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

Day-to-Day Technology

Phase 2, Volume 3

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Abstract

The Nationwide Public Safety Broadband Network (NPSBN) is being developed to provide a dedicated network for first responders' use. A wave of new communication technologies compatible with the NPSBN is on the horizon, as major research and development efforts for these technologies are ongoing. The aim of the NIST PSCR Usability Team is to gain a better understanding of the usability of communication technology for first responders, by investigating the contexts in which they work, their experiences with incident response, and their problems with and needs for communication technology. To this end, NIST's PSCR Usability Team conducted an exploratory, sequential, mixed-methods study to gather insights into the experiences and needs of first responders. The multi-phase study included in-depth interviews with 193 first responders (Phase 1), followed by a nationwide survey of 7 182 first responders (Phase 2).

This report is the third in the Phase 2 publication series, presenting survey results related to first responder experiences with their day-to-day devices: frequency of use of these devices, useful rankings of the devices, and problems experienced with them. Four themes were identified:

- Technology can be both a benefit and a burden.
- Technology of the future = current technology improved.
- Technology must be usable and useful.
- Technology costs are a major barrier to their use.

These themes that have implications for R&D of first responder communication technology are presented in this report, reinforcing the six user-centered design guidelines identified in the Phase 1, Volume 1 report [1]. These themes and guidelines can aid researchers, designers, and developers in the public safety domain in attending to those issues that are most important to first responders.

Key words

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

Audience

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

Disclaimer

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

Executive Summary

Background

The public safety domain is in the midst of major updates to their communications infrastructure. The Nationwide Public Safety Broadband Network (NPSBN) is being developed to provide a dedicated network for first responders' use during incident response. A wave of new communication technologies compatible with the NPSBN is on the horizon, as major research and development (R&D) efforts for these technologies have been ongoing since the NPSBN was mandated through federal legislation [15]. As a result of this mandate, the National Institute of Standards and Technology's (NIST) Public Safety Communications Research (PSCR) program developed a roadmap for communication technology R&D, identifying six key research areas necessary to advance communication technology for first responders [20]. One of these areas, User Interface/User Experience (UI/UX), focuses on a key component of developing new technology – ensuring that the tools developed for first responders are usable [21].

Usable public safety communications technology ensures that first responders complete their goals and tasks with effectiveness, efficiency, and satisfaction within the contexts that they work [14]. The first step to developing usable public safety communications technology is to determine first responders' characteristics, needs, and contexts of use. However, understanding what is needed to make technology usable for the first responder population is difficult due to the diversity of first responder disciplines – Communication Center & 9-1-1 Services (COMMS), Emergency Medical Services (EMS), Fire Service (FF), and Law Enforcement (LE) – and their tasks, environments, and experiences. The aim of the NIST PSCR Usability Team is to gain a better understanding of these aspects of the first responder population, by investigating the contexts in which they work, their experiences with incident response, and their problems with, and needs for, communication technology.

Methodology

NIST's PSCR Usability Team conducted an exploratory, sequential, mixed-methods study to gather insights into the experiences of first responders – what communication tools they use, what problems they experience with those tools, and what their technology needs are. The multi-phase study included in-depth interviews with first responders (Phase 1), followed by a nationwide survey (Phase 2). During the Phase 1 qualitative interviews, data was collected from 193 first responders about their context of work, communication technology needs, and communication technology experiences. The results of the Phase 1 interviews were used to inform the design of the survey used in Phase 2. The Phase 2 survey further explored the experiences and needs of first responders, capturing from 7 182 first responders their perceptions of their day-to-day devices, perceived usefulness of futuristic technology, key problems experienced with technology, and technology use during major disasters/events. The data from both phases provide a comprehensive look at communication technology use, problems, and needs across the four first responder disciplines – COMMS, EMS, FF, and LE.

Results

Several reports in the Voices of First Responders series have been published based on the results from this multi-phase study. From the Phase 1 interviews, Volume 1 presents overarching themes that initially arose from the data; Volume 2 highlights the problems experienced and functionality requested by first responders with their communication technology; Volumes 3 and 4 delve into specific first responder groups – those in rural areas, and COMMS personnel, respectively; Volume 5 provides practical guidance to improve the usability of communication technology for first responders. From the Phase 2 survey, Volume 1 specifies the methodological and demographic details of the survey and survey respondents; Volume 2 reports the results of the study related to futuristic technology, mobile devices, and large events.

This report is the third of the series of volumes on Phase 2, presenting the results of the analyses of the day-to-day device experiences of first responders: their day-to-day device use, usefulness rankings of day-to-day devices, and device problems experienced by first responders. In order to better understand each of the four discipline's unique technology uses and associated problems, results of the nationwide survey were analyzed and are presented for each discipline individually, referencing data from both phases of the study. Also included is a summary of the similarities and differences amongst first responder disciplines. Finally, the report closes with the results of the final open-ended survey question and a discussion of the results.

Several overarching themes that have implications for R&D of first responder communication technology emerged from the analysis of the data presented in this report:

- **Technology can be both a benefit and a burden.** First responders view communication technology as a double-edged sword that brings with it both positives and negatives. Developers of public safety communication technologies must consider the potential burdens that technology (current and future) can place on first responders, and the unintended consequences it might hold in their day-to-day work.
- **Technology of the future = current technology improved.** First responders are generally more concerned about making sure the current technology they have and use works better than adopting new technology. As new technologies are being developed for first responders, developers must work to reduce the problems (e.g., reliability, interoperability, connectivity) associated with traditional devices that are still widely used across public safety.
- **Technology must be usable and useful.** First responders need the technology they use to be both useful for their day-to-day tasks and usable within their contexts of work. Technology should be developed with and for first responders, driven by their user characteristics, needs, requirements, and contexts of use.
- **Technology costs are a major barrier to their use.** First responders consistently experience cost as the greatest barrier to technology access and adoption. Technology is rarely a one-time investment or a stand-alone cost; peripheral costs such as training, IT support, maintenance, and upkeep/updates must be considered as well.

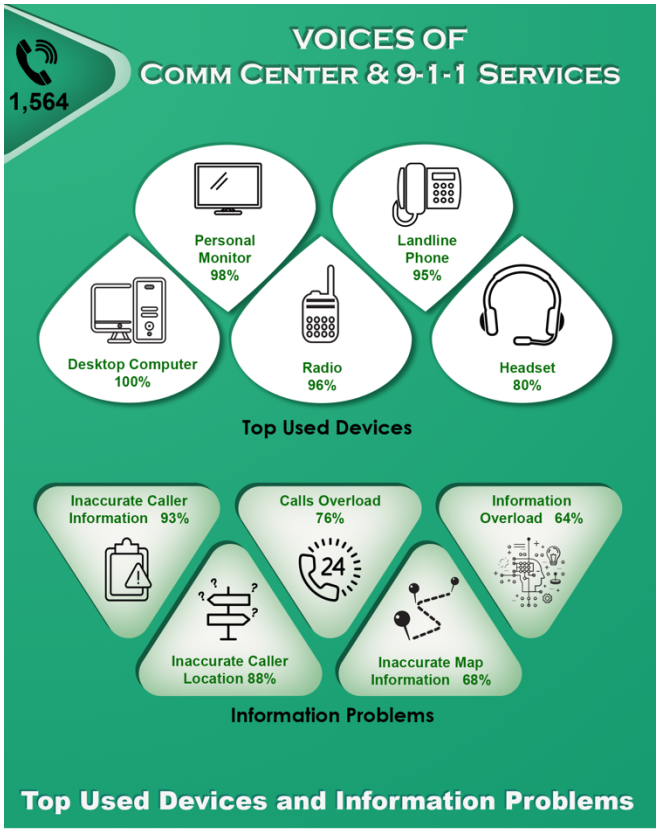
These themes reinforce the six user-centered design guidelines identified in the Phase 1, Volume 1 report [1].

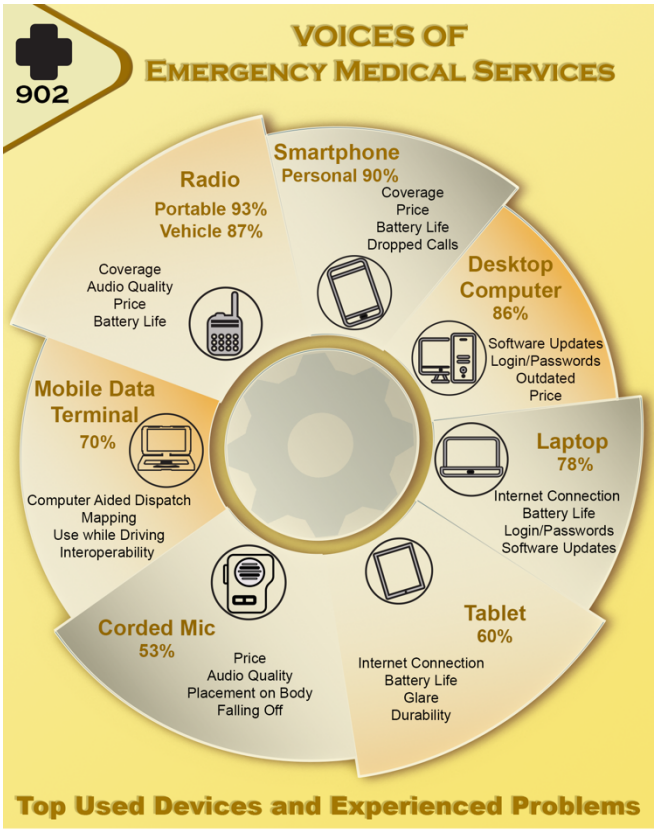
- Improve current technology
- Reduce unintended consequences
- Recognize 'one size does not fit all'
- Minimize 'technology for technology's sake'
- Lower product/service costs
- Require usable technology

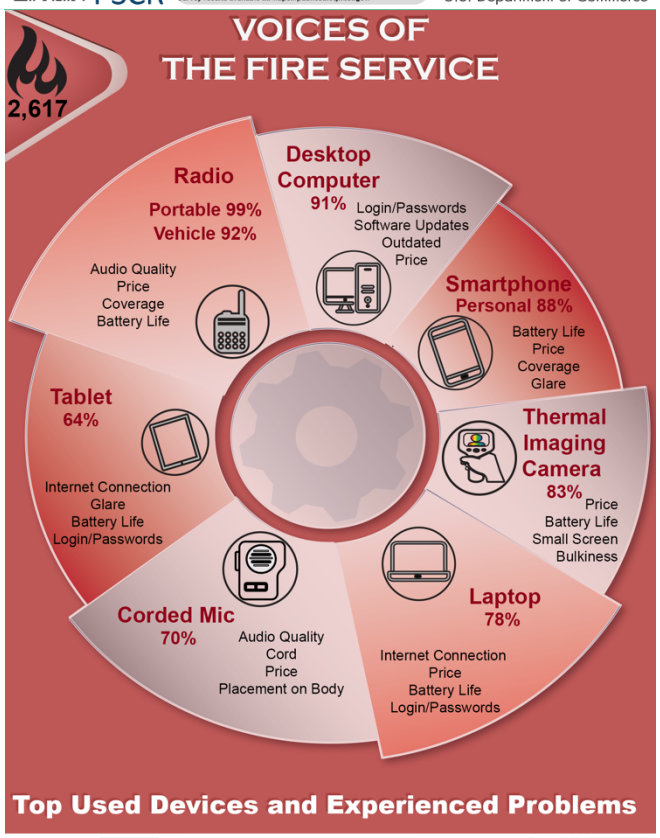
These guidelines resonate with the survey data related to the day-to-day technologies presented in this report, and can aid researchers, designers, and developers in the public safety domain in attending to those issues that are most important to first responders.

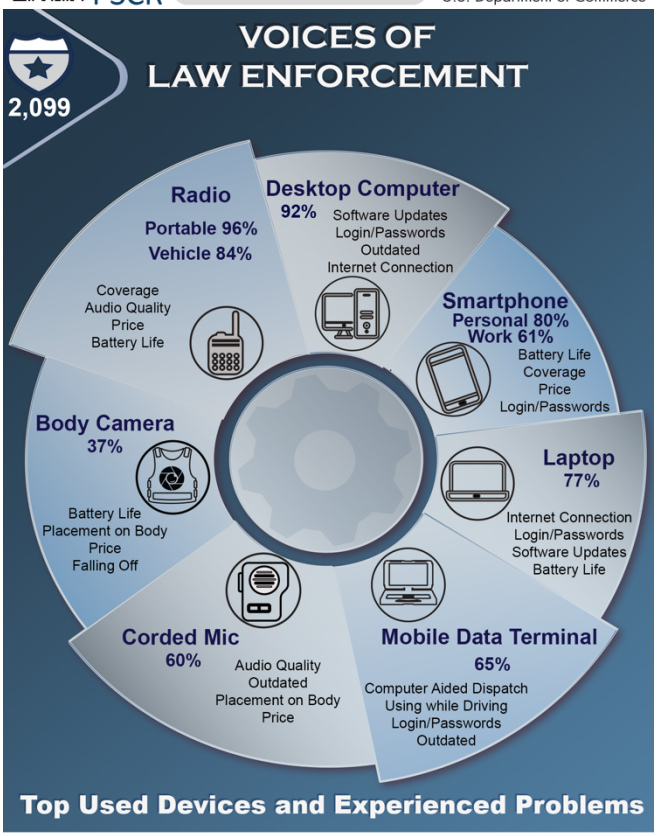
Impact

The data from both phases of the study show that first responders are not opposed to technology, but they want technology that is appropriate for their context of use and that makes their work easier to accomplish. Researchers, designers, and developers of communication technologies for first responders must listen carefully to their voices in order to produce useful technology. First responders, in general, want technology that is affordable, interoperable, reliable, and easier to use. To establish trust and encourage adoption, technology for first responders needs to be developed with them, driven by their user characteristics, needs, requirements, and contexts of use. This report contributes to the ability of the public safety R&D community to make informed decisions about public safety communication technology, and to engage in meaningful development and improvement of the NPSBN ecosystem moving forward.









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List of Acronyms and Abbreviations

AED.....Automatic External Defibrillator
Apps .....Applications
AVL .....Automatic Vehicle Location
CAC.....Common Access Card
CAD.....Computer-Aided Dispatch
Comm.....Communication
COMMS .....Comm Center & 9-1-1 Services
CPR .....Cardiopulmonary Resuscitation
D.C. .....District of Columbia
DOS .....Disk Operating System
ED .....Emergency Department
EHR.....Electronic Health Record
EKG.....Electrocardiogram
EM .....Emergency Management
EMR.....Electronic Medical Records
EMS .....Emergency Medical Services
EMT .....Emergency Medical Technician
EPCR .....Electronic Patient Care Reporting
ESINET .....Emergency Services Internet Protocol Network
FADO .....Fire Apparatus Driver Operator
FCC .....Federal Communications Commission
FEMA.....Federal Emergency Management Agency
FF.....Fire Service, Fire Fighting
Fig. .....Figure
GPS .....Global Positioning System
HD .....High Definition
HUDs .....Heads-Up Displays
Incl. .....Including
INT.....Interview
IP .....Internet Protocol
ISO.....International Organization for Standardization
IT .....Information Technology
LE.....Law Enforcement
LEADS .....Law Enforcement Automated Data System (LEADS)
LPR.....License plate reader
LTE.....Long-Term Evolution
MB.....Megabyte
MCI.....Mass Casualty Incident
MCT.....Mobile Computer Terminal
MDC .....Mobile Data Computer

MDT.....Mobile Data Terminal
Med. Control .....Medical Control (telemedicine instruction)
MGH .....Megahertz (also MGHZ)
Mic .....Microphone
N/A .....Not applicable
NG 911 .....Next Generation 9-1-1
NIST .....National Institute of Standards and Technology
NPSBN .....Nationwide Public Safety Broadband Network
OCA .....Originating Case Agency
OS.....Operating System
PCR .....Patient Care Report
PIN.....Personal Identification Number
PO2.....Partial Pressure of Oxygen
PSAP .....Public Safety Answering Point
PSCR .....Public Safety Communications Research
PTSD .....Post Traumatic Stress Disorder
PTT .....Push-to-talk
R .....Rural
R&D .....Research & Development
RAM.....Random Access Memory
RF .....Radio Frequency
RMS .....Records Management System
S.....Suburban
SCBA .....Self-Contained Breathing Apparatus
Sec. .....Section
TIC .....Thermal Imaging Camera
U .....Urban
UAV .....Unmanned Aerial Vehicle
UHF.....Ultrahigh Frequency
UI/UX.....User Interface/User Experience
VHF.....Very-High Frequency
VOIP .....Voice Over Internet Protocol
VPN.....Virtual Private Network
U.S. .....United States
VR .....Virtual Reality
YR .....Year

1. Introduction

As part of the 2012 Middle Class Tax Relief and Job Creation Act [15], funding was provided to create the Nationwide Public Safety Broadband Network (NPSBN). The NPSBN is currently in development and deployment, and once it is operational it will provide the public safety community with a dedicated long-term evolution (LTE) network. Not only will this network provide first responders with an independent and interoperable platform for communication during incident response, but creation of this network will also provide the opportunity for developers and designers to create communication technology specifically for first responders. Taken together, this network may greatly enhance the communication capabilities of public safety personnel.

A key component of developing new technology is ensuring that it is usable, meaning that technology should allow users to complete their goals and tasks with effectiveness, efficiency, and satisfaction within the contexts where they work [14]. In the context of first responders, technology that is usable has the potential to improve communication during incident response, ultimately helping first responders to more effectively and efficiently protect and serve their communities. Although developing usable technology is important, understanding what is needed to make technology usable for the first responder population is difficult due to the diversity of first responders' characteristics, environments, and needs. For instance, job tasks, experiences, and needs differ greatly across the first responder disciplines – Communication Center & 9-1-1 Services (COMMS), Emergency Medical Services (EMS), Fire Service (FF), and Law Enforcement (LE). There are also differences depending on the environments first responders work within. For example, first responders working in rural environments have many unique challenges not found in urban or suburban areas and vice versa. Therefore, before new technology can be developed, it is important to first understand public safety user groups, the contexts they work within, and their current experiences and problems with, as well as needs for, communication technology.

Because of this need, the Public Safety Communications Research (PSCR) community identified user interfaces and user experience (UI/UX) as a critical component for research and development [20][21]. The PSCR usability team has conducted an exploratory, sequential, mixed-methods study to gather insights into the experiences and needs of first responders. The study was designed to have two phases, an initial qualitative interview phase followed by a nationwide quantitative survey. Phase 1 consisted of in-depth interviews with 193 first responders across the four disciplines (i.e., COMMS, EMS, FF, and LE) to hear directly from first responders about their context of work, communication technology needs, and communication technology experiences. The qualitative approach allowed for an in-depth understanding into the experiences, needs, and problems experienced by first responders. Results from this phase were then used to create a nationwide survey to further explore the experiences and needs of first responders in Phase 2. The Phase 2 survey captured perceptions of day-to-day devices, perceived usefulness of futuristic technology, key problems experienced with technology, and technology use during major disasters/events. The survey was completed by 7 182 first responders across the nation, thus providing a comprehensive look at communication technology use, problems, and needs across first responders.

Reports from Phase 1 and Phase 2 provide insights into the experiences of first responders with communication technology. The qualitative Phase 1 interviews have been extensively reported on. Phase 1, Volume 1 [1] provides an in-depth look at first responders' context of use and behavior with communication technology. Phase 1, Volume 2.1 [5], takes a deeper dive into the communication technology experiences of first responders by exploring communication technology problems and needs. The Phase 1, Volume 2.1 report is supplemented by Phase 1, Volume 5 [2], which provides practical guidance and recommendations to improve the usability of communication technology for first responders across disciplines. Phase 1, Volumes 3 and 4 focus on specific user groups within the broader first responder populations: Phase 1, Volume 3 [13] details the experiences of rural first responders, and Phase 1, Volume 4 [22] examines experiences of COMMS responders. There are two reports reporting on the Phase 2 survey data. Phase 2, Volume 1 [12] details the survey methodology and demographics of the first responders who participated. Phase 2, Volume 2 [6] reports findings for survey respondents' mobile device (i.e., smartphones and tablets) and application/software use, futuristic technology needs, and technology used in major disasters/events.

This report, Phase 2, Volume 3 presents the day-to-day device experiences of first responders from the survey data. Specifically, this report includes analyses of day-to-day device use, usefulness rankings of day-to-day devices, and device problems experienced by first responders. Additionally, this report includes results from discipline-specific sections of the survey developed to better understand the unique needs of each discipline. For example, this report includes analysis of COMMS responders' information problems and EMS responders' medical technology use. Although the focus of this report is on the quantitative survey responses, this report also provides important qualitative data analyses. Analyses of open-ended survey questions related to day-to-day devices are included as well as analyses of the final open-ended survey question. This final question allowed first responders to voice any other thoughts they had on communication technology. This report also integrates findings from both phases by including interview quotes from Phase 1 where relevant to provide deeper insight into the experiences of first responders.

This report is structured to present survey results in separate sections for each discipline. In this way, each section focuses on the devices, problems, and needs specific to each discipline. This report also includes a summary of the similarities and differences amongst first responder disciplines. Finally, the report closes with the results of the final open-ended survey question and a discussion of the results. Because of the significant length of this document and the large number of survey topics discussed, section headers are marked with headings and subheadings to aid in navigation.

2. Methodology

2.1. Study Overview

This report is based on a larger study examining first responder work related to communication technology. This included an examination of their contexts of work, the technology they have currently, the technology they believe would be useful, and their beliefs and perceptions about communication technology in general. The research is based on a sequential, exploratory mixed

methods design. The first phase of the project was comprised of 193 interviews with first responders from all four disciplines across the country. This phase identified contexts of work, along with the needs and problems that first responders have related to communication technology [1][5][13][22]. Survey questions for Phase 2 of the project were developed based on qualitative data from Phase 1. The qualitative data was used to develop a large-scale, nationwide survey for Phase 2 of the project. This second phase allowed for greater representation of first responders from across the country and provided for the ability to do an integrated analysis of Phase 1 and Phase 2 data. Data from Phase 2 of the project include 7 182 survey responses, with representation from the four public safety disciplines surveyed, different geographical areas (i.e., rural, suburban, urban), jurisdictional levels, years of service, and age. The NIST Research Protection Office approved both phases of the project; the study complied with all institutional requirements and processes for human subjects research [12].

This report primarily focuses on survey results related to first responders' day-to-day communication technology. An overview of the survey methodology from relevant survey sections is provided below. Relevant qualitative interview analyses from Phase 1 are also presented in this report to allow for examination of where survey results and qualitative interview results converge or diverge as well as to provide additional context to the survey data. An expanded presentation of the methods used in this study, 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) [1][12]. Abbreviated summaries of the methodology from both Phase 1 interviews and Phase 2 survey are presented in Appendix A and Appendix B, respectively.

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

2.2. Survey Methods

The goal of the survey was to build upon findings from Phase 1 to provide a comprehensive view of the communications technology first responders currently have, what problems they experience, and what functionalities they need or want. Four guiding principles were employed to develop the survey.

First, the survey was guided by best practices in survey research, as well as the findings and themes obtained in Phase 1. This allowed us to further examine and support findings from Phase 1 with a larger sample. Although the survey primarily included quantitative questions, some open-ended questions were included as well to capture perceptions or thoughts on topics not included in the survey.

Second, the survey was also designed to focus on communication technology, especially devices, problems, and needs identified in Phase 1 (see [1] and [5]) as well as technology identified as PSCR research priorities [20]. Moreover, the survey focused specifically on day-to-day technology, as a majority of first responders' work involves responding to day-to-day incidents rather than responding to large events.

Third, the survey was tailored to each first responder discipline, as a key pattern that emerged from the Phase 1 interviews was that "one size" does not fit all regarding first responders and their communication technology [1]. Therefore, four different survey versions were developed, one for each discipline (i.e., COMMS, EMS, FF, LE). Each survey contained overlap in its overall structure and content, but each had unique content tailored to each discipline. Some survey sections were only presented to a specific discipline and not to the others for which the group of questions were not applicable. For example, while all disciplines answered questions related to technology use day-to-day, only COMMS participants received questions about call centers. Additionally, some questions and response options were specifically tailored to each discipline. This ensured they would be presented with content most relevant to their environment and work, and that they would not be presented with content not applicable to them. For example, all participants were asked questions about laptop computers. However, the LE survey included questions regarding body cameras that were not included in the other survey versions. Likewise, LE participants did not view questions regarding thermal imaging cameras (TICs) that were included in the FF survey. Developing four separate surveys helped ensure participants' time was respected by allowing them to focus only on answering questions most relevant to their work.

Fourth, the survey was designed to be easy to take and appropriate for first responders. The survey was kept short to respect first responders' time and was designed to take no longer than 15 minutes to complete. It was also available on mobile devices as well as computers. The survey was tested to ensure the content and language was appropriate for first responders. The survey instrument was reviewed by experts, tested in cognitive interviews, and piloted with first responders.

The Phase 2 Volume 1 document as well as Appendix B and Appendix C describe the survey methodology including the survey structure and logic in more detail [13].

These guiding principles ultimately resulted in four 15-minute surveys that focused on day-to-day technology use, problems, and needs. The survey sections are displayed in Table 1. Because survey results may be published in multiple Phase 2 volumes, the table also includes where results are published.

Recruitment of participants from across the U.S. involved three strategies. First, the sampling frame was an online database containing national public safety directory information. First responder departments and agencies were sent invitation emails requesting participation. Second, participants from Phase 1 of the project were contacted and asked to distribute the survey to their colleagues. The final recruitment strategy was contacting public safety organizations directly. Recruitment and sampling were conducted to ensure a large sample with variability across relevant demographic features would participate. Recruitment was prioritized to represent participants from across the four disciplines (COMMS, EMS, FF, and LE) and different geographic areas (urban, suburban, rural). First responders from the local jurisdictional level a priority because most incidents start at the local level. This resulted in 7 182 completed survey responses representing first responders across ages, years of service, FEMA regions, and other characteristics described in more detail below in Sec. 3.1 and in Appendix D. Additional recruiting considerations are provided in Phase 2 Volume 1 report [13].

Table 1. Survey Sections

Section	Discipline(s)	Description	Volume
Demographics	COMMS, EMS, FF, LE	Participant (e.g., age, gender) and discipline-specific (e.g., career vs. volunteer) descriptors	Phase 2 Volume 1 [12]
Call center information	COMMS	Questions about call center operations and capabilities	Current document; Phase 2 Volume 2 [6]
Use of technology in day-to-day work	COMMS, EMS, FF, LE	Tailored questions about devices first responders have and use	Current document; Mobile devices in Phase 2 Volume 2 [6]
Ranking of technology in day-to-day work	EMS, FF, LE	Ranking of most useful devices	Current document
Use of applications in day-to-day work	COMMS, EMS, FF, LE	Tailored questions about applications first responders have and use	Phase 2 Volume 2 [6]
Ranking of applications in day-to-day work	EMS, FF, LE	Ranking of most useful applications	Phase 2 Volume 2 [6]
Future Technology in day-to-day work	COMMS, EMS, FF, LE	Identification of futuristic technology or technology they do not have that would be most useful	Phase 2 Volume 2 [6]
Problems with day-to-day technology	EMS, FF, LE	Tailored questions for frequency of problems with day-to-day devices	Current document
Next Generation 9-1-1	COMMS	Questions about Next Generation 9-1-1	Current document; Phase 2 Volume 2 [6]
Information Problems	COMMS	Frequency of problems with information	Current document
Major Disaster/Large Events	COMMS, EMS, FF, LE	Questions about technology used during major disaster or large planned events	Phase 2 Volume 2 [6]
Virtual Reality (VR)	COMMS, EMS, FF, LE	Questions about utility of VR	Phase 2 Volume 2 [6]
EMS Medical Technology	EMS	Questions about most useful medical technology	Current document
Catch-all	COMMS, EMS, FF, LE	Final thoughts on communication technology	Current document

Participants voluntarily completed the survey, meaning that with the exception of one question, they were not required to answer all survey questions, they could skip any questions, and they could terminate the survey at any time. The only question that required a response was the item about the participant's discipline. A response for this question was needed to determine which discipline-specific survey they would receive.

3. Demographics

This section details the demographics of participants who participated in the interview and survey phases.

3.1. Survey Demographics

A total of 7 182 participants completed the entire survey. All four first responder disciplines were represented in the data, with 21.78 % of respondents primarily working in the COMMS discipline, 12.56 % in EMS, 36.44 % in FF, and 29.23 % in LE (see Fig. 1). All four disciplines had representation in each of the 10 FEMA regions (see Fig. 2) [10], and most survey participants indicated they mainly work in suburban (38.68 %) or rural (37.68 %) areas. Fewer participants worked in urban (23.25 %) and tribal (0.39 %) areas[1]. The majority of respondents worked in public safety at the local level (63.20 %) or the county level (31.87 %). Over a third (36.09 %) of respondents worked in public safety as chiefs, 15.55 % responded to incidents on the front lines, and 14.88 % worked in supervisory positions.

Most survey respondents were between 46 and 55 years old and most were male (see Appendix D). However, there was a higher number of female COMMS respondents, consistent with rates of women in the COMMS discipline nationwide [4]. Most COMMS, EMS, and LE respondents had between 21 and 25 years of service, while most FF respondents had between 26 and 30 years of service.

The survey also captured characteristics specific and relevant to each discipline:

- A majority of COMMS participants were civilian (92.11 %) rather than deputized; 73.08 % of COMMS participants dispatch for EMS, FF, and LE.
- A majority of EMS participants were in the public (67.04 %) rather than private sector.
- A majority of FF participants were career (67.96 %) rather than volunteer.

A selection of survey demographic characteristics are highlighted in Appendix D. Survey demographics are also described in-depth in Phase 2, Volume 1 [12] and Phase 2, Volume 2 [6].

[1] Due to the small sample size, meaningful analyses for this group could not be completed to further break down tribal respondents by discipline, FEMA region, or other variables. Therefore, the tribal responses are only included in the nationwide analysis of the survey results.

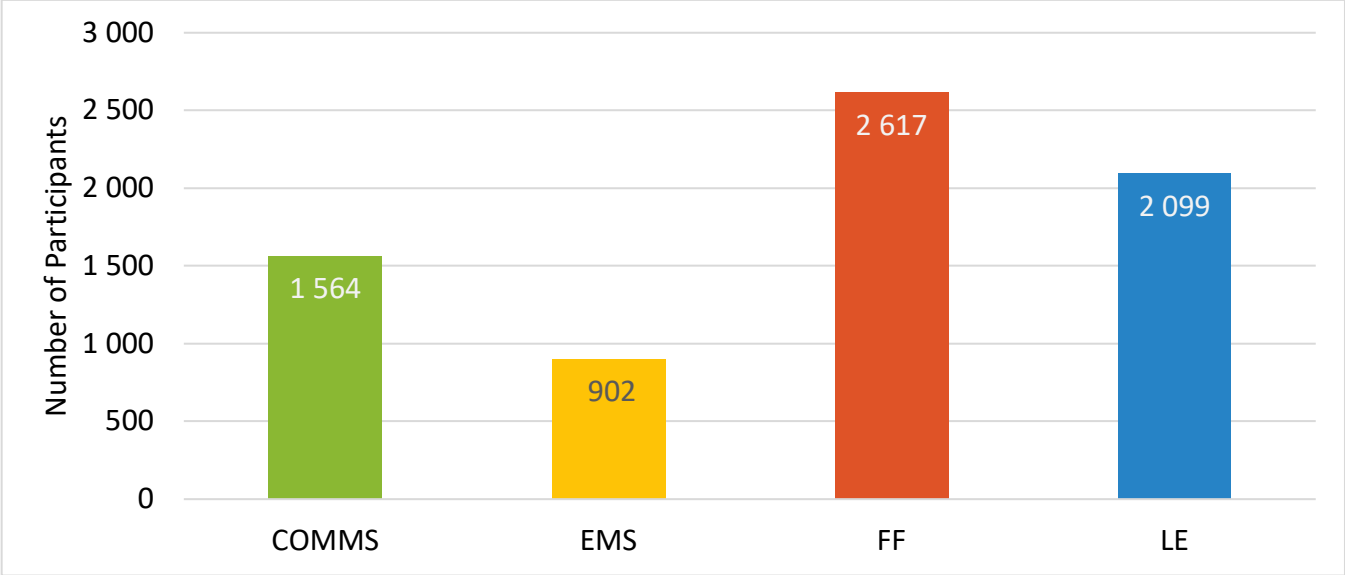

Fig. 1. Number of participants who completed the survey *(n=7 182)*

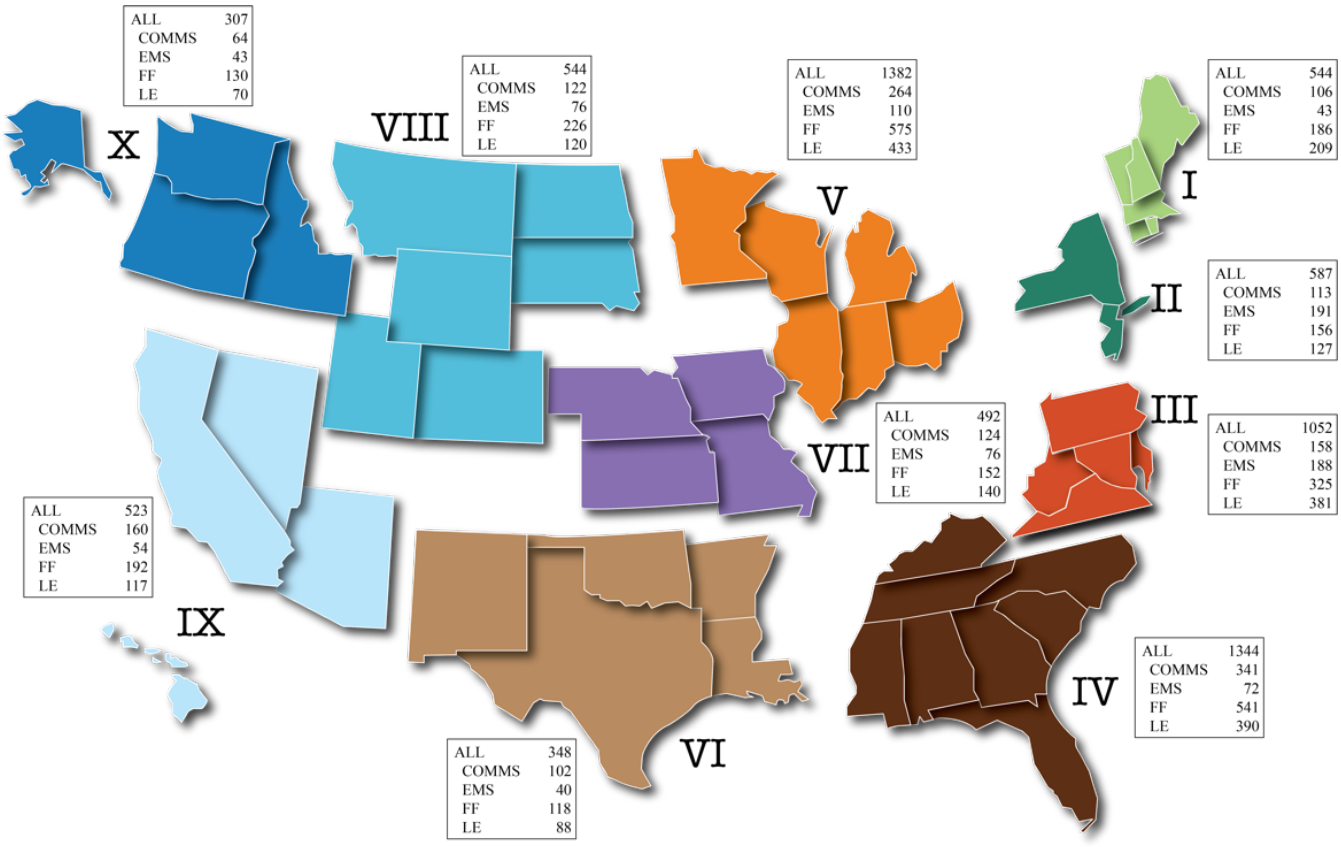

Fig. 2. Participants who completed the survey by discipline and FEMA Region *(n=7 123)*

3.2. Interview Demographics

The interviews were completed by 193 first responders across the four disciplines. Table 2 displays the number of participants across discipline and area. Although all four disciples were represented in the data, more FF and LE participants were interviewed compared to EMS and COMMS participants. First responders working in urban, suburban, and rural areas were also represented in the data. Details of the interviews including specifics of participants' demographics are described in Appendix A as well in Phase 1, Volume 1 [1] and other Phase 1 volumes [5] [13] [22].

The breakdown of gender, age, and years of service are displayed in Fig. 3. A majority of first responders interviewed were male (86 %) and between 26 and 55 years of age (25 % from 26-35, 28 % from 36-45, and 35 % from 46-55). First responders interviewed also had varying levels of experience in public safety. Most frequently, first responders interviewed had between 21 and 25 years of experience.

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*

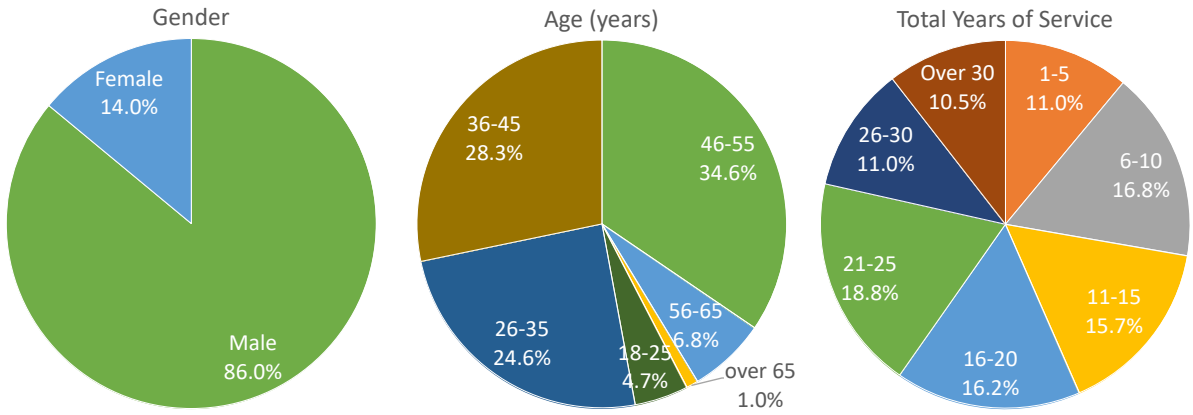

Fig. 3. Demographic data for participants interviewed

4. Results

This report presents the survey results tailored to each first responder discipline regarding day-to-day technology use, rankings, problems, and discipline-specific questions. Analyses specifically related to

mobile devices (i.e., personal smartphones, work-issued smartphones, and tablets) as well as applications/software, futuristic technology including VR, and technology used and desired for major disasters and large planned events are detailed in Phase 2, Volume 2 [6].

A total of 7 182 participants completed the survey in its entirety. Because the survey was voluntary, a varied number of participants responded to each question. The total number of responses, *n*, for each question or response option is designated in figures and tables as appropriate. Appendix E displays complete results tables with *n*'s.

The results in this report provide descriptive[2] data from analyses of the unweighted survey data. The lack of weighting has implications for interpreting and generalizing the data. Unweighted data can only be generalized to the first responder population surveyed. Generalization of the results to broader first responder population can only be made when these data are weighted.

In addition to descriptive data from the survey participants, quotes from the in-depth interviews are also included throughout the results to provide context to the results. Quotes are displayed where appropriate in blue, indented text. All quotes are verbatim taken from transcripts of audio-recorded interview sessions. Quotes selected are exemplars chosen because they represent participants' thoughts broadly or highlight key themes. The notation following each quote denotes the discipline of the respondent (COMMS; EMS; FF; LE), the type of area they serve (Urban=U; Suburban=S; Rural=R), and their record number referencing the source transcript. Additionally, these quotes are preceded by "INT" to designate that these quotes were provided in the interview phase. For example, an interview with transcript ID "007" with a firefighter from a rural area would have the notation (INT-FF-R-007). Quotes from the open-ended survey responses are also included where appropriate in this report. We present open-ended responses in those places where there is enough consistency amongst survey responses to provide meaningful analysis[3]. These quotes are not connected to specific participants, as all surveys were completed anonymously. These quotes are distinguishable from the interview quotes by the lack of the "INT" in the notation. For example, quotes from survey ID "1234" completed by a firefighter in a rural area would have the notation (FF:R:1234). For both interview and survey quotes, potentially identifiable information has been redacted. Redacted text appears in square brackets and is replaced with general information (e.g., [name redacted]).

The results in this report are broken up into six sections. Sections 4.2 through 4.5 focus on results for each first responder discipline (in alphabetical order: COMMS, EMS, FF, LE). Section 4.6 presents findings across first responder groups. The final section (Sec. 4.7) describes participants' final thoughts gathered in the last survey question. Next, Section 4.1 presents an overview of each section's organization of results. All devices presented throughout the results sections are listed in alphabetical order unless otherwise noted. All chart items are shown in descending order according to the data presented, unless otherwise noted.

[2] Inferential statistics will be reported in future volumes, as discussed in Sec. 5.

[3] All redacted open-ended responses, including responses to small *n* questions, are publicly available via the PSCR Usability Results Tool [19].

4.1. Organization of results

4.1.1. Per Discipline Results

Sections 4.2 – 4.5 detail results specific to each first responder discipline. As applicable to each discipline, results are then further organized into sub-sections (Table 3).

Table 3. Discipline-specific results sub-sections

Results Sub-section	Discipline(s)	COMMS	EMS	FF	LE
Call Center Information	COMMS	Sec. 4.2.2	N/A	N/A	N/A
Technology use for day-to-day work	All	Sec. 4.2.3	Sec. 4.3.2	Sec. 4.4.2	Sec. 4.5.2
Device Rankings	EMS, FF, LE	N/A	Sec. 4.3	Sec. 4.4.2	Sec. 4.5.2
Problems Experienced	All	Sec. 4.2.4	Sec. 4.3.4	Sec. 4.4.4	Sec. 4.5.4
EMS medical technology	EMS	N/A	Sec. 4.3.5	N/A	N/A

An overview of each sub-section is provided below. Detailed question descriptions, question stems, and response options for each sub-section are detailed in Appendix B and Appendix C.

Call Center Information

After demographic questions, COMMS respondents answered additional questions about their call centers. Some questions asked participants about their call center's capabilities, such as call centers' audio and data storage ability, as well as if their call centers can receive text messages, pictures, or videos. This section of the COMMS survey also included open-ended questions where COMMS participants could provide additional detail about call centers and their perceptions of different capabilities (e.g., text to 9-1-1). Results are detailed in Sec. 4.2.2.

Technology Use for Day-to-day Work

The next survey section asked about the devices first responders use for their day-to-day work. The list of technologies presented in this section included between 10 and 14 devices, depending on the discipline. While some of the devices were similar across the four disciplines (such as radios and MDTs), others were discipline specific, such as TICs (for firefighters) and body cameras (for law enforcement officers). COMMS respondents also answered additional questions about the number of personal monitors and shared monitors they use. A detailed analysis of smartphone and tablet use was reported in Phase 2, Volume 2, the previous report on the survey data featuring mobile device use [6]. A brief summary of the use of these devices is provided in each results section as appropriate.

Communication technology use is detailed for each discipline: COMMS in Sec. 4.2.3, EMS in Sec. 4.3.2, FF in Sec. 4.4.2, and LE in Sec. 4.5.2. In each discipline's section, a list of the relevant devices included in the discipline-specific survey is provided along with results. The list of devices associated with each discipline were based on the findings from the interview data. Throughout these subsections, abbreviated versions of the devices may be used (e.g., "MDT" instead of "MDT/MDC," "desktop" instead of "desktop computer"). A full list of devices is also displayed in Appendix C.

Day-to-day Device Rankings

EMS (Sec. 4.3), FF (Sec. 4.4.2), and LE (Sec. 4.5.2) completed a question ranking their top five most useful devices. The list of devices for each discipline was populated with devices that they currently had based on their responses to the technology use for day-to-day work question.

The percentage of first responders who selected each device within their top five was calculated out of the total number of first responders who answered the question for each device. Rankings for each device within the top five as well as how often each device was not ranked for each discipline and across EMS, FF, and LE disciplines are displayed in Appendix E.

Problems Experienced

For EMS (Sec. 4.3.4, FF (Sec. 4.4.4), and LE (Sec. 4.5.4), the survey included questions about problems experienced for devices used day-to-day. Participants were only asked questions about problems they experienced with up to three devices they ranked as most useful. 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 each discipline-specific results section, the problems list is presented with results for ease of exposition. Throughout the presentation of problems results, abbreviated versions of the problems with longer text will be used (e.g., "Subsidy for personal smartphone," "Logging in"). The full list of problems asked by device and discipline are displayed in Appendix C. Detailed analysis of smartphone and tablet problems can be found in the previous report on the survey data that featured mobile device use [6]. A brief summary is provided in the discipline-specific subsections where applicable.

Instead of questions about device problems, COMMS responders answered questions about how often they experienced a variety of information problems in their jobs. These results are described further in Sec. 4.2.4.

EMS Medical Technology

EMS participants were asked an additional open-ended question about the medical technology they use. This question was asked at the end of the survey because the focus of the survey was on communication technology, not medical technology. These results are presented in Sec. 4.3.5.

4.1.2. Across Discipline Results

The fifth results section (Sec. 4.6) provides insights into patterns observed across first responder disciplines by compiling results for questions and response options common across disciplines. This section includes similarities and differences across disciplines for day-to-day technology use (Sec. 4.6).

This section presents the results for device rankings and technology problems across EMS, FF, LE, who received these survey questions. Because COMMS responders did not have these question in their version of the survey, they are not included here. Across discipline patterns for smartphones and tablets, and additional details about smartphone and tablet problems are detailed in the previous report that focused on mobile device usage, Phase 2 Volume 2 [6].

4.1.3. Final Open-Ended Response Section

The final section of the report (Sec. 4.6) presents results from the last question asked in the survey which was an open-ended question asking participants if they had anything else to share related to their experiences with technology at work. All four disciplines were asked this open-ended question, allowing participants to provide input about technology that they felt was not captured elsewhere in the survey.

Open-ended responses to this final question were examined first by discipline, and then across disciplines. Data was first categorized by *a priori* topic areas (device, software, problem, need, etc.) that applied across disciplines, and then coded using emergent coding within each discipline. There were a wide variety of codes representing this data, although the responses across disciplines were remarkably similar. Responses could be categorized using multiple codes. For example, one response might be coded as both "*cost-budget*" and as "*old-outdated technology*." Per discipline counts are provided for each code, providing an overarching view of this data.

4.2. COMMS

4.2.1. Overview of COMMS Findings

COMMS participants were asked several questions about their technology use in their day-to-day work, as well as questions related to the technology used in their call centers and information problems they face. Below are highlights of the findings presented in detail in the subsequent Sec. 4.2.2 through 4.2.4.

- Survey responses show that COMMS respondents see the benefits of receiving pictures/videos and texts as 9-1-1 communication. However, open-ended responses show they are also adamant about the negative impacts of these particular technological advancements. Especially problematic is the increased time these technologies demand, and mental health issues related to the reception of pictures/videos.
- 75 % of COMMS respondents reported that 9-1-1 service has gone down at their call center, likely due to issues with phone utility companies (e.g., cut fiber lines). Findings show that most call centers have a backup plan in place should this occur (over 50 % reroute calls to a neighboring agency). Further, the backup plan for many call centers utilizes manual methods like paper cards.
- As expected, the most used technologies by COMMS participants were desktop computers and monitors. 70 % of COMMS respondents use between four and seven personal monitors, with many using additional shared monitors.

- Key problems COMMS respondents experience with information are related to information overload (e.g., too many shared monitors, high call volumes) and caller location (e.g., callers not knowing their location or giving an inaccurate location).

4.2.2. Call Center Information

COMMS respondents were asked specific questions about the capabilities of their call centers. Questions about call centers included:

1) questions related to receiving texts and/or pictures/video;
2) questions related to data management (audio recording, data storage, and data retrieval); and
3) questions about the stability of 9-1-1 service.

Question stems and response items can be found in Appendix C. In addition to the close-ended questions in this section, respondents also 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 receiving texts and pictures/video for their work. Thus, separate text boxes were provided for pros and cons responses, and most respondents provided input for both. (See the Phase 2 Volume 2 report [6] for a much more in-depth analysis of the open-ended data related to the pros and cons of receiving texts and pictures/videos). Sub-sections below discuss each of the call center questions, presenting an integrated analysis of the quantitative and qualitative data as applicable.

Receiving Texts

As seen in Fig. 4 below, 54.34 % of COMMS respondents say their call centers can receive texts, 43.22 % say they cannot receive texts, and 2.44 % are unsure whether their call centers can receive texts. According to the Federal Communications Commission (FCC), text-to-9-1-1 is only available in certain locations [9]. 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 addition, 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 negatives of receiving 9-1-1 text messages from the public. While many participants provided open-ended responses about both the pros and cons of receiving texts, the cons responses were often lengthy, detailed, and passionate arguments against text-to-911.

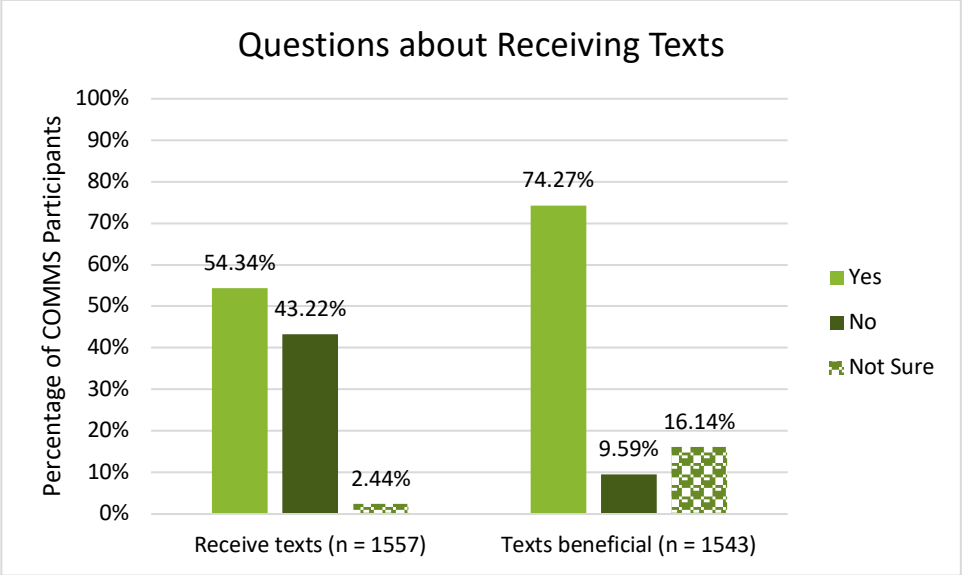

Fig. 4. COMMS Participants' response to questions about receiving texts

Overall, there were 1 235 open-ended responses about the pros of receiving texts. The categories of positive responses included: 1) the ability to communicate with 9-1-1 when calling is difficult, dangerous, or unavailable; 2) more convenient/better communication; and 3) influenced by variables such as age.

> Beneficial to deaf people and people in a situation where they can not talk or are afraid to talk. (COMMS:R:110)

> Easier communications with the public, and most people today text. It is the way of communication now. (COMMS:S:1525)

> Younger generation would be more likely to report crimes, etc. using text. (COMMS:R:2322)

Many respondents saw benefits (or potential benefits) associated with receiving texts in their call centers. Many of these responses noted the benefits this service would provide to callers who were in dangerous situations (such as domestic abuse or active shooter) as well as the ways it would benefit the deaf and hearing-impaired community. The ability of a call center to receive texts has the potential to have a positive impact in many ways. However, respondents also noted potential issues with this technology.

Potential issues were detailed in the 1 210 cons responses provided. Categories for the cons of receiving texts included: 1) the consequences of receiving texts; 2) information issues with text calls; 3) PSAP issues; and 4) caller safety issues.

> 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)

> 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)

> 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)

These responses focused heavily on how the reception of texts would require more time to process which has implications for staffing, training, and other issues. In addition, many respondents believe that false/prank/swatting and non-emergency calls would increase. Other important negatives were the lack of verbal cues and background noise which often provide important informational cues for COMMS personnel. In general, the open-ended response data provide a more nuanced picture of where and how COMMS respondents believe texting can be beneficial to their work. However, these responses also show that those working in COMMS are very concerned about what is already happening (and what may yet happen) as a result of receiving and responding to texts. A more detailed analysis of this data can be found in the Phase 2, Volume 2 report [6].

Receiving Pictures and/or Videos

As shown in Fig. 5, Only 9.48 % of respondents said their call centers can receive pictures and/or video, far fewer than the call centers that can receive texts. This much lower percentage may have to do with additional hardware and/or software technology needed by call centers that would allow them to receive, respond to, process, store, and retrieve 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 this is lower than the percentage of respondents who believe it would be beneficial to receive text messages (74.27 %), it is still a majority of those who responded. Once again, this differs from the open-ended data where many respondents were often vehement in their rejection of this technology, even more so than with the data on receiving text messages.

In addition, 28.66 % of respondents said they were not sure if this would be beneficial. This may be due to the fact that less than 10 % of them currently have this capability in their call center and they are uncertain about the benefit of pictures and/or video for their work. This uncertainty may provide an opportunity to help call centers and COMMS personnel better understand the potential of this technology for their work and address the concerns they have over its use.

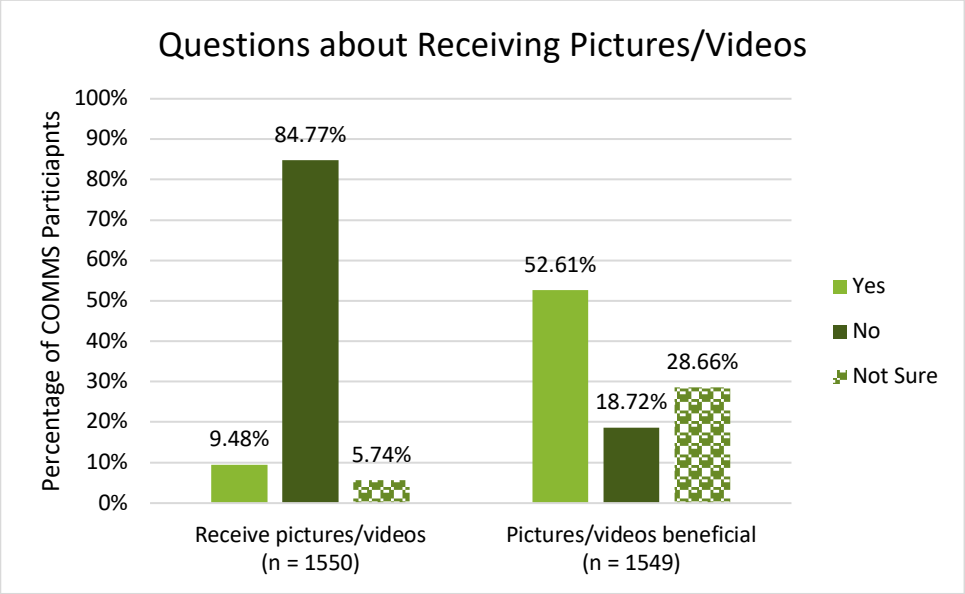

Fig. 5. COMMS Participants' response to questions about receiving pictures/videos

Overall, there were 1 008 open-ended responses about the pros of receiving pictures/videos. The categories of positive responses included: 1) the ability to capture additional information about an incident and 2) how that information could be used. The ability to obtain additional information about an incident also included comments about being able to visualize the scene, have real-time information, and potentially obtain location cues.

> 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)

Receiving visual data could provide additional information about an incident to responding units or be used as evidence, proof, or information for investigation.

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

In spite of the positive responses related to the reception of pictures/videos, many potential problems were detailed in the 985 cons responses provided. Categories for the cons of receiving pictures/videos included: 1) problems with images; 2) negative effects on COMMS personnel; 3) negative effects on call centers; 4) technical issues; and 5) issues for callers. As with the comments about reception of texts, these comments often presented multiple issues.

Problems with visual images included the reception of inappropriate/graphic images or images that are not relevant or of poor quality. In addition, some responses noted the need for verification or authentication of images, as well as the reception of images where the meaning was unclear or there was missing information.

> Possible explicit or inappropriate pictures. Liability of interpretation of what is seen. (COMMS:U:6368)

> Requires additional storage space. Need way to verify validity. (COMMS:R:5885)

In addition to problems with images, many responses noted the negative impact these images could have on COMMS personnel, including mental health issues, information overload, and potential liability issues.

> 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 potential negative effects on call centers were also detailed in many responses, including additional time for call/response, additional cost and/or resources, additional training, and possible negative effects on recruitment and retention.

> 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)

Technical issues were also identified, such as data storage/retrieval and chain of evidence issues, technical failures and potential viruses, and privacy issues—for both callers and for COMMS personnel.

> 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)

Finally, some responses identified potential safety issues for callers as problematic.

> 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)

These issues highlight a multitude of potential problems COMMS personnel identify with the reception of pictures/videos in their call centers. Overall, the open-ended response data provide a more nuanced understanding of how and when COMMS respondents believe pictures/videos can be beneficial to their work, but also of how and when it might be detrimental. These pros and cons should be taken into consideration as NG 911 technology becomes more widely available for call centers. A more detailed analysis of this data can be found in the Phase 2, Volume 2 report [6].

Dealing with Data Management

Participants overwhelmingly noted that their call centers audio recorded calls (97.95 %; see Fig. 6). This survey did not ask questions about what is done with audio recorded data and the policies associated with it (for example, how long data is kept once collected or where and how it is stored). However, only 5.47 % of respondents said their call centers have problems with data storage and only 4.85 % said their call centers have problems with data retrieval.

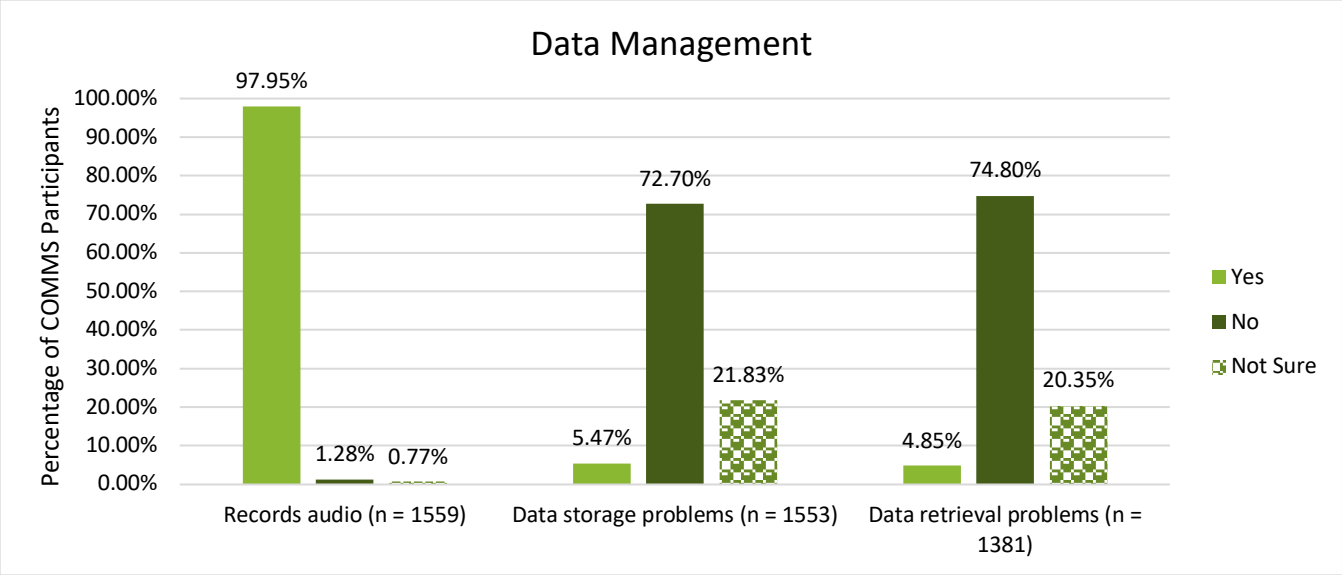

Fig. 6. COMMS Participants' response to questions about data management

No open-ended questions were asked specifically about audio recording, data storage, or data retrieval, however there were references to these issues in responses to other open-ended survey questions. For example, the survey did not make a distinction about what types of data might cause issues for data storage and/or retrieval, however in the open-ended responses about the pros and cons of receiving texts and/or pictures/video, some respondents specifically addressed storage and retrieval issues and the potential negative impact these could have.

> Text message short hand. 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)

> Do not want to slow down call processing as we still need to get responders enroute. Storage issues of media. Impact of violent photos/videos on call takers. (COMMS:S:2391)

> Takes up large amount of storage. May receive photos that are not necessary. Not sure in most cases it is necessary to receive it over a 911 system. Could this wait and the caller just be given an email address to send it in on. May bog down the 911 system, we use so many different programs, the idea of having those larger files coming across the airways and where and how to store them may be an issue. (COMMS:R:2567)

Some of these responses specifically identified the increased cost associated with the storage and retrieval of this additional data.

It is also interesting to note that over 20 % of respondents indicated they were not sure if their call center had 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 issues in their work as telecommunicators.

The Stability of 9-1-1 Service

When asked if 9-1-1 service had ever gone down in their call center, 73.75 % of respondents said that it had (see Fig. 7). Only 17.31 % said 9-1-1 service had not gone down in their call center, and 8.94 % said they were not sure if it had gone down. Thus, most COMMS respondents have experienced a situation where 9-1-1 service was down and they needed to make or have alternative arrangements for how to handle "regular" calls and emergencies, as well as those related to the emergency which caused 9-1-1 service to go down.

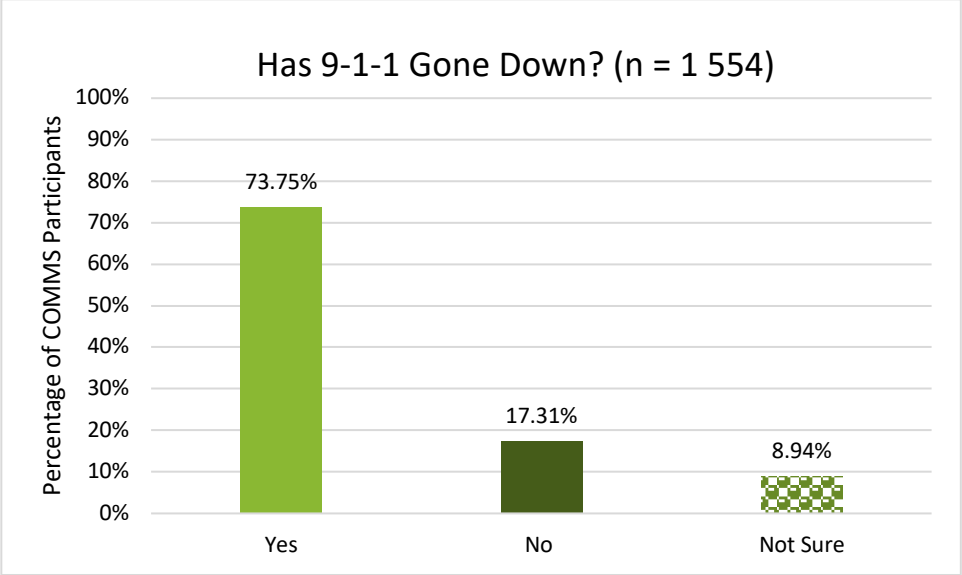

Fig. 7. COMMS participants frequencies of 9-1-1 service going down

It is problematic that essential public services like 9-1-1 go down, especially given that COMMS personnel are generally the first point of contact with the public in an emergency. Given the high percentage of COMMS personnel who have experienced 9-1-1 service going down in their call center, it is important that call centers have effective redundancy and backup plans in place. Additionally, the enhancement and development of communication technology for call centers should focus on the ability to ensure continuity of operations and on call centers' ability to provide effective and efficient plans for this continuity.

If COMMS participants replied that 9-1-1 service had gone down in their call center, they were also asked open-ended questions about what caused 9-1-1 to go down and what their call center did while it was down. There were 1 099 responses to the first question about what caused 9-1-1 service to go down, with many just providing very short responses about the problem, often only a word or two, for

example “technology” (COMMS:R:9855) or “not sure” (COMMS:S:9858) or “the system” (COMMS:R:8287). There was little consistency amongst these responses, except for those related to phone lines/phone company issues, which were mentioned in almost half (47.59 %) of the responses to this question.

> Technological failure on the part of the phone utility. (COMMS:S:9731)
>
> [Name redacted] provider outages, fiber cuts, trunk equipment failures, weather disruption to cell services. (COMMS:U:8811)

Miscellaneous responses were the next largest category, which included things such as “security breach I believe but am not sure that was the final outcome or that they really know why” (COMMS:S:9722) and “Something at the state level” (COMMS:R:9498).

As shown in Fig. 8 below, there were a variety of additional issues that respondents identified in the open-ended responses, including software or equipment failures (18.20 %), weather (10.37 %), power failure/outages (9.83 %), maintenance (1.09 %), or call volume (0.82 %).

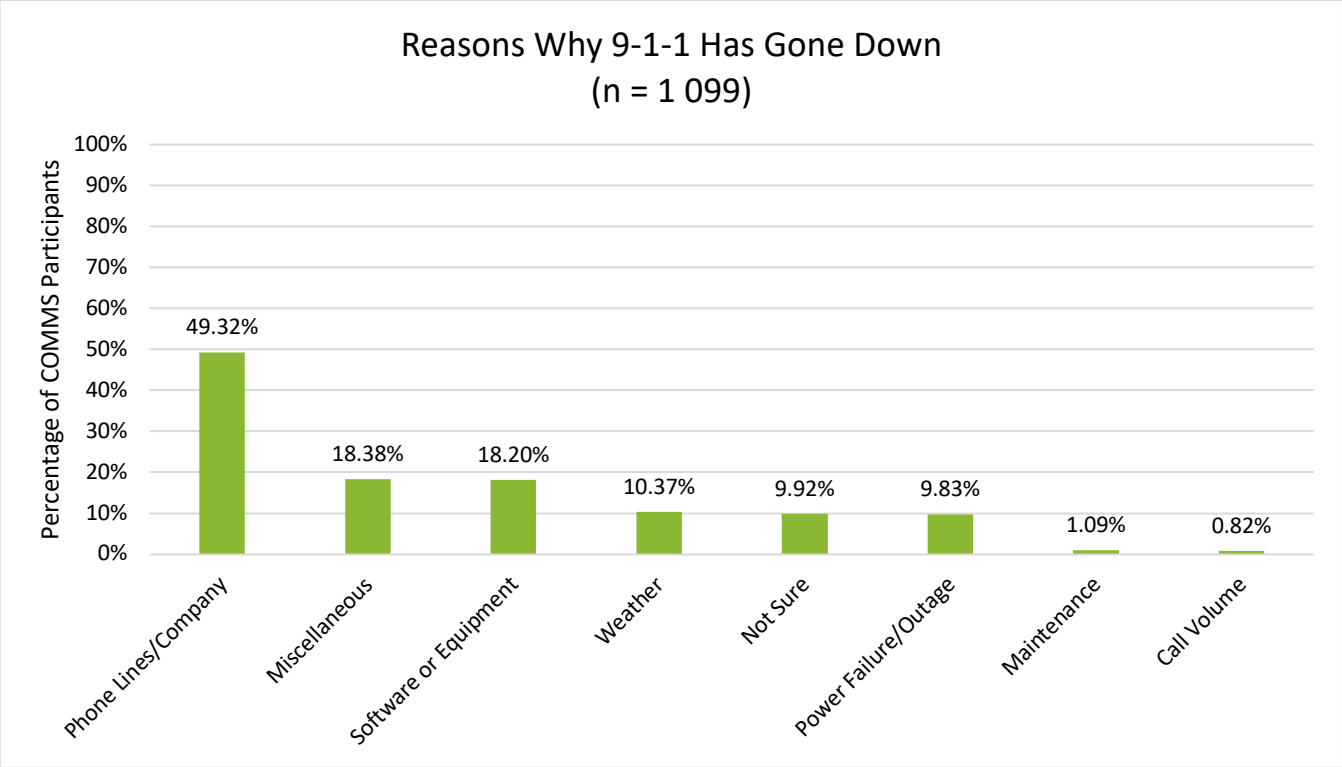

Fig. 8. Reasons why 9-1-1 service has gone down

Interestingly, almost 10 % (9.92 %) of respondents were not sure what had caused 9-1-1 service to go down.

In addition, there were 1 116 responses to the second question about what call centers did when 9-1-1 service went down. Fig. 9 below shows the distribution of these responses.

