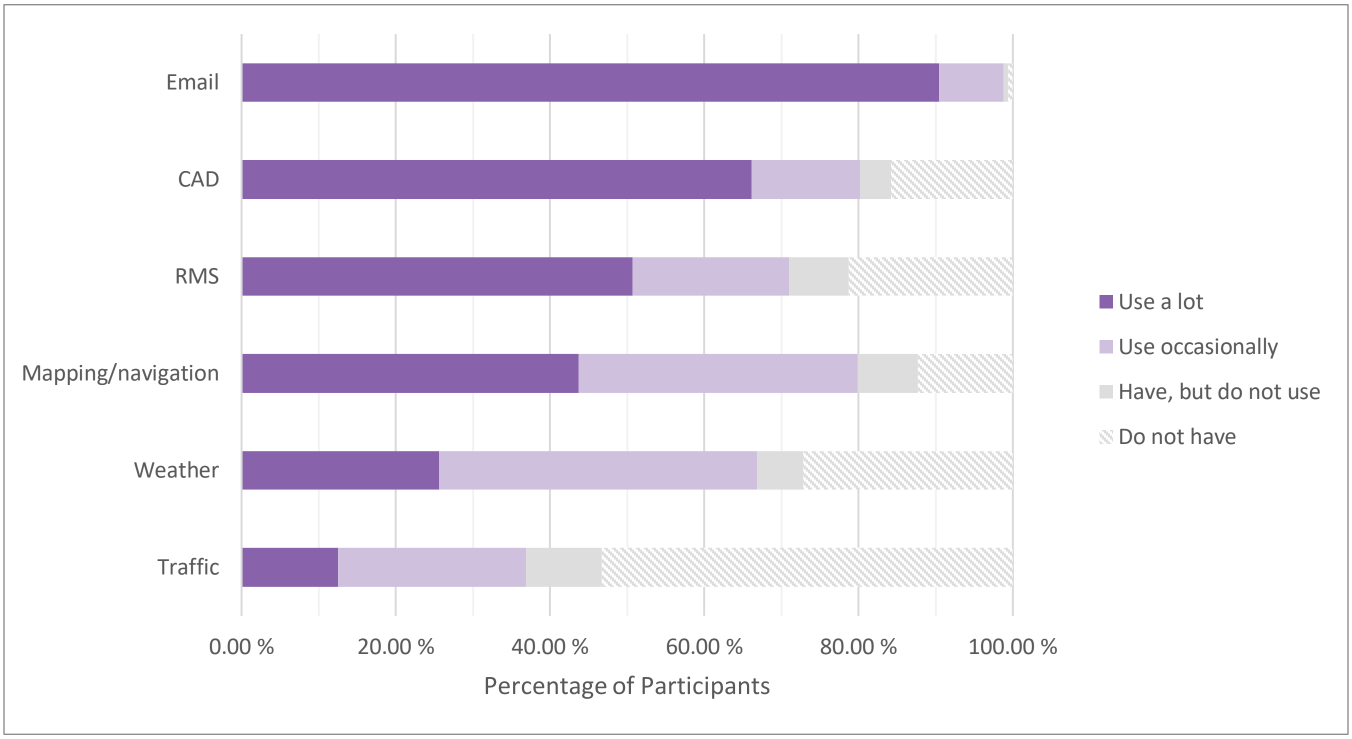

Fig. 34. Most frequently used applications/software, across disciplines

Fig. 35 provides greater granularity in those data, where the frequent use of “CAD” is far lower for EMS, FF, and LE than it is for COMMS (around 30 %). It is also interesting to examine the discipline-specific differences in the frequency of use for the “RMS” and “Mapping/navigation” applications/software. There is a clear distinction between the frequent use of “RMS” by COMMS and LE, and the more infrequent use by EMS and FF. It is also evident that LE does not use “Mapping/navigation” as frequently as the other three disciplines. The differences in “Mapping/navigation” could be due to the nature of LE work and their need to be intimately familiar with the area they patrol.

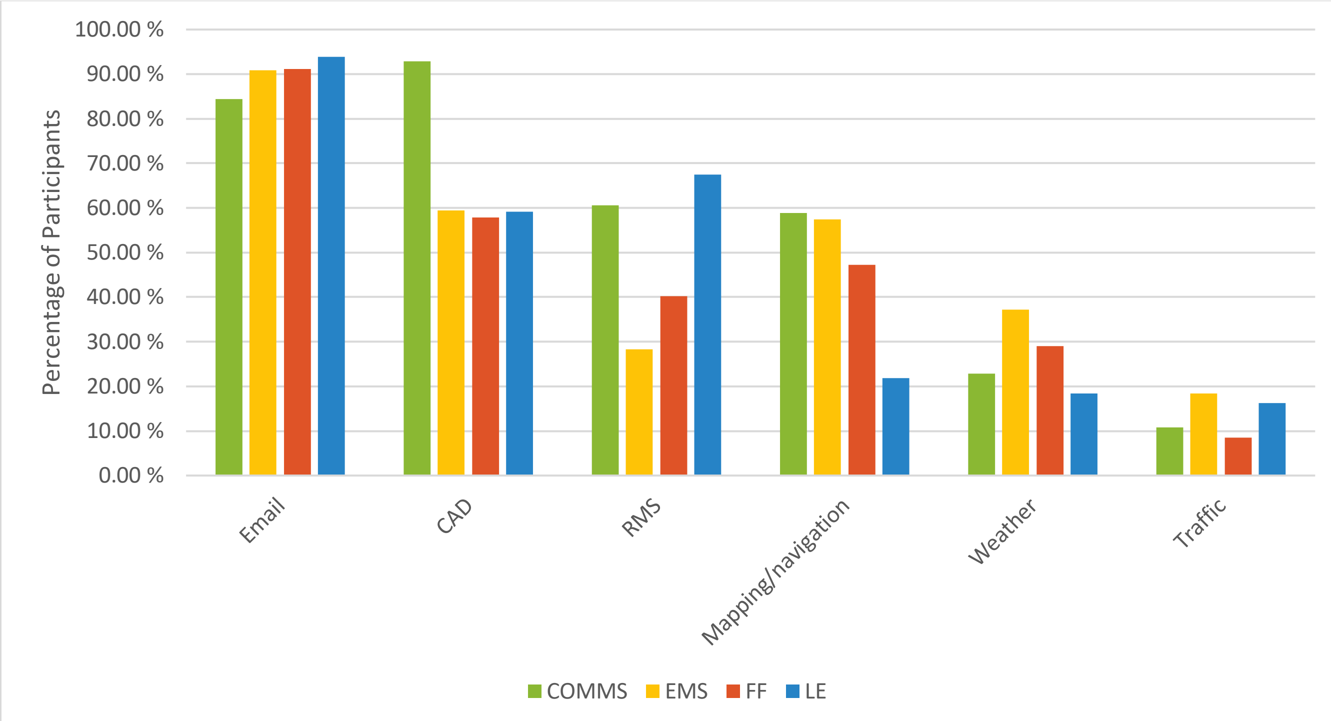

Fig. 35. Most frequently used applications/software, by discipline

As previously mentioned, in the final part of the applications/software frequency of use survey question, respondents were given an open-response text field to list any other applications/software they wanted to include. Relatively few survey respondents (only 176 of 7 182 total, or 2.45 % across disciplines) chose to respond to this question. The number of responses, per discipline, for this question ranged from about 1 % (for LE) to about 4 % (for COMMS) (see Table 13). The low numbers of responses for this particular survey question may indicate that the list of applications/software in the survey was quite extensive and generally covered the most frequently used applications/software.

Table 13 Participants with responses to applications/software open-ended question

	% of Participants
COMMS	4.03 %
EMS	2.55 %
FF	2.56 %
LE	1.10 %

Across all disciplines, there were a broad range of applications/software listed in the open-ended responses, many of which fell into the categories listed below (ordered from most responses to least).

Other responses were related to general web-based applications/software such as "Social media (for public information)" (FF:R:2118), or did not list applications/software relevant to the question asked.

- Specialty software
- Office/operations related
- Tracking/monitoring
- Traffic/weather
- Mapping

Of the open-ended responses, the "specialty software" category was most prevalent, with various discipline-specific applications/software being listed, such as volunteer response apps, medical triage apps, criminal database apps, 9-1-1 caller and reporting apps, and 9-1-1 dispatch and incident response apps. It is also interesting that some of the response categories were redundant with the applications/software already listed for the frequency of use question. This is not uncommon in survey research, and is generally interpreted as indicating that survey respondents intended to re-emphasize their question response(s). Although "Mapping/driving directions" was one of the most frequently used applications/software (as previously shown in Fig. 34), participants still chose to write in things like "Mapping location- used a lot" (LE:S:7252), or "personal GPS" (LE:S:1059).

Also of note is the number of non-incident response applications/software that respondents listed in the "Office/operations related" category. After "Specialty software," the most applications/software listed were in this category – related to administrative tasks. For example, "Microsoft Office" (FF:S:1418) and "Scheduling software" (COMMS:S:1865) or "staffing software" (LE:S:6775) were among the most commonly listed applications/software in this category.

The applications/software presented in this section all have one overarching characteristic in common: first responders use them frequently in their day-to-day work, whether for active incident response or supporting office activities. Having in-the-field access to applications/software is a primary reason why first responders use their mobile devices, as was clearly seen in the interview data. For example, one of the major findings from the interviews was the need for improved mapping and navigation software for first responders.

> "It's expected that you should know your area and know how to get there. We'd have just that function on our MDCs that we can route to a call. Maybe that is the biggest problem we have with technology, it's just horribly out of sync and, you get turn right now, you know. Five miles after your-- or, just continue ahead, and, it's just kind of odd directions." (INT-FF-U-007)

> "The one thing that seems to have been lacking on our ambulance for years is a built-in GPS. So we don't have the ability to open CAD computer and sort of GPS ourselves if we're confused of where we're going." (INT-EMS-U-011)

Personal smartphones provide a needed service in incident response; the interview data show that they are often used to fill these technological gaps. In some cases, survey respondents also specifically commented on the need for their personal phone for these applications/software.

> "*I use my personal phone for weather, traffic, mapping, language translation, ERG, communication and other reasons.* In my area I actually have better phone reception than radio reception and have talked with dispatch via phone instead of radio. *I don't know what I would do without my personal phone.*" (FF:R:806, *emphasis added*)

The applications/software used on mobile devices are essential to the work of first responders, as found in both the interview data as well as the survey data. Note that the survey did not ask separate applications/software questions for personal versus work-issued smartphones; as previously mentioned, a guiding principle in development of the survey was to keep it short, therefore asking the same set of questions twice (once for personal and once for work-issued smartphones) was not advisable.

4.2.2. Applications and Software Rankings

Whereas the preceding section presented applications/software data based on frequency of use as reported by survey participants, this section presents the per-discipline and cross-discipline applications/software data based on top five rankings. These data are from the survey question stem:

> "Of the following applications/software, rank up to 5 that **are most useful** in your **DAY-TO-DAY** work, with 1 being the most useful."

Participants could then click or drag each item into the desired rank position. This question was only presented to EMS, FF, and LE survey participants. As previously described, the COMMS survey was somewhat different than surveys for the other three disciplines. In order to keep surveys short and still allow COMMS participants to answer questions about their call center, COMMS participants were not asked the applications/software ranking question.

As described in Appendix B, for the applications/software ranking question, the list was populated based on a participant's responses to the applications/software frequency of use question: only those participants who selected "Use a lot," "Use occasionally," or "Have, but do not use" for a particular application/software were asked to rank that item (see Fig. 36). In other words, participants were only asked to rank applications/software that they currently have, as indicated by their responses to the previous applications/software frequency of use question.

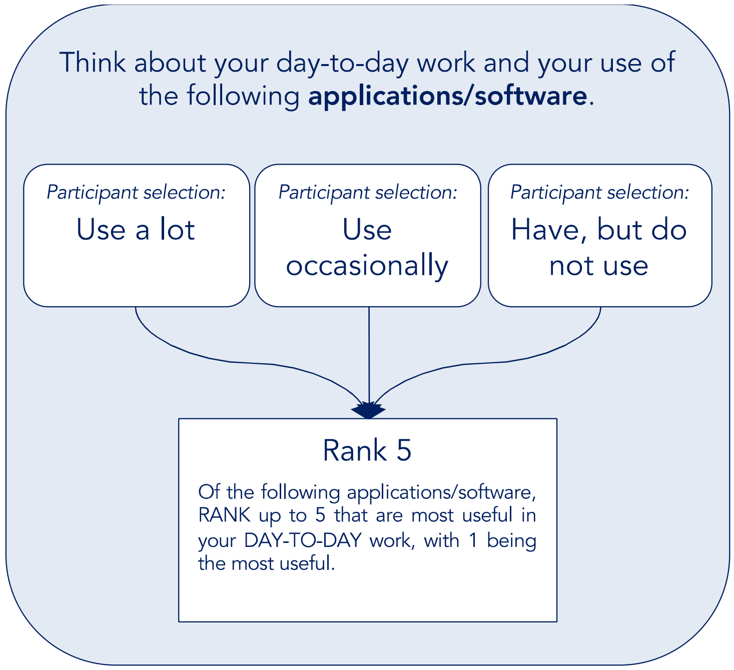

Fig. 36. Survey piping for day-to-day applications/software ranking question

Section 4.2.1 describes in detail the applications/software included in the list for the frequency of use survey question. As there were many types of applications/software surveyed, this section does not present individual top 5 rankings. Instead, a summary of the top 5 applications/software are discussed. The rankings for each individual application/software can be found in Appendix D.

In this section, the percentages of first responders who selected each application/software in their top five rankings are presented in Figs. 37 – 39, for EMS, FF, and LE, respectively (as described above, COMMS did not receive this particular question).

Overall, it is interesting to note that the first few applications/software in the top 5 of each discipline are relatively consistent. Additionally, particularly in EMS and FF, there is a sharp drop-off of 20-30 % after the first few applications/software. In looking at the most useful applications/software ranked for EMS, four applications/software stand out from the rest: “EPCR,” “CAD,” “Email,” and “Mapping/navigation” (see Fig. 37). The majority of EMS participants had these applications/software in their top 5. It is also clear that the discipline-specific “EPCR” is integral to the work of EMS responders.

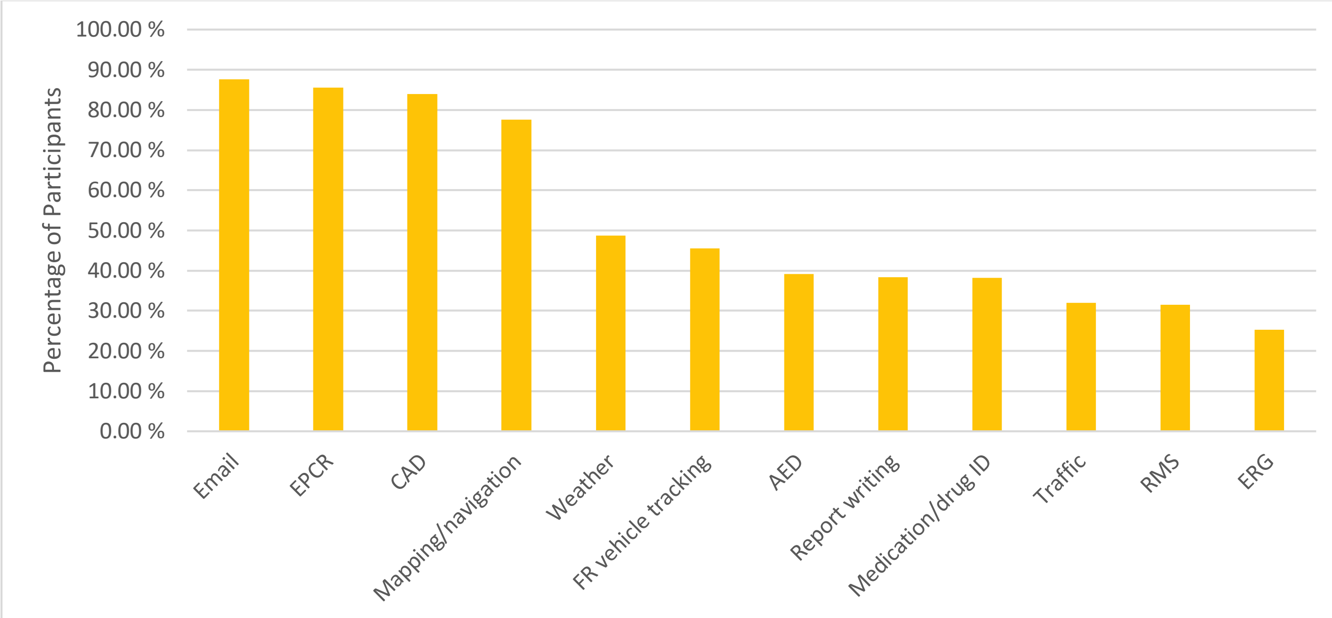

Fig. 37. Applications/software ranked in top 5 for EMS

In FF, three applications/software stand out as most useful for their work: “Email,” “CAD,” and “Mapping/navigation” (see Fig. 38). Around half of participants ranked the discipline-specific “Report writing,” “EPCR,” and “Hydrant location” applications/software in their top 5. Of note, approximately 30% more participants listed “Email” and “CAD” in their top 3 useful applications/software than “Mapping/navigation.”

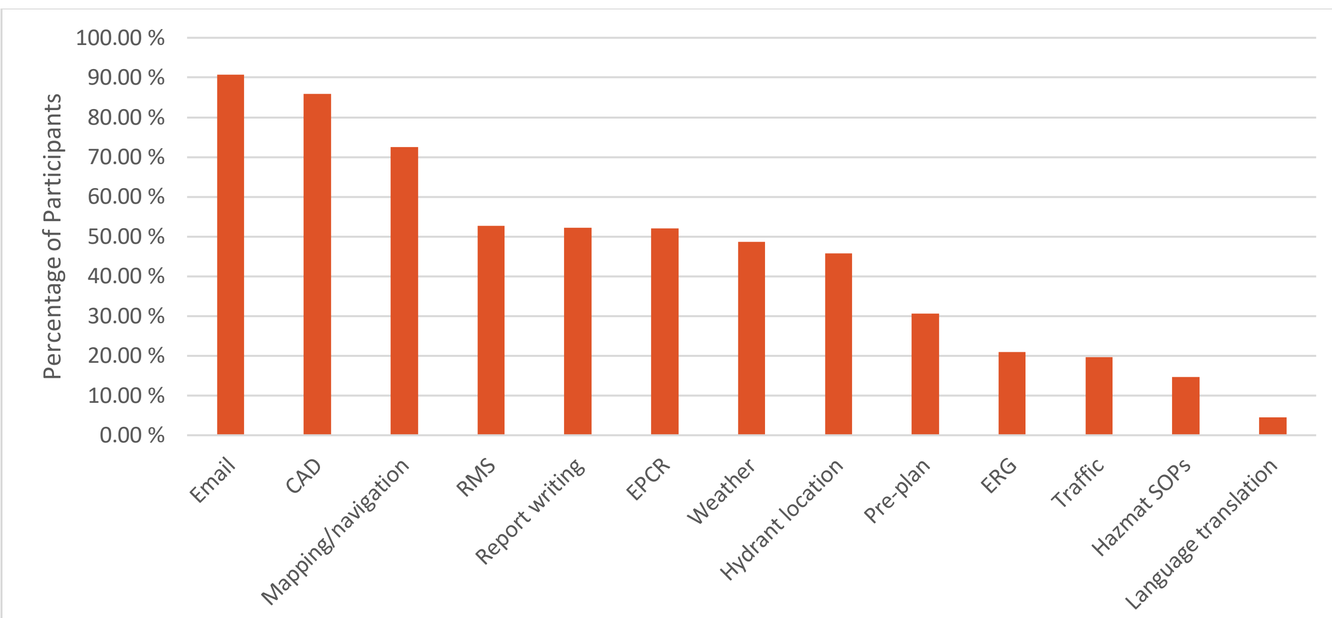

Fig. 38. Applications/software ranked in top 5 for FF

In examining the most useful applications/software for LE, the differences between rankings for applications/software was much more gradual in LE than the other disciplines, with most applications/software ranked in the top 5 by more than half of participants (see Fig. 39); there was less of a drop-off from the top applications/software to the bottom applications/software in LE than in the other disciplines. "Email," "CAD," and "RMS" were ranked in the top 5 by most of LE, followed by the discipline-specific "Criminal databases" application/software.

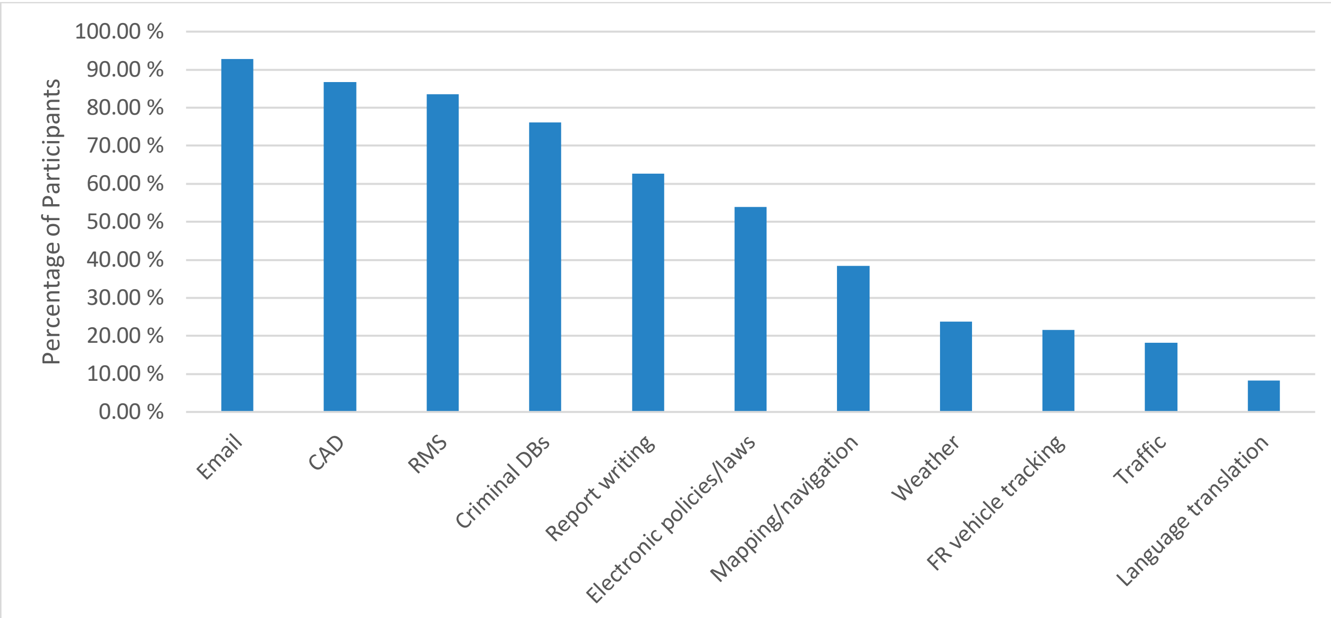

Fig. 39. Applications/software ranked in top 5 for LE

Overall, "Email" was largely the most frequently utilized and the top ranked application/software across disciplines. Much of first responder work also greatly requires other applications/software specific to public safety to facilitate communications; however, email can be seen as the primary means of communications in their day-to-day work. Additionally, mapping and navigation seems vital for their day-to-day work, but are not perceived as valuable when implemented on outdated public safety devices (as opposed to personal smartphones).

4.3. Futuristic Technology

This section presents per-discipline and cross-discipline data from the futuristic section of the survey (see Appendix B). The survey question was framed as follows:

> "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 day-to-day work."

The survey question stem was:

> "Which of the items below **would also be useful** for your **DAY-TO-DAY** work."

Respondents were asked to "Check all that apply." The goal here was solely to identify those items that respondents believed would be useful in day-to-day incident response (beyond those devices previously described). It was not to have them rank these items or indicate whether they were more or less useful than other items.

The list of items 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 in-depth interviews. 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. All technology where either no selection was made or "Do not have" was selected were piped forward to the futuristic technology list (i.e., any technology a participant indicated that they did not currently have; see Fig. 40). The items that were piped forward allowed respondents to select items they thought would be useful even if they did not currently have them.

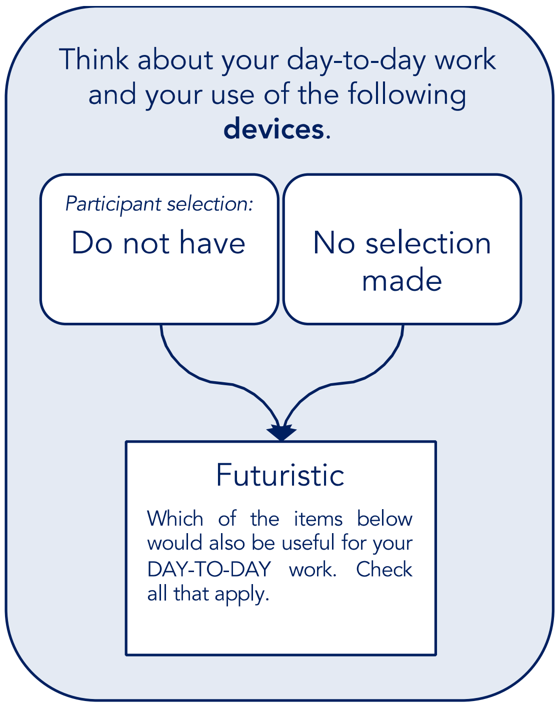

Fig. 40. Survey piping for futuristic technology list

*In this section, discipline-specific findings are presented for both the **preset list** of futuristic technology (Tables 14 – 17) and the list that was **piped forward** from participants' previous responses (Tables 18 – 21); these data are illustrated in Figs. 41 – 44, and 45 – 48, respectively. Note that percentages in these tables can add up to more than 100 % since respondents could check all items that applied to their work.*

Note that different first responder disciplines saw different lists of futuristic technologies. As previously mentioned, this is because the survey was driven by the interview data and the technologies that first responders discussed as potentially important for their work. The full list of technologies for each discipline, along with the responses for each technology, can be found in Appendix D.

In addition to the “Check all that apply” question, respondents were also provided with an open-ended text box where they could list additional technology or provide additional information:

> “Other (please specify).”

Only 193 respondents across all four disciplines (COMMS—63; EMS—34; FF—59: LE—37) provided additional input. The low number of open-ended responses to this question might reflect the exhaustive nature of the technology lists presented to respondents; they simply may not have had much information to add. The 193 open-ended responses varied widely and there was not a lot of consistency, either across or within disciplines. Open-ended responses will be discussed below where appropriate.

In examining the **preset list** of futuristic technologies, several discipline-specific items had high percentages of first responders who thought they would be useful in their day-to-day work. For example, over 70 % of COMMS respondents selected “Automatic caller location,” and “First responder tracking” was selected by more than half of COMMS participants (see Fig. 41 and Table 14). For EMS, more than half of respondents selected “Automatic transmission of patient vitals and information to the hospital;” nearly 40 % also thought “Health/vitals monitoring of patients” would be useful (see Fig. 42 and Table 15). A high number of first responders in both EMS and FF thought “AVL (automatic vehicle location)” would be useful in their day-to-day work (FF is shown in Fig. 43 and Table 16). In LE, over 30 % of respondents thought “Facial recognition software” and “Thermal imaging” would be useful (see Fig. 44 and Table 17). These technologies provide specific functions and support for their particular area of public safety and are of tremendous importance to the disciplines that use them.

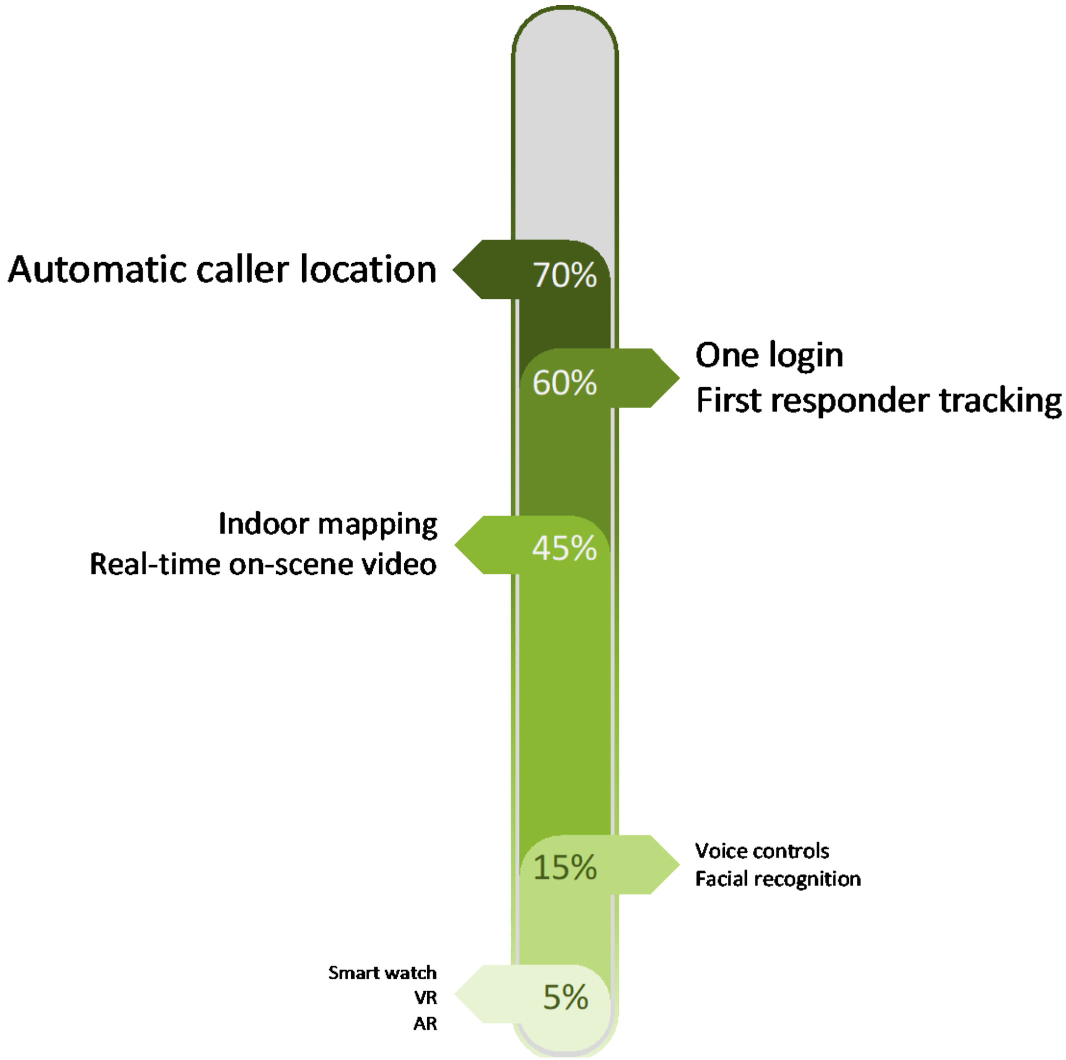

Fig. 41. *Preset list* of futuristic technology, COMMS

Table 14. *Preset list* of futuristic technology, COMMS

Technology	% of respondents who would use
Automatic caller location	71.23 %
One login (instead of many different usernames and passwords)	60.93 %
First responder tracking	60.55 %
Indoor mapping	48.15 %
Real-time on-scene video	39.51 %
Voice controls for hands-free input	17.90 %
Facial recognition software	16.05 %
Smart watch	7.23 %
VR (virtual reality)	4.92 %
AR (augmented reality)	4.80 %

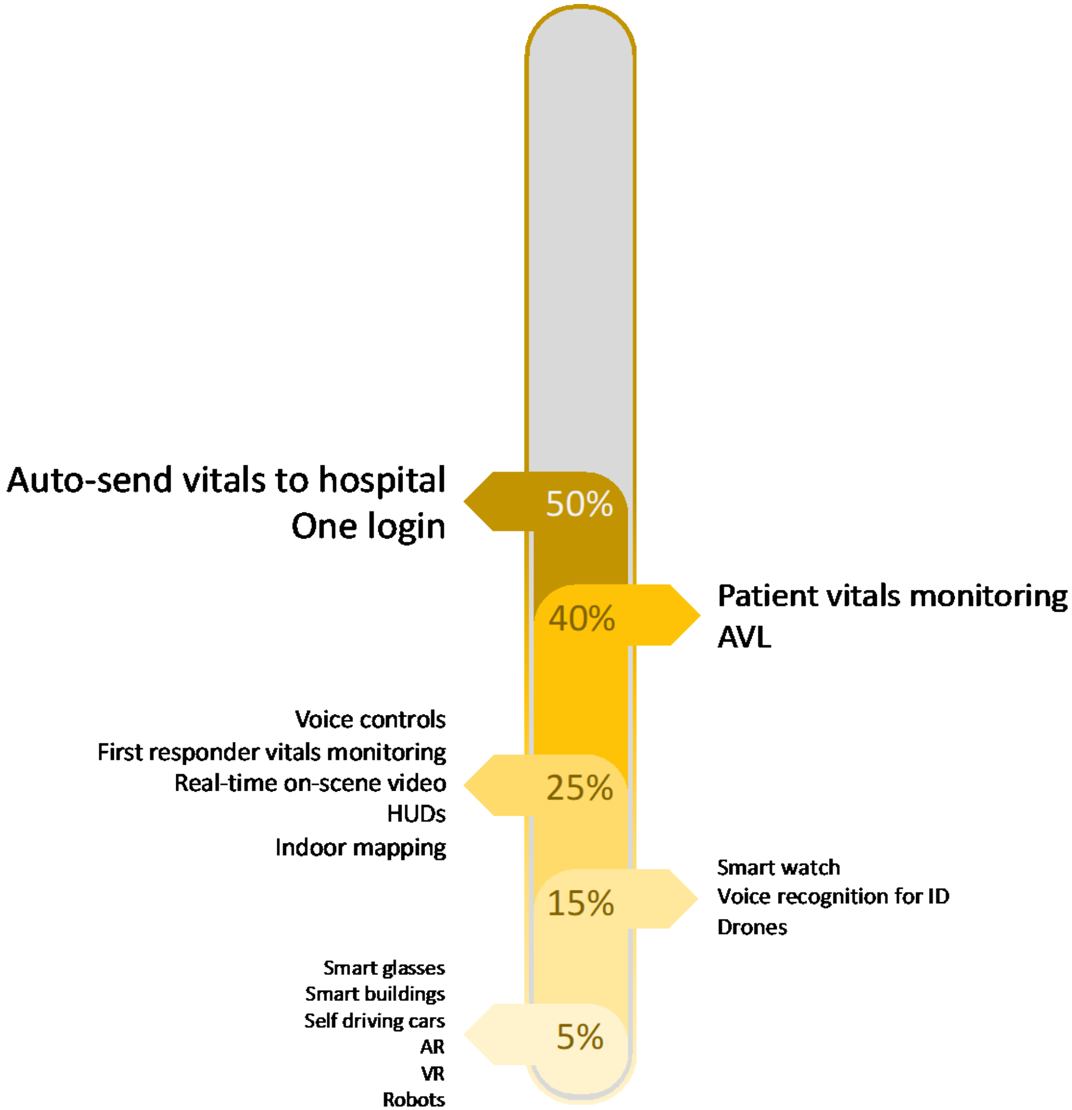

Fig. 42. *Preset list* of futuristic technology, EMS

Table 15. *Preset list* of futuristic technology, EMS

Technology	**% of respondents who would use**
Automatic transmission of patient vitals and information to hospital	56.43 %
One login (instead of many different usernames and passwords)	50.11 %
Health/vitals monitoring of patients	39.47 %
AVL (automatic vehicle location)	39.36 %
Voice controls for hands-free input	26.27 %
Health/vitals monitoring of first responders	25.17 %
Real-time on-scene video	24.94 %
HUDs (heads-up displays)	24.39 %
Indoor mapping	21.51 %
Smart watch	16.41 %
Voice recognition for identification	15.52 %
Drones	14.52 %
Smart glasses	8.98 %
Smart buildings	6.98 %
Self driving vehicles	6.21 %
AR (augmented reality)	4.55 %
VR (virtual reality)	3.33 %
Robots	2.00 %

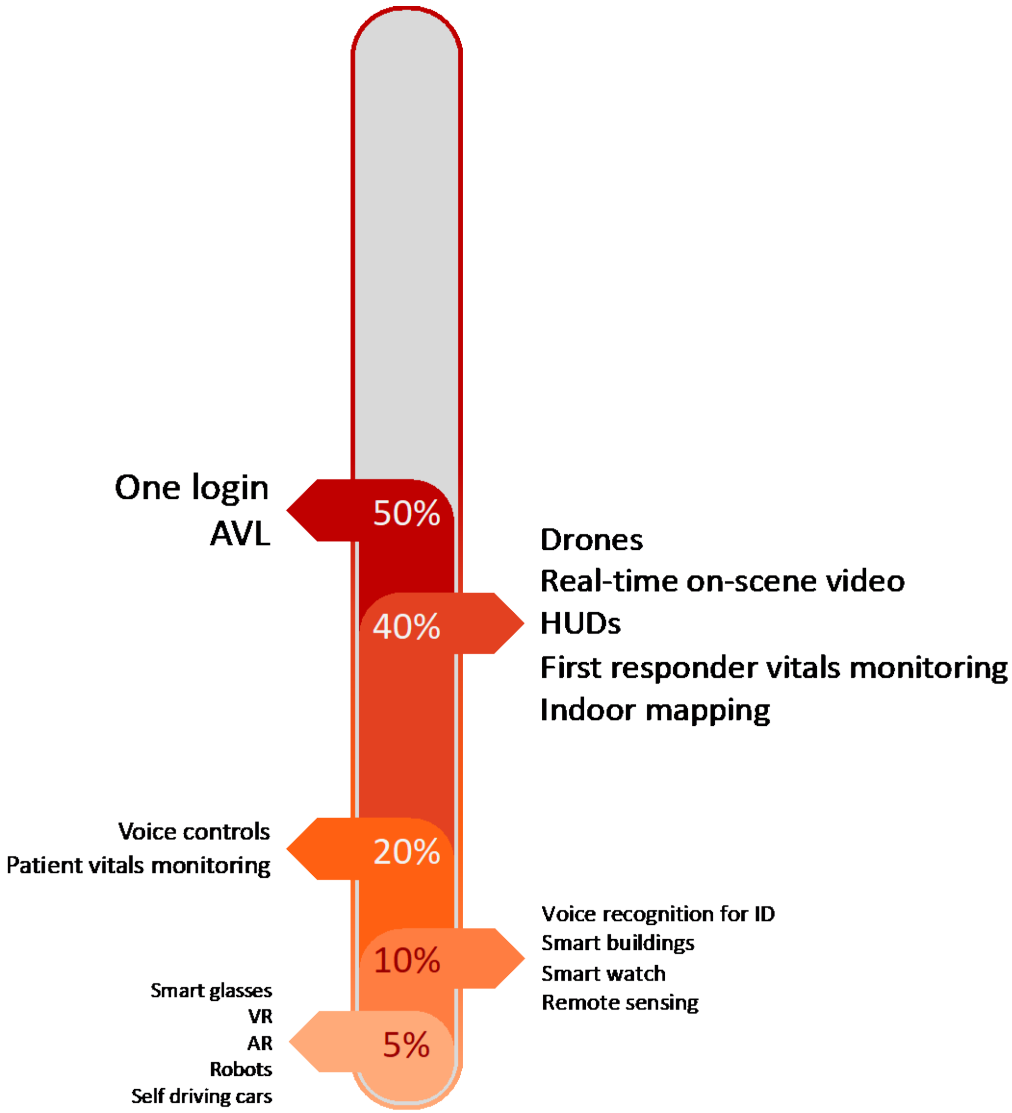

Fig. 43. *Preset list* of futuristic technology, FF

Table 16. *Preset list* of futuristic technology, FF

Technology	**% of respondents who would use**
One login (instead of many different usernames and passwords)	53.31 %
AVL (automatic vehicle location)	49.41 %
Drones	40.20 %
Real-time on-scene video	39.47 %
HUDs (heads-up displays)	38.29 %
Health/vitals monitoring of first responders	37.87 %
Indoor mapping	35.27 %
Voice controls for hands-free input	23.42 %
Health/vitals monitoring of patients	19.07 %
Voice recognition for identification	13.11 %
Smart buildings	12.99 %
Smart watch	12.95 %
Remote sensing (by aircraft or satellite)	10.58 %
Smart glasses	8.06 %
VR (virtual reality)	6.84 %
AR (augmented reality)	5.88 %
Robots	4.93 %
Self driving vehicles	3.97 %

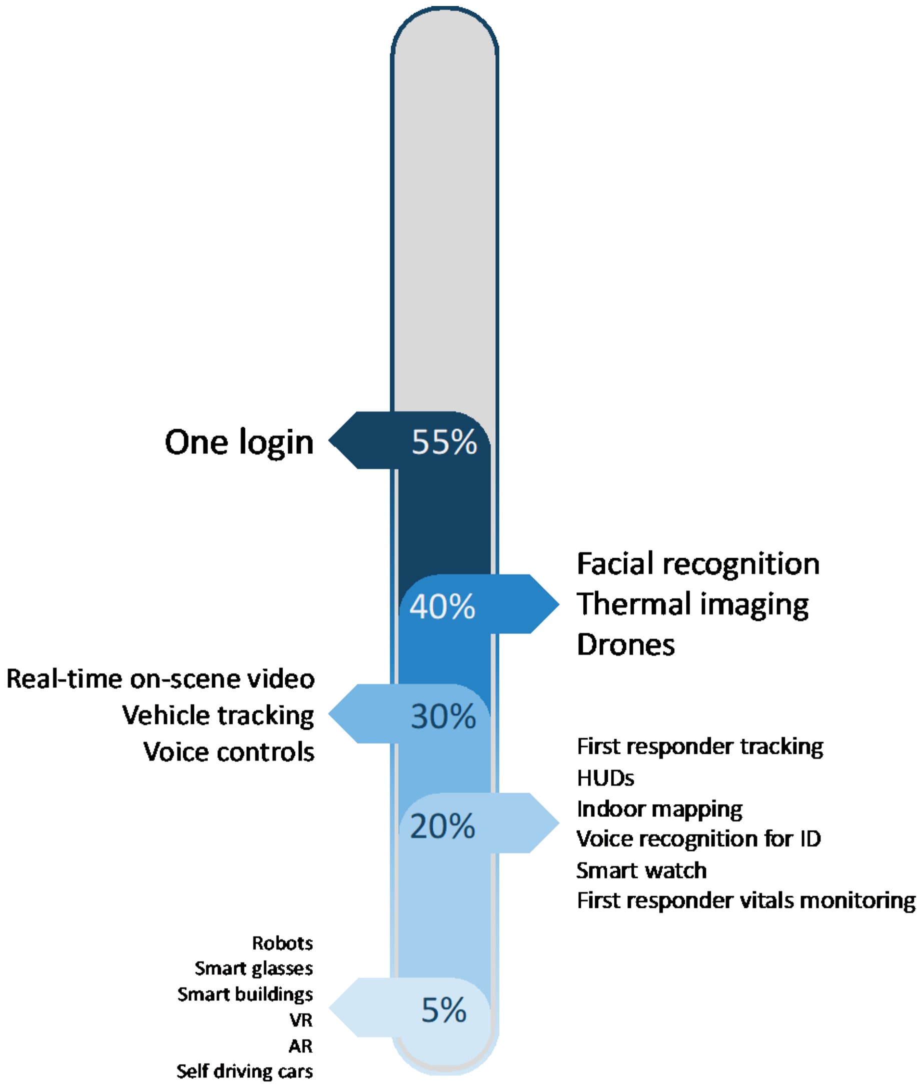

Fig. 44. *Preset list* of futuristic technology, LE

Table 17. *Preset list* of futuristic technology, LE

Technology	% of respondents who would use
One login (instead of many different usernames and passwords)	54.88 %
Facial recognition software	38.69 %
Thermal imaging	38.40 %
Drones	38.21 %
Real-time on-scene video	27.49 %
Vehicle tracking	26.39 %
Voice controls for hands-free input	25.96 %
First responder tracking	21.30 %
HUDs (heads-up displays)	19.39 %
Indoor mapping	18.87 %
Voice recognition for identification	16.77 %
Smart watch	15.39 %
Health/vitals monitoring of first responders	12.15 %
Robots	7.86 %
Smart glasses	7.86 %
Smart buildings	7.58 %
VR (virtual reality)	5.81 %
AR (augmented reality)	4.95 %
Self driving vehicles	3.53 %

The one item that over 50 % of respondents across disciplines chose was "One login (instead of many different usernames and passwords)". One login was the top item checked for FF and LE, and the second item for COMMS and EMS, demonstrating its importance across all four disciplines. This mirrors the findings from the interview data – having multiple logins and passwords was a major source of frustration for many first responders [5][9]. The open-ended survey responses also indicate that having only one login 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)

Open-ended responses highlight the quantitative data findings about the importance of having one login, showing that first responders believe it would save time and lead to less frustration. This is something developers and first responder agencies should focus on in order to ease the technological burden on first responders.