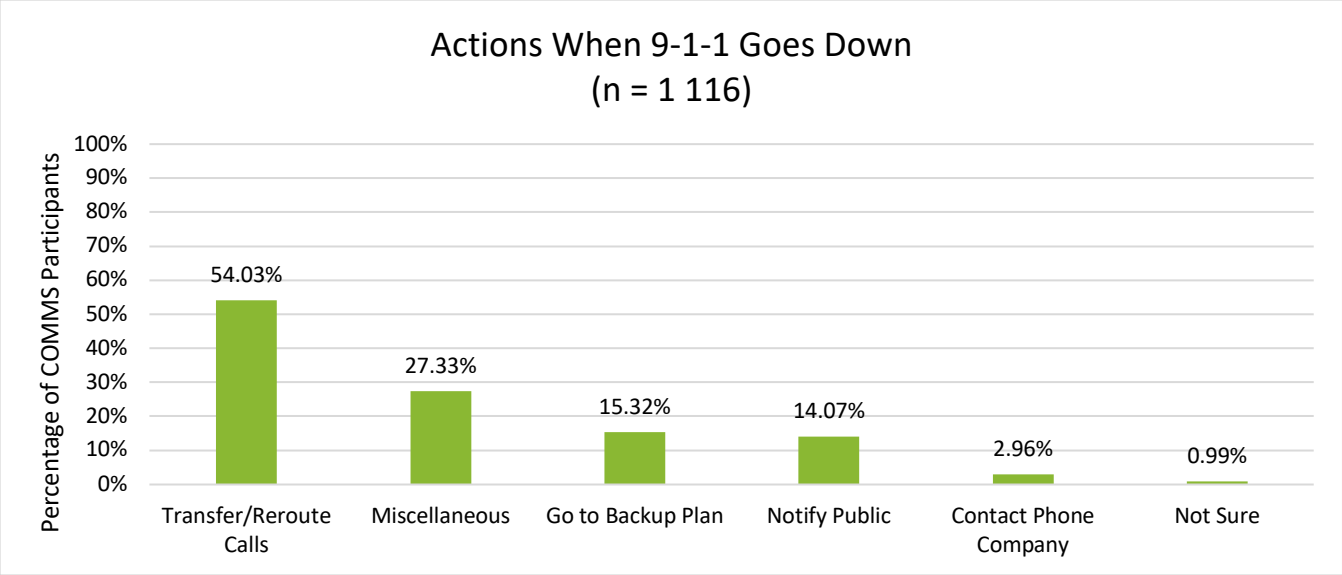

Fig. 9. Actions when 9-1-1 service goes down

Over half (54.03 %) of these responses spoke about rerouting or transferring calls to another agency or department.

> Transferred calls to neighboring center. Dispatched incidents accordingly. (COMMS:U:9808)

Rerouting or transferring calls is one form of back-up plan, but back-up plans were mentioned specifically by 15.32 % of respondents.

> We implemented our emergency back-up plan for re-routing 911 calls to an alternate number and manned that facility with our staff and dispatched off of portable radios. (COMMS:R:9240)

> If our call center was down, we would operate from the back-up center at a different location. Our calls are transferred to the neighboring county until we arrive at the back-up center. (COMMS:S:5917)

What emerges here is the importance of having backup and/or redundancy plans in place in order to avoid 9-1-1 services having to shut down. This could include rerouting calls or using alternative equipment. Alternative equipment ranged from using different types of phones such as "administrative phone lines" (COMMS:S:8932) to the use of "paper cards" (COMMS:U:8619) to "go to pen and paper" (COMMS:S:9546). Many of the redundancy and backup plans did not rely on computerized forms of technology, but rather on methods such as the use of manual forms of recording information (cards, paper/pencil, etc.). Finding ways to help call centers use technology in their redundancy planning is important here, but so is identifying and supporting the many non-technological ways in which they provide redundancy and backup.

Miscellaneous responses represented 27.33 % of this data, similar to the data above on why 9-1-1 service went down. These responses included things such as "We wrote everything down" (COMMS:R:9488) and "Notify responders" (COMMS:S:9439). In addition, several other categories emerged, including alerting the public (13.17 %) and contacting the phone company (2.96 %). Less than 1 % (0.99 %) reported they did not know or were unsure about what was done when the call center went down.

4.2.3. Technology Use for Day-to-day Work

In this section, responses for COMMS participants related to the use of technology for day-to-day incident response are presented. COMMS participants were asked about the specific devices they have and how often they use them. In addition, an open-ended text box was provided at the end of the section to capture additional devices they use in their day-to-day work or any additional comments they had. This gave participants the opportunity to identify communication devices not listed previously that they felt were useful in their work environments, as well as the ability to discuss other issues related to communication devices useful for their day-to-day work. These responses are discussed throughout this section where appropriate. The list of devices COMMS participants saw was developed from the interview data.

Day-to-day Devices

Devices listed for COMMS included:

- Desktop computer
- Foot pedal
- Headset
- Desktop microphone
- Clip-on microphone
- Personal monitor
- Shared monitor
- Pager
- Landline phone
- Radio
- Personal smartphone
- Work-issued smartphone.

Not surprisingly, the top devices that COMMS personnel indicated they "Use a lot" were desktop computers (98.96 %) and personal monitors (96.42 %). Radios (89.62 %) and landline phones (87.91 %) were also devices that COMMS survey participants indicated they "Use a lot". Given that communication, both with the public and with first responders in the field, is the main task of COMMS personnel, the reliance on computers, monitors, radios, and phones is not surprising.

It is interesting to note that in response to the "Other (please specify)" question at the end of this section almost 14 % of the 102 responses said they use a laptop or tablet either a lot or occasionally.

Tablet: work issued, use occasionally. (COMMS:U:6357)

[L]aptop that I use constantly at work and occasionally when not at work. (COMMS:S:2158)

The listing of laptops/tablets in the open-ended responses may represent the number of COMMS administrators who completed the survey, since they may be more likely to have access to these devices. In response to the "Other (please specify)" question at the end of this section, 12.75 % of responses noted they were not dispatchers, but COMMS managers or administrators.

Fig. 10 shows the frequency of use for all devices asked about on the COMMS survey.

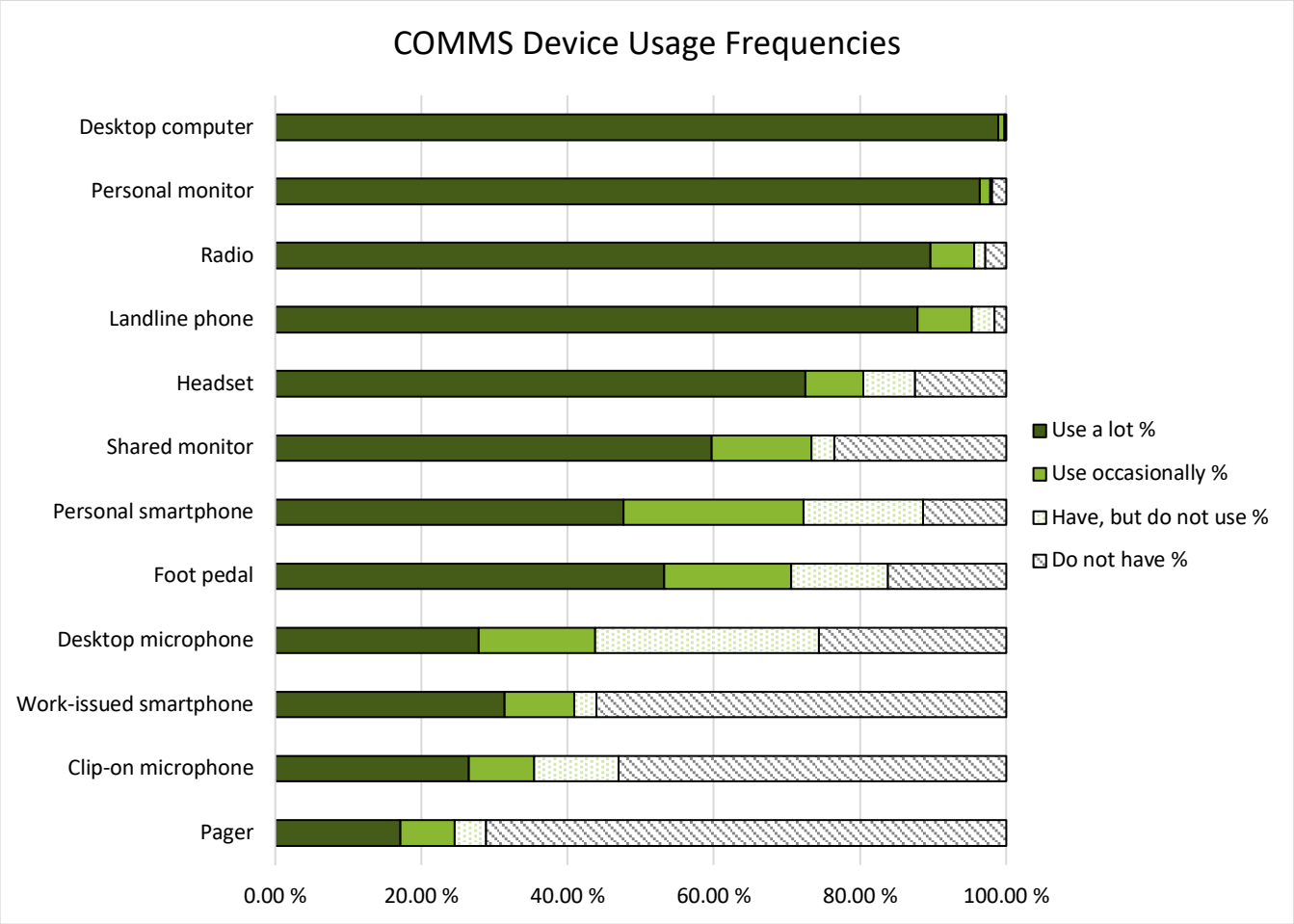

Fig. 10. COMMS device usage frequencies

While most respondents noted they "Do not have" a pager, it is interesting to note that 17.09 % of respondents said they use a pager "a lot." While this is considered by many outside of public safety to be outdated technology, they may continue to be used because they are seen as more reliable (see Phase 1, Volume 1 report) or because of cost.

Almost 45 % of COMMS participants said they have access to work-issued smartphones (although 3.05 % of those say they "Have but do not use" them). While not all COMMS respondents have work-

issued smartphones, over 70 % said they have and use (either a lot or occasionally) a personal smartphone at work. While most COMMS respondents indicated they have and use a personal smartphone at work, 16.38 % said they "Have, but do not use" a personal smartphone at work. These "Have, but do not use" responses are perhaps not surprising since open-ended survey responses to the "Other (please specify)" question at the end of this section, often noted that personal cell phones are not allowed in the COMMS workplace.

> 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)

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

Not being able to utilize personal smartphones at work, in conjunction with not having a work-issued smartphone, means that many COMMS personnel are unable to access and utilize some of the many applications/software that could help with their work.

In addition to the quantitative survey data on day-to-day devices, there were 102 open-ended responses to the "Other (please specify)" question at the end of this section which represents 6.52 % of COMMS participants. As previously stated, some of these noted that the respondent was an administrator rather than a dispatcher, while others listed specific forms of additional technology used such as laptops or tablets. Many listed a wide array of miscellaneous forms of technology, such as mouse, adjustable console and chair, and CD/DVD burner. Other than laptops/tablets, the items mentioned most often were printers/copiers/fax machines and video surveillance of the facility. It is interesting to note that many of the devices related to administration or clerical tasks rather than day-to-day incident response. Also of note is that in the open-ended data, participants most often referred to common, everyday devices, and not to more advanced forms of technology, something also found in the interview data (see the Phase 1, Volume 1 report for more specifics [1]).

Personal and Shared Monitors

All COMMS respondents use at least one monitor to gather and disseminate data and information. In order to understand how many displays COMMS personnel are responsible for monitoring, the Phase 2 survey asked them about the number of personal monitors they have at their individual workstation and how many shared monitors they have in their call center. Participants chose a number from a drop-down field for their responses. Frequencies of responses are displayed in the histograms below (Fig. 11 and Fig. 12).

There were no responses to the question about personal monitors where a respondent indicated they had zero monitors at their personal workstation and no survey responses indicated more than 10 monitors at a personal workstation. The majority of COMMS respondents, over 70 %, said they have between 4 and 7 monitors at their personal workstation. However, almost 4 % of respondents said their personal workstation only has one monitor.

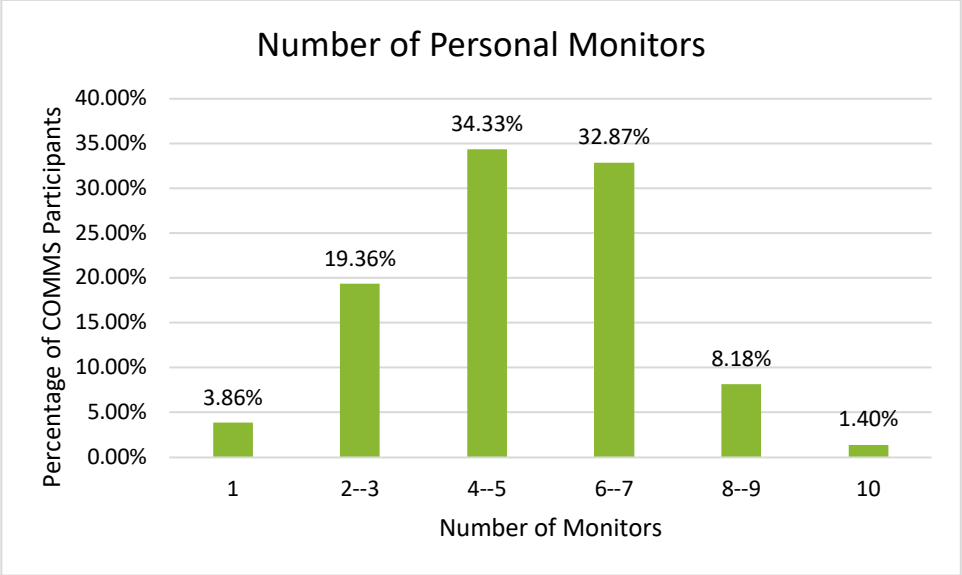

Fig. 11. COMMS number of personal monitors

In addition to their personal workstations, most COMMS personnel also have shared monitors in their call centers that are shared by all COMMS personnel on duty. These monitors provide additional data to review, such as weather, traffic cameras, or maps. Almost 30 % of respondents (29.85 %) said they have 2 or 3 shared monitors that provide additional input. Some call centers have more than this, with almost 5 % of respondents (4.78 %) saying there are 20 or more shared monitors for viewing in their call centers. Twelve participants said they have 100 additional monitors for shared viewing. However, just over 5 % of respondents noted they have no shared monitors for viewing.

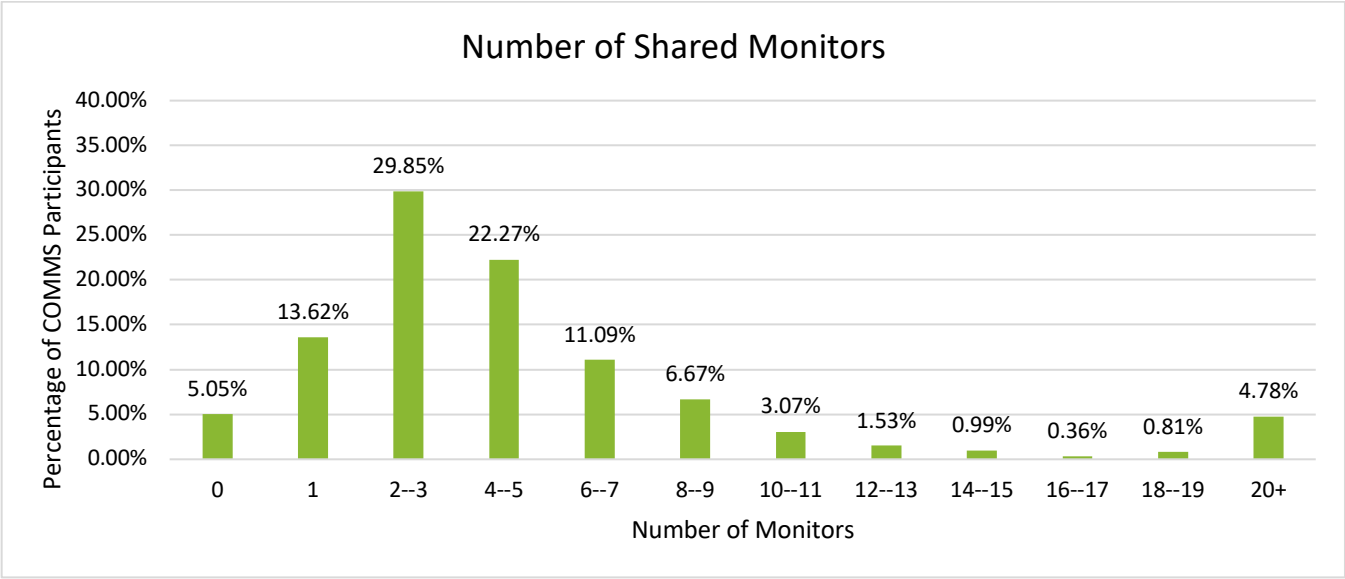

Fig. 12. COMMS number of shared monitors

While having no shared monitors may be problematic, having too many monitors may also be an issue.

> [O]ur center has more monitors than necessary and it causes an information overload that's not needed. (COMMS:S:6564)

When there are 4—7 monitors at a personal workstation plus additional monitors for shared viewing, one can imagine the amount of data and information that are being processed at any given time by COMMS personnel, and the potential overload this can create.

> We monitor security cameras around our building. We monitor over 70 securities cameras….We have several license plate readers throughout the [county redacted] that scans every plate coming through whether it be stolen vehicles and such. So, they're monitoring that. They are monitoring fleet tracking which is another program which tells them where our officers are at, how fast they're going, whether they've got a seatbelt on, whether their lights are running. We have a lot of programs. I'm trying to think…. They're monitoring the 'Are You Okay' program we have in our [county]….So, the amount of programs is… quite cumbersome sometimes because of the computers and the systems and logging in and keeping track of what's going on. (INT-COMMS-R-013)

This provides a sense of the tremendous amount of data and information that must be captured, reviewed, processed, and disseminated by COMMS personnel which, as survey respondent 6564 notes above, can contribute to cognitive overload for those who work in COMMS.

4.2.4. Information Problems Experienced

This section of the survey asked participants questions about information problems they encounter in their work. The information problems asked about in the survey were those commonly experienced by participants in the in-depth interviews. These included problems with callers, with cell phones, with information overload, and with maps/databases (see Appendix C). Respondents were asked to rate the frequency at which they experienced each of these problems, on a scale from "Always" to "Never."

In addition, there was an open-ended question at the end of this section that gave participants the ability to list additional information about issues they face. The item was listed as "Other (please specify)" and provided a text box that had no word limit on it. Of the 1 564 COMMS survey responses, only 43 provided additional information here. The responses were wide-ranging and there was little consistency, however, two response categories, staffing and accurate location information, were identified as problems in several responses.

> These issues are a question of adequate staffing, not technology. (COMMS:U:4380)

> Many phone providers CAN NOT provide good location information for their callers, if at all. We have one company that transfers calls to [us] from the other end of our state - which would be about an 8-hour response time. (COMMS:R:421)

Without access to both staffing (a human resource) and accurate location information (a technological resource) it is difficult for COMMS personnel to adequately do their work.

Fig. 13 below shows the frequency of experience for the five problems COMMS respondents identified in the interview data related to eliciting, gathering, processing, and disseminating information.

While some respondents indicated they “Always” experience these problems, it is perhaps most interesting to note what happens to the percentages when the frequency categories of “Always,” “Most of the time,” and “Sometimes” are combined. Examining the data this way is important since if a problem is experienced even sometimes, it can cause frustration and disruption for personnel. Looking at the data from that perspective shows that 60—90 % of COMMS respondents experience these problems at least some of the time.

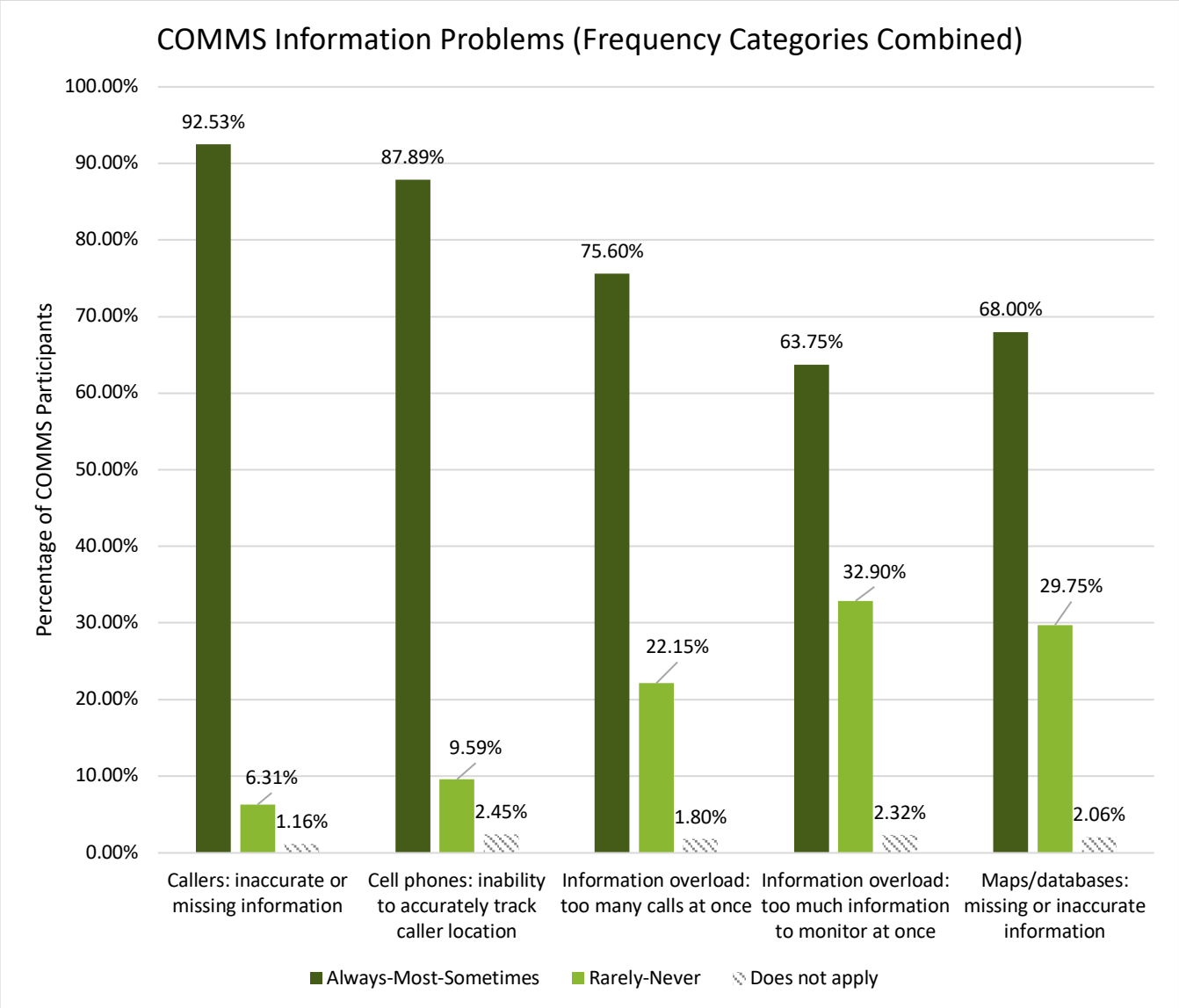

Fig. 13. COMMS information problems

The problem noted most frequently, that of callers providing inaccurate or missing information, is not specifically related to technology, and yet it is experienced by the vast majority COMMS personnel at least some of the time. This is supported by data from the interviews as well as by open-ended survey

data, where many participants noted that getting accurate information from callers was of utmost importance.

> Getting the important information from the caller and relaying that information to the responders timely and accurately. Getting it from that caller, no matter what the circumstances are and then relaying it timely and accurately. (INT-COMMS-R-016)

Getting accurate and important information from callers, especially location information, is an important part of COMMS work, if not the most important part. However, this information is often difficult to obtain.

> They think that if they call 9-1-1 we know where they are and we don't. We know what cell phone tower your cell phone hit off of and that's it and then if you call on a VoIP phone or a voice over IP phone it's wherever your VoIP was registered to. (INT-COMMS-U-007)

> Due to the portability of cell phones and people not knowing where they are any longer due to relying on GPS to get everywhere, people have a difficult time providing their location when they have an emergency. Even if asked what they see around them - sometimes, the only thing they state is that it is a street that they are not even on or near per their GPS. (COMMS:S:1331)

The public often think that COMMS personnel automatically know their location. While not specifically a technology issue, this is related to the fact that cell phones are now used for the majority of 9-1-1 calls, and cell phones do not always provide accurate location information.

> We have peaks where there are higher call volume times and during those moments it can feel overwhelming and frustrating….It would be helpful if all cellular providers sent over accurate locations on a regular basis. (COMMS:U:3211)

> Staff must have access to more precise location accuracy from cell phones which account for 77% of our 9-1-1 calls requiring services. (COMMS:S:3515)

The lack of accurate location information is an issue that creates a major source of frustration for those working in COMMS.

Information overload, especially due to high call volumes, also had high frequencies of responses when the frequency categories of "Always," "Most of the time," and "Sometimes" were combined (75.60 %). This was something also prevalent in the interview data and occurred in the open-ended survey data as well. As noted in previous reports [22], problems with recruitment, retention, and staffing are issues many call centers face today, often resulting in increased call volumes. This is especially true with the addition of texts and pictures/videos that some call centers now receive.

In addition, maps were identified as an information problem for many COMMS respondents. In this question, 68 % of respondents said they have problems with them at least some of the time. Given the importance of location information, this poses tremendous problems for COMMS personnel who need to have access to and relay accurate information.

> Mapping system for wrecker dispatch program can't get their maps updated by the company they use for mapping. Major roads in our city don't exist on their maps. (COMMS:U:3371)

> Google maps needs to be updated more frequently. Still have buildings showing that have been torn down for over 5 years. (COMMS:R:5851)

This problem can result in more time for response since they often have to look elsewhere for the correct information, decreasing efficiency and causing frustration.

Finally, one comment from the open-ended response question in this section highlights the problem of technology being improved/developed without the input of those working in COMMS.

> Technology being developed without Operational input. (COMMS:S:8012)

While only one comment in this section, this idea surfaced again and again in the interview data, as well as in open-ended data across the survey.

> Well…unless there's input from the users in developing and building it… that's the challenge that I see because if you're not sitting in that chair, dispatching, taking calls, well we can give that to communications as always a--but as you can see out here they have 5 computer screens in front of them. What does the technology do? Does it increase their workload, their responsibility, their--and with responsibility comes liability? Does it increase that or does it decrease that? Or is it kind of a neutral that this is going to be something new but it's going to help you take some of that workload off but it's going to replace that so is it going to be a neutral or is it going to be something that's going to increase their workload? (INT-COMMS R-016)

> Dispatchers need to be more involved in preplanning and equipment examination prior to purchase. For example, [State agency redacted] spent tons of money on a radio system and it sucks. Now we are left to make excuses for its flaws. We take the blame from every responder and caller when it doesn't work, but we had no input. Vendors should be mandated to set up the system so it can be used, for more than a few minutes in real time with that centers information. (COMMS:R:9667)

Thus, one challenge for the larger PSCR R&D community is to involve COMMS personnel in broader efforts to improve/develop current and new technology.

4.3. EMS

4.3.1. Overview of EMS Findings

EMS is a unique discipline in that many EMS responders are cross-trained as firefighters. However, they have some unique technological needs, as our findings show. Additionally, the survey provided an opportunity for EMS participants to provide more information about the medical technology they use. The highlights of the survey findings are summarized below. Detailed results are presented in subsequent Sections 4.3.2 through 4.3.5.

- Radios and personal smartphones were ranked as the most useful devices for EMS daily work. Radios and personal smartphones were also the devices used most often in their day-to-day work.
- Desktop and laptop computers were also used by over 80 % of EMS, but those who used them didn't find them as useful to their work as their other devices. Not as many EMS used work-issued smartphones or pagers, but those who did found them very useful to their day-to-day work.
- Most EMS did not have earpieces or wireless microphones; few had corded mics.
- Not as many in EMS had MDTs as those who had desktops, laptops, and tablets, but those who did found their MDTs very useful.
- The major problems EMS faced with their communication devices were cost, connectivity, and battery life. Reliability and usability were also issues EMS faced with many of their devices.
- Connectivity problems were re-emphasized in responses to the medical technology question, as was interoperability. These problems were of concern to EMS respondents in part due to their need to transmit patient information to hospitals or other medical centers.

4.3.2. Technology Use for Day-to-day Work

The list below includes the devices presented in the EMS survey. Similar devices are grouped into three categories for the purposes of displaying results (listed alphabetically within groups); devices were neither grouped in the survey nor analyses.

Devices listed for EMS included:

- Earpieces (corded earpiece, personal wireless earpiece, work-issued wireless earpiece), mics (corded mic, wireless mic), and radios (in-vehicle radio, portable radio)
- Desktop computer, laptop, MDT/MDC, and tablet
- Flip phone, pager, personal smartphone, and work-issued smartphone

Results for each device are displayed and interpreted below. Frequency of use percentages for each device are listed in Appendix E.

Participants were also given a final open-ended text box to capture any other devices they use in their day-to-day work. In the EMS survey, 36 participants (3.99 % of EMS respondents) provided responses. Notable findings from the open-ended questions included:

- Mention of specialty hardware not in the day-to-day device section of the survey, including Wi-Fi hotspots and Bluetooth devices
- Explanation that they buy or use their own personal technology (e.g., smartphones, mics, and earpieces) to perform job tasks
- The importance of using technology to access specialty software/apps
- The focus on using technology to facilitate communication with dispatch, hospitals, and other EMS responders, especially using radios and telephones
- Mention of using smartphones and tablets in their work

Other open-ended survey responses and interview quotes relevant to day-to-day devices presented in the survey are incorporated throughout this section where appropriate.

Summary of EMS Technology Use

Fig. 14 shows the frequency of use for each device for EMS.

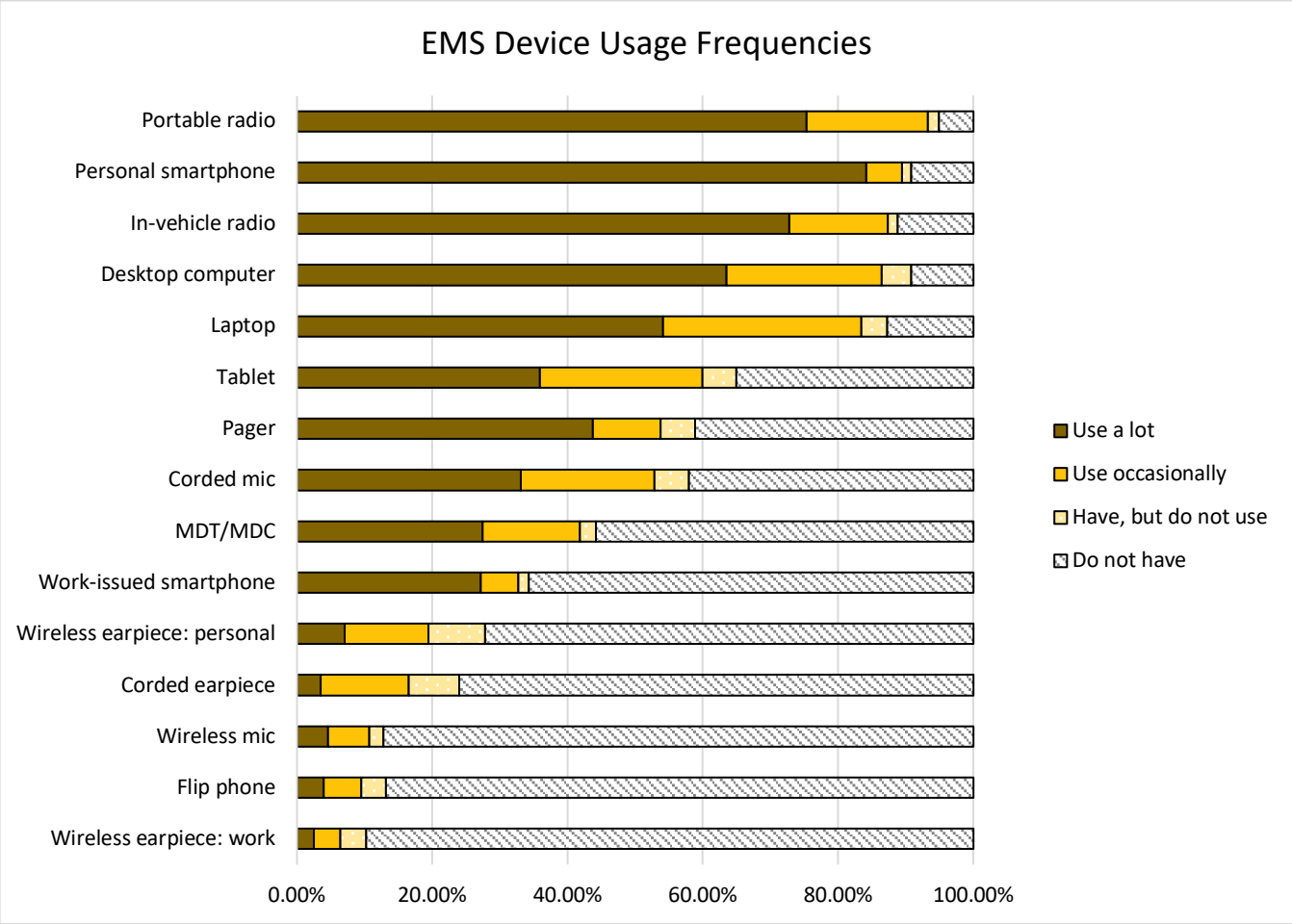

Fig. 14 EMS Device Usage Frequencies

EMS survey participants used their portable radios, personal smartphones, and in-vehicle radios most frequently as well as desktop and laptop computers. The importance of smartphones and radios were also seen in the interviews.

> So most of my communication is through cell phone... But there's a large sum of my day that I'm operating on the radio as well. Providers may be on the scene of a call having a difficult incident and may need to call me on the radio and then we'll talk back and forth on a secured channel and be able to talk securely and be able to talk about patient information." (INT-EMS-S-014)

As illustrated in the quote, communication is a vital task to EMS responders. Fewer EMS survey respondents had tablets, MDTs, pagers, and corded mics, but those that did have these devices used them often. EMS survey respondents tended to neither have nor often use flip phones, earpieces, or wireless mics.

Earpieces, Mics, and Radios

Earpiece, mic, and radio usage frequencies are displayed in Fig. 15.

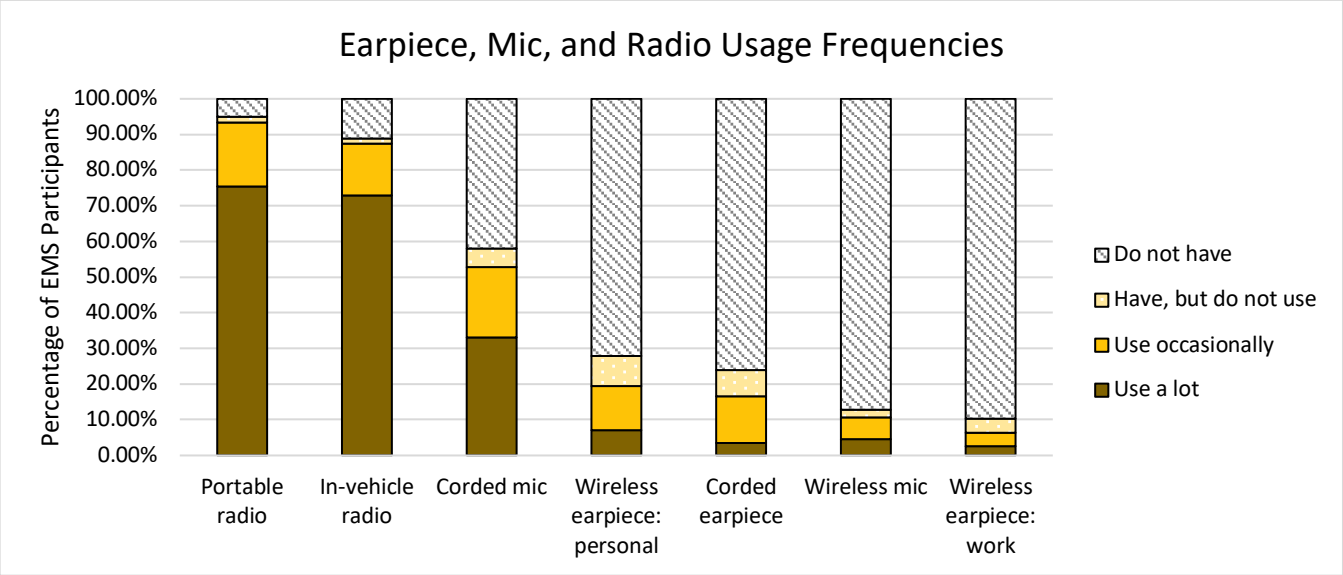

Fig. 15 EMS Earpiece, Mic, and Radio Usage Frequencies

EMS survey participants used their portable radios and in-vehicle radios often. Approximately 90 % of respondents selected “Use a lot” or “Use occasionally” for both types of radios. Additionally, some of the participants who provided responses in the open-ended question discussed the importance of radios in their work more generally, emphasizing their use of portable radios and in-vehicle radios, but also mentioning other types of radios such as base stations.

> Base station radio in my home Personal landline phone in my home Call em all automated phone message application (EMS:R:5584)
>
> Secondary UHF truck-to-truck system used frequently (EMS:U:9785)

While radio technology was used often by EMS participants, far fewer participants used or even had other types of audio communication technology. Half as many EMS survey participants used corded mics “a lot” or “occasionally” compared to personal and in-vehicle radios. Additionally, over 70 % of EMS participants did not have wireless earpieces (work or personal), corded earpieces, or wireless mics. Some open-ended responses mentioned mics and earpieces but indicated that these devices were personally purchased rather than provided by the department or agency.

> Self-purchased wired earpiece (EMS:U:5274)

> Mic with cord is a personal purchase. (EMS:S:4268)

> We were to have two portable radios in each vehicle. We do not. We are not issued ear pieces. Most of the equipment we have we bring as our own. Our system uses our phones for paging without any reimbursement. Smart phones are our own. There is a phone for Med. Control in the back of our rig. Rarely if ever used on scene. (EMS:S:893)

These issues may be related to the broader issues of costs and funding that were also mentioned in the interviews [1]. These issues may prevent some EMS responders from having and using the work-issued technology they need.

Desktop Computers, Laptops, MDT/MDCs, and Tablets

Desktop computer, laptop, MDT, and tablet usage frequencies are displayed in Fig. 16.

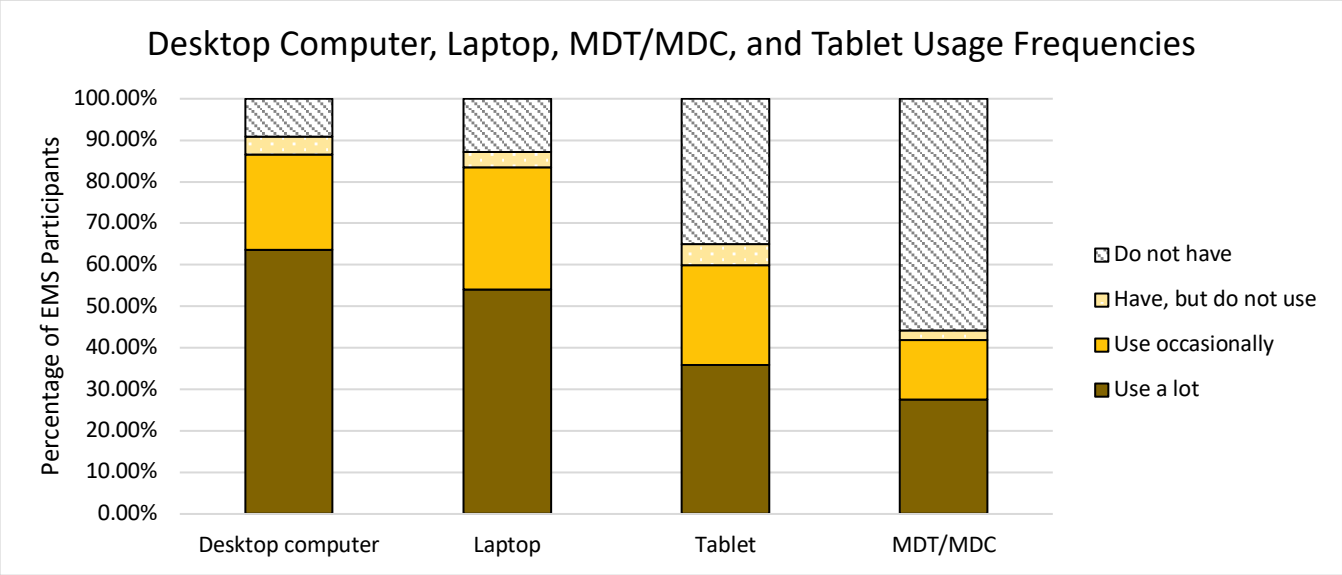

Fig. 16 EMS Desktop Computer, Laptop, MDT/MDC, and Tablet Usage Frequencies

A majority of EMS participants had desktop and laptop computers, with slightly more EMS survey participants indicating that they used their desktop computers “a lot” compared to using their laptops “a lot”. However, there was variability in how often these devices were used. For laptop computers, over half of the participants indicated that they used their laptops “a lot” and nearly 30 % reported that they used their laptops “occasionally”. For desktop computers, over 60 % reported that they used their desktops “a lot”, and 22.95 % indicated that they used them “occasionally”.

Computers and laptops were often mentioned in the interviews as useful for a variety of tasks in EMS responders’ day-to-day work.

> Yes. We use laptops for trip reporting. So every patient, we have a trip report that we have to write about them. And then it goes to a server, and it goes to billing, and it goes to the hospitals. So they can have a report of what happened before they ever got there. And different places have different abilities to make it better for the crews. And some places focus

> on-- I mean the billing is important because you need the money to keep doing the job. But some places it seems like a little higher priority [laughter] in making it better for billing, or QA, or research, versus the people that are running the 10 calls a day, who have to write the 10 trips reports per day... (INT-EMS-R-007)

> I have my portable Toughbook laptop where I keep all my information for a medical run. We can't communicate through that. There's no communication through that. That'd be great in case something happens. I could send an email out to maybe the alarm office or to my field chief who takes care of the district, through my Toughbook. That's a good idea. (INT-EMS-U-012)

> And I love it because it's got a computer screen in it and I can literally diagnose the truck, what's going on from that computer screen. So it's super important like it tells you everything. I can control all my lights from there, everything. So it minimizes my movements in the truck, which saves time overall in a call. I don't have to hop out, start a generator on top of the truck, get back down. I can just hit on my truck, and I know, I see it come on, and I can go help my team. (INT-EMS-R-002)

A majority of EMS survey respondents also used tablets "a lot" or "occasionally." Some open-ended responses mentioned that tablets either had similar functions to or had entirely replaced traditional laptops. One EMS respondent commented that, "Tablet and laptop are one in the same in this case" (EMS:U:697). This interest in having all-in-one devices that served multiple purposes was also seen in the interviews.

> …looking more specifically at tablets and getting away from laptops, because people don't like carrying laptops. Plus, they're a big target. Somebody wants to take one or whatever. But you can keep an [tablet redacted] or a [radio redacted]. You can keep those things. Some of our pockets on our EMS coats are gigantic. I mean, you could put that in there, no problem. So it would be really interesting to see the benefit in the programming knowledge there. Is it really hard to-- is it really that hard to mix and patch the dispatch information with our medical information, with the hospital's information? Is it really that difficult, you know? (INT-EMS-S-005)

Although some EMS responders felt that tablets had the potential to be an interoperable, all-in-one, portable device, not all respondents felt that tablets were the same as their laptops, as one EMS respondent wrote, "My agency issues the crew a tablet that is so difficult to use I bring my own computer" (EMS:U:671). Although some EMS respondents felt that tablets could perform many of the same functions as computers, some did not feel this way and still preferred laptops to tablets.

Compared to computers and tablets, fewer EMS survey participants had or used MDTs. Nearly half as many EMS survey participants used MDTs compared to desktop or laptop computers. However, those that had these devices used them frequently, with 41.81 % indicating they used these devices "a lot" or "occasionally". The benefits and uses of MDT for EMS responders was mentioned in the interviews.

> Well, currently each member has their own radio, their own portable radio. And then they have their MDC. Their mobile data terminal, or MDT. However you want to call it. Which was where

> they get their runs. They also have an MDC inside the firehouse where if they're in quarters they get their runs that way, and they have to-- basically it's a touchscreen where they have acknowledge their runs when they get them. Sometimes the firemen do it for them. They also have a mobile recording unit which is basically a laptop where they do all the patient care reports. (INT-EMS-U-010)
>
> ...I think our MDT is spot on and user-friendly in my opinion. (INT-EMS-S-006)
>
> So, what I do, when I get dispatched a call on my MDT, I looked at the time, the location, the incident. I'll look at if it's male, female, conscious and breathing. I look at most important information and that information will be there. The alarm office will have remarks on there depending on the caller. They also put on there, which is great, I'm glad they do that, it's called the [local PD] hashtag number. I know how to retrieve that number through my MDT. Down at the bottom, you're able to type in to send information. I'll type in that [local PD] number out to the alarm office and somehow, some way, it comes back to me with what the first 911 call was. What the call is from the call taker... (INT-EMS-U-012)

As illustrated by these quotes, the EMS responders who had MDTs found them useful for communication as well as coordinating information and resources during incident response.

Flip Phones, Pagers, and Smartphone

Flip phone, pager, and smartphone usage frequencies are displayed in Fig. 17.

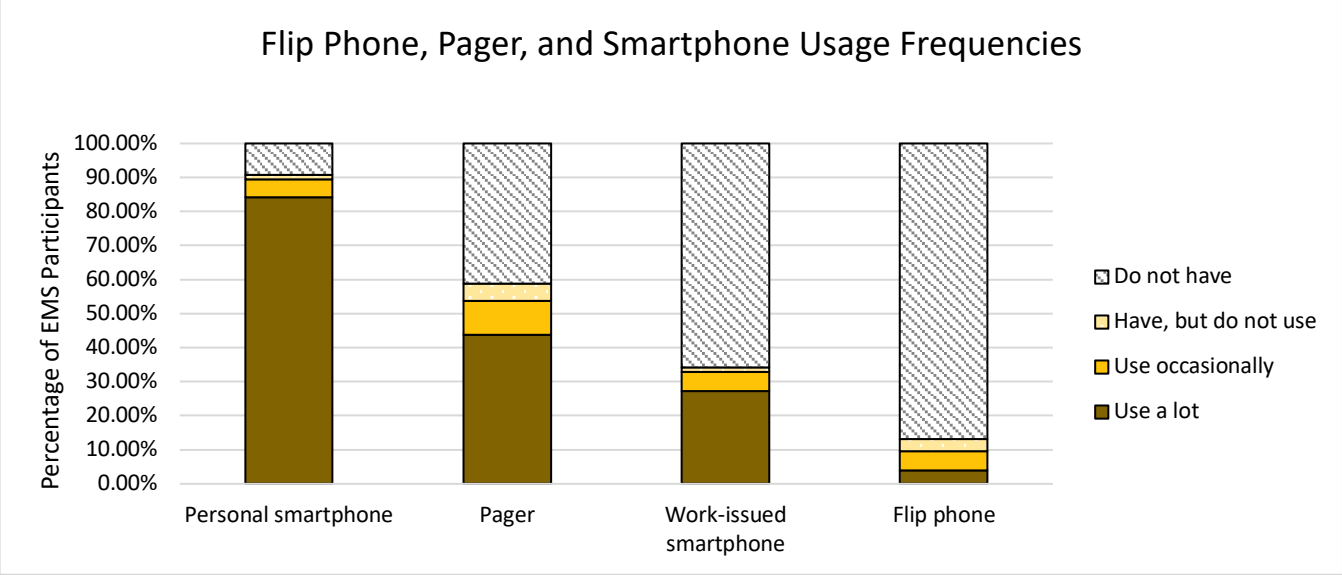

Fig. 17 EMS Flip Phone, Pager, and Smartphone Usage Frequencies

More EMS participants had personal smartphones than work-issued smartphones, pagers, and flip phones. Though not as frequently used as personal smartphones, EMS survey participants did often use pagers. Over half of the EMS survey participants had a pager, with 43.76 % using their pagers “a

lot." In contrast, over 80 % of participants did not have a flip phone and only 9.55 % used their flip phones "a lot" or "occasionally."

Some open-ended responses mentioned using non-smartphone phones, including flip-phones but also mentioning landlines in their day-to-day work. One participated mentioned that their, "Work-issued cell phone is neither a smart phone nor a flip phone. Rarely used..." (EMS:S:920) Other participants in the interviews also expressed that they used flip phones for communicating, but some mentioned that these devices were not ideal.

> [RE: flip phone] It's a department-issued cell phone for communication. So we use that to call the hospitals. We use that if a patient needs to call somebody to arrange a ride or let them know, so we're not having to give them our personal cell phones and them having our numbers. (INT-EMS-S-006)

> No, it's not even a-- yeah. It's actually, it's like a basic flip phone. It's not even a smartphone. So it's just your basic flip phone. I think they might have even disabled the data capabilities on it. So even the limited data capabilities it has on it, I don't know if they're enabled on the phones. They're used pretty much just for telephone communications (INT-EMS-U-017)

> [RE: paramedics] So now we do provide phones for them, however, they're flip phones, and they're locked down. So they can only call the hospital, they can only call the office, which is the fire alarm office, so they don't have the opportunity to send a text or make phone calls. And the same thing with their mobile reporting unit, the computer where they do their patient care reports. It's locked down for security reasons so they're not able to go on the Internet, they are not able to go search Google or whatever, do some research on it; it's locked down, so. (INT-EMS-U-010)

These statements may indicate that work-issued phones used by EMS participants utilized outdated phone solutions. As indicated by the survey data, few EMS survey participants had or used a work-issued smartphone. However, many EMS participants had and used their own personal smartphones in their day-to-day work. This may suggest EMS responders find the broader capabilities of their personal smartphones more useful than non-smartphone devices issued by their departments.

4.3.3. Day-to-day Device Rankings

EMS respondents ranked their top five most useful devices based on devices they currently have (see Appendix B and Appendix C for the methodology and question stems for rankings items). The percentages of EMS survey participants who selected each device in their top five rankings are displayed in Fig. 18. Rankings for each device can be found in Appendix E.

Over 75 % of EMS survey participants ranked their radios (both portable and in-vehicle) and smartphones (both personal and work-issued) in their top five most useful devices. A majority of EMS responders also selected their pagers, computers (laptops and desktop), and MDTs as most useful. Mics and earpieces were the least frequently selected, comprising less than 25 % of EMS respondents' top five rankings.

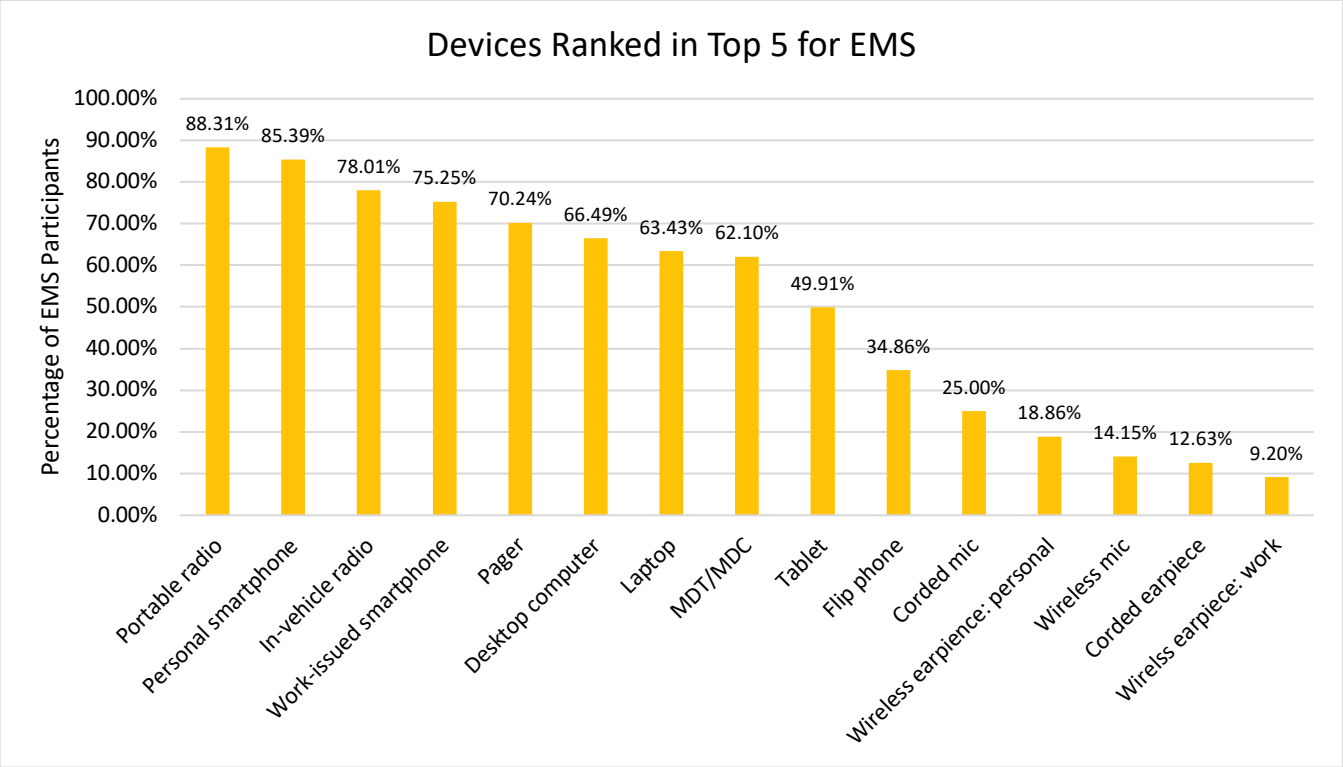

Fig. 18. Devices ranked in top 5 for EMS

4.3.4. Device Problems Experienced

This section reports on the problems EMS responders experience with the various communications devices they used, based on their previous survey responses (see Sec. 2.2). Since the problems associated with a device are dependent on the device, problems lists are provided with each device as they are presented. Also discussed for each device are the open-ended responses that gave participants the opportunity to comment with additional problems.

While it is essential to address the problems that first responders "Always" face, it is important to also consider the problems that occur only "Sometimes," since the uncertainty of failure diminishes the perception of those devices' reliability and problems experienced only "Sometimes" could have dire consequences. Throughout this section, graphics portray device problems that participants experienced at least "Sometimes" ("Always," "Most of the time," and "Sometimes"). *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."* The detailed percentages of the EMS responses for each device and its associated problems are listed in Appendix C.

EMS participants were asked problems for the devices below. Similar devices are grouped into three categories for the purposes of displaying results (listed alphabetically within groups); devices were neither grouped in the survey nor analyses. Since the specific devices presented to participants in this section of the survey was based on a participant's previous survey responses, the number of participants who were asked questions about each device varied. Of the 902 EMS who participated in

the survey, the number of participants who were asked about problems for a specific device, as well as the number of participants who selected a response option for each device problem, can be found in Appendix C.

- Mic and radio
- Desktop computer, laptop, MDT/MDC, and tablet
- Pager and smartphone

Overall, when asked about cost, EMS respondents indicated "price: too expensive" was their top problem "Always" experienced across devices[4]. Further, compared to other device problems, EMS experienced cost problems with their devices by a ratio of nearly 3:1 (an average of 2.8:1). Meaning, for a device, three times as many EMS respondents had cost problems than any other problem on that device. This gap is even wider for mics and pagers. The open-ended responses for the individual device questions reiterated the concerns in EMS about cost.

> Costs WAAAAY too much for the [redacted] hardware and software to program our radios. Costs WAAAAY too much to pay a radio company to do it for us. (EMS:R:2428)

> Voice pagers in our frequency range are too expensive so we live with what we have. (EMS:R:719)

Expensive costs often lead first responders to settle for technology that they feel is not suitable for their day-to-day work. Reducing the overall cost of technology for the devices that EMS utilize for incident response will allow them to acquire the tools they need to do their jobs more effectively.

Mic and Radio Problems

The problems associated with mics and radios, as presented in the survey for EMS responders, are shown in Table 4. In addition to the list of problems associated with a device, participants had the opportunity to provide other problems they experienced via an open-ended text box (see Appendix B and Appendix C for the methodology and question stems). For mics, there were 4 open-ended responses about problems experienced (6.56 % of the respondents who were asked about problems with mics); 99 EMS respondents provided open-ended responses about radio problems experienced (16.31 % of those who were asked about radio problems).

Table 4. Survey problems lists – EMS mics and radios

Mic	Radio
Audio quality	Audio quality
Cord	Battery life
Durability	Channel switching
Falling off	Cord

[4] "Price: too expensive" was not included in the list of problems for tablets (see Sec. 2).

Mic	Radio
Outdated/old	Coverage/dead zones
Placement on body	Durability
Price: too expensive	Interoperability
Talk button location	Outdated/old
Talk button size	Price: too expensive
	Radio discipline/etiquette
	Size/bulkiness

The top microphone problem experienced by EMS was “price: too expensive,” with 57.78 % of respondents experiencing the problem at least “Sometimes” with their mics (see Fig. 19). Further, expensive cost was the only problem with mics that more than 3 % of EMS “Always” experienced (17.78 %). Problems with the “audio quality” of mics were experienced by nearly 50 % of EMS, which is troubling given the primary function of microphones during incidents is to transmit audio.

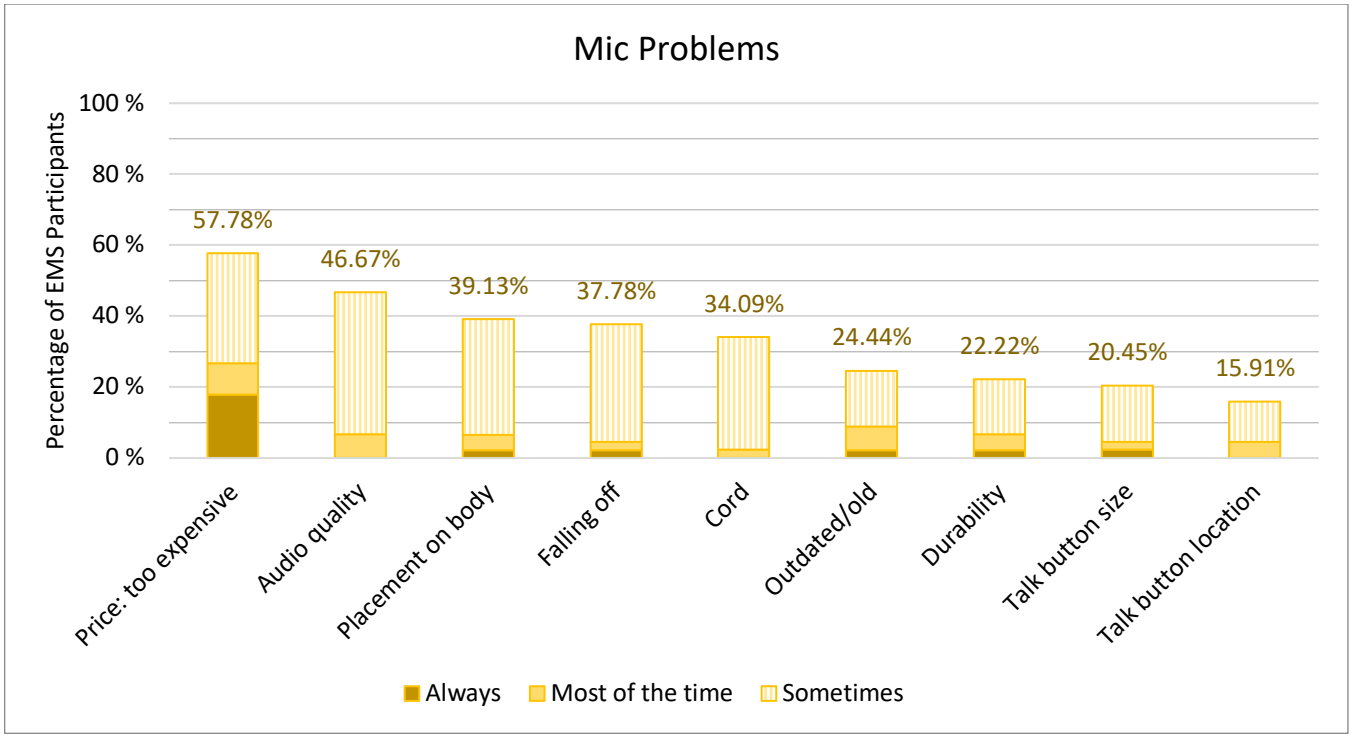

Fig. 19. EMS mic problems

Fig. 20 shows the problems experienced by EMS respondents at least “Sometimes” with radios. Table 5 summarizes the open-ended responses to the radio problems question, where they are categorized by the issues faced. The percentage of open-ended responses and exemplar quotes are provided for each category.

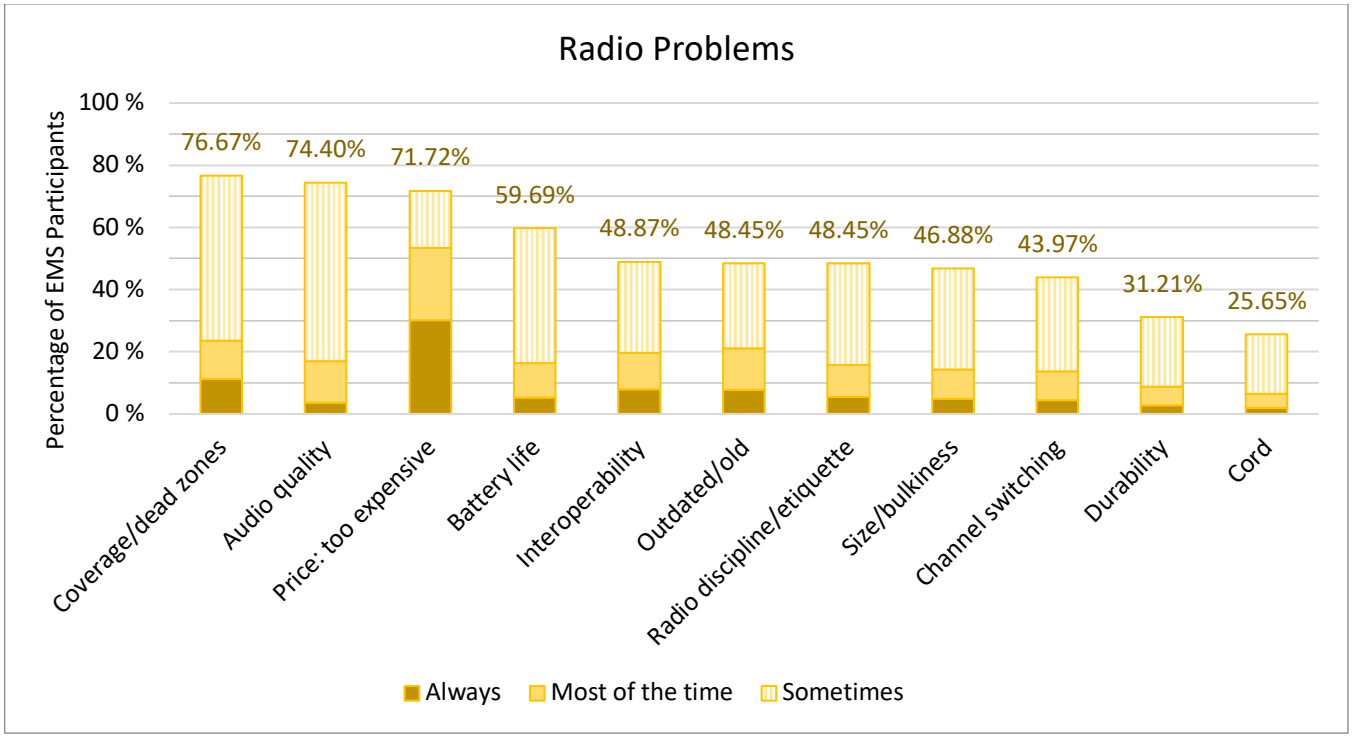

Fig. 20. EMS radio problems

Table 5. Categories of open-ended responses – EMS radio problems

Types of radio problems	% of responses *(n = 99)*	Exemplar Quotes
Coverage / Dead zones	34.34 %	dead zones in hospital (EMS:U:923)
Miscellaneous	25.25 %	Firmware bugs, poor programming, inability to use my programming skills to improve things. (EMS:R:4165)
Audio quality *(e.g., static, interference, volume)*	21.21 %	Ability to hear at noisy scenes. Voice clarity at noisy scenes. (EMS:R:8461)
Channels and programming	15.15 %	Too many channels, too complicated to use. So most new people avoid using it. (EMS:S:196)
Reliability	14.14 %	Sometimes unreliable due to remote/rural areas. (EMS:R:7205)
Usability	12.12 %	Adding carrying a radio that requires 2 hands with all our equipment to carry, trying to do cpr or some other medical thing and try to answer dispatch who never hear you correctly takes away patient care! (EMS:R:532)
Other transmission issues *(e.g., bonks/busy signals, traffic, etiquette)*	10.10 %	Sometimes do not hear audio from other people so sometimes have a lot of people show up for a call because they never heard the other people say they were going (EMS:R:6424)
Old	9.09 %	Radio system is outdated and needs updated to new digital system. Repeaters don't work currently and or are non existent. (EMS:S:2585)

Types of radio problems	% of responses *(n = 99)*	Exemplar Quotes
Battery	8.08 %	We do not have quarters and are therefore subjugated to sitting on street corners so the battery lives are always changed regardless the length of use. (EMS:S:893)
Interoperability	7.07 %	inter-operability as surrounding municipalities are on different bands and we do not have resources to upgrade to multi-band radios, so all intra-agency communication has to go through dispatch desk or cell phones (EMS:S:6663)
Cost	7.07 %	Never enough and can't afford to just buy one (EMS:R:2208)
Policies	5.05 %	Biggest issue is radio area coverage. Especially since the mandatory switch to narrow band (EMS:R:3070)
Robustness / Durability	4.04 %	We have cheap radios and they are not durable when confronted with more direct physical contact of a patient. (EMS:S:893)
Training	3.03 %	Just the basic understanding of usage. It seems only certain individuals are trained on programming, etc. and they become the go-to person instead of insuring everyone receives the same training. Knowledge is power. (EMS:R:681)

Note: An individual response could address problems in multiple categories. Therefore, percentages may not sum to 100 %.

"Coverage/dead zones," "audio quality," and "price: too expensive" were the biggest problems EMS faced with their radios, with more than 70 % of EMS having these problems at least "Sometimes." Of these, "price" was most often a problem, with 30.17 % of participants "Always" experiencing an issue with cost, and 23.28 % experiencing it "Most of the time." More than twice as many first responders in EMS "Always" experience problems with the high cost of radios than any other radio problem.

The top radio problem experienced in EMS was "coverage," reflected in both the quantitative data (76.67 % at least "Sometimes") and the open-ended responses (34.34 % of responses related to coverage issues). Open-ended responses expressed coverage and dead zone issues due to building structure, geography, and topography.

> The county topography makes radio coverage a challenge, however, add to that the fact that 1/3 is public land in which no communications towers can be placed- limits your ability to plan for improvements. The government mandates for technology improvements severely limits the small counties ability to keep pace. (EMS:R:2434)

> Simulcast phase distortion. Congestion of channels. Lack of dispatchers or revolving door dispatchers. Range issues, loss of coverage in buildings, audio quality in buildings. (EMS:S:9778)

Radio communication is stalled when coverage fails or when the audio quality is so poor the message is indecipherable. In addition to the 74.47 % of respondents who thought audio quality was a problem at least "Sometimes," another 21.21 % of the open-ended responses reiterated the issue.

> Stepping on each other with [simultaneous] transmissions or getting beeped out. Also in a dead spot. But worst of all is when the audio can't be understood ! (EMS:U:3845)

> Radios are outdated. We are having problems with the radio and mics not working. Also, the tones are loud when talking is [quiet]. (EMS:U:8600)
>
> Reception from dispatch staticy and undecipherable. (EMS:R:6251)
>
> [Interference] from on-channel or adjacent channel digital signals (our worst enemy) (EMS:U:1565)

Static and interference were some of the key issues respondents identified with the quality of audio via radios. Another major problem EMS faced with their radios was related to their battery life; nearly 60 % of EMS experienced this problem at least "Sometimes" (59.69 %). Open-ended survey responses expressed some concern for battery problems, with participants often simply stating "battery life issues" or batteries "dying."

Desktop Computers, Laptops, MDT/MDC, and Tablet Problems

The problems associated with desktop computers, laptops, and MDTs for EMS are shown in Table 6. In response to the open-ended questions about additional problems for these devices, 23 EMS participants provided feedback about using desktop computers (5.94 % of the participants who were asked about desktop problems), 18 about laptops (5.47 % of the participants who were asked), 31 about MDTs (19.87 % of the participants who were asked), and 13 about tablets (10.48 % of the participants who were asked).

Table 6. Survey problems lists – EMS desktop computers, laptops, MDT/MDCs, and tablets

Desktop computer	Laptop	MDT/MDC	Tablet
Internet connection	Battery life	CAD (computer-aided dispatch)	Battery life
Interoperability	Durability	Durability	Durability
Logins/passwords	Glare	Interoperability	Glare
Outdated/old	Internet connection	Lack of portability	Internet connection
Price: too expensive	Interoperability	Logins/passwords	Interoperability
Software crashes	Logins/passwords	Mapping/navigation	Logins/passwords
Software updates/upgrades	Outdated/old	Outdated/old	Report writing
	Power source/recharging issues	Price: too expensive	Size/bulkiness
	Price: too expensive	Size/bulkiness	Touchscreen
	Size/bulkiness	Using while driving	Weight
	Software crashes		
	Software updates/upgrades		
	Weight		

Fig. 21 shows the problems EMS experienced with desktop computers at least "Sometimes." Six of the seven problems associated with desktops were experienced by at least 45 % of EMS. Unsurprisingly,

issues related to computer software caused the most problems, with “software updates” and “logins/passwords” being the top two desktop issues faced (61.89 % and 56.16 %, respectively). While “interoperability” is a major concern for many of the other devices used by EMS, only 34.38 % found it to be a problem on desktop computers.

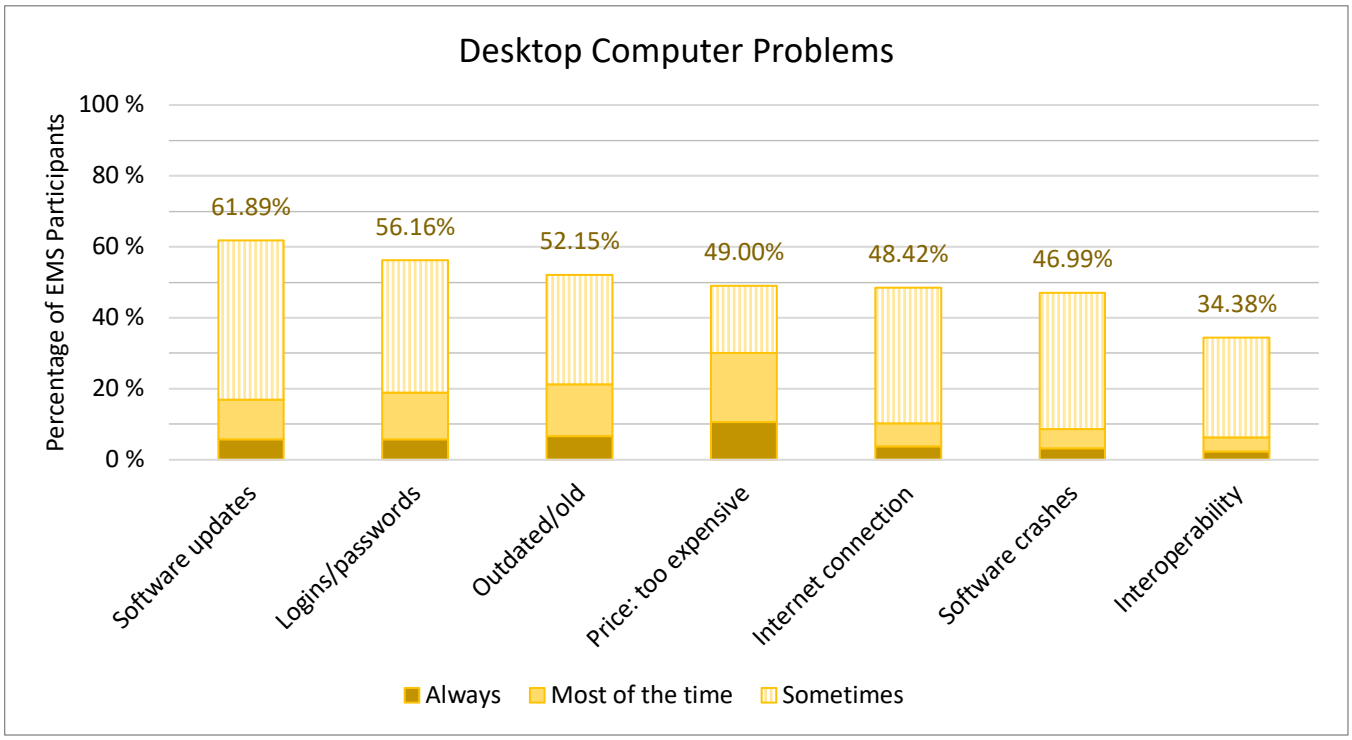

Fig. 21. EMS desktop computer problems

The problem the most EMS had with their laptops was “internet connection,” with nearly 80 % of EMS experiencing problems getting online at least “Sometimes” (see Fig. 22). While “price” was “Always” a concern by the majority of EMS, three other problems in addition to “internet connection” were problems at least “Sometimes” for more EMS respondents (“battery,” “login,” and “software updates”). Analysis of the interview data showed similar issues faced, with many EMS experiencing various types of connectivity problems on their laptops.

> I know we have issues with WiFi every once in a while. If I'm on the WiFi of the computer and then I drive to the hospital and now I'm inside the hospital writing my report and I'm on the hospital's WiFi and I go to leave, there is a space in between where I'm on neither network until I get away from the hospital. And I've had reports just get lost. (INT-EMS-S-015)

> We have a lot of software with connectivity between the patient care records we have on our laptops to our monitors, which are the 12-leads and defibrillators and all that. So I think a lot of times there could be ways to improve the connectivity between that because it's so integrated. And you can't finish reports if the connectivity is not there, and you can't upload your monitor to your computer… that's a hang up in our system often and increasing the time of the reporting. And getting back into service until the report's done. (INT-EMS-S-006)

There were 18 responses to the open-ended question about laptop problems experienced by EMS. Nearly all of the laptop problems listed were experienced by over half of EMS (9 of 13); “durability” and “outdated” were also experienced by close to half of EMS respondents (48.98 % and 48.64 %, respectively).

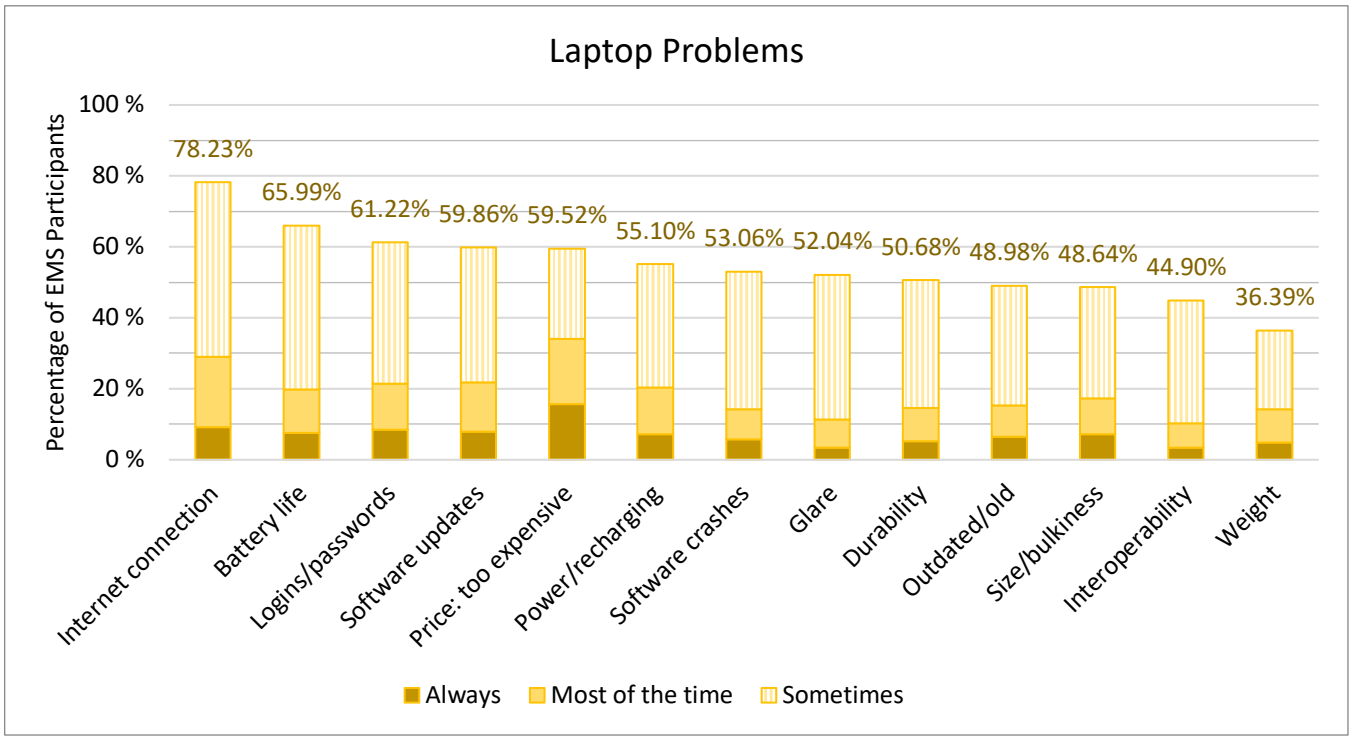

Fig. 22. EMS laptop problems

In analyzing the data where EMS had problems at least “Sometimes,” three MDT problems stand out from the rest, with more than 60 % of participants experiencing problems with the device: “CAD” (64.14 %), “mapping/navigation” (62.07 %), and “use while driving” (60.69 %) (see Fig. 23). The data show that most EMS experienced problems with “CAD” “Sometimes,” which is concerning since CAD is the main software used on MDTs. Consistent with the interview data is that many first responders always experienced problems with “price,” “using while driving,” “lack of portability,” “outdated,” and “mapping/navigation.” Interview participants especially expressed frustration with the mapping capabilities of their MDTs.

> 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)

Connectivity was not included in the problems list, but results of the analysis of the open-ended data showed it to be a key issue EMS experienced with their MDTs. 54.84 % of the 31 open-ended responses were related to connectivity and coverage issues, with respondents most often simply stating, “Connectivity.” Other major problems expressed in the open-ended data were related to the usability of MDTs; 32.26 % of the responses included information about this problem.

> …Screen brightness can be a problem at night, needs to be bright enough for me to see but not so bright that it affects the driver's night vision. (EMS:U:8395)
>
> Volume control display/format controls brightness controls Difficulty reading the display, because of small font, color, etc. (EMS:S:1475)

As demonstrated by these participants, display and brightness issues were the most expressed usability problems faced by EMS.

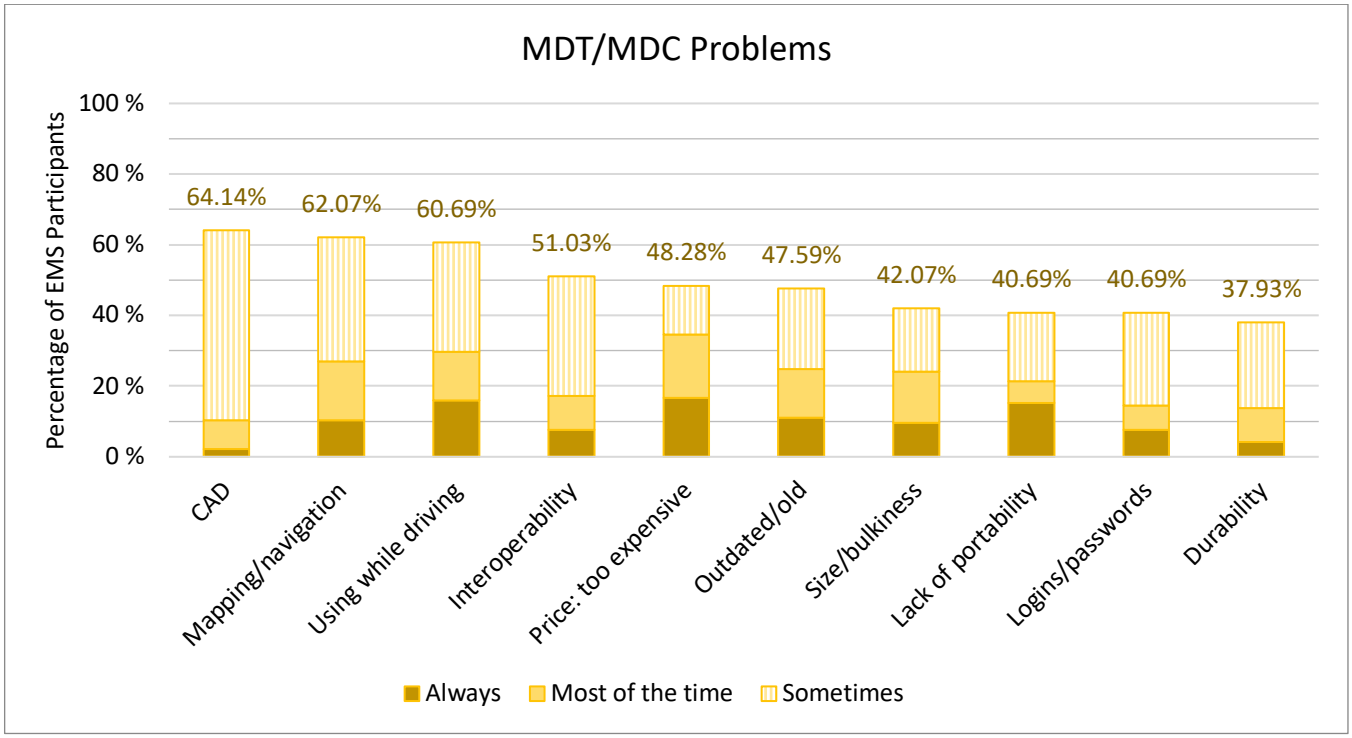

Fig. 23. EMS MDT/MDC problems

"Internet connectivity" was the top problem EMS had with tablets, with four in five EMS experiencing connectivity problems at least "Sometimes" (see Fig. 24). Like with other portable devices, coverage and connectivity continue to be major issues for effective communications in public safety. Analysis of the open-ended responses for tablets is reported in the Phase 2, Volume 2 report [6].

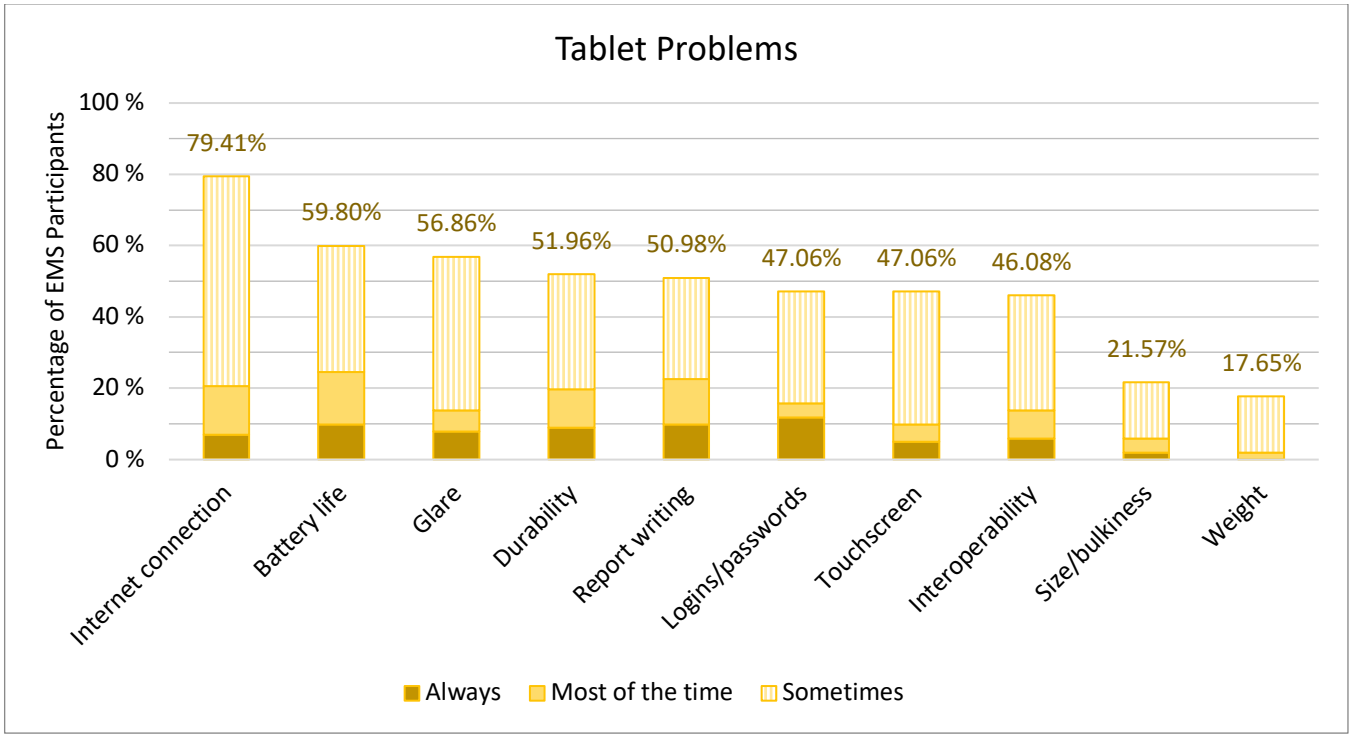

Fig. 24. EMS tablet problems

Pager and Smartphone Problems

The problems associated with pagers and smartphones for EMS are shown in Table 7. In response to the open-ended questions about additional problems for these devices, 47 EMS participants provided feedback about using pagers (18.43 % of the participants who were asked about pager problems) and 57 about smartphones (8.44 % of the participants who were asked).

Table 7. Survey problems lists – EMS pagers and smartphones

Pagers	Smartphones
Battery life	Battery life
Durability	Coverage/dead zones
Falling off	Data plans/data limits
Outdated/old	Dropped calls
Price: too expensive	Durability
Size/bulkiness	Glare
	Interoperability
	Logging in (PINS, passwords, usernames, etc.)
	Outdated/old
	Permission/access to apps
	Policies about usage

Pagers	Smartphones
	Price: too expensive
	Subpoena possibility for personal smartphone
	Subsidy for personal smartphone (insufficient or no subsidy)

When expressing their frustrations about pagers on the survey, EMS indicated price was much more of a problem at least "Sometimes" than the other pager problems (see Fig. 25). Additionally, of the 47 open-ended responses related to pager problems, the vast majority were related to reception and coverage issues (38.30 %). Another main issue revealed in the open-ended responses that EMS experienced with pagers was with their audio quality:

> The pagers in our area you cannot understand the audio. The reception and voice clarity is unreliable. (EMS:R:1759)

17.02 % of the open-ended responses similarly indicated garbled sound, static, or other audio quality issues when using pagers.

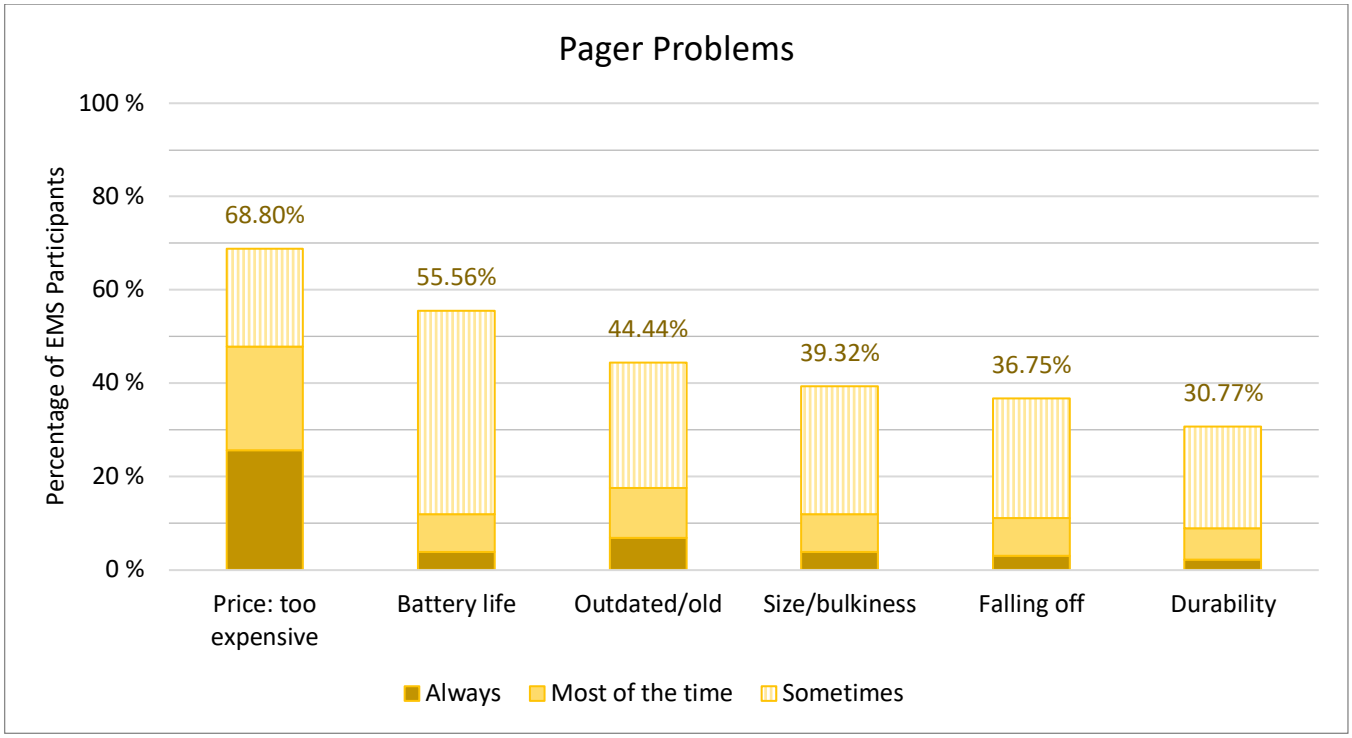

Fig. 25. EMS pager problems

As Fig. 26 shows, "Coverage" was the top problem EMS experienced at least "Sometimes" with their smartphones (75.04 %). Notably, only "subsidy" for their personal smartphones was "Always" a problem nearly as much as "price" (23.84 % and 25.76 %, respectively). With the widespread use of personal smartphones in their day-to-day work (see Sec. 4.3.2), it is understandable that EMS concerns about cost are tied to concerns about receiving little to no subsidy for smartphone use.

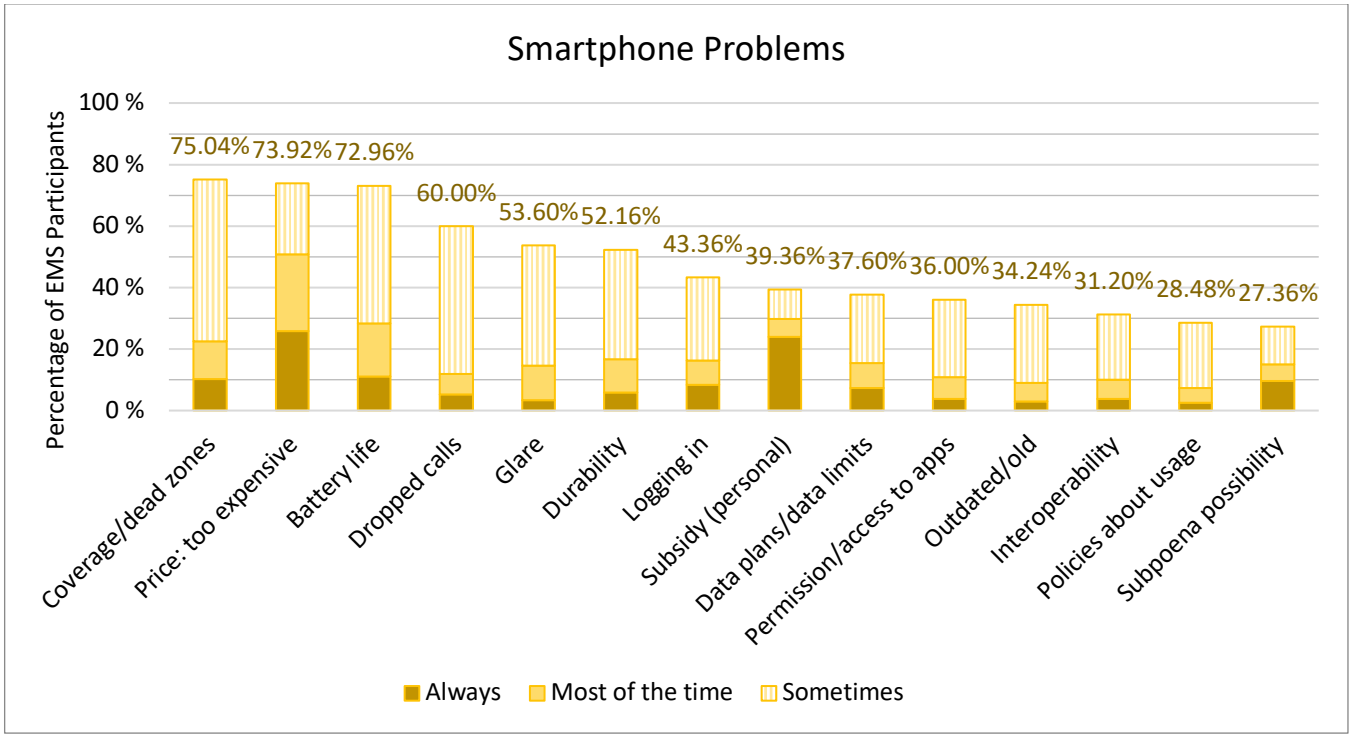

Fig. 26. EMS smartphone problems

Open-ended responses to the question about smartphone problems fell into 5 main categories for EMS:

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

Cost issues were not solely the experience with the high price of smartphones – many EMS voiced concerns over the cost of using their personal smartphones for work.

> 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)

The cost-related issues for smartphones often stemmed from the need for EMS to use their personal smartphones. A common reason for the use of personal devices was due to poor reliability. For EMS, coverage interruptions and hardware problems led to the perception that smartphones were unreliable for their day-to-day work.

> 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)

> Fell and cracked during a job. Battery is also an issue. (EMS:U:5155)

With cost and reliability being key smartphone issues, developers of mobile device technology may consider how to meet these needs of EMS responders going forward.

4.3.5. EMS Medical Technology

The penultimate survey question for EMS respondents was about the medical technology they use.

> While this survey is focused on communication technology, we are also interested in your views on **medical technology**. Please list the medical devices or applications/software that you think are most important for your work.

There were 450 responses to this open-ended question, just under 50 % of the 902 EMS responses to the survey. From the 450 responses, 1 220 pieces of data were coded. Each response could contain multiple pieces of coded data, since it may have listed multiple medical devices in it or mentioned a medical device and a piece of software. For example, the response "AED, Computer/internet for report writing (EMS:R:7613)" was coded to four categories: 1) Medical Device: AED; 2) Software/apps: report writing; 3) Communication Device: computer; and 4) internet/network coverage.

The initial coding of the responses to this question identified five general categories of analysis. A second round of coding broke down these categories into more specific codes. After the second round of coding, categories were reviewed for overlap and consistency and a final set of codes was created. Data were coded one final time using this final code list (see Table 8). Each response can be represented by multiple codes as appropriate. As noted above, many responses listed a variety of different devices, types of software, or general issues. There was no word or character limit to this open-ended text box, allowing participants to write as much as they wanted.

Table 8. Final list of codes and subcodes used for EMS Medical Technology

Medical Devices	Communication Devices	Software Apps	General Needs	Overarching Problems
AED CPR EKG Miscellaneous Device Monitor Patient Transport Ultrasound	Cell/Smart phone Computer/Tablet MDT/MDC Radio	EPCR Electronic Protocols Management Maps/GPS Med or Dosage List Miscellaneous Software/App Patient Tracking Report Writing Vehicle Tracking	Connectivity Comm with hospital Internet Telemedicine	Cost Interoperability Miscellaneous Problem Overreliance Safety/Security Training Usability

Fig. 27 below shows the breakdown of those responses with both the general categories and additional subcategories. Medical devices were the category of response mentioned most often (49.34 %), followed by software/applications (23.93 %), general needs (10.11 %), problems with technology (8.11 %), and communication devices (7.70 %). This breakdown is not surprising given that the question

specifically asked participants to list medical devices and software/applications. Perhaps what is more surprising are the other categories that emerged, such as general needs and overarching problems, even though the question did not specifically ask about them. Many of the responses simply listed devices or applications/software that participants have and believe are important. Other responses went into greater detail about what they have, what they think would be useful (but do not necessarily have), and problems they encounter with medical technology. Each of these general categories are discussed below.

Fig. 27. Categories of responses to EMS medical technology question

The category of medical devices had the greatest amount of coded data in it. The category included items such as: AEDs, monitors, EKGs, ultrasounds, and patient transport devices (such as stairchairs, assisted lift devices/cots, etc.).

> Cardiac monitor; Video Laryngoscopy; Mechanical CPR devices. (EMS:S:661)
>
> For EMS work, a good multifunction product like the [vendor redacted] series units are 90% of it. Add blood glucose and a thermometer and that's about all you need in the field. (EMS:R:1049)
>
> Vitals monitors, stethoscopes, AEDs, patient transport devices (stair chair, [vendor redacted]stretcher, power cot). (EMS:U:210)
>
> Cardiac Monitors that are easily maintained and not expensive for local municipalities. (EMS:R:2348)
>
> Epcr and tablets, laptops. But they are so expensive especially for volunteer agencies we aren't given much $ to run on each year. (EMS:R:532)
>
> Monitors!- They need to be lighter and more connected. [vendor redacted]monitors. Patient moving technology such as cots and stair chairs- also need to be lighter and with more mechanical assistance. Wireless vitals signs monitoring for multiple patients in an MCI. (EMS:U:8977)

These responses often included comments related to how these devices need to be improved, such as making them "lighter and with more mechanical assistance." Additionally, comments on cost and budget often surfaced in this category.

Most often, participants referred to current technology when listing medical devices. However, some responses identified devices that represented future technology participants would like to see developed, rather than medical devices they currently have.

> When the technology for testing capillary blood for glucose came out, it was a genuine boon to patient care. Devices that can test capillary blood for alcohol, opiates, cocaine, etc. seem to my mind to be a real possibility -- it sure would be cool if someone invented them. (EMS:S:8168)
>
> Technology interfaces to patient worn devices that would speed detection of a life threatening medical emergency. The patient's implanted pacemaker might detect a fatal heart rhythm and send a data alert to the EMS dispatch center. AI technology in the Communications Center to help rapidly process emergency calls, including those arriving by text and video, in addition to voice. AI could monitor the conversation between the 911 caller and the dispatcher and prompt them if AI detected a difference between what the caller said and what the dispatcher entered into CAD (e.g. an address mismatch). AI could prompt the dispatcher to ask certain questions that had not been asked (e.g. missed in executing the protocol). AI could aggregate information from multiple 911 callers and summarize critical information and even make recommendations based on new information. Technology to aid emergency response, including AVL, route assistance, traffic signal control and building access. Floor plans and building plans

> to help guide the EMS crew to the patient (e.g. in a shopping mall or multi floor office). AI technology to assist with patient care, capturing verbal information and inserting it into the PCR, answering questions about drug dosages, prompting the EMS crew if they are about to give the wrong drug or missed a drug that should have been given, accessing remote databases to find a list of the patients' current medications or their last 12 lead EKG. Patient monitoring and Point of Care systems that expand the range of diagnostic data beyond what is available today with a cardiac monitor and blood pressure/pulse/PO2. Field ultrasound with real time transmission of data allowing a remote physician to interpret the findings. Secure video consultation with a base station doctor to discuss patient care or to help convince a patient that they need to go to the hospital. UAV/Drones that can deliver an AED to the scene of a cardiac arrest (the [city redacted] pilot project), or deliver an Epi Pen; or respond and send back real time video of the car crash prior to the arrival of the first units. (EMS:U:8395)

The items mentioned in these responses represent a type of "wish list" of items that some participants would like to see developed. While these were rare amongst the responses, they do point researchers and developers toward ideas for future development.

The software/applications category included items such as: patient care reporting, report writing, electronic protocols, drug/medicine lists and dosages, and vehicle location. This was the category with the second highest number of coded data.

> Web based report writing and submission is very helpful. Using smart phone to contact outside agencies such as poison control and medical director. Being able to access the net to check drugs, drug interactions, medical conditions etc... (EMS:U:5455)

> [Vendor redacted] with a tablet is what we have currently. It leaves a lot to be desired. We should have a live microphone that transcripts patient information to the data record. Very little hand fed information should have to be entered and it all should easily be transferred to appropriate agencies. Additionally, any nationally recognized programs should easily adapt to changes in local medical terms and protocols. (EMS:S:5823)

> Drug dosages/ calculators for dosages. (EMS:S:6813)

> PCR/EHR software; CAD; Vehicle Tracking. (EMS:R:6883)

Some of the software and applications identified in these responses are management tools, others deal specifically with various protocols or lists, such as medication lists or drug dosages. By far, ePCR software was the largest category within software/applications. Better voice recognition software was noted as a future technology that participants thought would be important in the field.

General needs described in the open-ended responses included items such as: connectivity, telemedicine, and the ability to communicate with/transmit information to the hospital. Needs were identified in 10.90 % of the coded responses.

> Something that we have most problem with is not enough coverage in the county with our radios. (EMS:R:9120)

> Our monitor/defib is probably the most important. Software that would link the field to the hospital would be very helpful. Also a reliable internet connection in the rural areas would be a good benefit. (EMS:R:427)

> Currently we use [vendor redacted]Cardiac monitors for patient treatment and vital sign monitoring. These monitors are connected via wireless cellular modem. We utilize wireless patient data transmission during every patient interaction. (EMS:S:5509)

The responses above are indicative of many from this open-ended question in that they list devices or software/applications that participants use, but also highlight the importance of being able to connect to the internet and having good network coverage and connections. Many times, devices or software/applications are not usable if there is no coverage or connectivity in the area. While all public safety personnel are concerned with the transmission of information, what is unique about EMS is their need to transmit patient information to hospitals and other medical providers/personnel.

Many responses also identified problems that participants experienced related to the medical technology they use. These were things such as: cost, usability, interoperability, better/more training, security/safety, and having become too dependent on technology.

> Affordable and dependable integration between patient monitoring devices and EPCR's. (EMS:R:9108)

> More compact devices, many are still large and heavy making them [difficult to use]. The cost is also a major factor, there is so many devices that could help speed up the definite care of the sick and injured, but the cost is more than many agencies can afford. (EMS:S:8480)

> Interoperability between monitoring equipment and electronic patient care reporting software. Would like to see more voice recognition to assist with patient care documentation. Currently it is very tedious and time consuming. Technology to speed this up and eliminate redundant effort would be useful. (EMS:S:6666)

Often, these responses highlighted problems with current technology that participants would like to see fixed, such as size or weight of devices or improved voice recognition. Interoperability was a major concern and was the largest category of data coded as a problem. Similar to the data from the Phase 1, Volume 2 report [5], participants feel that interoperability will reduce their workloads, minimize their effort and stress, and improve patient care and outcomes.

Sometimes, as in the responses below, participants noted how technology can interfere with their work, especially when it is not interoperable or when devices and software/applications are not designed for their context of work (i.e., usability issues).

> Lighter cardiac monitors would be good. Compatibility between our ePCR, the cardiac monitor (to make uploading rhythm strips easier). Better WiFi access in ambulances & integration of dispatch, fire & EMS, & EDs and EMS. All our computers are on separate systems, and ePCRs take too long to write, & there are too many required fields. Technology is often interfering with patient care. (EMS:U:3939)

> There are no devices that replace common sense. (EMS:R:688)

In many ways, the items and issues identified in these responses mirror many of the findings from the interview data for this study [1][5]. First responders, in general, want technology that is easier to use (for example, lighter and less bulky); they want interoperability of devices and software/apps; and they want technology that makes sense within their context of work.

While the question did not specifically ask about communication devices or software, many were mentioned in the responses. These include items such as: phones/smartphones, computers and software (including laptops, desktops, CADs, and MDTs), and radios.

> EPCR; EKG; Cellular phones. (EMS:U:571)

> Personal cell phone. (EMS:S:9536)

> Cardiac Monitor that transmits information to hospitals such as vitals, EKG, and then transmits to upload to the PCR which is great for decreasing the time in documentation. GPS is used daily for getting to calls and relied on as maps have been pushed aside. [Tablet redacted] technology has assisted to take a number of apps with us to the street and also document on the go if time permits. (EMS:R:9736)

It is interesting to note that communication devices occurred at all in this data given that the question asked specifically about medical technology. The link between communication devices and software/apps was made in many responses, with participants noting their use of smartphones or tablets in order to access particular software/apps.

Some EMS respondents had difficulty answering the question or in being specific about their responses.

> I have no idea what is actually available. (EMS:R:1147)

> Anything that is updated than the technology we now have. (EMS:U:8869)

It is difficult to conceptualize what you need when you are unaware of the possibilities.

4.4. FF

4.4.1. Overview of FF Findings

FF respondents were asked about their technology use for general public safety communication devices but were also asked a more discipline-specific question about their use of TICs. Details of day-to-day device use and problems are detailed in Sections 4.4.2 through 4.4.4. Highlights of the survey findings are below.

- Over 80 % of FF used radios, desktop computers, personal smartphones, TICs. Radios were the most useful to FF; few found TICs as useful in their day-to-day work.
- 90 % of FF had TICs; understandably, TICs were used less frequently in FF than other communication devices.

- The vast majority of FF had neither wireless mics nor earpieces (20 % had earpieces, fewer had wireless mics). Due to the nature of their work environments and use with the equipment they don when responding to fires, the majority of FF often used corded mics. However, 25 % still don't have corded mics for incident response.
- Overall, more FF used laptops and tablets than MDTs. Some respondents indicated they were in the process of transitioning to MDTs, or that their MDTs were being replaced by tablets. However, 66 % of FF ranked MDTs as useful in their day-to-day work, compared to 44 % for laptops and 38 % for tablets.
- FF respondents typically did not have or use flip phones (less than 10 %). More FF found flip phones useful in their day-to-day work than earpieces and wireless mics.
- Around half of FF used pagers, and the majority of them thought they were among the most useful devices in their day-to-day work.
- Across FF devices, the expensive cost of technology was a major finding in the survey data, in both the quantitative and qualitative responses. FF also had problems with coverage and connectivity, device batteries (including battery life), and reliability.

4.4.2. Technology Use for Day-to-day Work

The list below includes the devices presented in the FF survey. Similar devices are grouped into three categories for the purposes of displaying results (listed alphabetically within groups); devices were neither grouped in the survey nor analyses. In addition to devices included across disciplines, the FF survey also asked about TICs.

Devices listed for FF included:

- Earpieces (corded earpiece, personal wireless earpiece, work-issued wireless earpiece), mics (corded mic, wireless mic), and radios (in-vehicle radio, portable radio)
- Desktop computer, laptop, MDT/MDC, and tablet
- Flip phone, pager, personal smartphone, and work-issued smartphone
- TIC

Results for each device are displayed and interpreted below. Frequency of use percentages for each device are listed in Appendix E.

Participants were also given a final open-ended text box to capture any other devices participants use in their day-to-day work. In the FF survey, 86 participants (3.29 %) provided open-ended responses. Notable findings from the open-ended questions included:

- Mention of specialty hardware not included in the survey, including gas/chemical meters, GPS tracking, cameras, headsets, and medical devices
- Use of technology to communicate using a variety of devices and specialty hardware as well as for other purposes including scheduling and administrative tasks
- Use of wireless capabilities such as Wi-Fi hotspots with equipment (e.g., tablets and TICs)
- Mention that tablets were used to access specialty software and apps used for incident response (e.g., CAD, call monitoring, EPCR, reporting)

- Emphasis that some devices (e.g., MDT, TICs) were only used in specific situations
- Explanation that chiefs had access to but often did not use the same technology frontline responders use, especially MDTs and TICs

Other open-ended survey responses are presented throughout this section where appropriate.

For similarities and differences between device usage for FF compared to COMMS, EMS, and LE, see Sec 4.6.

Summary of FF Technology Use

Fig. 28 shows the frequency of use for each device for FF.

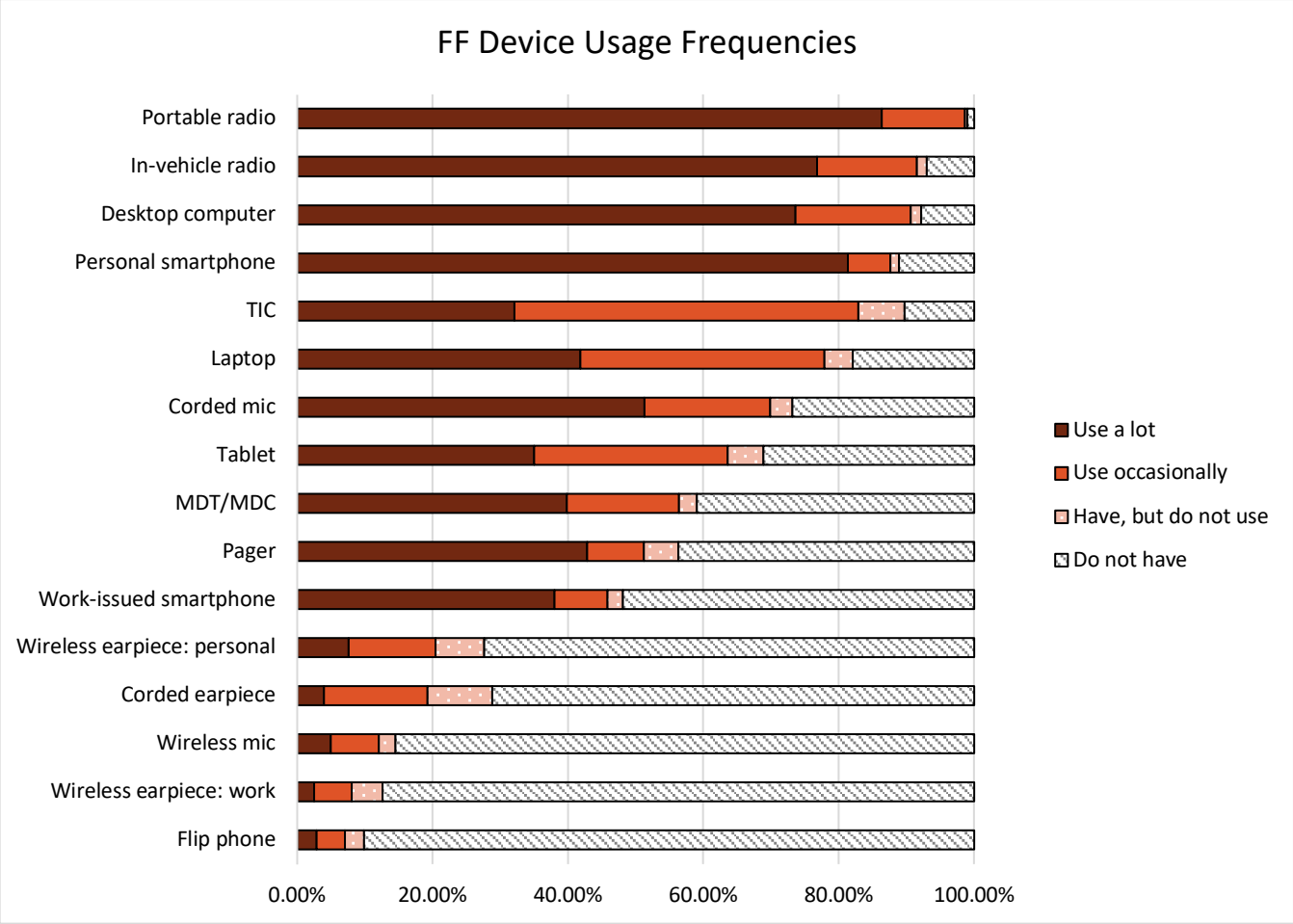

Fig. 28. FF Device Usage Frequencies

Portable radios, in-vehicle radios, and desktop computers were the most frequently used devices. While most FF survey participants had TICs, many survey participants only used them occasionally.

Many FF participants had MDTs and tablets but tended to use them with more variability. Earpieces, wireless mics, and flip phones were less often had or used by FF survey respondents.

Earpieces, Mics, and Radios

Earpiece, mic, and radio usage frequencies are displayed in Fig. 29.

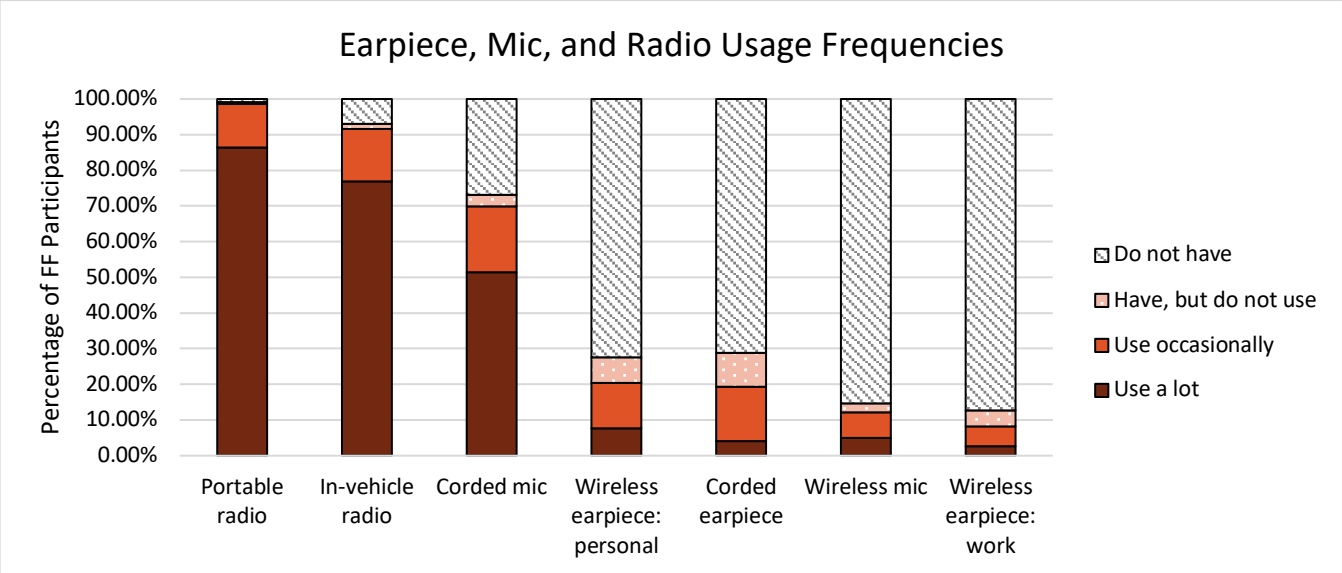

Fig. 29 FF Earpiece, Mic, and Radio Usage Frequencies

FF survey respondents had and used their audio communication technology often. Portable radios were the most frequently used device by FF survey respondents, with 86.37 % indicating they used these devices “a lot”. Not only were portable radios used frequently, but most of the FF survey respondents had a radio: less than 1 % of FF responders surveyed did not have a portable radio. In-vehicle radios were also prevalent, with over 90 % of FF participants having an in-vehicle radio and 76.83 % using them “a lot”. In the interviews, radios were often mentioned as an important tool for communication.

> Well, communication for us has been a major player when things go wrong. That's normally one of the-- probably the main, I would say, most common denominator of anything that's gone wrong in the fire service is the communication breakdown. So we use radios. The radios that we use are fairly good. Where it comes into issues with communication is when you're actually interior and you're actively doing something, and being able to communicate what's happening or what you're doing may not be as easy as it may seem. So plus talking through a face piece and into a radio mic, the clarity isn't the greatest. (INT-FF-U-025)

> So, one of the single best things we've done in my career in 23 years is we gave everybody a radio. That's a great thing because as I mentioned when we started this, our entire discipline depends on talking on these things. Whether I'm inside, outside, in the wilderness, in a big tall building, my success to bringing that instant under control depends on me being able to

> communicate down on the radio. So now that everybody has them, that's a great thing (INT-FF-U-022)

> Up here it seems to be fairly easy. I would consider fairly easy because our radios all have everybody's channels programmed into them and we can just go to their channel if we're not already scanning it and communicate with officers if we're going to a wreck or something like that or if it's, you know, we need to get in touch with them because we may get--they may be, you know, somewhere else in the [County redacted] or they may have left with patients from the [County redacted]... (INT-FF-R-052)

As described in the quotes, because communication and coordination were vital to FF participants' day-to-day responsibilities, using radios to communicate was important to participants.

Other types of audio communication technology were used less frequently, with the exception of corded mics. Nearly 70 % of FF survey participants used their corded mics "a lot" or "occasionally"; however, fewer FF participants had corded mics compared to radios; nearly a fourth of the sample did not have a corded mic. Rates of having earpieces and wireless mics were even lower, as over 70 % of the FF participants indicated they did not have these devices. These audio devices, along with headsets, were mentioned in several responses to the open-ended question.

> Radio headset [system] in the vehicle, we use both corded and wireless alot. (FF:S:4898)

> Bluetooth mic attached to Facemask, use occasionally. (FF:U:4767)

> Wired headsets use allot…Wireless Headsets do not have In vehicle hands free built in interface use allot (FF:S:6842)

Although fewer FF responders had audio accessories such as mics, earpieces, and headsets, those that did have access to these devices found them useful. The finding that audio accessories may be useful for FF responder was also found in the interviews, as these devices were mentioned as requested functionalities [5].

> It's a huge step for us to be able to have [earpieces]. The only step further is that if it's ever possible, some departments have some that are molded to each individual's ear. Because I've noticed, sometimes, with that, I would prefer that ear piece far more when trying to listen to that without a mic, because there's so much going on, it's hard. You have to lean over anyways. Having an ear piece in is great, but I've found several times they were popped out. And when I'm in the middle of something and I can't reach up and grab it right away, so I have to remember, "Okay, I'll pop that back in." And I think that problem is somewhat avoided with the ones that are molded to individuals, the specific individual's ear. (INT-FF-S-035)

> I think that the development of Bluetooth wireless technology for clear, better communication built into your air pack would be fabulous. And it needs to be bombproof, bulletproof, and so there can't be any loss of communication in smoke, heat, and all the other things that go along with it. (INT-FF-U-014)

As demonstrated in the quotes, the way in which audio devices currently exist may not be well-suited to the FF participants' environments. Although some FF participants did have access to wireless audio devices, far more FF participants did not have this technology even though it may be useful to them.

Desktop Computers, Laptops, MDT/MDCs, and Tablets

Desktop computer, laptop, MDT, and tablet usage frequencies are displayed in Fig. 30.

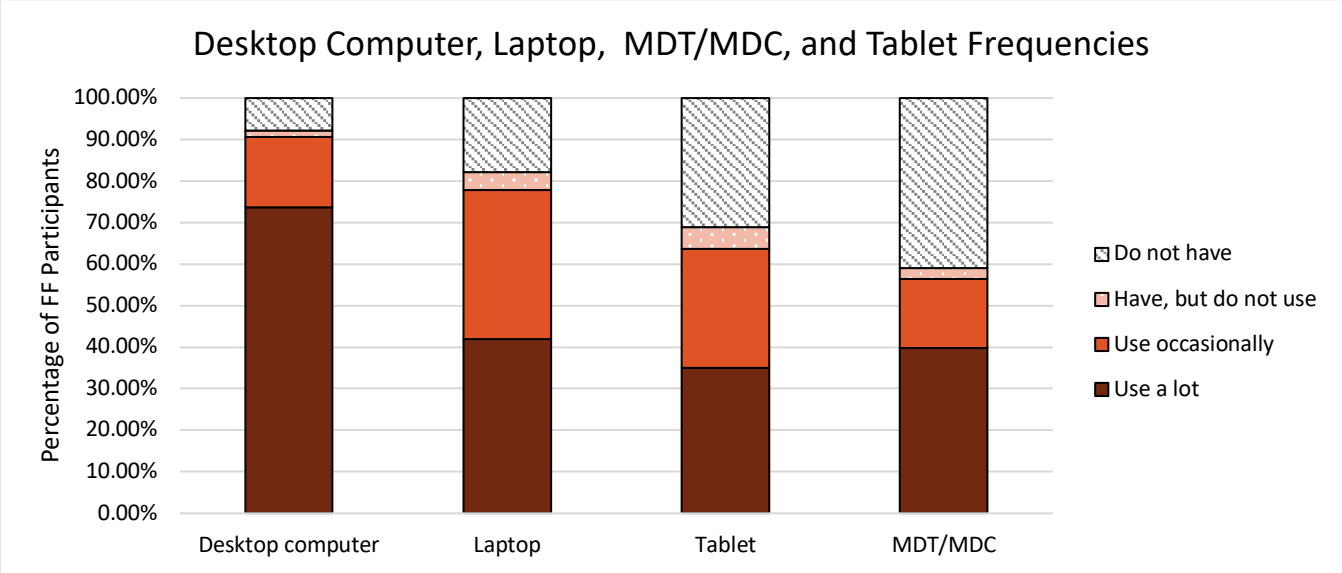

Fig. 30. FF Desktop Computer, Laptop, MDT/MDC, and Tablet Usage Frequencies

Desktop computers were the third overall most used device by FF, with 73.66 % of FF participants indicating they used these devices "a lot", and only 7.80 % indicating they did not have a desktop computer. Nearly half as many FF participants indicated they used laptops "a lot." For FF participants who had laptops, nearly as many selected they use their laptops "a lot" as "occasionally." Some open-ended responses as well as interview data specifically emphasized the importance of computerized technology.

> Computer, internet, and city owned and operated computer network system is extremely vital to the performance of my duties as an Assistant Chief of a small to medium sized career fire department. Numerous email, research on internet, and other technology based duties are so much easier and quicker using technology. I remember before the internet and computers being common place in the fire service and answers and information is much quicker and easier to obtain. (FF:S:8202)

> I'm a Battalion Chief Aide and a large portion of my day is spent using a computer for staffing and organization. (FF:U:4657)

> Newest fire engines use computer technology. (FF:U:3409)

> Computerized system for on call personnel availability and dispatching. (FF:S:1171)

> Cell phones. Well, we use our computers extensively. I mean, all the record keeping. Nothings done in pen and paper anymore except bills that auditors require a signature on. And what's interesting is I think people have really gotten away from, even though there are administrative assistants, I really don't use one very much. Once you get on the computer, I can type my own stuff fast just as fast as I can dictate or anything else. We have all sorts of software to do different things. We have report writing, of course, the whole Microsoft package. We use Excel extensively. And doing that all-citizen of responses and all that type of stuff (INT-FF-S-036)

> [W]e also have a computer in our rig which runs our dispatch over, gives us our information on where we're going - tips on street locations, cross streets. It also gives us, sometimes, information on what we're heading into like some-- I don't know why it never was completed, but there was like a high rise survey. So some buildings we'd get how many stories, standpipes, what stairwells, have smoke towers, stuff like that. It could definitely be used more efficiently. (INT-FF-U-027)

> [RE: laptops] So the battalion chiefs and upper issued them. It allows us to work remotely. We can bring them to meetings. I can do work at home. I try not to. I don't get overtime. We're exempt. But really, it's a way to kind of free us from the desk so we can work at the table. We can take it to the stations and use it for training if we want or whatever. (INT-FF-R-024)

As described in the quotes above, FF participants saw desktop computers, laptops, and computerized systems more generally as highly integrated into and important for FF responders' day-to-day work.

Although a majority of FF respondents had and used desktop and laptop computers frequently, use rates were different for MDTs. Nearly 40 % used MDTs "a lot". This may suggest that those that have MDTs tend to use them often. In the interviews, MDTs were mentioned as useful for day-to-day incident response for FF participants.

> [RE: info via MDC] You have to click on the incident information...tablet or tab on it. But it's pretty user-friendly. So...as long as you know that that feature exists, you can find it pretty easily... you can get additional information that maybe the dispatcher missed. (INT-F-S-039)

> ...we had the dot matrix, which was the Rip-N-Run. It was really cool... That was what the manufacturer called it. Even in the industry, it's still referred to as a Rip-N-Run because it's all your information in just a little piece of paper, and you grab it and run out the door. The CAD is actually what kind of-- or the MDTs is what replaced the Rip-N-Run. And so we went to really generic DOS-based MDT, the black with the green lettering and stuff like that. It worked well, but it was in transition. Now we've gone to a full MDT, so we have the Internet and everything in the trucks... (INT-FF-S-022)

However, nearly 40 % of FF respondent did not have an MDT. The open-ended responses provided some further insights into MDT use as shown in the quotes below.

> We are moving to MDT's and I will be using it more (FF:R:272)

> Tablet replaced MDT/MCT (FF:S:468)

> Our fire fighters have MDT and TIC, but I do not have one assigned…(FF:S:8125)

These responses illustrate that the FF participants surveyed had different reasons for not having or using MDTs, including not having it yet, using other technology that performs the same functions as MDTs, and personally not having or using MDTs for their job.

Over 60 % of FF participants had tablets. Some open-ended responses specifically discussed using tablets or computer/tablet hybrids. They described that computerized tasks are increasingly being performed on these devices.

> My computer is a [redacted] and I operate it mainly as a laptop but it can also be used as a tablet. I also have a dock and multiple monitors that it plugs into, so I also use it as a desktop. (FF:R:241)

> Tablet replaced MDT/MCT (FF:S:469)

While these responses mention tablets serving the same purpose as laptops and MDTs, having other types of functionalities integrated into tablets was also mentioned in the interviews as a requested functionality.

> I would love to have a tablet that I could get my calls on, that I could do my maps on, that I could do my pre-plans on, that I could have my inspection ship too. Because we still get stacks of dot-matrix-printed paper inspections. That I could do my EMS reports on. So I've got a mobile data computer mounted in the rig that I push en route and do all that. I've got a smaller one in the back, we take in for calls and enter information, and use it to transfer over via Bluetooth to the ambulance company. But I'd love to have one thing that I could just carry--that I could put my rig and put it in a docking station, use it to go en route. Get my maps and do my inspections, do my reports, do my pre-plans, do all that stuff. And I would love to see that one day, and when you came into the station, everything just downloaded into the system and you were good. (INT-FF-S-017)

As described in the quote, having a single device to perform multiple functionalities was of interest to FF participants. Tablets may be a device well-suited to this, and one FF participant even wrote, "I live on my tablet" (FF:S:5117), emphasizing the importance of this device for their day-to-day work.

Flip Phones, Pagers, and Smartphones

Flip phone, pager, and smartphone usage frequencies are displayed in Fig. 31.

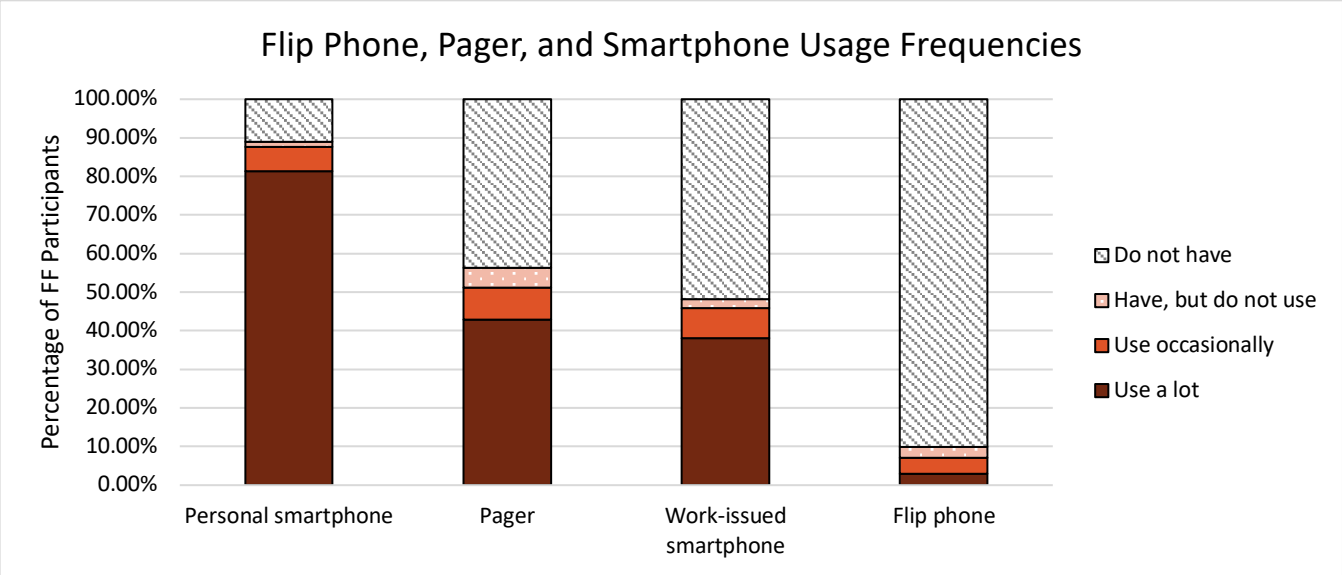

Fig. 31. FF Flip Phone, Pager, and Smartphone Usage Frequencies

Nearly 90 % of FF participants had personal smartphones and nearly 50 % had work-issued smartphones. Several open-ended responses described using different types of phones to communicate and gather information.

> Regularly use cell phone based Workplace to communicate with members of department on various levels. Also regularly use cell phone based Fire Text Response software as additional method of communicating alarms and other communications. (FF:R:3287)

> our personal cell phones have an app that we get dispatches on rather than having to carry our pager (FF:U:8314)

Responses included phones in the day-to-day device list (e.g., personal smartphones, flip phones) but also mentioned other types of phones including landlines and satellite phones, suggesting that not all FF responders are only using current cellular phone technology. However, survey results suggest that flip phones were not often used by FF participants; most FF participants did not have a flip phone (90.13 %). Although flip phones were not often used by FF participants, over half of FF participants indicated they have a pager and 42.80 % indicated that they used their pager "a lot." As was discussed by one interview participant, there were advantages to using pagers to communicate.

> I still carry a pager because it's not attached to any cellular network, and it's not impacted by civilians. So having that mode to be able to communicate or at least get information out that's not impacted by the event is huge. (INT-FF-S-015)

Because communication is critical to the day-to-day work of FF participants, it is not surprising they use multiple devices for communication purposes.

TICs

TIC usage frequencies are displayed in Fig. 32.

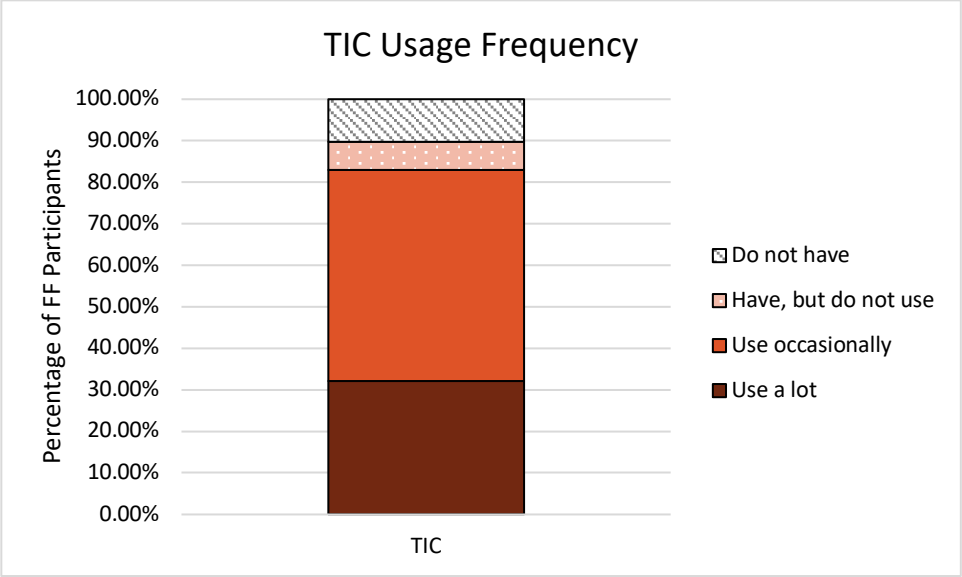

Fig. 32. FF TIC Usage Frequency

Nearly 90 % of FF participants had TICs. However, more participants used their TICs “occasionally” than “a lot”; while over half of the FF participants used their TICs “occasionally” and only a third used them “a lot”.

Several open-ended responses discussed TIC usage. Some responses indicated that TICs were less frequently needed in incident response, “Tic is used as needed” (FF:S:6309) and were typically not provided to every FF responder; rather, they were shared within each apparatus, “TIC's are assigned to the apparatus.” (FF:S:2253). Because TICs were only used when required and are not assigned to specific responders, this may explain the high rates of using TICs only “occasionally” rather than “a lot” in the survey results. TICs were also mentioned in the interviews.

> ...We have-- we call it TIC camera, thermal imaging camera... Where before, we'd tear this whole wall out, and now we can pretty much isolate certain areas and move it a little bit more beyond that... (INT-FF-S-022)

> [RE: TICs] Those are, to me, they're paramount for not only fire scenes but for propane leaks, a lot of different things so it really picks up good heat signatures. So it helps if you have something involving a grill car with chemicals, ammonias, anything like that. So those are very helpful. Obviously they make a big difference when searching in hazardous conditions, trying to locate victims and get them out... (INT-FF-U-021)

> ... A lot of people just thought TIC’s, thermal imaging cameras worked to find fires no. You can use that when you’re looking for an elderly person out here in a rural area that’s ran off, an ejection from a vehicle. I found a person out here that was ejected from a vehicle out on a dark

> country road. You know I will say you know technology has helped saved lives and keep us safer. (INT-FF-R-049)

As illustrated by the quotes, in specific circumstances, TICs were extremely useful to provide information to FF responders during incident response.

4.4.3. Day-to-day Device Rankings

FF respondents ranked their top five most useful devices based on devices they currently have (see Appendix B and Appendix C for the methodology and question stems for rankings items). The percentage of FF survey participants who selected each device in their top five rankings are displayed in Fig. 33. Rankings for each device can be found in Appendix E.

Nearly 90 % of FF survey participants selected their portable radio in their top five rankings, and there was a 15 % drop-off to the next most frequently selected device. A majority of FF survey participants included their desktop computers, smartphones (personal and work), in-vehicle radios, MDTs, and pagers in their top five rankings. There was another 15 % drop-off to the next most frequently ranked devices, with laptops, tablets, flip phones, mics, and earpieces being selected by less than half of the FF survey participants. TICs were selected by nearly 30 % of respondents.

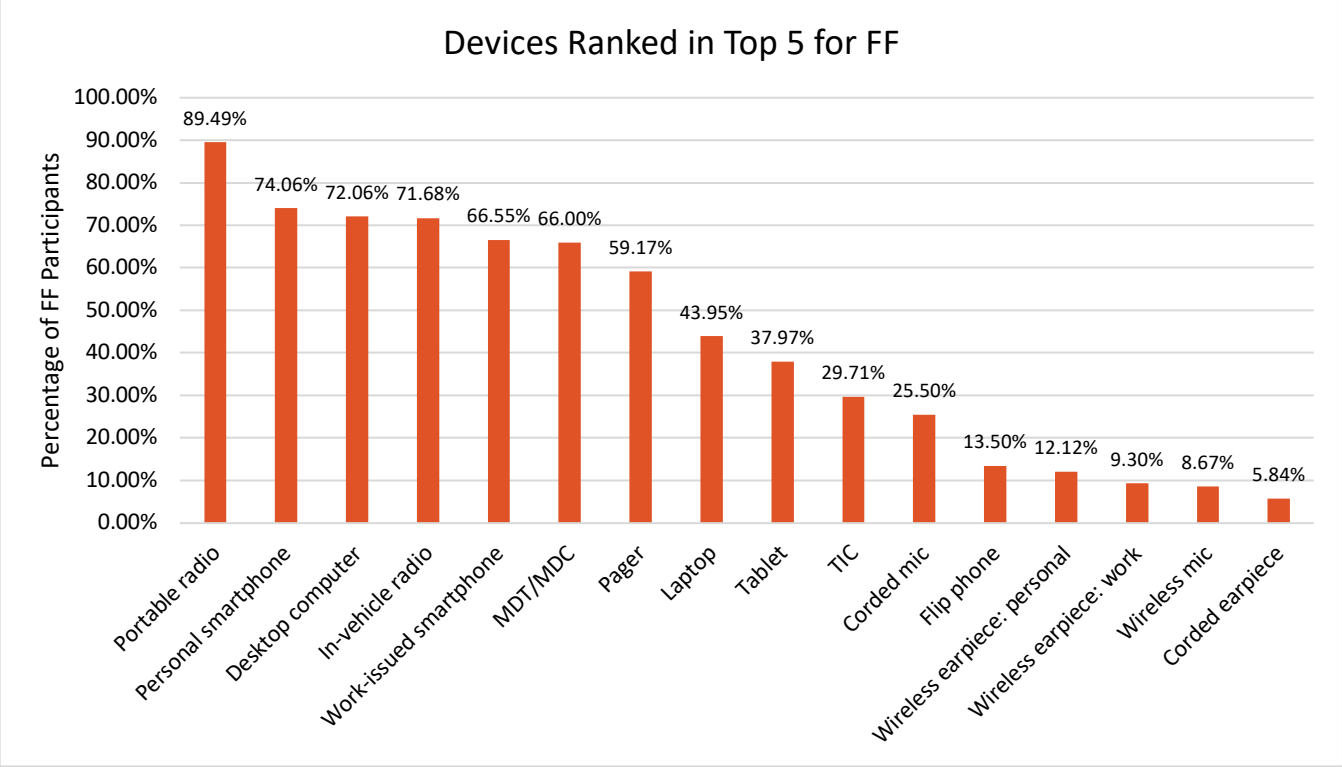

Fig. 33. Devices ranked in top 5 for FF

4.4.4. Device Problems Experienced

This section reports on the FF problems experienced with the various communications devices they used, based on their previous survey responses (see Appendix B). Since problems are dependent of the device, problem lists are provided with each device as they are presented. Also discussed for each device are the open-ended responses that gave participants the opportunity to comment with additional problems.

While it is essential to address the problems that first responders "Always" face, it is important to also consider the problems that occur only "Sometimes," since the uncertainty of failure diminishes the perception of those devices' reliability and problems experienced only "Sometimes" could have dire consequences. Throughout this section, graphics portray device problems that participants experienced at least "Sometimes" ("Always," "Most of the time," and "Sometimes"). *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."* The detailed percentages of the FF responses for each device and its associated problems are listed in Appendix C.

FF were asked problems for the devices below. Similar devices are grouped into four categories for the purposes of displaying results (listed alphabetically within groups); devices were neither grouped in the survey nor analyses. Since the specific devices presented to participants in this section of the survey was based on a participant's previous survey responses, the number of participants who were asked questions about each device varied. Of the 2 617 survey respondents in FF, the number of participants who were asked about problems for a specific device, as well as the number of participants who selected a response option for each device problem, can be found in Appendix C.