Three other items garnered relatively high percentages from first responders in all four disciplines. These are "Real-time on-scene video," "Indoor mapping," and "Voice controls for hands-free input." These three items had relatively high percentages across the four disciplines, making them important technologies for public safety in general. While these technologies were identified by all four disciplines as useful for day-to-day work, there were some differences amongst the disciplines. For example, COMMS and FF respondents chose "Indoor mapping" more often than their EMS and LE colleagues, while there was greater consistency across disciplines for "Real-time on-scene video" and "Voice controls for hands-free input."

Three disciplines were asked about "Drones:" EMS, FF, and LE. Large percentages of FF and LE selected this item, 40.20 % and 38.21 % respectively. A lower percentage of EMS respondents, 15.52 %, also chose it. The high percentages of FF and LE respondents who selected this item might indicate that they can envision possibilities for the use of drones in their day-to-day work, while EMS participants, who work more specifically with patients and medical issues, have a more difficult time imagining how drones might be useful to their work.

Perhaps more important than the items chosen by a large percentage of respondents, are the items that very few respondents selected. Over half of the items from each discipline's list were selected by less than 20 % of respondents from that discipline, with many being selected by 5 % or less of respondents. Many of these represent some of the most futuristic technology in the list. For example, "AR (augmented reality)" and "VR (virtual reality)" were in the bottom four items selected by all four disciplines; neither of them were selected by more than 7 % of respondents from any discipline. "Robots," "Self driving vehicles," and "Smart buildings" were some of the other items that were selected by low percentages of respondents.

While some of the items on the **preset list** of futuristic technology might not be considered futuristic in some arenas, these items have often not made their way into the world of public safety. Several open-ended responses indicated that first responders were not familiar with the technology or how it would be useful in their work.

> I don't even know what AR or indoor mapping are. I don't know the benefits to technology I don't know how to use, so how do I know what I would want? (FF:U:6230)

> Honestly, I don't know what most of these are. (COMMS:R:433)

> I don't know what half of this stuff does what would I use it for? (EMS:R:1147)

First responders may not consider these "futuristic" items to be useful because they do not know what they are or what they do. 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 summarized 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" [5].

In addition to the futuristic items on the **preset list**, any technology that a respondent indicated they did not currently have was **piped forward**. This included technologies that are often considered to be more mainstream today. Perhaps of most importance here are all the items that respondents still do not have, but that they believe would be useful, from computers and MDTs to radios and tablets.

The responses to the technologies on the **piped forward** list are shown in Fig 45 and Table 18 for COMMS; Fig 46 and Table 19 for EMS; Fig 47 and Table 20 for FF; and Fig 48 and Table 21 for LE. Similar to the **preset list** of futuristic technology, many of the items on the **piped forward** list were also discipline-specific. These discipline-specific items were often those chosen by the largest percentage of respondents from the disciplines who use them. For example, "Fingerprint scanner" (45.59 %) and "License plate reader" (46.11 %) were the top two devices chosen by LE respondents, with "Body camera" also chosen by a large percentage (31.96 %). "TIC" for FF (27.15 %) and "Headset" (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 identified them as useful for their day-to-day work, but they do not have access to them at this time. Finding ways to make these items more accessible to first responders is a good way to address discipline-specific technology needs.

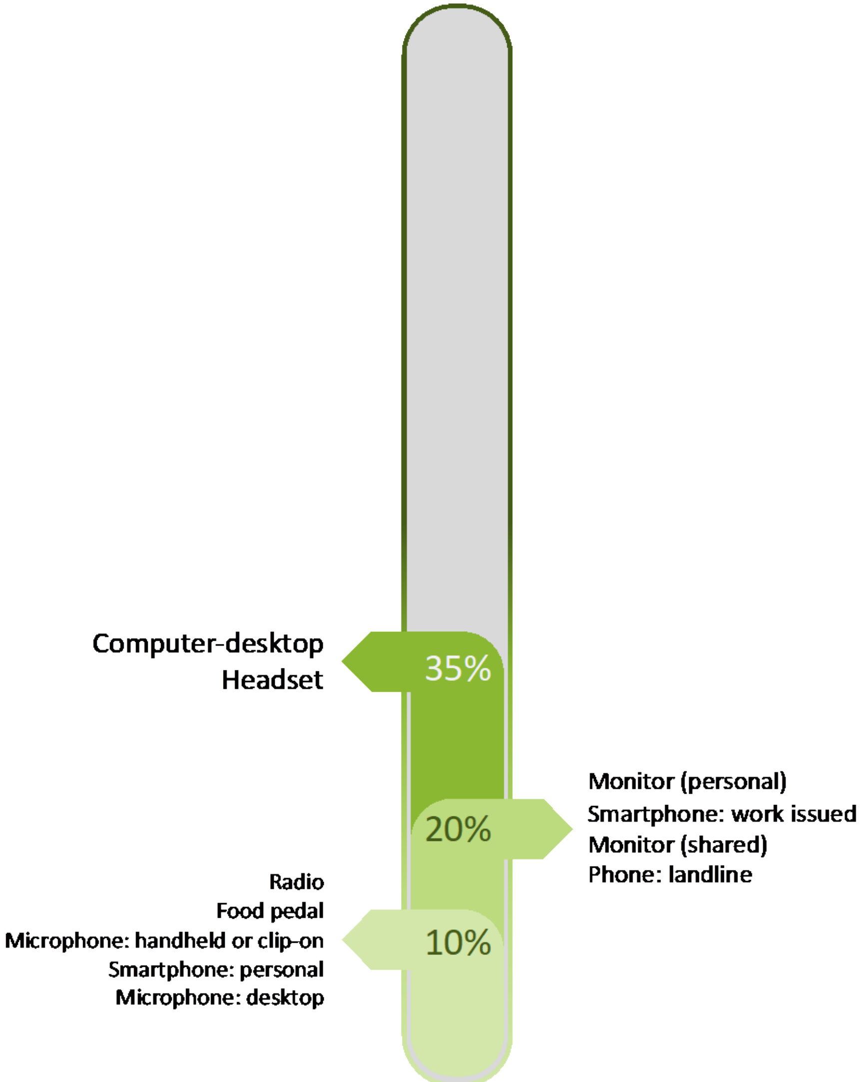

Fig. 45. *Piped list* of futuristic technology, COMMS

Table 18. *Piped list* of futuristic technology, COMMS

Technology	% of respondents who would use
Computer-desktop	38.46 %
Headset	32.47 %
Monitor (at your personal workstation)	25.00 %
Smartphone: work issued	21.08 %
Monitor (for shared viewing)	20.46 %
Phone: landline	16.67 %
Radio	11.94 %
Food pedal	10.87 %
Microphone: handheld or clip-on	9.08 %
Smartphone: personal	8.96 %
Microphone: desktop	7.16 %
Pager	1.33 %

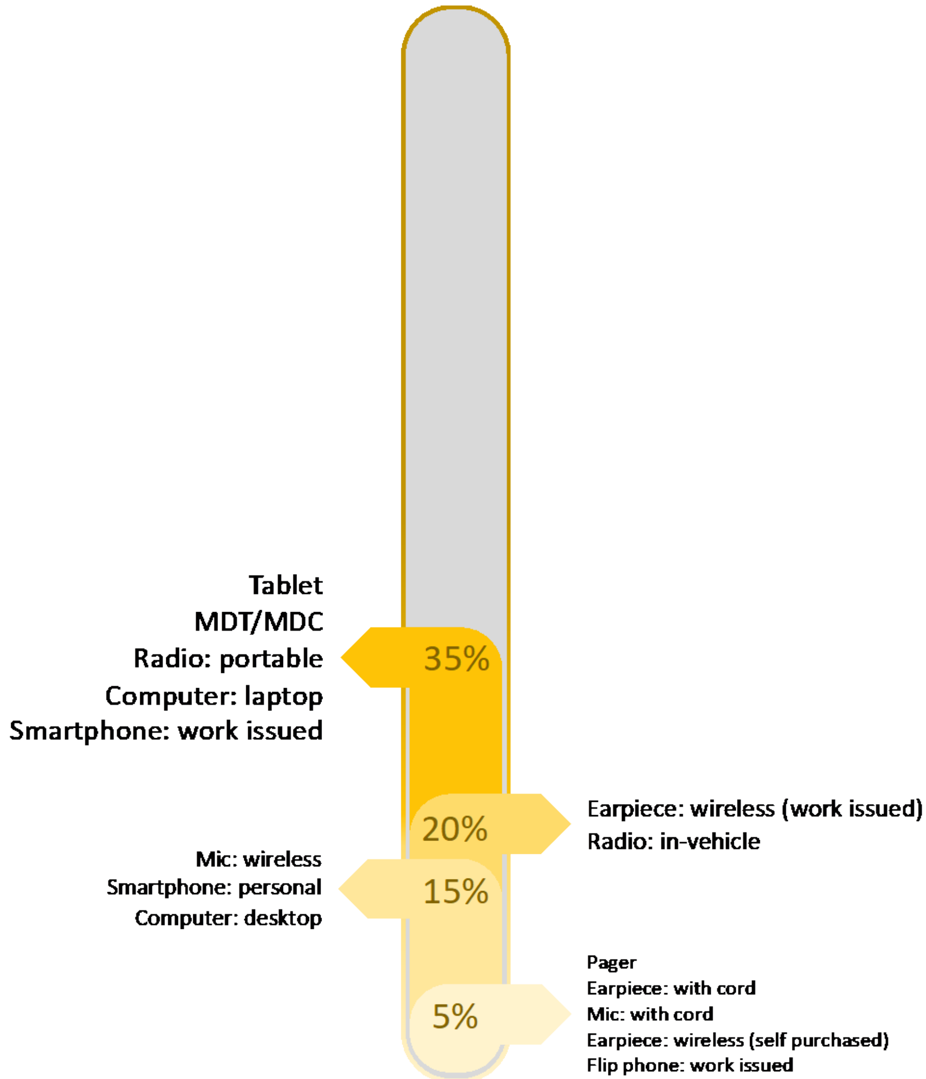

Fig. 46. *Piped list* of futuristic technology, EMS

Table 19. *Piped list* of futuristic technology, EMS

Technology	% of respondents who would use
Tablet	36.50 %
MDT/MDC (mobile data terminal/computer)	32.95 %
Radio: portable	32.79 %
Computer: laptop	31.62 %
Smartphone: work issued	31.11 %
Earpiece: wireless (work issued)	21.67 %
Radio: in-vehicle	21.62 %
Mic: wireless	15.04 %
Smartphone: personal	13.40 %
Computer: desktop	11.65 %
Pager	6.27 %
Earpiece: with cord	4.47 %
Mic: with cord	4.33 %
Earpiece: wireless (self purchased)	3.03 %
Flip phone: work issued	2.66 %

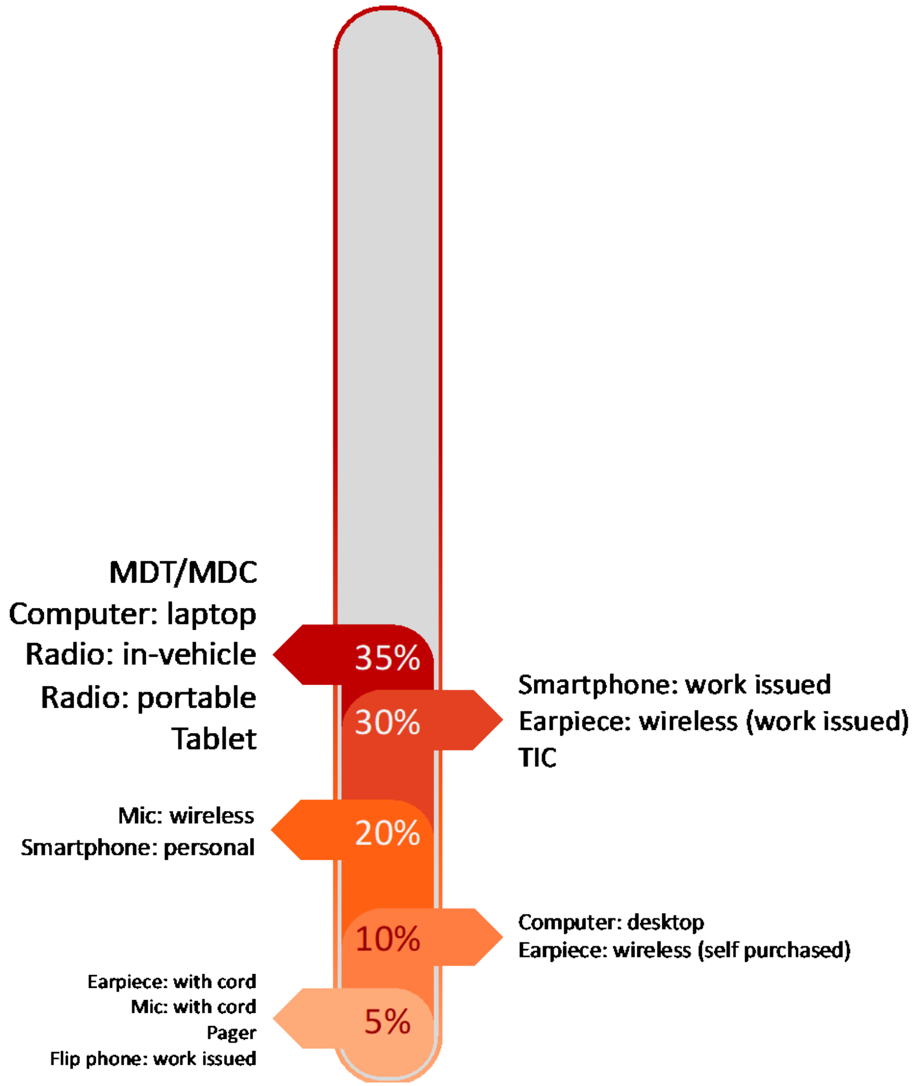

Fig. 47. *Piped list* of futuristic technology, FF

Table 20. *Piped list* of futuristic technology, FF

Technology	% of respondents who would use
MDT/MDC (mobile data terminal/computer)	38.98 %
Computer: laptop	35.93 %
Radio: in-vehicle	35.68 %
Radio: portable	34.88 %
Tablet	33.88 %
Smartphone: work issued	30.41 %
Earpiece: wireless (work issued)	28.95 %
TIC (thermal imaging camera)	27.15 %
Mic: wireless	19.50 %
Smartphone: personal	19.34 %
Computer: desktop	9.58 %
Earpiece: wireless (self purchased)	9.32 %
Earpiece: with cord	4.81 %
Mic: with cord	3.46 %
Pager	2.97 %
Flip phone: work issued	1.77 %

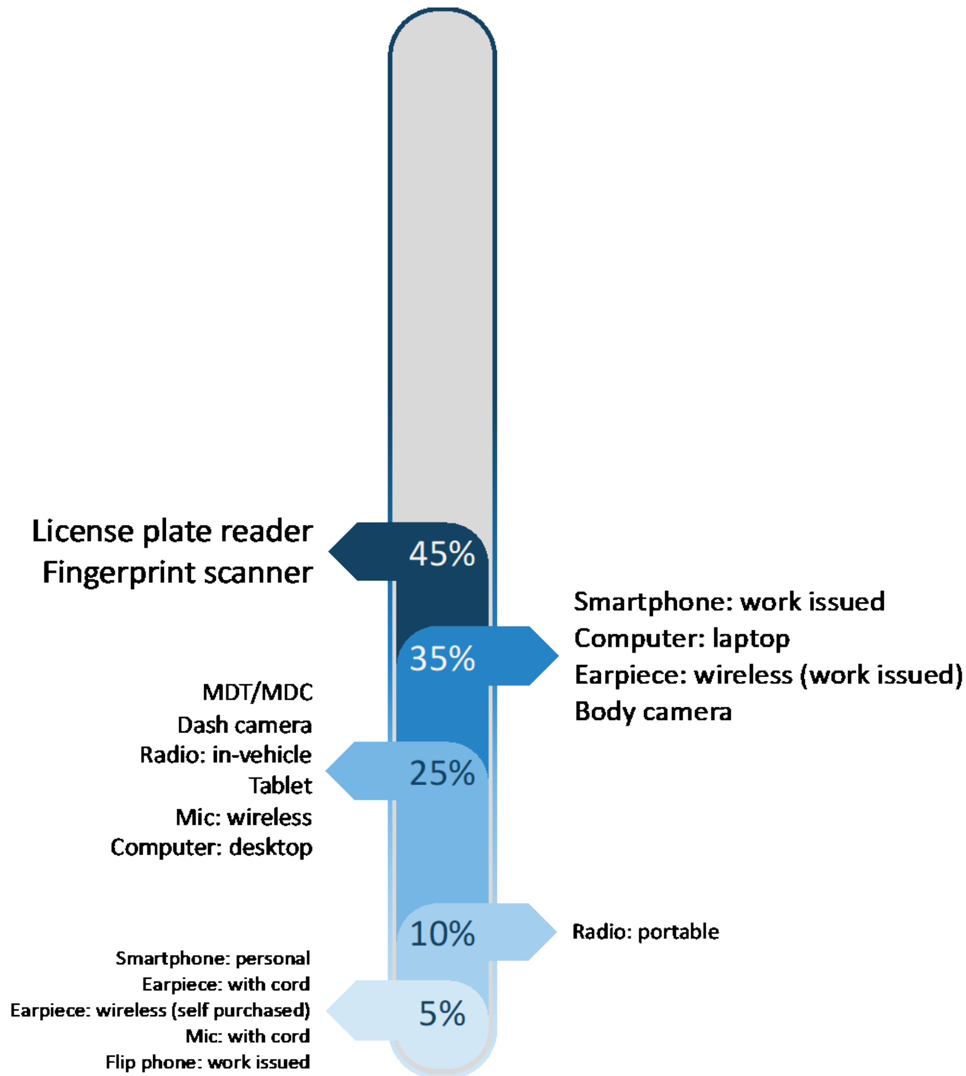

Fig. 48. *Piped list* of futuristic technology, LE

Table 21. *Piped list* of futuristic technology, LE

Technology	% of respondents who would use
License plate reader	46.11 %
Fingerprint scanner	45.59 %
Smartphone: work issued	39.34 %
Computer: laptop	38.66 %
Earpiece: wireless (work issued)	34.74 %
Body camera	31.96 %
MDT/MDC (mobile data terminal/computer)	28.46 %
Dash camera	25.43 %
Radio: in-vehicle	24.38 %
Tablet	23.33 %
Mic: wireless	19.40 %
Computer: desktop	19.39 %
Radio: portable	11.83 %
Smartphone: personal	8.05 %
Earpiece: with cord	6.63 %
Earpiece: wireless (self purchased)	4.67 %
Mic: with cord	3.08 %
Flip phone: work issued	2.47 %
Pager	0.55 %

Across the four disciplines, one item that respondents consistently identified as something that would also be useful in their day-to-day work was a “Smartphone: work issued.” Again, this is technology that currently exists. However, work-issued smartphones are something that many first responders do not have access to at this time. Several open-ended survey responses specifically noted cost as a major barrier here, which mirrors the open-ended responses previously described in Sec. 4.1.2. For example, the response of a rural participant who simply said: “Paid smart phone” (FF:R:2813). The interview data also show that many first responders do not have access to work-issued smartphones, 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)

As discussed in Sec. 4.1.1, many first responders currently use a personal smartphone because they do not have access to work issued devices. However, as previously noted, there are many problems with the use of personal smartphones, including the use of personal data plans, the lack of adequate (if any) subsidies, and the possibilities for the subpoena of a first responder’s personal smartphone. These problems may be why much greater numbers of first responders chose “Smartphone: work issued” as something they believe would be useful in their day-to-day work.

Aside from work-issued smartphones, the only other technology that crossed all four disciplines in a similar manner for the futuristic survey section was “Computer: desktop.” 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 work. While the percentages of EMS and FF who chose this item were somewhat low (EMS—11.65 %; FF—9.58 %), almost 20 % (19.39 %) of LE and almost 40 % (38.46 %) of COMMS respondents chose this item.

Several other items crossed three out of the four first responder disciplines—EMS, FF, and LE—those disciplines that are in the field. Over 25 % from each of the three disciplines identified “Computer: laptop” and “MDT/MDC (mobile data terminal/computer)” as important for their day-to-day work; over 20 % from all three disciplines chose “Earpiece: wireless (work issued)” as useful for their day-to-day work. “Radio: in-vehicle” (21.62—35.68 %) and “Radio: portable” (11.83—34.88 %) also had high percentages as items important for day-to-day first responder work. These all represent critical communication devices, something identified in the interviews as very important to first responders [5]. 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 the open-ended responses about other technologies that would be useful, three broadly-defined categories emerged across first responder disciplines: 1) Communication; 2) Location; and 3) Mapping.

Often, communication responses related to issues of coverage; location comments focused on location-based technology (for both callers and first responders); and mapping responses asked for maps at a variety of levels.

> Since we do not have cell phone coverage or mobile internet in our district, most of these items would be useless here. (EMS:R:4396)

> Dependable cell service. Because of the topography and geography of our county, this is a challenge which lends to limitations on additional technology. (LE:R:4295)

> Again, real time location of crews operating on a scene. With our departments mutual aiding more than ever before it needs to cover ALL FF's operating on a scene not just crews from one department. Thank you for doing this research. (FF:S:1252)

> Better location-based technology that pulls in local map data. (COMMS:S:9439)

> GPS system to give directions to calls. (EMS:S:4542)

> Integrated GIS [Geographic Information System] systems that incorporated state, federal, commercial, local information into one system rather that multiple sources. (COMMS:R:3788)

Responses from these categories were often intertwined, referencing issues of communication, location, and mapping in the same response. An example is the respondent above who noted that most items on the list would be useless without cellphone and mobile internet coverage. As the PSCR community considers technology that first responders believe is integral to their day-to-day tasks, they need to keep in mind the importance of communication, location, and mapping and the ways in which they are intricately linked.

Another issue that arose in the futuristic open-ended responses was cost. One open-ended survey response put this quite succinctly: "Oh and you have to throw in the fact that most of us have inadequate funding" (FF:S:5094). In the interviews as well, many participants also cited issues of cost and price as prohibitive factors related to the adoption of new forms of technology.

> They have things like thermal imaging cameras that can check heat. Well, they make them now where it can be embedded within your SCBA mask, so you don't have to carry a camera. It's like Terminator vision, right? So those kinds of things actually do exist. They're just incredibly cost prohibitive. (INT-FF-U-012)

> … but that takes money, 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, to name just a few. Cost may be one reason that respondents did not see some of this technology as useful for their day-to-day incident response. The problem of cost for futuristic technology is also consistent with the quantitative data on problems with mobile devices presented earlier in this document. Price was one of the top problems across disciplines and for all devices. The best technology in the world is not useful if those who need it cannot afford it.

In addition, the open-ended responses to this survey question often cited the need to focus more on basics and current technology needed by first responders rather than on new technology.

> Newer vehicles with working AC. (LE:S:8441)
>
> Until rural areas have a comms infrastructure that can support BASIC communications the rest is a fantasy. Most reliable comms is landline telephone - and it is a 100 years old and there's no investment to improve. (EMS:R:2434)
>
> Less technology and better more thorough training. Technology is great however cannot be solely relied on. (FF:U:1937)
>
> Mostly I think we just want radios that actually work and we can afford. (FF:R:5507)
>
> Instead of new stuff it would be good to know that the tools we already use would work better rather than getting new stuff. We already can't afford things. (FF:R:5506)
>
> None of these sound particularly useful and some could be disruptive to our normal work processes in dispatch. If one of the items listed was increased staffing then I would've happily checked that box. (COMMS:S:1545)
>
> Policing is nothing more than talking to people and resolving problems, none of the above helps me with that. (LE:S:2919)

These data resonate with interview data where new technology was not always perceived as the right answer to the problems faced by first responders. Interviewees consistently emphasized how the improvement of their current technology was what they wanted and what they believed would be the most helpful in their work. The quote below, an exemplar from the interview data, succinctly puts this in focus, and aligns with the open-ended response data from the survey.

> 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)

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.

4.4. Futuristic Technology: COMMS and Call Centers

COMMS respondents were asked specific questions about their call centers in two different sections of the survey. The first was early in the survey, just after the demographics section, where they were asked about 9-1-1 practices; the second was later in the survey where they were asked specifically about Next Generation 9-1-1 (NG 911)[7]. Since COMMS respondents were asked additional survey questions about their call centers and about NG 911, they were not asked questions about day-to-day device problems in order to adhere to the goal of keeping the survey short (see Appendix B).

A discipline-specific area of what could be considered futuristic technology was in the COMMS survey section on call center technology. Here, COMMS respondents were asked specifically about the capabilities of their call center, for example the ability to receive texts and pictures and/or video. The questions were as follows:

- Can your call center receive **9-1-1 text messages** from the public?
- Do you think this is/would be beneficial for your job?
- Can your call center receive **pictures and/or video** from the public?
- Do you think this is/would be beneficial for your job?
- Does your call center audio record calls?
- If yes, does your call center have problems with data storage?
- If yes, does your call center have problems with data retrieval?
- Has 9-1-1 ever gone down in your call center?

Response items for the questions listed above were all: Yes, No, or Not Sure.

In Fig. 49, questions are grouped as they appeared in the survey. For example, questions about texts appear together, questions about pictures and/or videos appear together, and questions about data appear together.

[7] A third COMMS section related to device use in call centers will be presented in future volumes.

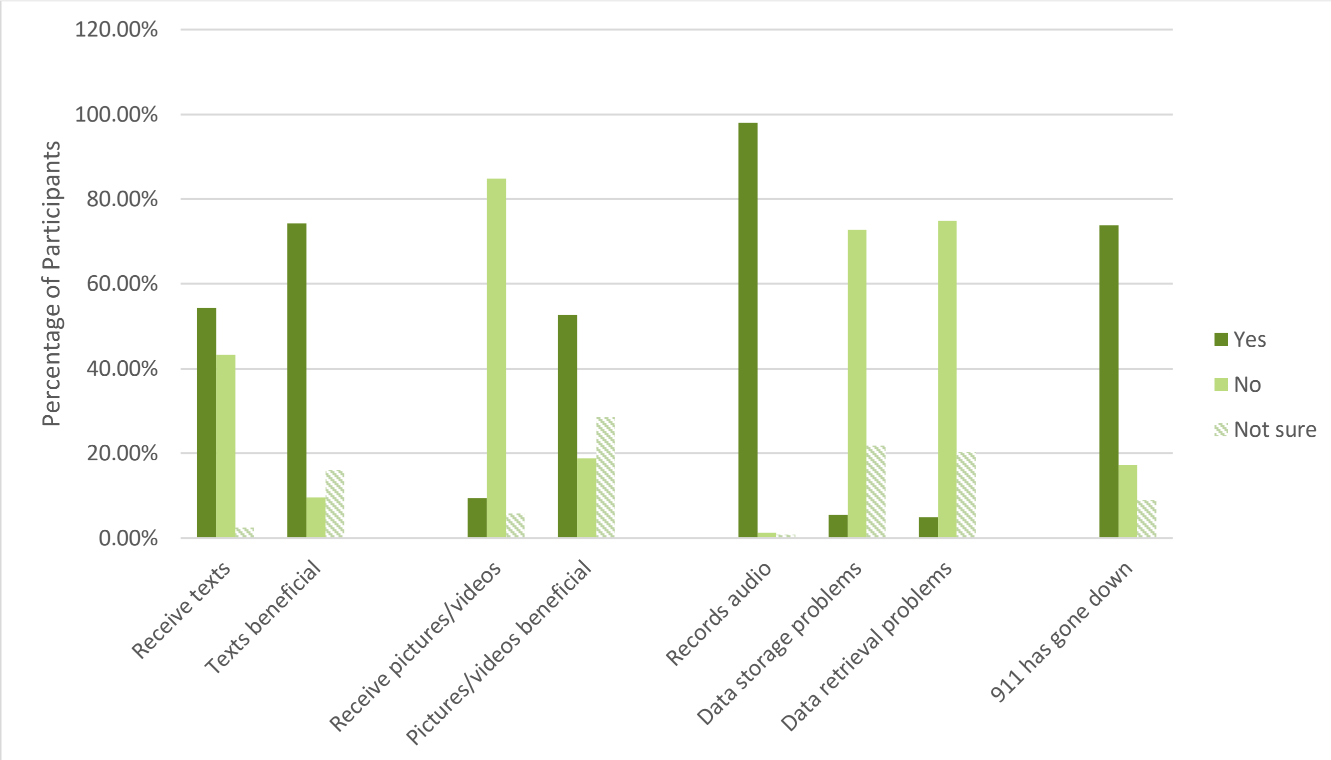

Fig. 49. COMMS call center information responses

According to the Federal Communications Commission (FCC), text-to-911 is only available in certain locations [13]. While they encourage PSAPs to accept texts, it is up to each call center to decide whether to, and how to, implement this technology. In this survey, the majority of respondents (54.34 %) said their call centers can receive texts at this time. As of 2018, the FCC estimated approximately 1 600 call centers have configured their 9-1-1 services to accept text messages, about one fourth of the 6 100 call centers in the country [1][12]. However, this survey focused on individual first responders and data were not collected at the department/agency level.

A large percentage of respondents, 74.27 %, said they believe texts would be beneficial for their job. This is interesting given the number and intensity of the open-ended responses about the cons of receiving 9-1-1 text messages from the public. As will be discussed below, many participants provided lengthy and detailed arguments against text-to-911. Perhaps when answering a generic question about whether receiving texts is beneficial or not, respondents considered it in the abstract. Being asked to provide specifics—pros and cons—may have allowed them to think more closely about the positives and negatives.

While over half of respondents said their call centers can receive texts, only 9.48 % said they can receive pictures and/or video. This much lower percentage may have to do with additional hardware and/or software tools needed by call centers that would allow them to receive, respond to, and process photo and/or video calls. Over 50 % of respondents (52.61 %) said they thought receiving pictures and/or video would be beneficial to their work. While lower than the percentage of respondents who believe receiving text messages would be beneficial (74.27 %), it is still a majority of those who responded. Once again, this is contrary to the open-ended data where many respondents were often vehement in their rejection of this technology. However, 28.66 % of respondents said they were not sure if this would be beneficial, demonstrating some uncertainty about the benefit of pictures and/or video for their work.

Participants overwhelmingly noted that their call centers audio record calls (97.95 %) and less than 6 % said they have problems with data storage (5.47 %) and data retrieval (4.85 %). However, over 20 % replied that they were not sure if there were problems with data storage (21.83 %) and data retrieval (20.35 %). This may be because they do not deal directly with data storage and/or retrieval in their work as telecommunicators.

Finally, 73.75 % of respondents said that 9-1-1 has gone down in their call center, and 8.94 % said they were not sure if it had gone down. Only 17.31 % said 9-1-1 had not gone down in their call center. Given the high percentage of COMMS personnel who have experienced 9-1-1 going down in their call center, it seems especially important to ensure that call centers have redundancy and backup plans in place and to focus technology development for providing these to PSAPs.

In addition to the closed-ended questions, respondents had the opportunity to provide open-ended responses to a variety of questions related to their call centers. The survey was intentionally designed to encourage COMMS participants to consider both the pros and the cons of texting and pictures and/or video for their work. Thus, separate text boxes were provided for pros and cons in questions 1 and 2 listed below, and most respondents provided input for both (pros and cons). The open-ended questions listed below are each discussed in subsequent sections.

1. List the pros and cons of receiving 9-1-1 text messages from the public.
2. List the pros and cons of receiving pictures and/or videos from the public.
3. If yes, what caused 9-1-1 to go down?
4. What did your call center do while 9-1-1 was down?

As seen in Table 22, high percentages of the 1 564 COMMS respondents who completed the survey took the time to answer all four of these open-ended questions, many writing extensive answers to all of them. In general, these questions elicited much longer responses than the data for any other open-ended question in the survey.

Table 22. Participants with responses to COMMS call center open-ended questions *(n = 1 564)*

Question	% of COMMS participants
Texts Pros	78.96 %
Texts Cons	77.37 %
Pics/Videos Pros	64.45 %
Pics/Videos Cons	62.98 %
What caused 9-1-1 to go down?	70.20 %
What did you do while 9-1-1 was down?	71.29 %

There were many different words used in the open-ended responses when referring to people who contact a PSAP. Some respondents used the word callers, while others used the term texters, especially in the open-ended responses related to the pros and cons of texting. It is interesting to note the ways in which technology changes the terminology used. Other terms used in open-ended responses to refer to people who contacted a PSAP were citizens, reporters, the public, or reporting party. In all cases, it is clear that respondents were referring to the person calling/texting into the PSAP to report an incident or other issue. This report follows the practice of the National Emergency Number Association (NENA) in using the generic term caller when referring to anyone requesting assistance from public safety, regardless of the media used for the request [21]. In the results presented below, open-ended responses are provided verbatim, with whatever terminology was used by the respondent to refer to a caller. However, in any discussion of the results, the term caller is used to refer to anyone contacting a PSAP to report an incident/issue or request assistance, regardless of the medium through which that report/request is made.

4.4.1. Call Centers Receiving Text Messages

As previously noted in Table 22, 78.96 % of COMMS respondents provided open-ended input for pros of texting; 77.37 % of COMMS respondents provided responses about cons of texting. A more fine-grained review of this data resulted in the creation of a variety of categories into which responses fell. Note that the percentages in the tables in this section can add up to more than 100 % since responses may have fallen into more than one category. For example, a positive comment could have mentioned texting being beneficial for both the hearing impaired and for situations where a victim's safety could be compromised by a phone call.

Pros of Texting

Exemplars from the open-ended data related to the categories of the benefits of receiving texts are presented in Table 23, in decreasing order from most responses within a category to least, and discussed in detail below.

Table 23. Categories of open-ended responses, texting pros *(n = 1 235)*

Broad Category	Subcategory	% of Responses	Exemplar Quote
Calling is difficult, dangerous, or unavailable	Safety of caller (abuse, active shooter, etc.)	64.05 %	Beneficial to deaf people and people in a situation where they can not talk or are afraid to talk. (COMMS:R:110)
	Hearing impaired	32.06 %	Ability to communicate with deaf/hard of hearing easier. Callers that cannot communicate verbally due to disability or situation can receive assistance. (COMMS:S:244)
	Lack of cell service or connection	7.53 %	Message may go through when phone call cannot be made because of weak cell signal. Weak cell signal is common this area. (COMMS:R:433)
Communication, general	More convenient; expectation of citizens	21.94 %	Easier communications with the public, and most people today text. It is the way of communication now. (COMMS:S:1525)
	Better communication	4.29 %	Callers become excited and unable to communicate clearly or listen to questions from dispatcher. When texting we are able to ask questions needed. (COMMS:R:2284)
Influencers	Age	3.89 %	Younger generation would be more likely to report crimes, etc. using text. (COMMS:R:2322)
	Time	1.94 %	May speed up response. (COMMS:R:2987)
	Ability to save/store information	1.13 %	Written record. (COMMS:S:3815)

** Note that the percentages can add up to more than 100 % since responses may have fallen into more than one category.*

Three response categories relate to the importance of texting in situations where calling is unavailable or a dangerous option for those in need of services. Situations where it was not possible for callers to talk included: 1) the safety of the caller could be compromised by a phone call (domestic abuse, active shooter, home invasion, etc.); 2) the caller is deaf/hearing impaired or otherwise disabled ; and 3) mobile and/or data coverage is unreliable. The latter is particularly important in rural or remote areas where mobile voice service can be limited but SMS service is more reliable. Overwhelmingly, the responses about pros of texting fell into these categories.

A large percentage of respondents spoke to the importance of texting in situations where calling is unavailable or is a dangerous option for those in need of services, as well as to how texting can assist the hearing-impaired community.

> Allows those who can't talk for whatever reason the ability to report or advise on situations. (COMMS:S:9769)

> Assists the hearing impaired community. We had a school shooting and I wish we had text at that time so the students would have felt safer, they were trying to whisper on the phone so as not to make any more noise than necessary. (COMMS:R:9048)

> Great for hearing impaired. Can text in situation where you can't call. Good for low cell signal area. (COMMS:U:3682)

> Beneficial to the deaf and hard of hearing, domestic violence victims that are unable to speak freely, anyone that has an issue verbally communicating. (COMMS:S:90)

In terms of access, numerous respondents indicated the benefits in areas where mobile and/or data coverage is unreliable.

> Can text when they cannot talk.   If there is cell service is spotty, they can usually text. (COMMS:R:6683)

> In situations where a caller cannot talk or has a poor cellular signal and can only text, texting is a very positive thing. (COMMS:S:6691)

> A means for the public to request help when they can't speak or they can't secure a voice cellular path. (COMMS:U:7759)

Often, these responses referenced rural or remote areas where there is "limited to no cell signal" (COMMS:R:8827), but as the exemplars above demonstrate, first responders from suburban and urban areas also listed this as a benefit.

Occasionally, responses did not provide specifics, and spoke more generally about the benefits of texting. These were categorized as "better communication." For example, some respondents indicated that texting allows callers to remain anonymous or that receiving reports via text may assist with language barriers.

In addition to texting being seen as a better form of communication for callers who are in imminent danger or who are unable to communicate verbally, many respondents also indicated that texting provides another venue for more convenient communication that citizens often expect today.

> More options available to the public to request help. Helps navigate language and speech barriers. Can *POSSIBLY* be more efficient if complainants communicate effectively. (COMMS:U:7933)

> Allows the public, specifically the younger generation who have become accustomed to text message as a primary form of communication, another avenue to obtain emergency assistance. (COMMS:S:3528)

> Better service to our citizens. Evolving with technology. (COMMS:U:3570)

> Citizens expect it. (COMMS:R:3974)

> A more modern approach of communication. (COMMS:R:5892)

> More citizens would contact police. (COMMS:S:227)

COMMS respondents from rural, suburban, and urban areas all believe this is something citizens and the public want and have come to expect. Technology is constantly evolving and the public expects to be able to communicate with public safety personnel quickly, from any device at any time [20].

In addition, respondents noted that younger people are often more comfortable communicating by text. Age occurred in the pros responses 48 times (3.89 %), specifically in references to the "younger generation."

> Younger generation is more likely to use this means (rather than not calling for help at all). (COMMS:R:1517)

> Generationally we are reaching a point where people are more comfortable with texting than placing a call. Texting is beneficial for the D/HOH (Deaf/Hard of Hearing) Community. Texting is beneficially when making a voice call could put the caller in danger. (COMMS:S:4938)

> Encourage anyone in a dangerous situation, who is unable to talk, to contact 911 dispatch. Encourage younger generations to contact 911 for emergencies. (COMMS:U:5224)

These responses often had to do with younger people being more likely to use text than voice as a means of communication.

Respondents also indicated that texting is valuable when it allows for the communication and capture of more detailed information from callers. For example, details such as addresses and license plate numbers, descriptions of people or events, and general information can be saved and/or stored. This is often information that is easy to forget or report incorrectly. It is also information that may be able to assist in getting the right responders to the right place quickly, with more complete information about the situations to which they are responding.

A small percentage of respondents (1.94 %) noted that the reception of texts could help speed up response time.

> Being able to help someone sooner. (COMMS:S:378)

> Quicker than taking a call from callers and transcribing the information into the CAD application. Information is imported directly into CAD. People sending 911 texts will not have to wait on hold if call volumes are high. Information can be more real time and is helpful during fluid events. (COMMS:S:615)

Positive responses about the amount of time needed to process and respond to texts were low, and as will be seen in the following section on cons of texting, contradict much of the data that respondents provided about the time it takes to receive, process, and respond to texts.

Several responses in the pros category spoke about the overarching benefit of text to 9-1-1, such as the following.

> Allows access to those who can not speak - whether due to physical limitations or situational circumstances. We have been doing text for a few years and the impact is minimal. Some dispatchers can handle multiple texts and non-emergency calls at the same time. We've had many success stories in our County/State as a result of the deployment of text to 911. (COMMS:S:5277)
>
> Our center has only received one text to 911 message. Which resulted in a phone call, not use of text. (COMMS:S:4979)
>
> If it saves 1 life it's worth it. Helps when someone's hiding. (COMMS:R:3460)

These quotes highlight some of the "success" and benefits of texting to 9-1-1, but also show how in some cases there has been very little impact as a result of text to 9-1-1 implementation, at least as reported in this survey.

While most of the responses to the question about pros of texting provided positive responses, several respondents wrote things like: "I don't think it's a good idea at all" (COMMS:U:9257) or "I'M NOT SURE THERE IS ANY" (COMMS:R:1122). These are clearly negative responses to the idea of being able to receive 9-1-1 text messages from the public, even though they occurred in the pros response box.

Cons of Texting

Respondents also had an open-ended text box where they could provide information on the cons of texting. There were 1 210 negative responses provided, many of which were quite lengthy. The negative responses were broken down further into 13 subcategories, listed in Table 24 below. Several categories related to consequences of receiving text calls, such as: more time and more staff needed for text calls; fears about false/prank calls; an increase in non-emergency calls; and responding to texts as just more difficult. Other categories represented information issues faced by COMMS personnel with text calls, such as: missing verbal cues and background information; language issues such as texting abbreviations and "lingo" or texting in a different language such as Spanish; and missing or compromised location information. Several other categories of responses had to do with PSAP related issues such as training for COMMS personnel, equipment needs, technical issues (for example, knowing whether texts were delivered/received; inability to initiate texts; inability to transfer between agencies; no way to copy messages into CAD system); and the cost associated with receiving texts (new equipment, training for personnel, etc.). A final category related to caller safety issues, specifically to the dangers of texting and driving. Exemplars from the open-ended data related to these categories are presented in Table 24 and discussed in detail below. The broad categories in the table are presented from most to least number of responses, and subcategories are also presented in decreasing order.

Table 24. Categories of open-ended responses, texting cons *(n = 1 210)*

Broad Category	Subcategory	% of Responses	Exemplar Quote
Consequences of receiving text calls	More time	44.05 %	Call processing time goes way up. (COMMS:U:5790)
	False/prank/swatting calls	29.50 %	Increase of prank calls, ties up 911 lines (COMMS:U:3083)
	Non-emergency calls	14.88 %	Receiving text messages in situations where it is not an emergency and lines tied up with non-emergency situations. (COMMS:S:2318)
	Staffing issues	9.92 %	Just one more task to add to the already over worked, short handed, and under paid staff. (COMMS:R:1536)
	More difficult	9.50 %	Response is sometimes difficult. (COMMS:U:2268)
Information issues with text calls	Missing verbal cues/background noise	21.98 %	No Vocal Cues (Tone of Voice, Background Noise, Dropped phone) Inability to distinguish different callers/reporters. (COMMS:S:1555)
	Location information	17.19 %	Not having exact location coordinates. (COMMS:R:1656)
	Language issues	9.75 %	Common text abbreviations may not be known to all and could be misinterpreted. (COMMS:R:5892) No language translation for texts not in English. (COMMS:S:1537)
PSAP issues	Technical	11.82 %	Response time between questions and answers, no guarantee the messages are received. (COMMS:U:310)
	Training	5.37 %	Training standards. Our department doesn't have the technology yet to be able to do this. (COMMS:S:1675
	Equipment	4.21 %	Information is extremely slow to come in. On our system, we have to do a command to switch to the phones which disables our ability to type in CAD, then we have to do another command to switch back to CAD which disables the ability to type back to the caller. (COMMS:U:1867)
	Cost	2.73 %	May not be cost effective, which is why we don't have text to 911 yet. (COMMS:S:7714)
Caller safety issues	Texting and driving	1.90 %	Extended time to obtain actionable information (life safety. Misuse (pranking). Texting and driving. (COMMS:U:760)

** Note that the percentages can add up to more than 100 % since responses may have fallen into more than one category.*

Overall, many respondents noted that receiving and responding to texts was very time consuming—more time consuming than a regular voice call. Time was mentioned by more participants than any other category—44.05 % of respondents noted something negative related to time and receiving 9-1-1 text messages from the public.

> Time consuming method of communicating. (COMMS:S:9735)

> Based on our experience, text to 911 messages take three times as long to process. Therefore they drag down our 911 answering capacity. Furthermore, the location information is still lacking. Texts to 911 are transported via the same commercial mechanisms as regular texts sent by the public, therefore there is no guarantee the text will be delivered, or when. It would be unwise to bet your life on a text that may not be delivered timely...if ever. Texts prevent the 911 Operator from gathering unspoken contextual clues to the emergency, such as heavy breathing, background noises, screams, gunshots, etc. (COMMS:U:1855)

> The public, who communicates casually by text more than voice, may begin to use Text-2-911 as a regular means of communicating. Texting takes considerably more time to communicate than voice communications, delaying the processing and response to emergencies. (COMMS:R:1668)

> People text even worse than they talk. Not coherent communication, often digressing into detail that's not as important as WHERE. They don't respond timely to questions or at all. They treat text as casual. It simply doesn't convey immediacy as a phone call. They have unrealistic expectations of what tech can do, thinking it's like TV and we can know immediately where they are, etc. They feel more anonymous, less responsible in text and act as such. And it's slow. Very slow communication. Most of the time we call them, or ask them to call us. I have yet to take a 911 text where texting was more appropriate than a phone call. I've taken plenty of 'test' texts, joke texts, automated by tech texts, and such. The few real texts were laboriously handled, 20mins of texting back and forth that could have been handled in 3 or 4 mins on phone call, and most have been switched over to phone calls to get the job done. (COMMS:S:7948)

These responses each highlight multiple issues, but perhaps most important is the belief that text communication takes much more time and that it might delay "the processing and response to emergencies." This has tremendous potential repercussions for COMMS personnel and their work, but also for the work of other first responders in the field who deal with emergency incidents.

In addition to taking more time, many respondents noted that handling of texts would demand an increase in staff and additional staff training, both of which contribute to additional costs.

> Currently understaffed, not enough positions. Budget issues for upgrades. Training for (older) staff members. Getting buy-in from the public. (COMMS:R:2154)

> Longer call taking times, inability to transfer means multi call-takers could be tied up on one call if in another jurisdiction, easier to prank. (COMMS:U:2108)

Staffing issues were of concern across the board, in urban, suburban, and rural areas and in many cases were mentioned in conjunction with time issues.

Other consequences of receiving texts include the belief that it will create an increase in the number of fake/prank/swatting incidents, as well as an increase in non-emergency communication. Almost 30 % of those who responded to this open-ended question (29.50 %) spoke about the negative impact of fake/prank/swatting calls.

> I cannot even begin to imagine the wayward texts our center will receive - it's bad enough with all of the pocket dials, 911 abandons and misdials from phones, watches, etc., the numbers of those will go thru the roof with text messages - especially when it's new - people will test it out to see if it actually works. Our center will be inundated and we don't need that. (COMMS:S:1943)

> Anonymous— easy to have swatting incidents (fake calls) due to not being able to track/trace the phone call. For example, someone uses a burner phone/prepaid cell phone to call in a fake call at an address and units respond to find there is no problem at the location. Citizen may not be able to spell correctly which may cause errors in reporting the correct location. It is time consuming, 911 operators would have to read the message and then retype the information into their call entry screen and also respond back to the citizen. Verbal calls are easier to multi-task as the operator can talk and type while the citizen is providing information. (COMMS:S:9227)

> Not efficient way of communicating an emergency. We already get a significant number of 911 mis-dials, pocket dials, etc which we follow up on each one. If you add in the additional text to 911 errors, this may become too laborious and result in a reduction of service. This may cause us to miss a legitimate 911. (Cry wolf theory) (COMMS:R:2169)

> Being flooded with random texts that are NOT emergencies (COMMS:S:2311)

The negative influence of these non-emergency calls was also noted in the interview data, where several interviewees expressed frustration with the volume of text calls and the stress that they place on a call center.

> And then with that we have received somewhere in the range of two hundred and thirty texts. A good probably 80 % or more of that are accidental texts to 911. […] Or believe it or not we get butt texts not sure how you do that (INT-COMMS-U-007)

All these issues make the work in 9-1-1 call centers more difficult and may take away from a call center's capacity to respond efficiently to actual emergencies. In addition, as the respondent below notes, it is just generally more difficult to communicate via text.

> Prolonged time communicating via text just to obtain at least the basic info to initiate a response. Inability for 9-1-1 dispatcher to hear sounds in the background or tone of callers voice which would otherwise provide additional insight for responders. Callers may use too

> many inconsistent abbreviations which may not be familiar to 9-1-1 dispatchers and may delay response. May lead to an increase of false, spoof, swatting calls to emergency services. (COMMS:S:2333)

COMMS respondents often expressed a general unease with the effects of receiving and responding to texts from the public, with most responses listing multiple, interconnected issues. As previously noted, some of these have implications not only for COMMS personnel, but also for first responder safety in the field.

Other open-ended cons responses about receiving 9-1-1 text messages from the public focused on information issues with text calls. Almost 22 % of those who wrote an open-ended response for cons, spoke about the lack of verbal cues and background noise in a text call. In a voice call, verbal cues (such as emotion) and background noise (such as gun shots) can provide COMMS personnel with vital information about the incident. With text calls, this information is lost.

> Hard to read emotion in a text. (COMMS:R:1707)

> 1. Takes more time to interact with callers. 2. Call taker can not ask rapid questions. 3. Call taker can not detect background noises, or tone of voice, which has huge officer safety implications. 4. Continuity of the phone call may be diminished. 5. Not able to easily transfer callers to other PSAPS. 6. May be subject to more prank calls. 7. Very difficult to get a feel for the urgency of the situation without speaking to caller by voice. (COMMS:S:2013)

> Voice call is still best so a dispatcher can hear the callers tone to help determine what type of response the call needs and able to hear background noise. May not be cost effective, which is why we don't have text to 911 yet. (COMMS:S:7714)

> Slow to process and obtain a dispatchable address. Lose all the audible clues that provide caller state of mind, background environment, and severity of event. (COMMS:S:9056)

COMMS personnel lose valuable auditory cues when information is received by text rather than a voice call. As with previous issues mentioned, the lack of verbal cues and background information can have “officer safety implications,” as noted above by COMMS:S:2013.

In addition, there can also be a loss of information or complications in understanding due to language issues. For example, if text calls are sent in languages other than English, COMMS personnel may not be able to understand or respond. Another potential issue is the form of language used in text calls where jargon, acronyms, and emojis/emoticons can express things that someone who is not familiar with them might not know.

> Text jargon can mean different things to different people. Would we be able to receive emojis? Crank/prank messages. Can take longer to receive and reply. Texts can be easily misinterpreted regarding content and context. (COMMS:R:8801)

> Text message shorthand. Emoji's and emoticons vary across phone platforms, users, and geography. Misuse for pranks, swatting or denial of service attacks to 911 systems. Increased cost involved with staffing, record retention, and evidence storage. (COMMS:U:6675)

> 1. Language barriers with the increased variety of nationalities within our demographics across the country. 2. Because of the latter, delay in service due to delay in text exchange, delay in call entry and no translator services for texting (which if existed would create a bigger delay). 3. Testing CPE will not be able to convert different languages into standard English. 4. Can be time consuming for some smaller agencies if limited in staffing (i.e. 2 minimum staffing per 12 hour shift) while other calls for service (911 and non-emergency) are being answered and entered. 5. Limited transfer capability for texting parties or agencies from jurisdiction to jurisdiction 6. Without thorough public knowledge and education, people attempting to use text to 911 will not understand that photos cannot be sent and it has to be used as a basic 911 function (it is an existing hindrance to our industry when people refuse to understand basics of 911. (COMMS:U.8879)

Responses related to language issues highlight the ways in which they might have an impact on the work of COMMS personnel, including the possibility for misinterpretation and lack of understanding. This can result in longer processing and/or response times.

Another information issue identified by some respondents is the perceived difficulty in eliciting location information. According to many respondents, the ability to identify or elicit location information is greatly reduced in text calls versus voice calls.

> It takes way too long to get useful information over text. Citizens don't know what information we need or the most critical order in which we need it. It's hard enough to get a location out of someone when you can talk to them. When they aren't responding to texts, it's next to impossible. Citizens aren't texting emergencies. They are texting because they don't want to have to engage by talking to someone. (I once took a 25 minute text conversation in which someone wanted to report a reckless driver. A 2 minute phone call took 25 minutes over text...not only that, but what are you doing texting while driving!) (COMMS:S:8570)

> Pranks; unable to determine location using phase II or other methods; no details such as voice of the caller to estimate age/gender; text shorthand that not all are familiar with. (COMMS:S:9084)

> Encourages more people to text 911 for unnecessary things (like driving by and seeing a man down on a bus bench). We have to bounce back and forth between two key boards. Adds way more key strokes because we have to triage the call... so every question we need answered has to be typed out, then we have to wait for a response, go back to our CAD computer, select the answer then back to the computer we use for text to 911 to type out the next question. We already get enough prank calls from kids reporting houses on fire. Texting about a house on fire is that much easier. For a city of 1.2 million people, we (the fire/medical side) only have two-four calltakers. If we get a text to 911 from someone who doesn't respond, that takes a

> calltaker out of the queue. It's a lot harder to narrow down a location over text... and a lot more key strokes. How long until someone texting 911 gets into an accident because of it and uses the fact that they were texting 911 as an excuse. (COMMS:U:5849)

The importance of location information was one of the findings highlighted in the interview data. "Accurate caller location is critical for effective communication from COMMS personnel to responding units" [28]. Location matters—it is the most vital piece of information needed by COMMS personnel and first responders in the field, yet many survey respondents noted particular difficulties in obtaining caller location from text calls.

A third category of cons responses related to PSAP issues, including the need for additional training, equipment and technical needs/issues, and the potential cost in enabling text-to-911. Training for COMMS personnel was identified by 5.37 % of respondents, and while not a large percentage, it is important to consider those factors that might inhibit a PSAP's ability to receive and respond to text calls.

> More training needed for dispatchers. (COMMS:R:9186)

> Inability to distinguish different callers/reporters. Inadequate legal support/preparation. Training/equipment shortfalls. Abuse by the public (Impatience, Pranks). Potential manpower/staffing issues. Time lag. Lack of a non-emergency alternative first (311 comes before 911). Non-traceable phones enabling a diversionary or wild goose chase scenario. Specially designed apps that subvert. (COMMS:S:1555)

> Training and dedicating personnel to this function. (COMMS:U:9421)

Another subcategory here related to additional equipment and technology that might be needed in order for PSAPs to accept and respond to texts from the public.

> Requires more time from limited staffing; requires more technology; requires more money to implement. (COMMS:R:6001)

> They use shorthand and would be difficult to question and receive responses on in progress information. The staffing levels of the department do not allow for the time that would be needed for a text call. They would have to hold so you can answer other emergencies. The integration with the CAD would be essential or the call taker would be going back and forth between two systems. There is no guarantee the CAD could interface with texting. (COMMS:S:5951)

Technical issues represent another subcategory of PSAP issues. These often related to the inability to transfer text calls, especially when the caller might be crossing jurisdictional lines or about the lack of interoperability of equipment in the processing of text calls.

> People don't answer the questions we send to get further information. Not all jurisdictions in this area accept texts therefore you cannot transfer the text session if needed. (COMMS:S:1865)

These training, equipment, and technical issues are often intertwined with issues of cost, which was identified by some respondents as a negative of texting to 9-1-1.

> The expense associated with upgrading the PSAP to provide this service. (COMMS:R:1592)

> Longer delays for call taking; training for call takers / dispatchers; must adapt hardware and software; costs (COMMS:U:1557)

> May not be cost effective, which is why we don't have text to 911 yet. (COMMS:S:7714)

Comments about the negative impact of cost came from respondents in rural, suburban, and urban areas, although the majority (66.67 %) came from rural respondents. This resonates with the findings from the interview data that show rural areas in general face more difficult budget issues than their suburban and urban colleagues [18].

Increased costs for additional staff, training, and equipment could be considerable, creating financial difficulties for some PSAPs. As one respondent put it: "Does the cost balance the need?" (COMMS:S:9708). This question, of cost versus need, is an important one that should be considered carefully as PSAPs move to implement aspects of NG 911 such as texting.

A final category in the open-ended data about the cons of texting was about caller safety issues, specifically about the dangers of texting and driving. The interview data are very clear that COMMS personnel, like the rest of their public safety colleagues, see themselves as serving the public: "Dedication. You have to want to do this job" (INT-COMMS-R-011); "…you don't necessarily do it for money, if you know what I am saying" (INT-COMMS-R-019). This may be why 1.90 % of respondents note concerns about texting and driving and the danger this poses to callers.

> Safety of the caller - we keep telling them NOT to text and drive, and some might try to text 911 while driving. If it is a time sensitive emergency, texting may take precious seconds away from the responding units versus the time to retrieve the information from an actual caller on the phone. (COMMS:S:5449)

> If caller is texting and driving that is dangerous. Another way made available for pranksters to use. Direct communications is lost, you can't hear the background and you can't hear the tone of the caller's voice. (COMMS:U:2145)

While most other comments spoke about the negative impact of texting on COMMS personnel, on other public safety personnel, and for the PSAP, these comments focused on care for the caller. Several of the responses, like COMMS:S:5449 above, note the discrepancy between encouraging callers to text while at the same time telling them "NOT to text and drive."

The quantitative survey data show that the majority of COMMS respondents (74.27 %) believe that it is beneficial to receive 9-1-1 text messages from the public. However, the qualitative survey data highlight a much different story. The open-ended survey data show the specifics of where and how COMMS respondents believe texting can be beneficial, but they also demonstrate that there is a lot of concern around what is already happening (and what may yet happen) as a result of receiving and responding to texts. It may be that in the abstract, COMMS respondents chose "Yes," that texting is beneficial, but when asked to provide specifics they were much more cognizant of both potential benefits and potential problems. This apparent discrepancy may also reflect the limitations of a closed-ended question that only allowed respondents to choose one response—Yes, No, or Not Sure. When allowed the option to provide information about both pros and cons, respondents did just that—providing a much more nuanced picture than just the quantitative results. Data from the interviews mirror these results.

> But baby, I don't want to talk to you on the phone, I'm not going to have a 30-minute conversation over text whenever I could hear your voice and… and I can really hear are you okay. I can't tell that over here. I can't tell if you're crying or--that's my fear with the Next Generation 911 is are we going to lose that important piece of our communications with technology. (INT-COMMS-R-016)

It is interesting to note that most COMMS respondents identified both pros and cons of texting. However, while many respondents provided both pros and cons in the open-ended text boxes, the cons they listed often negated the pros they identified. Perhaps the most important consideration here is thinking about texting and its relationship to usability. Usability is comprised of efficiency, effectiveness, and satisfaction, and from the perspective of many COMMS respondents all of these are compromised with the shift to texting to 9-1-1.

Also of note are the ways in which the pros and cons cited by survey respondents align with those identified in an Association of Public-Safety Communications Officials (APCO) report from 2012 that identified human and operational aspects of NG 9-1-1 [3]. The same concerns noted in that document remain today: time to process texts is longer than with voice calls; abbreviations and text "lingo" are inconsistent and not official; loss of audio clues such as emotion, tone of voice and background noise. Stress, frustration, and additional pressure from these new forms of communication are also discussed in the 2012 report—all issues that remain today according to COMMS personnel in this survey.

> "The impact of stress upon telecommunicators has long been documented. However, the impact of Next Generation on stress still remains to be seen. Will the assumed increase in processing times create call backups in the 9-1-1 center, leading to frustration, pressure and hurried calls? Will the lack of human contact associated with text messaging play a role? And while the scope of this white paper relates solely to text messaging, will future generations of technology that import real time videos of horrific crime, fire, and accident scenes directly into the PSAP place a different type of stress on those charged with handling these calls? Regardless of the answers, the public safety telecommunications community must be ready to address these challenges" (p. 24) [3].

In addition, the 2012 APCO report notes that training and policy must shift to address the changing communications environment. "Effective training of telecommunicators will be the key to a successful implementation of a solution. Administrators and training personnel must become versed in a methodology with which they may not be comfortable" [3]. According to results from this survey, this continues to be an issue today.

4.4.2. Call Centers Receiving Pictures and Videos

As previously noted, there were 1 008 responses in the pros open-ended text box and 985 cons responses. Similar to the data on texting, many respondents provided input in both the pros and cons open-ended response boxes, with many responses over 100 words, especially those from the cons open-ended text box. These respondents clearly cared about this issue and took the time to provide thoughtful information about it.

Pros of Pictures and Videos

As with the data on texting, a more refined analysis of this data resulted in the creation of a variety of categories and subcategories into which responses fell. Exemplars from the open-ended data related to the categories for the benefits of receiving pictures and videos are presented in Table 25 and discussed in detail below; the broad categories, as well as the subcategories contained within them, are presented from greatest to least. The open-ended responses for the pros of pictures and/or video fell into two primary categories: 1) the ability to gain information and 2) how that information can be used. Subcategories for the ability to gain information include additional information from the caller (scene and suspect descriptions for example, location clues, real-time information, and the ability to visualize the scene. Information use was further broken down into information that could be sent to responding units and information that could be used for evidence/proof or information for investigation.

Table 25. Categories of open-ended responses, pictures/video pros *(n = 1 008)*

Broad Category	Subcategory	% of Responses	Exemplar Quote
Information (incident, suspect, location, etc.)	Additional information about incident	44.15 %	Potential identification of suspects. Better reconstruction of events. (COMMS:S:9734)
	Visualize the scene	28.47 %	May paint a clearer picture of the scene. (COMMS:S:9439)
	Real-time information	11.31 %	1. Real time notification of what's going on. 2. Recording for future use. 3. Officers can see what they are going into. (COMMS:S:9794)
	Location clues	10.91 %	Could help with location and description info. (COMMS:R:9074)
Use of information	Information to responding units	23.41 %	Better ability to instruct first responders. (COMMS:U:8578)
	Evidence/proof, information for investigation	14.78 %	Great for evidence. (COMMS:R:9376)

** Note that the percentages can add up to more than 100 % since responses may have fallen into more than one category.*

As with the open-ended data about texting, several responses about the pros of receiving pictures and/or video were not really about the pros for COMMS personnel.

> Not able to think of any pros at this time. It may be beneficial for officers to have this information, but not sure how it can benefit dispatch. (COMMS:U:2069)

> It could help to clarify a location when there is ambiguity. I'm not really an advocate of this. (COMMS:S:2437)

Receiving pictures and/or video was generally seen as something that could be beneficial for officers and responding field units, but its use by COMMS personnel was seen as much less clear for some respondents. However, the majority of responses in the pros open-ended responses did highlight ways in which pictures and/or video could be useful for COMMS personnel. Almost all of the positive comments from the open-ended responses indicated that photo or video documentation would be beneficial in capturing details of an incident that might be lost without visual artifacts. Some responses articulated that this documentation could be helpful in preparing responders to address the emergency or situation, while others indicated that photo or video documentation could be useful as evidence post-incident or in furthering an investigation.

Overwhelmingly, respondents noted how this type of information could provide better details and descriptions of situations, including location information. More complete descriptions and details of emergency situations, suspects and vehicles, and emergency locations could assist COMMS personnel in a number of ways. Of note, respondents indicated that the ability to capture important details such as license plates and vehicle/suspect descriptions was significant, as was the ability of visual evidence to help locate a victim when the victim was not sure where they were located. Seventeen participants, like COMMS:S:3296, specifically used the phrase: "A picture is worth a thousand words."

> Picture is worth a 1000 words. Image of suspect could be sent to police officers. Gravity of situation could be quickly assessed and EMD might be administered more quickly. Medical personnel might be able to prepare before patient arrives at hospital. (COMMS:S:1885)

> Instant suspect description. Instant vehicle description. (COMMS:S:6367)

> Pictures of suspects, suspect vehicles, missing or abducted person(s). We would be able to get it out to the troops quicker. If the caller doesn't know where they are, they could take a picture for us to help them determine where they are. (COMMS:R:6338)

> Better understanding of what's going on, better location and descriptions. (COMMS:U:6143)

The additional information from pictures and/or video could aid COMMS personnel in understanding the situation better, in dispatching first responder units more quickly and appropriately, and in identifying location information.

In addition to gaining more information about a scene, suspect, and/or location, many participants noted the benefits of receiving real-time information for COMMS personnel.

> Live feed would aid in scene safety, apprehension of offenders. (COMMS:S:5972)

> Would give the call-taker the ability to actually see what is happening on a scene vs the caller trying to explain. (COMMS:S:9272)

> Being able to be live at a scene would be a huge tool to have as a dispatcher. The same with receiving pictures that could help with cases. (COMMS:R:9199)

> Live video of a crime in progress could be beneficial for law enforcement, provided capturing and storage is also available. Video or pictures could assist in determining location or the actual circumstances to aid in dispatch. (COMMS:U:8980)

This category is directly related to both responder preparedness and situational awareness for responding units.

Closely connected to the benefits of real-time information for COMMS personnel is the benefit that this information could provide for first responders in the field. Visual, real-time information could assist COMMS personnel in better preparing first responders in the field for what they will encounter when they arrive on the scene; it may also potentially decrease response time.

> Better descriptions of the scene for the units responding which would allow for better response, also can provide instructions for the officer about where the suspect is if they can be seen which would improve officer safety. (COMMS:S:9292)

> Direct information as it is happening. Having the dispatcher actually viewing what is/or has happened can streamline criteria questions and assist in pre-arrival instructions. This will also give the dispatcher a greater understanding of the call and area they are dispatching an officer response to. It will assist in officer safety issues. Faster, more incident verified emergency response to help manage resources. (COMMS:R:5805)

Over 20 % of respondents (23.41 %) explicitly indicated that communicating this kind of intelligence to field personnel would benefit first responders, many noting it would provide additional safety for responding units.

> It would be helpful to receive pictures or videos to get better descriptions of suspects, for the responders to know what they are walking in to, and for us to see exactly what is happening. (COMMS:S:7527)

> Increased accuracy of information to relay to responders. Increased officer/firefighter/emt safety. (COMMS:U:7256)

> Better situational awareness and ability to relay more accurate details to first responders. (COMMS:R:7392)

Real-time information can provide greater visualization of the scene, situational awareness, and responder preparedness, all of which are intricately linked and contribute to increased safety for first responders.

Respondents also specifically indicated that photo or video documentation could be helpful as evidence for a subsequent investigation.

> More evidence. Will help responding units, by providing them more detailed information when responding to the scene. (COMMS:S:6042)

> Might be good for evidence purposes. (COMMS:U:6659)

> Provide investigatory evidence for prosecution. Gives an opportunity for dispatch to give accurate details to responders. (COMMS:R:6024)

The ability to have pictures and/or video as artifacts for evidence and/or investigation was viewed as a positive by COMMS personnel, although as will be seen in the following section on the cons of pictures/video this positive view is tempered by potential liability issues.

Receiving pictures and/or video from the public was also seen as part of public safety’s commitment to providing a variety of ways for the public to communicate in an emergency.

> Part of evolving process of technology - Need to embrace. Allows public other opportunity to reach emergency services. Additional data/info to help the cause (resolving emergency). (COMMS:R:8922)

Staying up to date with technology and providing multiple ways for the community to communicate in an emergency are seen as part of public safety's commitment to the community.

Cons of Pictures and Videos

While many respondents provided input about the pros of receiving pictures and/or video for their work, many also wrote at length about the cons related to this type of information. Five broad categories emerged from the cons data, including: 1) problems with the images; 2) effects on COMMS personnel; 3) effects for PSAPs; 4) technical issues for PSAPs; and 5) issues for callers. Exemplars for each of these categories are presented in Table 26 in decreasing order from the most responses to the least, and discussed below.

Table 26. Categories of open-ended responses, pictures/video cons *(n = 985)*

Broad Category	Subcategory	% of Responses	Exemplar Quote
Problems with images	Negative images (inappropriate or graphic)	41.73 %	Possible explicit or inappropriate pictures. Liability of interpretation of what is seen. (COMMS:U:6368) Dispatchers don't need to see graphic photos from accident scenes while trying to dispatch. COMMS:R:6409)
	Not relevant or poor quality images	13.81 %	Overwhelm the system with superfluous photos. (COMMS:U:6416) Blurry video or pictures/poor video/picture quality. (COMMS:R:75)
	Need for verification or authentication	9.85 %	Requires additional storage space. Need way to verify validity. (COMMS:R:5885)
	Meaning unclear or missing information	9.04 %	There are many things I don't want to see in my job! images may not give entire pic and may lead to false assumptions. (COMMS:S:5544) Unable to reference the location because it is too tightly cropped. (COMMS:U:1086)
Effects on COMMS personnel	Mental health issues—PTSD	41.83 %	Dispatcher PTSD. New method of pranking. Potential to misinterpret because not asking questions. (COMMS:S:6341)
	Information overload	10.76 %	Information overload. Graphic images that calltakers may not be able to handle. (COMMS:R:7225)
	Liability issues	5.38 %	Possible explicit or inappropriate pictures. Liability of interpretation of what is seen. (COMMS:U:6368)

Broad Category	**Subcategory**	**% of Responses**	**Exemplar Quote**
Effects for PSAPs	Additional time for calls/response	11.37 %	Potentially more time in processing calls. Visualization of the call for call-taker (psychological effects). (COMMS:R:8736)
	Additional cost and/or resources	8.53 %	Slow the system down and cost to get it. (COMMS:R:8222)
	Additional training and/or policy development	5.58 %	Training that would need to take place would need to [be] extensive. What is the dispatcher/calltaker suppose to do with the information that is being texted to them. (COMMS:S:8474)
	Recruitment and retention	1.42 %	Additional training//retirements/resignations from personnel. (COMMS:S:8167)
Technical issues for PSAPs	Data storage and retrieval, including chain of evidence	12.1 %	Information overload; chain of evidence issues; storage (COMMS:U:9402)
	Technical failures, viruses, and other problems	11.37 %	With poor cell service we have in our area delivery of these may be very slow if they get delivered at all. (COMMS:R:8293) VERY high risk for virus/malware infection without running application in a sandbox. (COMMS:U:251)
	Privacy issues—for callers and for COMMS personnel	3.25 %	Privacy issues, pic could get released to public. (COMMS:R:9182) I most certainly do not want video chat where they can see us. I work in a small town, sometimes I have to go out in this town and I do not want to have someone recognize me from my job. (COMMS:S:6730)
Issues for callers	Danger due to taking/sending pictures and/or video	2.74 %	Cause citizens to take images unsafely. (COMMS:R:2970) Texting while driving. (COMMS:R:8846)

As previously noted, when providing responses about the positives of receiving pictures and/or video, many participants wrote about how a picture speaks a thousand words. Yet as the participants below articulate, that may not always be true. COMMS personnel often need much more information in order to make sense of an emergency situation than can be provided in a photo and/or video.

> Citizens may be more focused on trying to obtain or send a video than to actually make a 911 call which could provide a time delay. *Pictures and videos don't always speak a thousand*

> *words...without an explanation how would we understand the full details of the picture or video.* (COMMS:S:8553)

> People may get lulled into thinking a picture explains it all when it may not. (COMMS:U:1013)

This speaks to the complexity of the issue—pictures and/or video might speak 1 000 words, but interpreting and understanding the meaning of images without additional details, and specifically without talking to the caller, may make their work more difficult.

Many survey participants wrote lengthy responses in the cons open-ended text box that addressed multiple issues. These responses demonstrate the passion respondents feel related to the issue. The response below is just one of many lengthy responses about the cons of receiving pictures and/or video. It highlights a variety of the categories identified in Table 26 above, including trauma to COMMS personnel, technical issues for PSAPs, recruitment and retention of COMMS personnel, inappropriate and graphic images, data storage issues, policy development, and the additional cost for PSAPs.

> Exposure of public safety telecommunicators to potentially traumatic images or videos that is not necessary for dispatching emergency responders to the scene. Our agency does not currently have a method of relaying pictures and video to emergency responders while they are en route. Without that, it does not really serve a vital purpose. A verbal or text description of the situation can give the information needed to dispatch an appropriate response. Even if a specific image or video may be helpful, not all telecommunicators want to see that. That could cause existing telecommunicators to exit the field, and could alter the job pool of candidates who are interested in entering the field. Dispatch centers around the country already struggle with recruitment and retention. Adding another detractor to an already stressful field will not improve the situation. Further, it is likely that this capability will be extorted by some individuals to intentionally send inappropriate or harmful material. Pictures and videos require significant storage space. This will require development of systems to store these items in accordance with various agency retention periods, and funding for that development and for the ongoing storage requirements. (COMMS:U:4336)

This respondent carefully thought about and provided a response that was 191 words long. Words like “traumatic,” “vital,” “struggle,” “stressful,” and “significant” speak to the strength of the response. The same respondent also provided a response about the pros of pictures and/or video, but it was only 16 words long, and lacked the intensity of the language found in the longer negative response.

> Evidence for law enforcement investigation. Documentation of the situation prior to the arrival of emergency responders. (COMMS:U:4336)

This was typical across the data for pros and cons of pictures and/or video—longer and more passionate responses were provided in the cons responses than in the pros responses.

Below, exemplars of the data are provided for each of the cons categories. The responses are left in their entirety, to demonstrate the thoughtfulness and/or care put into them. The data specific to the category under discussion are *italicized* in the quote.

Many of the cons responses revolved around different problems with images, including graphic or inappropriate pictures and/or video that might be sent by the public. This subcategory was mentioned by the second largest percentage of respondents (41.73 %). These responses referenced both the sending of obscene images as well as graphic images from a scene.

> *The public may abuse the feature by sending obscene photos/videos.* An influx of unnecessary photos/videos. (COMMS:U:359)

> Dispatchers may not be prepared to see *violent or shocking images that may be sent. Examples pictures of a suicide or murder scene*. (COMMS:R:451)

> potential for abuse of system, 911 operators exposure to potentially graphic and disturbing imagery. (COMMS:U:330)

> Ease of information flow not so good. *Inappropriate or vulgar pictures being sent* with no way of tracing them if it's a phone with no service. (COMMS:S:3153)

Many of the responses that discussed obscene material also noted the difficulty PSAPs might have with tracing or verifying who had sent the material or where it came from. In addition, almost all of the responses that addressed the reception of graphic images from a scene also highlighted how this may cause mental health issues or work-related stress for COMMS workers.

In addition to graphic and obscene images, the poor quality and possible lack of relevance of images received are of concern to COMMS personnel.

> *Chaos. Jittery video. Unable to understand or make out the video.* Questioned later as to what was on the video vs. what was dispatched. Misinterpreting the video. (COMMS:R:6258)

> Possible HIPPA issues. *Blurry. Not getting the information you need in the picture.* (COMMS:S:1675)

> Videos are often very poor quality and difficult to make sense of without professional understanding. Without description or understanding, pictures can be unclear. (COMMS:S:46)

> *Someone sending a photo of a tree across the road or an auto accident without any location is pointless. Potential for being flooded with videos and photos of a dispute without additional context or location*. Caller may feel the video is sufficient enough and refuse to answer questions. (COMMS:S:9731)

Poor quality images often resulted in the meaning being unclear or in images where information was missing.

> Bloody or violent scenes may instigate a fearful response at the 911 Center; *poor camera quality or location may impede the communication's judgement on what exactly is happening*. (COMMS:U:7850)

> Every one will send in everything they see, *pictures won't tell the whole story*. (COMMS:R:9495)

> May cause delays with *trying to view and figure out the content provided.* (COMMS:S:8551)

Poor quality images can lead to difficulties in interpreting and understanding the context/situation. This can result in more time needed for COMMS personnel to process the call and determine the meaning of the images they receive.

Respondents also noted the need for and difficulty in verifying information when images are received from the public.

> *Verification of sender and location is questionable*. Information is one-dimensional. (COMMS:S:1798)

> Storage of the data received, *no ability to verify the source of the photo (is it from google images?)*, call taker/dispatcher may be subject to gruesome or graphic material and have to make a judgment call about how to relay that information, unclear what is actual evidence for the incident and how that evidence will be treated (legally). (COMMS:S:6444)

> *Validity of picture or video. Pictures maybe misleading or manipulated*. (COMMS:U:5442)

> *Quality of image/video*. Chain of command for images. *The lack of integrity of the photo/video.* (COMMS:R:3380)

Some respondents noted how dealing with the validity and verification of images will take additional time, adding to the cost of processing these calls.

Overarchingly, many COMMS respondents listed negatives related to problems with the images that the public might send. These problems span rural, suburban, and urban environments and constitute a major issue for COMMS personnel. Perhaps most important is the way in which many of these problems with images overlap, so that poor quality or not relevant images lead to questions about the meaning of the images or to questions about the validity of the information.