- TIC
- Earpiece, mic and radio
- Desktop computer, laptop, MDT/MDC, and tablet
- Pager and smartphone

Of the ten devices included in the problems section of the survey for FF, cost was the top problem "Always" experienced for nine devices, often by a ratio of at least 2:1 where twice as many FF had problems with price than any other problem[5]. Across devices, when asked if cost was a problem, more FF experienced issues with cost than other device problems by a ratio of more than 2:1 (2.3:1). That is, on average, more than double the number of FF respondents "Always" had a problem with cost than any other problem with a given device. Two devices had an even higher ratio of 3:1 – mics and pagers (radios was 2.8:1). Many open-ended responses for these devices expressed cost issues for various reasons.

> [RE: radios] Astronomical Cost (FF:U:5659)

[5] "Price: too expensive" was not included in the list of problems for tablet computers (see Sec. 2).

> [RE: laptops] The price of software that would be truly useful to the department is prohibitive. (FF:R:1781)
>
> Custom batteries for the [pagers] that cost a fortune. (FF:R:5257)
>
> [RE: mics] Durability (not water proof) Expensive (to get water proof) Outdated (to small of button) (FF:U:3169)
>
> [RE: radios] We currently are on 460 MHz radios, which are sufficient, but with the current trend towards the [statewide] system, I anticipate problems with deadspots, audio quality, and the expense of monthly subscriptions. (FF:R:2741)

Cost is often a barrier to FF responders in many ways. These participants show that reduced prices can alleviate concerns and open up opportunities for more useful technologies.

TIC Problems

As previously stated, the FF survey included devices specifically customized for their line of work, based on the findings from the interviews [12]. Specifically, problems with TICs were included in this section since many FF responders rely on them in their day-to-day work [1][5]. The list of problems associated with TICs, as presented in survey for FF responders, is below.

- Accuracy of information
- Battery life
- Durability
- Outdated/old
- Price: too expensive
- Size/bulkiness
- Small screen

Problems with TICs are displayed in Fig. 34. After problems with the cost of TICs, half of FF experienced problems with TICs “battery life” (53.97 %), “small screen” (49.21 %), and “size” (48.36 %). Battery issues were also expressed in the open-ended question for TIC problems; of the seven responses indicating problems FF experienced, five mentioned the TIC’s battery life. It is also interesting to note that while first responders want the screen to be larger, they experience problems with the device if it is too large or bulky. As revealed in our interview data, smaller, but more usable devices are among the functionality requested by FF.

> So I think smaller, lighter weight versions of all the equipment we already have, would be the wish of almost anybody. The number one line-of-duty injury for firefighters is usually vehicle accidents, and cancer, and some of those things. But a lot of times the injuries are back, knees, hips, so those are all repetitive stress things that happen. So that's the thing you'd like to see reduced, right? (INT-FF-U-012)
>
> We explored a TIC that was integrated into a helmet… The camera was really heavy. It added another 10 pounds to somebody's head… And if you'd look like an orange sitting on top of a

> toothpick, that's basically what it was. So it just proved that it just wasn't a good technology. (INT-FF-S-022)
>
> I mean, right now, on an incident, I'm carrying usually two 800 radios, a VHF, and two cellphones when I'm running an incident. And that's ridiculous… When someone's talking, I can't process all that information. So to fix that problem, we're not carrying so many different-- just to be able to talk to different people through cell phones, consolidate it down, but then, somehow, have it manageable. (INT-FF-R-019)

Also notable is that, compared to the other problems faced, FF have a relatively positive perception of the accuracy of information provided via TICs, with zero FF "Always" experiencing problems with "information accuracy."

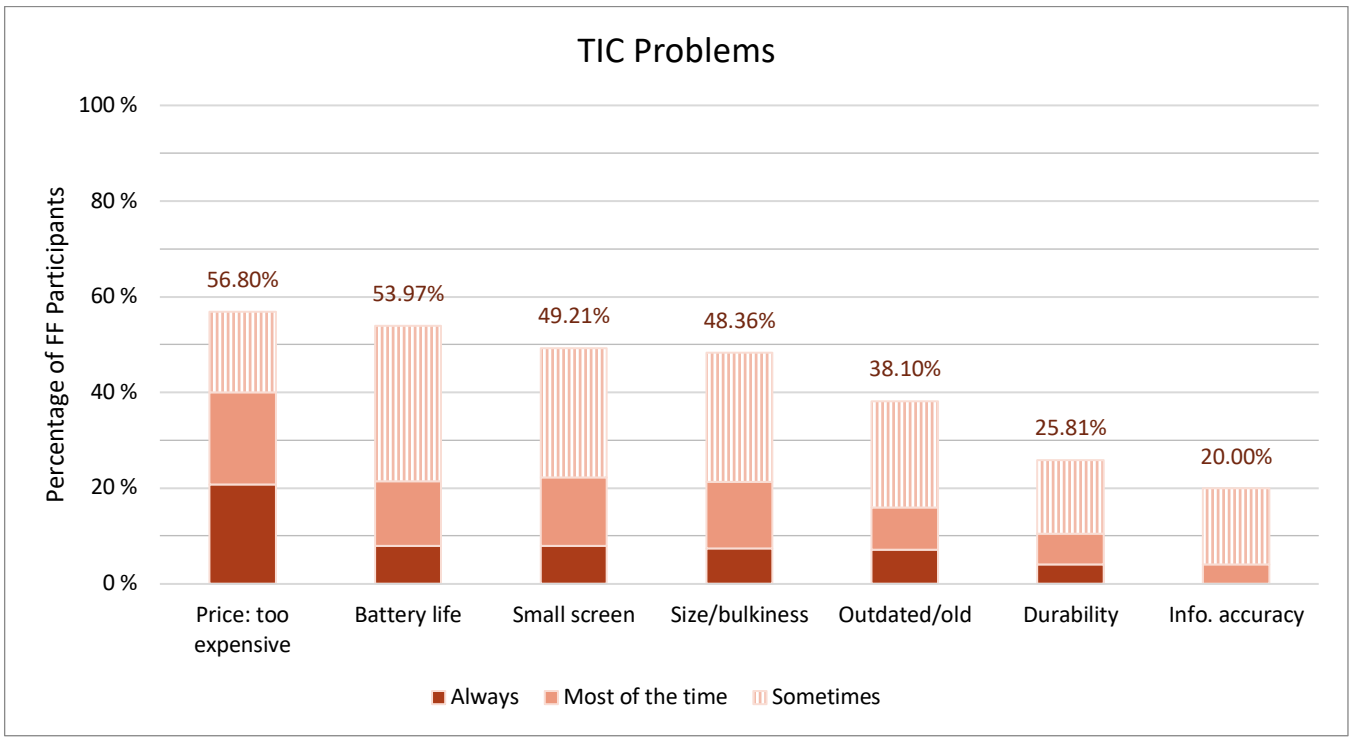

Fig. 34. FF TIC problems

Earpiece, Mic, and Radio Problems

The problems associated with earpieces, mics, and radios for FF are shown in Table 9. In response to the open-ended questions about additional problems for these devices, 336 FF participants provided feedback about radio use (18.53 % of the participants who were asked about radio problems), 21 about microphones (9.55 % of the participants who were asked), and 3 about earpieces (4.23 % of the participants who were asked).

Table 9. Survey problems lists – FF radios, mics, and earpieces

Earpiece	Mic	Radio
Audio quality	Audio quality	Audio quality
Battery life	Cord	Battery life
Durability	Durability	Channel switching
Fit/falling out	Falling off	Cord
Outdated/old	Outdated/old	Coverage/dead zones
Price: too expensive	Placement on body	Durability
Volume	Price: too expensive	Interoperability
Wireless (bluetooth pairing, etc.)	Talk button location	Outdated/old
	Talk button size	Price: too expensive
		Radio discipline/etiquette
		Size/bulkiness

The earpiece problems FF experienced at least "Sometimes" are shown in Fig. 35, where "price" is the top problem (55.74 %). Problems with "audio quality," "volume" (too high or too low), and "battery life" were experienced by nearly half of FF with their earpieces as well. Beyond these top problems, earpieces used in conjunction with radios (and often mics) presented a unique set of challenges when used by first responders. While none of the 71 FF participants "Always" experienced these issues, "fit" and "pairing" caused problems for 41.94 % and 27.87 % of FF participants, respectively.

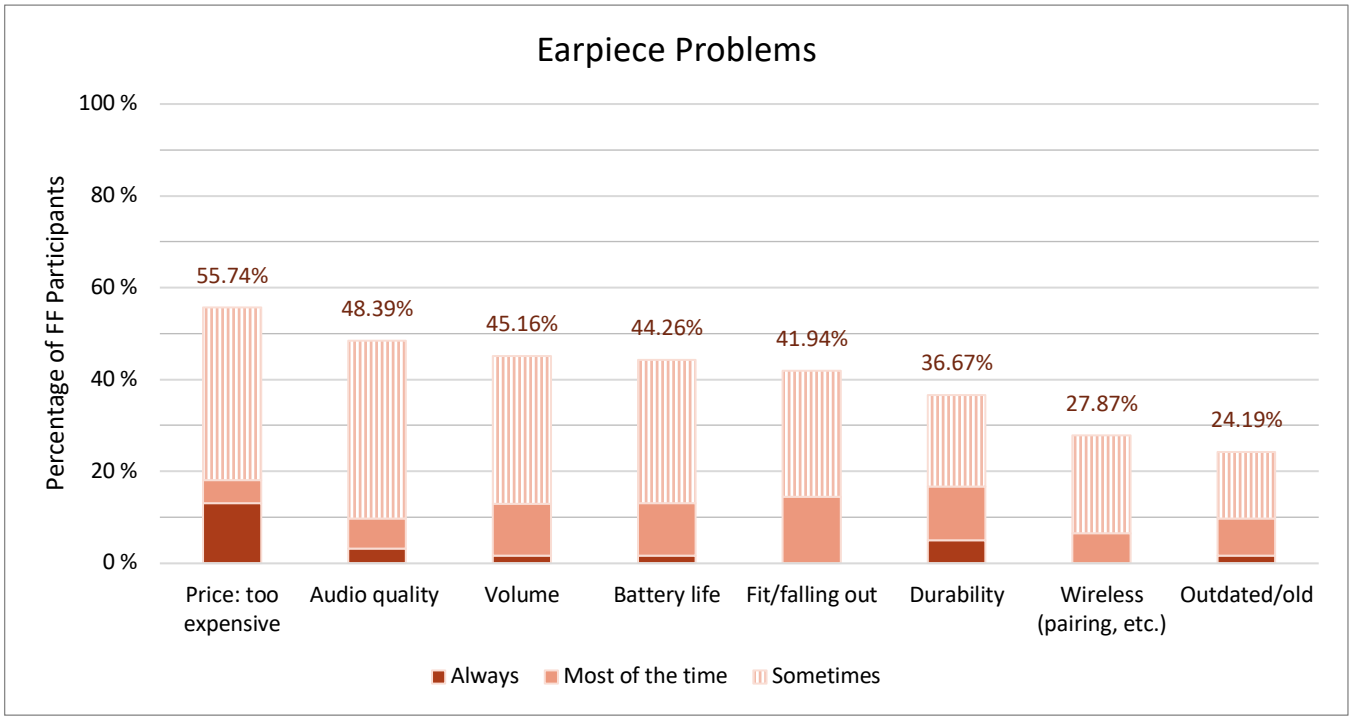

Fig. 35. FF earpiece problems

For mics, the main issue experienced, by far, was problems FF had with the quality of the mic's audio (see Fig. 36). Additionally, just over half of FF experienced problems with their microphone cord and expensive cost associated with mics. It is interesting to note that more FF experienced "audio quality" and "cord" problems at least "Sometimes" with their mics than "price: too expensive;" however, the cost of microphones was "Always" a problem three times more than other microphone problems.

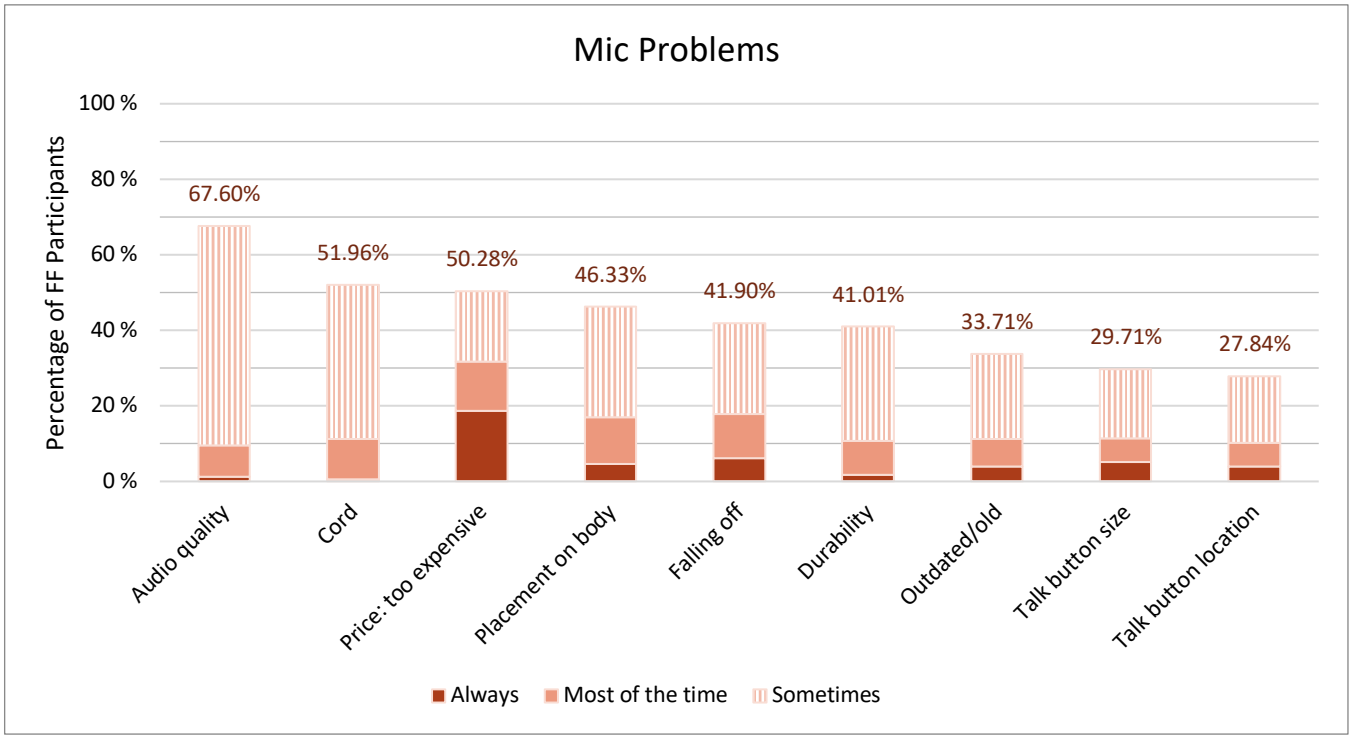

Fig. 36. FF mic problems

As previously noted, there were far fewer data from the open-ended response questions for mics and earpieces, resulting in insubstantial categorical analysis. However, FF participants did shed some light on particular issues they faced with their earpieces and mics, noting problems with the reliability of both earpieces and mics. Respondents also voiced problems experienced with the durability of their microphones under wet conditions, often stating that the lack of "resistance to water" (FF:S:2489), "ruins the mics" (FF:U:9230). The issue of waterproofing was a major finding from our interview data for mics, and especially, radios:

> If [the portable radio] gets wet, the radio might not function. We spray water all over the place all the time… That's another huge problem. So that's one thing I'd like to see. The fire service, anyways, to have radios that are specifically engineered and designed to withstand water… (INT-FF-S-033)

> We have the radio itself, the little brick, and then it has a cord and the cord comes up to a mic. We've had, with our new ones, we've had some challenges with that, with water and cutting out. And then you have the whole issue with the cable that goes from the radio up to the mic… (INT-FF-U-020)

The radio problems FF experienced at least "Sometimes" are shown in Fig. 37. There was also a large number of open-ended responses to the radio problems question (336), resulting in 14 categories related to radio problems (see Table 10). As the open-ended responses often echoed the quantitative data, the presentation of respondent quotes is interwoven with the quantitative radio problem results.

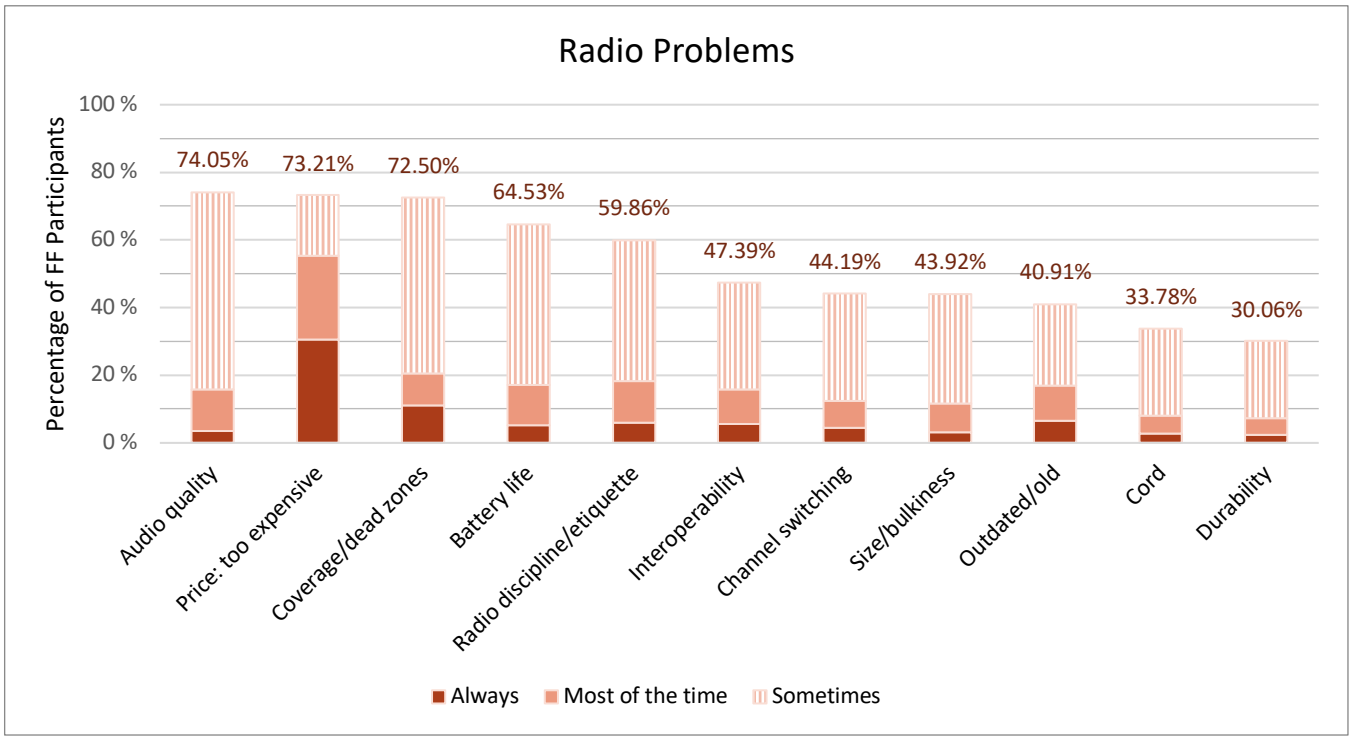

Fig. 37. FF radio problems

Table 10. Categories of open-ended responses – FF radio problems

Types of radio problems	% of responses *(n = 336)*	Exemplar Quotes
Coverage / Dead zones	33.63 %	Topography interrupting signal, as well as in building coverage. (FF:S:1470)
Miscellaneous	20.24 %	Cross contamination. I carry it in a leather strap around all day, after being in a fire. Even after decon, the radio is still off-gassing. (FF:U:8286)
Channels and programming	15.77 %	channel switching - difficult to maneuver between channels and banks of channels, particularly at night. (FF:S:371) Programming most radios is an arcane and complicated process. (FF:R:3803)
Reliability and safety	14.88 %	During fire ground ops, my radio will frequently be unable to transmit my message. I can hear most messages but cannot transmit. I find it very dangerous and unsettling. (FF:U:6455)

Types of radio problems	% of responses *(n = 336)*	Exemplar Quotes
Other transmission issues *(e.g., bonks, traffic, etiquette)*	13.10 %	Cannot transmit or receive messages [if] other radios are close to you. (FF:U:6857)
Robustness / Durability	13.10 %	Very often the PTT will freeze open when working in cold environments. Both on the portable radios themselves and the mic. (FF:R:3422)
Audio quality *(e.g., static, interference, volume)*	11.90 %	audio quality Feedback or echoes (FF:U:9327)
Interoperability	10.12 %	firmware incompatibility even within the same manufacturer/model of radio. (FF:R:9772)
Usability	9.82 %	the radios that we use are not firefighter friendly. the knobs are small and hard to change with firefighting gloves on, there is no voice announcer when switching channels (FF:R:9299)
Battery	9.23 %	New smart batteries frequently alert that they need to be reconditioned. When command response vehicle left outside overnight new radio batteries get too cold to operate. (FF:S:3253)
Cost	8.63 %	800MHz trunked system is only accessible to some of my mutual aid partners due to costs of the radio. (FF:S:9394)
Mic-related	7.14 %	Water and weather getting into the connection between the corded mike and radio. It would shut the channel down until shut off. (FF:U:3587)
Old	5.65 %	cost of county issued radios approaching end of life, no longer manufacture supported....city can not afford to replace (FF:S:9466)
Policies	4.76 %	Emergency button too sensitive (set mandatory by county with no delay) (FF:S:2768)

Note: An individual response could address problems in multiple categories. Therefore, percentages may not sum to 100 %.

The quantitative data show that the radio problems experienced by the most FF were “audio quality,” “price,” and “coverage,” which were experienced by more than 70 % of FF at least “Sometimes.” Perhaps the most telling results for radios, earpieces, and mics is that “audio quality” and “price” were major issues for all three devices.

Survey respondents continue to identify “price: too expensive” as a top problem for communication technologies. For FF, expensive costs experienced at least “Sometimes” were second only to “audio quality” of radios, were the top problem for earpieces, and third for mics. Further, for each of these three devices, FF “Always” experienced “price” more than any other problem, by a margin of more than 2:1; that is, two times more first responders in FF always had problems with the cost of earpieces, radios, and mics than any other problem with those devices. Across geographic areas, open-ended responses revealed various aspects of FF problems with the cost of radios.

> Funding for Software updates (FF:S:460)

> For my department alone we are looking at a cost of over $60,000. This to be completed on a budget of around $30,000 with us paying all of our own bills, insurance, fuel, water, sewer, electric, phone, etc. (FF:R:2562)

> Proprietary batteries (cost and compatibility with battery level identification on portable screen) (FF:S:1917)

> In my jurisdiction, dead zones are all over the place. We're doing our best with what we have but new technology is extremely expensive and our Board of Trustees is scoffing at high prices. To be honest, I'm really worried that someone is going to get hurt or killed before the issue is fixed. (FF:R:3375)

> Too expensive to issue one to everyone. (FF:U:4666)

First responders in rural areas often face challenges supplying resources needed for their day-to-day work due to the costs associated with the equipment and technology required [13]. However, as shown by these quotes, problems with the expensive cost of radios are not exclusively faced in rural environments. Some urban and suburban areas also experience challenges supplying the needs of their first responders due to the exceedingly high cost of technology.

"Audio quality" was the top problem for radios and mics, and second only to "price" for earpieces. Further, over 10 % of the 336 open-ended responses to the question about problems with radios were comments about audio quality issues. FF voiced concern about issues with radio signal interference, hearing static, and volume control and modulation:

> A lot of static making it difficult to understand. (FF:R:6259)

> Audio quality with wired microphone in wet environments. (FF:S:2207)

> Low or loose battery sometimes causes switching of zones. Lapel mics can get wet and malfunction. Radios can sound digital and unclear at times. (FF:R:8652)

> discrepancy between voice audio and alert audio volumes, making it difficult to keep the volume for voice at a level that alert tones don't hurt your ears (FF:U:6626)

> Volume is all over the place… earpiece is uncomfortable and leaves me deaf to the scene in that ear… (FF:S:6590)

Open-ended responses for radios that were related to audio quality issues often mentioned the associated difficulties with audio quality for mics and earpieces, as well. These problems with audio quality mirror our interview findings, where many first responders expressed difficulties when communicating during incident response:

> And depending on what's going on inside with other noises and things, that can sometimes challenge it. But every once in a while you get a garbled communication coming from somebody wearing a mask just because of placement of the radio and where they're talking. (INT-FF-S-038)

> If I have my radio up too loud and my officer's next to me, we get feedback. So you got to be careful of that. And it may not even be my officer, it may be the next firefighter next to me. So then if your radio is down too low, then [you can't hear]. (INT-FF-S-022)

An underlying cause of audio issues stems from interference or lack of coverage on the radio network. More than 7 in 10 FF respondents indicated that they experienced problems with "coverage/dead zones." Problems with radio reception, coverage, and dead zones were also expressed widely in the open-ended responses.

> Radio communication poor to [non-existent] due to dead spots. (FF:U:8158)

> Different agencies use different types, forcing me to carry multiple radios for incidents. We have a mix of VHF and 800 radios, depending on the incident. Dual bands are difficult and unreliable. All of the radios, regardless of type have significant dead zones due to our terrain. This is almost always a significant challenge on any event. (FF:R:4503)

> The main problems are being out of reach from the repeater system and not realizing this ahead of time to switch to simplex. Everyone keeps saying that 800 is the cure but it only creates more problems due to the short distance it transmits. (FF:R:7763)

> Not so much the radio itself but coverage from our system. A lot of dead spots. (FF:S:829)

> The downside is when a firefighter goes down in a basement, and his radio doesn't see a repeater, he can't call for help, so the radio is useless. So the fix to that is to go to a direct channel. The downside of being on a direct channel is only people within a mile can hear the radio, so other people across the city or incoming to the fire don't get to hear what's going on before they get there until they get into range of the direct channel. So that's a conundrum. I guess there are some fixes. You can put a repeater on every chief's buggy that will also take that direct channel and put it into a repeater system that way everybody to hear it that way. That requires infrastructure, investment, and installation, and so forth, and money, so. (INT-FF-U-016)

As shown by the quotes above, coverage issues are often not an issue with the radio itself, but with the supporting infrastructure. Newer technology with broader ranges of communication would be more effective with the build-out of an appropriately designed network infrastructure.

Another cause of coverage issues expressed in the open-ended data was structures that blocked the radio signal, especially in urban areas. 26.55 % of the coverage-related responses emphasized issues with communication from within buildings or other structures (e.g., tunnels).

> issues with dead zones are a big thing. Sometimes we cant hear each other inside of a warehouse. (FF:U:6405)

> Lose signal inside stores, schools and hospitals. (FF:U:2455)

> The firefighters inside a structure need to be able to reliably and easily hear everything that is said on the fire ground channel. 800 mgH trunked systems do not penetrate steel and

> concrete structures as well as the older technologies in my experience. Worked big city and now small city. (FF:S:8006)

> Constant coverage concerns!!! Numerous deadzones! Channels that switch at the slightest touch. Being forced to use 800mghz radios that DO NOT WORK ON INTERIOR INCIDENTS. (FF:R:5257)

FF experienced major frustrations with the lack of sufficient coverage during incident response, as this survey respondent expressed. Coverage issues were not the sole cause of audio transmission issues, according to FF open-ended responses. An additional 13.10 % of the open-ended responses were related to other radio transmission issues, including busy signals (i.e., bonks), radio traffic, radio etiquette. Likewise, the quantitative data show that "radio discipline" was a problem for 59.86 % of respondents, reflecting the findings from the interviews.

> Most radio issues have to do with radio etiquette and other agencies or reception issues. (FF:S:3495)

> Frequent bonk tone when the [queue] for radio traffic is full at the server. (FF:U:3891)

> … - radio coverage is problematic - too much & needless radio traffic … - radio transmissions often times have to be repeated when in close proximity to other radios because the transmissions are covered by a strange background noise. (FF:U:6085)

> Our digital system has trouble with multiple users, which can slow down, or put you in the queue so your transmission/message is then delayed due to too many users/traffic (FF:R:7402)

> Everybody has something to say about what they see or what they're doing. And everybody thinks it's the most important thing out there, right? But if you all try to say at one time then nobody's getting through and you get bogged. Only one person is going to get through at a time in one type of a channel. So if you have 30 people there in certain portions of that building or under whatever they're going through, someone's going to be waiting a while to get on the air. And it's hard. (INT-FF-S-035)

Battery issues were also among the top problems experienced by FF; survey data show that when asked about problems with their radios, 64.53 % of FF had problems with "battery life" at least "Sometimes." The qualitative data, both in open-ended survey responses and the interviews, illustrate the challenges first responders have to overcome with radio batteries. While open-ended responses were often simply "poor battery life" (FF:R:5088) or "battery failures" (FF:U:6496), many comments went further to explain some of the underlying battery problems.

> Cold Weather slows it or drains battery. (FF:R:4759)

> Failure of radio to warn of low battery until attempting to use (FF:S:3328)

> Sometimes the radio will malfunction with certain batteries inserted… (FF:U:8657)

> …aftermarket battery vendors are second rate batteries. Once they get below a certain voltage, the radio malfunctions including shutting off and on multiple times in 5 seconds, changing talk

> groups on it's own, and not switching to the correct talk group when turning the channel selector. (FF:U:1381)

While battery life is a major issue first responders face, open-ended responses also show that battery problems extend beyond just the life of a radio's battery.

While the interview data show "interoperability" to be a major concern for FF [5], survey results suggest it was not experienced as much as the aforementioned radio problems. Still, a solution to the problem of radio interoperability is of utmost importance considering that nearly half of FF experienced at least "Sometimes" (47.39 %).

> So we're always lacking, in my opinion, when it comes to radio communication. There's always problems, there's always problems getting on the right channel or being able to communicate with a different entity or different agency. You see that in, unfortunately, but you've got mass shootings and there's always a problem with cops being able to talk to firefighters. (INT-FF-U-021)

> Other mutual aid agencies using different radio bands - ie: VHF, UHF, 800, 700 There is a checkerboard pattern of frequencies in use which complicates mutual aid. Another complicating factor is conventional vs trunking systems in adjacent counties. (FF:U:1757)

> The biggest problem is that technology is changing fast and 15 years ago I could talk with my neighbors, but now I can't. They are using different technology that might work better or, many times worse. (FF:R:8081)

> Coverage area restrictions, interoperability, costs of equipment, software, and service (FF:S:3567)

> Base Stations are aging. Trunking system is very unreliable with many dead-spots. Lack of inter-operability with rural fire departments requiring changing channels and confusion. Expense there is no way our City can afford the cost of moving to the newest hardware. (FF:S:4349)

Perhaps surprisingly, the quantitative data show that issues with the radio "Cord" were experienced at least "Sometimes" by a lower percentage of participants than most of the other problems (33.78 %); only "Durability" was lower. The interview data show that the design of the cords was a major cause for concern in FF because of cords' "susceptibility to melting, entanglement, becoming disconnected, or problems integrating into uniform" [5]. These issues may be reflected in the microphone problems survey data, where over 50 % of FF experienced cord problems with their microphone at least "Sometimes" (51.96 %). Open-ended responses to the radio question echoed the issues with mic cords, often citing reliability or safety issues:

> …most firefighters use the Boston Strap which puts the radio at your waist with the cord coming up and across the chest...Stupidest set up ever!! Entanglement issues, cant reach the radio if its under the coat, have to plug in and unplug the earpiece cord, possibility of melting it if its on top of the coat, In my mind this is a huge safety issue. Captains should be assigned two radios; one that is permanently in the coat chest pocket for emergency scenes. (FF:S:6590)

First responder safety should be a top priority when designing tools for their day-to-day work. Reliability is key to safety.

Desktop Computers, Laptops, MDT/MDC, and Tablet Problems

The problems associated with desktop computers, laptops, and MDTs for FF are shown in Table 11. In response to the open-ended questions about additional problems for these devices, 75 FF participants provided feedback about using desktop computers (5.63 % of the participants who were asked about desktop problems), 29 about laptops (4.69 % of the participants who were asked), 115 about MDTs (16.96 % of the participants who were asked), and 24 about tablets (7.95 % of the participants who were asked).

Table 11. Survey problems lists – FF desktop computers, laptops, MDT/MDCs, and tablets

Desktop computer	Laptop	MDT/MDC	Tablet
Internet connection	Battery life	CAD (computer- aided dispatch)	Battery life
Interoperability	Durability	Durability	Durability
Logins/passwords	Glare	Glare	Glare
Outdated/old	Internet connection	Interoperability	Internet connection
Price: too expensive	Interoperability	Lack of portability	Interoperability
Software crashes	Logins/passwords	Logins/passwords	Logins/passwords
Software updates/upgrades	Outdated/old	Mapping/navigation	Report writing
	Power source/recharging issues	Outdated/old	Size/bulkiness
	Price: too expensive	Price: too expensive	Touchscreen
	Size/bulkiness	Size/bulkiness	Weight
	Software crashes	Using while driving	
	Software updates/upgrades		
	Weight		

Fig. 38 shows the problems FF experienced with desktop computers. Analysis of the open-ended responses resulted in 11 categories of data related to FF desktop problems, shown in Table 12. The open-ended data is presented together with the quantitative data throughout this section.

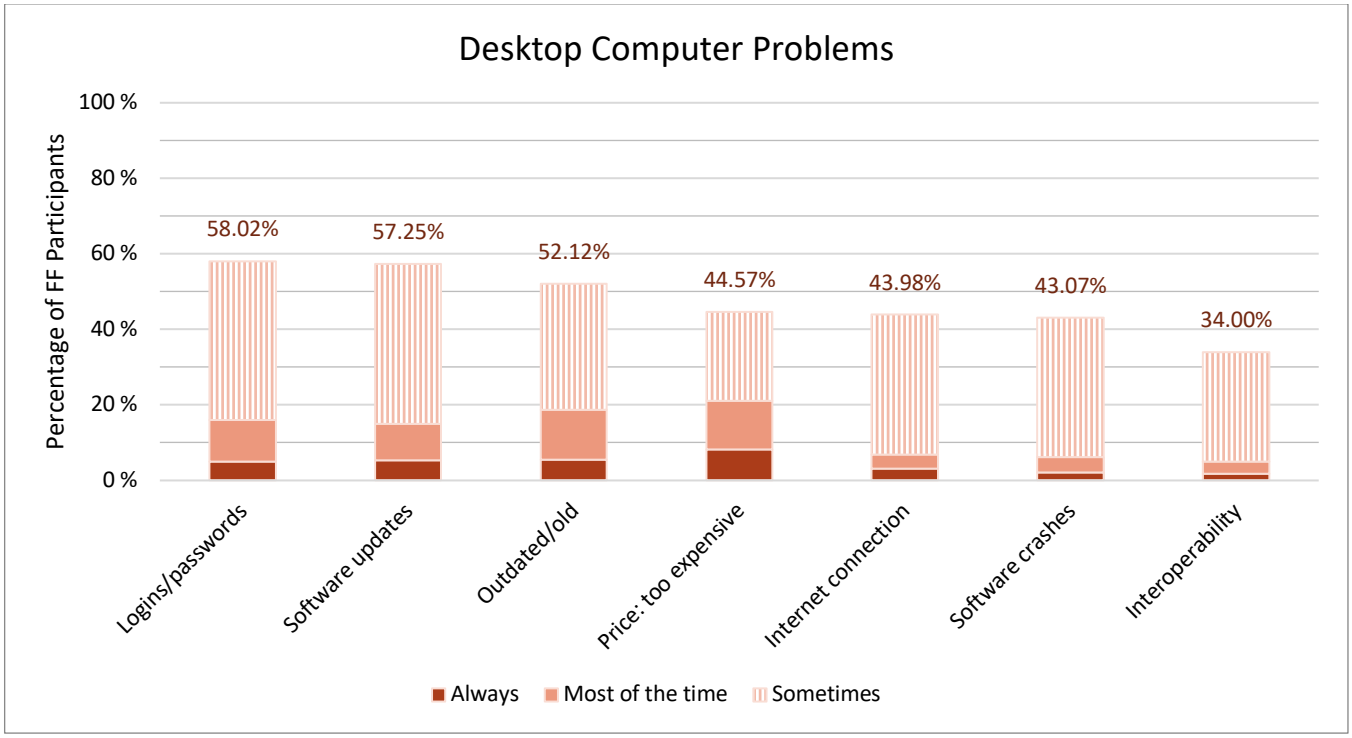

Fig. 38. FF desktop computer problems

Table 12. Categories of open-ended responses – FF desktop computer problems

Types of desktop problems	% of responses *(n = 75)*	Exemplar Quotes
Slow	25.33 %	The computers here at [station] are slower than any computer I have ever been on in the county. Trying to do video trainings is difficult because the computer is always buffering. (FF:R:806)
Miscellaneous	20.00 %	Too many browsers, and operating systems from computer to computer. Too much time spent working through system errors. Not very efficient considering the price and so called potential. (FF:S:1459)
Internet *(e.g., network interoperability)*	16.00 %	Network speed in our city is horrible. Software and hardware is outdated. City not willing to spend money for upgrades needed to keep us up to date in this century. Hard to accomplish work at the rate required with speeds that are provided to us. (FF:S:7412)
Access / permissions	16.00 %	Unable to have permission to update software (FF:R:162)
Software *(incl. update issues)*	14.67 %	Unwieldy to have to have admin constantly update software versions, apps, etc. (FF:U:5659)
Old	13.33 %	[The desktop I use] crashes from time to time. It's pretty old and should be replaced with something with updated equipment and programming installed. (FF:R:3611)
Reliability	13.33 %	At times when I log in the system drive are missing. I then have to shut down and start up again. This happens often. (FF:U:6261)

Types of desktop problems	% of responses *(n = 75)*	Exemplar Quotes
Security *(e.g., spam, viruses)*	6.67 %	Because of security concerns I am not able to fully connect to servers from remote locations. Which keeps critical data out of my reach in the field. (FF:S:1252)
Cost	5.33 %	Not all of the departments' computers can be upgraded in the same year due to financial restraints. This causes people in the same office area to have slightly different user experiences or functionality. (FF:S:1207)
IT support	5.33 %	FD has very poor IT support. (FF:S:2274)

Note: An individual response could address problems in multiple categories. Therefore, percentages may not sum to 100 %.

The major problems FF had with their desktop computers were "logins," "software updates," and "outdated," with over half of FF experiencing those problems. The open-ended data shed light on two of these problems, with many comments about software issues and desktops being outdated.

> [The operating system] will initiate updates in the middle of work. We can work 24/7/365, and don't have guaranteed down times for the update program to run. (FF:R:263)

> old software, not able to get certain software, computers are very slow (FF:U:1739)

> Desktops are outdated. I have a desktop, laptop, [tablet redacted], [smartphone redacted], [smart watch redacted]and many apps to go along with them. I have to know the language of Windows and Mac and constantly remember passwords and ID's. We need one device with a secure location to store data. (FF:S:4460)

As public safety moves toward the future of broadband technology, current technology is aging but still in use in many fire stations. FF indicated that the use of aging technology results in slower processes that affect their work.

> Older desktops issues with slow speed. (FF:U:7905)

> Slow. Needs more memory. (FF:S:947)

> Extremely long log in times of 5-15 minutes. This is occasional but wastes a lot of time and slows work progress. (FF:S:694)

The slowness of desktops that so many FF experienced has a negative impact on their day-to-day work as the participant above noted. Poor internet speed and network interoperability issues were also manifested in slow desktop computers.

> VPN network crashes and looses connection all the time (FF:S:7473)

> General network issues (printers, network drives, etc.); Sometimes (FF:S:1248)

> Only one Internet to use/ No good can't get them to fix. They seem to be way over their heads… We have Fiber optic coming in phone office but the old contactors and electrical parts are out of date stuff… (FF:R:3189)

Problems experienced by FF with their desktops are not simply due to the age of the technology, but because of the underlying infrastructure as well.

Another key issue that was revealed in the analysis of the open-ended responses was the barrier to access due to a lack of technological permissions.

> end-user flexibility/access vs. enterprise management (e.g. locked out of some functionality for the benefit of easy/central management) (FF:U:4629)

> Very limited access to add additional software or programs to enhance work operability. (FF:S:5899)

Issues with desktop computers were repeatedly seen by FF as an impediment to their productivity, operability, and efficiency. As the NPSBN is enabling greater use of mobile devices, it is important to continue to work to reduce the problems associated with traditional devices that are still widely used across public safety (e.g., desktop computers).

The problems associated with laptops for FF are shown in Fig. 39. By far, the problem the most FF experienced at least “Sometimes” with their laptops was connectivity; an overwhelming 74.05 % of FF had “internet connection” issues. As with many other devices, “price” was “always” an issue for FF than any other laptop problem. The responses to the open-ended question about laptop problems weren’t substantial enough to formulate new categories during analysis; however, many of the comments reiterated nearly all problem items listed for this question.

MDT problems FF indicated that they experienced at least “Sometimes” are shown in Fig. 40. The categorical analysis of the responses to the open-ended question about MDT problems is highlighted in Table 13, along with a quote to serve as an exemplar for each category of thought.

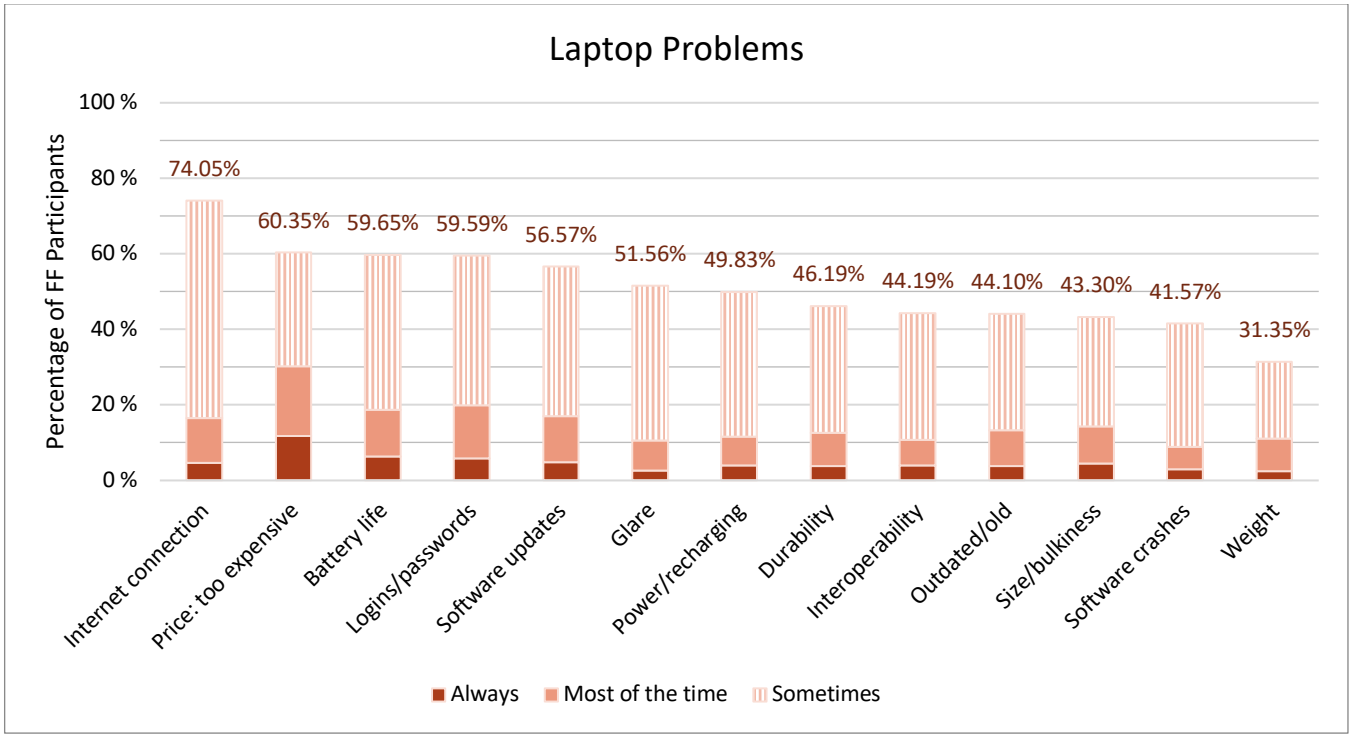

Fig. 39. FF laptop problems

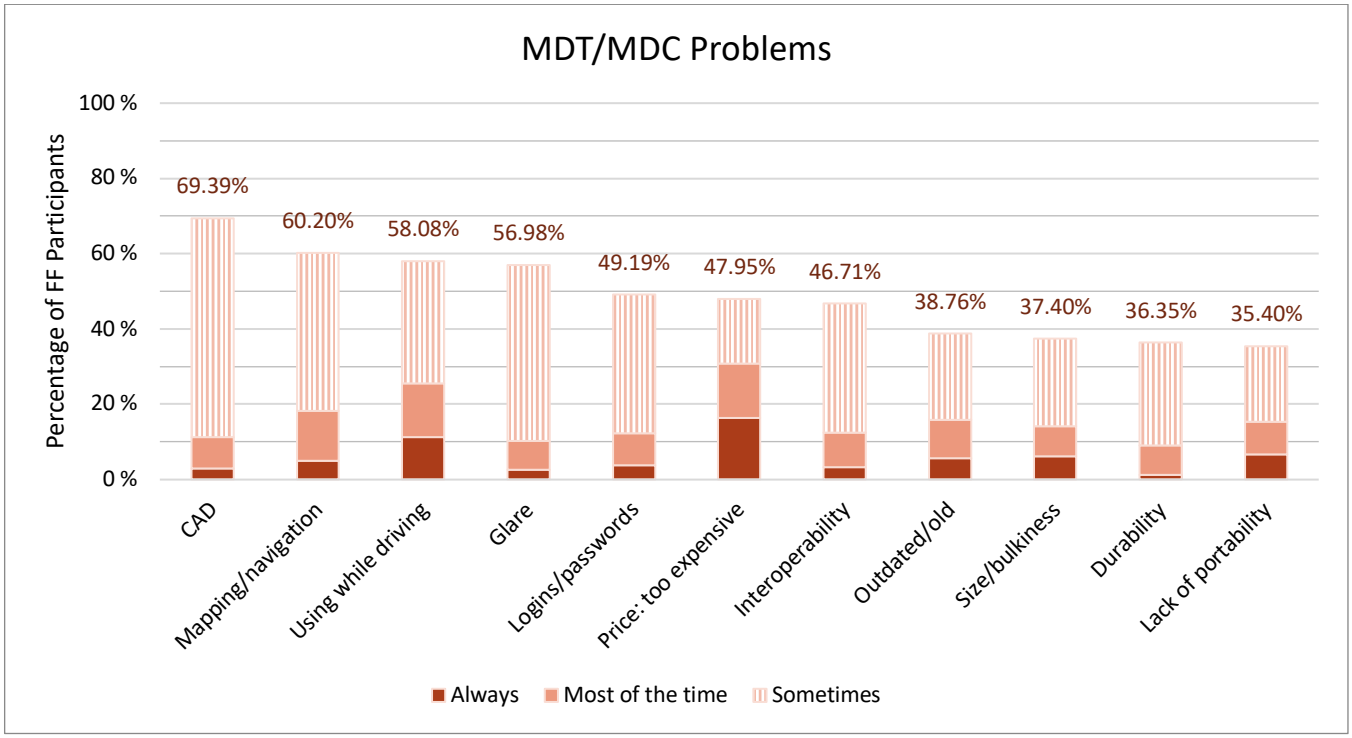

Fig. 40. FF MDT/MDC problems

Table 13. Categories of open-ended responses – FF MDT/MDC problems

Types of MDT/MDC problems	% of responses *(n = 115)*	Exemplar Quotes
Connectivity	46.09 %	Connectivity to the data service is problematic in many areas of the district. (FF:U:7480)
Miscellaneous	23.48 %	Software is great for Law Enforcement but does not address the need of Fire or EMS (FF:S:4917) Field configuration of software Requires multiple softwares for constant connectivity and VPN. Extra costs with that. (FF:R:2640)
Reliability	19.13 %	Reliability of the system, the system was outdated prior to being placed in service. (FF:U:3772)
Usability *(e.g., size, scrolling)*	13.04 %	Blocks view of traffic Software issue that puts important response information out of view in favor of system acknowledge messages (FF:U:4129)
Mapping	10.43 %	I don't like the way the mapping displays the map. North is [always] on top no matter what direction I am driving, I wish it was more like my phones mapping system. (FF:S:5984)
Use while driving	9.57 %	generally [difficult] to use an MDT while driving down the road, especially for mapping and typing (FF:U:6626)
CAD & AVL	7.83 %	Additional issues related to the MDC actually involve the CAD system infrastructure or the data connection which is provided via commercial cellular provider. AVL issues are nearly constant and reported by all fire companies. (FF:U:992)
Slow	7.83 %	switching from WiFi to cellular has a lag. (FF:U:8303)
Batteries	4.35 %	The [tablet redacted] batteries get cooked from constant charging in the dock. This type of MDT was not designed for fire service use and constant charging a vehicle mounted dock. (FF:U:2472)
Interoperability	4.35 %	If software was more tablet [tablet redacted] friendly this would work better but it seems there are always one or two software that require windows so this requires a laptop and docking station. (FF:S:3378)
Durability & robustness *(e.g., environment conditions)*	3.48 %	Sometimes connection is lost, sometimes the feed from the CAD experiences problems. At times during the summer 105 to 110 degree days, the computer overheats and shuts down. (FF:S:723)
Old	3.48 %	They do not connect to WI-FI due to the age of the computer (FF:U:5841)
Updates	3.48 %	Does not update automatically. When updating, the software logs off and has to be manually logged on. Inconvenience while updating enroute to a call. (FF:U:8992)

Note: An individual response could address problems in multiple categories. Therefore, percentages may not sum to 100 %.

Investigation of the MDT problems experienced by FF at least “Sometimes” shows several problems experienced by at least half of FF: “CAD,” “mapping/navigation,” “use while driving,” and “glare.” Arguably the most important software used on MDTs, “CAD,” topped the list with nearly 7 in 10 FF experiencing problems (69.39 %); further, the data suggests “CAD” was the most intermittent problem

experienced with MDTs with 58.10 % of FF having “CAD” problems “Sometimes.” Three of these top problems were also emphasized in the open-ended response data, with FF participants expressing issues with their MDT’s mapping software, issues with using their MDT while driving, and issues with the CAD & automatic vehicle location (AVL) systems.

> CAD/Mobile program installed (purchased by county) is not designed for fire/ems. Most programs are law enforcement driven. Need better integration for fire/ems. (FF:S:1924)

> our mapping software sucks, so does our CAD system. Way to outdated and frustrating. The single biggest frustration dealing with technology is dealing with our IT department. (FF:U:6501)

> needs touch screen devise, distracted driving because using MDT's. it would be nice not to need to look at a computer screen while driving (needs HUD or voice information) (FF:R:272)

> Doesn't map well, it sometimes cant find addresses, often fails, times out, [loses] connectivity, call doesn't come up on the dispatch scene, automatically scrolls with external updates thereby loosing what you're reading on the scene. Terrible units (FF:S:6590)

> Not user friendly. Very hard to get information while driving cause the touch screen areas are too small to activate prompt. Mapping and navigation is horrible. Mapping for calls is not accurate. Proper call information is not added or hard to find due to non essential information being added and [it’s] so small [it’s] hard to read the information. (FF:U:8158)

FF respondents displayed strong, negative feelings towards these MDT issues, especially the “horrible” mapping and navigation. This perspective was reflected in our interviews, where FF felt so strongly about the inefficiencies of mapping and navigation on MDTs that they often used the mapping apps on their personal devices for navigation.

> 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)

Also notable are the data showing where FF “Always” had problems with their MDTs. “Use while driving” and “price” were problems that over 10 % of FF “Always” experienced with MDTs. Additionally, while “lack of portability,” “size,” and “old” were at the lower range of problems experienced at least “Sometimes,” they round out the top 5 problems FF “Always” experienced.

Great consideration should be also be given to the standout categories from the open-ended analysis. Issues with connectivity, reliability, and usability were included in the overwhelming majority of the open-ended responses (71.30 %). Connectivity issues, especially, caused a great deal of frustration for FF, with nearly half of open-ended responses indicating experiences with “problematic” connectivity.

> Connectivity issues while getting calls from in quarters (FF:R:1081)

> Cell coverage drops in area of my station, so we sometimes have to leave the area before our computer connects to the network. (FF:U:1971)

> The connection is sometimes slow with receiving or sending information to and from the 911 center to the units operating. (FF:S:2303)

> Connection with either Wifi or cell coverage. Current MDC tablets have difficulty switching to Cellular when we depart the station. (FF:U:8641)

Additionally, many FF feel that some of the MDT's reliability issues stem from problems with network connectivity.

> MDTs are only as useful as the reliability of the cell service. (FF:S:4333)

> Reliability with network is always a problem (FF:S:6353)

> Loss of wireless connection. Unable to utilize while vehicle is in motion, (bounce) System lock up. (FF:S:8581)

As the last participant above shows, reliability issues mentioned were more often due to system crashes or failures. 63.64 % of responses in the reliability category were related to the MDT crashing, freezing, failing, or "locking up."

> Occasionally freezes up and/or needs to be rebooted, usually noticed during dispatch. (FF:U:414)

> It fails several times a shift. (FF:R:1112)

> Sometimes the MDT will take a dump and just stop working. Then it takes 10 minutes or more to get logged back in and up and running. (FF:U:3980)

> sometimes it just goes down until the computer system operator shows up and reboots it with his password (FF:U:2102)

MDT system crashes result in work inefficiencies for first responders while they wait an extended amount of time for the system to reboot.

Lastly, many in FF expressed concern with the usability of MDTs. Respondents had major issues with size, with just over half of the usability issues being about the size of the MDT screen or the text displayed (53.33 %). Some also voiced concern over the automatic scrolling feature, and the distractions it poses while driving.

> The size of the screen causes the font to be [too] small. It's sometimes hard for people needing to wear reading glasses. (FF:U:7621)

> Too small and placed in a location that cannot be read while driving (FF:S:8520)

> Our current one is too small to be operating while we're bouncing down these pothole-riddled roads [county redacted] has. (FF:U:7673)

> Repopulating causes information to relocate causing the need to scroll. Scrolling is difficult and ill advised while driving. (FF:S:6245)

MDTs, in both traditional and tablet forms have caused many different types of problems for FF. They need a device that is easy to use, and operable while driving an emergency vehicle.

"Internet connectivity" was the top problem FF had with their tablets, with 66.15 % experiencing the problem at least "Sometimes" (see Fig. 41). Issues with "glare," "battery life," and "logins" were also major concerns as more than half of FF experienced problems with those features. Analysis of the open-ended responses for tablets is reported in the Phase 2, Volume 2 report [6].

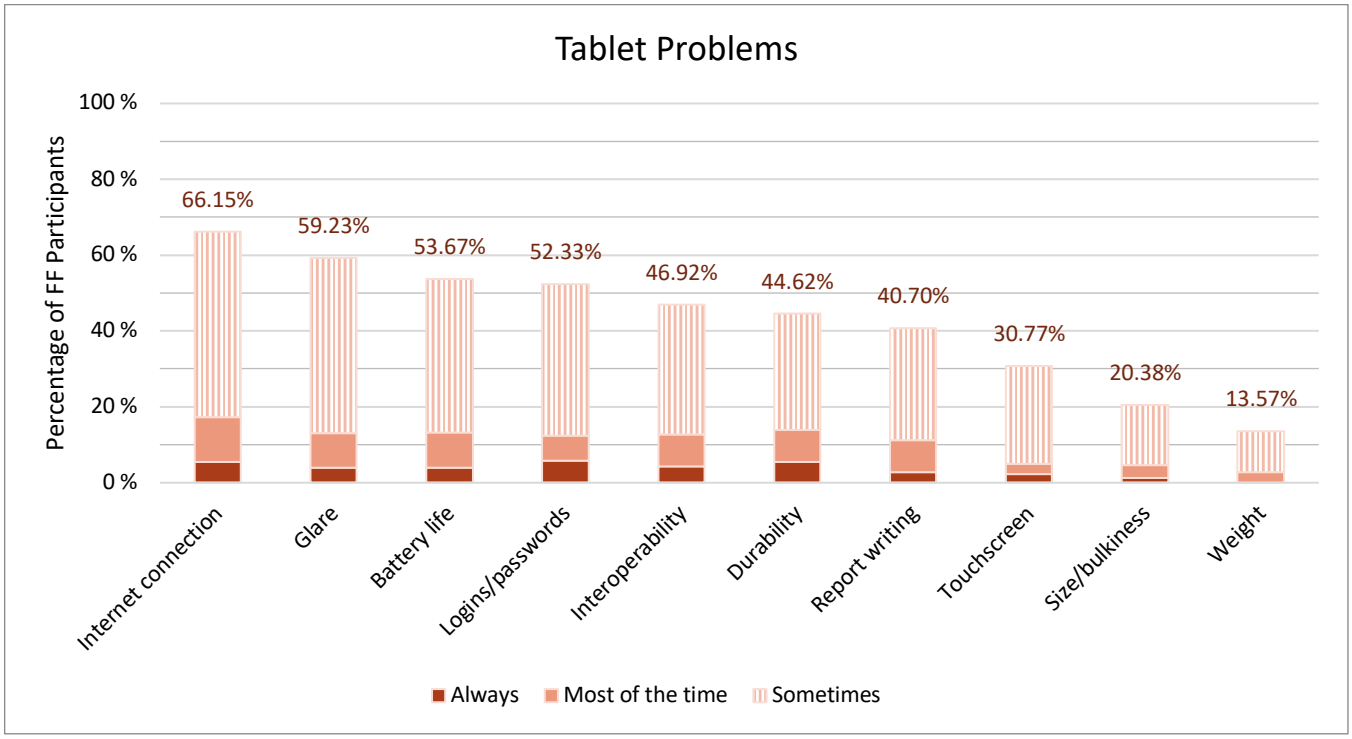

Fig. 41. FF tablet problems

Pager and Smartphone Problems

The problems associated with pagers and smartphones for FF are shown in Table 14. In response to the open-ended problems questions for these devices, 108 FF participants provided feedback about using pagers (18.21 % of the participants who were asked about pager problems) and 132 about smartphones (7.32 % of the participants who were asked).

Table 14. Survey problems lists – FF pagers and smartphones

Pagers	Smartphones
Battery life	Battery life
Durability	Coverage/dead zones
Falling off	Data plans/data limits
Outdated/old	Dropped calls

Pagers	Smartphones
Price: too expensive	Durability
Size/bulkiness	Glare
	Logging in (PINS, passwords, usernames, etc.)
	Outdated/old
	Permission/access to apps
	Policies about usage
	Price: too expensive
	Subpoena possibility for personal smartphone
	Subsidy for personal smartphone (insufficient or no subsidy)

The pager problems FF experienced at least "Sometimes" are shown in Fig. 42. The percentage of FF who experienced problems with the "price" of pagers was far more than the other problem with pagers. Nearly 70 % of FF experienced problems with the price of pagers at least "Sometimes;" further, three times more FF "Always" experienced problems with "price" than the other pager problems. Another factor to consider is that more than one in three FF experienced pager problems for each of the items listed on the survey.

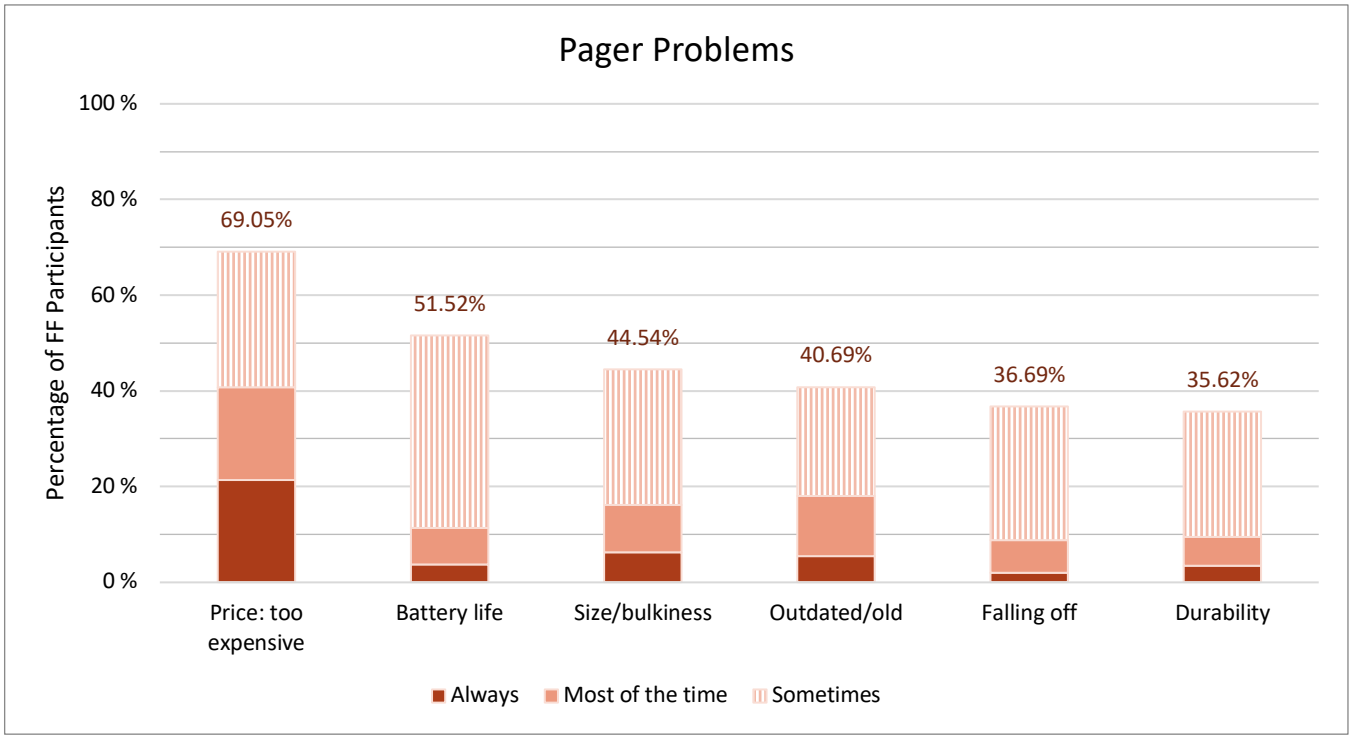

Fig. 42. FF pager problems

As previously mentioned, there was also a large number of open-ended responses to the pager problems question, resulting in seven categories related to pager problems (see Table 15).

Table 15. Categories of open-ended responses – FF pager problems

Types of pager problems	% of responses *(n = 108)*	Exemplar Quotes
Coverage	44.44 %	Reception based on poorly designed simulcast transmitter system. (FF:U:3159)
Battery/Charger	21.30 %	Battery seems to have issues with charging in the base on many pagers. (FF:U:1448)
Audio quality *(incl., static, interference)*	18.52 %	Audio, message transmission Quality Static (FF:R:1804)
Miscellaneous	17.59 %	It would be nice to have a pager that is both alphanumeric as well as an audio pager. Now I have to carry to separate pagers, quite annoying. (FF:R:4240)
Reliability	17.59 %	Poor reliability after minor damage during normal use - non-repairable. Problems obtaining special replacement batteries. (FF:R:1466)
Durability/Design	11.11 %	New technology pagers are not as durable and new range of distance decreases with newer versions. (FF:S:5916)
Cost	2.78 %	Durability, cost, updating (FF:S:1758)

The top category consisted of responses related to coverage problems experienced with pagers.

> Several crew members live in dead zones limited communications access due to hills or valleys disrupting pagers from alerting. (FF:R:4551)
>
> Poor reception in areas where there shouldn't be...missed pages. (FF:U:6506)
>
> Reception is not very good even within our county. (FF:S:3421)
>
> Pager range since narrow banding took effect (FF:R:5079)
>
> not pick up dispatches. We are on Low band radio system and pagers [do] not work well inside buildings. (FF:R:2662)
>
> Again, because of Low Band, too much static, incomplete recording of the call, broken dispatch (FF:R:1984)

FF indicated that coverage and connectivity for pagers were issues for various reasons, most often stated that it was due to issues with low bandwidth networks.

Many FF respondents also reiterated problems with pagers' battery life and charging base (21.30 %). Other top problems expressed in the open-ended data were related to pagers' audio quality and reliability.

> Getting tones with no message when dispatched to a call. Also not getting the message to come in clearly. (FF:R:835)
>
> The sound quality was very poor for the longest time. Receiving pages is even difficult at times. (FF:R:2369)
>
> 800 MHZ Pagers don't work well. They have a lot of clarity issues. (FF:S:5129)
>
> We have 800 MHz, poor battery life, poor coverage, size is to big (so it falls off easily) The cost is expensive The 800 just are not there in the [reliability] yet, calls are missed (FF:U:3169)
>
> Quality. I have tried/demo many different brands and models over the past several years, and none of them seem to stay working for more than a few years. (FF:R:3422)
>
> County government went away from a safer more reliable voice pager to a digital alphanumeric pager. Lack of situational awareness is dangerous. Not knowing who is on the assignment - other resources. Emergency Communications (FF:S:5151)

As with other devices first responders use for their day-to-day tasks (e.g., radios), the audio quality, coverage, and battery life issues with pagers present a reliability problem that jeopardizes the safety of FF first responders.

For smartphones, “battery life” was slightly more of a concern for FF than “price” and “coverage” (72.51 %, 70.87 %, and 67.01 %, respectively; see Fig. 43). Like EMS, “insufficient subsidy” was a major issue FF “Always” experienced, likely contributing to the issues with “price.” The possibility of their personal smartphones getting subpoenaed was also found to be a key issue, with more than 1 in 10 FF “Always” experiencing “subpoena” issues.

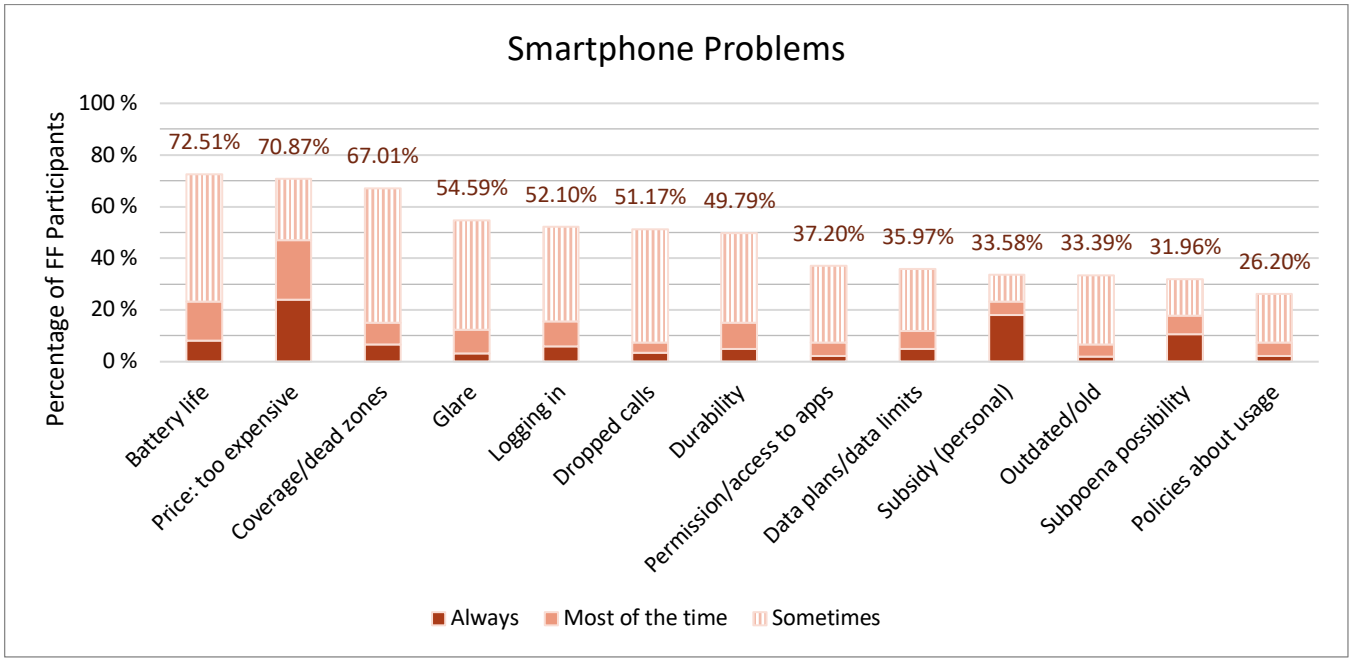

Fig. 43. FF smartphone problems

Open-ended responses to the question about smartphone problems fell into five main categories for FF:

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

FF expressed problems with the price of smartphones beyond the smartphone itself. The cost of associated data plans and apps were viewed as burdens for FF.

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

This participant expresses the frustrations with using smartphones for their day-to-day work; FF see the value in using smartphones, but the financial costs of both the phone and its use are high, as well as the constant concern that the phone may be subpoenaed if required.

Smartphone hardware issues were also a major concern for FF, specifically regarding the durability and robustness of the devices; responses often referred to a smartphone's inability to hold up in harsh weather conditions, stating things like "water intrusion" (FF:U:2317) as key problems.

Smartphones are seen as a valuable tool to FF responders. They just need the smartphones to be cost effective and reliable, designed for the environments in which they work.