In addition to problems with the images themselves, many responses discussed the effects these images might have on and/or for COMMS personnel. By far, the most comments in this subcategory related to the possibility of mental health issues, including PTSD, for COMMS personnel who now have to see and respond to graphic images from an incident. This subcategory was mentioned by the largest percentage of respondents, over 40 % (41.83 %), who all indicated concern about these images on the stress level and mental health of those working in COMMS.

> *Call takers could be negatively affected by graphic images*. More work for the call takers to view/analyze, retrieve and save images. May need more staff to keep up with other voice calls coming in because of time it would take to process images/videos. Until NG911 is available we would not have the ability to share this information with responders easily. (COMMS:U:2025)

> *This opens up our telecommunicators to a completely new level of stress, trauma, etc* and needs to be implemented with severe caution. (COMMS:S:2206)

> Data storage/retention considerations of files received. *Increased trauma /PTSD effects of videos/pictures received by dispatchers.* Callers not wanting to actually give information over the phone/ answer questions - thinking they can just send a photo to avoid having to answer time-sensitive/pertinent questions over the phone. Increased processing times of calls/events. (Would each call taker/dispatcher handle the video/picture downloads for their calls or would all the info be processed by a specific group of people?). (COMMS:U:7561)

> *Graphic images can be bad for mental health of telecommunicators*. Lawyers may try to use something in a picture that the telecommunicator does not see against them in the courtroom. (COMMS:R:3778)

Many COMMS respondents believe that having to see and process images from the field will increase the stress and mental health issues they already experience [28][15]. In their responses, many used the first person and spoke specifically about their own reaction to this.

> Viewing photos or videos of situations that I do not want to see. I do NOT like to see blood, gruesome scenes, etc. If I could do that, I would be a Deputy or a Paramedic not a Dispatcher. That is why I am a Dispatcher. I can be the first person in the link by obtaining information and sending a response. I don't have to respond to those scenes or see them firsthand. *If we will be required to see these types of pictures and/or videos, I will no longer be a Dispatcher.* (COMMS:R:5033)

> Since I am a dispatcher and not a deputy, there is no reason for me to see photos and/or videos of events that have happened or are happening. *There are a lot of* things I would honestly rather not see, which is why I'm against receiving video or photos. (COMMS:S:3666)

These very personal, strongly worded statements highlight how deeply some COMMS respondents feel about the negative effects of having to view images and incidents from the field.

> We have seasoned dispatchers/call takers that do this job because they are uncomfortable seeing the other side, *forcing them to see it at work I think is going to cause a large group of dispatchers to leave this field*, our imaginations are bad enough without having to see them. (COMMS:R:4823)

Having to receive and process images that in many cases may be graphic, violent, or disturbing may cause some dispatchers to "leave this field" or cause others to not consider 9-1-1 communications as a career. The reception of graphic images, and the stress and emotional toll this may create, may influence recruitment and retention of COMMS personnel. Again, these issues are tremendously interwoven and affect each other in a myriad of ways.

While many responses focused on the mental and emotional effects of images, other responses noted the information overload that might ensue for some COMMS personnel and PSAPs.

> Telecommunicator stress in needing to see photo's or video from scene. Deciding which information needs to be shared and which has little value. *Overwhelming dispatch during a major incident*. (COMMS:S:1075)

Some of the responses, like the one above discussed how images might overwhelm a PSAP. However, most of the responses in this subcategory spoke to the effects on COMMS personnel of having to deal with more screens and more information to monitor and make decisions about.

> *It's one more screen that we have to type on. One more keyboard/mouse combo to input with.* There is no way to copy/download messages received on the 911 console in a quick/easy manner. There are some things dispatch will not be prepared to see or that they don't want to see. (COMMS:R:1655)

> *Telecommunicators might be overwhelmed with information.* Might suffer from more PTSD. Could slow down response time. Pictures and video will take up more storage space and would need to be managed. (COMMS:S:1885)

> Requires a lot of re-training and additional personnel, increased stress/PTSD for call-takers, our ability to question effectively negates the need for pictures or videos, ESInets make sharing pictures and videos next to impossible without violating cybersecurity protocols, extra liability if a call-taker is multitasking and misses a key detail relayed only by picture/video, *becoming overwhelmed by incoming data feeds*. (COMMS:S:2534)

The information overload from dealing with an influx of pictures and/or video could contribute to additional cognitive load and stress for often overloaded COMMS personnel and in some cases might contribute to liability issues due to having "missed" something.

Liability in general was seen as a problem, with many responses noting how seeing images might increase the liability of COMMS personnel. In some responses, this was linked to information overload which might increase the potential for missing something in the image, something that could later prove crucial related to the incident.

> *Liability on seeing events and having to testify in court as a witness.* PTSD for the dispatchers. (COMMS:U:2069)

> Stressors of seeing incidents live. *Liability of making Dispatchers photo or video analysts. We're already held to a standard of interpreting both primary and subliminal messaging from telephone sources, now they're adding photo/video interpretation requirements in a fast moving, high pressure, very stressful environment. We will be held to account for the smallest indicator that we might have missed from photo/video*. As far as I know, there is no system to stream the photo/video to response units in the field, where they would be the most use. *Instead, we're sticking Dispatch with being the interpreters for often very fluid and unsavory scenes*. (COMMS:R:8705)

> *We see exactly what happened. This changes everything. How much liability on the dispatcher,* different training needed, mental health, staffing increases needed to assist. (COMMS:S:6755)

Several responses in this subcategory link liability with the potential for having to testify in court, something which is an additional cost for PSAPs. As with so many of these issues, the effects are intricately intertwined—with information overload contributing to additional stress and mental health issues as well as to potential liability for COMMS personnel.

In addition to the potential effects on COMMS personnel, receiving pictures and/or video also creates particular issues for PSAPs. A major issue identified by respondents was the additional cost that PSAPs would incur for additional technology, infrastructure, and/or human resources needed to receive, process, and store images.

> Major mental health issues. Consistent and unprompted viewing of traumatic scenes will lead to a higher instance of vicarious trauma in the 911 center. Also, *cost of infrastructure*, bad callers, shaky video and so on. (COMMS:S:2047)

> Overflow of information into our 911 center. Having storage in our computer to save images that may be used in court. Telecommunicators may not want to see the gruesome things that happen on scene of a call which may have been the reason they chose the route of telecommunications in the first place. In many cases, what is being seen in an image is not indicative of what is actually taking place on scene. There may not be a way to end a video stream that is coming into the center. The possibility of prank videos and pictures sent to 911. The possibility that people may pocket text an image to 911 and now we are having to double welfare check calls in order to be sure there is no emergency. *Buying new equipment for the 911 center to receive this information on an already tight budget.* Telecommunicators can talk, listen, and type at the same time, and with this introduced they will now have to do 4 things at once which is asking a lot out of our telecommunicators, speeding up the process of burnout. (COMMS:R:9200)

> I have concerns about exposing telecommunicators to images or video that are gruesome and/or difficult to see. It seems plausible that telecommunicators may be the first group to see the images or videos as they come in in real time and may be emotionally impacted by what they are witnessing. *Dispatch centers may have to consider increased staffing to allow for processing time (both physical processing of the media and the emotional processing time of their employees based on the content of the media). Most dispatch centers are operating with the minimum required staff to be effective.* (COMMS:S:3528)

> *Full time access to pictures and videos would require some type of built in controls to managing the data and would require additional personnel to distribute the data in a timely manner.* Recent programs we viewed only allowed the call taker to see the data, it could not be viewed by multiple positions. *It would be time consuming for a dispatcher or call taker to take on these extra duties of viewing real time data.* (COMMS:U:6794)

The issue of cost for receiving, processing, and storing pictures and/or video is congruent with the closed-ended data from earlier in this reportd that shows price as one of the top problems with mobile devices. Cost related to technology also emerged in the interview data as a major issue in the public safety community [5].

One reason cited for the additional cost to receive, process, and dispatch calls with pictures and/or video is that these calls take more time than traditional voice calls.

> *It may be time consuming to receive/process/watch.* Some people would send inappropriate or harassing pictures or video. I don't want to see gruesome crime scenes/injuries. (COMMS:U:7966)

> *Time consuming*. Calls are dispatched quickly and not always time to look at pictures or texts. Public does not know what is important and what is not in most incidences. Just like the information they relay over the phone, most of what they give is not necessary. Pictures received will be useless for the most part. (COMMS:R:2284)

> Pictures and Videos provide only a portion of the truth, yet for some reason they are trusted more than the spoken word. *Pictures and Videos may be valuable as evidence, but they will slow down the 9-1-1 process as it adds more to evaluate/collect/process during the information gathering phase which has the ability to slow the process down*. (COMMS:U:6905)

> *It could be a slippery slope due to increase call times and policy changes that would require dispatchers to stay on the line to get further details and follow extra protocols since we would technically be on scene first.* Could be a less cost efficient feature for the county. (COMMS:U:7980)

As many responses have indicated, it is not just about receiving pictures and/or video. COMMS personnel must look at or watch them, figure out the context and the content, evaluate them, process them, and dispatch based on them. This is seen as a much slower process than what is needed for traditional voice calls and can be much less efficient and effective. In addition, the extra time it can take to address these calls may mean the loss of valuable minutes or seconds for incident response.

Some respondents also mentioned that COMMS personnel would need additional training in order to effectively and efficiently be able to handle picture and/or video calls, and that PSAPs would need to develop additional policies and processes to guide the work of COMMS personnel related to them.

> Could be pretty brutal on the psyche. *Extra training to help prevent the additional psychological trauma.* It would cost a lot of money to store the extra data. (COMMS:R:3789)

> Just one more task to add to the already over worked, short handed and under paid staff. More difficult to keep pranksters from abusing. *Dispatch would need training to be able to identify and properly asses a picture or video.* (COMMS:R:1536)

> This would open the call takers to harm depending on what is sent. This could be used as a form of harrassment. *A new set of policies would need to be put into place.* (COMMS:U:3211)

> Dispatchers become the official first responder witnessing the incident and being responsible for relaying what they see to the Officers - IE: witnessing crime scenes; someone running from a suspect or active shooter. *Dispatchers will need to receive additional training on how to handle these situations not only because they are hearing them but also seeing them and the considerations they need to consider to make sure Officers are receiving the proper information.* This will also take their focus off of other duties they may be responsible if they are solo dispatching. Another major consideration will be the mental health of dispatchers witnessing these incidents. (COMMS:U:3966)

Additional policies will need to be developed to guide how COMMS personnel evaluate and process images, but policies will need to be developed as well to guide the storage, retention, and retrieval of these images. In addition, more training (and re-training) will need to be put in place in order to help COMMS personnel assess and evaluate images and aid them in dealing with potentially graphic images. Cost becomes a factor here as well since PSAPs will need to develop and pay for additional training for COMMS personnel.

Several responses specifically mentioned that this new aspect of the work for COMMS personnel could have implications for recruitment and retention.

> Managing the information, potential impact to employees receiving what may be visual violence or other disturbing things. Information overload is a potential with PSAPs often understaffed. *May require new perspective on candidate hiring and retention with these changes.* Would need to control access to stop unsolicited pics and vids. (COMMS:R:7380)

> *911 Operators are not prepared to see the images/videos that could be sent. The work is already very stressful and this new aspect could add unacceptable levels of stress. This could negatively impact our ability to hire, train and retain 911 Operators.* Furthermore, 911 Operators will be faced to make split second decisions with life threatening/saving consequences. They are human and won't always get it right. The image/video will later be seen by the public when it comes time to Monday morning quarterbacking. *This could prove to be very negative and dissuade people from becoming 911 Operators.* (COMMS:U:1855)

> If and when video/pics are introduced into our center, *we will have an increase in being exposed to traumatic events which can lead employee health concerns such as PTSD and other chronic illnesses which would undoubtedly affect recruitment/retention*. (COMMS:S:2333)

As previously noted, many respondents believe these changes significantly alter the work for COMMS personnel which may make it more difficult to recruit and hire. In addition, seasoned COMMS personnel may choose to leave the field as a result of having to deal with these new stressors. Once again, cost is a factor here that must be considered if it becomes more difficult to recruit and retain COMMS personnel.

While some responses, like those above, spoke about general implications for PSAPs related to the reception and processing of pictures and/or video, other responses specifically addressed technical capabilities and issues that PSAPs face if they accept pictures and/or video.

> 1. *Security concerns with malware or harmful viruses that may be introduced to the 9-1-1 system.* 2. 911 personnel are not trained to sift through visual representation of incidents. If vital information is missed and not disseminated, it can be counted a point of failure for 911. 3. Storage of the data can result in increased costs for the public safety agencies. (COMMS:U:1766)

> *Data limitation. Connectivity issues/speed.* More information for the call taker to process in a short time. Further promote bystanders to video rather than help victim (if viable). (COMMS:U:4210)

> Lack of staffing to be viewing and assessing data. *Lack of technology to get that media to responders*. (COMMS:R:2193)

Potential security issues were cited by several respondents, especially the potential for viruses or malware to be introduced. Other responses in this category addressed connection and service issues, noting that receiving pictures and/or video would be slow, if even possible, given current cell and satellite service. Most problematic perhaps is that some PSAPs do not have the technology necessary to receive and process images or the capability of sending images to first responders in the field, which is where most respondents believed the images would be the most useful.

> *Takes time / bandwidth for something that has no use to a dispatcher. We have no way to send this information to field staff for whom it MAY have benefit*. (COMMS:R:8476)

As noted above when discussing the pros of receiving pictures and/or video, many respondents believed that information from pictures and/or video could help with visualization of the scene, increase situational awareness, and provide enhanced safety for responding units. However, without the capacity to send this information to field staff, this benefit is compromised. Many of these issues are again intricately linked to cost and a PSAP’s ability to sustain increased costs for new technology and infrastructure.

In addition, many responses mentioned potential issues with data storage and retrieval, as well as chain of evidence concerns.

> Cost Benefits are questionable. *Technology and storing that information would be expensive.* Dispatcher's witnessing crimes on video is potentially PTSD issue. Dispatchers would likely now be witnesses to crimes and have more court time. (COMMS:U:8980)

> Shock/Trauma of received material. No filters. Misuse of what’s sent. *Collection and storage of material (court). Chain of evidence.* (COMMS:U:4380)

Photos and videos present the danger of greater emotional and psychological involvement for the dispatcher - PTSD resources may be lacking. *Photos and videos are considered physical evidence and require chain of custody storage and handling*. (COMMS:S:3702)

Many responses that cited chain of evidence concerns also mentioned how this might influence COMMS personnel having to testify in court. This creates a financial and staffing burden for PSAPs, and is another way that cost is connected to the technology.

Pictures and/or video by their very nature include personal information, and some respondents wondered about privacy issues related to the viewing and/or storage of this information.

Significant increase in cybersecurity and privacy issues. Potentially significant storage and public information act compliance issues. (COMMS:S:8345)

Possible fraudulent use. *Privacy concerns*. (COMMS:U:470)

Many dispatchers choose not to see certain incidents. Increased PTSD or other mental issues. *Confidentiality, etc.* (COMMS:R:3503)

In addition, the privacy of COMMS personnel is also at stake if live video is available, something that concerned respondents.

I like not having to see things. *I prefer to just hear it and I most certainly do not want video chat where they can see us. I work in a small town, sometimes I have to go out in this town and I do not want to have someone recognize me from my job.* (COMMS:S:6730)

I do not want to see any of *that*. None of it. I am not a police officer. I do not want to be a witness to anything beyond what I may already have to testify for in court for taking 911 phone calls. Also, I don't want to be seen by the other person calling 911. *I can't hide my facial expressions and I live in the city that I dispatch for - I don't need to be personally recognized by callers*. (COMMS:U:7311)

In either case, PSAPs will need to develop policies and processes for protecting COMMS personnel, callers, and people whose images are captured in pictures and/or video, as well as making sure they have the technological infrastructure for secure storage and retrieval.

Finally, some responses identified the potential danger to the public that capturing and/or sending images might pose. For example, callers may put themselves in dangerous positions to obtain a picture and/or video or they may be texting while driving in order to send the image.

Misuse. Influx of data that may not be relevant and would need a way to store data. Technology fails. *Could encourage texting or video taking while driving.* (COMMS:S:81)

People trying to take photos, videos while driving causing distractions. Graphic images and video that may find its way to the internet. Added stress to dispatchers from visuals in tragic incidents. (COMMS:R:8745)

> Too much data, dispatchers seeing video/pictures. PIA [Private Internet Access] issues, how to get to responders? *Citizens focused on picture and risking safety*. (COMMS:S:7229)

> Similar to the issues with the Vigilante app. that was suspended at the time - *It has the potential to encourage civilians to get closer to and more involved with a dangerous situation*. It makes 911 staff a CAPTIVE audience. This could play into a suspect's desire to have their crime viewed as it happens. We've all seen these movies! Adding video to the audio without the ability to go hands on just layers on the mental and emotional anguish that calltakers already live with. (COMMS:U:3733)

Similar to the responses about texting, COMMS personnel noted how the ability to receive and send pictures/video might encourage unsafe behavior on the part of the public.

Perhaps most important were the responses that addressed how receiving texts and images "changes everything" (COMMS:S:6755) related to the work of COMMS personnel. A major theme that emerged from the interview data was whether or not COMMS personnel are considered first responders. Many open-ended survey responses allude to this issue as well—COMMS personnel are the first to interact with the public in an emergency, yet they are often not considered first responders.

> *It would change our job entirely. We would absolutely be first responders.* We may not be prepared to handle what we see. (COMMS:S:3950)

> Again, the abuse may interfere with other real emergencies: photo shopped, imported or staged pics; pranks, etc. The increased volume of real or prank pictures will surely require more personnel on the job. *Stress placed on Call-takers that are already classified as only clerical personnel instead of the 1st Responders that we are*. (COMMS:S:5270)

> Bigger workload on call takers/dispatchers. It is already stressful to be talking to a caller and not being able to get help there, by adding video, you are now putting those dispatchers in the front seat to witness violent acts they are not able to stop. *This will lead to burn out and could result in more PTSD in Communication Professionals that are not given the same help as First Responders since their job titles are only Clerical.* (COMMS:S:1676)

As these responses note, many COMMS personnel are considered to be clerical workers, not first responders, something that emerged in the interview data as well [28]. Some cities and states are beginning to reconsider and make changes to this classification, however the former classification is still the norm across the country [1].

> …but when you still categorize us as secretaries but yet we deal with you know stress levels….an officer or a firefighter is doing something that you know upsets you on the radio then you've got a structure fire, you've got someone who is being stabbed, it's just the culmination of a day, or a shift, or a night isn't just the calls that come in. So, for us having the citizens expect one thing but not know what reality is like in the 911 center, we're kind of just the forgotten public safety realm I would say. (INT-COMMS-U-007)

Respondents also argued that receiving images in particular changes the scope of their work, in ways that they are not prepared to deal with. Again, this is something that is congruent with the interview data, as shown in the quote below.

> Mostly accepting pictures and video from the public directly into the 911 center. I don't want to have anything to do with that. Number one, I think it's going to be a huge liability. And then it's going to expose people to things that they didn't sign up to see a baby who may have died in their crib. They may not have signed up for being an investigator on a kidnapping that somebody took a video of and they missed something in that video that was critical and then some attorney down the road 6 months, 2 years down the road gets them on a witness stand and says why didn't you see this, whenever he's [had] 2 years to review that video and go, you know, you should have seen this piece of evidence in the video. I just don't want to have anything to do with it. (INT-COMMS-R-016)

While COMMS personnel are the first people to interact with the public, they are not in the field. This means they are not able to “help” in the same ways, they often do not hear how an incident ended, and they rarely get to see the culmination of their work (P1V4).

> Processing difficult scenes without being able to put hands on to help - very difficult for 911 personnel who are also field first responders, something we struggle with now but will be magnified when having to see photos / videos as well. PTSD potential is only magnified as well. (COMMS:R:2893)

As this respondent notes, these issues will be magnified when COMMS personnel have to deal with pictures/video. Both interview and survey data show that stress is inevitable in COMMS work—physical, cognitive, and emotional. What is important is that new technology, like the reception of pictures and video, not add additional work or stress to an already demanding job. COMMS respondents clearly take this issue very seriously given the number of people who responded and the length of their responses.

4.4.3. NG 911

In addition to the call center questions discussed above, a subsequent section of the COMMS survey asked participants if they had heard of NG 911 and if they believed it will be helpful in their work. These questions are listed below.

> “Have you ever heard of Next Generation 9-1-1?”
>
> “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?”

Response items for the questions listed above were: Yes, No, or Not Sure.

The survey intentionally used a simplified definition of NG 911 in the second question listed above. Interview data drove the design of the survey and indicated that some interview participants did not know what NG 911 was or how it would apply to their work. In addition, COMMS content expert reviews of the survey instrument provided feedback about the language describing NG 911 as initially too detailed and potentially confusing for call takers/dispatchers. As the survey was designed to gauge the use of technology for day-to-day operations, the NG 911 explanatory text focused on the front-end user interaction rather than the back-end technology implementation. While the definition used in the survey is simplified, content expert reviewers of the survey believed it better captured how call takers/dispatchers would define and understand it.

As demonstrated in Fig. 50, COMMS respondents overwhelmingly said they had heard of NG 911 (89.72 %) and most believed it will be helpful in their work (74.47 %). However, almost 20 % of respondents (19.55 %) said they were not sure that NG 911 will be helpful in their work. This may demonstrate a lack of clarity about NG 911 and the ways in which it might benefit COMMS workers.

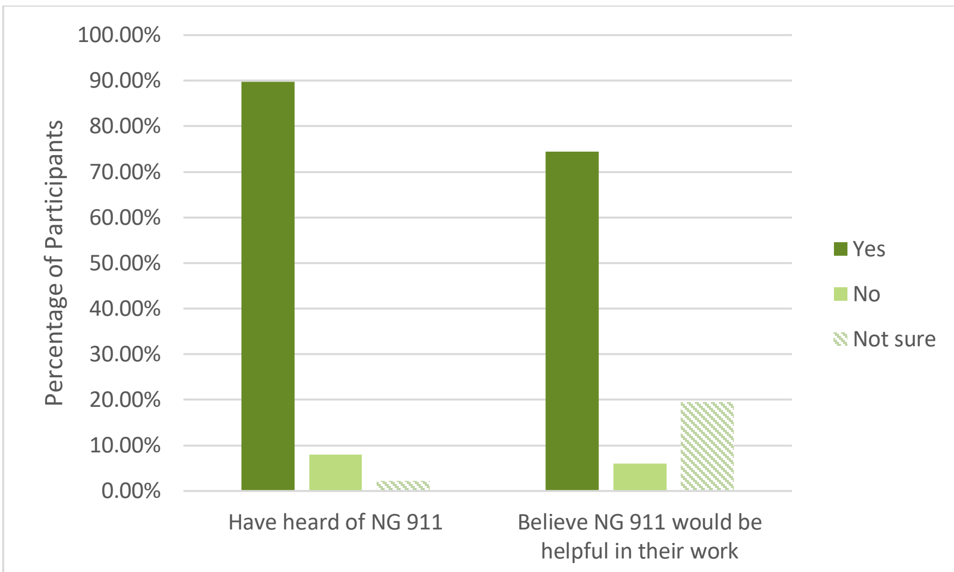

Fig. 50. Survey responses to NG 9-1-1 questions

4.5. Major Disasters and Large, Planned Events

Another section of the survey asked respondents about their work in contexts that were different than their day-to-day operations, such as a major disaster or a large, planned event. If respondents had not worked during a major disaster, they were re-directed to questions about large, planned events. Questions for the sections on major disasters and large planned events were identical except for how the two types of events were described. Major disasters were described as unplanned events that disrupted day-to-day operations, such as a hurricane, active shooter situation, or riot, while large, planned events were described as events such as a concert, football game, or parade. If respondents had not worked during a large, planned event, they were re-directed to the next section of the survey. Appendix B shows the logic and survey flow for this section of the survey. The detailed results of each survey question in this section are provided in Appendix D. Results from closed-ended and open-ended questions related to technology use during both a major disaster and a large, planned event are presented in this section.

4.5.1. Major Disasters

The first question in this section asked about work during a major disaster. Below is the question used for FF participants:

> "Have you ever worked in public safety during a **MAJOR DISASTER**, something disrupts your day-to-day operations? For example, an earthquake, hurricane, wildfire or a FEMA type 1 incident."

The specific examples of major disasters in the question stem were tailored appropriately for each discipline. The exact wording of all survey questions can be found in the previously reported Volume 1 [17]. Response items for this question were: "Yes" or "No."

There were 7 107 responses across disciplines to this question, with 75 non-responses. Over 60 % of respondents (62.78 %) said they had worked during a major disaster, while 37.22 % said they had not. The 4 462 respondents who replied "Yes" to this question were then asked several questions about their use of technology during a major disaster. See Fig. 51 below for percentages of first responders from each discipline who indicated they had worked during a major disaster.

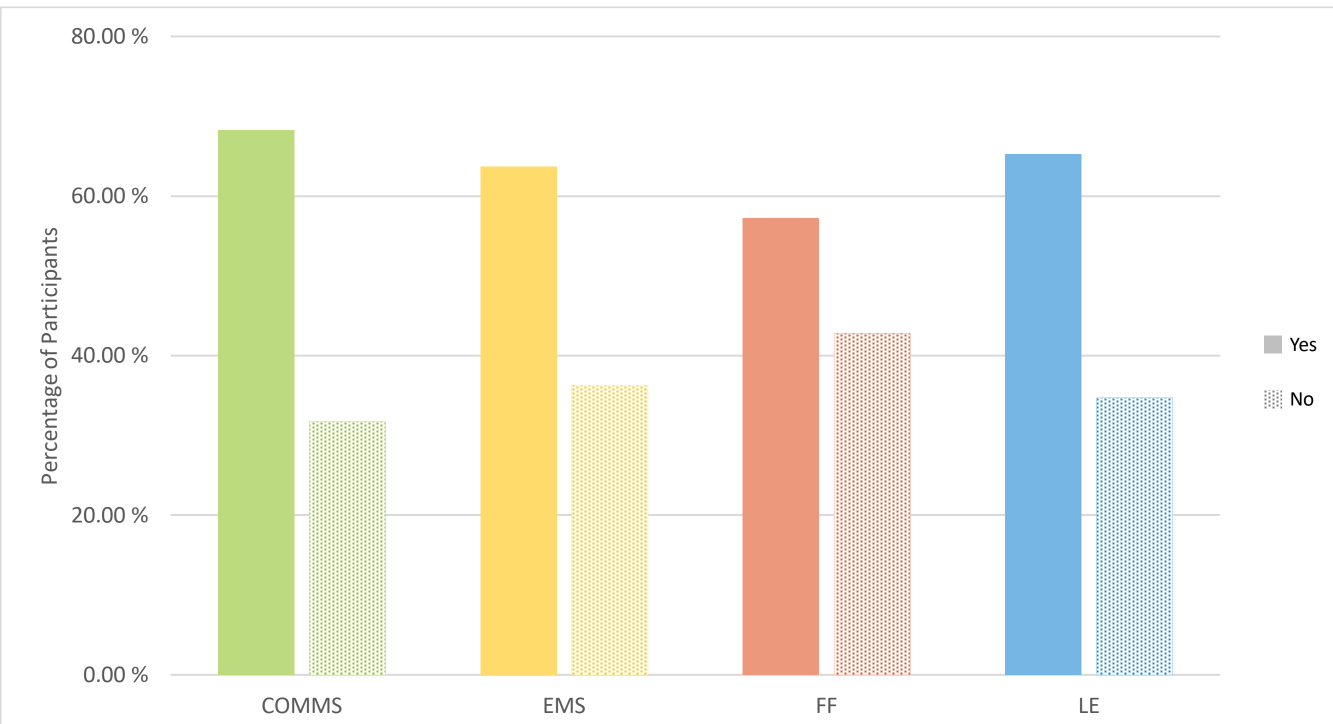

Fig. 51. Participant experience responding to a major disaster

If respondents indicated they had worked during a major disaster, they were then directed to the question below.

> "Think about the technology you use during a **MAJOR DISASTER**. How similar or different is it than the technology you use during your day-to-day work?"

Response options for this question were:

- I use mostly the same technology.
- I use some of the same technology, with some specialized technology.
- I use very different technology.

The 4 462 respondents who said they had worked during a major disaster saw this question. There were 4 335 responses and 127 non-responses across the four disciplines. As shown in Fig. 52, almost all respondents across all four disciplines said they use mostly the same technology during a major disaster that they use for their day-to-day operations. The consistency across all four disciplines is striking here, with 81.85 % of respondents saying they use mostly the same technology and only 18.15 % saying they use some of the same technology with some specialized technology. Perhaps most interesting is the very small number of respondents who said they use very different technology in the context of a major disaster (COMMS—1.05 %; EMS—3.19 %; FF—3.04 %; LE—1.86 %). Given these results, improving the technology used day-to-day by first responders is one of the most important things researchers and developers can do since it will also help in first responders' work during major disasters.

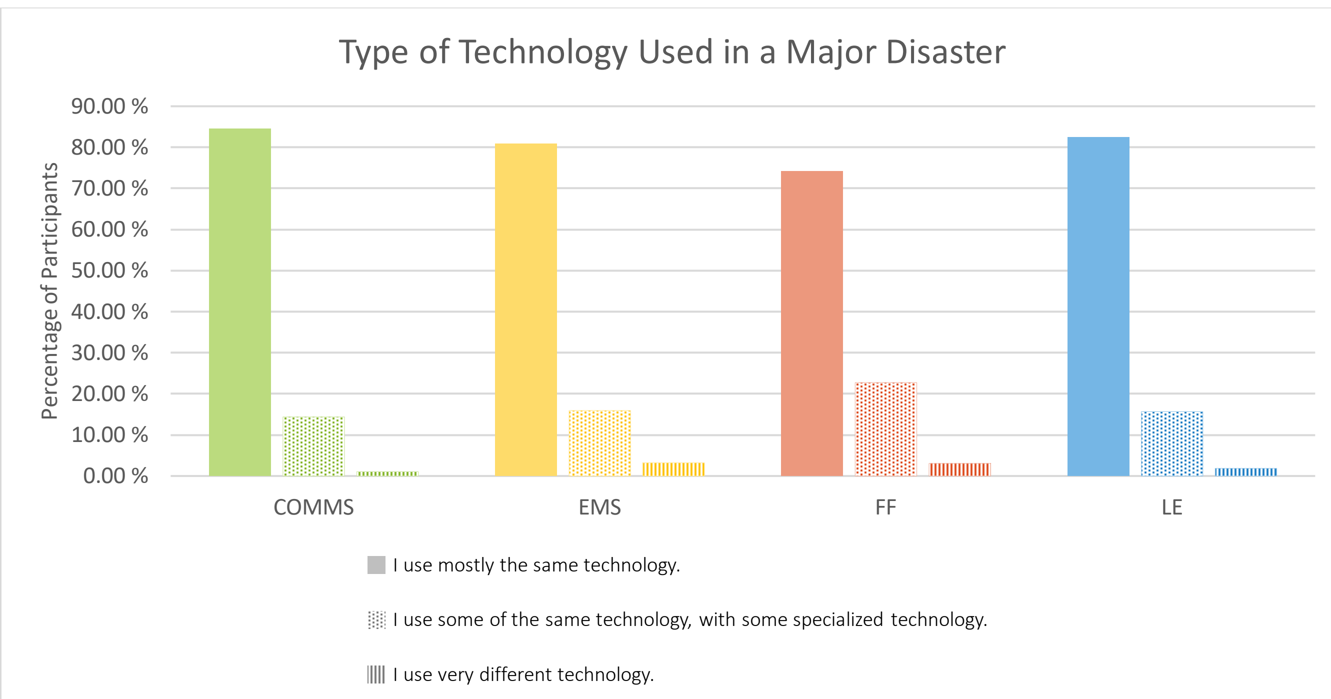

Fig. 52. Types of technology used during a major disaster

Specialized Technology for Major Disasters

In addition to the closed-ended questions about the type of technology used by respondents during a major disaster, there were two open-ended questions asking respondents to provide information on both the specialized technology and the most important technology they use during a major disaster.

> "Please list the **specialized** technology you use during a **MAJOR DISASTER**."

> "Please list the **most important** technology you use during a **MAJOR DISASTER**."

There were 1 434 responses (32.14 %) to the open-ended question on specialized technology and 2 606 responses (58.40 %) to the question about the most important technology used during a major disaster (see Table 27).

Table 27 Participants with responses to MAJOR DISASTER open-ended questions

	Specialized Technology	Most Important Technology
COMMS	28.73 %	48.30 %
EMS	30.69 %	59.61 %
FF	36.92 %	64.02 %
LE	30.15 %	59.63 %

The open-ended data about the *specialized* technology utilized during a major disaster varied widely, but overwhelmingly participants referred to using technology that was the same as the technology they use for their day-to-day work. The responses below represent just a few of the many where participants indicated that they use the same technology for a major disaster that they use for day-to-day response.

> Mostly the same tech. Nothing special. (LE:R:8035)

> Same as standard technology with the addition of Satellite communications. (FF:S:9319)

> The same pagers, radios and cellphone used in day to day operations. (EMS:T:9408)

> Nothing specialized ... same technology that is used every day, just the scale of use is bigger. (COMMS:S:6878)

While many responses, like those above, specifically said respondents use the same technology, other responses just listed the types of devices used during a major disaster, for example "CAD, LEADS [Law Enforcement Automated Data System], radio, computer, phone" (COMMS:R:122) and "Same radio as usual" (EMS:U:4885). Most often these were some type of communication device, such as radios or phones, that first responders also use for day-to-day incident response. Out of the 1 434 responses to the specialized technology question, 31.38 % mentioned radio in one way or another and 27.06 % listed some type of phone (cell phone, smartphone, satellite (SAT) phone, etc.), and the general term communication was used in 6.76 % of responses.

Maps were listed in 7.81 % of the responses across all four disciplines, including apps and software, but also wall maps for example. Computers (6.05 %) and CAD (5.23 %) were also mentioned multiple times. These technologies are all used in day-to-day incident response for first responders and do not necessarily represent specialized technology. Yet, they are items that respondents felt compelled to mention in a list of specialized technology they use during a major disaster, highlighting their importance to first responder work.

Some responses did provide examples of specialized technology used by first responders in a major disaster. These generally showed up in a list or as a single item in the text box.

> Smartphone, portable radio, CAD, Drone. (LE:S:8219)

> Mobile command center, Deployable communication technology (such as cell towers on wheels). (FF:U:3547)

> Regional software for overview, patient tracking, once upon a time we had a deployable network for the incident, now aged and outdated. (EMS:R:398)

> Generators, UPS battery back-up, tower/repeater selection. (COMMS:S:1530)

Mobile command center was the item that appeared the most across all four disciplines, showing up in 10.88 % of the responses across all four disciplines. Mobile command centers represent another form of communication and coordination for first responders and as such may account for the high percentage across disciplines. Tracking technology of one form or another was mentioned in 3.84 % of responses across disciplines, making it another important category. Tracking included vehicle tracking, first responder tracking, and phone tracking among others.

In addition, some discipline-based specialized equipment was mentioned. For example, generators were mentioned in 7.89 % of COMMS responses, some type of patient software (e.g., vitals monitoring, patient tracking) was mentioned in 5.75 % of EMS responses, drones were noted in 7.83 % of the responses for FF and 7.86 % of responses for LE, and robots were identified in 3.19 % of LE responses. Certainly, other items were mentioned in the data, however they were mentioned in so few of the responses (generally in less than .50 % of responses) that they did not constitute a trend.

Occasionally, respondents provided more in-depth responses. The response below is one of the rare instances where a respondent wrote at length about specialized technology.

> Additional software from Emergency Management. Depending on the point in the incident the demand and availability of technology, choke points and accessibility shifts. During the initial response for those on-scene the primary need generally is voice communication, while those at

> a command post need to be able to use technology to see the bigger picture - resource mapping, tracking, personnel assignments/allocations, multiple site tracking, etc. As the incident evolves to a stable state the needs shift again to fulfill the needs/demands of finance tracking, shift rotations (more resource tracking), potentially weather and other outside, uncontrolled factors, impact the incident. Early, accurate information about those unfolding, uncontrolled impacts could dramatically impact the outcome of the incident. (LE:U:6480)

This response, while not typical, is instructive in that it provides insight into how technology needs might vary for different types of first responders during a major disaster (those on-scene for the initial response versus those at a command post) and at different times during the incident.

Another category of responses from the text box on specialized technology points toward the importance of interoperability during a major disaster. These responses usually noted that first responders lack interoperable systems. This category constituted 1.74 % of responses across the four disciplines and is one area where respondents provided more than just a list of items. Sometimes interoperability referred to different programs and devices working together, while other times it referred to different agencies and departments being able to communicate with each other.

> We actually used less technology because our CAD between regions/agencies/etc. cannot be interoperable. We used only radios. (EMS:S:8784)

> 9-1-1 Phone system, CAD - Computer Aided Dispatch, Integrated Map, Radio with interoperability to surrounding jurisdictions (statewide if needed). (COMMS:S:5028)

> The specialized equipment as far as radios, hickory box to patch radio frequencies together, because the interoperability is still not where it needs to be. (FF:U:3169)

> Simplex radios and interoperable radios. Also drones and robots, cell/smart phones. MDCs. (LE:S:4389)

The issue of having equipment and systems that work together was also a finding in the interview data, as exemplified by the quote below.

> That's one of the technology things that we are continually struggling with, is compatibility. (INT-FF-S-035)

These responses note the importance of interoperability, but also the importance of the everyday technology that is used during a major disaster, such as radios, phones, CAD, and maps. Interoperability is of concern for both day-to-day operations and for work in a major disaster, underscoring its importance for all types of first responder work.

Some respondents also noted that cost is a barrier to accessing specialized technology, often meaning they must rely on what they have at their disposal, even during a major disaster.

> We do not have special technology due to the cost. (EMS:R:5196)

> We do not have the same technology as other departments. We are limited to our antiquated radio system, land and cell phones. (FF:R:4088)

> We use very little that's different from day-to-day as it is all we have. We expand the scope of usage to include links/channels to support resources we do not have, but desperately need. (EMS:R:2434)

Consistent with data from closed-ended questions discussed earlier in this report, price is one of the top problems identified by respondents, across disciplines and devices. It is interesting to note that the open-ended responses to this question that cite cost all came from rural respondents. This is consistent with the interview data where rural participants very often cited funding and cost as a major issue [18].

> It is a huge issue. I mean funding is a huge issue. Up until I think we're coming up on the first year of having the sales tax for our county and other than that we were funded by a yearly fundraiser. It was basically the town donating their personal money to protect them basically you know and that was I think the state did allow some funding, but I mean it wasn't enough to make a difference. If a truck went down that truck's gone until we can save up the money or get a grant or figure out something to fix that truck. I mean we were living year to year as a department you know and that depended on the size of the department and the size of the town. (INT-FF-R-048)

While the rural interviews in particular noted cost as an issue, it was not only rural interview participants who noted cost as a problem. This is consistent as well with the quantitative data from this survey that show price to be a problem across devices and disciplines [5].

> Is this compatible with that so we're not wasting hundreds of millions of dollars on all of that sort of stuff?" And for me, personally, that's really the name of the game and how are we most efficient with what we have now and will it integrate with some of the stuff in the future, and how do we go from there, so? (INT-LE-S-033)

Cost remains a barrier to technology acquisition and use, whether for day-to-day operations or major disasters, and needs to be a consideration in the development of new—and improvement of current—technologies for first responders.

Some responses, like the one below, noted how first responders could not depend on technology use during a major disaster.

> During a major event, sometimes you cannot depend on technology due to systems being disrupted or overloaded. What we had to [do] it was use non-technical procedures for communications, accountability and communications. (FF:U:9620)

Whether it is due to issues of cost, interoperability, or dependability, many first responders do not have access to or use specialized technology during a major disaster. Instead, survey responses indicate day-to-day technology as essential for both day-to-day incident response as well as for major disasters. Once again, solving problems with first responder day-to-day technology will also help for their work during a major disaster.

In addition to the open-ended text box on *specialized* technology, another open-ended text box asked about the *most important* technology utilized during a major disaster. There were 2 606 open-ended responses to this question. These data also varied widely, but again participants generally referred to technology that was the same as the technology they use for their day-to-day work.

> Same as day to day, possibly just paying more closer attention to weather. (COMMS:R:908)

> It's the people and the same day to day equipment that makes things work. (COMMS:S:9708)

> Same as day to day. (EMS:U:5228)

> Same as usual. (LE:U:1037)

> I use mostly the same technology but during a major disaster will rely on additional software applications (GIS, HazMat Decision Making Software, WebEOC, etc). (FF:U:992)

Again in this text box, respondents often just listed technology that they found to be the most important. Most often these were some type of communication device, such as radios (55.56 %) or phones (39.52 %), that first responders also use for day-to-day incident response. These are even higher percentages than those in the question on specialized technology. The general term communication appeared in 15.16 % of these responses. Maps, of all types, were listed in 6.21 % of responses, slightly less than in the specialized responses. CAD (9.25 %), computers (5.37 %) and mobile command centers (5.07 %) were also mentioned multiple times, similar to the responses about specialized technology.

In addition to noting the use of the same equipment as that used for day-to-day operations, some respondents noted how "old school" technology is often used. For example, one respondent just wrote "pencil and paper" (COMMS:U:7703) while another wrote "my brain and my training" (EMS:R:9736).

> Dry erase boards are critical for detailed tracking. I understand this is a technology survey, but after our numerous type 1 floods and fires, dry erase boards are the most important tool. They allow operational Law or Fire chiefs to work side-by-side with dispatchers, dialing into various details within a division/group. (COMM:S:4326)

> Radios, no technology gets used really. It is still pretty old school. (EMS:T:9856)

> Wall maps. Backup books. Paper forms. Cell phones in place of landlines. Laptops, tablets, backup radios. (COMMS:S:1657).

From dry erase boards, to wall maps, to paper forms, there were many everyday items—devices—that respondents listed as the most important technology used during a major disaster.

Responses to this question sometimes focused on resources other than technology that were important to first responder work in a major disaster. One non-technology resource that was cited several times was personnel.

> All of our resources are important all day everyday. The best technology, I think is a calm dispatcher that can prioritize properly so resources are used wisely. All the technology in the world won't work without the person calm and in control of an uncontrollable problem. You must ask proper questions. (COMMS:R:9667)

> Staffing to screen incoming information. (COMMS:R:4125)

> Besides personnel, the ability to quickly access additional human and equipment inventories is very beneficial. (LE:R:2088)

While human resources did not appear in a high percentage of responses (less than 1 %), it does seem an important component given that respondents chose to list/discuss it when it is not a form of technology.

Interoperability also showed up in these data, similar to the data on specialized equipment, in 1.34 % of responses.

> Interoperability of radios. (FF:R:6723)

> Radios with interoperability capabilities are essential to communicate with all agencies involved in operations. (LE:R:6486)

Again, interoperability of devices and between agencies was of importance to respondents.

Futuristic Technology for Major Disasters

Finally, respondents were asked a question about other, more futuristic, technology they thought would be useful during a major disaster.

> "In addition to the technology you use day-to-day, which of the following do you think would be helpful during a **MAJOR DISASTER**? Check all that apply."

Response items for EMS, FF, and LE included:

- Deployable communication technology (such as cell towers on wheels)
- Drones
- Helicopters
- Mobile command centers (MCCs)
- Remote sensing (by aircraft or satellite)
- Robots
- Other (please specify).

Response items for COMMS respondents included: Deployable communication technology (such as cell towers on wheels); Drones; Generators; MCCs; and Other (please specify).

The response items for this question were driven by the interview data and the technologies first responders discussed as being important for their work (see Appendix B). The list is consistent across the three disciplines of EMS, FF, LE. COMMS respondents were not asked about helicopters, remote sensing or robots since those technologies did not appear in the COMMS interview data. However, COMMS respondents were asked about generators since this was something COMMS interview participants mentioned often.

In this section, responses for EMS, FF, and LE are first presented together in Fig. 53 since these three disciplines were asked about the same six devices. Figures 54 - 57 show the data individually for the EMS, FF, LE, and COMMS disciplines, respectively, ordered from most useful technology to least.

It is extremely interesting to note both the consistencies and the differences amongst the responses for EMS, FF, and LE (see Fig. 53, ordered alphabetically). There was tremendous consistency for the top two ranked devices, MCCs and deployable communication technology. These two were checked by over 70 % of respondents from all three disciplines. This consistency may reflect the importance of communication to the general work of first responders, especially during a major disaster. Drones were the third-ranked technology here, with over 50 % of respondents from each of the three disciplines choosing this item (EMS—53.44 %; FF—70.95 %; LE—72.52 %). The high percentages for FF and LE are consistent with response percentages presented in Sec. 4.3 where respondents were asked about devices that would also be useful in their day-to-day work. However, in that earlier question only 14.52 % of EMS respondents chose drones, while for this question 53.44 % said they would be useful during a major disaster. This is one of the few instances where a specific technology was identified as useful for a major disaster but not necessarily for day-to-day work. In addition, similar to the responses in Sec. 4.3, some technologies from this list were checked by larger percentages of one first responder discipline than others. This is not surprising, given the specialized nature of first responder work. For example, robots were checked by a much larger percentage of LE (24.89 %) than FF and EMS (13.58 % and 8.47 %), which may relate to their use during active shooter, hostage, and/or bomb situations.

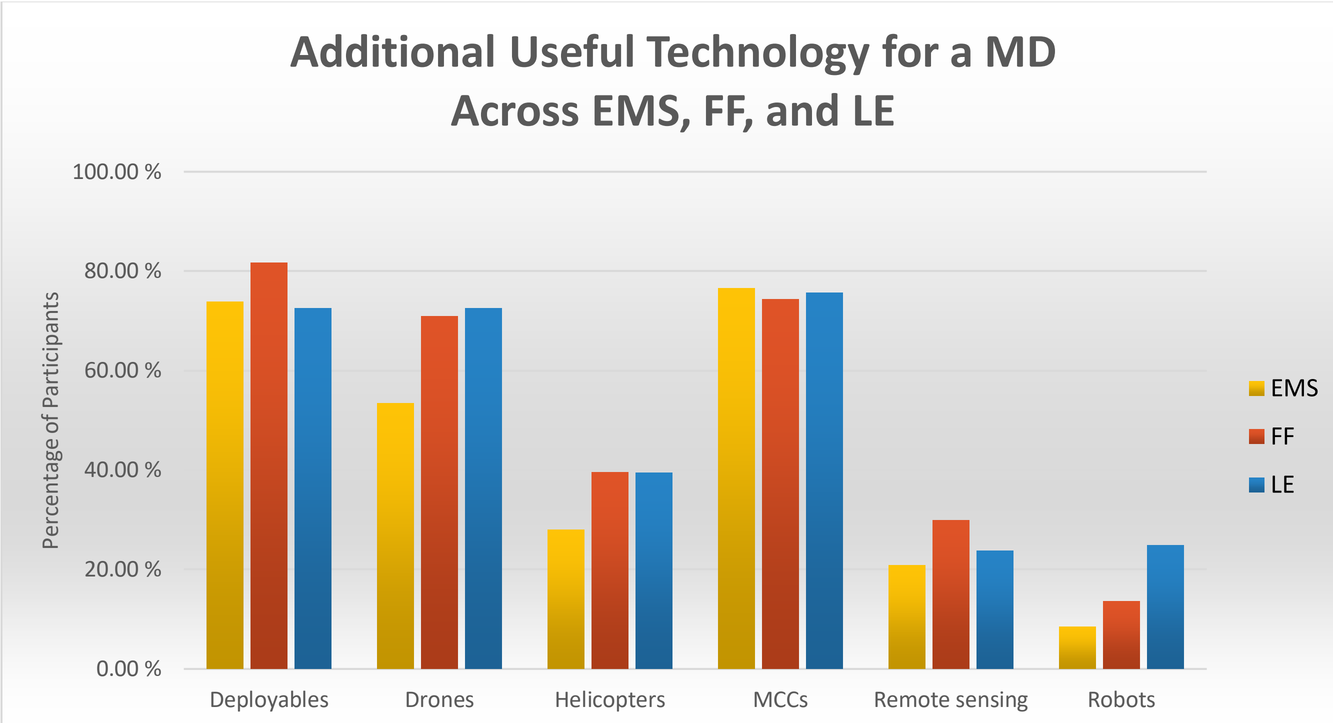

Fig. 53. Futuristic technology in major disasters, by discipline

Examining each discipline independently provides another interesting view of the data (see Figs. 54 - 57 for EMS, FF, LE, and COMMS, respectively; ordered from most useful technology to least). For example, one difference between the EMS responses and those for FF and LE is that there is slightly more than a 20 % drop after the top two checked items (MCCs and deployable communication technology), and then another large drop between the third and fourth checked items (drones and helicopters). Another difference in the EMS responses is the very low percentage of those who selected robots, which may reflect the nature of EMS work and how it may be difficult to envision how robots can contribute to it.

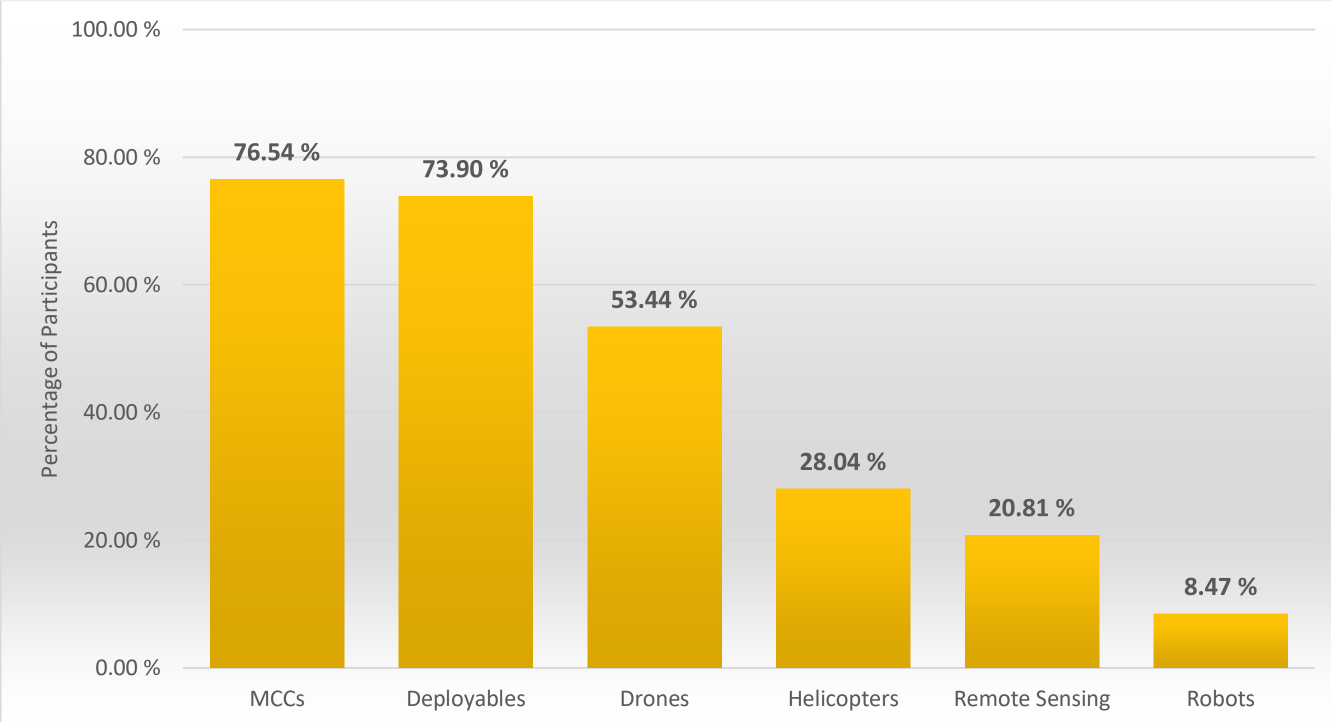

Fig. 54. Futuristic technology in major disasters for EMS

The data for FF and LE both show a large drop after the first three most-checked items, and not the first two as in the EMS data above, making drones something they can envision as useful technology for their work in a major disaster. FF respondents chose deployable communication technology more than MCCs, while LE respondents reversed that, but these two communication items were clearly seen as the most important. Drones were the third most selected item by all three disciplines, but the percentage of responses for FF and LE (70.95 % and 71.93 % respectively) were higher than those for EMS (53.44 %). Helicopters and remote sensing were the fourth and fifth most selected items and were selected by similar percentages of FF and LE as well, while robots were chosen by a larger percentage of LE than FF.

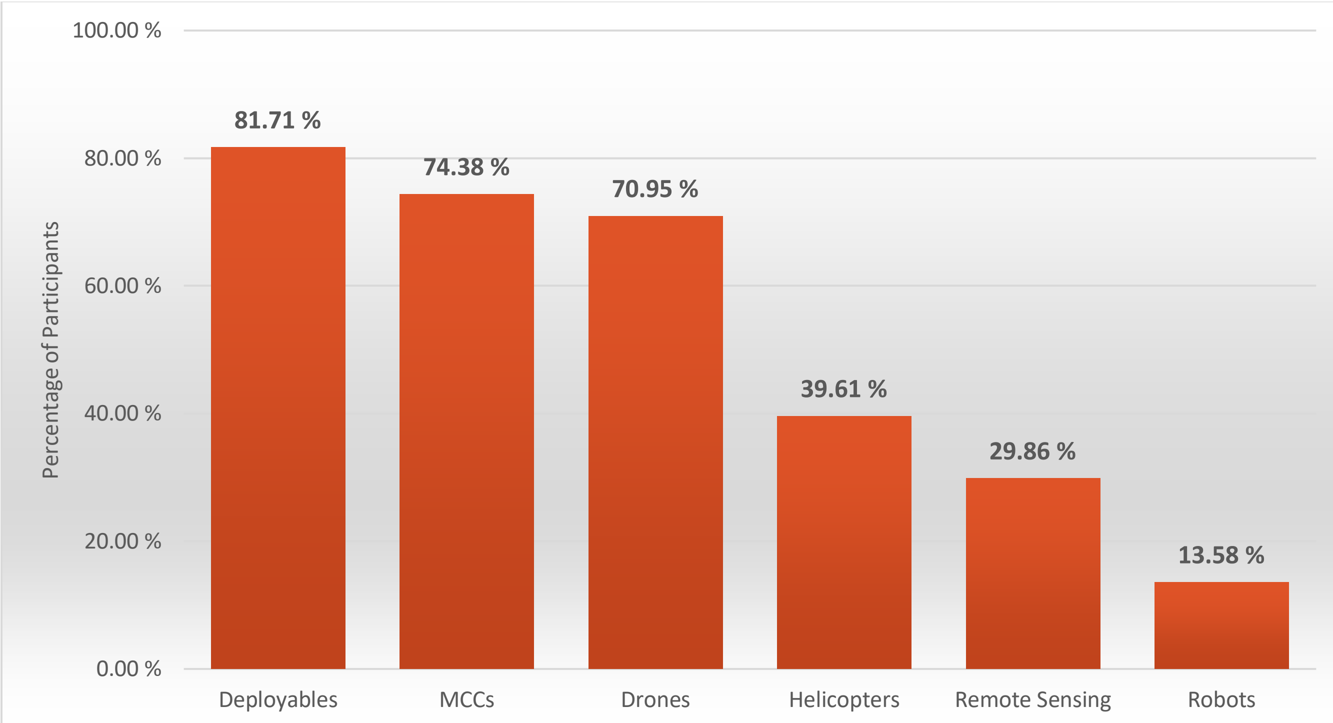

Fig. 55. Futuristic technology in major disasters for FF

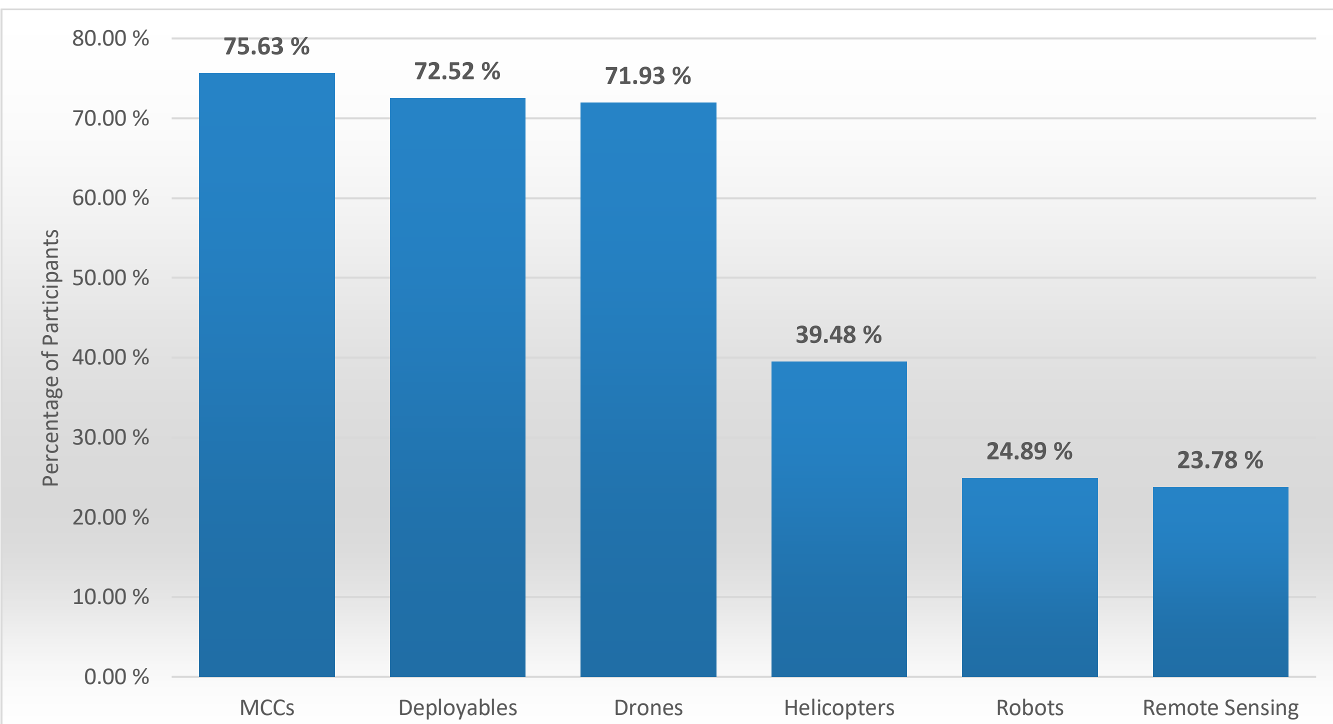

Fig. 56. Futuristic technology in major disasters for LE

COMMS respondents were presented with four technologies and asked which they thought would be useful in a major disaster. Results for this question are shown in Fig. 57. Similar to the data for the other disciplines, MCCs were the item most often identified as technology that would be helpful during a major disaster, with over 80 % of COMMS respondents (81.19 %) choosing this item. The high percentage of responses for MCCs might be due to the importance of having centralized communication structures in the field for COMMS personnel. Generators and deployable communication technology were the second and third most often checked items, each with over 68 % of respondents noting they would be useful. Again, these directly relate to mechanisms for communication (and for ways to ensure communication), the core of work for COMMS personnel. Drones were the item checked the least by COMMS respondents, although over 50 % still checked that they believe drones would be helpful during a major disaster.

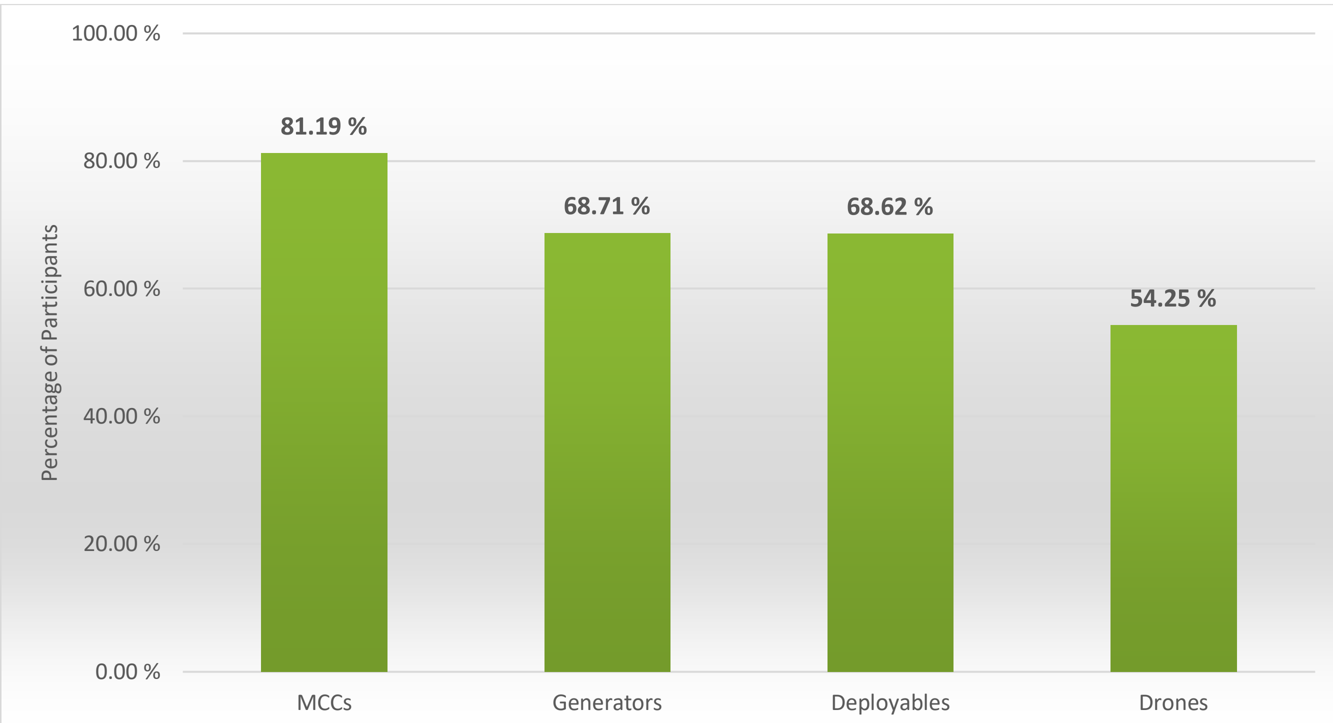

Fig. 57. Futuristic technology for major disasters: COMMS

Three of the futuristic technologies were presented to all four disciplines: deployable communication technology (such as cell towers on wheels), drones, and MCCs. Looking across disciplines, over 60 % of respondents indicated they thought all three of these would be helpful during a major disaster. These responses are interesting given the open-ended data presented in Sec. 4.3 above on the questions about the specialized and most important technology used during a major disaster. These items, especially drones, were not mentioned often in the open-ended responses, which could be seen as contradictory to the responses to this question. However, this more likely reflects the different wording and goals of the questions; the open-ended questions above asked about technology that respondents had used or found important during a major disaster whereas this question asked them about additional technology they believe might be helpful. While all three items are seen as potentially useful by a majority of respondents, MCCs and deployable communication technology were checked by over 70 % of respondents, highlighting again the importance of communication to the work of first responders.

There were only 165 open-ended responses (0.04 %) across the four disciplines to the “Other (please specify)” text box. The responses here were quite varied, but again communication and interoperability were common themes across disciplines.

> Any way to maintain communications. (FF:U:2080)

> Radios that work. Our network is horrible. (LE:R:5400)

> Actual interoperable radio systems, not just the same ole people who control the system not letting anyone onto their network. (LE:S:8031)

> Interoperable communication systems. Text-driven communication systems like Slack. (EMS:S:5535)

Responses sometimes had to do with the type of incidents respondents experienced or the geographic area of their incidents, as in the following rural responses.

> Satellite connectivity. COWS [Cell on Wheels] and COLTS [Cell on Light Truck] are too localized. They would serve just one small segment in a wide area in a major disaster. (LE:R:2356)

> However you can get Internet access would be good. And factor in the anti-cell-tower crowd, who successfully have prevented any cell towers from being constructed in my town, so nobody has any cell signal. (EMS:R:1049)

> Deployable boats and floatation devises for flooded areas. (LE:R:9051)

> None of this is realistic for our area. (EMS:R:7524)

These responses resonate with the data from rural interviews that show how rural first responders face specific geographic and resource challenges [18].

As in open-ended responses from other sections, some responses noted that first responders use the same technology as in their day-to-day work or that what is needed is not specialized technology, but much more basic items.

> I find it funny you have listed Drones and other things, when we need basics. All small Districts in [area redacted] need Basics. Please spend money on Basic stuff majority of the Districts and Villages need...I know what is needed in the State and my District. 1. Tornado and warning Sirens 2. Generators. 3. Bedding Cots to be kept at firehouse in case of emergencies. Just went through a cold snap where we could have opened up firehouse for warming centers. Just some of the Basics needed. (FF:R:3189)

> I think we have become too dependent on technology. Our department stopped updating paper copies of preplans and map books a little over a year ago. An event that took out the laptops we have become dependent upon on the rescues and engines could increase response times or leave us unaware of hazards if we are not in an area we are familiar with. (FF:R:1085)

As with the open-ended data about specialized and most important technology, staffing and personnel were items listed in the open-ended text box about additional technology that would be helpful during a major disaster.

> PEOPLE to help with radio systems. (FF:S:2274)

> More personnel. (LE:S:2918)

> Experienced and knowledgeable staffing. (EMS:S:893)

Across the open-ended data on major disasters, personnel and staffing were identified as an important resource for first responders during a major disaster. While not technology per se, this data highlights that there is a need for personnel to operate and interface with the technology.

Several ideas surfaced in all of the areas where respondents were asked to provide open-ended data related to major disasters: 1) the importance of day-to-day technology; 2) the importance of interoperability; and 3) the importance of resources other than technology, such as personnel. Glaringly absent from this list is a demand for specialized technology for a large segment of the first responder population. These findings are similar to the interview data where participants rarely noted the use of technology other than day-to-day items [5].

4.5.2. Large, Planned Events

The 2 645 respondents who answered "No" to the question about having worked during a major disaster, plus the 75 respondents who did not answer (for a total of 2 720 respondents), were re-directed to a different set of questions about large planned events. As noted above in Sec. 4.5, the questions asked in this section were the same as those asked about major disasters, with only the context being different (large planned event versus major disaster). See Fig. 58 for the branching logic for the questions in this survey section.

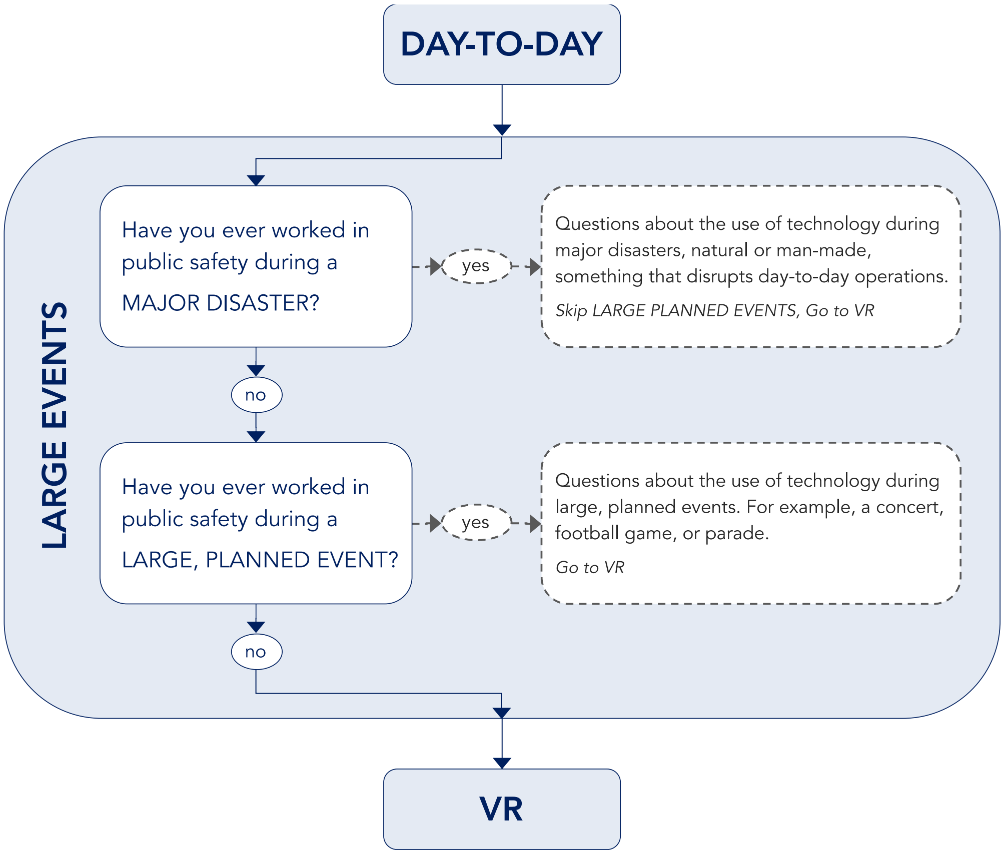

Fig. 58. Survey branching logic for large events section

The first question in this section asked:

> "Have you ever worked in public safety during a **LARGE, PLANNED EVENT**? For example, a concert, football game, or parade."

Response items for this question were: Yes or No.

Of the 2 720 total participants who saw this question, 2 678 responded, with 1 816 (66.76 %) saying they had worked during a large, planned event and 862 (47.47 %) saying they had not worked during one. The respondents who replied "Yes" to this question were then asked several questions about their use of technology during a large, planned event. The 862 who responded "No," plus the 42 who did not respond, were asked no other questions in this section. See Fig. 59 below for percentages of those who have worked during a large planned event.

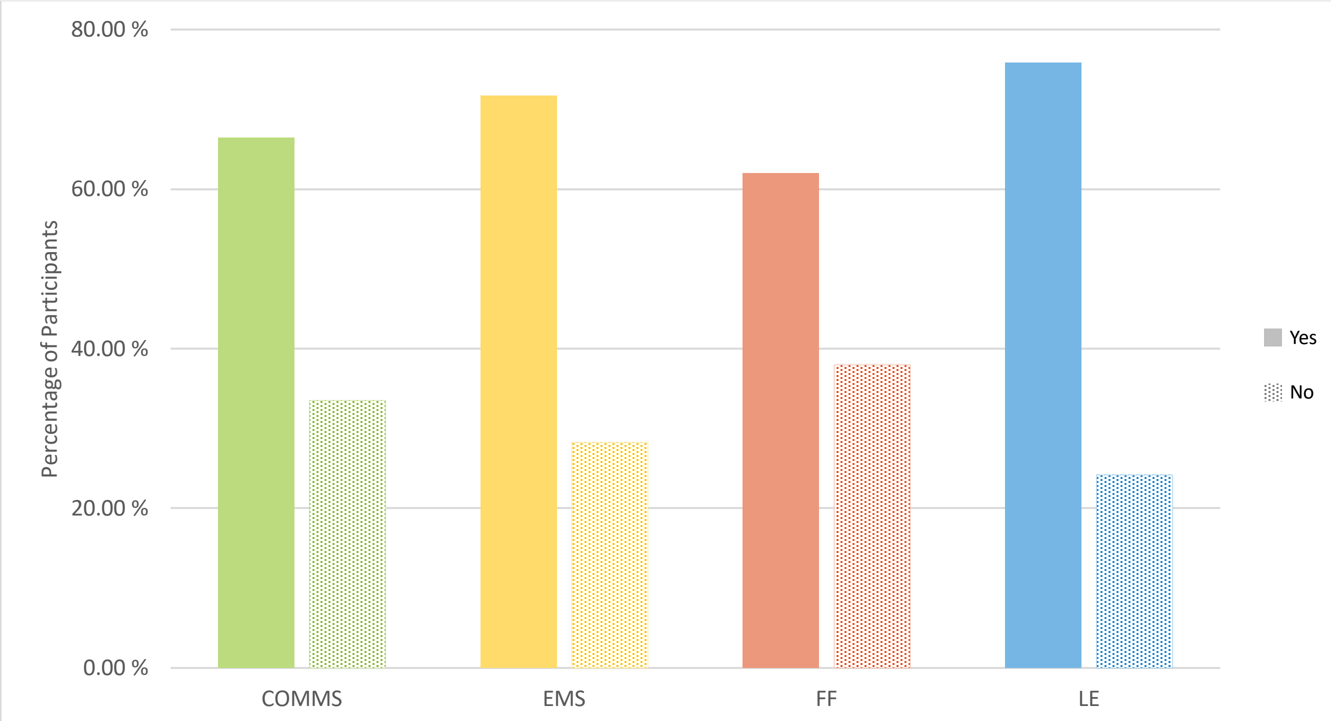

Fig. 59. Participant experience responding to a large, planned event

If respondents indicated they had worked during a large, planned event, they were then directed to a series of questions about technology use for large, planned events. These were the same questions asked about major disasters in Sec. 4.5.1, but with the question framing of 'a large planned event' instead. They began with the question below.

> "Think about the technology you use during a **LARGE, PLANNED EVENT**. How similar or different is it to the technology you use during your day-to-day work?"

Response options for this large, planned event question were the same as for the question about technology use during a major disaster.

- I use mostly the same technology.
- I use some of the same technology, with some specialized technology.
- I use very different technology.

There were 1 816 respondents who saw this question based on their answer about having worked during a large, planned event, with 1 806 responses and 10 non-responses across the four disciplines.

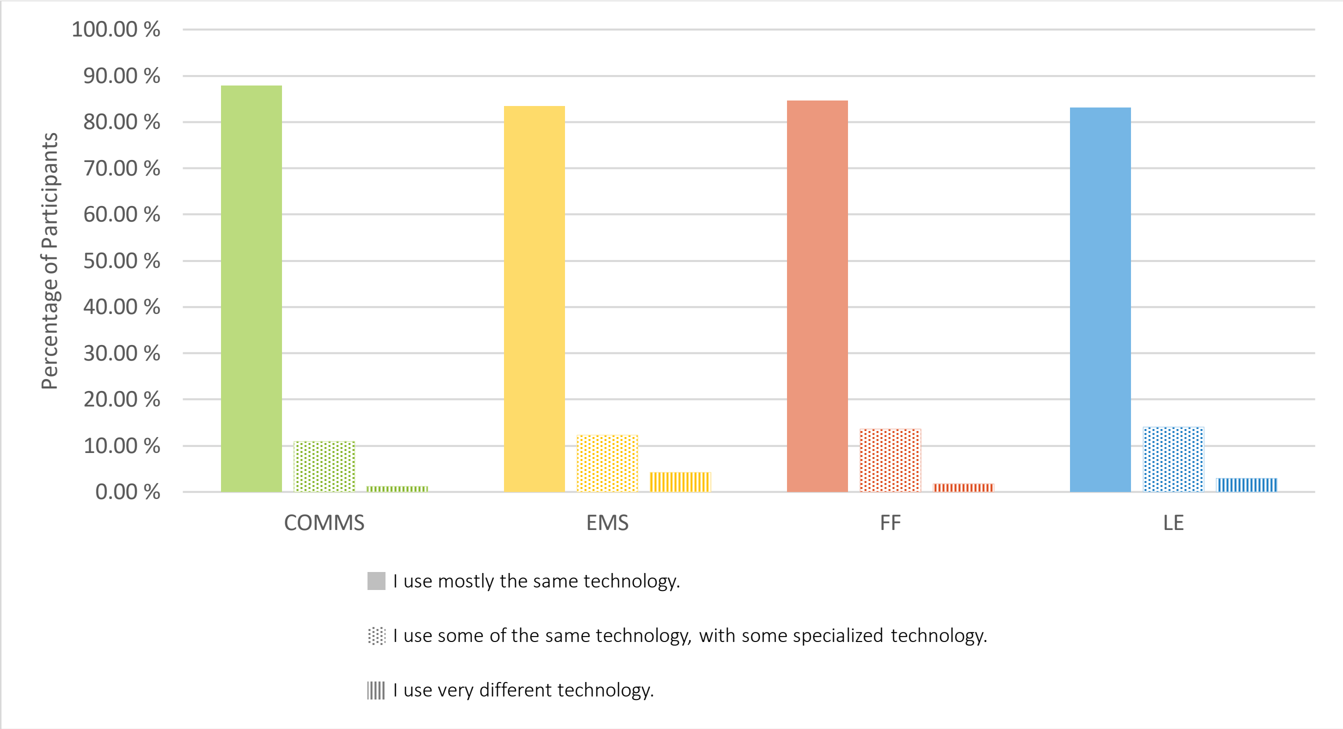

Fig. 60. Types of technology used during a large, planned event

Similar to the data for those first responders who had worked during a major disaster, responses about the type of technology used during a large, planned event overwhelmingly show that most first responders use mostly the same technology that they use for their day-to-day work, over 80 % from each of the four disciplines (COMMS—87.88 %; EMS—83.47 %; FF—84.66 %; LE—83.06 %). Less than 15 % of respondents across all four disciplines said they use some of the same technology, with some specialized technology (COMMS—10.91 %; EMS—12.29 %; FF—13.6 %; LE—14.03 %). Similar to the data about major disasters, some respondents did indicate they use very different technology for a large, planned event. Again, these numbers were quite small (COMMS—1.47 %; EMS—4.24 %; FF—1.74 %; LE—2.91 %), highlighting the importance of day-to-day technology for large, planned events as well as for major disasters.

Specialized Technology for Large, Planned Events

In addition, the same two open-ended questions that were asked about major disasters were asked here as well about large, planned events.

> "Please list the **specialized** technology you use during a **LARGE, PLANNED EVENT**."

> "Please list the **most important** technology you use during a **LARGE, PLANNED EVENT**."

There were 435 responses (23.95 %) to the open-ended question about specialized technology and 811 responses (44.66 %) to the question about the most important technology used during a large, planned event (see Table 28).

Table 28 Participants with responses to LARGE, PLANNED EVENT open-ended question

	Specialized Technology	Most Important Technology
COMMS	20.24 %	34.14 %
EMS	26.27 %	50.00 %
FF	25.50 %	46.54 %
LE	23.24 %	46.31 %

The responses to the open-ended question about the *specialized* technology utilized during a large, planned event were varied, but participants overwhelmingly referred to using technology that was the same as the technology they use for their day-to-day work. The responses below are representative of those where participants indicated the use of day-to-day technology for a large, planned event.

> We have CAD, RMS, IDACS [Indiana Data and Communications System]/NCIC, our phone lines, radio system…basically our day to day things we need to work. (COMMS:U:1413)

> All technology remained the same as day to day technology. (EMS:S:9552)

> Same stuff. Radio's, CAD's, Tablets, smart phones etc. (FF:U:4450)

> Same stuff, different day. (LE:U:11)

As these responses indicate, technology used for day-to-day operations also represents the specialized technology used by first responders during a large, planned event.

While the majority of responses note the use of the same technology during large, planned events, there were a few instances where participants wrote about using different items.

> Different portables than used daily. Not as familiar with their functions. (EMS:U:871)

> Different equipment, much newer and higher quality along with interoperability from agency to agency with clear guidelines and s.o.p.'s. (FF:R:1030)

> During our large planned events the same technology is available for use, but it is not used. The majority of the technology is tied to buildings or vehicles, that can not be used when working large planned events on foot. For those events it's back to a portable radio, paper, and pen for those deployed to the field. Cell phones are carried, but only as a secondary means of

> communication, as none of the criminal databases, CAD, RMS, or report writing software is available on them. (LE:S:157)

While these responses show the use of different types of technology, most of the items identified still represent current technology that is not specialized per se—portable radios, paper, and pens. While FF:R:1030 cited above notes having access to different equipment that is "newer and higher quality," this was not generally the case across the data.

Similar to the data for the analogous question about major disasters, radio (COMMS—22.39 %; EMS—46.77 %; FF—42.94 %; LE—32.56 %) and phone (COMMS—8.96 %; EMS—25.81 %; FF—23.16 %; LE—17.05 %) were the two items mentioned the most across the four disciplines, followed by MCCs (COMMS—31.34 %; EMS—4.84 %; FF—10.17 %; LE—19.38 %). The exemplar quotes below represent just some of the many that identified these devices as important for first responder work during large, planned events.

> Separate radio system (both issued by us and by another agency). Mobile command unit. Live cameras around the area of the mobile command unit. (COMMS:R:2061)

> Radios, command trailers. (EMS:R:440)

> Tablet, Cell Phone, Portable Radios, Mobile Command Center. (FF:R:14)

> Portable radio and cellular phone. (LE:S:4062)

Computers (includes general reference to computers, laptops, or desktops) were another item mentioned across the four disciplines (COMMS—10.45 %; EMS—8.06 %; FF—14.12 %; LE—12.40 %).

> CAD, radio, telephones, personal computer. (COMMS:R:8195)

> Laptop and radios. (EMS:R:6478)

> Radios, Computers, Weather stations, Phones. (FF:S:4002)

> Computer desktop, computers laptop, radios, corded mics, smartphones, flip phones, CAD software, records management. (LE:S:4455)

In addition to the devices above, CAD was listed by 14.93 % of COMMS, 6.78 % of FF and 6.20 % of LE respondents.