4.5. LE

4.5.1. Overview of LE Findings

LE survey participants were asked about their day-to-day usage of several discipline-specific technologies. While they used these devices less overall than the more general devices for incident response, the subsections here provide insight into their use (Sec. 4.5.2 through 4.5.4). Highlights from the findings are presented below:

- The communication devices used by the most LE were radios and desktop computers. Laptops and MDTs were also heavily used, while tablets were used less frequently.
- Corded mics and earpieces were used by more LE than the wireless versions of those devices. More LE had, but did not use corded earpieces than any other device; fingerprint scanners and license plate readers (LPRs) were close seconds.
- While more than half of the LE respondents used corded mics, only a quarter of them found them the most useful in their day-to-day work.
- Fewer LE respondents used work-issued smartphones (60 %) than personal smartphones (80 %), but this was swapped in the data on perceived usefulness. 80 % of LE who used work-

issued smartphones thought they were most useful in their day-to-day work, compared to 65 % for personal smartphones.
- For LE-specific devices, just under 40 % of LE had body cameras, with 60 % of them finding bodycams useful in their day-to-day work. Very few of the 20 % who used fingerprint scanners found them useful in their day-to-day work; likewise for the 15 % of LE who used LPRs.
- Fewer than 1 in 10 LE had flip phones; fewer than 1 in 20 had a pager. Interview data shows that pagers are being replaced by cell phones.
- Top problems LE experienced with their devices were price, coverage and connectivity, reliability, and usability. Login issues and battery life were also problems LE had with some devices.

4.5.2. Technology Use for Day-to-day Work

The list below includes the devices presented in the LE survey. Similar devices are grouped into three categories for the purposes of displaying results (listed alphabetically within groups); devices were neither grouped in the survey nor analyses. In addition to devices included across the disciplines, four devices specific to LE were included in the survey: body camera, dash camera, fingerprint scanner, and LPR.

Devices listed for LE included:

- Earpieces (corded earpiece, personal wireless earpiece, work-issued wireless earpiece), mics (corded mic, wireless mic), and radios (in-vehicle radio, portable radio)
- Desktop computer, laptop, MDT/MDC, and tablet
- Flip phone, pager, personal smartphone, and work-issued smartphone
- Body camera, dash camera, fingerprint scanner, LPR

Results for each device are displayed and interpreted below. Frequency of use percentages for each device are listed in Appendix E.

Participants were also given a final open-ended text box to capture any other devices participants use in their day-to-day work. In the LE survey, 52 LE respondents (2.48 %) provided open-ended responses. Notable findings from the open-ended questions included:

- Explanation that frontline officers use many of the devices listed in the day-to-day devices section, but chiefs or those who work in the office do not
- Listing hardware not included in the survey including both common technology (e.g., GPS, Bluetooth, audio recording, cameras) and specialized equipment used in incident response
- Combination of multiple devices or using a single device to serve multiple purposes; for example, work-issued smartphones with body camera technology was mentioned
- Description that many participants supplement their work equipment with technology they purchase themselves, especially personal smartphones.
- Use of technology to communicate using a variety of devices and specialty hardware

Other open-ended survey responses are presented throughout this section where appropriate.

For similarities and differences between device usage for LE compared to COMMS, FF, and EMS, see Sec 4.6.

Summary of LE Technology Use

Fig. 44 shows the frequency of use for each device for LE.

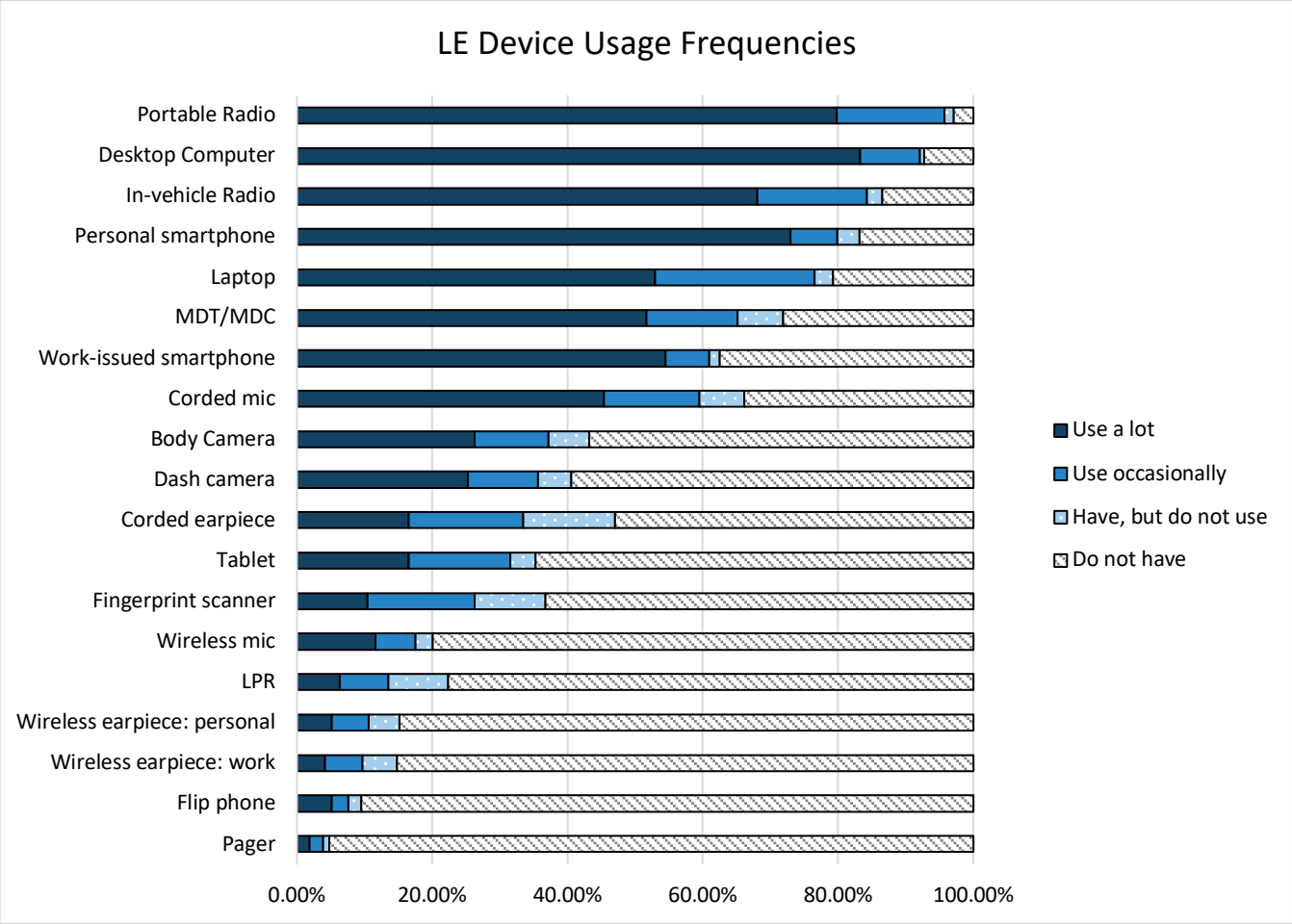

Fig. 44 LE Device Usage Frequencies

Portable radios, desktop computers, and in-vehicle radios were used most frequently. Although personal smartphones were also used frequently, many LE survey participants also had work-issued smartphones. Over half of the participants also used laptops, MDTs, and corded mics. Less than half had or used tablets, wireless earpieces and mics, and LE-specific technology such as body cameras, dash cameras, fingerprint scanners, and LPRs. While those that had body and dash cameras tended to use these devices frequently, use was more occasional with fingerprint scanners and LPRs.

Earpieces, Mics, and Radios

Fig. 45 displays earpiece, mic, and radio usage frequencies.

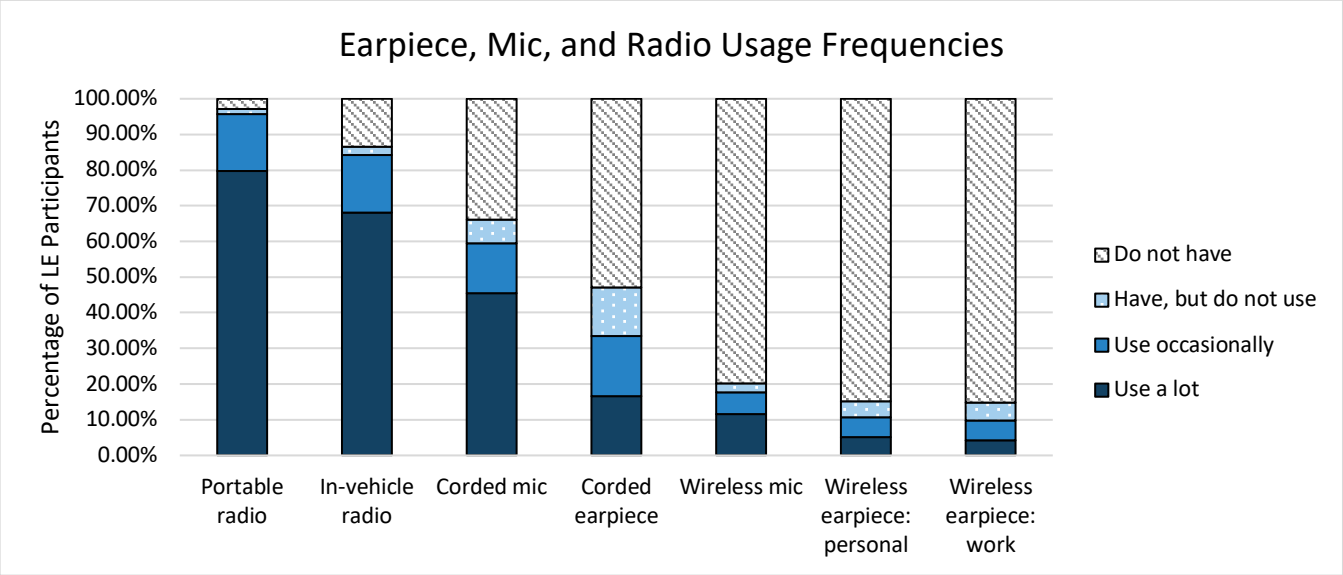

Fig. 45 LE Earpiece, Mic, and Radio Usage Frequencies

Radio use was prevalent for LE survey participants. Nearly 80 % of LE survey respondents used their portable radios “a lot” and nearly 70 % used their in-vehicle radios “a lot.” LE survey respondents also had high rates of having these devices; less than 3 % indicated they did not have a portable radio, and less than 14 % did not have an in-vehicle radio. The reliance on radios was also discussed in the interviews.

> I mean, the radio is extremely important. It is our lifeline. When we need it, it doesn't always work. It works most of the time. I mean, a high percentage. (INT-LE-S-027)

> [S3] Cell phone or radio. The county is with radio. [County redacted] we can communicate with them through our radio. The jail we can through our radio. We do have frequency on there for it’s called [Organization redacted] which is other state agencies that we can speak with but most of the time we don’t need to speak with anybody else out of [county redacted] major county. (INT-LE-R-045)

> The majority of the time it was all through, you know, radio. You would get dispatched via radio, you would communicate via radio. Supervisors would contact you. You know I think more recently text messages and emails are kind of becoming the norm but I think for most patrol officers radio is their main line of communication. (INT-LE-U-055)

> Our radios now and it wasn’t always like this but our current radio capabilities allow us multiple channels for our own department’s use and then access to [Name redacted] Police Department’s zone one, zone five which are the bordering beats or zones for [City redacted] PD as well as mutual aid channels that are used anytime that we have a large scale incident. Incident could be a special event or an actual response. (INT-LE-U-049)

Fewer LE survey respondents used mics and earpieces. Nearly 60 % used corded mics “a lot” or “occasionally”, and only a third of LE survey participants used their corded earpieces “a lot” or

"occasionally". However, it is also noteworthy that nearly as many LE participants used their corded earpieces "a lot" as "occasionally", and 13.52 % had corded earpieces, but did not use them. A majority of the LE survey participants did not have other types of wireless audio communication technology such as mics or earpieces (both work and personal).

Desktop Computers, Laptops, MDT/MDCs, and Tablets

Fig. 46 displays LE participants' usage rates for desktop computers, laptops, MDTs, and tablets.

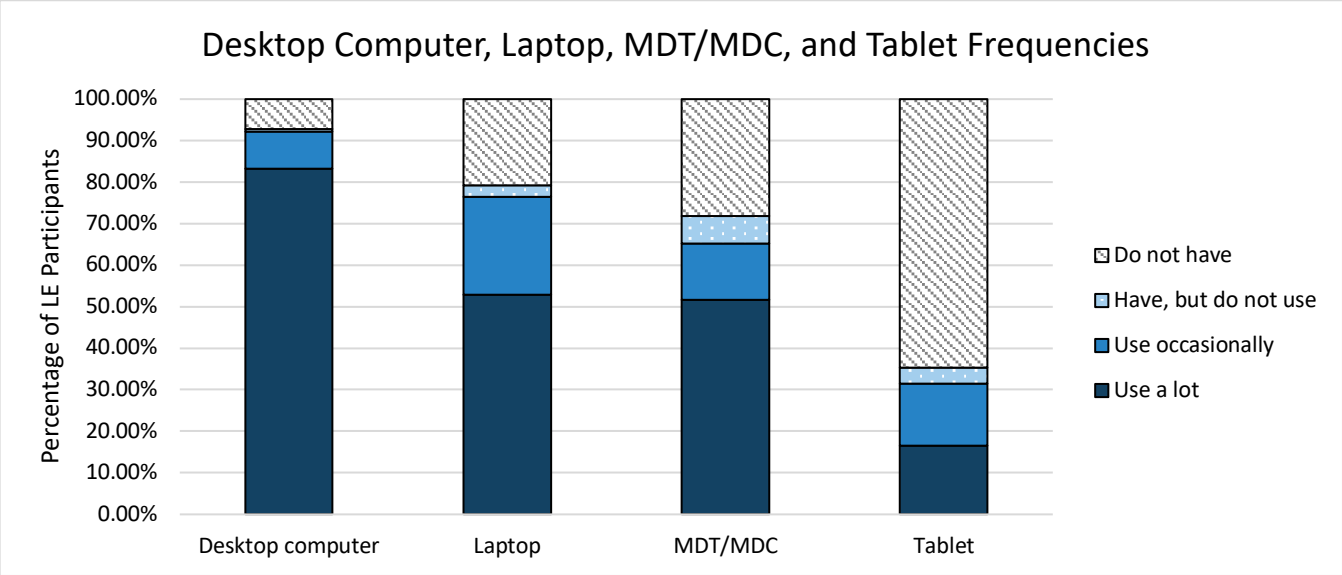

Fig. 46 LE Desktop Computer, Laptop, MDT/MDC, and Tablet Usage Frequencies

Desktop computers were also prevalent among LE survey respondents. Only 7.22 % did not have a desktop computer, and of those that did have one, over 80 % reported that they used them "a lot." In the interviews, computers were often mentioned as useful for LE responders' day-to-day work.

> The computer has become very indispensable between CAD being right there, all the involvement, all the just people searches you can do, location searches you can do, report writing. If it weren't for the computer, it's either write it with hand or go back to the substation every time and write it there. And that's a time killer. That's a resource killer. And so that is incredibly important. I mean, there's a lot of tools that we have that we can't get rid of, mostly on our build. But as far as communication goes, yeah, the radio and the computer. (INT-LE-U-004)

> Yeah. Yeah. I mean, because the reality is your camera and that sort of stuff, it's all tied-- so your camera is tied into your computer and you can see everything and it tells you if it's on and all that sort of stuff. So obviously, you need to know if your radio is working and all that sort of stuff. If your microphone isn't working, the computer tells you if your microphone's not working. So I mean, the systems are intelligent enough where you can see whether it is operational or not without having to do a bunch of troubleshooting. (INT-LE-S-033)

> ... We began to see the advances in computer technology that has led to everything from mobile alcohol detection to mobile fingerprint and identification, speed enforcement and the advances that have been made there from radar to laser, video surveillance... (INT-LE-U-049)

The ability for computers to house multiple programs and functionalities relevant to LE responders' day-to-day work was mentioned in the interviews. While the survey results showed that desktop computers were often used, laptops and MDTs were used slightly less. Twice as many LE survey participants reported that they did not have a laptop or MDT compared to those that did not have desktop computers. Additionally, usage for laptops was more variable than usage for desktop computers, with a larger proportion indicating they used their laptops "occasionally" compared to the proportion who used their desktop computers "occasionally."

Similar to computers more generally, some participants in the interviews described laptops and MDTs as useful for multiple aspects of their day-to-day work.

> Yeah. He has got his laptop with everything he needs, to mean report writing, everything like that. I mean, for the most part, you are basically a self-contained machine in there. I mean, everything you really do need is accessible on your laptop. (INT-LE-S-061)

> ...But the ability for everybody to have the access to the information they need very quickly. And the MDTs are great for that because you can read our notes as somebody's typing in our dispatch, rather than having to wait for you to file it, so. And they trust us with a radio and a gun, so they might as well trust us with [laughter] (INT-LE-U-040)

However, some responses in both the interviews and survey responses indicated that many of the functionalities of these devices are also available in tablet or portable touchscreen form.

> Our Tablets are the MDT (LE:R:6928)

> [RE: mobility of laptops] ...I used to when I was on patrol. If I had a burglary, I know it's going to be in there for a while, put in a bunch of the information, you have to [inaudible] safe. Get the computer, come back in, "Can we sit down?" Okay, give me all the information. SO yeah. And hopefully more and more if we make that change to more of a tablet style. Hopefully, that will help. (INT-LE-S-015)

> [RE: MDTs] So that's only in the patrol cars, so I don't have one in my car. But like I said, we've got the now busted tablet [laughter] that we can take with us wherever. Yeah. But all the patrol cars have one, and it's very handy. (INT-LE-R-018)

Tablets were used "a lot" or "occasionally" by nearly 30 % of participants. As supported in the quotes above, LE participants were interested in tablets that can perform many of the functions of computers, laptops, and MDTs, but have portability and touch-screen capabilities that make the devices easy to use.

Flip Phones, Pagers, and Smartphones

Flip phone, pager, and smartphone usage frequencies are displayed in Fig. 47

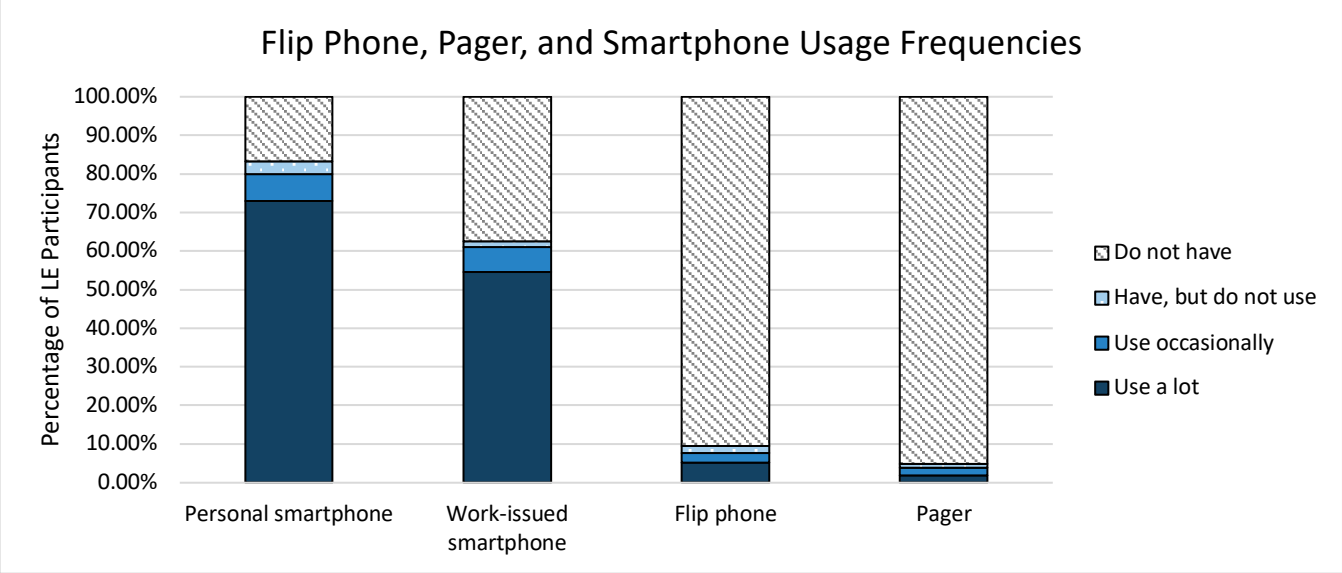

Fig. 47 LE Flip Phone, Pager, and Smartphone Usage Frequencies

The least had and used devices for LE participants were flip phones and pagers, with over 90 % of the LE survey participates indicating they do not have these devices. Responses during the interviews mentioned that pagers had previously been used extensively, but more recently have been replaced by cell phones.

> ... And then you look at as technology increased-- because I came from such a small agency, we didn't keep up quite as quickly with it. But I mean, there was a period of time when we were on call so-- back in the day when everybody had a pager, we all had pagers we had to wear. And then obviously cell phone technology started to increase and wiped all that out. (INT-LE-S-028)

> Yeah. Communications-wise, it is the ability to have the mobile data terminals. The ability to have the [tablet redacted]. The ability to have-- I have a phone now instead of a text pager.... Body cameras, our body cameras don't have to be docked to get the evidence, we can do it off our cellphones, things like that. So as the technology for the world increases, it increases for us. (INT-LE-U-040)

The importance of using phones, especially both personal and work-issued smartphones, was seen in the survey results, as these devices were used by a majority of LE survey participants. The high rates of using work-issued smartphones may stem from work-issued smartphones being used as body cameras, as mentioned in the Phase 2 Volume 2 report [6].

Body Cameras, Dash Cameras, Fingerprint Scanners, and LPRs

Body camera, dash camera, fingerprint scanner, and LPR usage frequencies are displayed in Fig. 48.

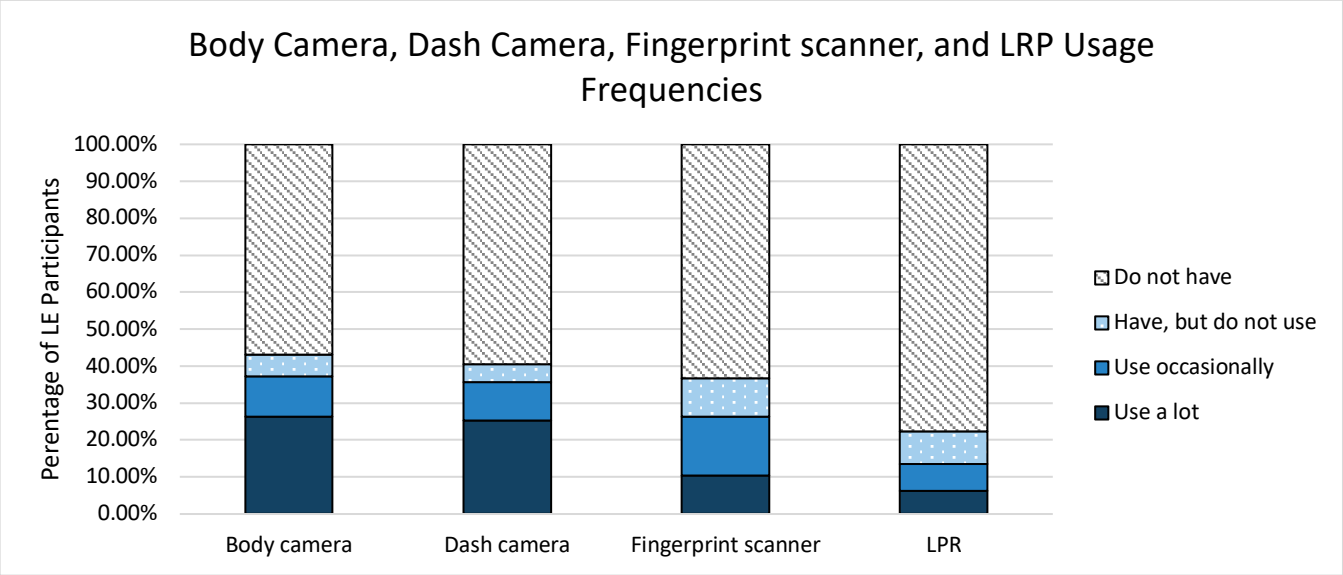

Fig. 48. LE Body Camera, Dash Camera, Fingerprint Scanner, and LPR Usage Frequencies

Less than half of the LE survey participants had or used LE-specific communication technology such as body cameras, dash cameras, fingerprint scanners, and LPRs. Those that had body cameras and dash cameras, however, tended to use them "a lot." The positives of these technologies were discussed in the interviews.

> ...I love having the cameras. I've got almost exactly the same voice recorder from before we had the body-worn cameras, and it's very handy. (INT-LE-R-018)

> Yes. So a nice little advent for the department is every officer is assigned a cell phone now. That was a good addition because it really helped. Because we have the cell phone that's engaged now, we have the body worn cameras. They're linked together now. So you're going to have one with the other to be able to utilize them. (INT-LE-U-014)

These quotes also illustrate that body cameras were often incorporated into the cell phones LE participants used. This was also mentioned in the open-ended responses.

> Body Worn Camera phone device (agency issued). Used a lot." (LE:U:6943)

> 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 demonstrated by the latter quote, although body cameras can be integrated into a smartphone device, sometimes combining these technologies precluded using the work-issued smartphone as a smartphone.

Fingerprint scanners and LPRs were used with lower frequency and greater variability; more LE survey respondents used these devices "occasionally" than "a lot". Interestingly, nearly 10 % of LE survey respondents had fingerprint scanners and LPRs but did not use them. However, in the interviews, these devices were discussed as being very useful in providing LE responders with additional information they otherwise would not be able to easily obtain.

> [RE: mobile fingerprint readers] we got a lot of positive feedback about it. It's a very, very useful tool, and we have a policy that is in place where there are rules about when you can use them, how you can use them and everything, but it's been a very successful technology implementation. (INT-LE-S015)

> The other technology, we have the license plate readers for the vehicle plates. That's huge. A lot of it's for investigations so the LPR will either-- if we're doing an investigation or we're trying to locate a particular vehicle, that's a huge resource, and that's just a wealth of information for the city and for other surrounding agencies so that's huge. The ShotSpotter systems that currently doesn't push out to our phones as an alert that I'm aware of, that would be good having that pushed out. Because right now, you have it on the desktop and if there's an alert, then it will come up and it'll tell you-- the dispatch will let us know often if there's a ShotSpotter activation. (INT-LE-U-014)

Several participants mentioned these devices in the open-end survey question as well. Open-ended responses suggest that these devices may be used with lower frequencies because only certain roles within LE use these devices for incident response.

> Our agency has many of the items listed above, due to my position I do not use them personally (LPR, dash camera, etc). (LE:S:4069)

> As the Chief of Police I do not use some of the technology listed in my daily job. Our agency does have some of the technology in our patrol cars such as MDT's and dash cameras. I noted that we have them but that I do not personally use them. (LE:S:4909)

> Fingerprint scanner is owned by and located at the Sheriffs' Office. Use is as needed which is not often. (LE:R:6486)

Thus, while these devices are used and available within the department, they are not personally allocated to each LE responder.

4.5.3. Day-to-day Device Rankings

LE respondents ranked their top five most useful devices based on devices they currently have (see Appendix B and Appendix C for the methodology and question stems for rankings items). The percentage of LE survey participants who selected each device in their top five rankings are displayed in Fig. 49. Rankings for each device can be found in Appendix E.

Portable radios were included in the top five list of nearly 90 % of LE survey participants. This supports findings from the interviews that emphasized radios as important. As one LE participant states, "The radio is extremely important. It is our lifeline..." (INT-LE-R-018). LE survey participants also ranked

work-issued smartphones higher than personal smartphones, though both were ranked in the top five by over 65 % of LE survey participants. Desktop computers, in-vehicle radios, and MDTs were all used by over 70 % of LE survey participants. Of LE-specific devices, body cameras were ranked most frequently, with 60 % of LE respondents including it in their top five most useful devices list. While nearly 50 % ranked laptops in their top five list, fewer than a third of responders ranked the remaining devices in their top five.

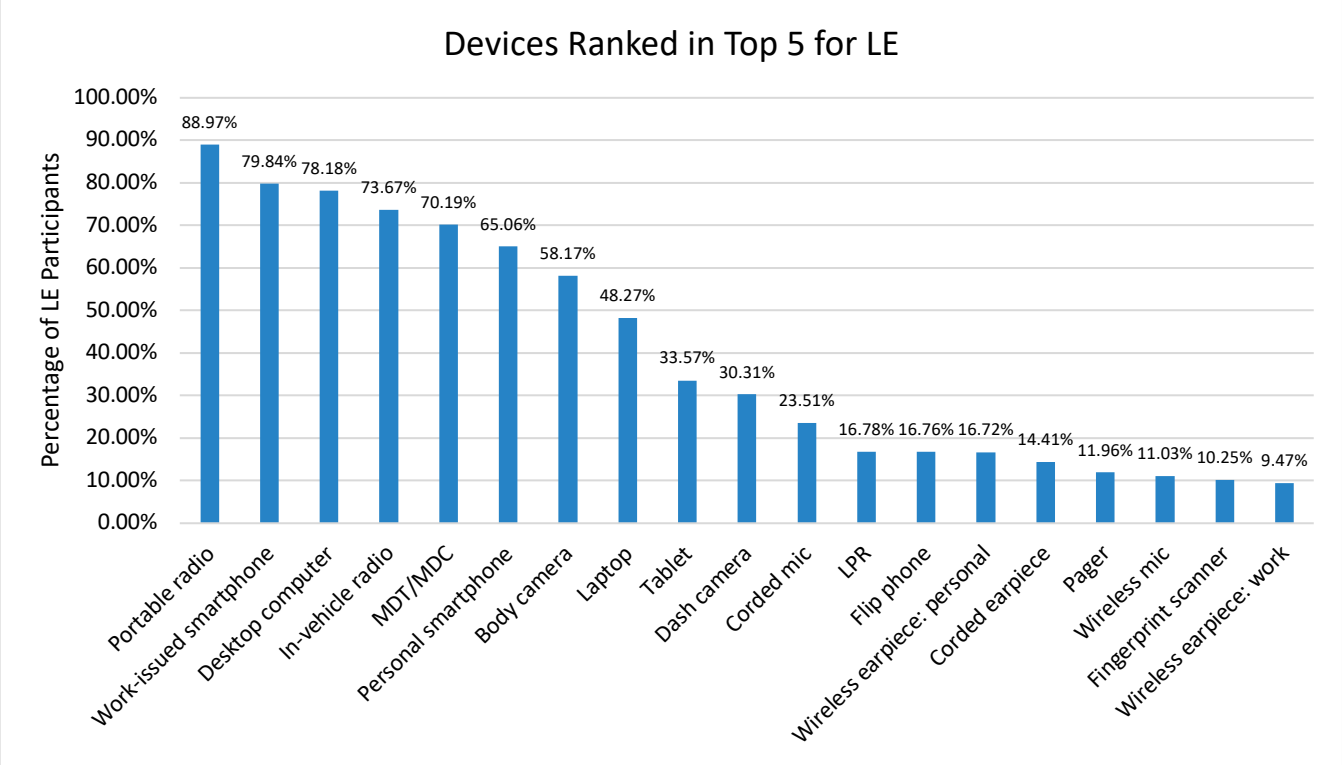

Fig. 49. Devices ranked in top 5 for LE

4.5.4. Device Problems Experienced

This section reports on the problems LE experience with the various communications devices they used, based on their previous survey responses (see Sec. 2). Since the problems experienced are dependent on the device, each device and their corresponding problems are presented together throughout this section. Also discussed for each device are the open-ended responses that gave participants the opportunity to comment with additional problems experienced.

While it is essential to address the problems that first responders “Always” face, it is important to also consider the problems that occur only “Sometimes,” since the uncertainty of failure diminishes the perception of those devices’ reliability and problems experienced only “Sometimes” could have dire consequences. Throughout this section, graphics portray device problems that participants experienced at least “Sometimes” (“Always,” “Most of the time,” and “Sometimes”). *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." The detailed percentages of the LE responses for each device and its associated problems are listed in Appendix C.

LE were asked problems for the devices listed below. Similar devices are grouped into four categories for the purposes of displaying results (listed alphabetically within groups); devices were neither grouped in the survey nor analyses. Since the specific devices presented to participants in this section of the survey was based on a participant's previous survey responses, the number of participants who were asked questions about each device varied. Of the 2 099 LE who participated in the survey, the number of participants who were asked about problems for a specific device as well as the number of participants who selected a response option for each device problem is reported in Appendix C.

- Body camera, fingerprint scanner, and license plate reader
- Earpiece, mic and radio
- Desktop computer, laptop, MDT/MDC, and tablet
- Pager and smartphone

Across the board, "price: too expensive" was the top problem LE "Always" experienced with each of the 12 devices listed above. Problems for three devices — radios, LPRs, and tablets — resulted in the largest margins, with more than twice as many LE responders "Always" experiencing issues with cost than with any other problem with those devices. Open-ended responses for many of these devices emphasized the problem of cost, further explaining some of the specific cost issues faced.

> [RE: smartphones] Subsidy would be nice (could not do this job without a phone) (LE:U:509)
>
> Due to me having to purchase my own earpieces, I typically go with a cheaper option which results in lower quality. Therefore, I have frequently had issues with the earpiece randomly failing mid-shift. (LE:S:410)
>
> [RE: desktop computers] Cost of tech support (LE:R:9243)
>
> Can't afford radios with new technology (LE:S:3176)
>
> [RE: radios] POOR REPEATERS CITY HAS NO MONEY TO FIX (LE:U:3976)
>
> Can't afford to replace old, existing radios. (LE:R:9324)
>
> [RE: radios] features not activated, such as gps, due to cost or non-existing tech upgrades (LE:U:4443)

As these quotes show, cost issues were wide ranging, from the expensive price of the actual devices to the auxiliary costs associated with maintaining their use and infrastructure support. Additionally, expensive costs are not solely the burden of public safety departments. As respondents 509 and 410 above demonstrate, personally owned technologies are widely used for incident response; these personal costs place even more of a burden on first responders. As found in the interview data [1], "lower product/service costs" is a key guideline that should drive technology development for LE responders.

Body Camera, Fingerprint Scanner, and License Plate Reader Problems

Several devices in the problems section were specific to LE based on their day-to-day work and the interview data [12][1][5]. Problems for bodycams, fingerprint scanners, and LPRs were only asked to LE responders [12]. The problems associated with these devices are shown in Table 16. In response to the open-ended questions about additional problems for these devices, 26 LE participants provided feedback about using bodycams (10.83 % of the participants who were asked about bodycam problems), 1 LE participant provided feedback about problems with fingerprint readers (5.00 % of the participants who were asked), and 3 about LPRs (12.00 % of the participants who were asked). Given the limited open-ended data for these devices, the analysis of the open-ended responses only for bodycams is presented in this section.

Table 16. Survey problems lists – LE bodycams, fingerprint scanners, and LPRs

Body camera	Fingerprint scanner	License plate reader
Battery life	Battery life	Ability to accurately read plates
Durability	Capture of fingerprints	Interoperability
Falling off	Glare	Outdated/old
Interoperability	Interoperability	Power source
Outdated/old	Logins/passwords	Price: too expensive
Placement/location on body	Outdated/old	Range
Price: too expensive	Price: too expensive	Receiving results quickly
Size/bulkiness	Quality of fingerprints	
Turning on/off	Receiving fingerprint results quickly	
Using/tagging recorded video data	Sending fingerprints	
Video quality	Size/bulkiness	
Video transfer/storage		

The problems LE experienced with bodycams at least “Sometimes” is shown in Fig. 50. While there were few overall responses to the open-ended question, some recurring issues were noted in the data. The categories of these issues, along with percentages of open-ended responses and exemplar quotes are shown in Table 17.

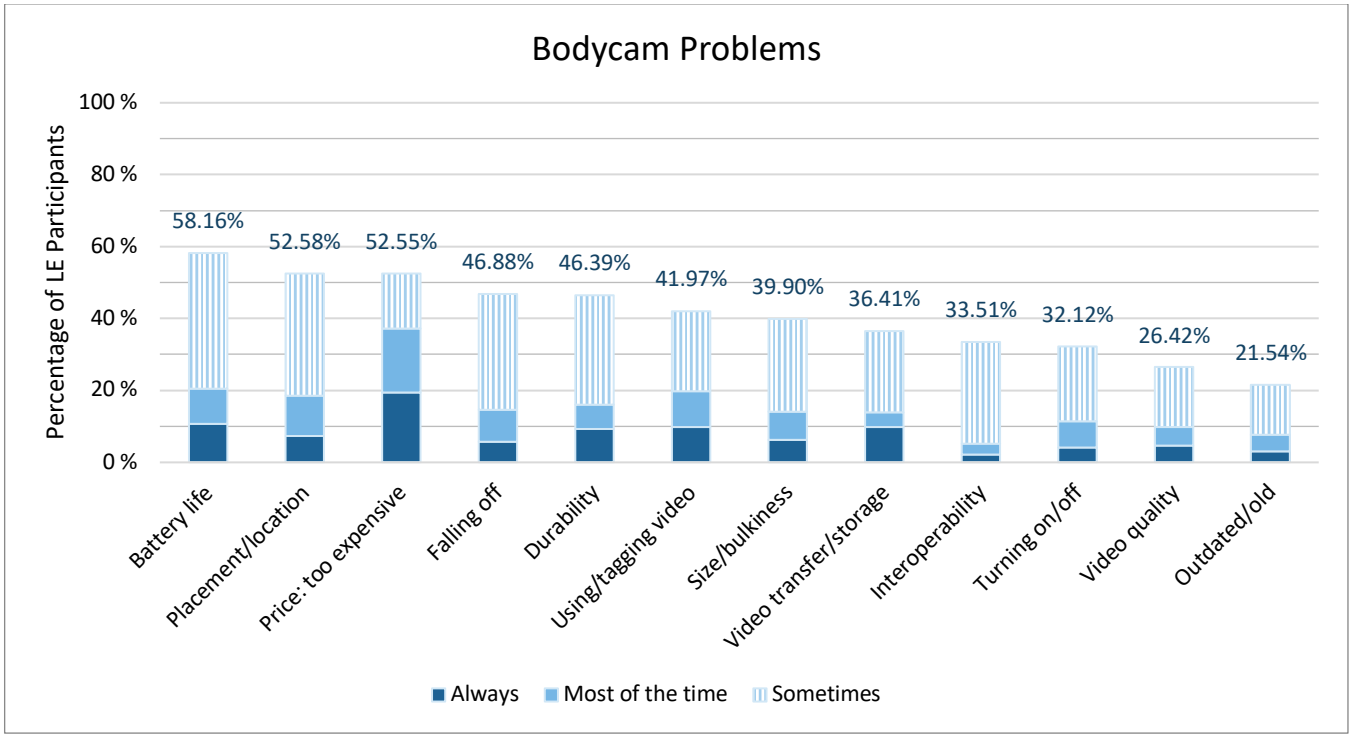

Fig. 50. LE bodycam problems

Table 17. Categories of open-ended responses – LE bodycam problems

Types of bodycam problems	% of responses *(n = 26)*	Exemplar Quotes
Miscellaneous	30.77 %	Police administrators that [know] nothing about law enforcement deciding what an officer did in a split second was right or wrong […] being able to review hours and hours of video waiting for an officer to make a mistake. The public also suffers because Officers now have almost no discretion when dealing with minor offenses. (LE:S:6359)
Download speed	26.92 %	Servers are too slow during the download & sorting processes. (LE:R:861)
Reliability	23.08 %	Equipment failure, software problems (LE:U:3015)
Cost	19.23 %	reminder beep is sometimes an officer safety issue and the funding to update to the cameras that are able to turn the beep off is not available (LE:R:9799)
Usability	19.23 %	Body worn cameras, as stand alone systems, have significantly more opportunity for user error and are often not turned [on] when they should be or not turned off when they need to be. The cameras don't have standardized features yet like most in-car cameras and officers suffer from that. (LE:U:6121)
Storage	11.54 %	massive amounts of digital data created for costly storage. (LE:S:5981)
Durability & Robustness	7.69 %	does not work after getting wet in the rain (LE:R:602)

Types of bodycam problems	% of responses *(n = 26)*	Exemplar Quotes
Battery life	7.69 %	Batteries fail during shift. Cameras no longer supported by manufacturer. So replacement ($$$$$$) is the only option. (LE:S:3257)

Note: An individual response could address problems in multiple categories. Therefore, percentages may not sum to 100 %.

More than half of LE experienced body camera problems with "battery life," "placement," and "price" at least "Sometimes." The placement issues and problems with bodycams "falling off" (46.88 %) mirror interview data that show challenges LE face using the devices.

> [Body cams fall off] all the time especially when you have the seatbelt on. I have my seatbelt on in the police car, and I come out of the car… or every altercation I've ever been in or helped out, it falls, because it's on a magnet and you can't attach it to your uniform because it'll rip your uniform. (INT-LE-U-010)

> [RE: body cam, clip mount and magnet mount] They've both fallen off me at different times. So trying to handcuff people or if you get in a fight with someone, they all fall off." (INT-LE-U-036)

Interview participant 036 above shows that bodycam attachment issues are not due to one specific type of bodycam; the problem is universal.

Analysis of the open-ended survey responses showed strong LE opinions about slow download speeds and the unreliability of bodycams.

> Video downloads, no matter where they occur (i.e. on a station data link, mobile data link) seem to take an inordinate amount of time for larger files compared to other video files (of comparable size) commonly exchanged. (LE:S:8258)

> Turns off after non-use and takes too long to transfer video files. (LE:S:3432)

> With regard to the remote watch, sound has been muted during altercations before and the camera has also been turned off during fights before. (LE:U:8561)

> Tech support and lack of reliability for day to day (LE:R:5075)

Across the board, the need for communication devices to be reliable was a key finding in the study. This is also true of bodycams for LE. As officers use of bodycam technology increases, they need to be able to trust that it will work as intended effectively. Similarly, LE need to be efficient in doing their day-to-day work. Downloading bodycam data should be seamless as to not interfere with their tasks. Bodycams, like other communication devices used in public safety, should efficiently and effectively support first responders in carrying out their work.

Two devices used by LE to retrieve information, fingerprint scanners and LPRs gave LE problems with accuracy and quality of information. As shown in Fig. 51, 25.00 % of LE had problems with the "quality of fingerprints" at least "Sometimes." Nearly 60 % of LE had problems with the "accuracy" of LPRs at least "Sometimes" (59.09 %; see Fig. 52). For fingerprint scanners, LE experienced difficulty with the

primary use of the device more than any other problem by far, with 40.00 % of LE having issues with the “capture of fingerprints.”

Additionally, one of the top problems for both devices was the speed at which results of the information retrieval were received (20.00 % fingerprint scanner; 45.45 % LPR). Further investigation of the problems experienced “Always” and “Most of the time” shows that for fingerprint scanners, “receiving results quickly” was a leading concern for LE (15.00 %), even more than “price” (10.53 %); for LPRs, “receiving results quickly” (18.18 %) was second only to price (33.33 %), and was the only other problem LE “Always” experienced with LPRs.

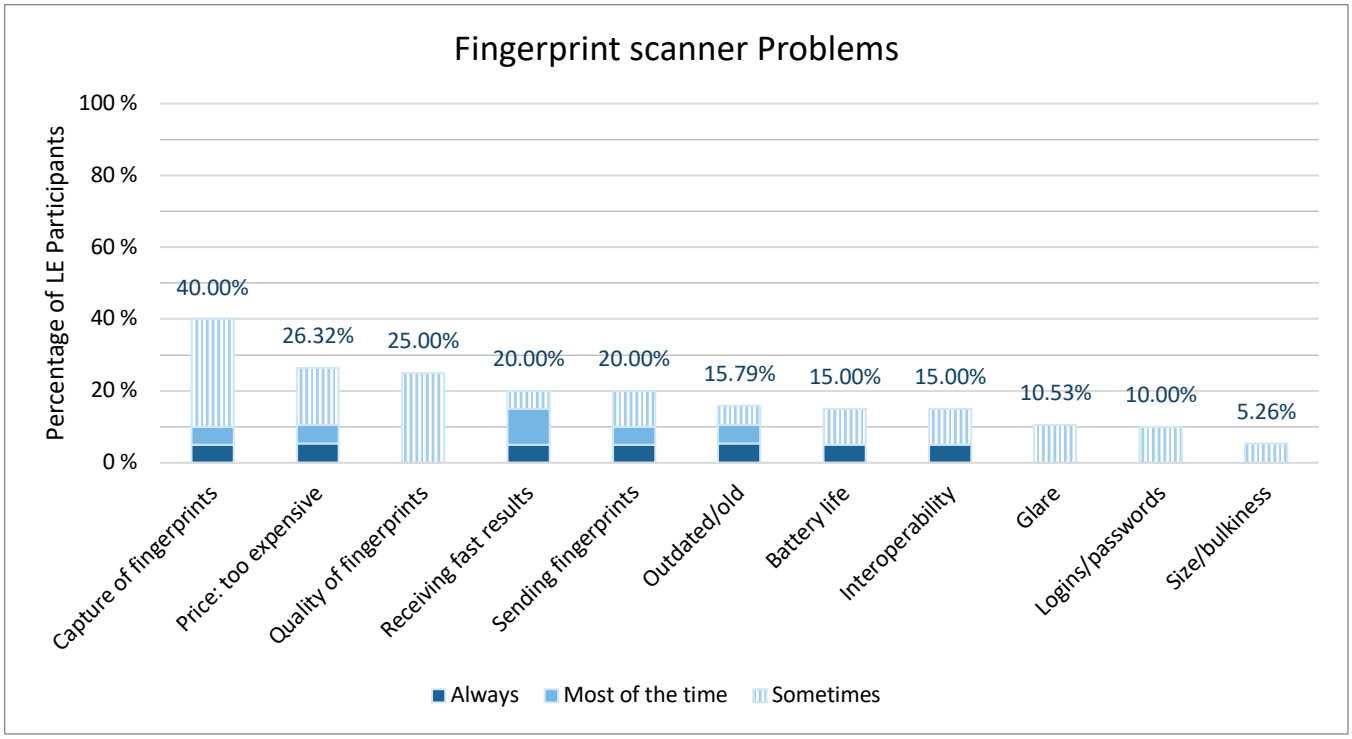

Fig. 51. LE fingerprint scanner problems

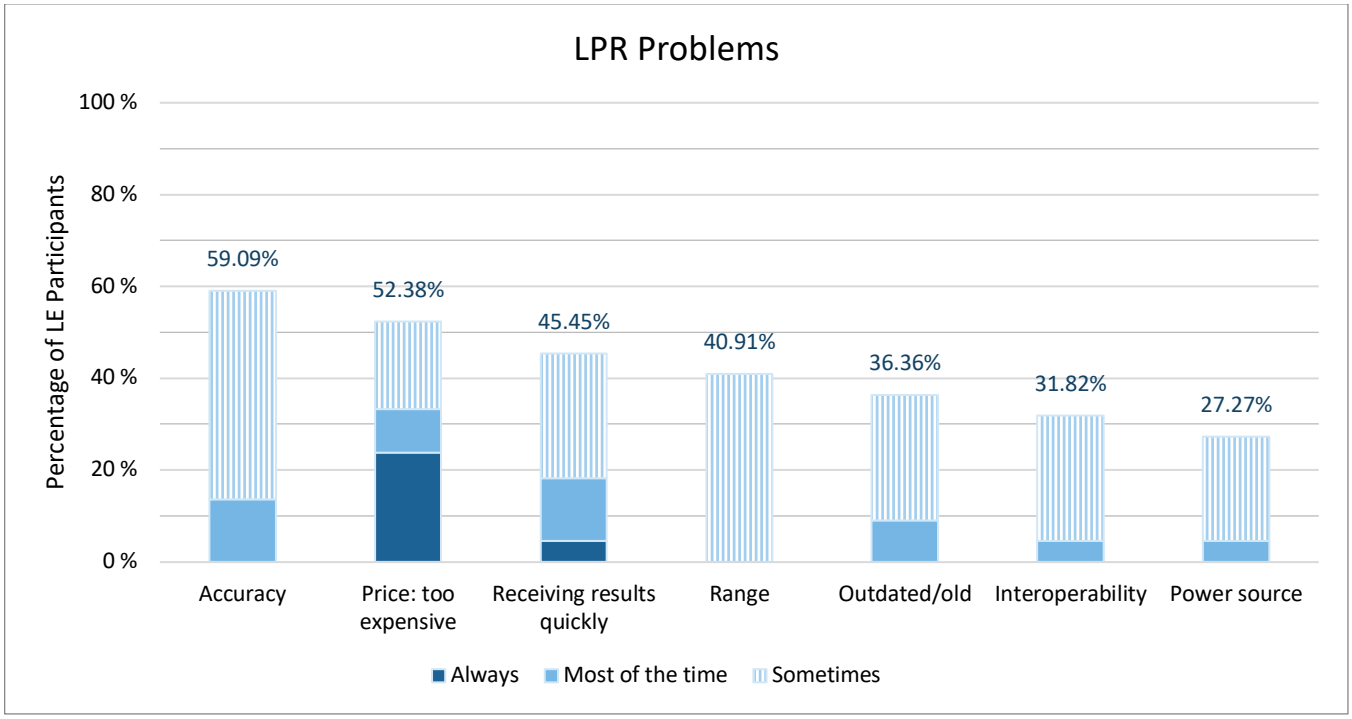

Fig. 52. LE LPR problems

Earpiece, Mic, and Radio Problems

The problems associated with earpieces, mics, and radios for LE are shown in Table 18. Additionally, there were 195 open-ended responses about problems with radios (12.53 % of the respondents who were asked about radio problems) and 12 open-ended responses about problems for both microphones (8.05 % of the respondents who were asked) and earpieces (13.33 % of the respondents who were asked).

Table 18. Survey problems lists – LE earpieces, mics, and radios

Earpiece	Mic	Radio
Audio quality	Audio quality	Audio quality
Battery life	Cord	Battery life
Durability	Durability	Channel switching
Fit/falling out	Falling off	Cord
Outdated/old	Outdated/old	Coverage/dead zones
Price: too expensive	Placement on body	Durability
Volume	Price: too expensive	Interoperability
Wireless (bluetooth pairing, etc.)	Talk button location	Outdated/old
	Talk button size	Price: too expensive
		Radio discipline/etiquette
		Size/bulkiness

Like FF, the quality of audio via earpieces, mics, and radios often was a key problem for LE. Problems with "audio quality" cut across each of these three devices in both the quantitative and qualitative survey data; this intersection is discussed later in this section.

The earpiece problems LE experienced at least "Sometimes" are shown in Fig. 53. "Audio quality," "volume," "price," and "fit" are the top problems LE faced with their earpieces. For mics, what stands out most in the quantitative data is that "old/outdated" is second only to "audio quality" (see Fig. 54). Old technology is something first responders repeatedly voiced concerns about in the interviews, but survey data analyses revealed that LE typically had greater problems with their other devices than the age of the device itself. Upon closer inspection of the earpiece and mic problems, "price" and "old/outdated" were "Always" experienced by more LE respondents than any other problem with those devices.

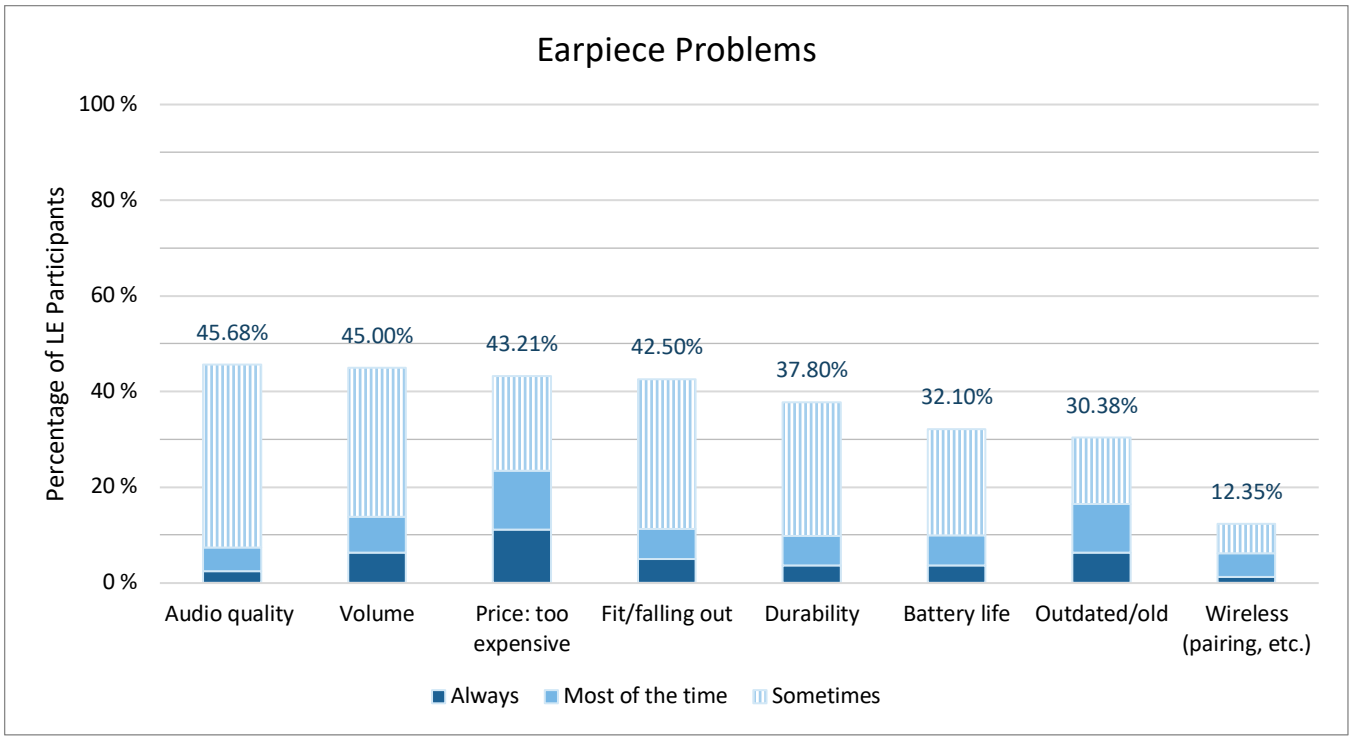

Fig. 53. LE earpiece problems

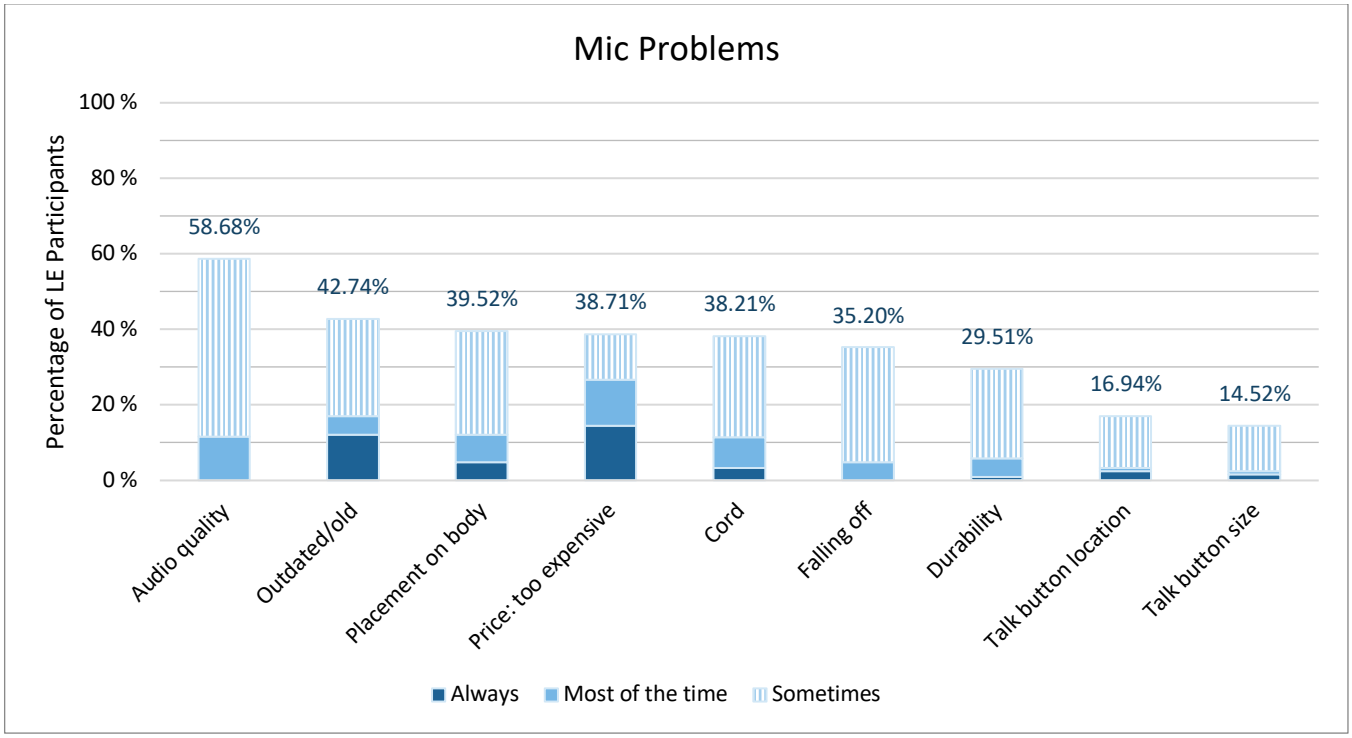

Fig. 54.LE mic problems

As mentioned at the start of this section, there were far fewer data from the open-ended response questions for earpieces and mics than for radios; however, LE participants did voice some concerns in the open-ended responses that overlapped with the radio problem categories discussed next. For instance, durability was an issue expressed for both mics and earpieces, with participants stating that their mic “breaks easily” (LE:U:3347), and that their earpieces have “faulty connections” (LE:S:7965) and a propensity for “failing mid-shift” (LE:S:410).

A few participants also expressed issues with their earpieces being “too loose” (LE:U:6748) or having a tendency to “fall out” (LE:U:3976). This was repeatedly a concern of first responders in the interviews, showing that first responders need earpieces that fit more properly by conforming to their ears.

> The nice thing about this system that I use, I use a small earbud because I want to be able to hear not only this, but whoever's over here. There are specialized ones that you can get that are form-fit to your ear. They make it to where you can hear really well on the radio, but I can't hear anything on this side of my head. So I want to make sure that I can still hear so it can't completely shut off. It can't be like earmuffs are. (INT-LE-S-021)

The radio problems LE experienced at least “Sometimes” are shown in Fig. 55. Several of these radio problems were magnified in the open-ended responses, in which many LE participants reiterated the issues in the problems list. Table 19 shows the different types of open-ended responses for radio problems and the percentage of responses for each type of problem.

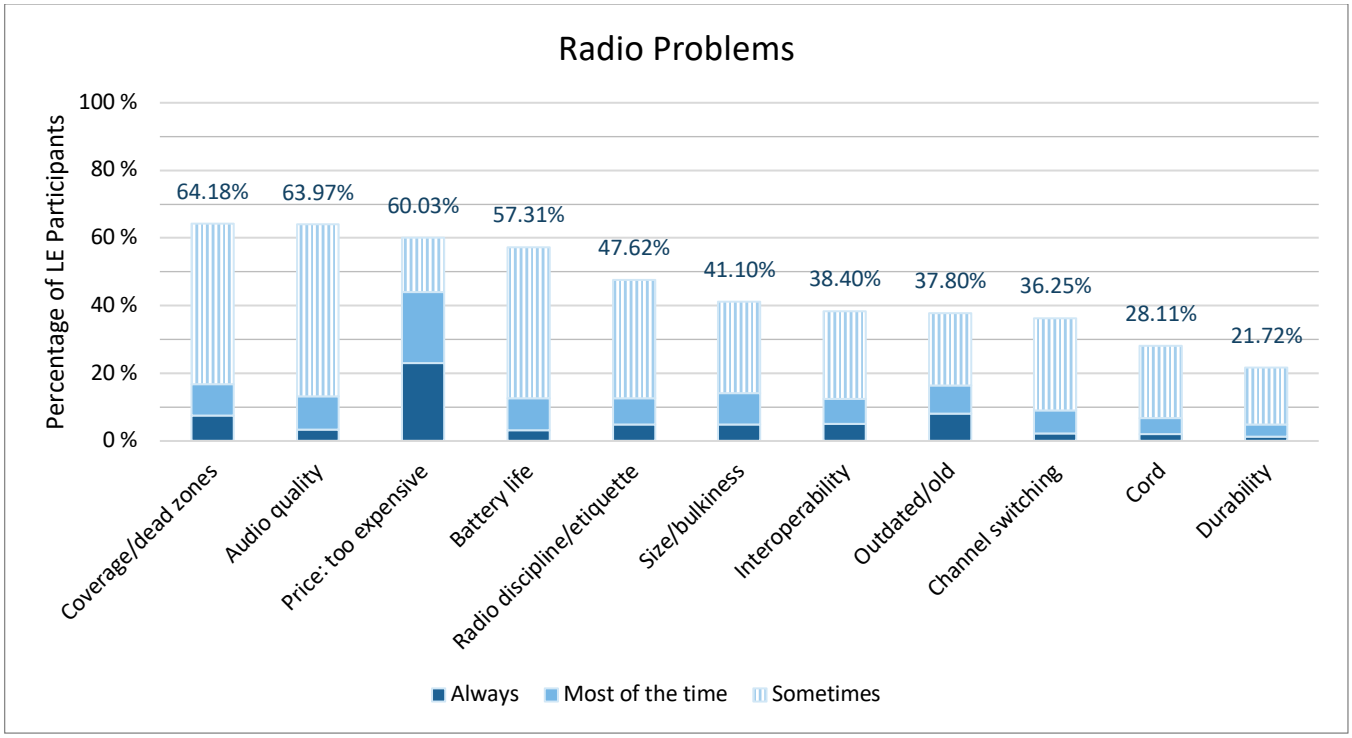

Fig. 55. LE radio problems

Table 19. Categories of open-ended responses – LE radio problems

Types of radio problems	% of responses *(n = 195)*	Exemplar Quotes
Coverage / Dead zones	37.44 %	When we went from wide band to narrow band on vhf radios, the audio got better, but the dead spots grew in quantity. (LE:R:8580)
Miscellaneous	25.13 %	Encryption standards, standardization, coordination. (LE:S:1615)
Audio quality *(incl. static & interference)*	15.38 %	Interference/static Nearby stations with same frequency (LE:S:600)
Reliability and safety	12.82 %	Coverage area, specifically buildings. Cell phones used over the radio. Huge officer safety issues. (LE:R:6439)
Interoperability	12.82 %	[The radio] often does not work inside buildings or residences. Presents a huge officer safety issue. Because it is unreliable, our fire department does not use it. Therefore we have no communication with fire command at a scene. (LE:R:2984)
Other transmission issues *(incl. bonks, traffic, & etiquette)*	8.72 %	Officers with "open mics" are a daily occurrence, tying up the radio or broadcasting unwanted dialogue. (LE:S:307)

Types of radio problems	% of responses *(n = 195)*	Exemplar Quotes
Old	8.72 %	Outdated end user technology as well as 20+ yr old technology makes up the infrastructure Software updates are expensive and constant. Resistance in developing new systems. (LE:R:2011)
Cost	7.69 %	The inability to keep up with radio technology because of the cost due to the financial situation of our village to provide an adequate budget to update our portables and squad car radios. (LE:S:8148)
Battery	7.18 %	Change out of batteries can be difficult in cold weather. Usually have to expose bare hands to elements to accomplish task. (LE:U:1479)
Channels and programming	6.67 %	Too many units needing to use the same channel at one time for separate incidents where dispatch (we have a consolidated dispatch center which services all first responders) has little capability to separate traffic to alternate channels. (LE:R:6486)
Usability and Size	5.13 %	Troubles due to not fully understanding all the features such as getting stuck in scanning mode or having the channel lock engaged and not being able to switch channels. Also trouble with accidentally flipping to a different channel during foot chases for example. (LE:R:7128)
Mic-related	4.10 %	Water / element damage, corrosion of contact points for shoulder mic extension. (LE:S:7292)
Robustness / Durability	3.59 %	long antenna bulky, has gotten snagged, broke off an antenna in the patrol car door recently (LE:S:178)

Note: An individual response could address problems in multiple categories. Therefore, percentages may not sum to 100 %.

Survey data show that LE experienced radio problems in three key areas along with "audio quality." Issues with "coverage," "price," and "battery life" were experienced by more than half of LE. LE expressed their concerns about the three main radio problems in both the open-ended survey responses and the interviews, often stating more than one of these issues in their responses.

> Radio upgrades and maintenance is expensive. Sometimes issues with reception, and being able to transmit both inside and outside of large thick buildings. Batteries don't always hold enough charge especially as batteries age. (LE:S:9232)

> Not being able to use encrypted channel(s) due to cost directly to agency. Not being able to communicate w/ other agencies, which then causes Officers to have to use their personally owned & paid for cell phones for direct communication, using apps such as [vendor redacted], which amounts to costs for the Officer(s) that are never reimbursed or paid for by agencies. (LE:S:2927)

> Due to our rural and remote location we are forced to use mobile repeaters, and they are less than reliable. Also, due to the restrictions of narrow-band radios and the low power output of

> the ones our agency can afford, actually reaching our dispatch center (which is several miles away) is hit-and-miss at best. There are higher-powered radios available, we just cannot afford them, and it seems that when the Federal government mandated the switch to narrow-band transceivers, it exacerbated an already bad situation for small and rural agencies like ours. (LE:R:8193)

> We get into terrain issues with the mountains and no matter how much we use to try to fill in our gaps, we're not going to put a 750,000-dollar tower to fill in one canyon. But it's important for us to talk in that canyon… (INT-LE-U-020)

> Coverage indoors can be an issue in larger multi-story buildings or malls. Newer construction material can hamper reception in these areas as well. (LE:U:469)

> In the 90's, we had Huge radios, but could speak pack-to-pack for miles easily. Now, we have smaller digital radios with tons of features we don't use, that can barely reach across town. (LE:U:5620)

> You go into a low spot then you lose [radio coverage]. If we go south and we go east, we've got a straight shot, no hills, no bumps, or anything, you could go miles and miles and miles and still listen to the radio. You go two blocks in our city north, and you hit on the other side of the hill, and you lose transmissions. So the more towers we can get, the better. The more signal that we can get out, the better. (INT-LE-S-021)

> Our portable radios will not get out on most every call we answer. I've told administration many times this will get an officer hurt or killed one day. We are told we do not have the money to update to radios that work. (LE:R:7589)

As the response above alludes to, unreliable coverage during incident response is a major concern for officers regarding their safety. Safety is the driving motivation of many of the issues stated in the open-ended responses.

> There are huge areas of zero coverage (dead zones). Literally (today), the radio in my patrol vehicle does not work. There are not enough repeaters or antennas in the area. This is a huge officer safety issue. (LE:R:4768)

> Dead Zones everywhere!! Especially in the police station or the hospitals. Very Dangerous! (LE:U:1037)

As the LE response above demonstrates, many of the open-ended responses related to coverage specifically expressed issues with reception indoors (26.03 % of the coverage-related responses). It is vital that first responders are able to perform their day-to-day tasks effectively, regardless of environment, without having to worry about the potential safety issues resulting from difficulties using their communication devices.

It is interesting to note that although “coverage/dead zones” was in the list of problems, the largest percentage of responses to the open-ended question about radio problems were related to issues of coverage and dead zones (37.44 %). Similarly, “interoperability” and “old” were included in the list of

problems, yet much attention was given to these problems in the open-ended responses as well (12.82 % and 8.72 %, respectively). In both the survey and interview data, first responders expressed interoperability issues within and between counties, jurisdictions, and agencies.

> We have no interoperability with most surrounding agencies. (LE:S:4021)
>
> Only interoperable with first responders in my county. No out of county or state interoperability. (LE:R:6434)
>
> not compatible with other neighboring and inter-jurisdiction agencies. (LE:U:4394)
>
> No communication as you move from County to County. Should be one National Band Police Frequency that gives coverage no matter where you are. (LE:U:5385)
>
> It takes longer to get things done just because there's a lag time, obviously. If I'm telling my dispatcher to tell the fire department dispatcher to tell the firefighter or paramedic to do something. (INT-LE-S-034)
>
> I guess the biggest thing, I think, that would help first responders is an easier, more efficient way to communicate with each other when we have to. Like us and the fire department. I mean it's not something we need to do every night, but when we need it, it's important. So the more time we can cut down on that, the better. (INT-LE-S-037)

As with other problems faced by first responders, the public safety community intends for the NPSBN to be a shared network in order to alleviate the concerns over the interoperability of devices; concerns that are the impetus for much of the research performed under the PSCR program [20]. Participants felt that interoperability issues were, in part, related to the use of outdated radio technology.

> Portable [radios] are extremely poor in sending and receiving transmissions. [Our] entire radio system is damaged, outdated and in immediate need of replacement. The portables lack multi frequency ability. It is difficult to monitor and communicate cross agency. (LE:R:3716)
>
> Radio system is past end of life. Needs to be replaced. (LE:U:3012)
>
> System is very old and a lightning strike away from being useless. (LE:R:67)
>
> Cost to repair old radios has increased significantly to the point that we must start replacing the equipment. The cost to repair will continue to increase. Our in-car radios are older and some are having a hard time transmitting on the first or second activation. [Radio redacted] is killing my budget and preventing us from being able to purchase body cameras. (LE:R:6174)

As the responder above noted – there is a relationship between the use of outdated technology and the high costs of new technology. When it comes to replacing outdated radios, cost is often a barrier. Additionally, the use of outdated technology, especially radios, is a serious officer safety issue that needs to be addressed.

As previously highlighted, a major finding in the LE problems data across earpieces, microphones, and radios is audio quality. “Audio quality” was one of the top two problems LE experienced with their

radios and earpieces, and the top problem by a large margin experienced with mics. Participants also expressed strong opinions in the open-ended data about audio quality, with over 15 % of the responses related to audio quality.

> static, garbled or otherwise inaudible (LE:U:5375)

> Radio does not pick up transmissions. I'll hear dispatch say, "10-04" but never heard a unit speak. People's voices sound robotic and it's difficult to distinguish which officer is speaking. (LE:S:1057)

> We have areas in town that the radio transmissions are unreadable. There is a delay/echo when you're in the police station and attempt to transmit on your portable radio. Also, if you are within ten feet of another officer with their radio on, there will be heavy feedback. (LE:R:2973)

Static and radio interference were common problems expressed in the survey data. Another major concern regarding audio was volume control. As one participant said about their mic, the "lack of ability to adjust volume" (LE:U:2889) led to frustrations in LE.

> Volume. In car radio has integrated speaker with in face of radio. Dispatch can come in overly loud, while I am unable to hear some officers. Can not find a good volume setting to hear both equally. Unknown solution to issue. (LE:U:8550)

> Volume modulation would be great. Now you are [either] constantly struggling to hear the radio [or] getting your ears blown out [with the radio] at the same volume level. (LE:S:6946)

> Volume controls do not work. Radio is either off or blasting your ears. Static and feedback are common. (LE:S:307)

The last quote above perfectly sums up the audio quality complaints expressed in the survey data: volume issues, static, and interference are commonly experienced communications issues in LE with radios, microphones, and earpieces. This mirrors the interview data – a major source of frustration, particularly with earpieces, was the unpredictable volume level, where one transmission may sound like a whisper and the next is unbearably loud.

> We're constantly, all day, just twisting our [volume] knob back and forth. So dispatch is loud, [motorcycle cops] are loud, everybody else is quiet, so you're just back and forth, back and forth, until you can get a balance… (INT-LE-S-021)

Given their nature and circumstances of their use, the clarity and accuracy of audio transmissions is critical to the work of first responders, and effective volume moderation is essential for their physical health.

Overall, LE earpiece, mic, and radio problems should not be considered in isolation from one another. Earpiece and mic audio issues are directly related to radio audio quality. Additionally, problems with outdated technology, interoperability, audio quality, coverage, battery life, and cost of radios are intertwined and should be addressed as a whole when designing and developing communications systems for first responders.

Desktop Computers, Laptops, MDT/MDC, and Tablet Problems

The problems associated with desktop computers, laptops, and MDTs for LE are shown in Table 20. In response to the open-ended questions about additional problems for these devices, 65 LE participants provided feedback about using desktop computers (5.18 % of the participants who were asked about desktop problems), 27 about laptops (5.17 % of the participants who were asked), 113 about MDTs (15.29 % of the participants who were asked), and 7 about tablets (7.14 % of the participants who were asked).

Table 20. Survey problems lists – LE desktop computers, laptops, MDT/MDCs, and tablets

Desktop computer	Laptop	MDT/MDC	Tablet
Internet connection	Battery life	CAD (computer- aided dispatch)	Battery life
Interoperability	Durability	Durability	Durability
Logins/passwords	Glare	Glare	Glare
Outdated/old	Internet connection	Interoperability	Internet connection
Price: too expensive	Interoperability	Lack of portability	Interoperability
Software crashes	Logins/passwords	Logins/passwords	Logins/passwords
Software updates/upgrades	Outdated/old	Mapping/navigation	Outdated/old
	Power source/recharging issues	Outdated/old	Price: too expensive
	Price: too expensive	Price: too expensive	Report writing
	Size/bulkiness	Size/bulkiness	Size/bulkiness
	Software crashes	Using while driving	Touchscreen
	Software updates/upgrades		Weight
	Weight		

The problems LE faced at least “Sometimes” with their desktop computers is presented in Fig. 56. An analysis of the open-ended responses resulted in 11 categories, listed in Table 21.

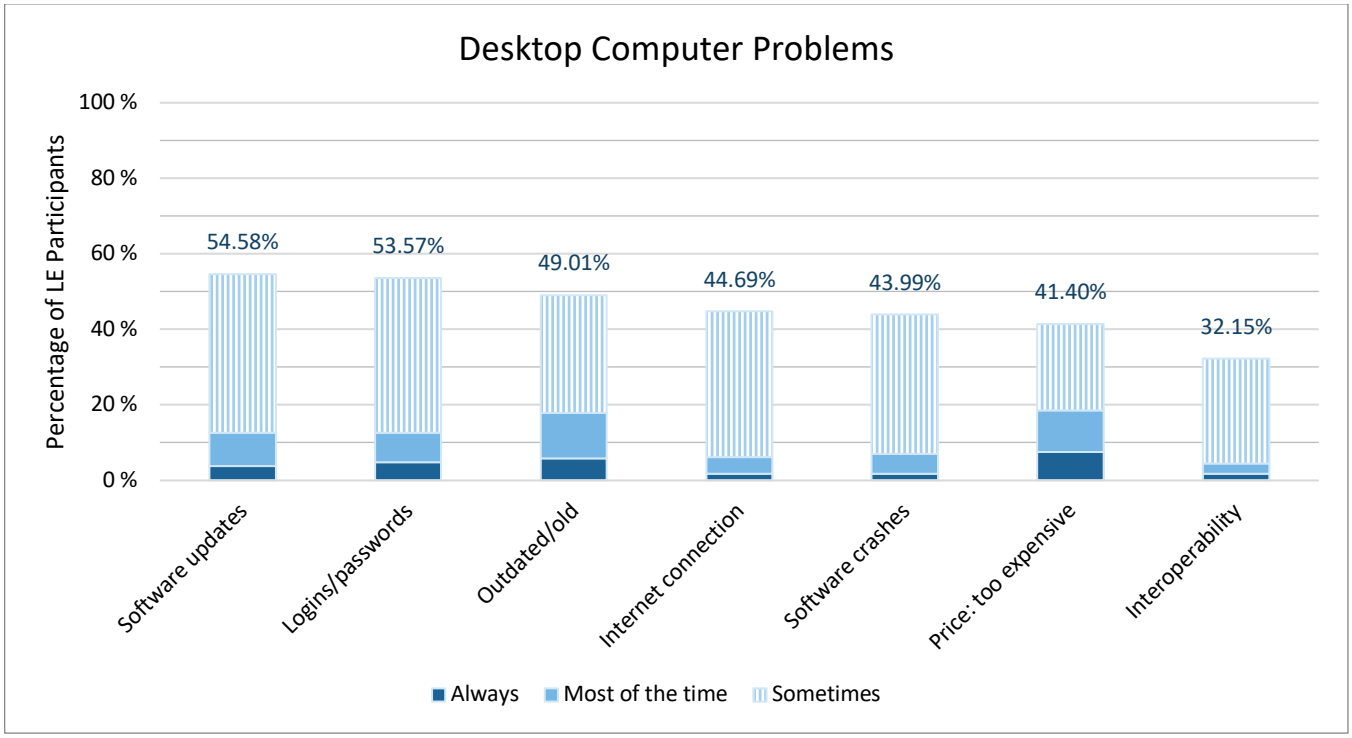

Fig. 56. LE desktop computer problems

Table 21. Categories of open-ended responses – LE desktop computer problems

Types of desktop computer problems	% of responses *(n = 65)*	Exemplar Quotes
Reliability	29.23 %	City doesn't keep up with replacing old worn out desktops and installs updates that crash them because they cannot handle the additional load. (LE:U:6484)
Miscellaneous	23.08 %	Lack of program interoperability (programs do not readily talk to one another) (LE:U:5835) Our computers are so old they are a constant hindrance with regards to my ability to do my job effectively. We do not have HD monitors to view HD security video, we do not have the ability to do required updates, memory and RAM are insufficient, network connectivity is very slow. (LE:U:6505)
Slow	23.08 %	System can be very slow if multiple users are logged in (LE:S:6067)
Connectivity	21.54 %	The internet lags at peak hours of the day on a daily basis, affecting RMS and Mobile CAD. (LE:U:8463)
Old	16.92 %	We have outdated programs and are having to use old programs for work, resulting in extra time and work. (LE:R:5820)

Types of desktop computer problems	% of responses *(n = 65)*	Exemplar Quotes
Access/permissions	13.85 %	lack of access due to multiple people working at the same time (LE:U:4832) unable to download useful apps/ programs due to [IT department] restrictions (ridiculous) (LE:S:577)
Storage	10.77 %	Storage is minimal on the desktop and we do not have a server setup at this time (LE:R:9799)
Passwords/logging in	9.23 %	The CAC reader cables disconnect randomly. […] All three computers I use are older than my children and get bogged down by their lack of RAM and connectivity alike. […] I have to enter my CAC PIN about 50 times per day between the three systems. (LE:U:6184)
Updates	7.69 %	Internet is often slow cost of replacement is high, given the number of computers Software updates are expensive as well Too many secured accounts that all require different and unique type usernames and passwords. (LE:S:9232)
Security *(e.g., viruses)*	6.15 %	Constant attempts at intrusion. (LE:S:3139)
Cost	4.62 %	Speed is expensive (LE:R:5358)

Note: An individual response could address problems in multiple categories. Therefore, percentages may not sum to 100 %.

For desktop computers, the top problems were “software updates” and problems with “logins and passwords;” over half of LE experienced these problems at least “Sometimes.” While “price” was at the lower end of desktop problems, it is “Always” a problem for 8 in 10 LE respondents. Respondents reiterated these problems in the open-ended responses but were more adamant about other desktop-related issues – namely, reliability, slow speed, and internet connectivity.

The quantitative responses show 43.99 % of LE respondents at least “Sometime” having an issue with “software crashes” on their desktop computers. Problems with the system crashing was further emphasized in the open-ended data, with 84.21 % of the reliability-related responses focusing on the desktop “freezing” or “crashing.”

> The processing power and storage capacity are fairly low, so large files (video surveillance, phone extractions, etc.) can often bog the system down or crash it. (LE:S:7369)

This response provides additional detail about what causes LE desktops to crash – the nature of their work requires better processors and storage to work effectively. If not causing computers to crash, they slow them down tremendously.

> Software, or the number of applications running, exceeding the computer's available resources (RAM). (LE:S:8370)

> It's too old, doesn't have enough RAM, and the processor is too slow. I prefer to have several different software programs and documents open simultaneously and juggle between them. (LE:U:539)

> Viruses, Slow up-load/ down-load speed (LE:S:7519)

Another cause of slow speeds is poor internet connectivity, especially for uploading and downloading information. Given the nature of their work, and most work in the public safety landscape, a fast and reliable internet connection is vital for first responders. Understandably, LE respondents voiced many concerns over the lack of sufficient connectivity for their desktop computers.

> Sometimes my Outlook inbox won't load messages because it doesn't want to connect. The computers don't run software well, crash often, and won't accept my preferences because I'm not an admin. They also take too long to start up, but not as long as it takes PowerPoint to load. (LE:U:6184)

> Northeastern [state] suffers from providers with outdated infrastructure, single fails several hundreds of miles away can cause us to lose connectivity. (LE:R:5288)

Internet connectivity problems may be caused by lags on the local desktop but may also be attributed to network infrastructure issues as these participants show. Both need to be addressed to have a positive impact on the lives of LE responders.

Likewise, LE often experience spotty connectivity with their laptops; nearly 70 % of LE had “internet connection” problems at least “Sometimes.” 10 % more LE experienced problems with laptop “internet connection” than any other problem with their laptops. While price is the clear top problem that is “Always” an issue, when investigating the problems experienced at least “Sometimes,” “logins,” “software updates,” and “battery life” caused problems for more first responders than “price.”

As indicated to start this section, there were limited data in response to the open-ended question about laptop problems. While categorical analysis was not appropriate for this data size, there was one particular issue that was mentioned in over a quarter of the responses – the unreliability of laptops. LE participants repeatedly noted issues with their laptops “freezing up” or “crashing,” with one response elaborating on the plight experienced, stating, “I would use a laptop constantly if I had one that worked. We have outdated non functioning laptops.” (LE:S:148). The quantitative data show that “software crashes” were experienced by 45.24 % at least “Sometimes;” these qualitative findings provide a voice to those frustrations.

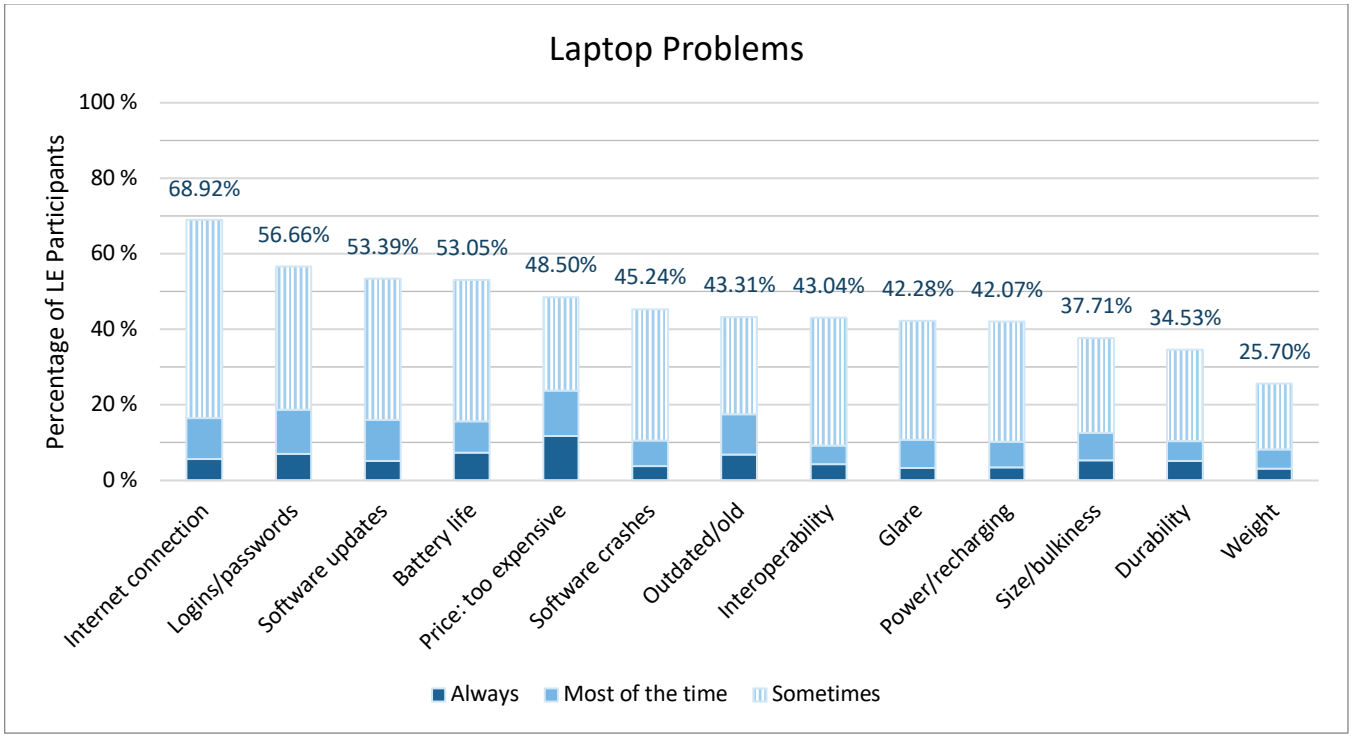

Fig. 57. LE laptop problems

The problems experienced by LE at least "Sometimes" with their MDTs are shown in Fig. 58. The 113 open-ended responses to this question were analyzed, resulting in 12 categories of data. These categories, along with the corresponding percentage of responses and exemplar quotes, are listed in Table 22.

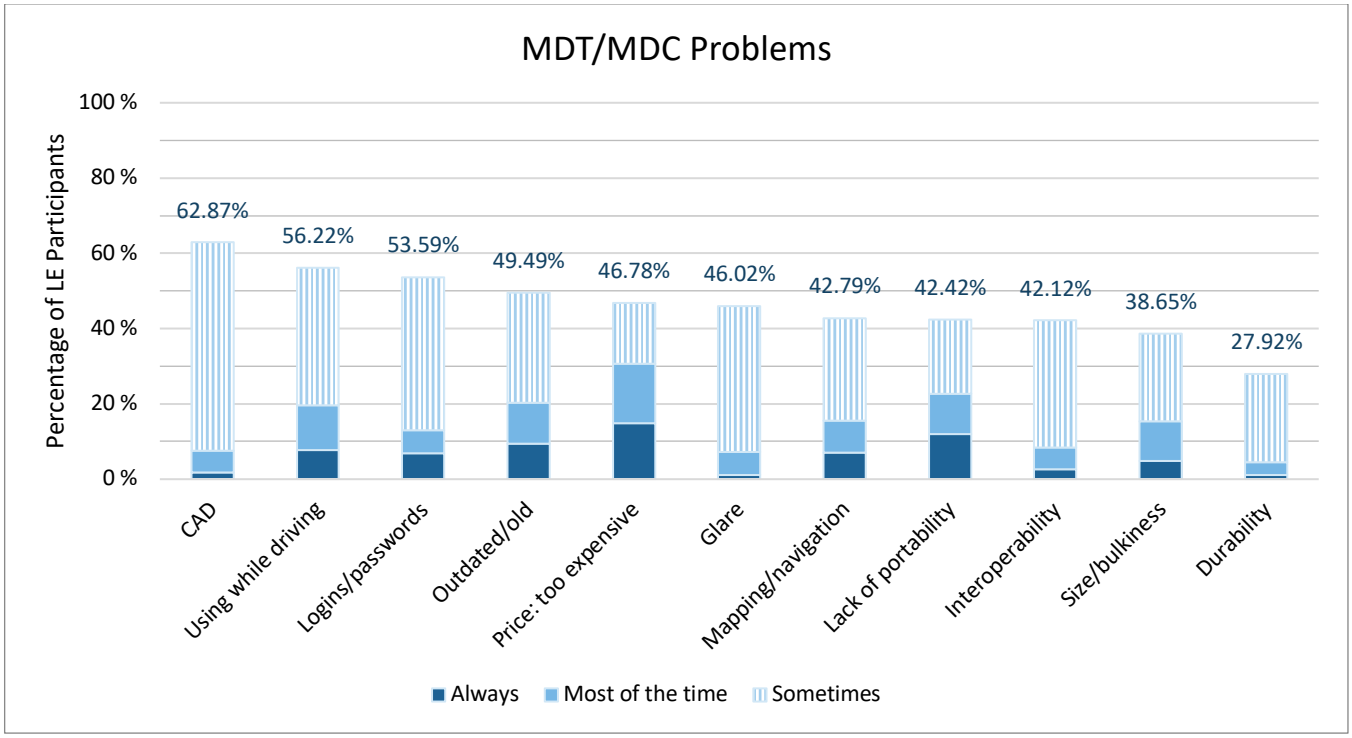

Fig. 58. LE MDT/MDC problems

Table 22. Categories of open-ended responses – LE MDT/MDC problems

Types of MDT/MDC problems	% of responses *(n = 113)*	Exemplar Quotes
Connectivity	47.79 %	Its so slow because our network is from the days of Alexander G. Bell. Pathetic really (LE:U:3107)
Reliability *(e.g., crashes, bugs, glitches)*	23.89 %	software crashes or bugs that force one to reboot the MDC. Out of date software (OS and apps) (LE:U:1169)
Slow	17.70 %	Trying to get logged on first thing so dispatch can see you, and it decides to take its sweet time to update. (LE:S:7317)
Software *(e.g., updates, CAD, mapping)*	17.70 %	Keeping Software updated, constant changes in software governing bodies making mandates that are unfunded or underfunded. Changes that make systems that are functioning obsolete and require replacement and retraining which takes front line Law Enforcement Staff away from working with the public. (LE:R:3868)
Usability *(software & hardware)*	16.81 %	Touchscreen does not react, cannot recalibrate at user level, keyboard does not brighten at night, night mode on screen is not viewable due to lack of contrasting colors (currently red letters on grey background), touch pads does not react, no instant dim switch […] (LE:U:3222) voice recognition would be a nice feature to alleviate the officers from taking their eyes off of the road while driving or while stopped with a violator (LE:S:8148)

Types of MDT/MDC problems	% of responses *(n = 113)*	Exemplar Quotes
Miscellaneous	16.81 %	Our MDC work in conjunction with the radio system and even though we use two batteries we experience problems with them connecting to a tower or having enough power to go on line. Sometimes we have to wait a period of time to charge the back battery because of the draw of the equipment. (LE:S:329) Pure age keeping up with technology. Costs every five years or so are high to outfit the entire department. (LE:R:2358)
Old	13.27 %	Outdated operating system. Overall age of MDT. Wireless connection / air card issues. (LE:S:3282)
Durability & Robustness *(e.g., environment, hardware issues)*	12.39 %	Extreme weather conditions, excessive heat or cold and also connect ability due to geographical limitations (LE:R:4610) Wireless card frequently comes detached. Cord connecting wireless card snags. Mounts are not adjustsble along y-axis. (LE:S:1440)
Interoperability	5.31 %	Our MDT software does not link with CAD, other than to generate an OCA. There is no way to port information over from [state database redacted] to a report, adding several repetitive steps to every call. An activity log, which could be automatically generated by CAD, also doesn't port over so officers have to manually enter information on every single thing they do even though CAD already has a record of it. (LE:U:6121)

Note: An individual response could address problems in multiple categories. Therefore, percentages may not sum to 100 %.

The greatest problem experienced in LE with their MDTs was "CAD," with 62.87 % having problems at least "Sometimes." Further, more than half of LE sometimes have "CAD" problems and sometimes do not, which could lead to considerable frustration for first responders using MDTs (55.41 %). "Using while driving" is also a top problem with MDTs, mirroring the interview findings where some LE responders spoke about the potential benefits of using hands-free controls or windshield HUDs.

> You always have the issue of officers looking at the computer when they should be looking out the window. So a way to have a more heads-up display would be great. (INT-LE-S-015)
>
> "Have a voice activated, 'Hey, run this plate,' where you don't have to even look at it… I mean, you would think that just having the-- telling the plate and it being run would probably save-- I mean, I know of supervisors and people that have gotten into car accidents because they're [looking down]." (INT-LE-U-024)
>
> One of the things that really bothers me is we have officers staring. You're in a car and a call comes in and I'm having to look down there… MDT is right here, and I end up getting a lot of cars dented because people are looking at [their MDT] to look at the call, and they kind of don't realize the traffic has stopped. A lot of updates come up on here… There's got to be a way to put that information up where I can look through it… something that puts the information up there, so that I'm not looking down there. That always bugs me… from a safety standpoint, I really don't like people looking down. So the heads up would be fantastic… fighter jets I know

> they have a heads-up display that they can put everything up there. It would be phenomenal to be able to do that... We've never had a bad accident because of it, but I have a lot of rear end accidents that I think could be avoided. (INT-LE-U-029)

"Login" issues were also experienced by more than half of LE at least "Sometimes" with their MDTs (53.59 %). The issues LE experience with logins and passwords provide context to their strong desire for single sign-on for their devices [6]. In looking more closely at the problems "Always" experienced by LE, "price" and "lack of portability" top the list.

The open-ended responses revealed two key issues with MDTs separate from the items included in the problems list for this question. First, problems with network connectivity were mentioned in nearly half of the open-ended responses.

> loss of signal multiple times during the shift (LE:U:6441)
>
> loss of coverage some parts of town do not have service so unit will not work. (LE:R:2907)
>
> constantly losing connection/ service (LE:S:2745)
>
> It loses it's connection easily. Not always user friendly especially when trying to complete a report or do a search for persons or vehicles. (LE:S:8290)
>
> Connection is a frequent issue. Everything tied into MDT's in today's policing. When network is either down or delayed all statistical productivity is stalled. (LE:S:307)
>
> The internet card for the MDT frequently fails, and when the MDT does not have internet provided to it, the MDT might as well be a brick. (LE:S:410)

As these participants demonstrate, when the internet connection on MDTs is "constantly" being dropped, it has a negative impact on the productivity of LE activities.

The second key issue in the open-ended responses was related to the reliability of the MDTs. Typically, reliability issues are related to a device freezing during use or crashing completely. For LE, reliability also refers to bugs and glitches they experienced when using MDTs.

> locks up sometimes and the mouse cursor goes crazy clicking on various icons (LE:R:9719)
>
> map issues, report writing glitches, compatibility with traffic citations and accidents (LE:S:4738)
>
> software is buggy. Interface with air card is problematic. response times can be slow. (LE:S:3692)
>
> Computer would randomly shut off or lose connectivity (LE:U:8828)
>
> Does not get a signal. Have to shut down and turn on multiple times to work, etc. (LE:S:8387)

Problems LE experienced with reliability and connectivity of their MDTs are intertwined. Intermittent connectivity leads to the perception of unreliable technology. As a previous participant noted, when communication devices fail – when their internet connection fails – they are useless.

LE most experienced issues with “cost,” “internet connectivity,” “battery life,” and “glare” with their tablets, with over 40 % of LE having each of these problems at least “Sometimes” (see Fig. 59). A large number of participants also “Always” had problems with logging into their tablets, their tablet’s “durability,” and their tablets being “outdated.” Analysis of the open-ended responses for tablets is reported in the Phase 2, Volume 2 report [6].

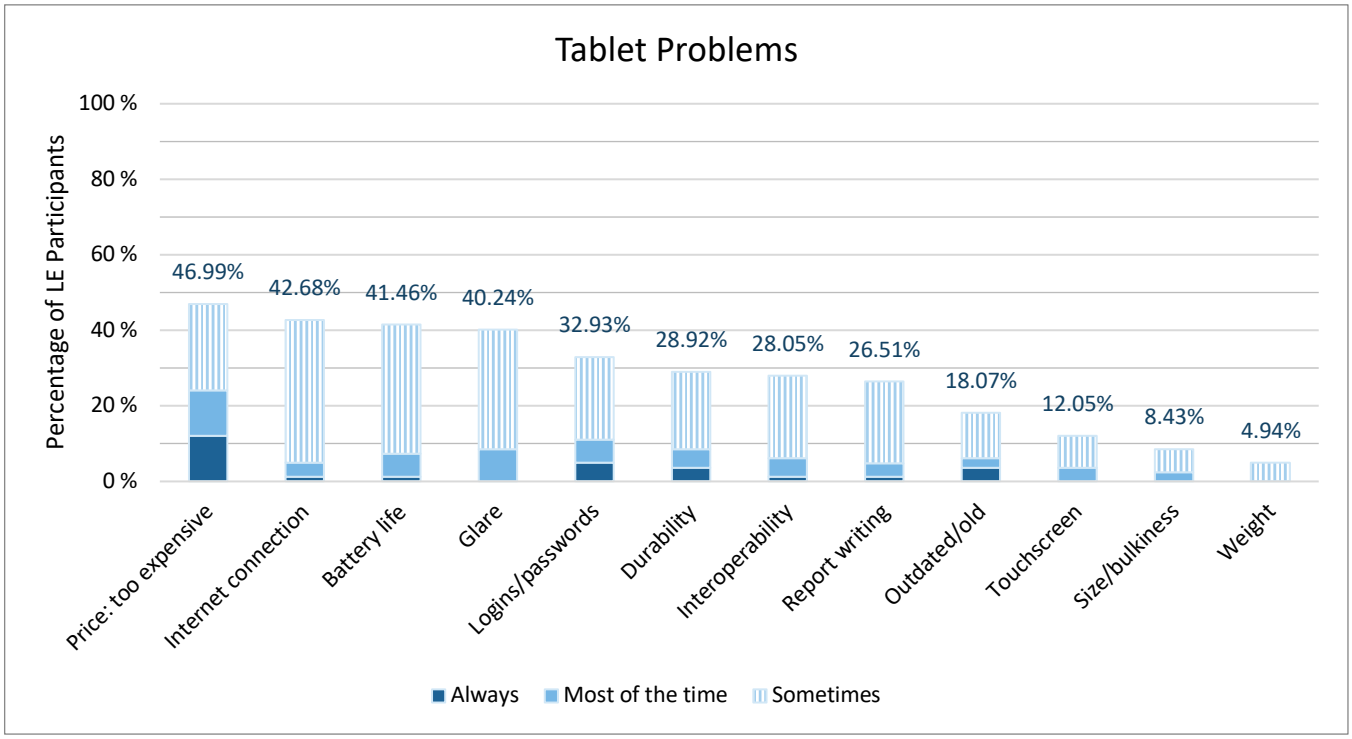

Fig. 59. LE tablet problems

Pager and Smartphone Problems

The problems associated with pagers and smartphones for LE are shown in Table 23. In response to the open-ended questions about additional problems for pagers and smartphones, only 2 LE participants provided feedback about using pagers (28.57 % of the participants who were asked about pager problems) and 82 about smartphones (6.07 % of the participants who were asked).

Table 23. Survey problems lists – LE pagers and smartphones

Pagers	Smartphones
Battery life	Battery life
Durability	Coverage/dead zones
Falling off	Data plans/data limits
Outdated/old	Dropped calls

Pagers	Smartphones
Price: too expensive	Durability
Size/bulkiness	Glare
	Logging in (PINS, passwords, usernames, etc.)
	Outdated/old
	Permission/access to apps
	Policies about usage
	Price: too expensive
	Subpoena possibility for personal smartphone
	Subsidy for personal smartphone (insufficient or no subsidy)

Fewer LE responders overall were asked pager problems than problems for other devices (see Appendix C). Of the people who responded to the questions about pager problems (*n*=4 for each problem), most found "outdated" to be the problem experienced most often, while "durability" was the problem experienced least often. "Price" of pagers was only a problem "Most of the time" or "Always." LE pager problems are displayed in Fig. 60.

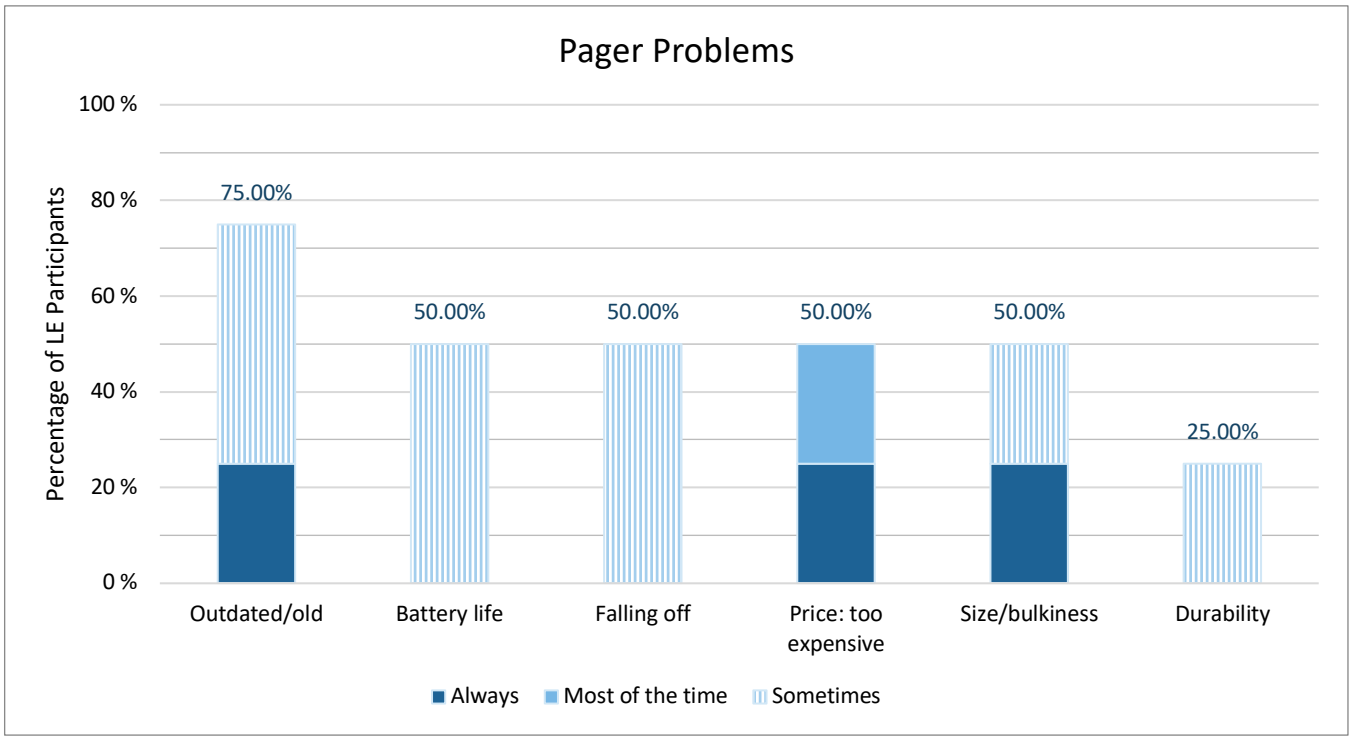

Fig. 60. LE pager problems

Most LE experienced battery, network connectivity, and cost issues with their smartphones (see Fig. 61). Further, the smartphones problems with lack of "personal subsidy" and "price" are related, as due to price many first responders rely on their personal smartphones for their day-to-day work. Of note

here is that the risk of their smartphones being subpoenaed is “Always” a problem for more than 10 % of LE.

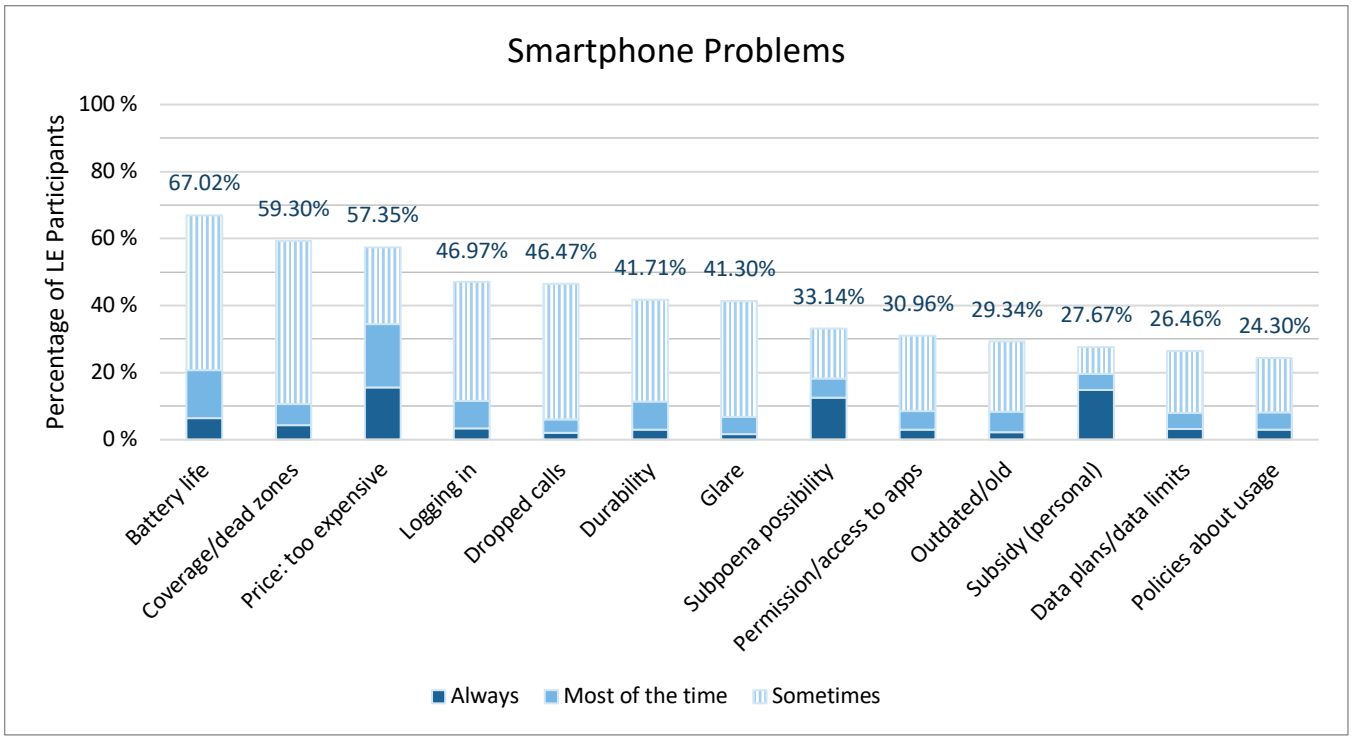

Fig. 61. LE smartphone problems

There were five main categories of problems in response to the open-ended smartphone problem question for LE:

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

The scope of cost-related issues for LE included both financial and personal loss. Financially, LE respondents who used personal smartphones often spoke of issues with “insufficient” (LE:R:3069) to “vastly underfunded” (LE:U:6512) subsidies.

> 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)

The majority of personal phone issues were related to inadequate or non-existent subsidies and the need for work-issued smartphones. A hinderance to their day-to-day work, LE experienced cost burdens for potential loss as well as financial. Especially for LE, a smartphone subpoena is always a possibility given their line of work.

> 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)

These all contribute to LE responders' perception that cost is a major hurdle in the use of smartphone devices.

Hardware issues experienced by LE varied, but many were related to the use of smartphones in a rough environment; responses often mentioned weather, environment, durability, and robustness.

> Poor performance in below freezing cold weather (battery crashing, screen locking up). (LE:R:5774)

This respondent summed up the wide-ranging hardware issues in response to this question. LE feels that making robust and durable smartphones available would have a positive impact on their work and their ability to perform their day-to-day tasks.

4.6. Technology Use and Problems, Across Disciplines

Results for each device, across disciplines, are displayed and interpreted below. Where appropriate, an overview of the data for devices associated only with EMS, FF, and LE is also provided. Note that because a different number of participants in each discipline saw and/or answered each question, the number of responses for each discipline in the results discussed differ. The number of responses can be found in the data tables in Appendix E.

4.6.1. Similarities Across Disciplines

Technology Use

Five devices were presented across all four disciplines' surveys: radios, desktop computers, pagers, personal smartphones, and work-issued smartphones (see Appendix C for a side-by-side list of all devices presented to the four disciplines about technology use). Fig. 62 displays usage frequencies for these devices across all survey participants. Results show that a majority of first responders across disciplines had and used radios, desktop computers, and personal smartphones. Fewer had work-issued smartphones and pagers, but those who had these devices used them frequently.

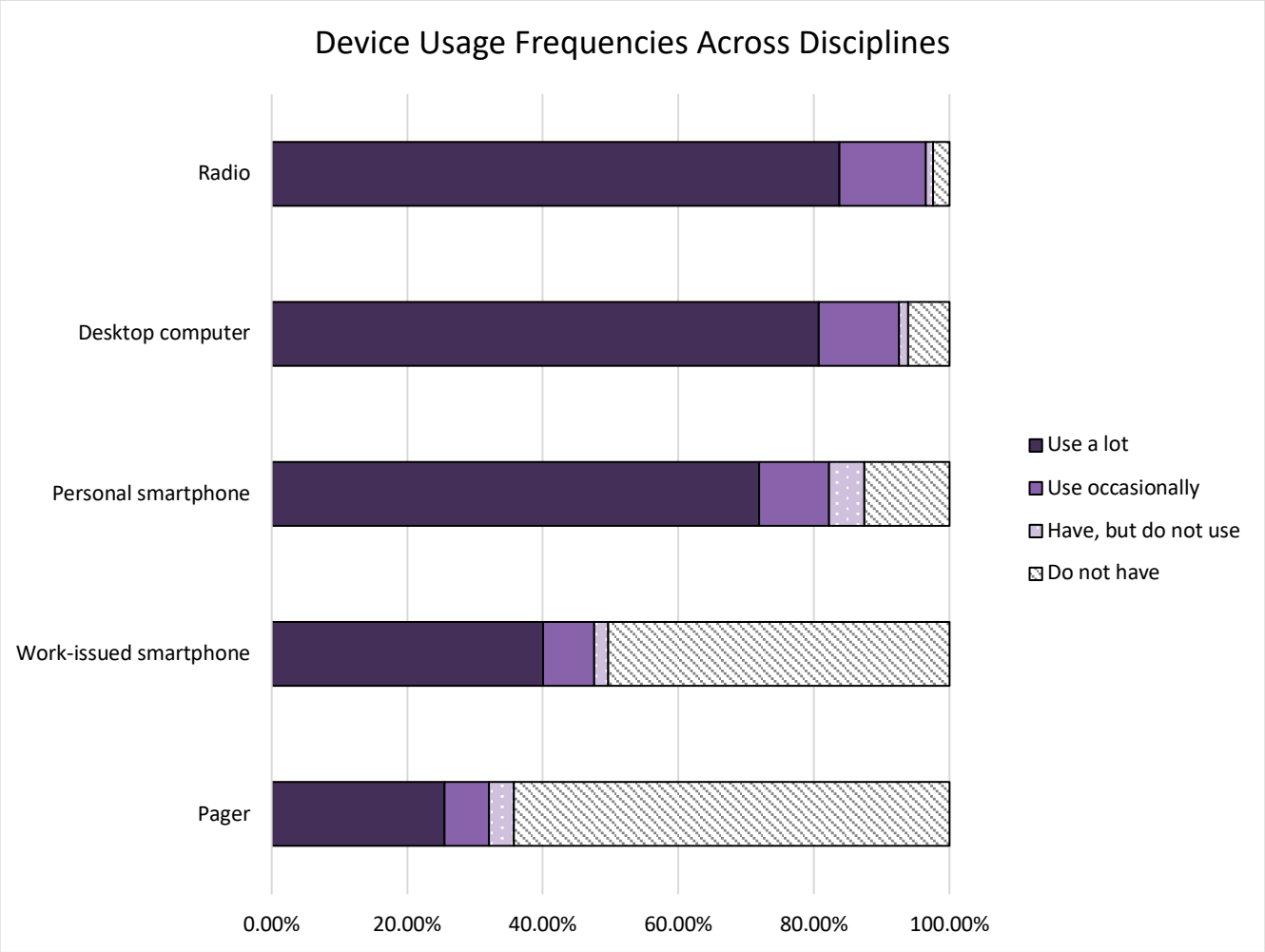

Fig. 62 Device Usage Frequencies Across Disciplines

In addition to these five devices, three disciplines – EMS, FF, and LE – were presented with several other common devices. The common devices across EMS, FF, and LE are listed below; Similar devices are grouped into three categories for the purposes of displaying results; devices were neither grouped in the survey nor analyses.

- Desktop computer, laptop, MDT/MDC, and tablet
- Earpieces (corded earpiece, personal wireless earpiece, work-issued wireless earpiece), mics (corded mic, wireless mic), and radios (in-vehicle radio, portable radio)
- Flip phone, pager, personal smartphone, and work-issued smartphone

In analyzing the device use across EMS, FF, and LE, frequencies of use for radios (both portable and in-vehicle), desktop computers, and personal smartphones were high, consistent with the analysis of the device use across all four disciplines. Additionally, over 50 % of respondents used laptops, corded mics,

and tablets in their day-to-day work, while fewer used pagers, work smartphones, mics, earpieces, and flip phones. Fig. 63 displays frequencies of usage across EMS, FF, and LE disciplines.

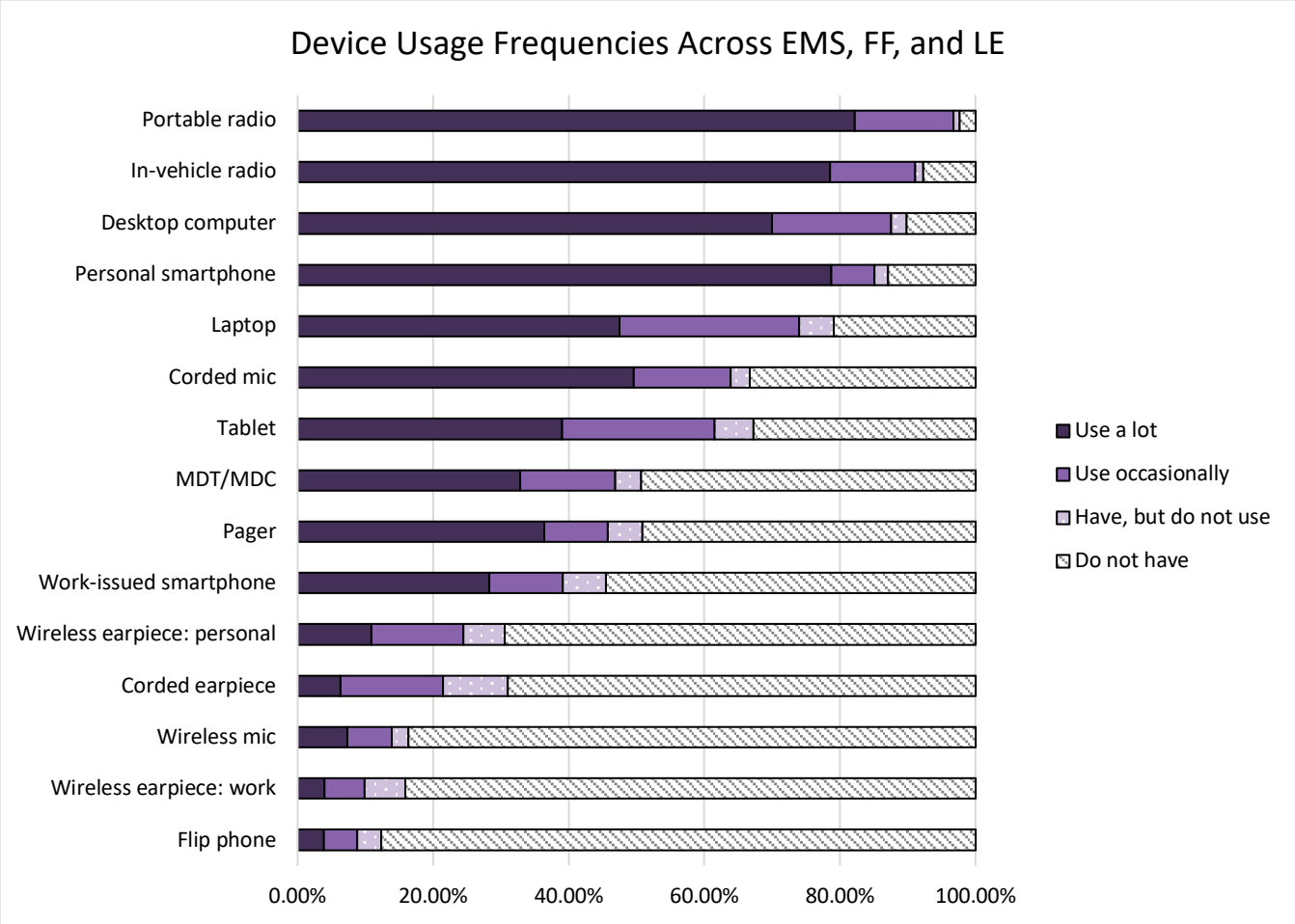

Fig. 63 Technology use frequencies, across EMS, FF, and LE

When EMS, FF, and LE participants ranked the devices they use, in addition to the top used devices above, work-issued smartphones were included in over 70 % of respondents' top five rankings lists. While MDTs and pagers were used by just under half of respondents across these three disciplines, the majority of respondents included them in the rankings lists of their top five most useful devices. Top five rankings across EMS, FF, and LE are displayed in Fig. 64.

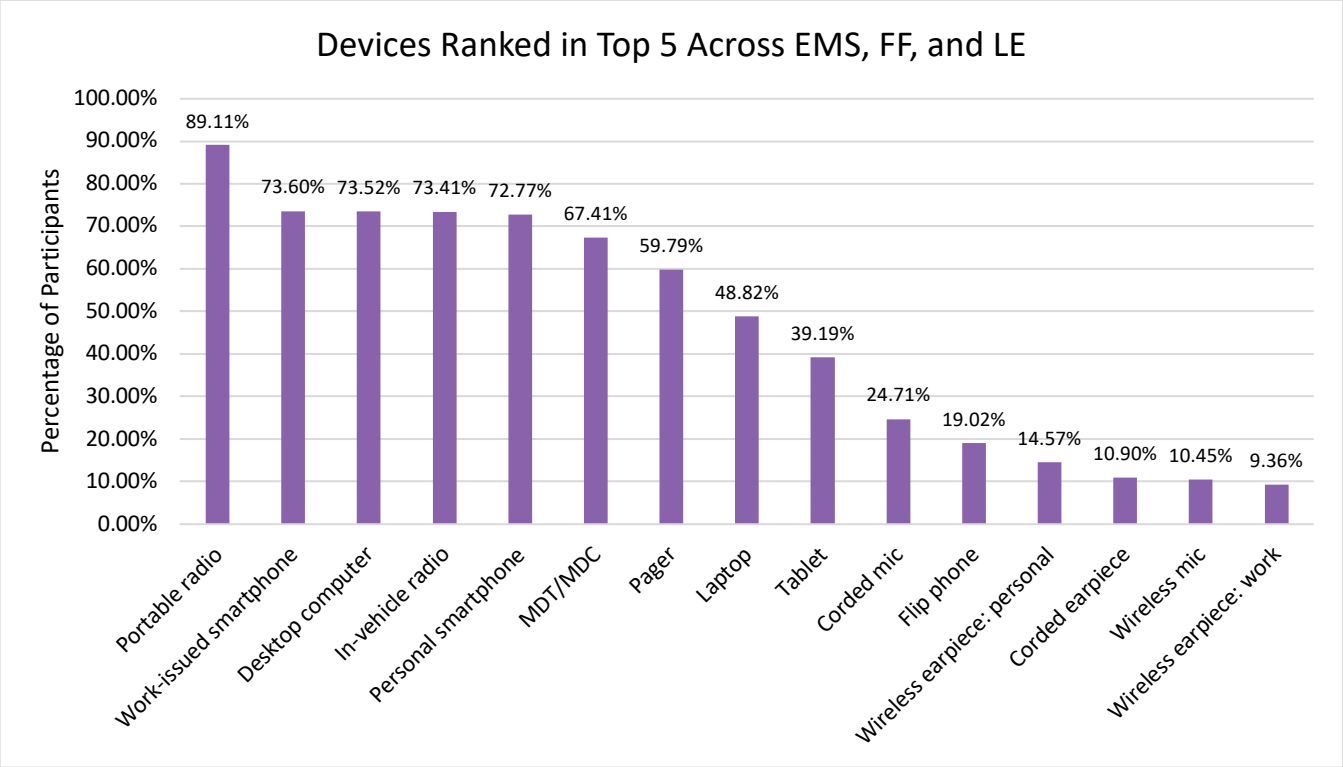

Fig. 64. Devices ranked in top 5 across EMS, FF, and LE

Device Problems

Devices and problems common across EMS, FF, and LE are listed below (see Appendix C for a side-by-side list of all problems for each device presented to these three disciplines). Note that while there were 15 common devices across the three disciplines, only eight devices are listed below for two reasons: 1) problems were not asked for each device presented in the frequency of use survey question (e.g., flip phones); and 2) problems were only asked for a device type, not its variants (e.g., smartphone problems instead of both personal smartphone problems and work-issued smartphone problems).

- **Desktop computer**: Internet connection; Interoperability; Logins/passwords; Outdated/old; Price: too expensive; Software crashes; Software updates/upgrades
- **Laptop**: Battery life; Durability; Glare; Internet connection; Interoperability; Logins/passwords; Outdated/old; Power source/recharging issues; Price: too expensive; Size/bulkiness; Software crashes; Software updates/upgrades; Weight
- **MDT/MDC**: CAD; Durability; Interoperability; Lack of portability; Logins/passwords; Mapping/navigation; Outdated/old; Price: too expensive; Size/bulkiness; Using while driving; Glare (FF and LE only)
- **Mic**: Audio quality; Cord; Durability; Falling off; Outdated/old; Placement on body; Price: too expensive; Talk button location; Talk button size
- **Pager**: Battery life; Durability; Falling off; Outdated/old; Price: too expensive; Size/bulkiness

- **Radio**: Audio quality; Battery life; Channel switching; Cord; Coverage/dead zones; Durability; Interoperability; Outdated/old; Price: too expensive; Radio discipline/etiquette; Size/bulkiness
- **Smartphone**: Battery life; Coverage/dead zones; Data plans/data limits; Dropped calls; Durability; Glare; Logins/passwords; Outdated/old; Permission/access to applications; Policies about usage; Price: too expensive; Subpoena possibility for personal smartphone; Subsidy for personal smartphones
- **Tablet**: Battery life; Durability; Glare; Internet connection; Interoperability; Logins/passwords; Report writing; Size/bulkiness; Touchscreen; Weight

Results in this section describe device problems that participants experienced at least "Sometimes," meaning that they occurred "Always," "Most of the time," or "Sometimes". As mentioned in previous sections, even problems occurring "Sometimes" could have dire consequences during incident response.

Across all disciplines and devices, price was the most common problem. It was identified as a problem at least "Sometimes" for over half of the participants across disciplines for pagers, laptops, smartphones, and radios. Of the problems categories, problems with price also had the highest rates of occurring "Always." Although first responders experience many problems with their devices, price is the most frequently experienced problem and is a concern across devices. Rates of price problems for each discipline are displayed in Fig. 65 in descending order averaged across disciplines[6]. The open-ended survey data further support the finding that expensive costs are major issues for EMS, FF, and LE. The Phase 2, Volume 2 report explored the issues associated with cost more fully [6]; a device's expenses include maintenance, training, subscriptions, and software, and are not limited to the cost of the device itself. Problems with price were consistent across open-ended survey responses and experiences expressed during the interviews.

> 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)

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

> It would be awesome to have [the shoulder mic system for portable radios] cordless opposed to a long cord that tends to… [be] pulled off your uniform shirt, or stretched, or gets caught on something where a Bluetooth-affixed microphone would be really nice… but it's really expensive, and they're not going to buy that for 1,100 officers. (INT-LE-S-037)

Each discipline faces unique issues with the cost of their technology that impact their ability to effectively carryout the tasks in their day-to-day work.

[6] Note: The problem, "price: too expensive" was not asked for tablets across EMS, FF, and LE.

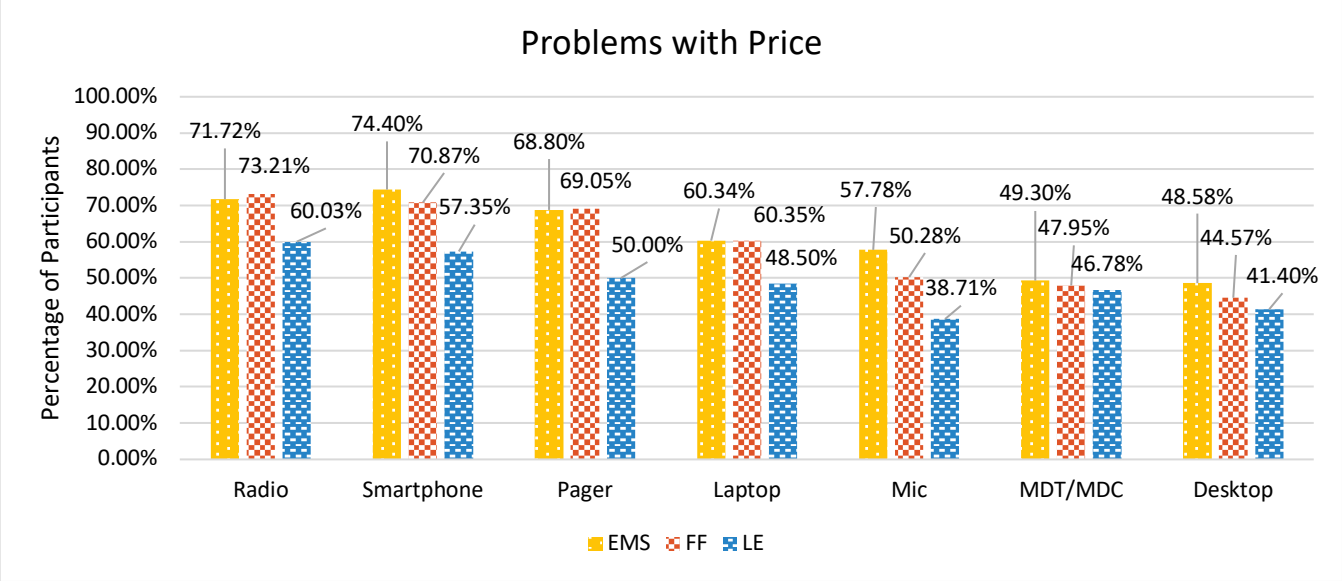

Fig. 65. Price problems by discipline and device

Another common problem was connectivity for devices. Coverage was one of the top three problems across EMS, FF, and LE for both radios and cell phones. Internet problems on laptops, computers, and tablets were also experienced by over 40 % of EMS, FF, and LE participants. Data from the problems section of the survey revealed connectivity to be a major problem, and this was also amplified in the open-ended answers. Fig. 66 displays frequencies of participants with coverage problems at least "sometimes" for radios and smartphones as well as frequencies of participants with internet problems with laptops, tablets, and desktop computers in descending order averaged across disciplines. Like cost, coverage and connectivity issues were prevalent in the interview data as well as the open-ended survey responses.

> The big issues with our communications are the dead zones and kind of holes in our communications. (INT-EMS-S-016)
>
> It all comes back to the same thing, bandwidth. The more that you want the officers to be able to receive on their computers, you need the bandwidth. (INT-LE-U-012)
>
> Wifi issues or other connectivity issues inside and outside of the station. (FF:S:6245)

First responders across disciplines had issues with both network coverage and internet connectivity for many of their devices, both inside and outside of building structures in their jurisdictions. Not only is this an impediment to their work, but it is also a major safety issue that needs to be resolved as well.

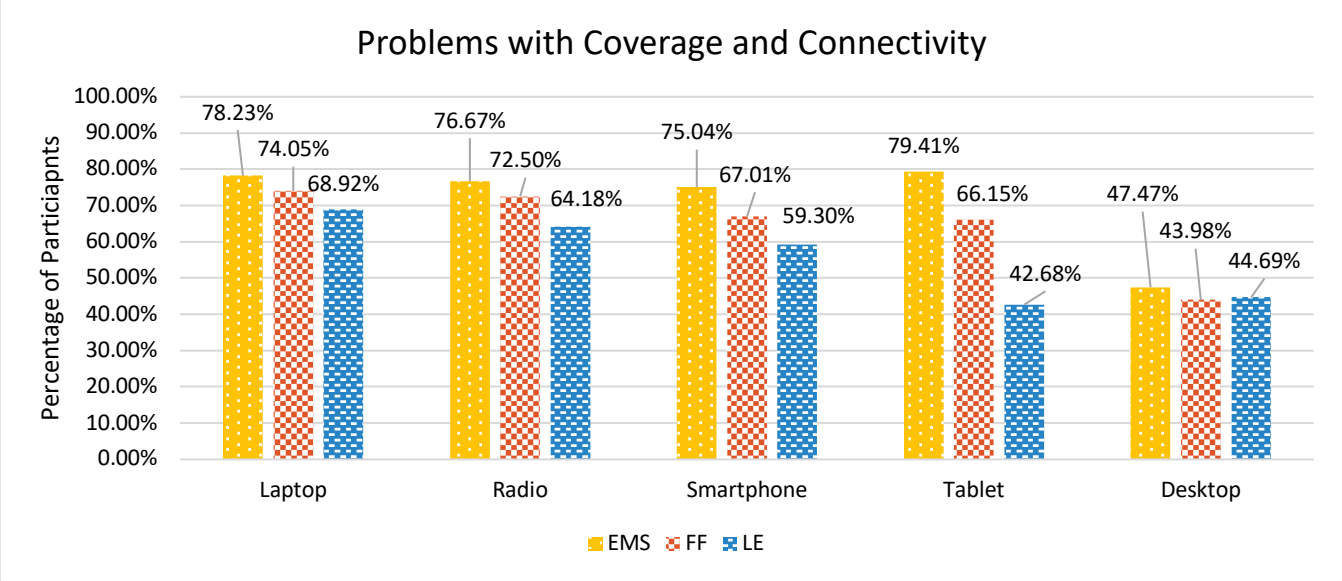

Fig. 66. Coverage and Connectivity problems by discipline, at least "Sometimes"

Finally, over half of the survey respondents across disciplines experienced problems with the batteries of their radios, laptops, tablets, pagers, and smartphones. Like price, this problem was experienced by a majority of the first responders surveyed and was an issue across multiple devices. Rates of battery problems for each discipline are displayed in Fig. 67 in descending order averaged across disciplines[7]. Battery problems are major issues, as many first responders expressed in the interviews.

> Everything has to be powered. How are we powering it? And power is your limitation. And it could be a cord or battery or fuel, but that is your limitation. And how do you extend that and get more efficiency and more power? Got to get that too because it's got to be more effective. (INT-FF-U-012)

> How long's that battery last? 45 minutes. Okay, so it's not that terrific, right? … that's with our thermal imagers, with our radios, with our rescue tools. You name it. We are limited by the distance of a power cord or the distance of battery. (INT-FF-U-012)

> We have a cardiac monitor which plugs in because it's battery operated. We have a suction unit that is battery operated. We have this, that, and the other thing that's all battery operated. It's all plugged in. When an ambulance is not running, it's on a shoreline plug… And if you forget to plug your ambulance in for an hour, it's dead. I mean, it's just the electric load, which is a technology issue as well… Whatever else we hang in an ambulance cannot be a power concern. (INT-EMS-R-008)

[7] Note: The problem, "battery life" was not asked for mics, MDT/MDC, and desktop computers.

As voiced by these participants, batteries are increasingly being used to power devices and technologies used in public safety. This reliance on electrical power amplifies this critical issue for first responders.

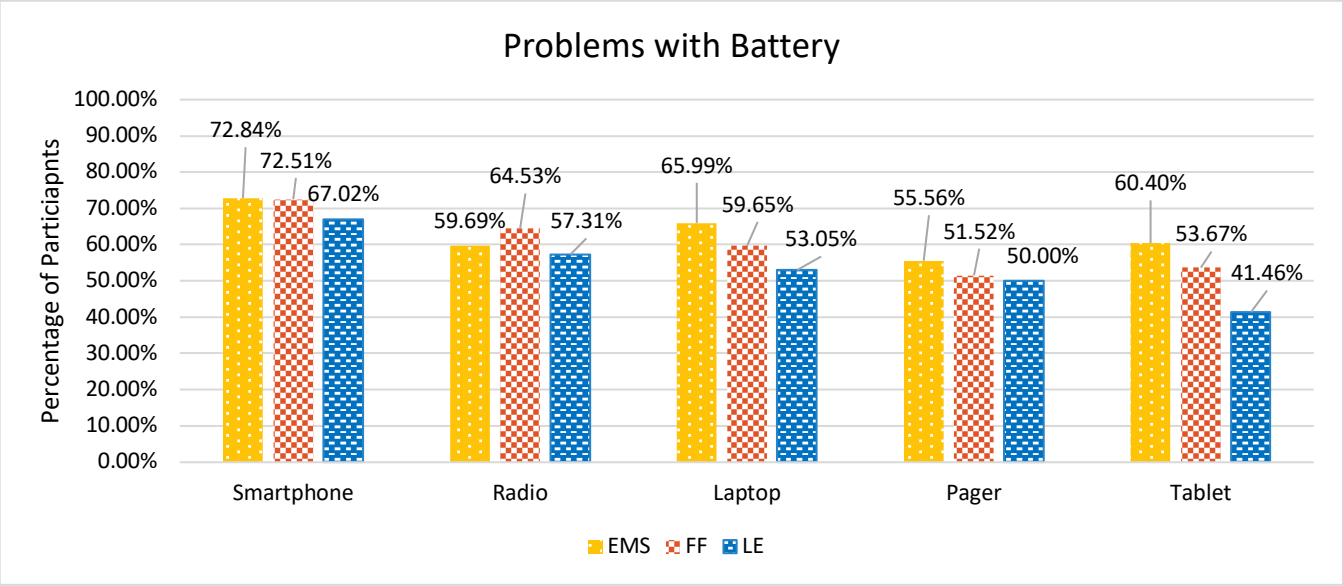

Fig. 67. Battery problems by discipline, at least "Sometimes"

In addition to price, connectivity, and battery problems, over half of the participants across EMS, FF, and LE experienced the following problems at least “Sometimes:”

- Coverage /dead zone problems with radio and smartphones
- Audio quality problems with radio and mics
- Radio discipline/etiquette problems
- Problems with dropped smartphone calls
- Logins/password problems with MDT/MDC, laptop, and computers
- Internet connection problems with laptops and tablets
- Glare on MDT/MDC and tablets
- Software update problems with laptops and computers
- Problems with MDT/MDCs when using CAD, mapping/navigation, and while driving
- Problems having old/outdated computers

As suggested by this constellation of problems, first responders across EMS, FF, and LE had the most problems with the communication capabilities of these devices rather than with their physical attributes. First responders not only have problems hearing other responders in real-time, but sometimes their devices are unable to connect, preventing them from communicating at all.

These data also suggest that first responders have significant usability problems with their devices and may be unable to effectively and efficiently access these devices during incident response. Problems with CAD, software, and logging into devices may slow down first responders when responding to

incidents. Moreover, if they are unable to connect their devices to the internet, they are not able to perform the functions necessary for incident response.

4.6.2. Differences Across Disciplines

Technology use

Fig. 68 displays usage frequencies in descending order averaged across disciplines for each device separately for each of the four disciplines, where participants selected “Use A Lot” or “Use Occasionally.” The data suggest that the device usage of COMMS participants is often different from EMS, FF, and LE. COMMS had the highest percentage of participants having and using desktop computers and had fewer instances of having or using personal smartphones. This is unsurprising, as COMMS personnel work predominately at their computer stations for dispatching, and many described that they are often not permitted to use their personal smartphones [22].

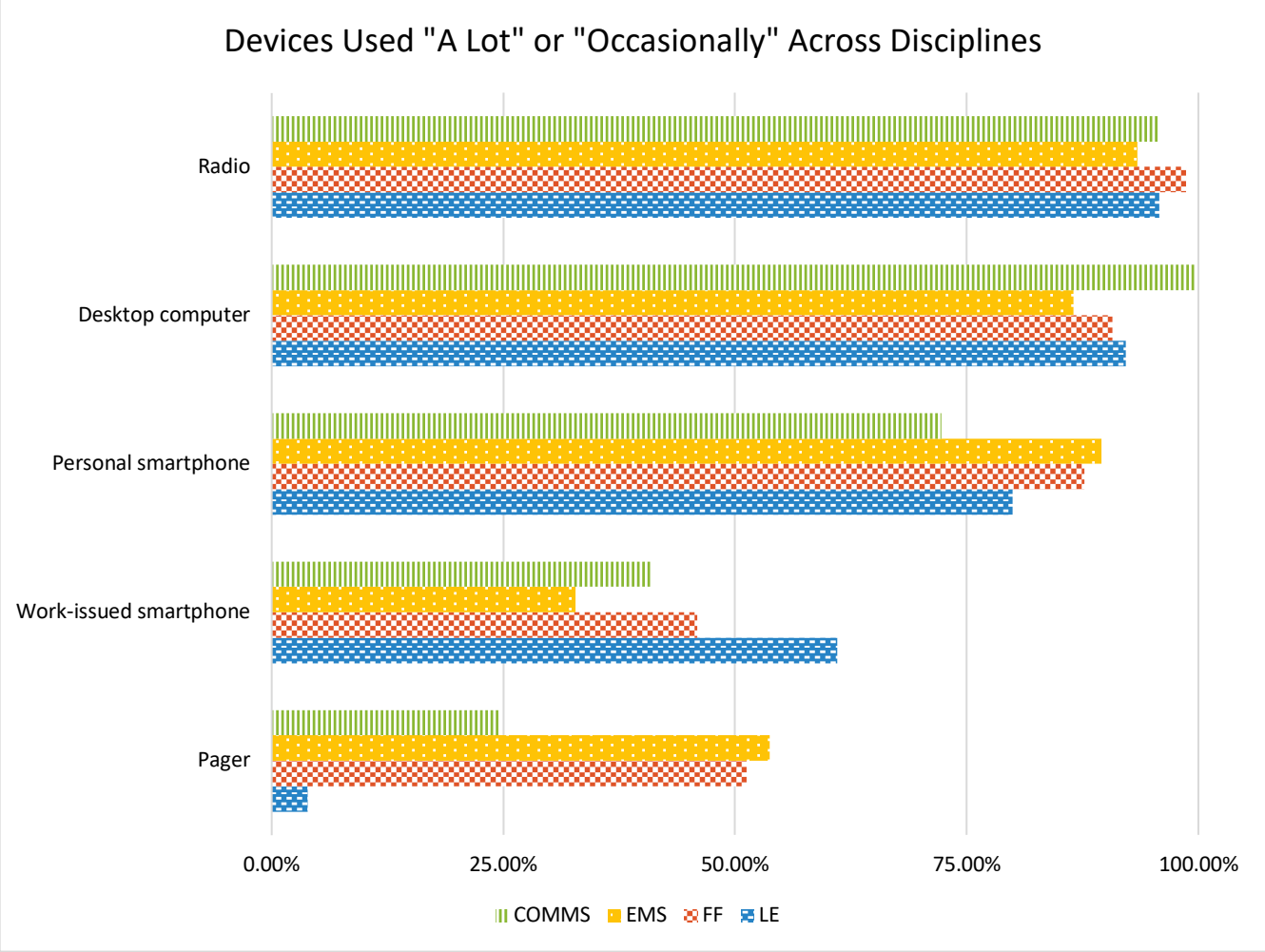

Fig. 68 Technology use frequencies, by discipline

Differences in device usage also emerged across disciplines for pagers and work-issued smartphones, both of which were used by fewer participants. COMMS, FF, and EMS more often used pagers

compared to LE participants; EMS and FF participants had the highest rates of using pagers, with over half of participants in each discipline selecting “Use A Lot” or “Use Occasionally.” In contrast, less than 10 % of LE participants had or used pagers. COMMS responders fell in the middle of these two groups, with only one fourth of participants having and using pagers. Patterns for work-issued smartphones, and their associated software and applications, are described in detail in Phase 2 Volume 2 [6].

Upon further investigation of the data across EMS, FF, and LE, day-to-day device use was most different for LE participants compared to EMS and FF, though EMS and FF usage frequencies did differ for some devices.