> We use MCC7500 lap top radios and portable radios, computer desk tops with CAD installed, and land line telephones. The cell company installs cell towers for internet. (COMMS:R:247)

> The same phone system, CAD system, telephone system, and computer systems we use daily. (COMMS:S:3668)

> Radio, CAD, MDT. Nothing changes from routine. (FF:S:2331)

Laptop, smartphone, radio- portable and mobile, CAD, mobile command unit. (LE:R:4461)

It is not surprising that COMMS respondents identified CAD over twice as much as their FF and LE colleagues, given that this is one of the main communication tools they use. The top cited items all relate specifically to communication, not surprising given that communicating is at the heart of first responder work. What is perhaps most interesting here is that responses to a question asking about specialized technology focused almost exclusively on day-to-day technology.

While almost every response across the disciplines noted the use of day-to-day technology, drones were one of the few specialized pieces of technology identified in some responses across three of the disciplines (COMMS—5.97 %; FF—5.65 %; LE—6.98 %).

Mobile command post, mobile communications center, drones. (COMMS:R:9067)

Whether it's a football game, parade, high profile in town, etc. we all use our radios and phones to keep in touch and to carry out preplans of objective(s). There is on occasion when a drone(s) is used to assist in watching crowds and or tracking suspect(s). (LE:S:7737)

Drones to have a better perspective of the area that will be covered and access issues. Also use the drones for thermal imaging for post-fireworks display to locate hot spots. (FF:S:5899)

Several other *specialized* items were mentioned by few respondents in a single discipline, such as helicopters and robots for LE; TIC for FF; and EPCR or other patient software for EMS. While small numbers of responses identified specialized technology, more often than not, responses indicated a reliance on what departments and agencies already have.

We only have what we have, so not a lot of specialized doo-dads. (FF:R:5507)

As with the data from Sec. 4.5.1 on major disasters, these findings suggest that improving day-to-day technology for first responders will also improve their ability to work large, planned events, since this is the technology they rely on in that work.

In addition to the open-ended text box on *specialized* technology, another asked about the *most important* technology utilized during a large, planned event. There were 811 open-ended responses to this question. Overarchingly, participants again referred to technology that was the same as the technology they use for their day-to-day work.

I use the same equipment as I use every day. (COMMS:R:7312)

Same equipment we use day to day. Nothing that our department has would be considered specialized. (LE:U:4394)

Similar to the question above on specialized technology, radio (COMMS—60.18 %; EMS—73.73 %; FF—69.35 %; LE—32.56 %) and phone (COMMS—13.27 %; EMS—27.12 %; FF—25.39 %; LE—68.09 %) were the two items mentioned the most across the four disciplines. The exemplar quotes below represent just some of the many that identified these devices as the most important technology for work during large, planned events.

> Radio systems and pagers for effective communications, and CAD systems, which are our main input. (COMMS:S:50)
>
> Phone, AED, Computer, Radio. (EMS:R:548)
>
> Radios & phones. (FF:S:26)
>
> Radio communications equipment. (LE:U:7)

What is perhaps most interesting here is the extremely high percentage of respondents from all four disciplines who said that radios were the most important technology they use during a large, planned event.

Very few other items emerged as important for use in a large, planned event, other than CAD which was listed in 35.40 % of COMMS responses to this question. While drones appeared in approximately 6 % of the responses for COMMS, FF, and LE when asked about *specialized* technology, drones were rarely mentioned as the *most important* technology used during a large, planned event (COMMS—0 %; EMS—0 %; FF—1.24 %; LE—0.78 %). This highlights the tremendous importance first responders place on radios and phones in their work for a large, planned event.

Futuristic Technology for Large, Planned Events

Finally, respondents were asked a question about other, more futuristic, technology they thought would be useful during a large, planned event.

> "In addition to the technology you use day-to-day, which of the following do you think would be helpful during a **LARGE, PLANNED EVENT**? Check all that apply."

Response items for EMS, FF, and LE included:

- Deployable communication technology (such as cell towers on wheels)
- Drones
- Helicopters
- Mobile command centers
- Remote sensing (by aircraft or satellite)
- Robots
- Other (please specify).

Response items for COMMS respondents included: Deployable communication technology (such as cell towers on wheels); Drones; Generators; MCCs; and Other (please specify). As previously noted in Sec. 2, the response items for this question were driven by the interview data.

In this section, data for EMS, FF, and LE are presented side by side in Fig. 61, since these three disciplines were asked about the same six devices, like with the major disasters question (see Sec. 4.5.1). Data for the EMS, FF, LE, and COMMS disciplines, individually, are presented in Figures 62—65, respectively. Note: percentages can add up to more than 100 % since respondents could check all items that they believed would be helpful to their work during a large planned event.

MCCs were the item checked by the most respondents across the three disciplines (EMS—60.17 %; FF—67.58 %; LE—60.18 %). In addition, there were similar percentages across the three disciplines for both MCCs and deployable communication technology (see Fig. 61; technologies shown in alphabetical order), which is consistent with the data for the analogous question that was asked about major disasters. Again, this consistency may reflect the importance of communication to the general work of first responders, in both day-to-day incident response and for a large, planned event. One difference from the data on major disasters is that for large, planned events, drones were selected by FF and LE more than deployable communication technology, and LE respondents chose drones more than MCCs. As noted in Sec. 4.5.1, the selection of drones by FF and LE is consistent with the responses in Sec. 4.3 where participants were asked about devices that would also be useful in their day-to-day work. In that question, approximately 40 % of FF and LE respondents identified drones as a device that would also be useful in their day-to-day work, while less than 15 % of EMS respondents selected drones, similar to responses here.

Perhaps most striking in the data for large, planned events is the sharp drop-off between the top three and the bottom three devices. The same three devices were in the bottom three in Sec. 4.5.1, however they were selected by larger numbers of respondents than in this section. Helicopters, remote sensors, and robots were selected here by less than 20 % of respondents from any of the disciplines. In addition, discipline-specific selections are not as prominent here, as was the case in Sec. 4.5.1 on major disasters, perhaps indicating that with a large, planned event first responder needs are more similar across disciplines. This may be due to the planned nature of events like concerts, football games, and parades. First responders have time in advance to plan for and decide upon the use of technology in these instances.

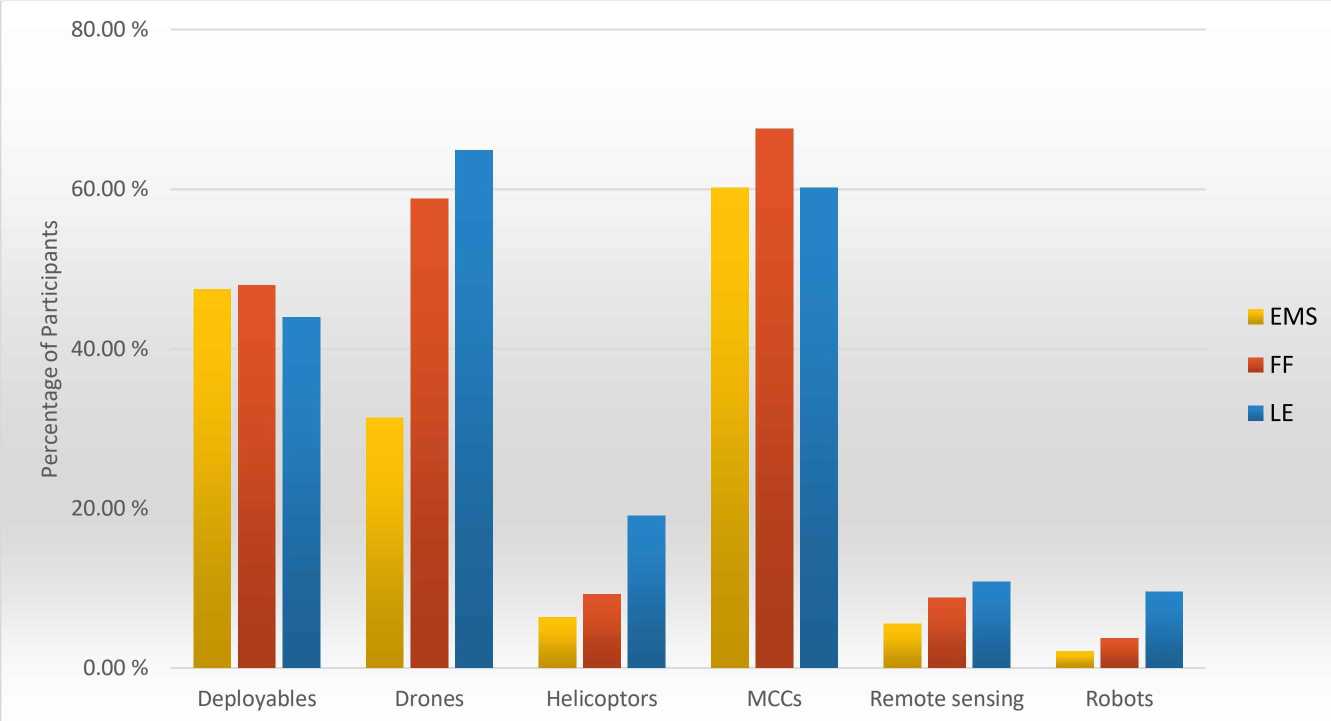

Fig. 61. Futuristic technology in large, planned events, by discipline

Looking at the data for individual disciplines (see in Figs. 62—65; ordered from most useful technology to least useful technology), there are some interesting similarities and differences between the data for large, planned events and the responses to the same questions for major disasters. The order of EMS responses to this question mirror those seen in Sec. 4.5.1 on major disasters, with the only difference being the percentages for each item. However, for FF, the order of the top three selected items was reversed for large, planned events: MCCs first, then drones, then deployable communication technology. The order of the top three items for major disaster was deployable communication technology first, then MCCs, then drones. The data for LE is also surprising here, with drones being the item most often selected, followed by MCCs, then deployable communication technology. The major disaster data for LE show MCCs as the top item, followed by deployable communication technology, then drones. The high number of responses identifying drones as additional technology that would be helpful during a large, planned event may be related to the nature of large, planned events, which provide time for coordination of operations, including the use of drones. In addition, many large, planned events are held outdoors, making drones more likely to be used for monitoring, surveillance, or other purposes.

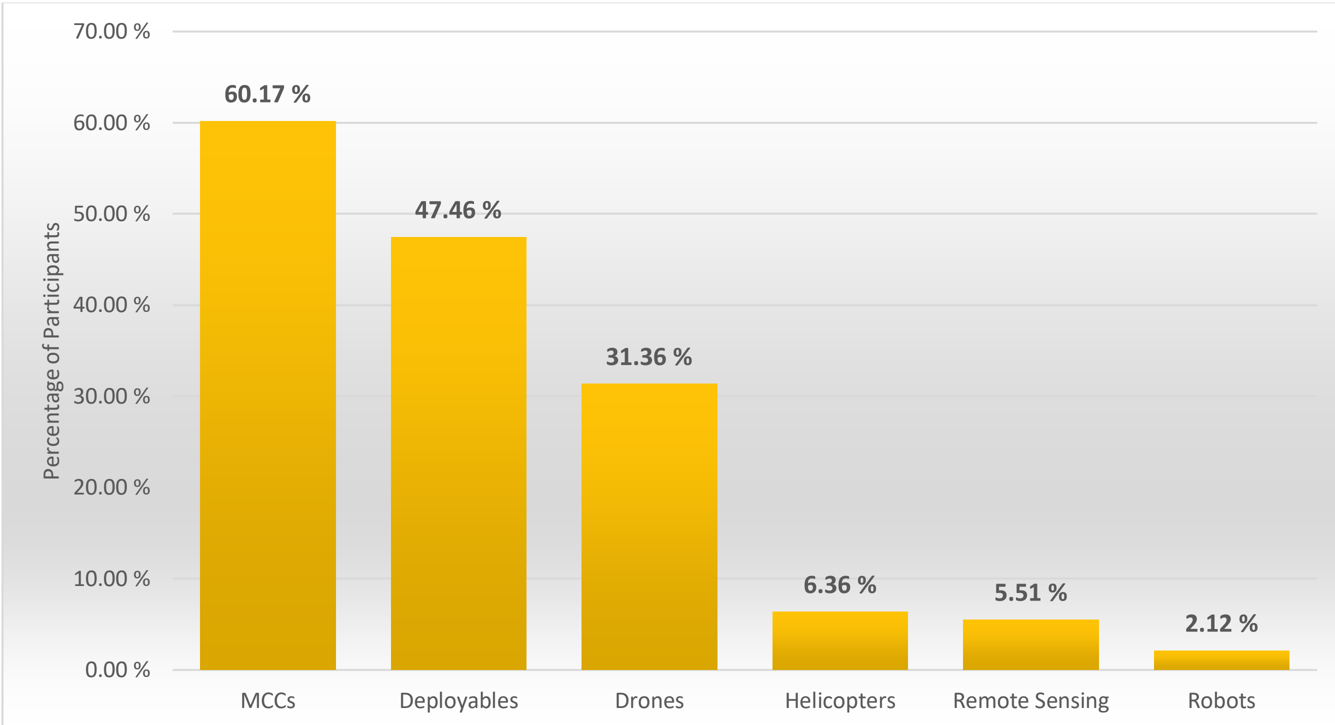

Fig. 62. Futuristic technology in large, planned events for EMS

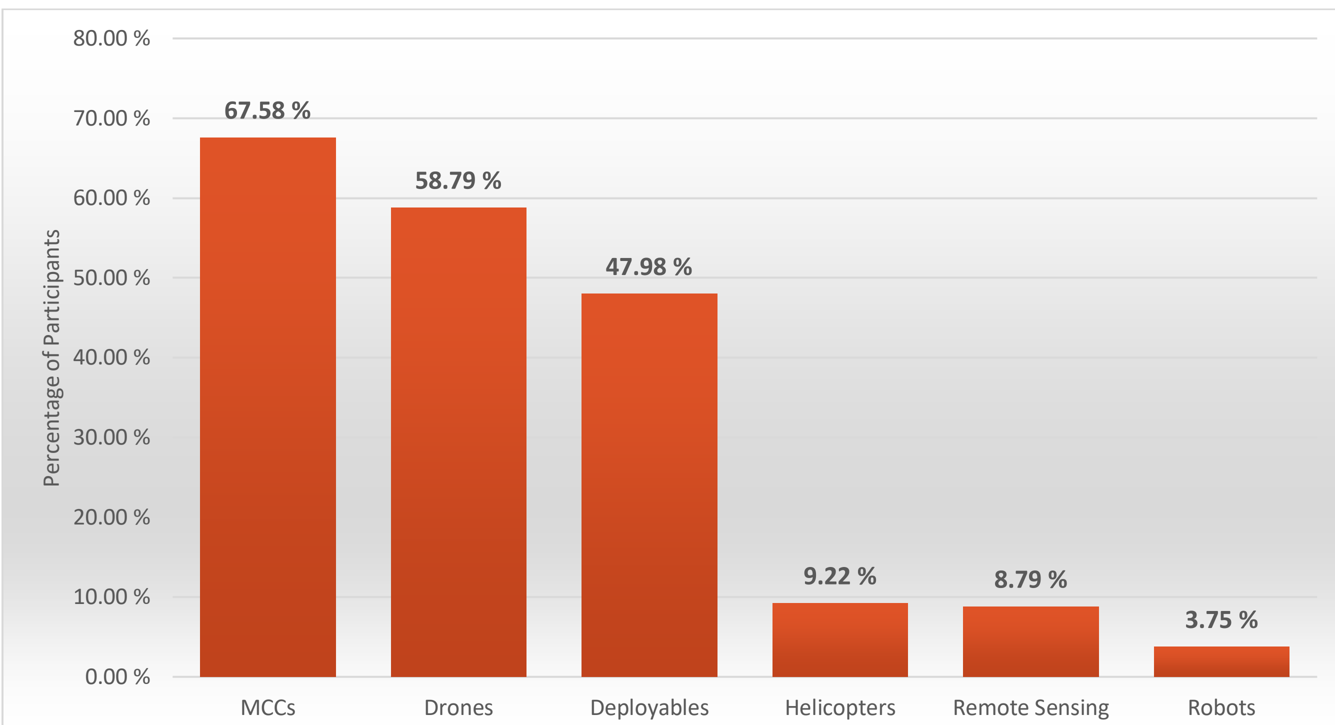

Fig. 63. Futuristic technology in large, planned events for FF

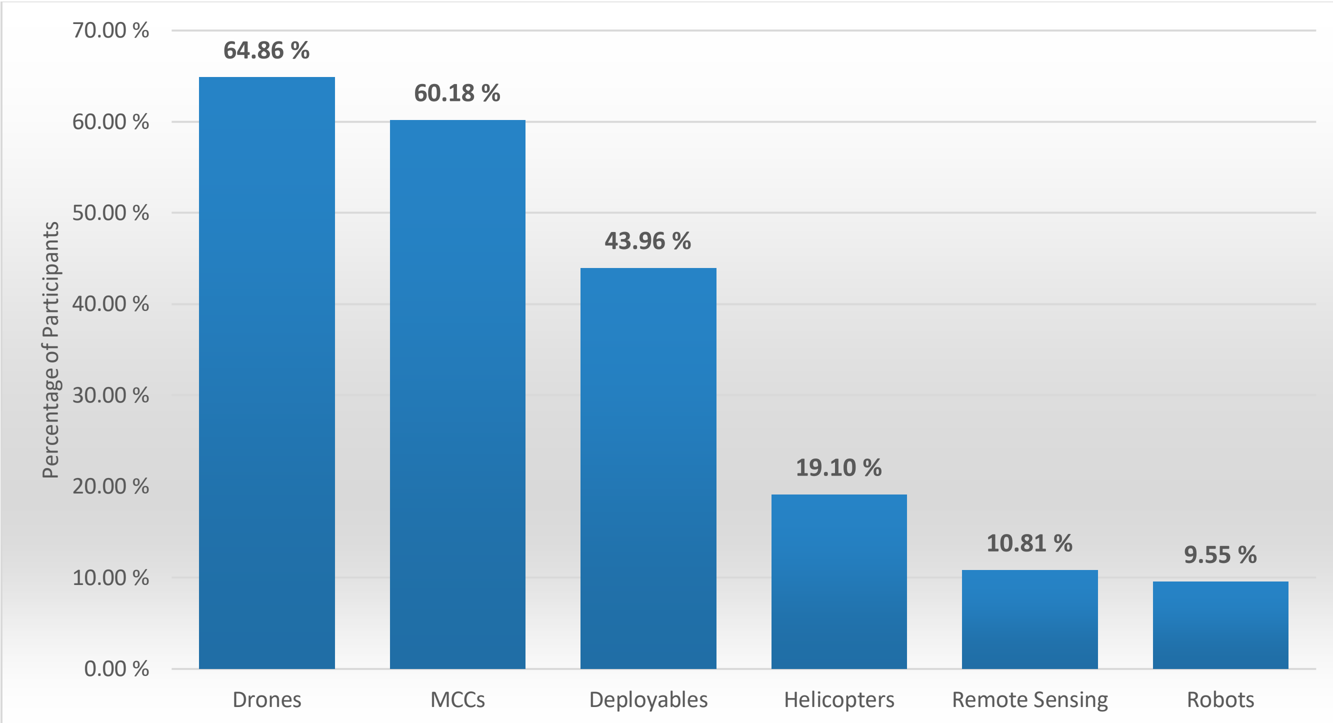

Fig. 64. Futuristic technology in large, planned events for LE

As in the data for this same question about major disasters, COMMS respondents chose MCCs more than any other technology (71.90 %). However, one difference between the large planned events data and that for major disasters is the percentage of COMMS respondents who chose devices other than MCCs (see Fig. 65). All three of the other devices (deployable communication technology, drones, and generators) were selected by over 50 % COMMS respondents as devices that they believed would be useful during a major disaster. Here, when asked about the same devices and their usefulness during a large, planned event, less than 50 % of COMMS respondents selected these items. While MCCs were the top item chosen for both major disasters and large, planned events, the next two items were reversed. Here, drones were chosen by more COMMS respondents than deployable communication technology. Similar to the data above for EMS, FF, and LE, drones may have been chosen more due to the planned and outdoor nature of many large, planed events.

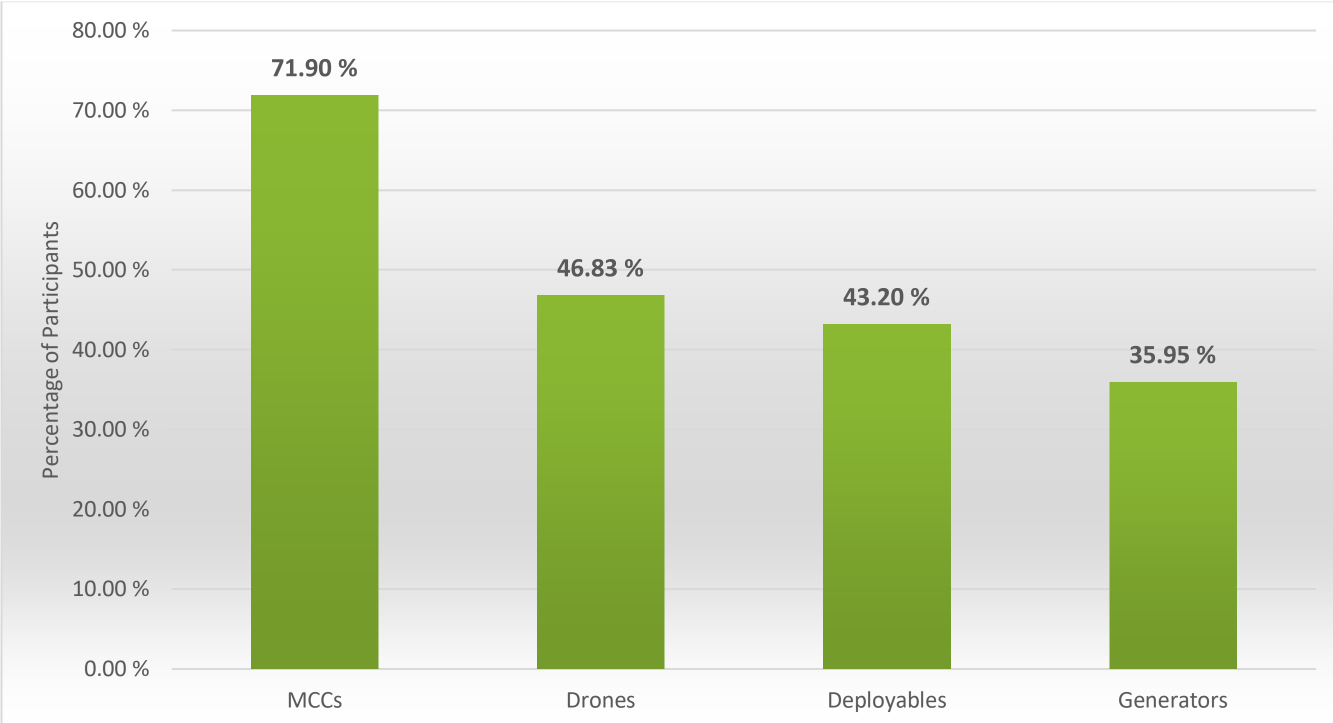

Fig. 65. Futuristic technology for large, planned events: COMMS

Across the four disciplines, there were only 47 responses (0.02 %) to the open-ended "Other (please specify)" text box for this question. These responses varied widely from "Police canine" (LE:R:2431) and "Equestrian units" (LE:S:5215) to "golf carts would be helpful or a gator type vehicle" (LE:R:28712) to "Deployable CCTV" (LE:S:7481). While many items only showed up in one response, such as the examples above, several did show up more than once. For example, interoperability is something that multiple respondents mentioned, from three of the four disciplines.

> Radio interoperability links. (COMMS:R:2930)

> Assurance of interoperability. Well-integrated interagency ops. (EMS:S:920)

> Interoperable frequencies. We can't get disparate systems to cooperate. (FF:R:47)

Another item that appeared in more than one response was earpiece. This device was listed in five responses, with at least one EMS, FF and LE respondent listing earpiece as important additional technology that would be useful during a large, planned event.

> Ear pieces. (EMS:S:6662)

> Earpiece. (FF:S:9357)

> Ear pieces during loud events. (LE:U:312)

Earpieces represent devices used by first responders in their day-to-day work, but are also seen as useful tools for large, planned events.

Finally, several responses noted that none of the items listed, or other additional technology, would be useful.

> Really none of the above, this stuff is just too over the top for our needs. (FF:R:5506)

> Large planned events have a way of getting really over-the-top really quickly when the planners get involved. The most important thing for me is to make sure my regular way of communicating still works, and that I can use it to reach all the people I might need to talk to. (FF:S:9767)

> A large planned event isn't really a problem in a county of six thousand people. (COMMS:R:9254)

These responses are consistent with the findings in other sections and highlight that first responders do not always have a need for additional technology when dealing with a large, planned event, and that the "regular" technology, used in their day-to-day work, is what is most useful.

4.6. Virtual Reality

In the penultimate section of the survey[8], all respondents were asked specific questions about the use of VR for training and for other purposes, given its importance to the PSCR research agenda (see Appendix B). The questions in this section asked:

"Do you think **VR (virtual reality)** would be useful for training in your work?"

"Do you see **VR** as useful in other ways for your work?"

The response options for both questions were the same:

- Yes
- No
- Not Sure

The final question in this section gave respondents an opportunity to provide additional details about their answers to the VR questions listed above. This open-ended question was:

"Please explain."

[8] The final survey section provided respondents an opportunity to leave us any feedback or additional information; results from this section will be presented in future volumes.

Per-discipline quantitative VR question results are shown in Figs. 66 and 67. The responses for the open-ended question follow. Detailed data for the responses to the VR questions can be found in Appendix D.

Responses on the use of VR for training show that 50 % or more 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. 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.

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. Many of the open-ended responses in this survey section noted particular categories of training where VR might be useful. Most of these were from LE respondents. For LE, these included: scenario-based training; training for major events and disasters; scene command; and active shooter scenarios. For EMS and FF, one category was mentioned specifically—search and rescue. Again, LE respondents might have had an easier time providing examples here for training given the amount of scenario-based training they currently do, for example on use of force.

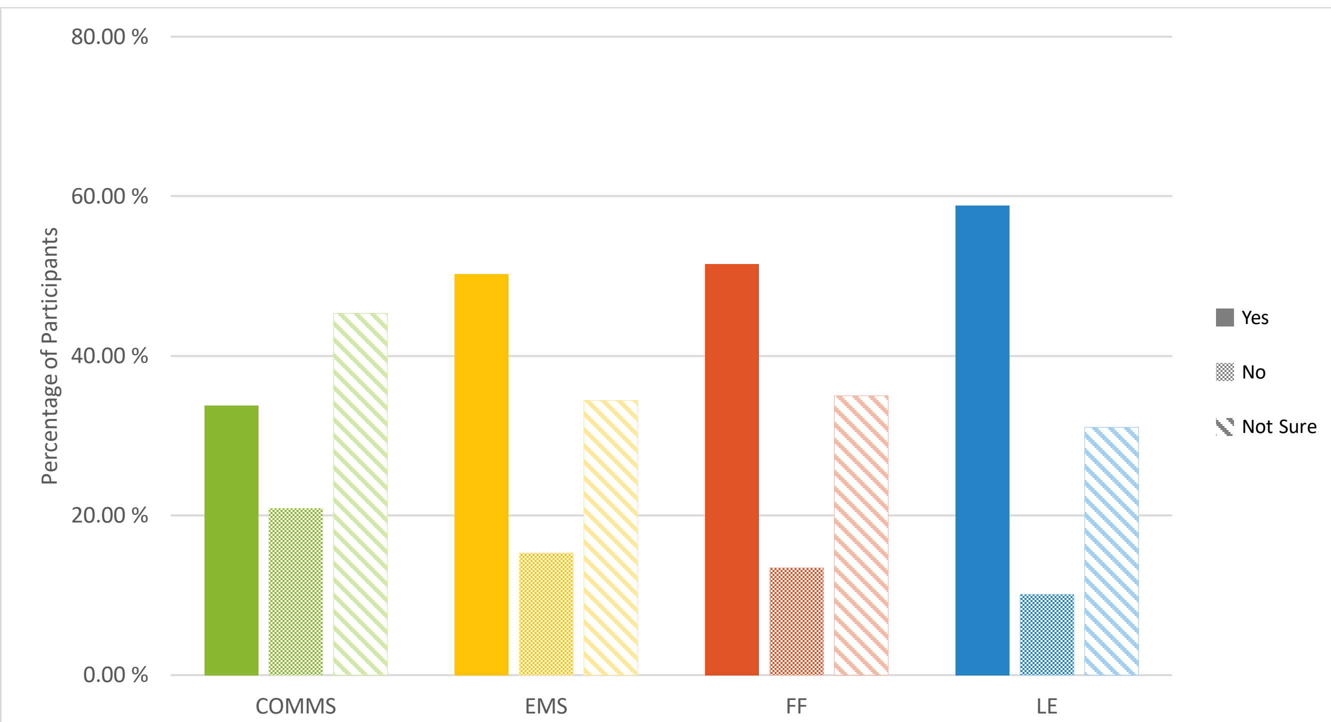

Fig. 66. Usefulness of VR for training

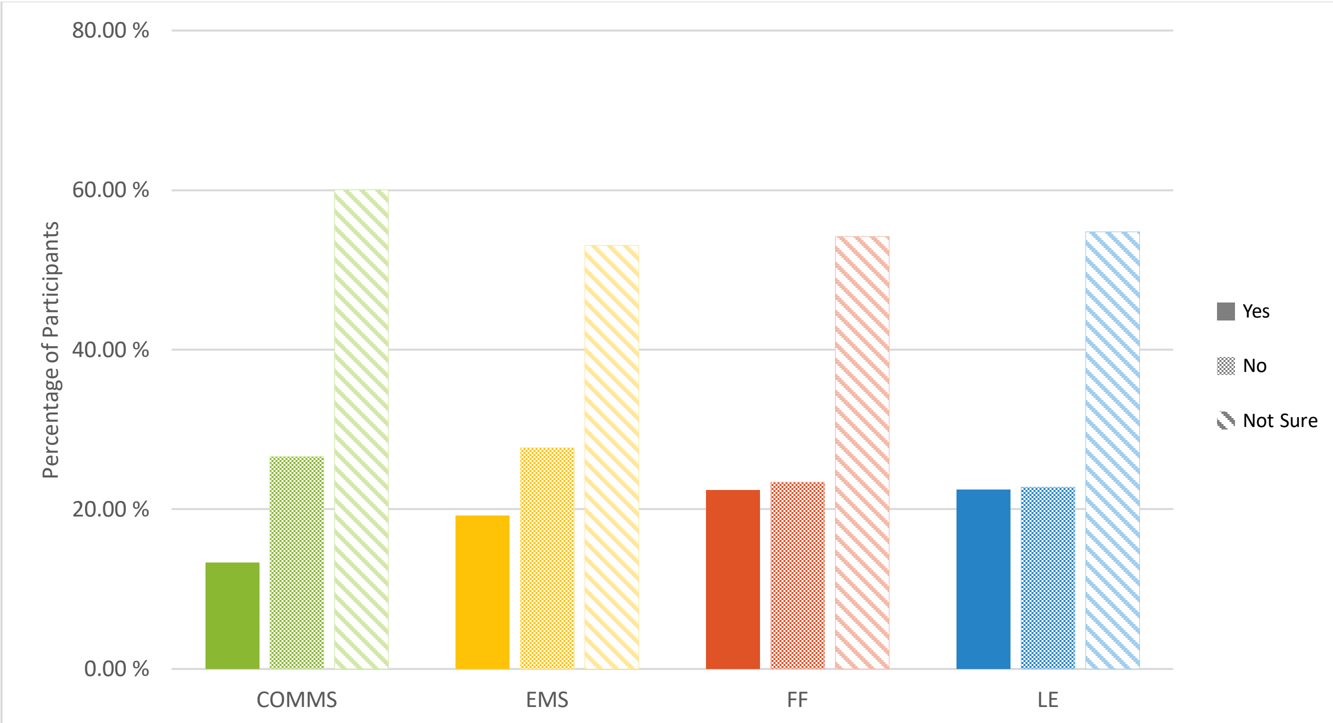

Fig 67. Usefulness of VR for other purposes

The high number of positive responses to the question about VR's use for training is interesting given how low the responses for VR were in Sec. 4.3 when respondents were asked to check any forms of futuristic technology they thought would be useful for their day-to-day incident response activities. When asked about utility for their day-to-day incident response, very few respondents (COMMS—4.92 %; EMS—3.33 %; FF—6.84 %; and LE—5.81 %) checked that VR would be useful, and VR was one of the lowest items chosen in the list. These differences may be due to the way the question was framed. When respondents were asked to consider VR's usefulness for daily incident response, most thought it would not be useful. However, when thinking about the use of VR for training purposes, many more thought it could be useful. This highlights the importance of the way questions were framed and the ways in which respondents were able to relate questions to their work contexts.

In addition to the question above that asked specifically about VR for training, the second question in this survey section was more general and asked respondents about VR for other purposes in their work. Responses to this question were very different than for the question related to training. Over 50 % of respondents from all four disciplines were not sure that VR would be useful in other ways for their work. In fact, more respondents in all four disciplines chose "No," that they did not see VR as useful in other ways for their work, than those who chose "Yes" (see Fig 67 above). The difference in the responses between the two questions again might have to do with how the question was framed: one was more specific (the use of VR for training) while the other was more general (the use of VR for other purposes). Respondents might have had difficulty imagining other situations in which VR might be useful, whereas when they were asked to think specifically about VR and training, they were more able to recognize its potential utility.

Respondents were also given an open-ended response item at the end of the survey section asking them to explain their answers to the VR questions. Out of 7 182 respondents, 1 115 provided input to the open-ended question. This means that 15.52 % of respondents took the time to write an open-ended response about VR. This percentage was consistent across disciplines (COMMS—15.22 %; EMS—15.41 %; FF—16.16 %; LE—15.01 %). Responses ranged from one-word answers to those that were over 100 words, including one response that was 280 words. Even at the end of the survey, respondents took the time to provide additional information and feedback.

Table 29 below shows the numbers and types of responses per discipline. Responses were categorized as positive, negative, not sure/don't know about VR, or misunderstood VR. The percentages displayed in Table 29 reflect the percentage of responses to the open-ended question. For example, the percentage of COMMS respondents who provided a positive open-ended response is 28.57 % of the 238 total COMMS open-ended responses. Exemplar quotes from each category are provided and discussed below.

Table 29. Categories of open-ended responses, VR

	Positive	**Negative**	**Not Sure / Don't Know About VR**	**Misunderstood VR**
COMMS *n=238*	28.57 %	28.15 %	31.09 %	12.19 %
EMS *n=139*	53.96 %	11.51 %	17.99 %	16.55 %
FF *n=423*	57.82 %	14.22 %	18.72 %	9.24 %
LE *n=315*	60.95 %	7.94 %	12.70 %	18.41 %

Across all four disciplines, there was support for VR in the open-ended comments. Many of these just noted generic support for VR, while others gave an indication of how/where VR could be used. The most common category listed in the open-ended responses was "training."

> Training is the only obvious area of use that I can think of at this time. (LE:U:1890)

> Primarily for training purposes. (FF:R:1109)

> VR may be good for scenario training in dispatch. (COMMS:S:1138)

Often, training was the only word listed in these positive responses. In other cases, specific forms of training or other uses were provided. Often, the categories of training represented "high risk-low frequency" (FF:S:2018) scenarios, such as active shooter training, major events/disaster training, or search and rescue training.

> VR for training could simulate an unusual and difficult-to-replicate situation, such as a major disaster, including all of the background noise and activity instead of just what is on the screen or coming through the headset. I do not see how it may be useful other than that. (COMMS:U:340)

> You can go a long time without being exposed to certain scenarios so VR could help prepare your teams for possible encounters with difficult scenarios. (EMS:S:5227)

One response in particular was passionate in its support of VR for first responder training.

> VR can be used more in the fire service for training firefighters in decision making in a safe environment. I lost a friend in a training fire and although lessons learned from his death will save others in the future, one lost life is not worth it. Harnessing VR can help reduce the risk of putting firefighters in a toxic environment for training. (FF:U:5440)

While several responses noted VR could provide safer training environments, none were as clear or personal in their response as this one.

Many of the positive comments supported the use of VR for training, but also specifically said VR had no place in operations.

> 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)

> 911 calls are organic and an operator must be able to adapt and address situational circumstances as they arise. I believe VR may be useful in the field for field responders but I'm not sure how it would be useful in the communications center other than training simulation. (COMMS:S:330)

Responses varied by discipline but included additional categories such as driver education/training (for first responders and teenagers), pre-planning, public education about the role and work of first responders, and stress relief/mental health.

> Public education. (FF:U:7754)

> Counseling, PTSD. (LE:R:5053)

> Stress relief. (COMMS:R:7553)

Positive responses to the use of VR most often referenced training, and the word “training” appeared 355 times in the VR open-ended responses across the four disciplines. Respondents were less likely to note its positive use in other areas of their work, and no other category was mentioned more than 20 times across the four disciplines.

Each discipline also had a variety of negative comments about VR, exemplified by those listed below. Very often the negative comments about VR related to a perceived lack of its usefulness or application to first responder work.

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

> I can't think of a way it would be useful, sounds cool, but doubt it could be useful. (LE:R:252)

Many of the negative responses also noted how VR could never provide the same experience as hands-on, on-site, physical training.

> It may look fun and exciting it cannot replace real physical buildings, cars, patients. Get your fat ass out there and do the work and see how it is to do your job when you heart rate is up and you are tired. Carry your gear or equipment and learn where it is located before you have to use it. (EMS:R:9490)

> There is no replacing real experience. As the number of fires dwindle nationwide, I think our dumbed down hyper sterilized training has become a detriment to firefighters. It is no longer realistic and does not prepare us. (FF:S:818)

While there were fewer negative responses than positive responses, the negative comments often used stronger language and were more vehemently stated than the positive comments.

> You are wasting money that could be used to supplement manpower. Require more from your training department instead of buying more useless technology that will be obsolete by the time you pay it off. (FF:S:664)

> We have a difficult enough time with real reality, much less virtual (non-real) reality. (COMMS:S:8199)

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

> VR compromises real work experience. After several demonstrations I believe VR gives a false sense of security to users because all 5 senses aren't engaged. It is going to lead to problems when responders have to function in the real world. (FF:U:2144)

As evidenced by the exemplars above of negative comments, many respondents used strong language in their responses. Negative comments often used words such as: "fad," "silly," "cannot replace," "no place in," "don't trust," or "a waste." Positive responses were generally more neutrally worded and indicated more of a willingness to try VR than the negative responses where respondents were often adamant about not "wasting" money and/or time on it.

Some responses also specifically discussed the benefit of augmented reality (AR) as more potentially useful to their tasks and work environments than VR.

> VR or more correctly, AR (augmented reality) could be of great value in training and application of policies, suggested actions etc. (COMMS:S:4807)
>
> Augmented would be helpful. (FF:S:1435)
>
> Probably better to use AR than VR. (LE:U:5835)
>
> I see more applications where AR would be useful, not sure of the situations wherein VR would be applicable other than training. (LE:S:9006)

The identification of AR as more useful than VR might be due to first responders who believe it is more important to keep a connection to "reality," whether it be for training or operations.

Another category of responses was where respondents indicated a lack of familiarity with VR and/or their inability to speak to its use in their discipline.

> Not quite sure what virtual reality entails and it's workings. (COMMS:R:1485)
>
> Not familiar with VR. (EMS:S:224)
>
> I haven't had a lot of exposure to VR. I can imagine how it is useful in entertainment and design work but haven't seen any examples of how it could be used in emergency response. (FF:R:250)

These responses indicate a lack of familiarity with the technology. However, unlike many of the negative responses, these did not demonstrate a closed mind to the possibility of its use.

In addition to some respondents not knowing about or having experience with VR, others seemed to misunderstand what VR was, what it could do, and how it might be useful.

> Conference calls/meetings. (FF:R:9714)
>
> VR video while officers are on scene. (LE:U:7618)
>
> Messages - One way communication - to push out uniform message to the masses, Help Desk, Troubleshooting. (COMMS:U:1727)
>
> Maybe when someone is arrested and they aren't familiar with the procedures of going to court for an arraignment, then a bond will be set, what happens if you post bond or can't post bond, etc. etc. Not only for someone that is arrested but if their family could be advised as to how things will work that would be nice. Maybe dealing with the inmates when they constantly ring the buzzer. If a VR answered them instead of a person maybe they would give up because they just are doing it to be an #$. (LE:S:49)

In some instances, VR was confused with Artificial Intelligence (AI) capacities, or with online video communication tools. Misunderstandings about what VR actually represents may be what contributed to large percentages of respondents choosing "Not Sure" when asked about other uses of VR for their work. If respondents are not sure what VR is or does, they would not be likely to know how it could be applied to their work.