LE participants used pagers and tablets less frequently than both EMS and FF participants. While half of EMS and FF participants use pagers at least occasionally, this was true for fewer than 4 % of LE participants. Additionally, half as many LE participants (31.52 %) used tablets as EMS (59.63 %) and FF participants (63.59 %). However, LE participants had higher rates of using work smartphones at least occasionally compared to EMS and FF participants.

LE participants also had the highest rates of using MDTs “a lot” or “occasionally”, though this rate was very similar to that used by FF participants. EMS participants had the lowest rate of using MDTs “a lot” or “occasionally.” It is noteworthy that EMS differed from FF participants in MDT usage frequencies, as generally across devices they had very similar frequencies. Fig. 69 displays frequencies of using MDT/MDCs, pagers, tablets, and work-smartphones “a lot” or “occasionally” for EMS, FF, and LE in descending order averaged across disciplines. For additional details about discipline-specific smartphone and tablet use, please see the Phase 2 Volume 2 report [6].

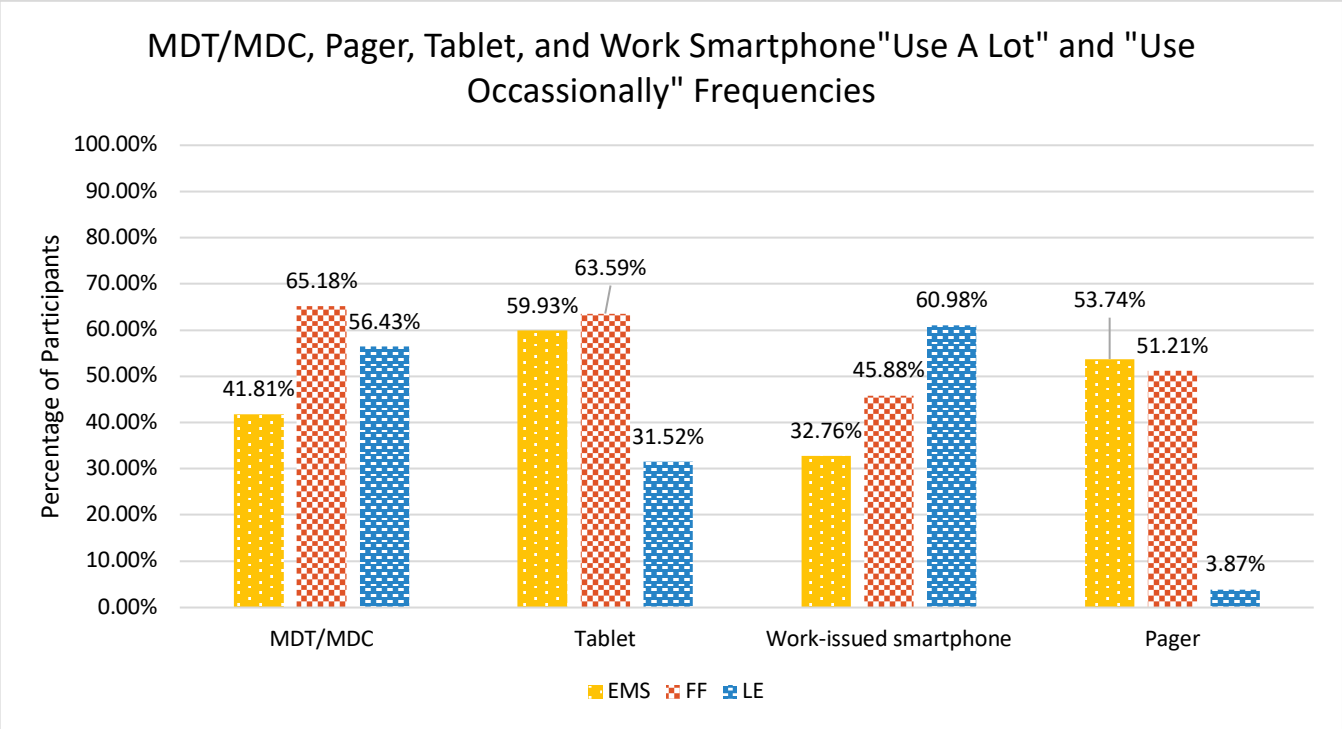

Fig. 69 MDT/MDC, pager, tablet, and work smartphone use frequencies, by discipline

LE participants also used earpieces and mics with differing frequencies compared to EMS and FF participants. More LE respondents reported using corded earpieces and wireless mics “a lot” or “occasionally” compared to EMS and FF. However, nearly half as many LE participants reported using personal wireless earpieces compared to EMS and FF participants. This pattern of results may suggest that LE have different audio needs compared to EMS and FF disciplines.

EMS respondents had lower rates of using corded mics “a lot” or “occasionally” than both FF and LE participants. FF participants used corded mics “a lot” or “occasionally” more than LE participants. Like MDTs, corded mic usage was one of the few areas where EMS participants had a marked difference from FF participants. Fig. 70 display frequencies of using mics and earpieces “a lot” or “occasionally” for each discipline in descending order averaged across disciplines.

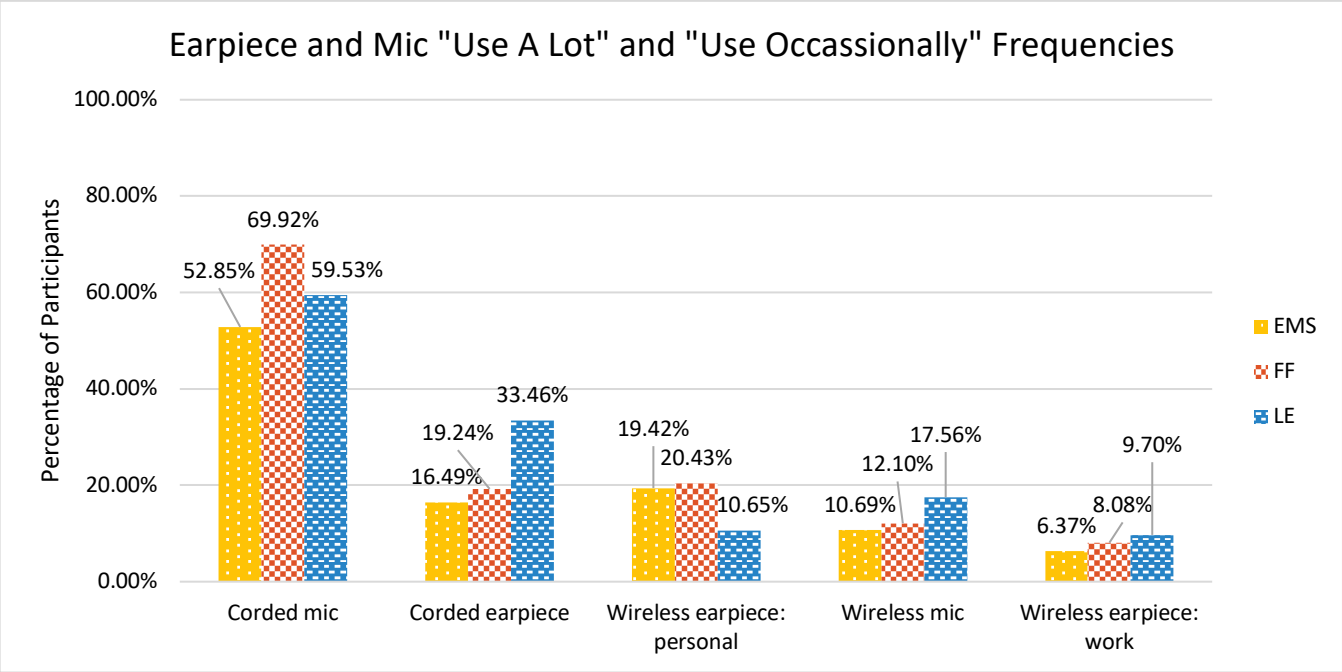

Fig. 70. Earpiece and mic use frequencies, by discipline

Device Problems

Although some problems were found to be similar across EMS, FF, LE, there were some unique differences for each discipline. The frequencies of EMS and FF participants’ problems with devices were similar, especially for problems with radios and pagers. More EMS and FF participants had problems with radios (i.e., radio coverage, audio quality, price, interoperability, durability and radio discipline/etiquette) compared to LE participants. Smartphone problems were similar across disciplines, although more EMS participants had subsidy problems. More EMS and FF participants also experienced problems with their pagers, while very few LE participants had pager problems; however, only seven LE respondents were asked about pager problems due to the design of the survey, where respondents were only asked problems for their top three devices (see Sec. 4.1.1, Appendix B, and Appendix C).

Differences were also observed between disciplines for mic problems. Mic problems were especially evident for FF participants, as more FF participants had problems with their mics' cords, durability, button size, and button location compared to EMS and LE participants. LE participants also had unique mic problems: more LE participants "Always" had problems with their mics falling off. These data suggest that more FF and LE participants had problems with audio quality compared to EMS participants. However, it is important to note that only 61 EMS participants were asked about mic problems due to the design of the survey (see Sec. 4.1.1, Appendix B, and Appendix C).

For laptops, more EMS and FF participants had problems (i.e., price, glare, and durability) compared to LE. More EMS participants had challenges with their laptop software crashing compared to FF and LE participants. Overall, more EMS and FF participants had problems with their tablets compared to LE participants. There were also differing patterns in problems with MDTs between disciplines. Compared to LE participants, more EMS and FF participants had problems with their MDT's map navigation and durability. More FF participants had problems with glare compared to LE[8]; however, fewer FF participants had problems with MDTs being old or outdated. On the other hand, fewer EMS participants had problems with logging in and passwords compared to FF and LE participants.

4.7. Final Open-ended Response Section

This section presents results from the final question asked in the survey, an open-ended question asking participants if they had anything else to share related to their experiences with technology at work. All four disciplines were asked this question, which provided participants with a space where they could give input about technology that they felt was not captured elsewhere in the survey.

> Is there anything else you would like to tell us about your experience with technology in your work?

The open-ended text box allowed for an unlimited number of words and characters so participants could write as much, or as little, as they wanted in their responses.

Responses were examined by discipline, and then across disciplines, in order to identify issues specific to a discipline as well as those that crossed disciplines. Data was first coded by general topic areas (Device, Software, Problem, Need, etc.) and then coded with more specific categories, such as *Old/outdated technology* and *Staffing/recruitment/retention*. This second round of coding used a priori codes that came from themes identified in previous analyses. During this second round of coding, emergent codes were identified and added to the code list. At this time, the code list was reviewed for overlap and consistency and a final set of codes was created. Data were coded one more time using this final code list.

Multiple codes could be applied to a single response as appropriate. For example, one response might be coded as both *Cost-budget-funding* and as *Old-outdated* or *Lack of technology*. There were a wide

[8] EMS was not asked about the glare on MDTs.

variety of codes representing this data. In general, the responses across disciplines were remarkably similar, however some codes were discipline specific, such as *Overload* in COMMS responses.

There were 1 065 responses to this open-ended question. Some responses simply said "No" or "Not at this time," while others were over 150 words. Like all questions in this survey, a response to this question was not required. However, many participants cared enough to take the time to provide additional information, even at the very end of the survey. The categories that cut across the disciplines are discussed below, followed by a section that discusses discipline-specific findings related to these categories of responses.

4.7.1. Final Open-Ended Question: Similarities Across Disciplines

This final open-ended question asked participants to share anything else about their experience with technology in their work. Fig. 71 shows the categories of responses that occurred across disciplines.

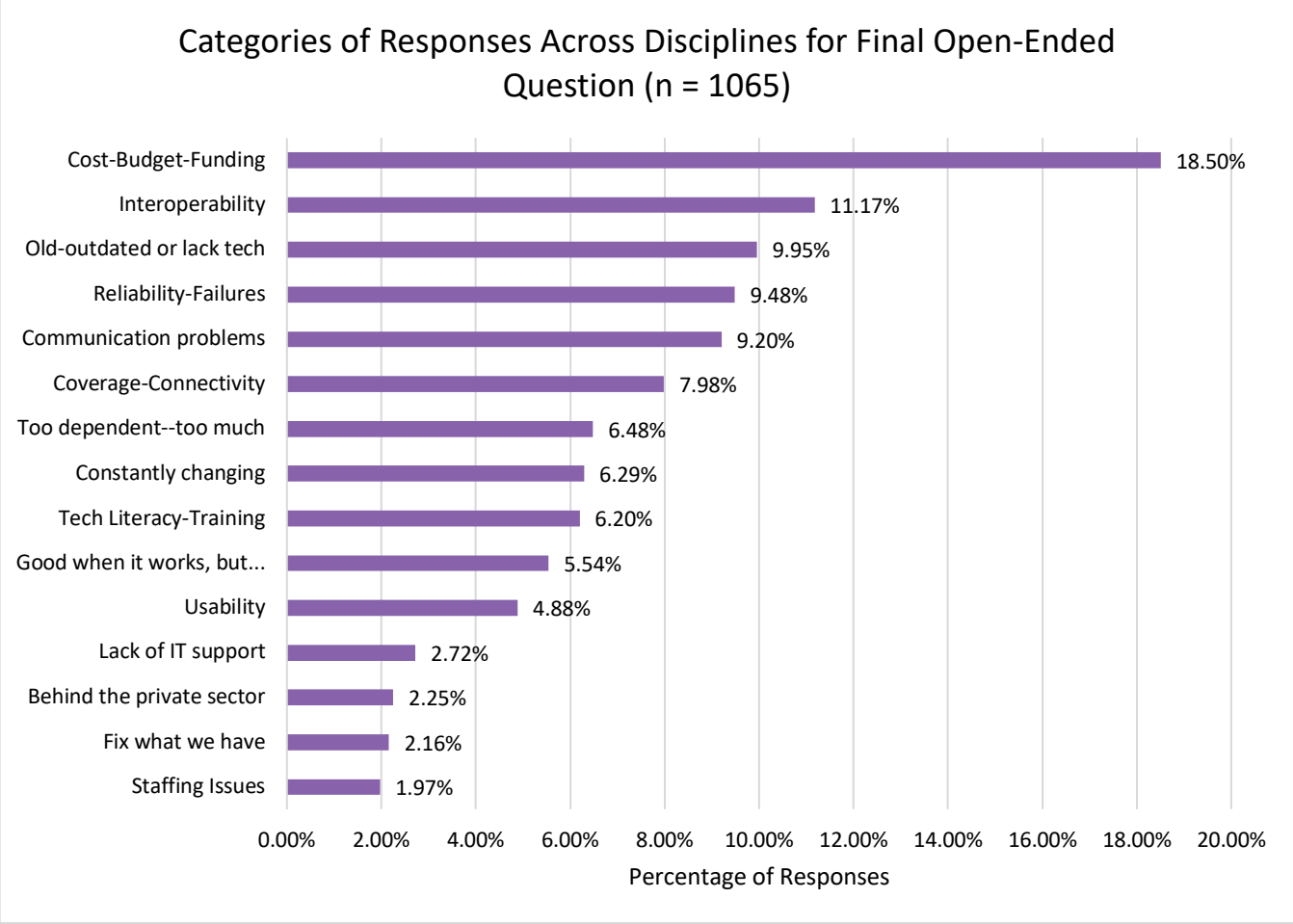

Fig. 71. Categories of Responses Across Disciplines for Final Open-Ended Question

Note: An individual response could address problems in multiple categories. Therefore, percentages may not sum to 100 %.

It is interesting to note that across all four disciplines, the top category to emerge from this open-ended question was *Cost-Budget-Funding*. In a space designed for comments related to experience with technology, participants chose to highlight the high cost of technology and how this served as a barrier for many of them to access and utilize it in their work. This is consistent with data from the interviews where participants also identified cost as a major barrier to adoption and use of technology, even though cost was not explicitly asked about during the interviews.

> 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)

> We are behind the technological advances that occur in the private sector nor do we have the budget necessary to upgrade to the systems and equipment that are becoming increasingly necessary to perform our duties to the expectations of a technologically-reliant public who have no idea how 9-1-1 works. We are short-staffed, working on antiquated systems created when only landlines existed; and, even then they were rarely used to call 9-1-1. Now, everyone calls on their cell phones, overloading the system, to report emergencies that we 'should be able to find' with technology we do not have (if my uber driver can find me, why can't you?) (COMMS:U:6340)

> We try to stay updated but with tight budgets and changing technology and software and govt requirements with no funding for requirements it's not easy for volunteer depts. Radios are something we just can't keep updates on not to mention purchasing new ones. (EMS:R:3347)

> For something that we rely so much on, its cost prohibitive for smaller depts. to keep up with technology. And that causes issues for us. We can't afford $7000 for one radio. So we have to settle for used or lesser quality. We make do with technology that other, bigger departments have given up on 20 years ago. (FF:R:5128)

> Our department seems to be years behind other agencies due to lack of funds. (LE:S:8441)

Cost-Budget-Funding was the top category across all four disciplines, demonstrating its importance for first responders and the role it plays in their ability to access technology.

The importance of cost is also supported by the quantitative findings presented earlier in this report showing that cost was the top problem participants have with all the devices identified in this survey (see Sections 4.3.4, 4.4.4, and 4.5.4). Data from other open-ended survey questions, specifically those that asked first responders about problems they experience with their technology, also indicate cost as a major barrier.

> 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)

Data from across this study show that the high cost of technology is a major barrier for access to new and updated technology. This is especially true in rural departments [22] where there are extremely "tight budgets" (EMS:R:3347).

The high cost of technology means that many first responder departments operate with old, outdated technology or that they lack technology needed to accomplish their missions.

> We need to make sure that all Communication Centers are at the forefront for upgrades on technology. We are the true first responders. How are we supposed to send help, if we don't have updated technology to send responders? Thank you for allowing us to be a part of this survey and giving us a voice. (COMMS:R:7377)

> It is expensive and is out of date before you know it. (EMS:R:8372)

> The agencies that I have worked for are usually constrained by cost to keep up with advancing technology. My cure t agency has an antiquated cad system with no mapping features or all capabilities. Desktop computers are all we have and no technology in the vehicle to get cad info or avl, no prep land available from the system either. (FF:R:1973)

> Our agency is outdated and very behind with technology. (LE:U:7069)

Also related to the high cost of technology is the fact that it is constantly changing, and as a result often needs to be updated. Like cost, the fast pace of technology change was also prominent in the interview data.

> It seems like everyday something new is rolling out, and then the next day it's old news. (INT-FF-U-006)

> I think some technology can cause some problems. Technology advances can be an issue, maybe as not catching as fast as we want. Or maybe we're using a system that's one down from what's already happening because I'm sure you know as well as I do, technology is always moving, and a jurisdiction has to operate under here because they've already spent a lot of money on particular ends, and it may not communicate with that technology because it's outdated. (INT-EMS-S-014)

> It is hard for any communications center to keep up with all the new and changing technology. It is also difficult to determine which technology is necessary and which will be a passing fad or outdated by technology coming next week, month or year. (COMMS:S:1075)

> Communication technology evolves quickly and devices become outdated or not supported in less time than budgets allow for replacement. (FF:R:2209)

The constantly changing nature of technology is one factor that contributes to departments having to use old or outdated technology. It is also related to the high cost of technology since many department budgets are unable to adequately keep up with these changes.

Interoperability is recognized as a major communication problem in the public safety community. It is a pervasive issue that crosses all four disciplines and occurs on multiple levels: systems (e.g., radios) that do not talk to each other; forms that do not auto-fill even though information was entered on one platform; devices that cannot communicate with each other; or organizations that cannot connect with each other even though they use similar devices. Qualitative data from both interviews and open-

ended responses also demonstrate the importance of interoperability to the first responder community.

> We've got one design for body cams, we've got one design for in-car cams, we've got one design for CAD, and then we've got all these other small things. And they're all from different vendors, because of whatever reason. The city was trying to beg, borrow, steal these things from different vendors and they didn't want to pay full price, so none of them integrate well together, which is a huge issue for us. (INT-LE-U-005)

> It's very easy to have 12 different devices that all do one thing. For the most part, if we can get three devices that are somewhat compatible with it or there's a lot of ability to sort of do multiple things, then we're always going to try to do that. But there's still a lot of diversity out there in terms of technological platforms…. I think that I would like to see a-- well, in time interoperability…. For example, we have [vendor redacted] phones, we have the [vendor redacted] tablets, we have whatever it may be. And some of those don't mesh well, as far as trying to transfer information, or whatever. That's one of the technology things that we are continually struggling with, is compatibility. I personally try not to get uni-taskers. (INT-FF-S-035)

> I know no one wants a monopoly.....but it sure would be nice if the Comm Center could have one application for many different things, where they could all interface and work together instead of having all these different programs. There are so many stand alone type of products and then they each come with their own maintenance agreements etc.....Or if a product does promise you it will do most of the things you want, it just never seems to hold true, or doesn't live up to the expectations. It seems our officers want more and more information much quicker, not realizing some of the hoops that we have to go through while still performing the other functions of our jobs, like answering other phone calls etc... (COMMS:S:1877)

> Technology should seamlessly integrate and complement our existing operations. It should not dictate, nor hinder, our operations. (EMS:U:8389)

> We need interoperability in CAD/RMS and EPCR. There needs to be standards introduced that provide the necessary link between these different systems, especially pre-hospital and hospital PCR systems. (FF:U:2080)

The lack of interoperability often means that departments, devices, and systems cannot communicate with one another, making the work of first responders less efficient and effective and much more time consuming and difficult. Many of these responses indicate frustration with the lack of interoperability and the additional workload or problems it often causes.

Similar to the interview data [5] and the open-ended survey responses to the problems questions, the reliability of technology also came up in these open-ended responses. Many of these responses noted that technology often failed, and the consequences this could have for first responders.

> Windows-based CAD systems are designed to fail on both a technological and user level. I'm not sure how the shift towards this technology came about, but it is counterproductive and does

> not allow the dispatcher to do more than one thing at a time without losing windows or vital information. The user/dispatcher cannot rely solely on mouse-based action, because a keyboard is necessary to document information - in the same respect, a keyboard cannot select between various windows presenting information to maintain control of an incident. There is also an inherent system instability when too many processes are attempted, the system freezes and crashes. With an ever-increasing call volume, dispatchers are required to rapidly multitask - saddling them with unreliable and uncooperative technology will result in preventable losses. (COMMS:S:9731)

> My job is technology in the fire service. Sometimes the latest and greatest technology has been applied with little regard to its practical application. TICs that were not water resistant. Lapel mics that go into emergency after a healthy dose of water. Bluetooth SCBA mics that disconnect from the radio in high ambient RF environments (read WiFi interference in the same band). (FF:U:9770)

> Technology cannot be relied upon to work 100% of the time. For example, using a TIC to get into a space, and having that TIC fail leaves you lost if you do not maintain good situational awareness. Knowing your district works better than a laptop map telling you where a street is if your computer dies. (FF:R:9818)

> I think it is imperative to acknowledge the fact that technology is great but it is not 100% and we should always have a back-up plan in place. To rely solely on technology is unwise. Likewise, to spend a massive amount of funds, tax-payer dollars, on technology and not so much on the personnel, their training/well-being/continuous education, etc. is just as unwise as relying on technology without a back-up plan. (COMMS:S:5270)

A related category was that technology is "good when it works, but____." Again, responses coded to this category often identify failure of technology as a major problem, and speak to the frustration it causes when it fails.

> When it works it's great. When it doesn't it's frustrating and time consuming to get it operating. I have found that vendors promises you things they can not deliver and it is expensive. I have found many officers have become too reliant on technology and have no idea how to do their job when technology fails them. (LE:R:5818)

> Great when it works but most of the time it fails and is extremely hard to keep up on and pay for. (LE:R:6548)

Some of the responses from both of these categories highlight how technology for first responders is often developed without their contexts of use in mind (TICs that are not water resistant, for example). In addition, many of these participants believe that there is always the possibility that technology will fail, for a variety of reasons, so it is important to ensure that first responders know what to do in the case of failure and that there are backup plans in place.

While a few responses identified the benefits of technology, most presented problems and issues that first responders have with their technology. A variety of responses detailed how participants believe

that first responders have become too reliant or dependent on technology, or that there is too much technology being used. The overreliance on technology was a theme in the interview data as well.

> I think if you-- if you start doing too much with technology and relying on it too much when it goes down, you won't know how to-- or a person wouldn't know how to respond if you relied too heavily on technology. I think it's good for us to move forward with it, but I don't think we should put too much weight into it because then, like I said, if it goes down-- like when a computer goes down at work, and you're scrambling to find a notepad so you can write down addresses and things of that nature. (INT-LE-S-038)

> No matter how good and how reliable. It WILL FAIL and you must train personnel to continue to function to accomplish the mission. Employees become too dependent upon technology. Technology changes every day and employees hate change. (COMMS:R:6271)

> Personally feel that technology can enhance one's abilities as a medical provider, however can hinder when providers become too reliant on devices, software, etc. causing them to freeze when technology fails. And it does eventually fail; programs freeze, batteries die, etc. (EMS:S:8857)

> We increasingly paint ourselves into a corner with total reliance on technology. (FF:U:8663)

These responses often noted how technology "can hinder" first responder work when it is relied on too heavily, in part because this reliance has resulted in first responders not knowing how to function without it.

> Our actual productivity is significantly less than it was before more technology was added. We also have more complaints and officers taking calls over the phone or via e-mail! Taking a burglary report over phone and a list of missing items via e-mail is not police work, yet our IT folks think that [is] fine.... (LE:S:5283)

> While ever changing in the field and a great asset I have seen our dependence on technology and what happens when we suddenly don't have it. Much in EM and fire service is becoming way too dependent on technology. A loss would be critical: For example notification and response is almost exclusively via smart phone apps in our area with very reliable service. We lose cell service or internet or fiber lines we have an issue. Same with dependence on our phones/ cell and wifi for retrieving info on a scene. (FF:U:5659)

> Technology tends to dumb people down, leading to ineffectiveness when the technology does not work properly. Technology is a great tool, but only one tool of many that we use. It should not be depended on as much as it is. (FF:S:9059)

As noted in the responses above, first responders often feel they lose something—effectiveness, productivity, and common sense to name just a few—when they rely too heavily on technology.

Usability, a major theme in the interview data, was also present across the disciplines in responses to this final open-ended survey question. Participants want technology that is easy to learn, easy to use, and saves them time.

> In the police world, if you want somebody to use something, it has to be simple. The more complicated it is, it's very seldom getting used. (INT-LE-R-001)

> I am old school and technology has to be easily used, reliable, and easily taught. Frankly I know my territory and can get there faster than a GPS unit can. Use of personal intelligence has to maintained as thoroughly as technology. Technology is only as good as the providers using it. (EMS:S:9784)

> Keep it simple! The most important thing is to make sure the basic stuff works, all the time. For future development, I'd love to see technology that helps us have better scene awareness, especially early on at a structure fire scene- things like interior mapping and real-time firefighter location could be very helpful- as long as we only have to direct little or no attention to making these technologies work. (FF:S:9767)

Keeping it simple was mentioned over and over in the data, in both interviews and open-ended survey responses, highlighting the importance of usability to the first responder population.

While survey and interview participants often expressed a desire for more usable technology, data also indicated that many first responders are not "technologically savvy" enough to use and/or benefit from technology, and that greater technology literacy is needed.

> I mean there's a lot of folks that just don't use it [the new system for car to car communications]. A lot of the old-timers, so to speak, that are not technologically savvy, they are not interested in even attempting to figure it out. (INT-LE-S-033)

> Advanced technology is great, but until the pay is advanced enough to recruit and retain technologically savvy manpower, it can be overwhelming and detrimental to the overall picture. (COMMS:R:1668)

> As important is the use and access to technology is the IT skills of the users. There are many people challenged by the use of current technology systems that have a negative impact on organizations. (FF:U:1454)

> Not everyone is at the same level of understanding and using technology. Technology does not solve all the problems in policing. (LE:R:9243)

Because some first responders are "challenged" by the current technology they have and use, training was cited as something first responders need if they are to keep up with current and developing technology, in part because technology is constantly changing.

> It is always changing and we could use more training to keep up with the technology. (COMMS:R:6464)

> When new technology is implemented, training would be appreciated. We often receive new technology, ie active 911, and we receive no input on how to use it or how it works. (COMMS:R:6470)

> Need educational classes on real life use of technology to make it more useful. (FF:S:7705)

Age was specifically mentioned in some of these responses as a barrier to technology adoption, while resistance to technology in general was mentioned in others.

> And especially as our department-- some of the older generations, a lot of them are retiring and we're becoming a younger department again. So a lot of these guys, they're good with computers. The old guys, I've heard them complain about computers and stuff. The young guys are obviously much more comfortable but on top of that, they haven't ever had to learn how to do it without it, so now that even makes it worse because now they're really dependent on that technology. (INT-FF-U-004)

> I am too old to learn what our young EMTs use so easily. I have been active for 15 years and have been on more than 3,000 squad calls. Now that we are required to use computers for all reports, I am suddenly lost. I have taken workshops but find everything so difficult. I'm at a point of whether to quit volunteering anymore which saddens me. (EMS:S:6726)

> There is little ambition to use technology more because leaders are older, less open to the opportunities to improve patient care, and don't understand or regularly use the technology themselves. (EMS:U:4998)

> Fire service traditionally has been a stubborn user of emerging techs. Also FFs are skeptical by nature and it's very important to have a game plan when introducing new tech to the fire service. Ready...Fire...Aim doesn't work!! (FF:S:4915)

In addition to training, responses also identified adequate IT support as a necessary component of technology adoption, and one that is often missing.

> Our biggest problem is our department does not maintain our technology. The town I/T dept does. They are M-F 9-5 so any issues outside that usually are not addressed. Dispatch is also very low on the to be repaired/upgraded/maintained list. While all our public safety technology should be considered (in my opinion) critical infrastructure it is not in our community. (COMMS:S:1673)

> Technology is only as good as the people who understand how to use it. In rural [state redacted], skill sets for this are not as available as those areas with larger populations. Rolling out technology must be carefully planned to include, training, support, and practical use during everyday use, and disasters. (FF:R:3109)

> Technology is great but it's only as good as the IT department that supports it. Fire departments need to have robust support systems that function on a 24 hour work cycle as opposed to a 40 hour work week. We need technology to work all the time, and not just have help when IT is in their office during the week. (FF:U:6501)

> It works most of the time...but its expensive and you need good IT support that is timely. Especially for an organization that works 24 x 7. (LE:R:4603)

> Technology is great, but most smaller agencies, which most are, can not afford the equipment and ongoing maintenance. Most smaller agencies do not have the ability to employ an IT

> person to maintain all the equipment. State mandates of technology has greatly affected our budgets and reduced our ability to perform the tasks we are actually required to perform. Systems need to be designed for small agencies on a very very limited budget. (LE:R:2984)

Having access to good IT support, at all times, is imperative for first responders if they are to be expected to use technology if they are not comfortable and not familiar. The categories of technology literacy, training and IT support were interwoven with issues related to staffing, as well as issues of cost. First responder departments and agencies need to consider not only the cost of the technology itself, but the cost of ongoing training and IT support – budget items that are often not within the reach of many departments and agencies.

In addition to making sure that technology is easy to use and that first responders are well trained to use it, a variety of responses noted how participants prefer to have their current technology work better, rather than seeing the development of new, "fancy" technology. What is most important is "to make sure the basic stuff works, all the time" (FF:S:9767). These data also resonate with earlier findings from the interviews, where "fix what we have" was a major theme that emerged.

> 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)

> Need to slow down and maximize our current technologies. Too much push to leap into the future without trying to increase of the value of current technologies. (EMS:U:8813)

> I'd rather see useful tech resources (eg . . . license plate readers) in a small / affordable package implemented in a prolific manner in the field rather than some new, fancy tech of limited use. (LE:U:509)

> Need to finish working on the basics across the country first. Basic safe equipment. Too much technology is extremely dangerous. Fire trucks are breaking down now due to computers. (FF:S:5151)

One interview participant put it quite succinctly: "Give us good, basic technology" (INT-LE-U-013). Many participants in both phases of this study say that it is more important to improve their current technology rather than to develop new technology. In part, this is related to the high cost of technology that makes it difficult for departments to purchase more advanced or updated technology.

It is worth reiterating here that a response to this question, like all questions on the survey, was not required. Yet a large number of participants chose to take the time to provide additional input here at the very end of the survey. What emerged consistently across all these responses was that first responders want technology that is driven by their user characteristics, by their needs and requirements, and by their specific contexts of use. Most important for technology access and adoption is cost—and not just the cost of the technology itself. Peripheral costs must be considered as well, such as training, IT support, maintenance, and upkeep/updating to name just a few. All this must be taken into account as researchers, developers, and vendors think about how best to meet the technology needs of first responders.

4.7.2. Final Open-Ended Question: Differences Amongst the Disciplines

While there were many similarities across the four first responder disciplines in the responses to this question, there were a few differences worth noting when the data are examined by discipline. This is not surprising given the different contexts in which first responder work takes place, and the differences in the technology they use. Table 24 shows the five categories with the most open-ended responses; for each discipline, the categories are ordered from one to five, with one having the most responses and five having the least. These data show that *Cost-Budget-Funding* was the top category of response across all four disciplines— a constant in all of the data for this study. While several other categories were in the top five, only *Cost-Budget-Funding* occurred across all four disciplines. Other categories showed up in two or three disciplines but varied in their order. For example, *Interoperability* showed up three of the four disciplines, but was second in the FF responses and third in the EMS and LE responses. All of the top five categories show up in at least two of the four first responder disciplines. Additionally, each discipline had one or two categories of response that were unique to that discipline (or only occurred in one or two of the disciplines).

Table 24. Top 5 categories of responses for final open-ended question, by discipline

Category Order *(by Number of Open-ended Responses)*	**COMMS**	**EMS**	**FF**	**LE**
1	Cost-Budget-Funding	Cost-Budget-Funding	Cost-Budget-Funding	Cost-Budget-Funding
2	Old-Outdated-Lack of Technology	Coverage-Connectivity	Interoperability	Old-Outdated-Lack of Technology
3	Communication Problems	Interoperability	Reliability-Failures	Interoperability
4	Reliability-Failures	Reliability-Failures	Communication Problems	Too Reliant-Too Dependent-Too Much
5	Technology Literacy-Training	Too Reliant-Too Dependent-Too Much	Coverage-Connectivity	Technology Literacy-Training

As shown in Fig. 72, most of the differences in these responses were seen between COMMS and the other three first responder disciplines. This is not surprising given that COMMS personnel do not operate in the field and have a very different context of use; thus, they need different types of technology and experience different types of problems.

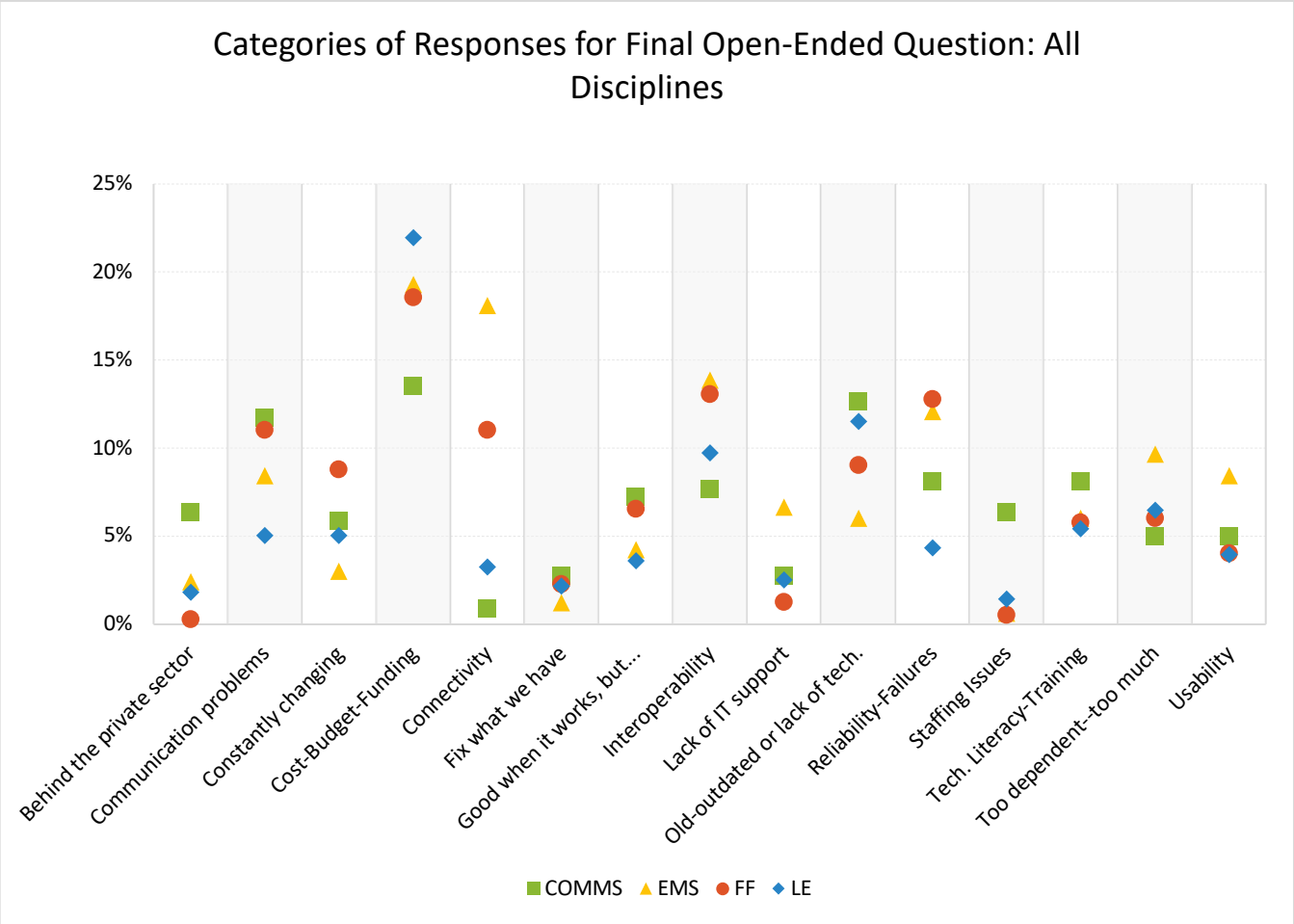

Fig. 72. Categories of Responses for Final Open-Ended Question: All Disciplines

Note: An individual response could address problems in multiple categories. Therefore, percentages may not sum to 100 %.

Staffing Issues occurred predominately in COMMS responses and were rarely mentioned in responses for the other three disciplines. Current trends in COMMS show difficulty in recruiting, hiring, and retaining personnel [22].

> Right. So even just one person is a massive difference. So, and a lot of things contribute to the lack of personnel. Partially it's retention, partially it's recruitment and then also it's just you know when you have people that work like overtime all the time, sometimes they get really overtaxed so got to take a break and stuff so yeah. (INT-COMMS-U-006)

> All the technology in the world can not be enough if there is not train people to access it and use critical thinking skills. There is a nationwide staffing shortage in dispatch centers. Less qualified people are seeking out the job. The pay for the long shifts, crazy hours and stressful jobs is not enough. Dispatchers/Call-takers are classified as office assistants, little more than secretaries, but the scope of their job goes way beyond that. More and more studies are showing the same PTSD symptoms of Police and Fire officers in dispatchers. This is due to

> exposure to the same instances, but with very little opportunity for closure. I think the focus should not be on the technology so much, but the human behind it. The human who needs to be trained to use it. The human who needs to rely on functioning technology to save lives. And if that technology fails, the human fails and they have to live with the outcome. (COMMS:U:1879)

Problems with staffing in COMMS was identified across the data set as a major issue: in the interviews; in the responses to this final open-ended survey question; and in open-ended survey responses from other areas of the survey (see Sec. 4.2.1). Staffing comments from the other disciplines mostly revolved around staffing for IT personnel (see Sec. 4.7.1).

Overload was a response category that occurred specifically in COMMS responses to this final open-ended survey question. This category was intertwined with *Staffing Issues* in many responses, as in the first exemplar quote below.

> Technology has been a great tool in taking our jobs to that next level but too much is overwhelming and running our staff down. Rather than focus on technology, maybe we should focus on the people who use the technology. The stress of these jobs can be very taxing on our staff and most leave before their retirement age. New contracts have now increased the retirement age to later because they are considered clerical staff and not First Responders. We were at 55 and now new hires can't retire with a full pension until they are 62 years old. They will never make it with how technology is growing and the need to be accurate, efficient and on task will impact public safety. Some of my best staff have retired years before they reached 55 years old due to the normal decline in their own cognitive abilities and not wanting to put their officers or the public at risk. 911 is an extremely hard and taxing job on our minds and body. I would prefer to see more efforts in how we should be taking care of our staff then bring on more technology. (COMMS:S:3624)

> Technology has been both beneficial and a hindrance. As we implement more technology it has helped us save time yet we don't use our brains as much due to computers/etc making decisions for us. Also I see that as we add technology to the center we have to potential to overload the person - in other words we have so many tools in the toolbox that we don't always pick the correct tool, but one that can get the job done quickly. (COMMS:R:1237)

Overload was major theme in the interview data as well, with many COMMS participants noting the amount of multitasking COMMS personnel do along with the amount of data they need to process.

> It's the hearing and being able to listen to four channels at one time and type the information and remember this officer wants this information and this officer needs this information, you kind of got to prioritize. You got to be able to work on the phone and prioritize who gets what information first, because it could determine what's going on, you know, for that officer. (INT-COMMS-R-019)

> Our center has more monitors than necessary and it causes an information overload that's not needed. (COMMS:S:6564)

This all creates cognitive overload for COMMS personnel as they have to worry about so many screens, so many calls, and so much information to process. This was seen in open-ended survey data from other areas of the survey as well. (see Sec. 4.2.1).

While location was cited as important across the disciplines in the interview data, only COMMS participants noted it with any regularity in their responses to this final open-ended survey question. This may be because they are concerned about location on many different levels: location of callers, location of the incident, and location of first responders.

> The private sector is always far more advanced than emergency services because we are not willing to pay for the innovation. [Ride-share companies redacted] work better than locating people for 9-1-1. That is a sad state of affairs. Additionally the focus is on technology, but it should also be on the people behind the technology. 9-1-1 Dispatchers are highly trained professionals and should be classified as emergency services personnel, not clerical staff. (COMMS:R:5846)

> The biggest improvement that all 9-1-1 public safety dispatchers would like to see is the location accuracy of wireless cell phone devices and for the FCC to enforce/fine wireless providers when they fail to meet established mandates on location accuracy. It is literally costing lives whenever a dispatcher cannot locate a caller who is calling in from a wireless device and the location accuracy is poor or non-existent. Wireless calls account for over 80% of our inbound emergency calls. (COMMS:S:2333)

> I primarily handle the IT work and radio maintenance for our Dispatch Center. So I am concerned with implementing the Next Gen 911 features. With strained budgets, staff and resources it makes it difficult to readily setup and use the new technologies. While video is good to have, better wireless 911 location data would be more useful to all dispatch centers. (COMMS:R:6021)

Location information is especially difficult since most calls are from cell phones today that do not accurately indicate location. Many responses to this question noted how current technology available to the public works better than what they currently have, or how public safety would like to see telecommunication do more to provide location accuracy. This was true in responses from COMMS personnel in rural, suburban, and urban locations.

Interestingly, *Connectivity* was not noted in many COMMS responses to this question. This may be because it is more important to those first responders out in the field, and to callers. For example, *Connectivity* was a major category of response to this question for EMS participants, mentioned almost as much as cost in the open-ended survey responses to this final question, much more consistently than in any of the other disciplines.

> Coverage is a MAJOR issue...!!! (EMS:U:2084)

> The two biggest challenges I've consistently faced with technology in EMS are internet connectivity and interoperability. Internet connectivity is increasingly mission-critical, but multifactorial problems continue to prevent it from working reliably; these include cellular dead

> zones, issues with vehicle-mounted cellular antennas, issues with cellular modems, and issues with WiFi access points in vehicles. Interoperability is a well-known problem in public safety, but little progress has been made in the last decade. Our radio systems and CAD systems have limited ability to talk to other regional EMS/Fire agencies and no ability to talk to LE. Solutions such as channel patching only seem to work about 30% of the time. Additionally, our CAD systems are completely isolated from other agencies and LE that are dispatched from a different communications center. (EMS:S:5535)

While some of these responses came from suburban and urban participants, the majority of the responses came from participants in rural areas, who seem to face particularly difficult challenges related to cell and network connectivity.

> Rural America has been left behind. I've worked in technology for 20 years before moving to public safety. 10 years ago I had connectivity to my desktop (100mb) at work that's 2x as large as the link to any county office today. (EMS:R:2434)

> Being in a rural area we struggle with connectivity all the time. I would like to utilize more of the technology available, but we just can't get the consistent connections we need. I know the First Net system is supposed to help with that but it will be many years before we see substantial improvement where we are. (EMS:R:1267)

> We are located in an area where our 911 dispatch does not always have cell service and there are lots of dead spots in our coverage area. Makes utilizing cell and internet communications difficult even with a hot spot on the rigs. (EMS:R:6011)

Sometimes the lack of connectivity is due to the distances rural first responders need to cover, in addition to the geographic issues they face (mountains, forests, remote areas, etc.).

> Geography often is a drawback to connections with WiFi and/or cellular service. (EMS:R:2398)

> The closest hospital is 75 miles away. Sketchy cell tower coverage is a problem. (EMS:R:8485)

Other times the volunteer nature of many rural EMS departments also has an impact on what they can afford and provide for their personnel.

> So much of this does not apply to small town rural volunteer. There are so many issues at the county level that are out of our control or someone else is managing. We do not use ePCRs, we have little to no cell coverage in our town, and cannot afford much in regard to fun extras. (EMS:R:546)

> In a rural area, radio coverage is severely hampered by distance and cell phones experience regular, known dead zones. Our CAD system for text message dispatching through our county regularly fails - messages aren't transmitted fully or at all for periods of time. Our county is served by volunteer fire companies and ambulance squads who upgraded to high band radio systems through AFG grants in the last decade, but our county 911 center now wishes to switch systems again to dynamic channels rather than fixed, necessitating expensive firmware updates

> for some companies and outright replacements for others. It is not known how this will be funded. (EMS:R:504)

While some FF and LE participants identified *Coverage—connectivity* as an issue, it did not emerge to the extent that it did for EMS participants in this final open-ended survey question. One explanation for why these issues may be especially prevalent in the EMS data is that over half of the EMS survey respondents were in rural areas (see Appendix D), which often have poor coverage—connectivity. Indeed, coverage—connectivity problems also emerged in the interview data where rural participants [13]. For an expanded discussion of these and other rural challenges, see the Phase 1 Volume 3 [13] report detailing the interview data for rural first responders.

Too dependent—too much technology was also a category that emerged more in the EMS responses than in the other disciplines. Some of these responses noted how the time spent on technology was time taken away from patient care, while others noted how the overreliance on technology could result in less ability to know what to do when technology failed.

> While there is a great benefit of technology already in use, I see a lot of providers spend so much time inputting the data or using the device they lose focus on the one thing that matters, the patient. This is not limited to the public safety environment. I see the same issue in the healthcare field in general. Providers take so much time documenting or setting the equipment up to use, the patient care suffers. (EMS:S:8480)

> Personally feel that technology can enhance one's abilities as a medical provider, however can hinder when providers become too reliant on devices, software, etc. causing them to freeze when technology fails. And it does eventually fail; programs freeze, batteries die, etc. (EMS:S:8857)

> We work around it to make it function in our environment. Many times work would be completed more quickly by excluding the use of technology. (EMS:R:5235)

The greater prevalence of this category in the EMS responses than in the other disciplines may be because they are dealing with patient care reporting requirements, patient care reporting technology, and medical technology in addition to communication technology, creating additional burdens for use.

> Our technology at my agency is a joke. It often doesn't work right, and most of my day is spent dealing with crappy I.T. equipment/programs/problems. I accept that technology is an increasing part of my job as a paramedic, but it suffers from poor design & interferes with my patient care. (EMS:U:3939)

The focus for EMS participants is on patient care and not necessarily on the technology.

No specific categories emerged for FF and LE, and in general the category distribution for these disciplines was consistent with the general trends that emerged across disciplines (see Fig. 72 above and Sec. 4.7.1).

5. Discussion and Future Directions

With the development of the NPSBN, it is imperative to understand the current patterns of technology usage by first responders, the problems they experience with technology, and the types of technology first responders believe are important moving forward. This survey, with responses from over 7 000 first responders, provides insight into what first responders have, want, and believe they need related to communication technology, along with the technology problems they currently face. As the NPSBN works to expand communication technology for the first responder community, understanding the technology problems and needs identified by first responders can help facilitate decisions about how best to move forward in this endeavor. In this section major themes related to day-to-day communication technology are identified and their implications for R&D of first responder communication technology are discussed. Finally, this section concludes with a review of user-centered guidelines previously developed from the Phase 1 interview data and detail how they continue to resonate in these survey data, providing public safety technology researchers and developers with some specific data-driven ways to improve technology for first responders.

5.1. Overarching Themes from the Survey Data

When analyzing results from the survey, several overarching themes emerge related to first responder communication technology. These themes cut across all four of the first responder disciplines and are supported by both quantitative and open-ended data from the survey, as well as by qualitive data from the interview phase of the study.

- Technology can be both a benefit and a burden.
- Technology of the future = current technology improved.
- Technology must be usable and useful.
- Technology costs are a major barrier to their use.

Each of these themes is discussed in more detail below, along with the implications they hold for R&D in the public safety domain.

Technology can be both a benefit and a burden. Technology has the potential for positive impact on the work of first responders. However, while it holds the potential for great benefit, there is also the possibility for technology to place additional burden(s) on first responders. While those in the R&D community often see technology as a tremendous benefit for the work of first responders, data from this study show that first responders themselves do not always agree with this assessment. First responders often view technology as a double-edged sword that brings with it both positives and negatives.

> Technology is similar to all tools created by mankind: it has the potential to be positive or negative. (FF:S:8202)

When the burdens outweigh the benefits, technology is often not adopted or not utilized to its fullest extent. The R&D community must consider the potential burdens that technology (current and future) can place on first responders, and the unintended consequences it might hold for their work. For

example, as discussed in Sec. 4.2.2, many COMMS respondents believe that the reception of pictures/videos in a call center will result in possible mental health issues for COMMS personnel. First responders need to trust that the benefits of technology will outweigh the burdens if they are going to adopt and utilize these tools, or at the very least that the burdens have been considered and policies/procedures put in place to help mitigate them.

Technology of the future = current technology improved. The NPSBN is designed not only for new technology being developed for future use, but also to support the technology first responders currently use today. While some first responders can envision the usefulness of futuristic types of technology, they are far more concerned about making sure the current technology they have and use works better. For example, the technology used the most and believed to be the most useful are radios, desktop computers, and smartphones. These are not new or cutting-edge forms of technology, rather they are the tools that first responders are familiar with and likely to use going forward. However, first responders continue to experience major problems such as reliability, interoperability, and connectivity (to name just a few) with their current technology.

> Focus on making the technology we currently have work, and work properly before introducing more technology into the L.E. workplace that may bring the same struggles. (LE:S:3)

As the NPSBN works to identify and develop new technologies for first responders, it is important to continue to work to reduce the problems associated with traditional devices that are still widely used across public safety (e.g., radios and desktop computers). First responders need to trust that the R&D community will take seriously the challenge to improve their current technology as part of their push for new technology.

Technology must be usable and useful. If first responders do not know how to use a tool or if it is not easy to use within their context of work (like radio buttons that are small and difficult to push when wearing gloves) then they are not likely to use it. Likewise, if a tool works, but is not useful within their context of work (for example, body cameras that fall off easily) first responders are more likely to not use it or be frustrated with having to use it. The most practical way to ensure their communication technology is usable and useful is to include first responders in the design process.

> Simple is better, no technology can ever replace knowledge gained from experience. the more we try to implement technology without seeking the opinion of the people that will be relying on it first we fail. (FF:S:7798)

In the survey, those devices that first responders say they use are lot are also those that are ranked higher in importance. These are the devices that first responders believe help them the most to accomplish their day-to-day tasks. First responders need to trust that the technology they are asked to use is both useful for their day-to-day tasks and usable within their contexts of work.

Technology costs are a major barrier to their use. It is telling that first responders, across disciplines, identify problems with the cost of day-to-day technology as the most important and persistent problem they face. Across the survey data, cost emerged as the greatest barrier to technology access and adoption for first responders. The high cost of technology for first responders also serves to create

a system of "haves" and "have nots," where some first responders have access to a wide variety of the newest and most effective technology, while others do not [13].

> Technology is over priced for the fire service in general, keeping many new advances in technology inaccessible to departments for long periods of time. For example, wireless communications have been in the industry for years, but we cannot afford them for our personnel. This makes it harder to do our job in our fast moving environment because we are always a few steps behind. (FF:U:6626)

However, it is not just the cost of the technology itself that prohibits public safety agencies from having access to what they need. Rarely is technology a one-time investment or a stand-alone cost. Peripheral costs must be considered as well, such as training, IT support, maintenance, and upkeep/updates to name just a few. First responders need to trust that they will be able to afford the technology they need for day-to-day incident response, and all its associated costs.

What consistently emerges across the dataset is that technology is about more than just the tools. It is also about the myriad of issues associated with different forms of technology. Sometimes these other issues are more important than the technology itself. As noted above, cost is a huge barrier for access to technology, and usability and usefulness figure heavily in the adoption of technology. However, other factors such as the rapid pace of change, the lack of clear guidelines and policies, and the need to reduce unintended consequences all influence first responder access to and adoption of technology. What seems most important here is listening to the voices of first responders in any of the work to develop and improve communication technology.

> It appears that most changes in technology are not field tested (or at least not tested enough) by end users and are more likely the choice of the technology and the finance departments. (LE:S:7988)

Listening to and taking into consideration the voices of first responders could go a long way in helping them trust improved and newly developed technology.

5.2. User-Centered Design Guidelines

The themes discussed in the previous section map very closely to the six user-centered design guidelines identified in the interview phase of this study as central to what first responders want from technology [1]. These guidelines can aid researchers and developers in the public safety domain to attend to those issues that are most important to first responders [1][5][7][11].

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 guidelines continue to resonate with the survey data related to day-to-day devices presented in this report. Below these six user-centered guidelines are discussed in relationship to the overarching themes previously presented.

The guideline "Improve current technology" maps very clearly to the theme of "Technology of the future = current technology improved." Survey data from both quantitative and open-ended responses, along with data from the interviews, show that it is not necessarily new technology that first responders want. Instead, it is the improvement of current technology that they believe is most important. Survey data show that the rates at which first responders experience problems with their current technology increase their likelihood of losing trust and lacking confidence in it. While there were no explicit questions about trust or reliability in either the survey or the interviews, responses clearly indicate that first responders need to trust that the technology they use for day-to-day incident response will work well, work consistently, and be affordable. The theme of "Technology of the future = current technology improved" also resonates with the guideline "Minimize technology for technology's sake." First responder survey and interview responses show that participants believe new technology is not always better technology, and that more technology is not always what they need. As the NPSBN is being built out, there is a tremendous opportunity for the R&D community to address problems with first responders' current communication technology.

Given the survey results related to the problems first responders experience with their communication technology, the guideline "Reduce unintended consequences" is clearly still critical for technology adoption and implementation. This is especially noticeable in the extensive narrative comments contributed by first responders. This guideline aligns very closely with the theme "Technology can be both a benefit and a burden." Survey data show that participants believe that futuristic technology will come with unintended consequences. For example, COMMS personnel detail the many issues they believe will occur if they begin to receive texts and/or pictures/videos. Survey and interview data both show that first responders worry that new technology may create additional physical, cognitive, or emotional burdens, and may put an undue strain on personnel and resources.

The survey data very much reinforce the importance of the guideline "Require usable technology." 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.

Overwhelmingly, survey responses continue to reflect the importance of the guideline to "Lower product/service costs," which reflects the survey theme that "Technology costs are a major barrier to their use." The problem of price was a major finding in the survey data, as well as the interview data, emphasizing the continued importance of price in access to, and adoption of, technology for first responders. Over and over again, participants reiterate that technology must be developed at price points that they can afford. They also note that cost does not only refer to the initial cost of purchasing

the technology, but must also factor in costs such as maintenance, upgrades, IT support, training, and data plans. The PSCR R&D community has an opportunity here to address a major pain point that first responders experience related to communication technology. When designing new or improving current technology, it needs to be affordable, with scalability for widespread distribution whenever possible.

In spite of the many similarities found across the four first responder disciplines, there is also evidence of important differences between public safety disciplines. As with the interview data, survey data suggests that there are some disciplinary differences in the technology used for day-to-day incident response. This highlights that the "Recognize one size does not fit all" guideline permeates the survey data as well. 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.

5.3. Future Directions and Opportunities

The survey data presented in this report are part of a multi-year, multi-phase project that has provided 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 [23] and a compilation of scenarios for incident response [3]. In addition, a series of volumes [1][5][13][22][2] and refereed articles [7][8][11][16][17]. related to the interviews in Phase 1 of the study have been published. The first volume in the Phase 2 reporting series provides detail about the methods used for development and dissemination of the survey [12], serving as a research roadmap for future researchers in this space. A report on survey responses related to mobile devices, software/apps, futuristic technology, and technology for major disasters and large planned event has been published as well [6]. Additionally, the results from Phase 1 *and* Phase 2 are publicly available via an interactive web-based query tool [19].

The data in the reports listed above are by no means exhaustive, and additional analyses of the survey data are planned, including analyses based on demographic variables. Currently, analysis is ongoing to examine if differences exist in device and software/app usage and problems of those first responder participants in more traditional frontline roles and those who are in chief/management or supervisory roles. Additional analyses may examine differences based on gender, age, years of experience, area, volunteer versus career FF, or public versus private EMS. Analyses based on these demographic variables may provide a more nuanced view of the similarities and/or differences in technology usage, problems, and needs of first responders.

First responders have taken the time to provide input about the technology they have, the problems they experience with technology, and the technology they believe would be most helpful in the future. What is clear from their input is that first responders often see technology as a burden: financially, physically, and cognitively. Participants are not opposed to technology, but they want technology that makes sense to them and makes their work easier to accomplish. First responders, in general, want technology that is affordable, interoperable, reliable, and easier to use. Most importantly, they want technology that makes sense within their context of use.

Moving forward, it is up to the public safety R&D community to take this information and put it into practice. If researchers and developers truly want to produce technology that helps first responders, they must listen carefully to first responder voices. For example, developing meaningful improvements in their current technology would increase their trust and interest in future technology. To establish trust and encourage adoption, technology FOR first responders needs to be developed WITH them, driven by their user characteristics, needs, requirements, and contexts of use. This will allow for the development of trust on the part of first responders: trust in the technology as well as trust in the R&D community [1]. This report contributes to the ability of the R&D community to make informed decisions about public safety communication technology, and to engage in meaningful development and improvement of the NPSBN moving forward.

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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 [1].

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 [12].

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, EMS, FF, 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 [1][5][13][22], 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 [5]. 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 [1][5]. 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. 73).

Fig. 73. Major survey components and flow

Surveys were nearly identical for EMS, FF, and LE (see Fig. 74), while differing somewhat more for COMMS (see Fig. 75), due to the different nature of their working environment [22]. 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 [12].

Fig. 74. Survey flow for EMS, FF, and LE

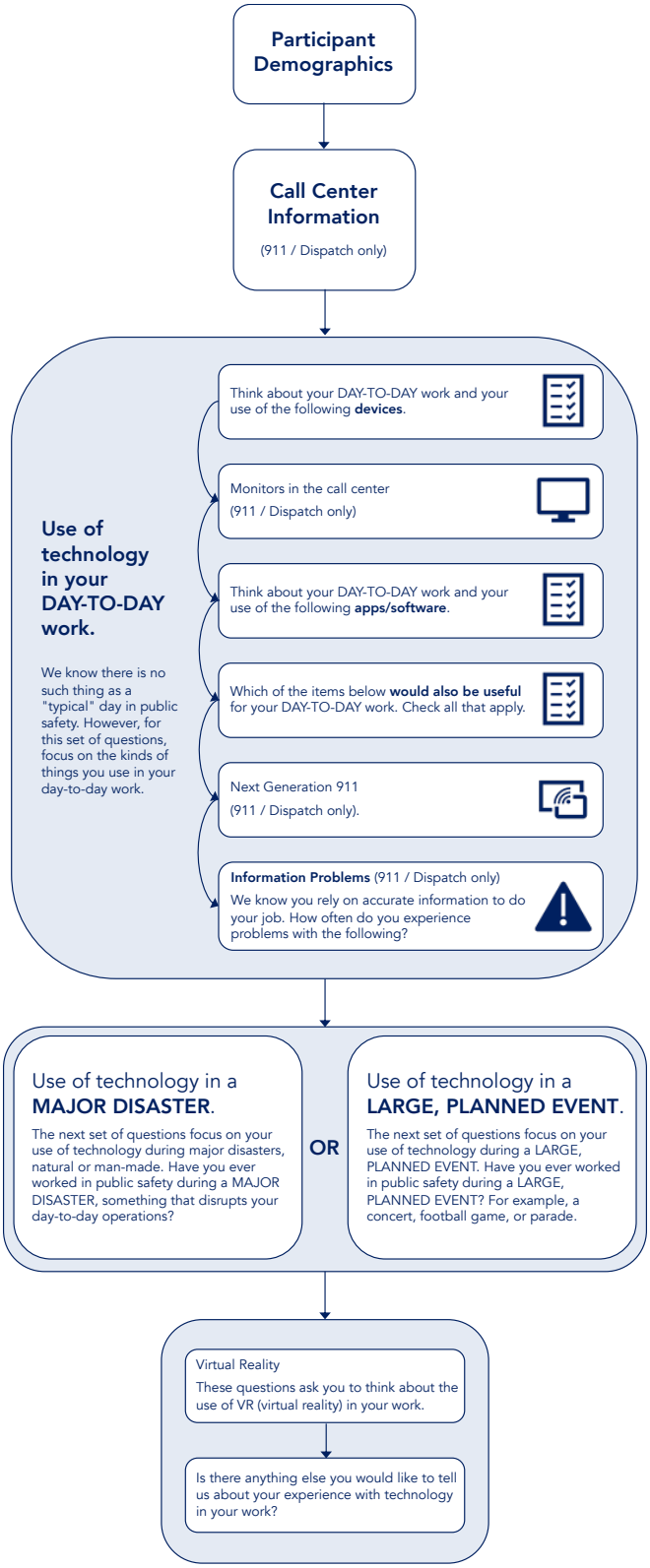

Fig. 75. Survey flow for COMMS

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. 76. 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.

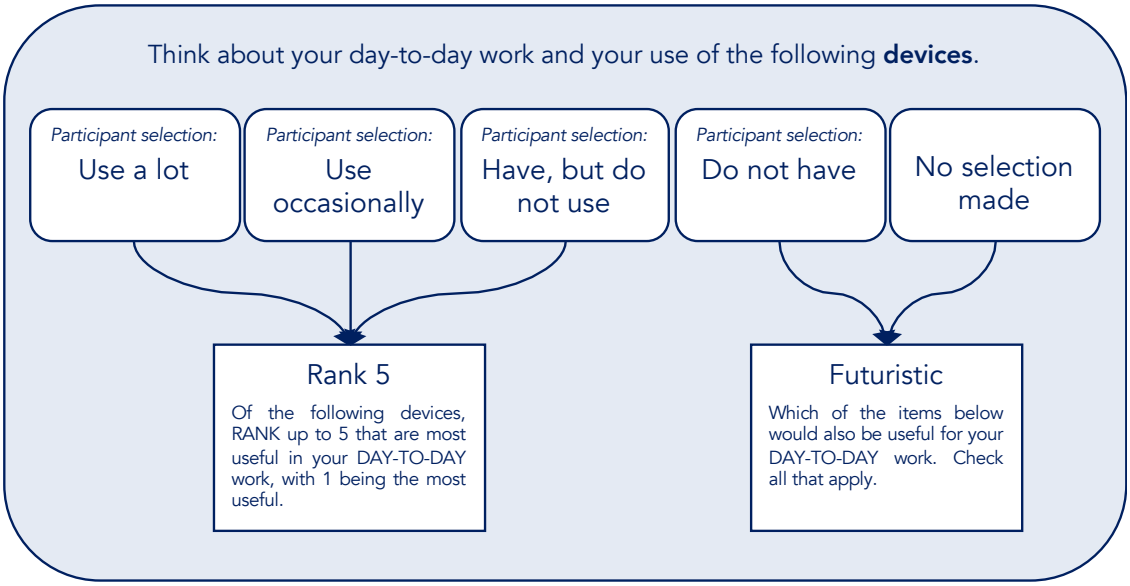

Fig. 76. Survey logic for day-to-day devices

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). After ranking their top five devices, participants then answered the problems questions for their top three devices. Figure 77 shows the survey logic for the problems section of the survey. Note that only participants in EMS, FF, and LE disciplines were asked questions about problems; rather than questions about device problems, COMMS were asked questions about information problems.

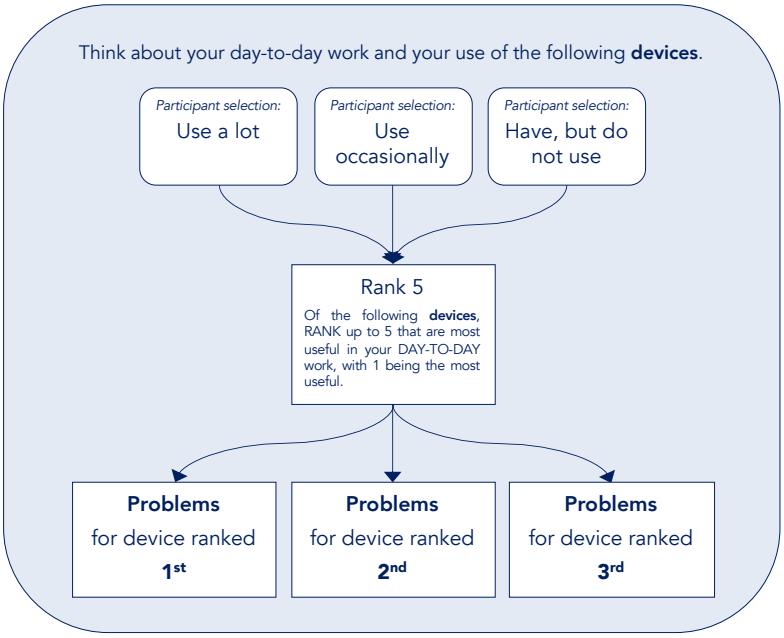

Fig. 77. Survey piping for day-to-day problems questions

Lastly, a summary of the survey flow for large event technology questions is shown in Fig. 78. Survey respondents in all four disciplines were asked about their experiences with technology during major disasters *or* large planned events.

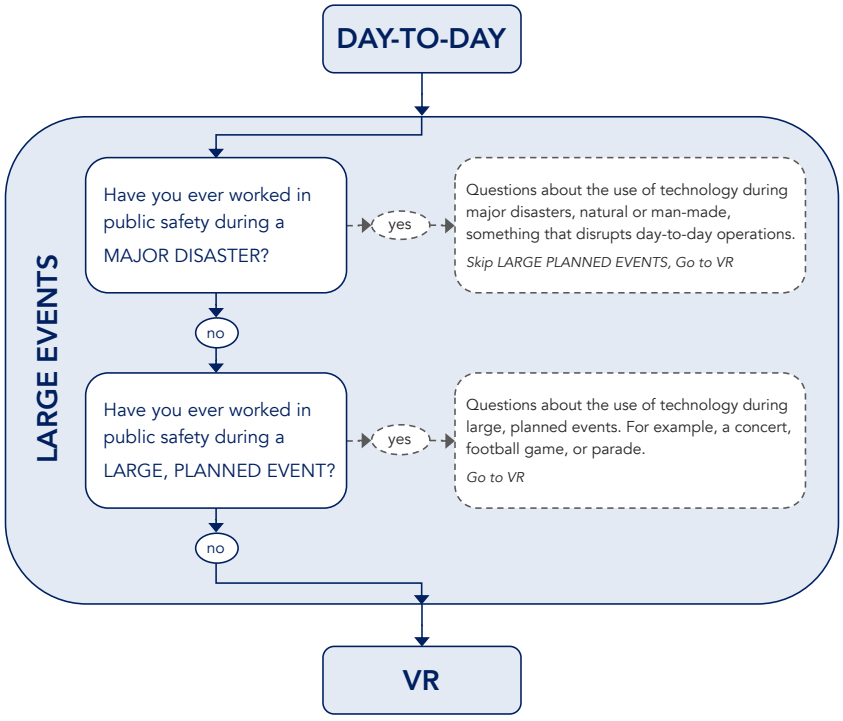

Fig. 78. Survey flow for large events

Appendix C: Survey question stems

Question descriptions and stems for the technology use for day-to-day work, device rankings, and problems experienced sections of the survey are presented here. A brief description of each discipline-specific section (i.e., COMMS call center information and EMS medical technology) is also provided. Details about question response options and stems for questions pertaining to mobile devices, applications, futuristic devices, and large events are detailed in Phase 2, Volume 2 [6].

Call Center Information

COMMS respondents answered questions related to information received in their call centers, including:

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

Response options included "EMS", "fire", and "police".

They also answered questions about text and picture capabilities in call centers. First COMMS respondents were asked about receiving 9-1-1 text messages, then whether or not they believed receiving text messages was beneficial:

> "Can your call center receive **9-1-1 text messages** from the public?"

> "Do you think this is/would be beneficial for your job?"

Response options for both questions were "no", "yes", and "not sure". Following these questions, they were also asked an open-ended question:

> "List the pros and cons of receiving 9-1-1 text messages from the public."

Following the question text, participants were presented with two text-entry boxes, one for "Pros" and one for "Cons". In this way, participants could provide an open-ended response to pros or cons, or provide both pros and cons.

They then answered a series of parallel question about the call center's ability to receive pictures and/or video from the public:

> "Can your call center receive **pictures and/or video** from the public?"