In addition to noting where/how VR might be used, some respondents specifically noted barriers to the use of VR, for example cost.

> I'm not familiar with virtual reality. I assume it could be used for scenarios in training, however we probably would not be able to afford it. (COMMS:R:4508)

> Way too expensive and technology dependent. Our applications are rarely fixed asset or fixed point that would allow supporting such technologies. (EMS:S:951)

> I see it as a gimmick that will have an immense price tag, not work as planned, finally being used as a toy and left in the corner to collect dust. (FF:R:4854)

> I think the VR technology is a helpful training tool, but not worth the expense for a small agency like ours. If we could have a shared VR venue at perhaps the state level, it may be more useful. (LE:U:7371)

This data is similar to the quantitative findings in this survey as well as to the findings from the interview data, where interview participants often spoke about cost as a barrier to the adoption of new technology [5], especially in rural areas [18].

While most of the comments related to the cost of VR saw it as prohibitive, three respondents (all in LE) noted how VR could possibly reduce training costs and provide departments with more cost-effective mechanisms for training, such as the exemplar comment below.

> Training is crucial and VR could help reduce training costs and increase practicality and applicability. (LE:R:4295)

In addition to cost, some respondents noted how age might play a role in the acceptance and use of VR in training.

> I have an even mixture of younger and older firefighters. The younger firefighters would embrace VR use, the more senior firefighters would not, In short, there is a resistance to technology by most members born before 1970. (FF:S:2586)

> As a small, rural agency with an aging membership, the spin-up cycle to use VR training is likely going to be harder for us to accomplish than any benefit yield we'd see from such training, even discounting the costs of switching to such a training system. In our County, we cannot even get umbrella agencies to provide for remote classroom capabilities - VR is likely another technological generation (if not a physical generation) down the road for us. (EMS:R:435)

The responses about the influence of age mirror the findings from interview data, where interview participants often spoke of a "generation gap" in the acceptance and use of new technology.

In addition, some respondents noted that a focus on the technology currently in use was preferable to the introduction of new technology, like VR. In the open-ended response to the VR question, one FF noted: "Ensure firefighters have safer basic equipment first" (FF:S:5151). This is similar to open-ended responses discussed in Sec. 4.3 on futuristic technology, as well as to the interview data.

Overall, the quantitative and qualitative data from the VR questions show support across all four first responder disciplines for the use of VR for training in public safety. However, the open-ended data is somewhat more qualified, with first responders noting how things like cost, age, and other factors affect VR's utility, even for training. However, there is very little support in the quantitative or qualitative data for the use of VR for other purposes related to first responder work. Based on the quantitative and qualitative data to the VR questions, perhaps the most important consideration will be helping first responders understand what VR is, what it does, and how it can help them in the specific contexts of their work, something previously noted in Sec. 4.3 on futuristic technology.

5. Discussion and Future Directions

The findings from the nationwide survey of over 7 000 first responders, together with prior nationwide interviews of 193 first responders, offer a combined dataset with breadth and depth of great value to the public safety community. In order to fully realize the potential of the NPSBN, addressing the mobile device problems identified by first responders will facilitate the ability to purchase, access, and utilize applications/software in the field for incident response. With the new NPSBN, understanding the current patterns of mobile device usage, problems experienced with those mobile devices, technology for large events, as well as first responder visions for future-looking technologies are all of utmost importance. In this section we summarize and discuss implications of the major findings and themes for each of these topics. Finally, we conclude with overarching guidelines for consideration by public safety technology developers, purchasers, implementers, and public safety agencies.

5.1. Summary and Implications

This document begins by focusing on mobile devices most likely to be used on the NPSBN, in particular, smartphones and tablets. The data on smartphone frequency of use paint an interesting picture of the differences between personal versus work-issued devices for public safety. Across the four first responder disciplines – COMMS, EMS, FF, and LE – nearly two times the number of first responders use personal smartphones than work-issued smartphones. When examining individual disciplines, the percentage of LE using work-issued smartphones is notably higher than in the other three disciplines (EMS, FF, and COMMS). LE report using smartphones for tasks other than making calls, such as using them for body cameras only, with calling and messaging not enabled. Given the high percentages of first responders across disciplines who carry both a personal and a work-issued device, it is not surprising that an "all-in-one" smartphone is of great interest to them. Furthermore, the high percentages of first responders who use their personal smartphones to conduct their public safety work suggests that *affordable devices and data plans* for the NPSBN could fill a significant gap in the public safety technology space. It is telling that the first responders who experienced problems with the cost of mobile devices outnumbered all other problems experienced by a factor of 2-to-1. This is especially pertinent given the fact that issues with personal phone subsidies (being insufficient or non-existent) is one of the top problems experienced with smartphones across disciplines, as well. Also of note for the smartphone problems experienced, is the high percentage of LE who were concerned about the possibility of subpoena for their smartphones, especially their personal phones. Again, this suggests that broader access to affordable work-issued smartphones and data could help public safety if implemented with care.

Certain types of data and applications/software are of particular interest to first responders. In addition to public safety-specific applications/software like CAD and RMS, first responders largely use apps that are common to the general public, specifically email and mapping/navigation. Mapping and navigation are critical in public safety incident response, as a dispatchable address is necessary for responding units to find the incident location. Unfortunately, the problems first responders often experience with outdated public safety mapping/navigation can lead them to prefer personal smartphone use in many instances, in order to have the most up-to-date maps. The desire to have access to data through smartphone apps for first responders in the field is another reason that the NPSBN build-out is so important for public safety.

The NPSBN is designed to support not just today's technology, but forward-looking technology of the future as well. First responders can envision "futuristic" technology if it is solving a problem or pain point that matters to them; for them, it is utility driven. This is perhaps most apparent in first responders' perceptions of VR. VR may be useful for high risk, low frequency training scenarios; but the interview and survey data show that more evidence about the usefulness and direct benefit of VR in their work is needed before first responders accept its utility. It is also important to understand that what many first responders want for the future of public safety is technology that already exists for the general public, it just is not yet widespread in the public safety domain. This is amplified by the additional numbers of first responders who expressed their requests for new functionality in the interviews [9]. For example, single sign-on exists for many businesses, government agencies, and other entities. While not yet ubiquitous, SSO is becoming increasingly widespread in the consumer world, but is still uncommon in public safety—in public safety, one login is still "futuristic" technology. SSO is something that was widely requested across disciplines, in both the interviews and the survey, in order to help first responders deal with the burden of many usernames and passwords. While the desire for one login (or SSO) was consistent across disciplines, there were some discipline-specific visions for futuristic technology as well. In particular, automatic caller location for COMMS and automatic transmission of patient vitals for EMS. Additionally, the use of drones was more common for futuristic technology envisioned by FF and LE. While these technologies may not cut across all of the various public safety disciplines, they have the potential to make a significant difference in the work of the discipline(s) they serve. Their importance should not be discounted; first responders' needs can begin to be addressed by making discipline-specific technology, like drones, more accessible. As with SSO, drones are widely available in the consumer space, yet are not as widely used in public safety. This may be in large part due to the higher burden their use places on first responder agencies in terms of necessitating supporting policies, procedures, and ongoing training.

The issue of ongoing technology expenses is not limited to drones, SSO, smartphones, or any one technology, and the theme for many issues with technology is that new technology is not a one-time investment. It requires ongoing maintenance, upgrades, training, policies, procedures, data plans, etc., to support the initial purchase investment. It is often the ongoing expenses such as these that preclude many agencies from being able to afford new technology they would otherwise like to have. As additional technology becomes embedded in public safety, there are more ongoing costs associated with maintaining this new and emerging technology. This may mean more grant applications, fundraisers, memorandums of understanding (MOUs) with neighboring agencies to share technology, purchasing with other agencies for efficiencies of scale, or other means of defraying technology costs. Perhaps there are creative ways for universities to partner with public safety agencies for IT tech support and tech training, as it is clear that many public safety agencies—especially smaller rural ones—cannot afford dedicated IT staff. The interview data showed that there already exist successful examples of neighboring agencies partnering with one another so they can have enhanced access to technology they could not afford on their own, and mutual aid for incident response.

The need to partner and build relationships with neighboring agencies is not unique to day-to-day incident response and is just as important—if not more so—for large events, both major disasters and large planned events. Of note, the devices and apps/software that are most useful in day-to-day incident response are mostly the same as those used in large events. This makes it extremely important for technology researchers and developers in the public safety space to focus on solving the problems that first responders have with technology used for daily incident response, as it will also help them during large events. Many first responders do not use or have access to specialized technology during a major disaster due to cost, interoperability, or dependability issues. Of course there are some notable technologies that are more unique to large and extended duration events, such as MCCs, COWs, generators, and helicopters, but the basic technology (radios, smartphones, tablets, etc.) is often largely the same for most first responders surveyed. For large events, first responders have a need for greater interoperability and non-technological resources (e.g., personnel), in addition to their use of mainly day-to-day technology for major disasters and large, planned events. This resonates with the findings from the Phase 1 interviews and the user-centered design guidelines from the Phase 1 Volume 1 report [5]. These cross-disciplinary guidelines for researchers and developers include things such as improving current technology over developing new technology, developing technology that does not interfere with the primary tasks of first responders, and lowering the cost for both current and future technology. Findings from the open-ended survey data on specialized technology in large events certainly support these guidelines.

Regardless of whether technology is being used for day-to-day incident response or for major disasters or large planned events, public safety technology must be implemented with great care. In order to realize the full potential of new technologies and the NPSBN, developers, policy makers, purchasing officials, and public safety leaders all need to be aware of first responders’ concerns regarding technology, their currently experienced technology problems, and their perceptions of new and emerging technologies. As in the general public, so too in public safety there is often a perception of the "double-edged sword" of technology, and the need to balance multiple considerations and perspectives. For example, the issue of cost versus need is an important discussion for public safety agencies, and problems with price were consistently experienced the most, by far, across disciplines; as previously discussed, this may in large part be due to the ongoing costs associated with new technology, rather than simply the initial purchase.

Beyond the more concrete considerations, such as technology price, are the harder to measure issues in terms of unintended consequences arising from the adoption of new technology. For example, participants considered the unintended consequences of removing the human voice element in text-to-911, or the unintended mental and emotional consequences for COMMS—such as increased risk of PTSD—that may result from viewing inappropriate and/or graphic images and video with NG 911. The issue of unintended consequences is part of the larger theme of the "promise and peril" of new technology, a theme that was pervasive and consistent in both the interview and survey data. This was extremely evident in the COMMS open-ended survey data, where the thoughtfulness and length of responses were impressive, as respondents carefully considered both the pros and the cons of receiving texts, pictures, and videos from the public. Across disciplines, the length and frequency of open-ended survey responses shows how very committed and dedicated first responders are to their work. Only by listening to the voices of first responders, and engaging actively with them, can new technology be designed and implemented such that it meets user needs and facilitates public safety incident response. It is necessary to recognize and address both the promise and the peril of new technology so that its adoption will ultimately be as successful as possible.

Towards this end, the overarching user-centered guidelines for developers, previously reported in Phase 1, Volume 1, remain important and applicable; the six guidelines below initially identified in analysis of one-on-one interviews with first responders were mirrored and amplified in the largescale nationwide survey data [5]. Here we present the original user-centered guidelines, as well as a discussion of how they remain applicable given the new survey data. See Appendix E for the guidelines as originally published.

1. Improve current technology
2. Reduce unintended consequences
3. Recognize 'one size does not fit all'
4. Minimize "technology for technology's sake"
5. Lower product/service costs
6. Require usable technology

As seen in the survey data showing the large numbers of first responders who often experience problems with their current technology and frequently used mobile devices (see Sec. 4.1.2), it is clear that the guideline "Improve current technology" still rings true. Data from both the survey and the interviews highlight that it is not necessarily new technology that first responders want, but the improvement of current technology that they believe is most important; first responders want improved functionality, affordability, and reliability in their current technology. Survey data show that the problems first responders experience at least sometimes are high enough frequencies that those problems likely lead to lack of trust and lack of confidence in the idea of truly reliable technology; it is not surprising that trust in technology emerged as a major theme from the interview data. While there were no explicit questions about trust or reliability in either the survey or the interviews, it is clear that first responders need their technology to consistently work when they need it, how they need it. As the NPSBN is being built out, there is a golden opportunity to fix problems with first responders' current systems while introducing new communications technology.

Given the wealth of survey data on technology problems, and especially the extensive narrative comments contributed by first responders, the guideline "Reduce unintended consequences" is clearly still critical for technology adoption and implementation. Unintended consequences are expected to be prevalent in futuristic technology, especially for COMMS. While unintended consequences were identified in both the survey data and the interview data, the survey data show that rather than solely causing potential distractions, new technologies may put an undue strain on personnel and resources (see Sec. 4.4). The survey data on technology problems and unintended consequences together support the idea that "Minimizing technology for technology's sake" remains an important guideline. The more technology is introduced, the more likely there are to be problems and unintended consequences with said technology, meaning that technology must solve a problem or pain point for first responders, not merely be introduced for its own sake. Similarly, while all-in-one devices and applications may solve many of the problems first responders face across disciplines, it would not be prudent to incorporate too many technologies or unrelated technologies into one.

Despite many similarities across disciplines, the survey data also showed evidence of important differences between public safety disciplines. As with the interview data, this suggests that the "Recognize one size does not fit all" guideline still applies. While technology standardization across disciplines is important for consistency, compatibility and quality, technology must be easily adaptable to a wide variety of public safety needs. These technologies must also be developed at price points that departments can afford. The problem of price was a major finding in the survey data, as well as the interview data, reemphasizing the "Lower product/service costs" guideline above. In particular, the issues with ongoing technology costs in terms of maintenance, upgrades, IT support, training, data plans, and policies and procedures must be considered. When designing new technology, lower price points should be considered, with scalability for widespread distribution.

The survey data on technology problems all point towards the importance of the guideline "Require usable technology" for first responders. Note that while this document is focused on specific mobile devices—smartphones and tablets—there is a wealth of additional survey data on problems with other devices as well, which will be presented in future volumes; the many issues that first responders experience with a wide variety of technologies support the need for usable technology. Technology, in general, 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. 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. The user-centered design guidelines can promote first responders' trust with technology, people, and organizations.

Technology should be developed with and for first responders, driven by their user characteristics, needs, requirements, and contexts of use.

5.2. Future Directions

The survey data reported on here are part of a multi-year, multi-phase project that is aimed at providing a variety of resources for those interested in public safety communication research, including industry developers, researchers, and first responder organizations. These resources include a usability handbook for public safety communication [29] and a compilation of scenarios for incident response [6]. In addition, a series of volumes [5][9][18][28] and refereed articles [10][16] related to Phase 1 of the study have been published. The first volume in the Phase 2 reporting series provides great detail about the methods used for development and dissemination of the survey [17], serving as a research roadmap for future researchers in this space. Additionally, the results from Phase 1 *and* Phase 2 are publicly available via a web-based query tool [27].

Despite the significant length of this report, the data contained herein is by no means exhaustive. Although a large portion of the survey data is presented in detail, there are other devices and technologies not discussed here that will be presented in future volumes. Other devices listed in the survey could be considered mobile, e.g., laptops, MDTs/MDCs, flip phones, and pagers, but were not within the scope of this report. Presentation of frequency of use and problems data for these additional devices is one important avenue for future work, as well as additional analyses. Additionally, this survey was geared primarily toward local jurisdictions; a focus for future research might be on federal entities, such as FEMA, who respond to very different types of events. This might mean focusing on the work of specific agencies, like FEMA, or on specific roles, like Emergency Managers, in order to identify device and software/application use and problems in that context. Another potential area of interest lies in ongoing survey research in this area. The design, development, and dissemination of the survey instrument for this project are clearly outlined in the Phase 2, Volume 1 report, providing a detailed and thorough roadmap for future researchers who are interested in pursuing this work. While this may be beyond the scope of the current NIST project, we hope that other researchers and entities will consider repeating the survey—either in part or in whole—to provide more opportunities for the voices of first responders in research that examines how their experiences with, and views of, technology change with time.

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Appendix A – Summary of Interview Methodology from Phase 1

This appendix provides a detailed summary of the interview methodology and protocol design, including information about the sampling, data collection, and analysis performed during the qualitative interview process. Extensive details about the interview protocol and methodology can be found in the Phase 1, Volume 1 report [5].

Qualitative research is an iterative process that focuses on the importance of participants' voices and perspectives throughout the research process. This process consistently returns to the research questions to inform future elements such as data collection and data analysis. The research design for Phase 1 began by developing research questions that would guide the work during the course of the project. This important formative stage of the research served as a foundation and provided a focus for data collection and data analysis. Data collection and data analysis were conducted in tandem and occurred iteratively, each informing future iterations.

Sampling strategy

Purposive sampling was applied in the Phase 1 interviews in order to insure representation of first responders from all four first responder disciplines: COMMS, EMS, FF, and LE. Geographic diversity was also important and attention was paid to including first responders from urban, suburban, and rural areas. In addition, representation from different jurisdictional levels (local, county, and state) and different ranks were included, recognizing that their work, and the technology needed to accomplish that work, might vary. Demographic factors such as age, years of service, and gender were also considered when scheduling interviews. Phase 1 was also a convenience sample in that participants were often those who were available during data collection times and trips. There were 193 first responders interviewed for Phase 1.

Data collection and analysis

A semi-structured interview protocol was developed for use in Phase 1. Interview protocol questions fell into two main categories: 1) context of work and 2) perceptions of and experiences with communication and technology. Questions about context of work included descriptions of: their overall job, tasks, and daily routine; relationships with other people (their direct colleagues, other first responders, dispatch, the community, and the media, for example); and what work is like—both in and out of the station or specific work environment. Prior to beginning the interview, participants completed a short demographic questionnaire.

Analysis for Phase 1 began with coding of the interview transcripts. Qualitative coding is a process of labeling sections or chunks of narrative data that helps to reduce and/or reconfigure the data in an organized and meaningful way; it is the beginning of the analysis process. Phase 1 analysis began with the development of an *a priori* code list that came from the research questions, relevant literature, and an understanding of the communication and technology space in the first responder community. Each research team member used this list to code the same five randomly chosen transcripts. The goal was to identify where there was convergence and divergence amongst team member usage of the codes, as well as to identify codes that emerged from the data. Each team member then coded a subset of the remaining transcripts.

Qualitative analysis is the process of exploring relationships found in the data and amongst the codes to identify broader themes. Thematic analysis was used to identify themes that cut across the data. The team used tools like thematic analysis, analytic memoing, and negative case analysis in the Phase 1 analysis.

Appendix B – Summary of Nationwide Survey Methodology from Phase 2

The survey instrument methodology and design were highlighted in the Sec. 2 of this report; this appendix provides a more detailed summary about the sampling, dissemination, and instrument design of the survey. Extensive details about the survey instrument and survey methodology can be found in the Phase 2, Volume 1 report [17].

Sampling and Dissemination

In survey research, the target population represents the entire population of interest. The sampling frame is a subset of the target population who are contacted to participate in the survey. The sample is those individuals who ultimately participate in the survey (as not everyone who is contacted will actually choose to participate). The target population for this survey was first responders in the United States, including COMMS (911 call takers, dispatchers, and other communication specialists); Emergency Medical Services (EMS); Fire Service (FF); and Law Enforcement (LE). In order to reach first responders, outreach occurred at the department/agency level.

The sampling frame consisted of an online database that was purchased from a national public safety directory and data firm. Three different types of outreach occurred during survey dissemination: 1) emails sent to a general sample from the online database (including first responder departments/agencies in all 50 states and D.C.); 2) via previous points of contact within the public safety community; and 3) through a variety of different public safety organizations. Individuals contacted were asked to forward the request to as many of their personnel as possible, as well as to colleagues from other departments/agencies. The goal was to reach as many departments and agencies as possible, and through them to reach first responders, in order to have broad representation.

Survey Instrument

Two major categories of questions were used in the final survey instrument: the first section focused on day-to-day incident response and the second section focused on large events (major disasters or large planned events). Empirical evidence from Phase 1 showed that day-to-day operations were more prevalent for first responders [5][9][18][28], therefore greater emphasis was placed on these questions in the survey. However, it was also important to capture information from first responders who had worked in major disasters or other situations that that were different than the scope of their day-to-day operations (for example, large parades, concerts, or football games).

Survey questions about technology, including per-discipline customizations, were developed with careful and thorough review of the technology problems and requested functionality identified in Phase 1 interviews with first responders [9]. Throughout the survey, discipline-specific question framing was used where appropriate. For instance, the examples given for major disasters were tailored for each discipline (e.g., active shooter situation for LE, but mass casualty incident (MCI) for EMS).

Given the myriad of different types of communication technology used by first responders, decisions had to be made about which ones to include. Phase 1 qualitative interview data were key here to identifying what to include, with problems and requested functionality listed in the survey coming directly from the data in Volumes 1 and 2 [5][9]. In particular, the types of devices and apps/software utilized and needed were somewhat different for each discipline, along with the problems experienced. It became clear there would need to be four different surveys, tailored for each discipline. The goal was to not have first responders go through a list of technology that did not pertain to their work. This was part of the effort to keep the survey short out of respect for first responders and their time.

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 (see Fig. 68).

Fig. 68. Major survey components and flow

Surveys were nearly identical for EMS, FF, and LE (see Fig. 69), while differing somewhat more for COMMS (see Fig. 70), due to the different nature of their working environment [28]. For example, COMMS respondents were asked questions about call centers and Next Generation 911 (NG 911). More detailed descriptions of survey logic, branching, and all questions can be found in the preceding volume – Phase 2, Volume 1 [17].

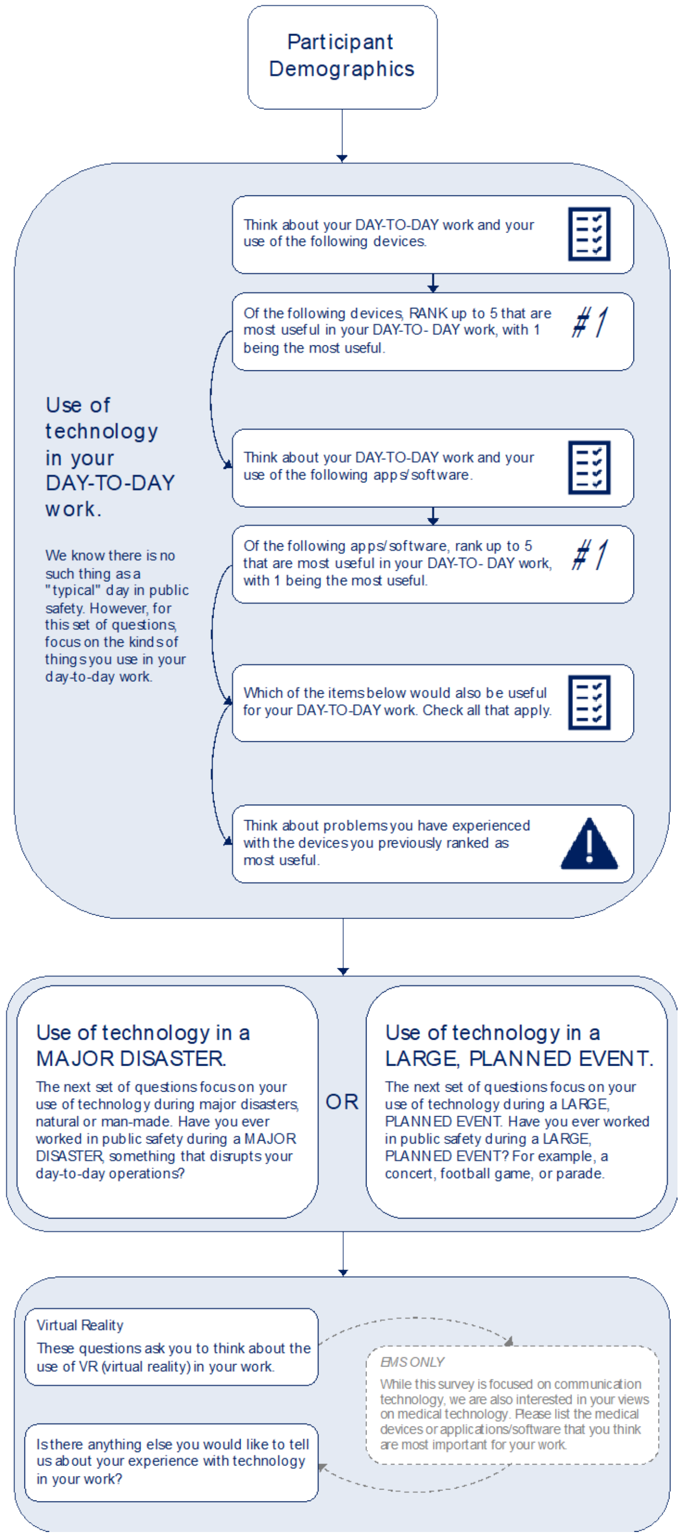

Fig. 69. Survey flow for EMS, FF, and LE

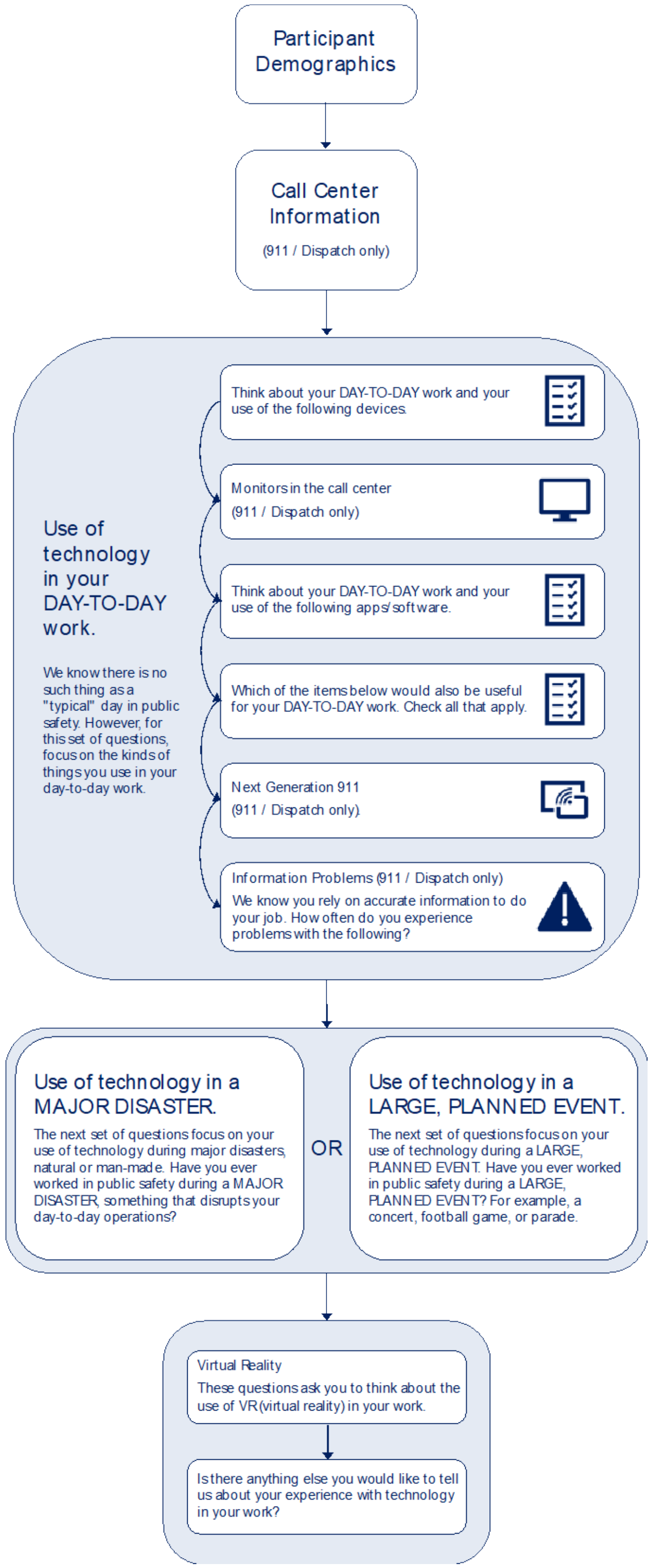

Fig. 70. Survey flow for COMMS

For all four disciplines, lists of technologies were used for questions about responders' day-to-day device use, day-to-day application/software use, future use of day-to-day devices, and technology use during major disasters/large planned events. For EMS, FF, and LE, lists of common problems were used for each device presented; a list of common problems with information was used for COMMS. All lists used in the survey were the result of a thorough review of the problems and requested functionality identified in the Phase 1 interviews with first responders. Survey respondents were asked to rank a subset of the devices listed; likewise for the list of applications/software. The logic for the survey question ranking devices, along with the logic for the list of devices included in the futuristic technology question, is shown in Fig. 71. Note that only EMS, FF, and LE were asked to rank their top 5 devices; COMMS were not asked to rank their top devices. All four disciplines were asked about the technology they though would be useful in the future.

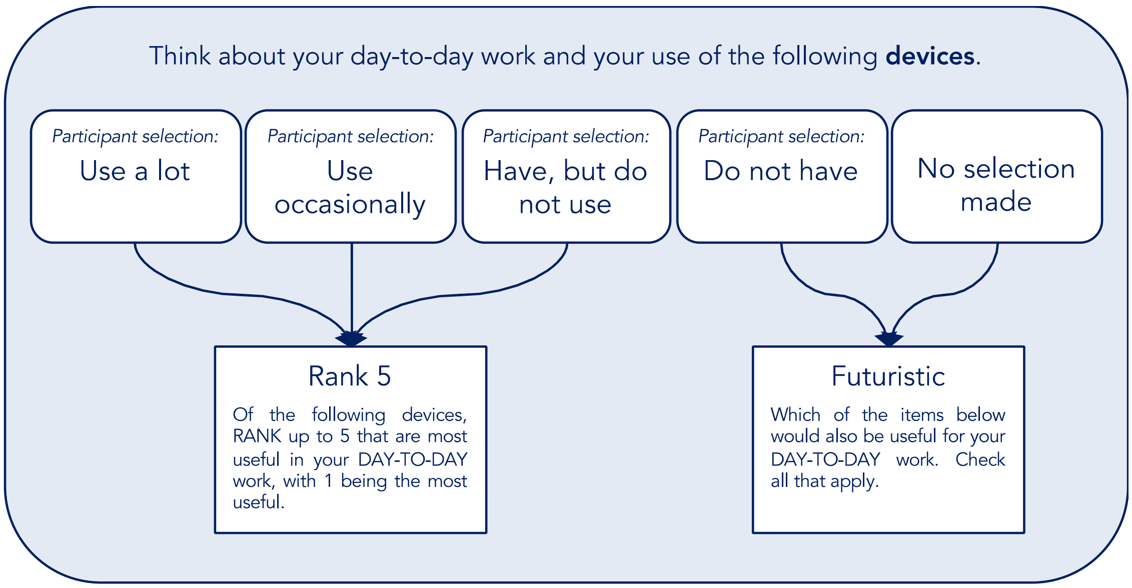

Fig. 71. Survey logic for day-to-day devices

The final questions in the day-to-day section were centered around problems first responders face with technology. Each of the devices included in the survey had a pre-determined list of common problems associated with the device (based on Phase 1 interview data). Note that EMS, FF, and LE were asked questions about problems with their top 3 ranked devices only. Rather than questions about device problems, COMMS were asked questions about information problems.

Lastly, a summary of the survey flow for large event technology questions is shown in Fig. 72. Survey respondents in all four disciplines were asked about their experiences with technology during major disasters *or* large planned events.

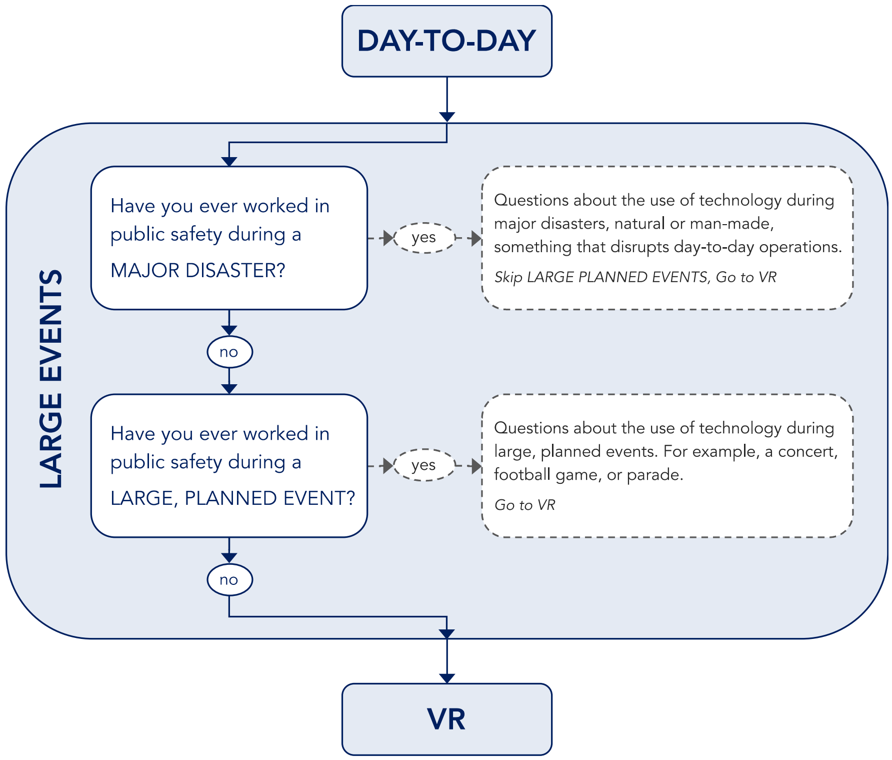

Fig. 72. Survey flow for large events

This publication is available free of charge from: https://doi.org/10.6028/NIST.IR.8314

Appendix C – Additional Nationwide Survey Demographics

The figures included this appendix were originally published in Phase 2, Volume 1 of this project [17]. As such, detailed discussions about the demographics portrayed here can be found in that report.

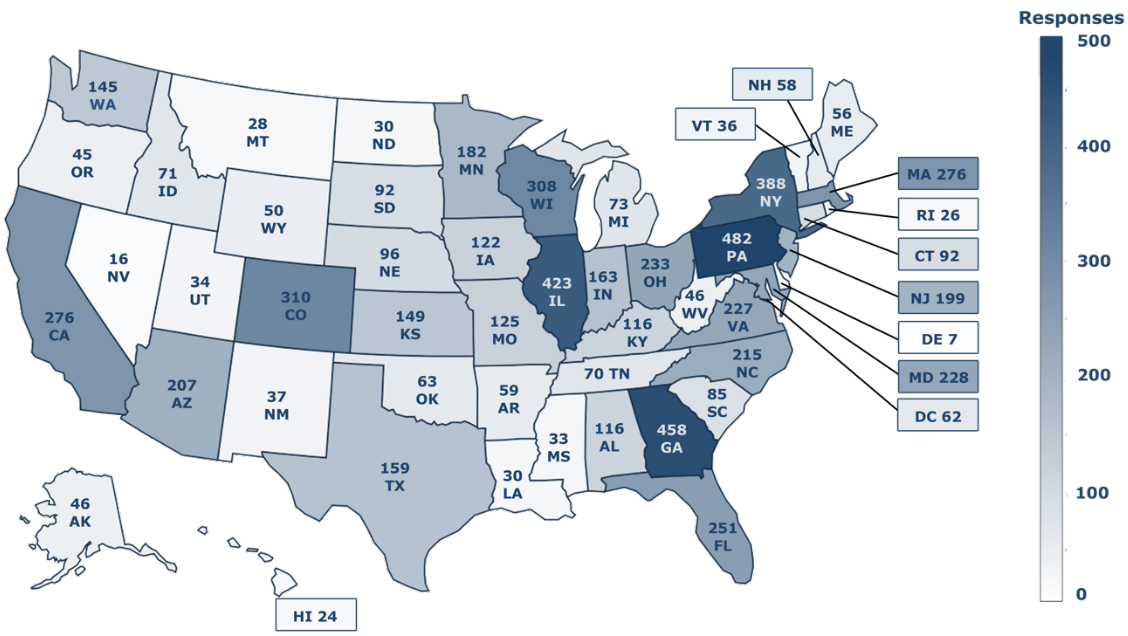

Fig. 73. Heatmap of number of participants who completed the survey, by state

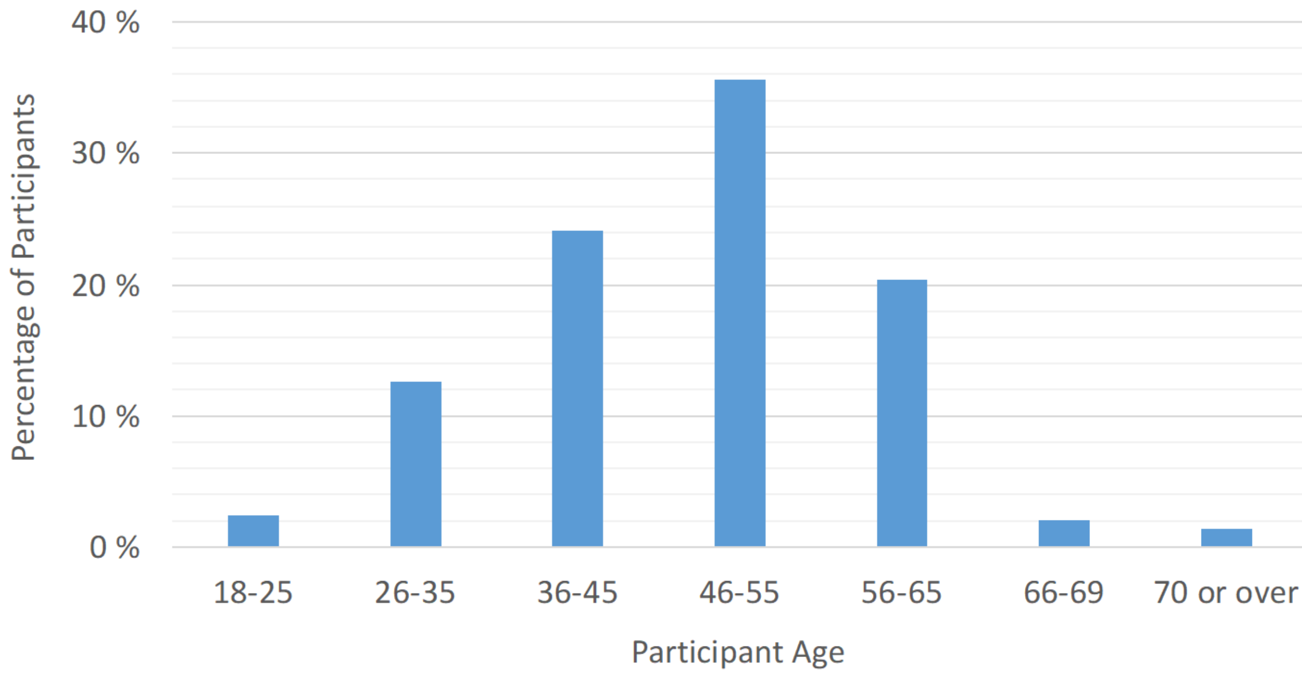

Fig. 74. Number of participants who completed the survey, by age *(n=7 092)*

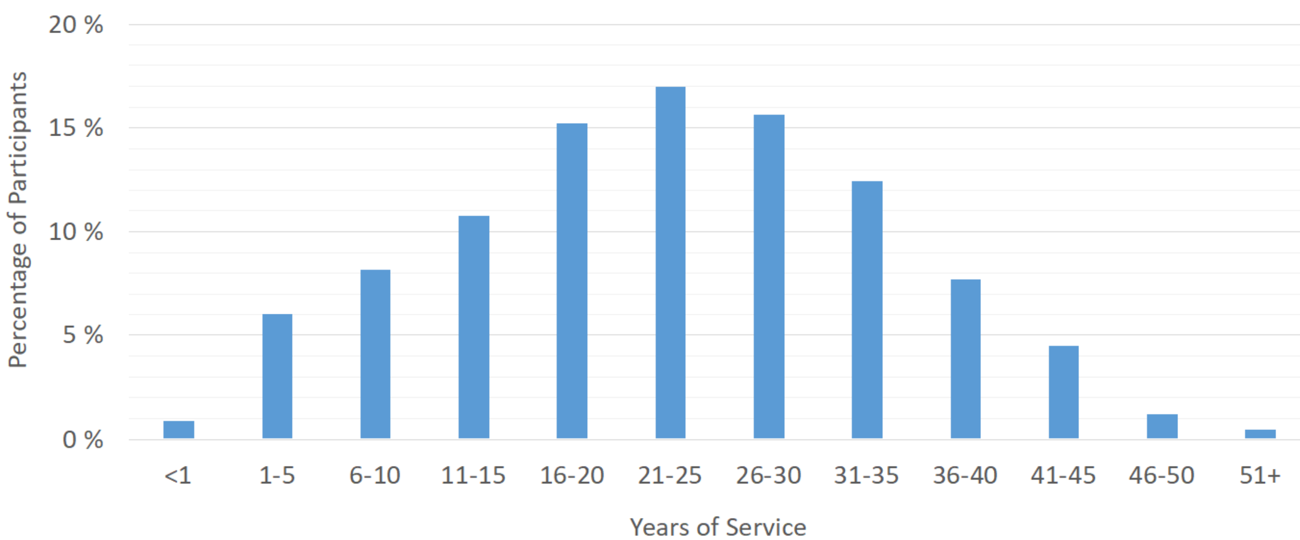

Fig. 75. Number of participants who completed the survey, by total years of service *(n=7 167)*

Overall, 80.86 % of the survey participants were male; 19.14 % were female (see Fig. 76). These percentages of male and female first responders are comparable to nationwide population of first responders [7][8][11][22].

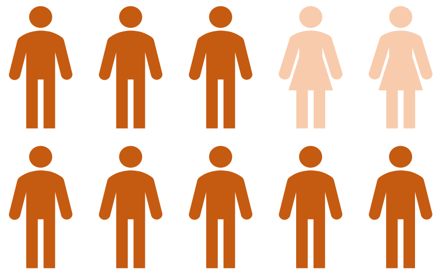

Fig. 76. Proportion of participants who completed the survey, by sex *(n=7 101)*

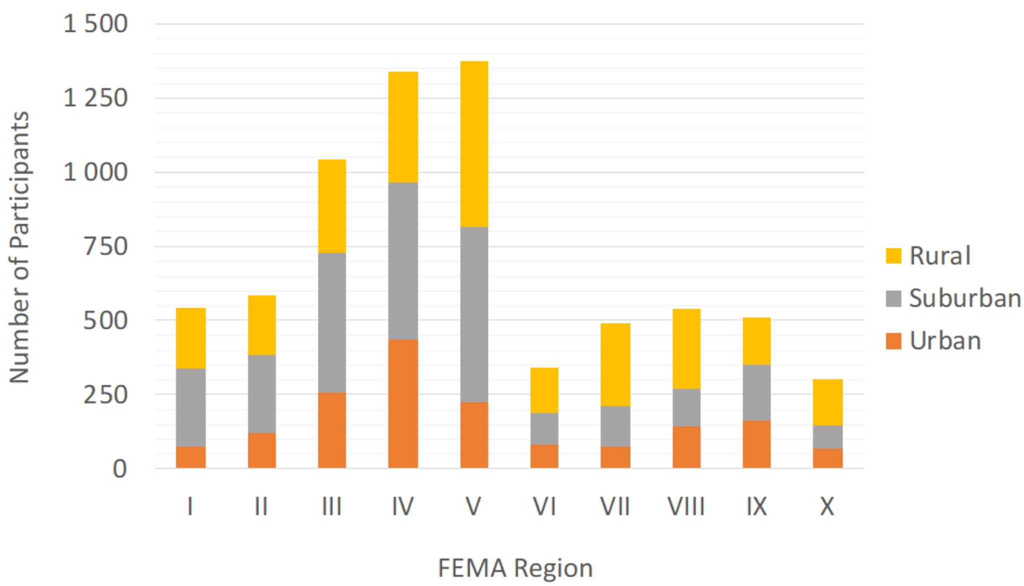

Fig. 77. Number of Participants who completed the survey, by FEMA Region and area type *(n=7 109)*

Appendix D – Total Responses Per Question

A total of 7 182 first responders completed the survey. However, as respondents were not required to answer every question, the total number of participants who responded to each question varied. This appendix lists the total percentages for responses to the questions presented in the Discipline-Specific Demographics section (Sec. 3.1.2) and Results section (Sec. 4) of this report. Results for the survey demographics questions are shown in Tables 30 through 34; mobile device use and problems survey questions in Tables 35 – 46; applications/software survey questions in Tables 47 – 54; futuristic survey questions in Tables 55 – 59; survey questions on large events in Tables 60 – 65; and VR survey questions in Tables 66 – 68. Most tables in this appendix present results from survey questions with multiple response options; these tables also include the total number of first responders, *n*, who answered each question. For survey questions where there was a single response option (e.g., open-ended questions), the tables include the total number, *n_asked*, of participants asked the question. Where *n* or *n_asked* is the same for each question asked (i.e., Table 58), the *n* or *n_asked* is referenced in the caption of the table. All technologies are listed alphabetically unless otherwise noted.

Table 30 Demographics question results: Area

	Urban	Suburban	Rural	Tribal	*n*
COMMS	22.13 %	36.69 %	40.99 %	0.19 %	*1 559*
EMS	14.92 %	29.84 %	54.45 %	0.78 %	*898*
FF	23.96 %	41.64 %	34.14 %	0.27 %	*2 613*
LE	26.78 %	40.27 %	32.42 %	0.53 %	*2 091*
Total	23.25 %	38.68 %	37.68 %	0.39 %	*7 161*

Table 31 Demographics question results: Jurisdiction

	Local	County	State	Federal	Tribal	*n*
COMMS	37.48 %	59.30 %	2.38 %	0.64 %	0.19 %	*1 553*
EMS	60.83 %	28.51 %	9.20 %	0.67 %	0.79 %	*891*
FF	76.56 %	20.48 %	1.88 %	0.84 %	0.23 %	*2 607*
LE	67.96 %	27.78 %	2.78 %	1.20 %	0.29 %	*2 088*
Total	63.58 %	32.06 %	3.17 %	0.88 %	0.31 %	*7 139*

Table 32 Demographics question results: Age

(in years)	COMMS	EMS	FF	LE	Total
18-25	3.36 %	5.84 %	1.46 %	1.50 %	2.41 %
26-35	18.56 %	13.93 %	10.90 %	10.29 %	12.61 %
36-45	28.01 %	22.47 %	23.19 %	24.27 %	24.16 %
46-55	31.69 %	26.97 %	36.75 %	42.67 %	35.69 %
56-65	16.88 %	23.82 %	23.19 %	18.83 %	20.37 %
66-69	0.97 %	3.71 %	2.54 %	1.75 %	2.09 %
70 or over	0.52 %	3.26 %	1.96 %	0.68 %	1.42 %
n	*1 546*	*890*	*2 596*	*2 060*	*7 092*

Table 33 Demographics question results: Total years of service

(in years)	COMMS	EMS	FF	LE	Total
< 1	2.11 %	0.67 %	0.54 %	0.48 %	0.88 %
1-5	10.63 %	10.47 %	2.91 %	4.54 %	6.00 %
6-10	12.49 %	11.58 %	5.24 %	7.07 %	8.13 %
11-15	14.86 %	11.25 %	8.95 %	9.74 %	10.74 %
16-20	15.25 %	12.36 %	14.88 %	16.81 %	15.18 %
21-25	17.62 %	13.47 %	15.80 %	19.53 %	16.96 %
26-30	12.81 %	13.03 %	16.72 %	17.53 %	15.61 %
31-35	8.01 %	11.69 %	14.80 %	13.23 %	12.45 %
36-40	4.16 %	8.24 %	10.41 %	6.73 %	7.69 %
41-45	1.54 %	5.46 %	6.81 %	3.34 %	4.47 %
46-50	0.38 %	1.45 %	2.07 %	0.72 %	1.23 %
51 +	0.13 %	0.33 %	0.88 %	0.29 %	0.47 %
n	*1 561*	*898*	*2 614*	*2 094*	*7 167*

Table 34 Demographics question results: Gender

	Male	Female	*n*
COMMS	43.88 %	56.12 %	*1 545*
EMS	78.39 %	21.61 %	*893*
FF	97.26 %	2.74 %	*2 592*
LE	88.99 %	11.01 %	*2 071*
Total	80.86 %	19.14 %	*7 101*

Table 35 Mobile device frequency of use question results: "Smartphone: personal"

	Use a lot	Use occasionally	Have, but do not use	Do not have	*n*
COMMS	47.66 %	24.58 %	16.38 %	11.38 %	*1 538*
EMS	84.20 %	5.30 %	1.35 %	9.14 %	*886*
FF	81.33 %	6.30 %	1.28 %	11.09 %	*2 571*
LE	73.00 %	6.90 %	3.30 %	16.80 %	*2 030*
Total	71.91 %	10.35 %	5.18 %	12.56 %	*7 025*

Table 36 Mobile device frequency of use question results: "Smartphone: work issued"

	Use a lot	Use occasionally	Have, but do not use	Do not have	*n*
COMMS	31.36 %	9.55 %	3.05 %	56.04 %	*1 540*
EMS	27.19 %	5.57 %	1.48 %	65.76 %	*879*
FF	38.02 %	7.86 %	2.28 %	51.85 %	*2 546*
LE	54.51 %	6.48 %	1.51 %	37.51 %	*2 053*
Total	40.03 %	7.54 %	2.12 %	50.31 %	*7 018*

Table 37 Mobile device frequency of use question results: "Tablet"

	Use a lot	Use occasionally	Have, but do not use	Do not have	*n*
EMS	35.89 %	24.04 %	5.08 %	34.99 %	*886*
FF	35.04 %	28.55 %	5.28 %	31.13 %	*2 557*
LE	16.49 %	15.02 %	3.78 %	64.70 %	*2 037*
Total	28.28 %	22.79 %	4.69 %	44.23 %	*5 480*

Table 38 Mobile device frequency of use question results, open-ended

	Number of mobile device-related responses	Percentage of open-ended responses	Total number of open-ended responses	Percentage of total survey participants	*Total number of survey participants (n_asked)*
COMMS	14	13.73 %	102	0.90 %	*1 564*
EMS	12	32.43 %	37	1.33 %	*902*
FF	20	23.26 %	86	0.76 %	*2 617*
LE	8	15.38 %	52	0.38 %	*2 099*
Total	54	19.49 %	277	0.75 %	*7 182*

Table 39 Problems question results, EMS: "Smartphone"

	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Battery life	11.02 %	17.25 %	44.57 %	21.09 %	5.59 %	0.48 %	*626*
Coverage/dead zones	10.24 %	12.32 %	52.48 %	20.96 %	3.68 %	0.32 %	*625*
Data plans/data limits	7.35 %	7.99 %	22.20 %	29.23 %	27.80 %	5.43 %	*626*
Dropped calls	5.10 %	6.69 %	47.93 %	33.92 %	5.41 %	0.96 %	*628*
Durability	5.89 %	10.67 %	35.35 %	34.71 %	12.10 %	1.27 %	*628*
Glare	3.36 %	11.20 %	39.04 %	30.72 %	13.12 %	2.56 %	*625*
Interoperability	3.70 %	6.27 %	21.38 %	33.28 %	23.79 %	11.58 %	*622*
Logging in	8.29 %	7.81 %	27.11 %	31.26 %	20.10 %	5.42 %	*627*
Outdated/old	2.89 %	6.10 %	25.36 %	28.73 %	28.25 %	8.67 %	*623*
Permission/access to apps	3.86 %	6.92 %	25.44 %	29.79 %	27.86 %	6.12 %	*621*
Policies about usage	2.57 %	4.82 %	21.19 %	31.46 %	31.46 %	8.51 %	*623*
Price: too expensive	25.93 %	25.12 %	23.35 %	10.31 %	9.66 %	5.64 %	*621*
Subpoena possibility (personal)	9.66 %	5.31 %	12.56 %	19.97 %	39.61 %	12.88 %	*621*
Subsidy (personal)	23.84 %	5.92 %	9.60 %	10.40 %	23.84 %	26.40 %	*625*

Table 40 Problems question results, FF: "Smartphone"

	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Battery life	8.14 %	15.19 %	49.19 %	22.66 %	4.28 %	0.54 %	*1 659*
Coverage/dead zones	6.63 %	8.38 %	51.99 %	28.71 %	3.68 %	0.60 %	*1 658*
Data plans/data limits	4.96 %	6.89 %	24.12 %	33.13 %	26.90 %	3.99 %	*1 654*
Dropped calls	3.30 %	4.14 %	43.73 %	42.05 %	5.70 %	1.08 %	*1 667*
Durability	4.89 %	10.27 %	34.62 %	37.58 %	11.54 %	1.09 %	*1 655*
Glare	3.20 %	9.12 %	42.27 %	33.70 %	10.33 %	1.39 %	*1 656*
Logging in	5.95 %	9.50 %	36.66 %	32.75 %	12.62 %	2.52 %	*1 664*
Outdated/old	1.81 %	4.75 %	26.84 %	38.33 %	20.88 %	7.40 %	*1 662*
Permission/access to apps	2.18 %	5.22 %	29.79 %	38.90 %	19.42 %	4.49 %	*1 648*
Policies about usage	2.19 %	5.29 %	18.72 %	37.63 %	27.78 %	8.39 %	*1 645*
Price: too expensive	24.07 %	22.86 %	23.94 %	14.60 %	8.44 %	6.09 %	*1 658*
Subpoena possibility (personal)	10.53 %	7.26 %	14.16 %	19.67 %	37.71 %	10.65 %	*1 652*
Subsidy (personal)	18.04 %	5.24 %	10.30 %	10.30 %	24.92 %	31.20 %	*1 641*

Table 41 Problems question results, LE: "Smartphone"

	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Battery life	6.45 %	14.20 %	46.37 %	25.22 %	7.02 %	0.73 %	*1 225*
Coverage/dead zones	4.32 %	6.20 %	48.78 %	33.36 %	5.87 %	1.47 %	*1 226*
Data plans/data limits	3.20 %	4.68 %	18.57 %	30.40 %	37.06 %	6.08 %	*1 217*
Dropped calls	2.03 %	3.97 %	40.47 %	44.28 %	7.87 %	1.38 %	*1 233*
Durability	3.02 %	8.24 %	30.45 %	39.67 %	16.82 %	1.80 %	*1 225*
Glare	1.56 %	5.25 %	34.48 %	38.18 %	18.23 %	2.30 %	*1 218*
Logging in	3.27 %	8.27 %	35.43 %	33.63 %	17.10 %	2.29 %	*1 222*
Outdated/old	2.12 %	6.19 %	21.03 %	38.14 %	25.67 %	6.85 %	*1 227*
Permission/access to apps	2.95 %	5.49 %	22.52 %	38.00 %	25.88 %	5.16 %	*1 221*

	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Policies about usage	3.03 %	5.07 %	16.20 %	36.66 %	32.65 %	6.38 %	*1 222*
Price: too expensive	15.60 %	18.79 %	22.96 %	15.20 %	16.58 %	10.87 %	*1 224*
Subpoena possibility (personal)	12.55 %	5.74 %	14.85 %	20.18 %	34.78 %	11.89 %	*1 219*
Subsidy (personal)	14.70 %	4.93 %	8.05 %	10.34 %	26.11 %	35.88 %	*1 218*

Table 42 Problems question results, open-ended: "Smartphone"

	% of Respondents	*n_asked*
EMS	8.59 %	*675*
FF	7.32 %	*1 804*
LE	6.21 %	*1 352*
Total	7.15 %	*3 831*

Table 43 Problems question results, EMS: "Tablet"

	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Battery life	9.90 %	14.85 %	35.64 %	26.73 %	11.88 %	0.99 %	*101*
Durability	8.91 %	10.89 %	32.67 %	27.72 %	17.82 %	1.98 %	*101*
Glare	7.84 %	5.88 %	43.14 %	27.45 %	13.73 %	1.96 %	*102*
Internet connection	6.86 %	13.73 %	58.82 %	10.78 %	7.84 %	1.96 %	*102*
Interoperability	5.94 %	7.92 %	32.67 %	20.79 %	18.81 %	13.86 %	*101*
Logins/passwords	11.76 %	3.92 %	31.37 %	32.35 %	16.67 %	3.92 %	*102*
Report writing	9.80 %	12.75 %	28.43 %	32.35 %	9.80 %	6.86 %	*102*
Size/bulkiness	1.96 %	3.92 %	15.69 %	38.24 %	34.31 %	5.88 %	*102*
Touchscreen	4.90 %	4.90 %	37.25 %	28.43 %	21.57 %	2.94 %	*102*
Weight	0.00 %	1.96 %	15.69 %	42.16 %	37.25 %	2.94 %	*102*

Table 44 Problems question results, FF: "Tablet"

	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Battery life	3.86 %	9.27 %	40.54 %	33.59 %	11.97 %	0.77 %	*259*
Durability	5.38 %	8.46 %	30.77 %	38.85 %	15.77 %	0.77 %	*260*
Glare	3.85 %	9.23 %	46.15 %	29.62 %	10.38 %	0.77 %	*260*
Internet connection	5.38 %	11.92 %	48.85 %	27.69 %	4.23 %	1.92 %	*260*
Interoperability	4.23 %	8.46 %	34.23 %	33.08 %	13.08 %	6.92 %	*260*
Logins/passwords	5.81 %	6.59 %	39.92 %	31.78 %	13.57 %	2.33 %	*258*
Report writing	2.71 %	8.53 %	29.46 %	32.56 %	13.57 %	13.18 %	*258*
Size/bulkiness	1.15 %	3.46 %	15.77 %	41.54 %	36.15 %	1.92 %	*260*
Touchscreen	2.31 %	2.69 %	25.77 %	38.08 %	30.38 %	0.77 %	*260*
Weight	0.00 %	2.71 %	10.85 %	38.37 %	46.12 %	1.94 %	*258*

Table 45 Problems question results, LE: "Tablet"

	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Battery life	1.22 %	6.10 %	34.15 %	35.37 %	23.17 %	0.00 %	*82*
Durability	3.61 %	4.82 %	20.48 %	34.94 %	36.14 %	0.00 %	*83*
Glare	0.00 %	8.54 %	31.71 %	30.49 %	29.27 %	0.00 %	*82*
Internet connection	1.22 %	3.66 %	37.80 %	47.56 %	9.76 %	0.00 %	*82*
Interoperability	1.22 %	4.88 %	21.95 %	45.12 %	21.95 %	4.88 %	*82*
Logins/passwords	4.88 %	6.10 %	21.95 %	48.78 %	17.07 %	1.22 %	*82*
Outdated/old	3.61 %	2.41 %	12.05 %	44.58 %	30.12 %	7.23 %	*83*
Price: too expensive	12.05 %	12.05 %	22.89 %	21.69 %	15.66 %	15.66 %	*83*
Report writing	1.20 %	3.61 %	21.69 %	31.33 %	22.89 %	19.28 %	*83*
Size/bulkiness	0.00 %	2.41 %	6.02 %	36.14 %	51.81 %	3.61 %	*83*
Touchscreen	0.00 %	3.61 %	8.43 %	44.58 %	39.76 %	3.61 %	*83*
Weight	0.00 %	0.00 %	4.94 %	37.04 %	55.56 %	2.47 %	*81*

Table 46 Problems question results, open-ended: "Tablet"

	% of Respondents	***n_asked***
EMS	10.48 %	*124*
FF	7.95 %	*302*
LE	7.14 %	*98*
Total	8.40 %	*524*

Table 47 Applications/software frequency of use question results, COMMS

	Use a lot	**Use occasionally**	**Have, but do not use**	**Do not have**	***n***
CAD (computer-aided dispatch)	92.89 %	3.23 %	1.16 %	2.71 %	*1 548*
Criminal databases	70.23 %	13.97 %	4.50 %	11.29 %	*1 532*
Electronic policies/laws	37.34 %	41.99 %	6.87 %	13.80 %	*1 529*
Email	84.36 %	13.94 %	0.91 %	0.78 %	*1 535*
Emergency notification system (for informing the public)	17.33 %	50.94 %	13.16 %	18.57 %	*1 535*
First responder vehicle tracking	48.35 %	13.29 %	5.31 %	33.05 %	*1 543*
Language translation	22.36 %	53.92 %	9.14 %	14.58 %	*1 543*
Mapping/driving directions	58.85 %	24.56 %	5.64 %	10.95 %	*1 543*
RMS (records management system)	60.60 %	15.46 %	9.52 %	14.42 %	*1 533*
Traffic apps/software	10.84 %	23.56 %	7.79 %	57.82 %	*1 541*
Weather apps/software	22.81 %	36.42 %	5.31 %	35.45 %	*1 543*

Table 48 Applications/software frequency of use question results, EMS

	Use a lot	Use occasionally	Have, but do not use	Do not have	*n*
AED (automatic external defibrillator) locator	10.71 %	38.56 %	16.35 %	34.39 %	*887*
CAD (computer-aided dispatch)	59.41 %	9.75 %	3.51 %	27.32 %	*882*
Email	90.83 %	6.68 %	1.36 %	1.13 %	*883*
EPCR (electronic patient care reporting)	79.53 %	5.15 %	3.24 %	12.08 %	*894*
ERG (emergency response guide)	10.25 %	58.00 %	21.06 %	10.70 %	*888*
First responder vehicle tracking	27.82 %	12.16 %	8.22 %	51.80 %	*888*
Mapping/driving directions	57.43 %	24.02 %	4.69 %	13.85 %	*895*
Medication/drug identification or interaction	27.18 %	37.14 %	10.40 %	25.28 %	*894*
Report writing software (other than patient care reports)	27.98 %	13.60 %	6.40 %	59.55 %	*890*
RMS (records management system)	20.73 %	14.92 %	7.74 %	48.97 %	*878*
Traffic apps/software	18.45 %	19.91 %	7.42 %	54.22 %	*889*
Weather apps/software	37.14 %	33.45 %	4.81 %	24.61 %	*894*

Table 49 Applications/software frequency of use question results, FF

	Use a lot	Use occasionally	Have, but do not use	Do not have	*n*
CAD (computer-aided dispatch)	57.83 %	17.48 %	3.91 %	20.78 %	*2 580*
Email	91.09 %	7.86 %	0.46 %	0.58 %	*2 582*
EPCR (electronic patient care reporting)	30.15 %	18.49 %	13.85 %	37.52 %	*2 564*
ERG (emergency response guide)	3.44 %	71.37 %	19.98 %	5.22 %	*2 588*
Hazmat (guides or operating procedures)	4.04 %	68.23 %	21.09 %	6.64 %	*2 575*
Hydrant location	29.48 %	50.17 %	8.52 %	11.82 %	*2 605*
Language translation	0.85 %	19.32 %	24.54 %	55.29 %	*2 588*
Mapping/driving directions	47.25 %	38.69 %	6.76 %	7.30 %	*2 603*
Pre-plan software	12.90 %	39.88 %	12.08 %	35.14 %	*2 590*

	Use a lot	Use occasionally	Have, but do not use	Do not have	*n*
Report writing software	42.65 %	22.75 %	6.86 %	27.73 %	*2 593*
RMS (records management system)	40.18 %	25.37 %	9.05 %	25.41 %	*2 586*
Traffic apps/software	8.55 %	26.75 %	9.97 %	54.73 %	*2 598*
Weather apps/software	28.95 %	45.10 %	5.59 %	20.35 %	*2 594*

Table 50 Applications/software frequency of use question results, LE

	Use a lot	Use occasionally	Have, but do not use	Do not have	*n*
CAD (computer-aided dispatch)	59.21 %	19.91 %	6.41 %	14.46 %	*2 074*
Criminal databases	52.18 %	37.43 %	5.10 %	5.29 %	*2 060*
Electronic policies/laws	39.88 %	47.40 %	4.51 %	8.20 %	*2 061*
Email	93.83 %	5.79 %	0.19 %	0.19 %	*2 073*
First responder vehicle tracking	13.15 %	25.19 %	12.86 %	48.79 %	*2 068*
Language translation	1.60 %	25.90 %	22.89 %	49.61 %	*2 058*
Mapping/driving directions	21.90 %	46.96 %	12.02 %	19.12 %	*2 055*
Report writing software	49.95 %	19.67 %	6.56 %	23.82 %	*2 074*
RMS (records management system)	67.50 %	19.21 %	4.38 %	8.91 %	*2 077*
Traffic apps/software	16.25 %	24.05 %	12.08 %	47.62 %	*2 062*
Weather apps/software	18.44 %	43.37 %	7.60 %	30.59 %	*2 066*

Table 51 Applications/software frequency of use question results, open-ended

	% of Respondents	*n_asked*
COMMS	4.03 %	*1 564*
EMS	2.55 %	*902*
FF	2.56 %	*2 617*
LE	1.10 %	*2 099*
Total	2.45 %	*7 182*

Table 52 Applications/software ranking question results, EMS

	1st	2nd	3rd	4th	5th	Not in top 5	*n*
AED (automatic external defibrillator) locator	6.20 %	6.39 %	7.48 %	12.41 %	9.12 %	58.39 %	*548*
CAD (computer-aided dispatch)	34.53 %	24.43 %	16.78 %	6.84 %	5.05 %	12.38 %	*614*
Email	44.68 %	15.37 %	12.77 %	10.40 %	7.21 %	9.57 %	*846*
EPCR (electronic patient care reporting)	23.02 %	34.66 %	18.39 %	9.39 %	3.57 %	10.98 %	*756*
ERG (emergency response guide)	0.27 %	2.04 %	4.21 %	7.87 %	12.89 %	72.73 %	*737*
First responder vehicle tracking	1.50 %	8.50 %	16.25 %	13.00 %	9.50 %	51.25 %	*400*
Mapping/driving directions	6.40 %	18.12 %	22.34 %	21.80 %	12.81 %	18.53 %	*734*
Medication/drug identification or interaction	1.77 %	3.54 %	9.16 %	12.38 %	14.15 %	59.00 %	*622*
RMS (records management system)	1.20 %	4.56 %	7.67 %	9.59 %	10.79 %	66.19 %	*417*
Report writing software (other than patient care reports)	0.88 %	5.90 %	10.32 %	9.73 %	13.86 %	59.29 %	*339*
Traffic apps/software	0.26 %	4.36 %	6.41 %	8.97 %	13.33 %	66.67 %	*390*
Weather apps/software	1.71 %	5.59 %	9.16 %	14.13 %	20.34 %	49.07 %	*644*

Table 53 Applications/software ranking question results, FF

	1st	2nd	3rd	4th	5th	Not in top 5	*n*
CAD (computer-aided dispatch)	36.84 %	30.16 %	11.94 %	6.28 %	3.69 %	11.08 %	*1 976*
Email	59.72 %	14.44 %	8.04 %	5.88 %	5.08 %	6.84 %	*2 500*
EPCR (electronic patient care reporting)	3.32 %	14.56 %	16.25 %	11.18 %	8.84 %	45.84 %	*1 538*
ERG (emergency response guide)	0.26 %	1.66 %	3.79 %	6.71 %	9.98 %	77.60 %	*2 295*
Hazmat (guides or operating procedures)	0.18 %	0.62 %	2.53 %	4.75 %	7.50 %	84.41 %	*2 252*
Hydrant location	1.60 %	6.28 %	13.02 %	14.76 %	12.56 %	51.79 %	*2 182*
Language translation	0.09 %	0.09 %	0.82 %	1.74 %	2.11 %	95.14 %	*1 091*
Mapping/driving directions	5.06 %	19.59 %	22.75 %	16.96 %	11.25 %	24.39 %	*2 312*
Pre-plan software	0.57 %	2.08 %	6.63 %	9.66 %	13.51 %	67.55 %	*1 584*

	1st	2nd	3rd	4th	5th	Not in top 5	*n*
RMS (records management system)	2.45 %	15.27 %	14.57 %	12.61 %	10.33 %	44.78 %	*1 840*
Report writing software	2.46 %	11.26 %	12.89 %	15.57 %	12.55 %	45.27 %	*1 785*
Traffic apps/software	0.36 %	1.96 %	3.39 %	6.77 %	8.20 %	79.32 %	*1 122*
Weather apps/software	1.22 %	8.78 %	10.71 %	13.39 %	16.89 %	49.01 %	*1 971*

Table 54 Applications/software ranking question results, LE

	1st	2nd	3rd	4th	5th	Not in top 5	*n*
CAD (computer-aided dispatch)	39.91 %	17.53 %	13.61 %	10.96 %	6.75 %	11.25 %	*1 734*
Criminal databases	7.18 %	17.91 %	18.33 %	20.02 %	15.00 %	21.55 %	*1 893*
Electronic policies/laws	1.04 %	9.23 %	11.37 %	15.52 %	18.58 %	44.26 %	*1 830*
Email	44.06 %	18.03 %	14.69 %	10.02 %	7.56 %	5.65 %	*2 036*
First responder vehicle tracking	0.59 %	1.97 %	4.15 %	7.31 %	8.59 %	77.39 %	*1 013*
Language translation	0.00 %	0.40 %	1.01 %	1.72 %	5.45 %	91.42 %	*991*
Mapping/driving directions	0.99 %	5.97 %	8.27 %	10.63 %	13.74 %	60.41 %	*1 609*
Report writing software	13.40 %	26.80 %	21.34 %	15.13 %	8.75 %	14.59 %	*1 851*
RMS (records management system)	3.40 %	13.93 %	17.72 %	16.29 %	13.34 %	35.32 %	*1 529*
Traffic apps/software	0.10 %	1.83 %	3.94 %	6.54 %	6.54 %	81.06 %	*1 040*
Weather apps/software	0.15 %	2.10 %	3.63 %	5.29 %	13.56 %	75.27 %	*1 379*

Table 55 Futuristic technology results, preset list

Technology	COMMS *n_asked = 1 564*	EMS *n_asked = 902*	FF *n_asked = 2 617*	LE *n_asked = 2 099*
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 56 Futuristic technology results, piped forward list

Technology	COMMS	EMS	FF	LE
Body camera				31.96 % *n_asked = 1 214*
Computer: desktop	38.46 % *n_asked = 26*	11.65 % *n_asked = 103*	9.58 % *n_asked = 240*	19.39 % *n_asked = 196*
Computer: laptop		31.62 % *n_asked = 136*	35.93 % *n_asked = 501*	38.66 % *n_asked = 476*
Dash camera				25.43 % *n_asked = 1 266*
Earpiece: wireless (self purchased)		3.03 % *n_asked = 661*	9.32 % *n_asked = 1 931*	4.67 % *n_asked = 1 799*
Earpiece: wireless (work issued)		21.67 % *n_asked = 812*	28.95 % *n_asked = 2 297*	34.74 % *n_asked = 1 802*
Earpiece: with cord		4.47 % *n_asked = 694*	4.81 % *n_asked = 1 890*	6.63 % *n_asked = 1 147*
Fingerprint scanner				45.59 % *n_asked = 1 349*
Flip phone: work issued		2.66 % *n_asked = 788*	1.77 % *n_asked = 2 369*	2.47 % *n_asked = 1 906*
Foot pedal	10.87 % *n_asked = 276*			
Headset	32.47 % *n_asked = 231*			
License plate reader				46.11 % *n_asked = 1 644*
MDT/MDC (mobile data terminal/computer)		32.95 % *n_asked = 516*	38.98 % *n_asked = 1 116*	28.46 % *n_asked = 615*
Microphone: desktop	7.16 % *n_asked = 433*			
Microphone: handheld or clip-on	9.08 % *n_asked = 859*			
Mic: wireless		15.04 % *n_asked = 791*	19.50 % *n_asked = 2 251*	19.40 % *n_asked = 1 696*
Mic: with cord		4.33 % *n_asked = 393*	3.46 % *n_asked = 752*	3.08 % *n_asked = 746*

Technology	COMMS	EMS	FF	LE
Monitor (at your personal workstation)	**25.00 %** ***n_asked = 56***			
Monitor (for shared viewing)	20.46 % *n_asked = 391*			
Pager	1.33 % *n_asked = 1 125*	6.27 % *n_asked = 383*	2.97 % *n_asked = 1 178*	0.55 % *n_asked = 2 002*
Phone: landline	16.67 % *n_asked = 42*			
Radio	11.94 % *n_asked = 67*			
Radio: in-vehicle		21.62 % *n_asked = 111*	35.68 % *n_asked = 213*	24.38 % *n_asked = 320*
Radio: portable		32.79 % *n_asked = 61*	34.88 % *n_asked = 43*	11.83 % *n_asked = 93*
Smartphone: personal	8.96 % *n_asked = 201*	13.4 % *n_asked = 97*	19.34 % *n_asked = 331*	8.05 % *n_asked = 410*
Smartphone: work issued	21.08 % *n_asked = 887*	31.11 % *n_asked = 601*	30.41 % *n_asked = 1 391*	39.34 % *n_asked = 816*
Tablet		36.50 % *n_asked = 326*	33.88 % *n_asked = 856*	23.33 % *n_asked = 1 380*
TIC (thermal imaging camera)			27.15 % *n_asked = 291*	

Table 57 Futuristic COMMS results: Call center information

		Yes	No	Not sure	*n*
Receiving Texts	Can your call center receive 9-1-1 text messages from the public?	54.34 %	43.22 %	2.44 %	*1 557*
	Do you think this is/would be beneficial for your job?	74.27 %	9.59 %	16.14 %	*1 543*
Receiving pictures/ videos	Can your call center receive pictures and/or video from the public?	9.48 %	84.77 %	5.74 %	*1 550*
	Do you think this is/would be beneficial for your job?	52.61 %	18.72 %	28.66 %	*1 549*
Audio recorded calls	Does your call center audio record calls?	97.95 %	1.28 %	0.77 %	*1 559*
	If yes, does your call center have problems with data storage?	5.47 %	72.70 %	21.83 %	*1 553*
	If yes, does your call center have problems with data retrieval?	4.85 %	74.80 %	20.35 %	*1 381*
9-1-1 down	Has 9-1-1 ever gone down in your call center	73.75 %	17.31 %	8.94 %	*1 554*

Table 58 Futuristic COMMS results, open-ended: Call center information *(n_asked = 1 564)*

Question	Percentage of COMMS Respondents
Texts Pros	78.96 %
Texts Cons	77.37 %
Pics/Videos Pros	64.45 %
Pics/Videos Cons	62.98 %
What caused 9-1-1 to go down?	70.20 %
What did you do while 9-1-1 was down?	71.29 %

Table 59 Futuristic COMMS results: NG 9-1-1

	Yes	No	Not sure	*n*
Have you ever heard of Next Generation 9-1-1?	89.72 %	8.03 %	2.25 %	*1 556*
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?	74.47 %	5.98 %	19.55 %	*1 555*

Table 60 Major disaster questions results

Question	Response Options	COMMS	EMS	FF	LE	Total
Worked during a major disaster?	Yes	68.26 %	63.71 %	57.21 %	65.28 %	62.78 %
	No	31.74 %	36.29 %	42.79 %	34.72 %	37.22 %
	n=	*1 550*	*890*	*2 599*	*2 068*	*7 107*
How similar or different is technology you use in a major disaster than the technology you use during your day-to-day work?	I use mostly the same technology.	84.57 %	80.88 %	74.22 %	82.48 %	80.02 %
	I use some of the same technology, with some specialized technology.	14.38 %	15.93 %	22.73 %	15.66 %	17.75 %
	I use very different technology.	1.05 %	3.19 %	3.04 %	1.86 %	2.23 %
	n=	*1 050*	*565*	*1 478*	*1 341*	*4 434*

Table 61 Major disaster questions results, open-ended

	Specialized Technology	Most Important Technology	*n_asked*
COMMS	28.73 %	48.30 %	*1 058*
EMS	30.69 %	59.61 %	*567*
FF	36.92 %	64.02 %	*1 112*
LE	30.15 %	59.63 %	*718*
Total	32.14 %	58.40 %	*4 462*

Table 62 Major disaster questions results: Additional technology

Question	Response Options	COMMS	EMS	FF	LE
Which would be helpful during a major disaster?	Deployable communication technology (such as cell towers on wheels)	68.62 %	73.90 %	81.71 %	72.52 %
	Drones	54.25 %	53.44 %	70.95 %	71.93 %
	Generators	68.71 %	(not asked)	(not asked)	(not asked)
	Helicopters	(not asked)	28.04 %	39.61 %	39.48 %
	Mobile command centers (MCCs)	81.19 %	76.54 %	74.38 %	75.63 %
	Remote sensing (by aircraft or satellite)	(not asked)	20.81 %	29.86 %	23.78 %
	Robots	(not asked)	8.47 %	13.58 %	24.89 %
	n=	*1 058*	*567*	*1 487*	*1 350*

Table 63 Large, planned event questions results

Question	Response Options	COMMS	EMS	FF	LE	Total
Worked during a large, planned event?	Yes	66.47 %	71.73 %	62.02 %	75.82 %	67.81 %
	No	33.53 %	28.27 %	37.98 %	24.18 %	32.19 %
	n=	*498*	*329*	*1 119*	*732*	*2 678*
How similar or different is technology you use in a large, planned event than the technology you use during your day-to-day work?	I use mostly the same technology.	87.88 %	83.47 %	84.66 %	83.06 %	84.61 %
	I use some of the same technology, with some specialized technology.	10.91 %	12.29 %	13.60 %	14.03 %	13.07 %
	I use very different technology.	1.21 %	4.24 %	1.74 %	2.91 %	2.33 %
	n=	*330*	*236*	*691*	*549*	*1 806*

Table 64 Large, planned event questions results, open-ended

	Specialized Technology	Most Important Technology	*n_asked*
COMMS	20.24 %	34.14 %	*331*
EMS	26.27 %	50.00 %	*236*
FF	25.50 %	46.54 %	*694*
LE	23.24 %	46.31 %	*555*
Total	23.95 %	44.66 %	*1 816*

Table 65 Large, planned event questions results: Additional technology

Question	Response Options	COMMS	EMS	FF	LE
Which would be helpful during a large, planned event?	Deployable communication technology (such as cell towers on wheels)	43.20 %	47.46 %	47.98 %	43.96 %
	Drones	46.83 %	31.36 %	58.79 %	64.86 %
	Generators	35.95 %	(not asked)	(not asked)	(not asked)
	Helicopters	(not asked)	6.36 %	9.22 %	19.10 %
	Mobile command centers (MCCs)	71.90 %	60.17 %	67.58 %	60.18 %
	Remote sensing (by aircraft or satellite)	5.51 %	8.79 %	10.81 %	5.51 %
	Robots	2.12 %	3.75 %	9.55 %	2.12 %
	n=	*331*	*236*	*694*	*555*

Table 66 Virtual Reality questions results: Useful for training

	Yes	No	Not Sure	*n*
COMMS	33.78 %	20.89 %	45.33 %	*1 551*
EMS	50.28 %	15.30 %	34.42 %	*889*
FF	51.54 %	13.45 %	35.01 %	*2 602*
LE	58.83 %	10.11 %	31.05 %	*2 077*
Total	49.64 %	14.33 %	36.03 %	*7 119*

Table 67 Virtual Reality questions results: Useful for other purposes

	Yes	**No**	**Not Sure**	***n***
COMMS	13.34 %	26.62 %	60.04 %	*1 544*
EMS	19.19 %	27.72 %	53.09 %	*891*
FF	22.41 %	23.41 %	54.18 %	*2 593*
LE	22.44 %	22.78 %	54.78 %	*2 072*
Total	20.04 %	24.46 %	55.49 %	*7 100*

Table 68 Virtual Reality questions results, open-ended

	Percentage of Respondents	***n_asked***
COMMS	15.22 %	*1 564*
EMS	15.41 %	*902*
FF	16.16 %	*2 617*
LE	15.01 %	*2 099*
Total	15.52 %	*7 182*

Appendix E – User-Centered Design Guidelines

Originally published in the Phase 1, Volume 1 report, the six user-centered design guidelines below resulted from the analysis of the interviews with first responders [5]. The guidelines were identified from first responders' communication technology needs, and serve as requirements for technology developers in the public safety domain.

1. **Improve current technology** – improve functionality of what first responders currently have, make them 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.
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.
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, contexts of use. All are different, requiring easy adaptability and configurability.
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.
5. **Lower product/service costs** – develop technology at price points that departments can afford, lowering costs for technology. For example, consider the '*One Laptop per Child*' approach where various entities collaborated to make and widely distribute rugged, low-cost, low-power, connected technology in areas that could not otherwise afford such devices [23]. The goal was not only to design the tool, but to design it at a price-point that made it feasible and scalable for widespread distribution.
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.