> "Do you think this is/would be beneficial for your job?"

Response options for both questions were "no", "yes", and "not sure". Then respondents were presented with an open-ended question:

> "List the pros and cons of receiving pictures and/or videos from the public."

This question also had the two text-entry boxes for pros and cons.

Following these questions, they were also asked a series of questions about call center operations. For each question, response options included "no", "yes", and "not sure":

- 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?

Finally, COMMS responders had two open-ended questions about 9-1-1 service going down:

- If yes, what caused 9-1-1 to go down?
- What did your call center do while 9-1-1 was down?

For both questions, participants were provided with text boxes in which to type their responses.

Technology Use for Day-to-day Work

COMMS, EMS, FF, and LE completed questions about the communication technology they use day-to-day for their work. 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**."

The question stem had additional clarification for EMS and FF disciplines to ensure responses were relative to communications technology specifically.

For EMS:

> "Think about your **DAY-TO-DAY** work and your use of the following **devices**. (We know medical equipment is vital to EMS work, however this list focuses specifically on communication technology and not on things like blood pressure cuffs, CPR masks, tourniquets, etc.)"

For FF:

> "Think about your **DAY-TO-DAY** work and your use of the following **devices**. (We know SCBAs are vital to firefighter work, however this list focuses specifically on communication technology and not on things like masks, respirators, etc.)

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

Although a list of common devices was presented across disciplines, there were also discipline-specific devices included in the lists based on insights from the qualitative interview phase of the project (see Appendix B) [1][5]. Table 25 displays the devices included in the survey for each discipline.

Table 25 Devices Surveyed in Day-to-day Work Section

Device	**COMMS**	**EMS**	**FF**	**LE**
Desktop computer	•	•	•	•
Pager	•	•	•	•
Personal smartphone	•	•	•	•
Work smartphone	•	•	•	•
Corded earpiece		•	•	•
Corded mic		•	•	•
Flip phone		•	•	•
In-vehicle radio		•	•	•
Laptop		•	•	•
MDT/MDC		•	•	•
Portable radio		•	•	•
Personal wireless earpiece		•	•	•
Tablet		•	•	•
Wireless mic		•	•	•
Work wireless earpiece		•	•	•
Foot pedal	•			
Headset	•			
Microphone: desktop	•			
Microphone: handheld or clip-on	•			
Monitor (at your personal workstation)	•			

Device	COMMS	EMS	FF	LE
Monitor (for shared viewing)	•			
Phone: landline	•			
Radio	•			
TIC			•	
Body camera				•
Dash camera				•
Fingerprint scanner				•
License plate reader				•

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.

COMMS respondents were presented with two additional questions about the number of monitors they work with. Respondents typed in their answers into text boxes. The question stems were:

> "How many monitors do you have at your personal work station?"

> "How many monitors do you have for shared viewing in your call center?"

Day-to-day Device Rankings

To capture which devices were most useful to first responders, EMS, FF, and LE survey participants ranked devices. COMMS respondents were not presented with this question. Response options for the ranking question were populated based upon responses to the day-to-day device use question. Devices in which responders selected the "use a lot", "use occasionally", and "have, but do not use" were included in their list of devices to rank. Therefore, respondents only ranked devices they had. The survey question stem was:

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

For each device in the ranking technology list, respondents could position the devices in rank order from one through five, via click or drag and drop.

Problems Experienced – EMS, FF, LE Disciplines

EMS, FF, and LE answered questions related to problems they have with devices. 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). For example, the question stems for laptops were:

> "With your **LAPTOP**, 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

In the technology use for day-to-day work section, some devices (e.g., radio, mic, earpiece) were presented in multiple variations (e.g., portable radio, in-vehicle radio). However, in the problems section, because the problems experienced by those device variations were not unique, they were collapsed into a single instance in the problem section. For example, although in-vehicle radio and portable radio were both included in the technology use for day-to-day work and day-to-day device ranking section, in this section, respondents only answered one section of questions for problems with their radios.

EMS, FF, and LE were asked questions about problems with their top 3 ranked devices only. However, respondents were not asked about their problems with flip phones, and EMS respondents were not asked about earpieces. Problems questions were also included for devices specific to each discipline. TIC problems were only asked of FF participants, and problems with body cameras, fingerprint scanners, and LRPs were only asked of LE participants. As mentioned previously, the questions presented for devices common to EMS, FF, and LE included the same problems. Table 26 through Table 34 display device problems in the survey for each discipline.

Table 26 Radio Problems by Discipline

Device	**Problem**	**EMS**	**FF**	**LE**
Radio	Audio quality	•	•	•
Radio	Battery life	•	•	•

Device	Problem	EMS	FF	LE
Radio	Channel switching	•	•	•
Radio	Cord	•	•	•
Radio	Coverage/dead zones	•	•	•
Radio	Durability	•	•	•
Radio	Interoperability	•	•	•
Radio	Outdated/old	•	•	•
Radio	Price: too expensive	•	•	•
Radio	Radio discipline/etiquette	•	•	•
Radio	Size/bulkiness	•	•	•

Table 27 Mic Problems by Discipline

Device	Problem	EMS	FF	LE
Mic	Audio quality	•	•	•
Mic	Cord	•	•	•
Mic	Durability	•	•	•
Mic	Falling off	•	•	•
Mic	Outdated/old	•	•	•
Mic	Placement on body	•	•	•
Mic	Price: too expensive	•	•	•
Mic	Talk button location	•	•	•
Mic	Talk button size	•	•	•

Table 28 Pager Problems by Discipline

Device	Problem	EMS	FF	LE
Pager	Battery life	•	•	•

Device	Problem	EMS	FF	LE
Pager	Durability	•	•	•
Pager	Falls off easily	•	•	•
Pager	Outdated/old	•	•	•
Pager	Price: too expensive	•	•	•
Pager	Size/bulkiness	•	•	•

Table 29 MDT/MDC Problems by Discipline

Device	Problem	EMS	FF	LE
MDT/MDC	CAD	•	•	•
MDT/MDC	Durability	•	•	•
MDT/MDC	Interoperability	•	•	•
MDT/MDC	Lack of portability	•	•	•
MDT/MDC	Mapping/navigation	•	•	•
MDT/MDC	Logins/passwords	•	•	•
MDT/MDC	Outdated/old	•	•	•
MDT/MDC	Price: too expensive	•	•	•
MDT/MDC	Size/bulkiness	•	•	•
MDT/MDC	Using while driving	•	•	•
MDT/MDC	Glare		•	•

Table 30 Smartphone Problems by Discipline

Device	Problem	EMS	FF	LE
Smartphone	Battery life	•	•	•
Smartphone	Coverage/dead zones	•	•	•
Smartphone	Data plans/data limits	•	•	•

Device	Problem	EMS	FF	LE
Smartphone	Dropped calls	•	•	•
Smartphone	Durability	•	•	•
Smartphone	Glare	•	•	•
Smartphone	Interoperability	•		
Smartphone	Logging in (PINS, passwords, usernames, etc.)	•	•	•
Smartphone	Outdated/old	•	•	•
Smartphone	Permission/access to apps	•	•	•
Smartphone	Policies about usage	•	•	•
Smartphone	Price: too expensive	•	•	•
Smartphone	Subsidy for personal smartphone (insufficient or no subsidy)	•	•	•
Smartphone	Subpoena possibility for personal smartphone		•	•

Table 31 Laptop Problems by Discipline

Device	Problem	EMS	FF	LE
Laptop	Battery life	•	•	•
Laptop	Durability	•	•	•
Laptop	Glare	•	•	•
Laptop	Internet connection	•	•	•
Laptop	Interoperability	•	•	•
Laptop	Logins/passwords	•	•	•
Laptop	Outdated/old	•	•	•
Laptop	Power source/recharging issues	•	•	•
Laptop	Price: too expensive	•	•	•
Laptop	Size/bulkiness	•	•	•

Device	Problem	EMS	FF	LE
Laptop	Software crashes	•	•	•
Laptop	Software updates/upgrades	•	•	•
Laptop	Weight	•	•	•

Table 32 Tablet Problems by Discipline

Device	Problem	EMS	FF	LE
Tablet	Battery life	•	•	•
Tablet	Durability	•	•	•
Tablet	Glare	•	•	•
Tablet	Internet connection	•	•	•
Tablet	Interoperability	•	•	•
Tablet	Logins/passwords	•	•	•
Tablet	Report writing	•	•	•
Tablet	Size/bulkiness	•	•	•
Tablet	Touchscreen	•	•	•
Tablet	Weight	•	•	•
Tablet	Outdated/old			•
Tablet	Price: too expensive			•

Table 33 Desktop Computer Problems by Discipline

Device	Problem	EMS	FF	LE
Desktop computer	Internet connection	•	•	•
Desktop computer	Interoperability	•	•	•
Desktop computer	Logins/passwords	•	•	•

Device	Problem	EMS	FF	LE
Desktop computer	Outdated/old	•	•	•
Desktop computer	Price: too expensive	•	•	•
Desktop computer	Software crashes	•	•	•
Desktop computer	Software updates/upgrades	•	•	•

Table 34 Earpiece Problems by Discipline

Device	Problem	EMS	FF	LE
Earpiece	Audio quality		•	•
Earpiece	Battery life		•	•
Earpiece	Durability		•	•
Earpiece	Fit/falling out		•	•
Earpiece	Outdated/old		•	•
Earpiece	Price: too expensive		•	•
Earpiece	Volume		•	•
Earpiece	Wireless (Bluetooth pairing, etc.)		•	•

The final question for each device in the problems section was a yes/no question asking about other problems associated with the device. For example, the laptop question was:

> "Have you experienced other problems with your **LAPTOP**?"

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

Problems Experienced – COMMS Information Problems

COMMS respondents answered questions related to information problems they experience. The question stem was:

> "We know you rely on accurate information to do your job. Looking at the list below, how often do you experience problems with:"

Then they were presented with five questions:

- Callers: inaccurate or missing information
- Cell phones: inability to accurately track caller location
- Information overload: too many calls at once
- Information overload: too much information to monitor at once
- Maps/databases: missing or inaccurate information

Respondents answered by selecting an option from a six-point scale ranging from always to never, and they could also select "does not apply".

A final open-ended text box was presented after with question with the instruction, "Other (please specify)".

EMS Medical Technology

EMS respondents answered an additional question before the final question of the survey asking about their views on medical technology. The question stem was:

> "While this survey is focused on communication technology, we are also interested in your views on **medical technology**. Please list the medical devices or applications/ software that you think are most important for your work."

Respondents could then type in responses listing the type of medical technology most useful to them.

Final Open-Ended Response Section

As the last question of the survey, all participants were asked for their final thoughts with an open-ended question. The question stem was:

> "Is there anything else you would like to tell us about your experience with technology in your work?"

Participants could then type their answers into a text box.

Appendix D: Additional Nationwide Survey Demographics

Full demographic data and analyses can be found in previous reports [6][12]. A report detailing survey results by first responder role will be included in a future publication.

Roles of survey respondents

In the demographics section of the survey, participants were asked the question, “What is your title?” and typed in their responses. These responses were later categorized into one of the four categories in Table 35.

Table 35 Survey respondent role categories

Role	Title Examples
Frontline Responder	Dispatcher, communications officer, EMT, paramedic, firefighter, fire apparatus driver operator (FADO), police officer, deputy (sheriff)
Supervising Responder	Communications manager, captain, lieutenant, corporal, sergeant
Chief/Management	Chief, Commander, Commissioner, Director
Non-Frontline Responder	Technician, education coordinator, training, fire safety officer, investigator, administrator/admin, fire marshal

Roles across disciplines are displayed in order from the largest role category to the smallest in Fig 79. Across respondents, 45.29 % were in chief or management level roles, 23.74 % were frontline responders, 22.44 % were supervisor-level, and 8.54 % were non-frontline responders. Roles in descending order from the largest role category to the smallest are displayed split by each discipline in Fig. 80.

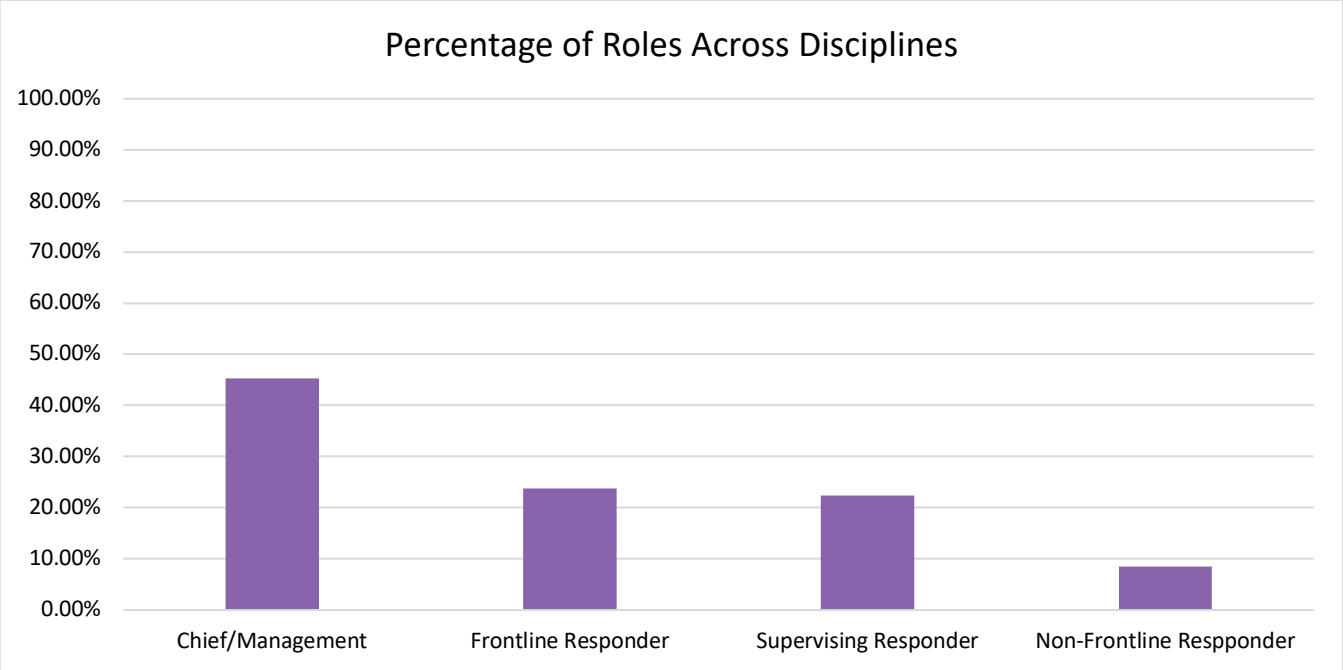

Fig 79. Roles across disciplines (*n=6 971)*

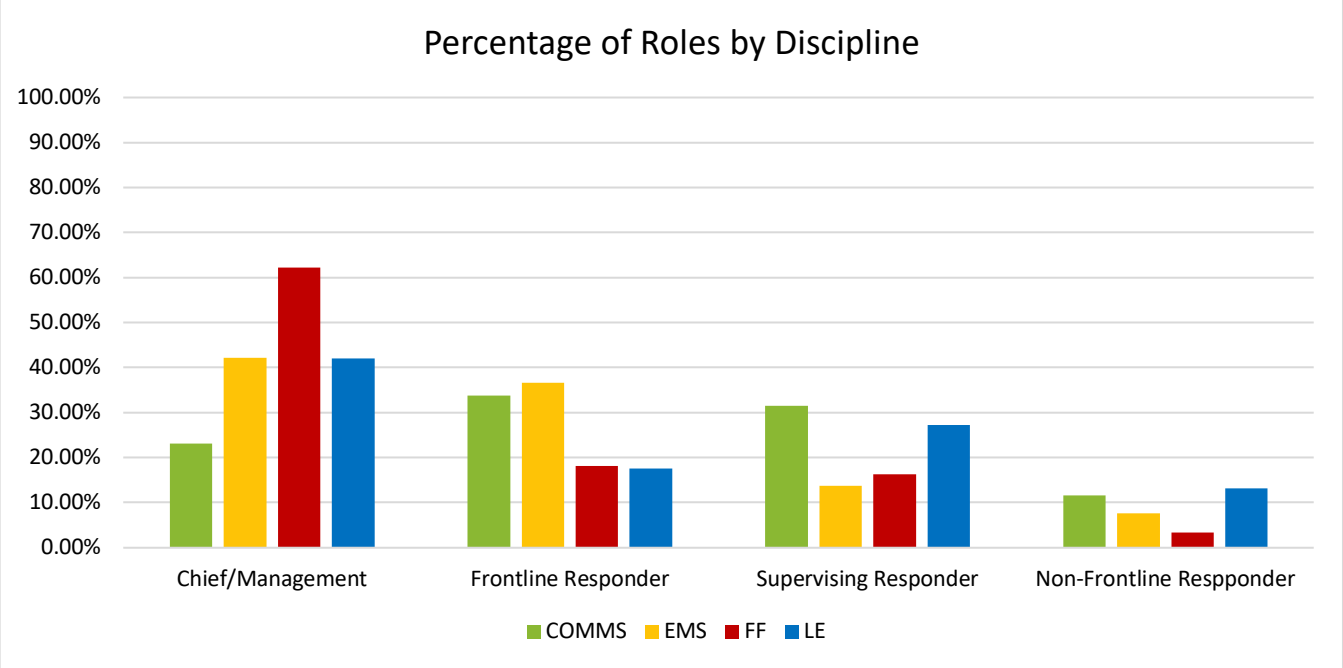

Fig. 80. Roles by discipline (*n=6 971)*

Other demographic information

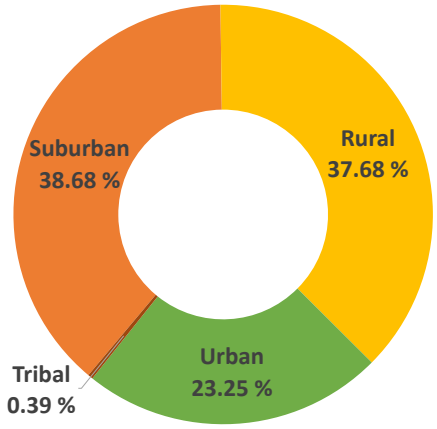

Fig. 81. Participants who completed the survey by area type *(n=7 161)*

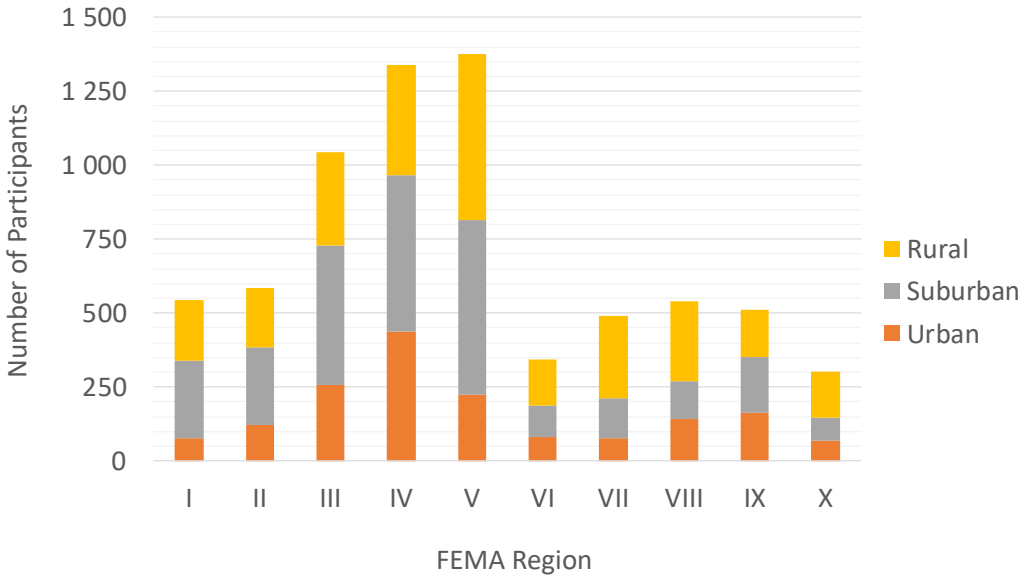

Fig. 82. Number of Participants who completed the survey, by FEMA Region and area type *(n=7 109)*

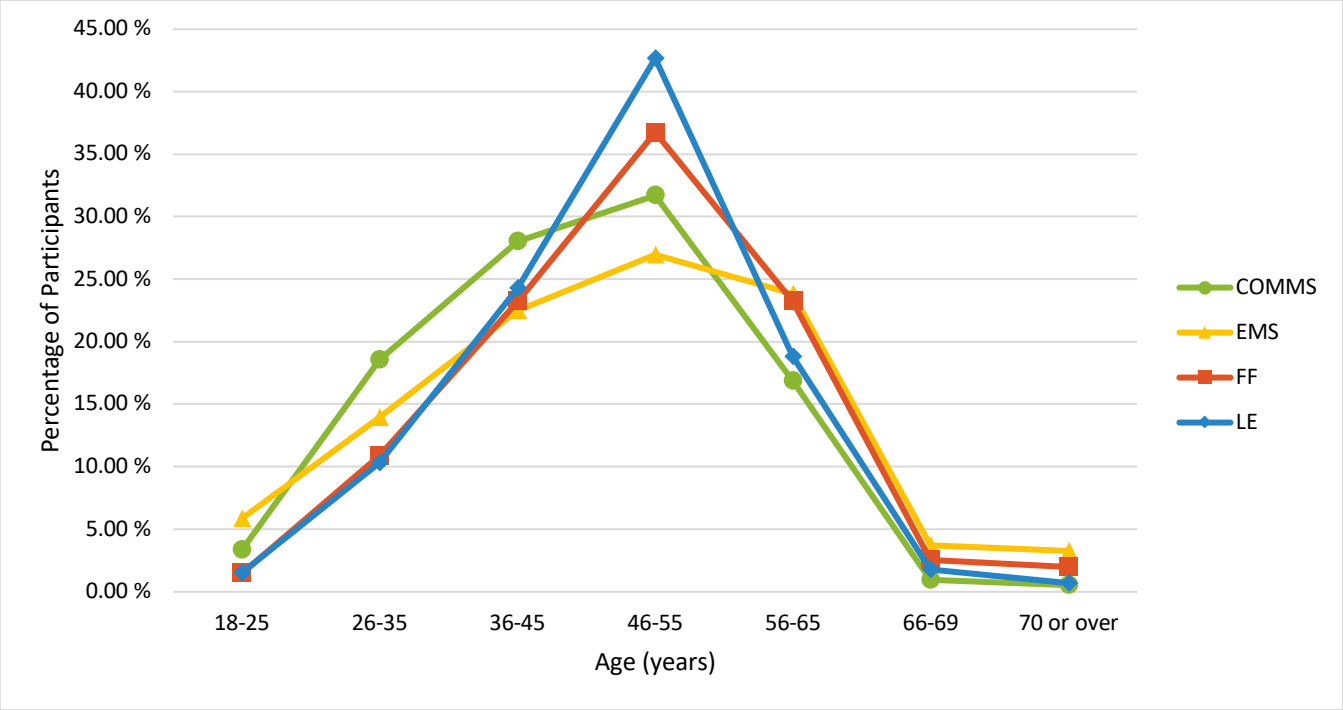

Fig. 83. Participants who completed the survey by age and discipline

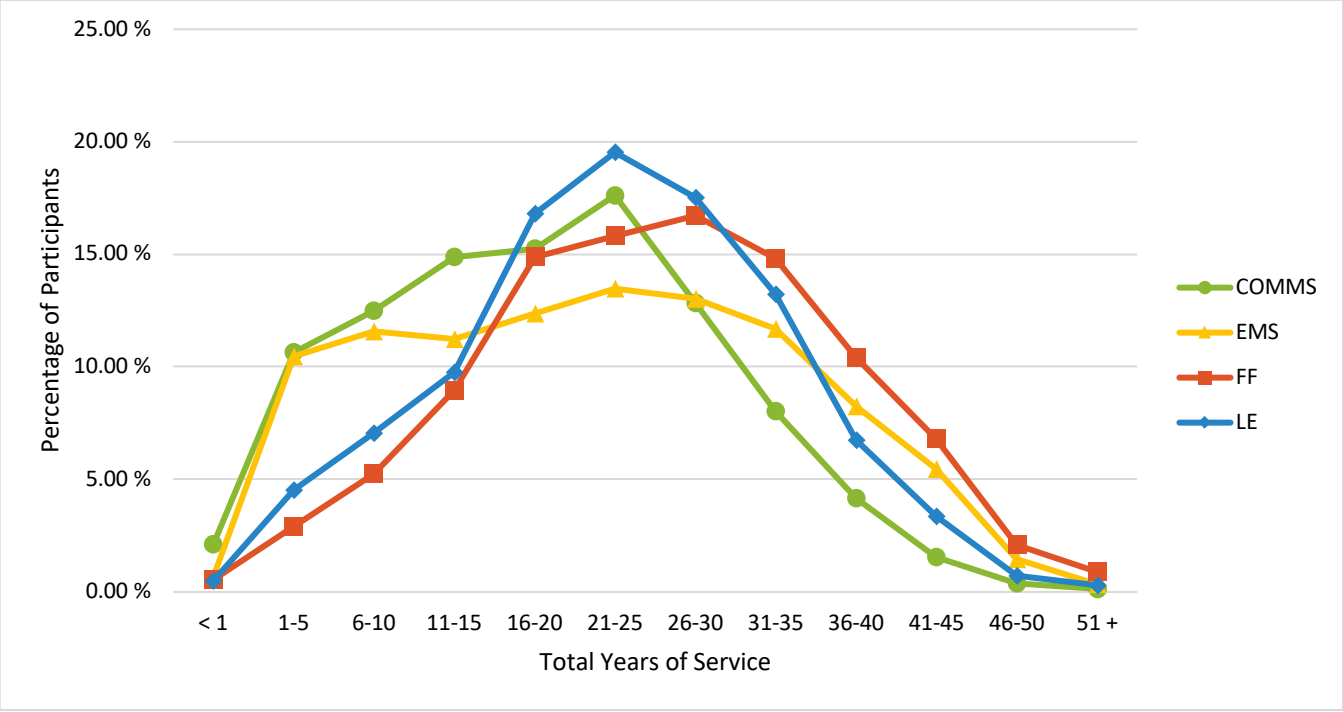

Fig. 84. Participants who completed the survey by total years of service and discipline

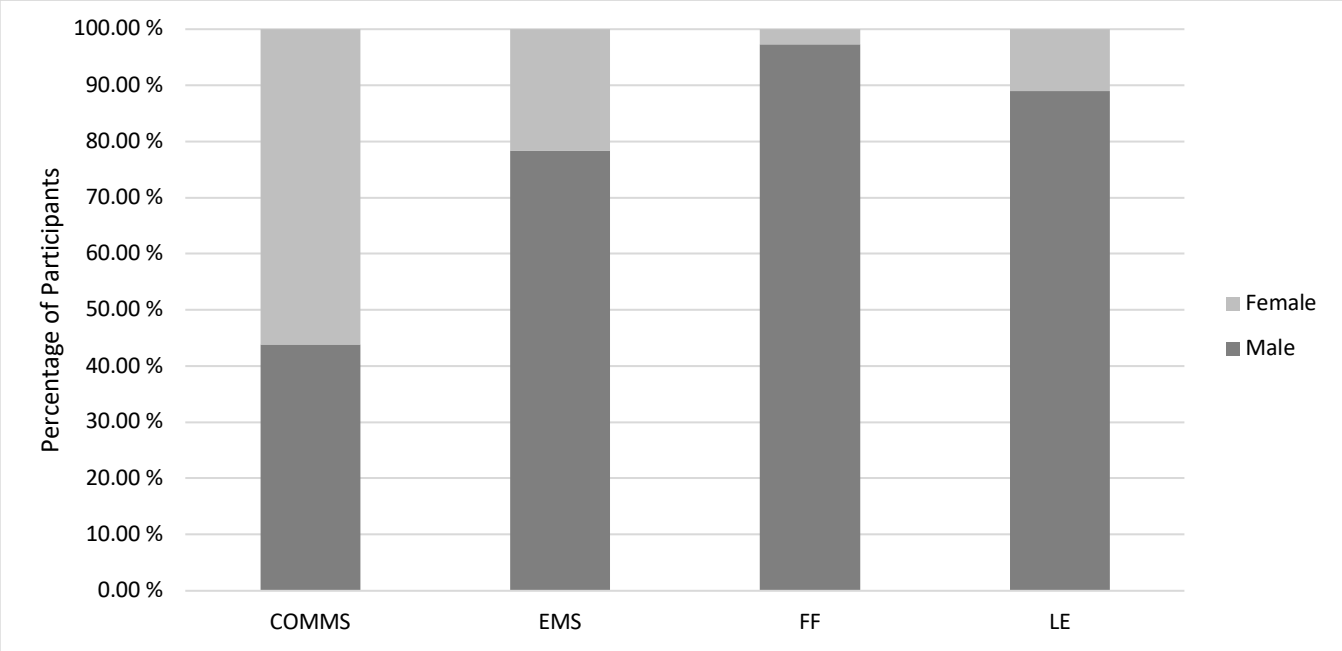

Fig. 85. Participants who completed the survey by sex and discipline

Appendix E: Total Responses Per Question

The results for each survey question presented in this report are tabulated in this appendix, by discipline. Where relevant, across discipline data is also presented. The number of participants, *n*, who selected a response option for a given question are included in the tables. For the problems survey questions, the number of participants who were asked about problems for a specific device, n_{asked}, is also provided. Full survey results are available on the PSCR Usability Results Tool website [19].

Table 36 Device frequency of use question results: COMMS

Device Name	Use a lot	Use occasionally	Have, but do not use	Do not have	*n*
Desktop computer	98.96 %	0.78 %	0.13 %	0.13 %	*1 540*
Foot pedal	53.26 %	17.32 %	13.28 %	16.15 %	*1 536*
Headset	72.54 %	7.88 %	7.16 %	12.42 %	*1 522*
Desktop microphone	27.83 %	15.92 %	30.66 %	25.59 %	*1 520*
Clip-on microphone	26.52 %	8.93 %	11.53 %	53.03 %	*1 501*
Personal monitor	96.42 %	1.43 %	0.20 %	1.95 %	*1 538*
Shared monitor	59.71 %	13.62 %	3.13 %	23.53 %	*1 534*
Landline phone	87.91 %	7.37 %	3.10 %	1.62 %	*1 547*
Radio	89.62 %	6.04 %	1.49 %	2.86 %	*1 541*
Personal smartphone	47.66 %	24.58 %	16.38 %	11.38 %	*1 538*
Work-issued smartphone	31.36 %	9.55 %	3.05 %	56.04 %	*1 540*
Pager	17.09 %	7.50 %	4.27 %	71.14 %	*1 521*

Table 37 Device frequency of use question results: EMS

Device Name	Use a lot	Use occasionally	Have, but do not use	Do not have	*n*
Corded earpiece	3.46 %	13.03 %	7.50 %	76.01 %	*867*
Corded mic	33.14 %	19.70 %	5.13 %	42.03 %	*878*
Desktop computer	63.52 %	22.95 %	4.32 %	9.20 %	*880*
Flip phone	3.91 %	5.64 %	3.57 %	86.88 %	*869*
In-vehicle radio	72.81 %	14.61 %	1.46 %	11.12 %	*890*
Laptop	54.10 %	29.38 %	3.76 %	12.76 %	*878*

MDT/MDC	27.49 %	14.32 %	2.41 %	55.78 %	*873*
Pager	43.76 %	9.98 %	5.10 %	41.16 %	*882*
Personal smartphone	84.20 %	5.30 %	1.35 %	9.14 %	*886*
Wireless earpiece: personal	7.05 %	12.37 %	8.44 %	72.14 %	*865*
Portable radio	75.40 %	17.95 %	1.58 %	5.08 %	*886*
Tablet	35.89 %	24.04 %	5.08 %	34.99 %	*886*
Wireless mic	4.60 %	6.09 %	2.07 %	87.24 %	*870*
Wireless earpiece: personal	7.05 %	12.37 %	8.44 %	72.14 %	*865*
Wireless earpiece: work	2.50 %	3.87 %	3.87 %	89.76 %	*879*
Work-issued smartphone	27.19 %	5.57 %	1.48 %	65.76 %	*879*

Table 38 Device frequency of use question results: FF

Device Name	Use a lot	Use occasionally	Have, but do not use	Do not have	*n*
Corded earpiece	3.96 %	15.28 %	9.54 %	71.22 %	*2 526*
Corded mic	51.33 %	18.59 %	3.22 %	26.86 %	*2 550*
Desktop computer	73.66 %	16.99 %	1.55 %	7.80 %	*2 578*
Flip phone	2.83 %	4.26 %	2.79 %	90.13 %	*2 513*
In-vehicle radio	76.83 %	14.78 %	1.39 %	7.00 %	*2 585*
Laptop	41.87 %	36.01 %	4.23 %	17.89 %	*2 577*
MDT/MDC	39.83 %	16.59 %	2.60 %	40.98 %	*2 543*
Pager	42.80 %	8.41 %	5.09 %	43.70 %	*2 556*
Personal smartphone	81.33 %	6.30 %	1.28 %	11.09 %	*2 571*
Portable radio	86.37 %	12.28 %	0.42 %	0.92 %	*2 598*
Tablet	35.04 %	28.55 %	5.28 %	31.13 %	*2 557*
TIC	32.10 %	50.85 %	6.79 %	10.26 %	*2 592*
Wireless mic	4.93 %	7.16 %	2.47 %	85.44 %	*2 513*
Wireless earpiece: personal	7.60 %	12.83 %	7.16 %	72.41 %	*2 486*
Wireless earpiece: work	2.52 %	5.56 %	4.53 %	87.38 %	*2 536*

Work-issued smartphone	38.02 %	7.86 %	2.28 %	51.85 %	*2 546*

Table 39. Device frequency of use question results: LE

Device Name	Use a lot	Use occasionally	Have, but do not use	Do not have	*n*
Body camera	26.29 %	10.88 %	6.00 %	56.83 %	*2 050*
Corded earpiece	16.49 %	16.98 %	13.52 %	53.01 %	*2 026*
Corded mic	45.41 %	14.13 %	6.60 %	33.87 %	*2 046*
Dash camera	25.28 %	10.33 %	4.97 %	59.43 %	*2 053*
Desktop computer	83.28 %	8.87 %	0.63 %	7.22 %	*2 051*
Fingerprint scanner	10.44 %	15.87 %	10.44 %	63.25 %	*2 041*
Flip phone	5.12 %	2.51 %	1.87 %	90.49 %	*2 030*
In-vehicle radio	68.04 %	16.20 %	2.29 %	13.47 %	*2 056*
Laptop	52.93 %	23.58 %	2.73 %	20.75 %	*2 048*
LPR	6.28 %	7.27 %	8.79 %	77.66 %	*2 037*
MDT/MDC	51.67 %	13.51 %	6.68 %	28.14 %	*2 065*
Pager	1.88 %	1.98 %	0.94 %	95.19 %	*2 018*
Personal smartphone	73.00 %	6.90 %	3.30 %	16.80 %	*2 030*
Portable radio	79.82 %	15.92 %	1.36 %	2.90 %	*2 066*
Tablet	16.49 %	15.02 %	3.78 %	64.70 %	*2 037*
Wireless mic	11.63 %	5.94 %	2.54 %	79.89 %	*2 004*
Wireless earpiece: personal	5.15 %	5.50 %	4.49 %	84.86 %	*1 982*
Wireless earpiece: work	4.18 %	5.52 %	5.07 %	85.23 %	*2 011*
Work-issued smartphone	54.51 %	6.48 %	1.51 %	37.51 %	*2 053*

Table 40 Device frequency of use question results: across disciplines

Device Name	Use a lot	Use occasionally	Have, but do not use	Do not have	*n*
Desktop computer	80.72 %	11.83 %	1.32 %	6.13 %	*7 049*

Pager	25.48 %	6.55 %	3.71 %	64.25 %	*6 977*
Personal smartphone	71.91 %	10.35 %	5.18 %	12.56 %	*7 025*
Radio *(Portable radio for EMS, FF, and LE)*	83.80 %	12.69 %	1.07 %	2.44 %	*7 091*
Work-issued smartphone	40.03 %	7.54 %	2.12 %	50.31 %	*7 018*

Table 41 Device frequency of use question results: across EMS, FF, and LE

Device Name	Use a lot	Use occasionally	Have, but do not use	Do not have	*n*
Corded earpiece	6.31 %	15.15 %	9.55 %	68.99 %	*5 434*
Corded mic	49.61 %	14.23 %	2.88 %	33.28 %	*5 481*
Desktop computer	69.95 %	17.65 %	2.27 %	10.14 %	*5 514*
Flip phone	3.86 %	4.94 %	3.54 %	87.66 %	*5 364*
In-vehicle radio	78.57 %	12.56 %	1.12 %	7.75 %	*5 526*
Laptop	47.48 %	26.54 %	5.07 %	20.91 %	*5 520*
MDT/MDC	32.78 %	14.09 %	3.84 %	49.29 %	*5 466*
Pager	36.41 %	9.38 %	5.04 %	49.17 %	*5 491*
Personal smartphone	78.71 %	6.36 %	2.04 %	12.89 %	*5 487*
Portable radio	82.18 %	14.54 %	0.95 %	2.32 %	*5 550*
Tablet	39.04 %	22.44 %	5.74 %	32.77 %	*5 489*
Wireless earpiece: personal	10.88 %	13.59 %	6.09 %	69.45 %	*5 388*
Wireless earpiece: work	3.93 %	5.92 %	6.02 %	84.13 %	*5 452*
Wireless mic	7.37 %	6.53 %	2.43 %	83.66 %	*5 387*
Work-issued smartphone	28.27 %	10.88 %	6.33 %	54.52 %	*5 451*

Table 42 Device ranking question results: EMS

	1st	2nd	3rd	4th	5th	Not in top 5	*n*
Corded earpiece	0.00 %	0.51 %	1.01 %	8.08 %	3.03 %	87.37 %	*198*
Corded mic	0.62 %	1.86 %	5.99 %	7.02 %	9.50 %	75.00 %	*484*

Desktop computer	26.88 %	11.82 %	8.18 %	8.05 %	11.56 %	33.51 %	*770*
Flip phone	1.83 %	2.75 %	7.34 %	6.42 %	16.51 %	65.14 %	*109*
In-vehicle radio	5.56 %	16.82 %	20.18 %	20.57 %	14.88 %	21.99 %	*773*
Laptop	15.25 %	13.09 %	11.61 %	11.07 %	12.42 %	36.57 %	*741*
MDT/MDC	11.83 %	14.25 %	13.71 %	10.75 %	11.56 %	37.90 %	*372*
Pager	17.26 %	14.48 %	15.08 %	13.49 %	9.92 %	29.76 %	*504*
Personal smartphone	25.54 %	23.38 %	13.98 %	12.07 %	10.42 %	14.61 %	*787*
Portable radio	12.91 %	15.47 %	22.53 %	22.41 %	14.98 %	11.69 %	*821*
Tablet	4.47 %	5.72 %	8.05 %	13.06 %	18.60 %	50.09 %	*559*
Wireless mic	0.00 %	0.00 %	4.72 %	3.77 %	5.66 %	85.85 %	*106*
Wireless earpiece: personal	0.88 %	3.95 %	2.63 %	3.95 %	7.46 %	81.14 %	*228*
Wireless earpiece: work	0.00 %	4.60 %	1.15 %	3.45 %	0.00 %	90.80 %	*87*
Work-issued smartphone	17.63 %	23.39 %	17.63 %	7.12 %	9.49 %	24.75 %	*295*

Table 43 Device ranking question results: FF

	1st	2nd	3rd	4th	5th	Not in top 5	*n*
Corded earpiece	0.14 %	1.57 %	0.57 %	1.28 %	2.28 %	94.16 %	*702*
Corded mic	0.67 %	3.78 %	4.83 %	7.06 %	9.17 %	74.50 %	*1 800*
Desktop computer	35.40 %	12.32 %	7.42 %	7.46 %	9.46 %	27.94 %	*2 305*
Flip phone	1.27 %	2.95 %	2.53 %	2.11 %	4.64 %	86.50 %	*237*
In-vehicle radio	3.52 %	12.46 %	17.75 %	22.56 %	15.38 %	28.32 %	*2 327*
Laptop	11.75 %	9.54 %	7.24 %	6.27 %	9.15 %	56.05 %	*2 043*
MDT/MDC	11.58 %	14.67 %	16.18 %	12.89 %	10.69 %	34.00 %	*1 459*
Pager	11.57 %	14.09 %	14.67 %	9.85 %	8.99 %	40.83 %	*1 391*
Personal smartphone	21.92 %	18.49 %	12.00 %	10.96 %	10.69 %	25.94 %	*2 217*
Portable radio	13.70 %	16.74 %	25.17 %	21.49 %	12.39 %	10.51 %	*2 503*
Tablet	2.77 %	4.72 %	7.96 %	10.02 %	12.50 %	62.03 %	*1 696*
TIC	0.67 %	1.43 %	3.52 %	7.57 %	16.53 %	70.29 %	*2 245*
Wireless mic	1.16 %	0.29 %	2.89 %	1.16 %	3.18 %	91.33 %	*346*

Wireless earpiece: personal	0.31 %	2.91 %	3.07 %	2.45 %	3.37 %	87.88 %	*652*
Wireless earpiece: work	0.00 %	1.00 %	1.66 %	2.66 %	3.99 %	90.70 %	*301*
Work-issued smartphone	14.87 %	26.89 %	10.84 %	7.48 %	6.47 %	33.45 %	*1 190*

Table 44 Device ranking question results: LE

	1st	2nd	3rd	4th	5th	Not in top 5	*n*
Body camera	8.34 %	6.03 %	8.69 %	15.87 %	19.24 %	41.83 %	*863*
Corded earpiece	0.87 %	1.31 %	3.60 %	3.38 %	5.24 %	85.59 %	*916*
Corded mic	0.69 %	3.74 %	4.05 %	6.64 %	8.40 %	76.49 %	*1 310*
Dash camera	0.25 %	3.80 %	5.28 %	7.24 %	13.74 %	69.69 %	*815*
Desktop computer	43.05 %	12.51 %	7.34 %	7.93 %	7.34 %	21.82 %	*1 879*
Fingerprint scanner	0.28 %	0.69 %	1.80 %	2.35 %	5.12 %	89.75 %	*722*
Flip phone	0.00 %	3.78 %	2.16 %	4.32 %	6.49 %	83.24 %	*185*
In-vehicle radio	9.19 %	14.56 %	18.62 %	18.85 %	12.45 %	26.33 %	*1 751*
Laptop	12.10 %	9.89 %	8.63 %	8.32 %	9.33 %	51.73 %	*1 587*
LPR	0.69 %	0.69 %	3.68 %	4.83 %	6.90 %	83.22 %	*435*
MDT/MDC	13.80 %	16.84 %	16.98 %	12.77 %	9.80 %	29.81 %	*1 449*
Pager	0.00 %	3.26 %	2.17 %	5.43 %	1.09 %	88.04 %	*92*
Personal smartphone	7.12 %	17.56 %	14.36 %	11.83 %	14.18 %	34.94 %	*1 657*
Portable radio	12.96 %	19.03 %	24.09 %	19.84 %	13.06 %	11.03 %	*1 976*
Tablet	3.14 %	3.57 %	5.43 %	9.86 %	11.57 %	66.43 %	*700*
Wireless mic	0.51 %	0.51 %	2.56 %	2.82 %	4.62 %	88.97 %	*390*
Wireless earpiece: personal	1.05 %	2.09 %	3.48 %	3.83 %	6.27 %	83.28 %	*287*
Wireless earpiece: work	0.00 %	2.46 %	1.40 %	2.81 %	2.81 %	90.53 %	*285*
Work-issued smartphone	16.92 %	24.35 %	14.94 %	12.65 %	10.99 %	20.16 %	1 265

Table 45 Device ranking question results: across EMS, FF, and LE

	1st	2nd	3rd	4th	5th	Not in top 5	*n*

Corded earpiece	0.50 %	1.32 %	2.15 %	3.08 %	3.85 %	89.10 %	*1 816*
Corded mic	0.67 %	3.51 %	4.70 %	6.90 %	8.93 %	75.29 %	*3 594*
Desktop computer	36.98 %	12.31 %	7.51 %	7.73 %	8.98 %	26.48 %	*4 954*
Flip phone	0.94 %	3.20 %	3.39 %	3.77 %	7.72 %	80.98 %	*531*
In-vehicle radio	5.90 %	13.91 %	18.45 %	20.90 %	14.24 %	26.59 %	*4 851*
Laptop	12.47 %	10.27 %	8.49 %	7.82 %	9.77 %	51.18 %	*4 371*
MDT/MDC	12.59 %	15.58 %	16.25 %	12.59 %	10.40 %	32.59 %	*3 280*
Pager	12.48 %	13.69 %	14.19 %	10.57 %	8.86 %	40.21 %	*1 987*
Personal smartphone	17.27 %	18.99 %	13.17 %	11.46 %	11.89 %	27.23 %	*4 661*
Portable radio	13.30 %	17.40 %	24.36 %	21.02 %	13.04 %	10.89 %	*5 300*
Tablet	3.18 %	4.64 %	7.38 %	10.56 %	13.43 %	60.81 %	*2 955*
Wireless mic	0.71 %	0.36 %	2.97 %	2.26 %	4.16 %	89.55 %	*842*
Wireless earpiece: personal	0.60 %	2.91 %	3.08 %	3.08 %	4.88 %	85.43 %	*1 167*
Wireless earpiece: work	0.00 %	2.08 %	1.49 %	2.82 %	2.97 %	90.64 %	*673*
Work-issued smartphone	16.11 %	25.35 %	13.45 %	9.82 %	8.87 %	26.40 %	*2 750*

Table 46 COMMS information problems question results

Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Callers: inaccurate or missing information	9.40 %	22.15 %	60.98 %	6.31 %	0.00 %	1.16 %	*1 553*
Cell phones: inability to accurately track caller location	9.54 %	21.26 %	57.15 %	9.47 %	0.13 %	2.45 %	*1 552*
Information overload: too many calls at once	5.56 %	11.25 %	59.12 %	21.09 %	1.16 %	1.81 %	*1 546*
Information overload: too much information to monitor at once	3.71 %	8.07 %	52.64 %	28.95 %	4.29 %	2.34 %	*1 537*
Maps/databases: missing or inaccurate information	6.65 %	9.68 %	51.81 %	28.19 %	1.61 %	2.06 %	*1 550*

Table 47. Number of participants, n_{asked}, presented problems by device and discipline

Device	EMS	FF	LE
Body camera	-	-	240
Desktop computer	387	1333	1255
Earpiece	-	71	90
Fingerprint scanner	-	-	20
Laptop	329	618	522
License plate reader	-	-	25
MDT/MDC	156	678	739
Mic	61	220	149
Pager	255	593	7
Radio	607	1813	1556
Smartphone	675	1804	1352
Tablet	124	302	98
TIC	-	190	-

Table 48 Device problems question results, at least "Sometimes" across EMS, FF, LE

	Desktop Computer	Laptop	MDT/MDC	Mic	Pager	Radio	Smartphone	Tablet
Audio quality	-	-	-	61.74 % n= 345	-	70.18 % n=3 810	-	-
Battery life	-	58.71 % n=1 344	-	-	52.71 % n= 793	60.99 % n=3 812	70.66 % n=3 510	52.94 % n= 442
CAD (computer-aided dispatch)	-	-	65.76 % n=1 440	-	-	-	-	-
Channel switching	-	-	-	-	-	41.07 % n=3 784	-	-
Cord	-	-	-	44.80 % n= 346	-	30.32 % n=3 750	-	-
Coverage/dead zones	-	-	-	-	-	69.91 % n=3 809	65.75 % n=3 509	-
Data plans/data limits	-	-	-	-	-	-	32.94 % n=3 497	-
Dropped calls	-	-	-	-	-	-	51.05 % n=3 528	-
Durability	-	43.14 % n=1 342	32.54 % n=1 429	34.49 % n= 345	34.22 % n= 786	27.00 % n=3 789	47.35 % n=3 508	43.47 % n= 444

	Desktop Computer	Laptop	MDT/MDC	Mic	Pager	Radio	Smartphone	Tablet
Falling off	-	-	-	38.97 % n= 349	36.80 % n= 788	-	-	-
Glare	-	48.51 % n=1 342	51.20 % n=1 287 FF & LE only	-	-	-	49.79 % n=3 499	55.18 % n= 444
Internet connection	44.72 % n=2 786	73.16 % n=1 345	-	-	-	-	-	64.86 % n= 444
Interoperability	33.27 % n=2 756	44.08 % n=1 334	44.97 % n=1 432	-	-	44.13 % n=3 784	21.34 % n= 622 EMS only	43.34 % n= 443
Lack of portability	-	-	39.25 % n=1 437	-	-	-	-	-
Logging in (PINS, passwords, usernames, etc.)	55.87 % n=2 767	58.92 % n=1 346	50.42 % n=1 442	-	-	-	48.73 % n=3 513	47.51 % n= 442
Mapping/navigation	-	-	52.16 % n=1 438	-	-	-	-	-
Outdated/old	50.81 % n=2 763	44.93 % n=1 340	44.78 % n=1 445	35.73 % n= 347	41.98 % n= 779	40.86 % n=3 786	32.15 % n=3 512	18.07 % n= 83 LE only
Permission/access to apps	-	-	-	-	-	-	34.84 % n=3 490	-
Placement on body	-	-	-	42.94 % n= 347	-	-	-	-
Policies about usage	-	-	-	-	-	-	25.96 % n=3 490	-
Power source/recharging issues	-	48.29 % n=1 344	-	-	-	-	-	-
Price: too expensive	43.75 % n=2 761	56.19 % n=1 333	47.53 % n=1 435	47.11 % n= 346	68.98 % n= 793	67.86 % n=3 799	66.77 % n=3 503	46.99 % n= 83 LE only
Radio discipline/etiquette	-	-	-	-	-	53.37 % n=3 794	-	-

	Desktop Computer	Laptop	MDT/MDC	Mic	Pager	Radio	Smartphone	Tablet
Report writing	-	-	-	-	-	-	-	40.41 % n= 443
Size/bulkiness	-	42.54 % n=1 340	38.49 % n=1 434	-	43.06 % n= 792	43.27 % n=3 795	-	18.43 % n= 445
Software crashes	43.92 % n=2 771	45.38 % n=1 342	-	-	-	-	-	-
Software updates/upgrades	56.71 % n=2 756	56.26 % n=1 342	-	-	-	-	-	-
Subpoena possibility for personal smartphone	-	-	-	-	-	-	31.59 % n=3 492	-
Subsidy for personal smartphone (insufficient or no subsidy)	-	-	-	-	-	-	32.55 % n=3 484	-
Talk button location	-	-	-	22.38 % n= 344	-	-	-	-
Talk button size	-	-	-	23.03 % n= 343	-	-	-	-
Touchscreen	-	-	-	-	-	-	-	31.01 % n= 445
Using while driving	-	-	57.54 % n=1 439	-	-	-	-	-
Weight	-	30.64 % n=1 325	-	-	-	-	-	12.93 % n= 441

Table 49 EMS device problems question results: Desktop computers

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Software updates/upgrades	5.73 %	11.17 %	44.99 %	28.08 %	8.02 %	5.73 %	*349*
Logins/passwords	5.73 %	13.18 %	37.25 %	28.94 %	14.33 %	5.73 %	*351*

Outdated/old	6.59 %	14.61 %	30.95 %	27.79 %	16.62 %	6.59 %	*349*
Price: too expensive	10.60 %	19.48 %	18.91 %	20.06 %	16.33 %	10.60 %	*352*
Internet connection	3.72 %	6.59 %	38.11 %	37.82 %	14.90 %	3.72 %	*356*
Software crashes	3.15 %	5.44 %	38.40 %	39.26 %	12.32 %	3.15 %	*351*
Interoperability	2.29 %	4.01 %	28.08 %	36.96 %	20.34 %	2.29 %	*349*

Table 50 EMS device problems question results: Laptops

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Internet connection	9.18 %	19.73 %	49.32 %	17.35 %	3.40 %	1.02 %	*294*
Battery life	7.48 %	12.24 %	46.26 %	21.77 %	10.88 %	1.36 %	*294*
Logins/passwords	8.50 %	12.93 %	39.80 %	26.87 %	10.20 %	1.70 %	*294*
Software updates/upgrades	7.82 %	13.95 %	38.10 %	25.85 %	11.90 %	1.70 %	*292*
Price: too expensive	15.65 %	18.37 %	25.51 %	14.97 %	10.54 %	13.61 %	*290*
Power source/recharging issues	7.14 %	13.27 %	34.69 %	26.19 %	16.67 %	1.70 %	*293*
Software crashes	5.78 %	8.50 %	38.78 %	33.33 %	12.59 %	1.02 %	*294*
Glare	3.40 %	7.82 %	40.82 %	31.97 %	13.95 %	1.02 %	*291*
Durability	5.10 %	9.52 %	36.05 %	30.27 %	16.33 %	2.04 %	*292*
Outdated/old	6.46 %	8.84 %	33.67 %	27.55 %	18.03 %	5.10 %	*293*
Size/bulkiness	7.14 %	10.20 %	31.29 %	29.93 %	18.37 %	2.72 %	*293*
Interoperability	3.40 %	6.80 %	34.69 %	27.89 %	14.63 %	11.22 %	*290*
Weight	4.76 %	9.52 %	22.11 %	32.99 %	24.83 %	3.40 %	*287*

Table 51 EMS device problems question results: MDTs/MDCs

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
CAD (computer- aided dispatch)	2.07 %	8.28 %	53.79 %	30.34 %	3.45 %	2.07 %	*145*
Mapping/navigation	10.34 %	16.55 %	35.17 %	24.83 %	4.83 %	8.28 %	*145*
Using while driving	15.86 %	13.79 %	31.03 %	17.93 %	9.66 %	10.34 %	*143*
Interoperability	7.59 %	9.66 %	33.79 %	24.83 %	13.79 %	10.34 %	*145*

Price: too expensive	16.55 %	17.93 %	13.79 %	8.28 %	6.21 %	35.17 %	*142*
Outdated/old	11.03 %	13.79 %	22.76 %	24.14 %	20.69 %	6.90 %	*144*
Size/bulkiness	9.66 %	14.48 %	17.93 %	24.14 %	19.31 %	13.79 %	*144*
Lack of portability	15.17 %	6.21 %	19.31 %	25.52 %	20.00 %	13.79 %	*145*
Logins/passwords	7.59 %	6.90 %	26.21 %	36.55 %	15.86 %	6.90 %	*145*
Durability	4.14 %	9.66 %	24.14 %	35.86 %	20.00 %	5.52 %	*144*

Table 52 EMS device problems question results: Microphones

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Price: too expensive	17.78 %	8.89 %	31.11 %	15.56 %	6.67 %	20.00 %	*45*
Audio quality	0.00 %	6.67 %	40.00 %	44.44 %	8.89 %	0.00 %	*45*
Placement on body	2.17 %	4.35 %	32.61 %	39.13 %	17.39 %	4.35 %	*46*
Falling off	2.22 %	2.22 %	33.33 %	42.22 %	17.78 %	2.22 %	*45*
Cord	0.00 %	2.27 %	31.82 %	59.09 %	6.82 %	0.00 %	*44*
Outdated/old	2.22 %	6.67 %	15.56 %	51.11 %	15.56 %	8.89 %	*45*
Durability	2.22 %	4.44 %	15.56 %	55.56 %	20.00 %	2.22 %	*45*
Talk button size	2.27 %	2.27 %	15.91 %	34.09 %	38.64 %	6.82 %	*44*
Talk button location	0.00 %	4.55 %	11.36 %	40.91 %	36.36 %	6.82 %	*44*

Table 53 EMS device problems question results: Pagers

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Price: too expensive	25.64 %	22.22 %	20.94 %	12.39 %	8.97 %	9.83 %	*234*
Battery life	3.85 %	8.12 %	43.59 %	32.48 %	11.97 %	0.00 %	*234*
Outdated/old	6.84 %	10.68 %	26.92 %	23.08 %	21.37 %	9.83 %	*231*
Size/bulkiness	3.85 %	8.12 %	27.35 %	31.62 %	22.65 %	5.98 %	*233*
Falling off	2.99 %	8.12 %	25.64 %	44.87 %	16.24 %	1.28 %	*232*
Durability	2.14 %	6.84 %	21.79 %	43.16 %	24.36 %	1.28 %	*233*
Price: too expensive	25.64 %	22.22 %	20.94 %	12.39 %	8.97 %	9.83 %	*234*

Battery life	3.85 %	8.12 %	43.59 %	32.48 %	11.97 %	0.00 %	*234*
Outdated/old	6.84 %	10.68 %	26.92 %	23.08 %	21.37 %	9.83 %	*231*
Size/bulkiness	3.85 %	8.12 %	27.35 %	31.62 %	22.65 %	5.98 %	*233*
Falling off	2.99 %	8.12 %	25.64 %	44.87 %	16.24 %	1.28 %	*232*
Durability	2.14 %	6.84 %	21.79 %	43.16 %	24.36 %	1.28 %	*233*

Table 54 EMS device problems question results: Radios

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Coverage/dead zones	11.15 %	12.35 %	53.17 %	19.21 %	3.26 %	0.86 %	*583*
Audio quality	3.61 %	13.40 %	57.39 %	23.71 %	1.55 %	0.34 %	*582*
Price: too expensive	30.17 %	23.28 %	18.28 %	6.03 %	6.21 %	16.03 %	*580*
Battery life	5.15 %	11.15 %	43.40 %	32.59 %	7.38 %	0.34 %	*583*
Interoperability	7.80 %	11.79 %	29.29 %	33.45 %	14.38 %	3.29 %	*577*
Outdated/old	7.73 %	13.23 %	27.49 %	22.16 %	21.48 %	7.90 %	*582*
Radio discipline/etiquette	5.50 %	10.31 %	32.65 %	35.05 %	14.43 %	2.06 %	*582*
Size/bulkiness	4.86 %	9.38 %	32.64 %	33.51 %	16.84 %	2.78 %	*576*
Channel switching	4.48 %	9.14 %	30.34 %	38.10 %	16.03 %	1.90 %	*580*
Durability	2.76 %	6.03 %	22.41 %	42.59 %	24.66 %	1.55 %	*580*
Cord	1.91 %	4.51 %	19.24 %	37.26 %	24.09 %	13.00 %	*577*

Table 55 EMS device problems question results: Smartphones

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Coverage/dead zones	10.24 %	12.32 %	52.48 %	20.96 %	3.68 %	0.32 %	*625*
Price: too expensive	25.76 %	24.96 %	23.20 %	10.24 %	9.60 %	5.60 %	*621*
Battery life	11.04 %	17.28 %	44.64 %	21.12 %	5.60 %	0.48 %	*626*
Dropped calls	5.12 %	6.72 %	48.16 %	34.08 %	5.44 %	0.96 %	*628*
Glare	3.36 %	11.20 %	39.04 %	30.72 %	13.12 %	2.56 %	*625*

Durability	5.92 %	10.72 %	35.52 %	34.88 %	12.16 %	1.28 %	*628*
Logging in (PINS, passwords, usernames, etc.)	8.32 %	7.84 %	27.20 %	31.36 %	20.16 %	5.44 %	*627*
Subsidy for personal smartphone (insufficient or no subsidy)	23.84 %	5.92 %	9.60 %	10.40 %	23.84 %	26.40 %	*625*
Data plans/data limits	7.36 %	8.00 %	22.24 %	29.28 %	27.84 %	5.44 %	*626*
Permission/access to apps	3.84 %	6.88 %	25.28 %	29.60 %	27.68 %	6.08 %	*621*
Outdated/old	2.88 %	6.08 %	25.28 %	28.64 %	28.16 %	8.64 %	*623*
Interoperability	3.68 %	6.24 %	21.28 %	33.12 %	23.68 %	11.52 %	*622*
Policies about usage	2.56 %	4.80 %	21.12 %	31.36 %	31.36 %	8.48 %	*623*
Subpoena possibility for personal smartphone	9.60 %	5.28 %	12.48 %	19.84 %	39.36 %	12.80 %	*621*

Table 56 EMS device problems question results: Tablets

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Internet connection	6.86 %	13.73 %	58.82 %	10.78 %	7.84 %	1.96 %	*102*
Battery life	9.80 %	14.71 %	35.29 %	26.47 %	11.76 %	0.98 %	*101*
Glare	7.84 %	5.88 %	43.14 %	27.45 %	13.73 %	1.96 %	*102*
Durability	8.82 %	10.78 %	32.35 %	27.45 %	17.65 %	1.96 %	*101*
Report writing	9.80 %	12.75 %	28.43 %	32.35 %	9.80 %	6.86 %	*102*
Logins/passwords	11.76 %	3.92 %	31.37 %	32.35 %	16.67 %	3.92 %	*102*
Touchscreen	4.90 %	4.90 %	37.25 %	28.43 %	21.57 %	2.94 %	*102*
Interoperability	5.88 %	7.84 %	32.35 %	20.59 %	18.63 %	13.73 %	*101*
Size/bulkiness	1.96 %	3.92 %	15.69 %	38.24 %	34.31 %	5.88 %	*102*
Weight	0.00 %	1.96 %	15.69 %	42.16 %	37.25 %	2.94 %	*102*

Table 57 FF device problems question results: Desktop computers

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Logins/passwords	4.87 %	11.01 %	42.14 %	30.17 %	11.25 %	0.56 %	*1 253*

Software updates/upgrades	5.20 %	9.77 %	42.27 %	30.58 %	10.33 %	1.84 %	*1 249*
Outdated/old	5.44 %	13.19 %	33.49 %	28.14 %	15.75 %	4.00 %	*1 251*
Price: too expensive	8.23 %	12.86 %	23.48 %	23.72 %	13.58 %	18.13 %	*1 252*
Internet connection	3.01 %	3.80 %	37.16 %	43.98 %	11.57 %	0.48 %	*1 262*
Software crashes	1.99 %	4.06 %	37.02 %	42.68 %	12.34 %	1.91 %	*1 256*
Interoperability	1.68 %	3.28 %	29.04 %	43.12 %	17.12 %	5.76 %	*1 250*

Table 58 FF device problems question results: Earpieces

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Price: too expensive	13.11 %	4.92 %	37.70 %	24.59 %	6.56 %	13.11 %	*61*
Audio quality	3.23 %	6.45 %	38.71 %	30.65 %	16.13 %	4.84 %	*62*
Volume	1.61 %	11.29 %	32.26 %	30.65 %	19.35 %	4.84 %	*62*
Battery life	1.64 %	11.48 %	31.15 %	26.23 %	13.11 %	16.39 %	*61*
Fit/falling out	0.00 %	14.52 %	27.42 %	33.87 %	17.74 %	6.45 %	*62*
Durability	5.00 %	11.67 %	20.00 %	36.67 %	20.00 %	6.67 %	*60*
Wireless (bluetooth pairing, etc.)	0.00 %	6.56 %	21.31 %	31.15 %	14.75 %	26.23 %	*61*
Outdated/old	1.61 %	8.06 %	14.52 %	32.26 %	24.19 %	19.35 %	*62*

Table 59 FF device problems question results: Laptops

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Internet connection	4.67 %	11.76 %	57.61 %	19.72 %	5.19 %	1.04 %	*578*
Price: too expensive	11.65 %	18.61 %	30.09 %	18.96 %	12.70 %	8.00 %	*575*
Battery life	6.26 %	12.35 %	41.04 %	32.17 %	7.48 %	0.70 %	*575*
Logins/passwords	5.87 %	13.99 %	39.72 %	28.67 %	10.19 %	1.55 %	*579*
Software updates	4.84 %	12.11 %	39.62 %	32.18 %	9.34 %	1.90 %	*578*
Glare	2.60 %	7.96 %	41.00 %	33.04 %	14.01 %	1.38 %	*578*
Power/recharging	3.98 %	7.61 %	38.24 %	31.83 %	16.44 %	1.90 %	*578*
Durability	3.81 %	8.82 %	33.56 %	35.81 %	16.78 %	1.21 %	*578*

Interoperability	3.99 %	6.76 %	33.45 %	33.80 %	13.00 %	9.01 %	*577*
Outdated/old	3.82 %	9.38 %	30.90 %	31.94 %	17.53 %	6.42 %	*576*
Size/bulkiness	4.52 %	9.74 %	29.04 %	33.91 %	19.48 %	3.30 %	*575*
Software crashes	2.96 %	5.91 %	32.70 %	42.26 %	13.91 %	2.26 %	*575*
Weight	2.45 %	8.58 %	20.32 %	38.88 %	26.09 %	3.68 %	*571*

Table 60 FF device problems question results: MDTs/MDCs

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
CAD (computer- aided dispatch)	2.95 %	8.35 %	58.10 %	26.02 %	2.95 %	1.64 %	*611*
Mapping/navigation	4.89 %	13.38 %	41.92 %	29.85 %	7.50 %	2.45 %	*613*
Using while driving	11.26 %	14.19 %	32.63 %	23.49 %	9.95 %	8.48 %	*613*
Glare	2.63 %	7.55 %	46.80 %	32.68 %	8.21 %	2.13 %	*609*
Logins/passwords	3.75 %	8.47 %	36.97 %	32.74 %	13.68 %	4.40 %	*614*
Price: too expensive	16.26 %	14.61 %	17.08 %	15.11 %	6.40 %	30.54 %	*609*
Interoperability	3.29 %	9.21 %	34.21 %	35.03 %	11.18 %	7.07 %	*608*
Outdated/old	5.70 %	10.10 %	22.96 %	32.90 %	15.64 %	12.70 %	*614*
Size/bulkiness	6.10 %	8.07 %	23.23 %	30.31 %	20.59 %	11.70 %	*607*
Durability	1.15 %	7.89 %	27.30 %	44.08 %	16.61 %	2.96 %	*608*
Lack of portability	6.69 %	8.65 %	20.07 %	31.00 %	23.49 %	10.11 %	*613*

Table 61 FF device problems question results: Microphones

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Audio quality	1.12 %	8.38 %	58.10 %	23.46 %	8.38 %	0.56 %	*179*
Cord	0.56 %	10.61 %	40.78 %	29.61 %	15.64 %	2.79 %	*179*
Price: too expensive	18.64 %	12.99 %	18.64 %	13.56 %	12.43 %	23.73 %	*177*
Placement on body	4.52 %	12.43 %	29.38 %	29.94 %	19.77 %	3.95 %	*177*
Falling off	6.15 %	11.73 %	24.02 %	34.08 %	22.91 %	1.12 %	*179*
Durability	1.69 %	8.99 %	30.34 %	38.20 %	20.22 %	0.56 %	*178*
Outdated/old	3.93 %	7.30 %	22.47 %	26.40 %	27.53 %	12.36 %	*178*
Talk button size	5.14 %	6.29 %	18.29 %	34.86 %	32.00 %	3.43 %	*175*
Talk button location	3.98 %	6.25 %	17.61 %	37.50 %	31.82 %	2.84 %	*176*

Table 62 FF device problems question results: Pagers

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Price: too expensive	21.29 %	19.50 %	28.26 %	16.82 %	8.41 %	5.72 %	*559*
Battery life	3.76 %	7.51 %	40.25 %	38.64 %	9.48 %	0.36 %	*559*
Size/bulkiness	6.26 %	9.84 %	28.44 %	34.35 %	18.60 %	2.50 %	*559*
Outdated/old	5.47 %	12.59 %	22.63 %	32.85 %	19.34 %	7.12 %	*548*
Falling off	1.98 %	6.83 %	27.88 %	44.96 %	17.45 %	0.90 %	*556*
Durability	3.44 %	5.97 %	26.22 %	45.03 %	18.99 %	0.36 %	*553*
Durability	3.44 %	5.97 %	26.22 %	45.03 %	18.99 %	0.36 %	*553*

Table 63 FF device problems question results: Radios

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Audio quality	3.38 %	12.37 %	58.30 %	22.97 %	2.75 %	0.23 %	*1 746*
Price: too expensive	30.58 %	24.73 %	17.90 %	8.32 %	4.65 %	13.83 %	*1 743*
Coverage/dead zones	10.98 %	9.61 %	51.92 %	23.79 %	3.43 %	0.29 %	*1 749*
Battery life	5.08 %	12.05 %	47.40 %	31.07 %	4.05 %	0.34 %	*1 751*

Radio discipline/etiquette	5.96 %	12.33 %	41.57 %	29.47 %	8.49 %	2.18 %	*1 744*
Interoperability	5.46 %	10.34 %	31.59 %	36.59 %	14.47 %	1.55 %	*1 741*
Channel switching	4.39 %	7.97 %	31.83 %	39.23 %	16.00 %	0.58 %	*1 731*
Size/bulkiness	3.16 %	8.44 %	32.32 %	37.14 %	14.58 %	4.36 %	*1 742*
Outdated/old	6.58 %	10.27 %	24.06 %	28.39 %	20.77 %	9.92 %	*1 733*
Cord	2.75 %	5.26 %	25.77 %	40.85 %	19.75 %	5.61 %	*1 711*
Durability	2.41 %	4.77 %	22.87 %	48.16 %	21.09 %	0.69 %	*1 740*

Table 64 FF device problems question results: Smartphones

Device Problem	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*
Price: too expensive	24.07 %	22.86 %	23.94 %	14.60 %	8.44 %	6.09 %	*1 658*
Coverage/dead zones	6.63 %	8.38 %	51.99 %	28.71 %	3.68 %	0.60 %	*1 658*
Glare	3.20 %	9.12 %	42.27 %	33.70 %	10.33 %	1.39 %	*1 656*
Logging in (PINS, passwords, usernames, etc.)	5.95 %	9.50 %	36.66 %	32.75 %	12.62 %	2.52 %	*1 664*
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*
Permission/access to apps	2.18 %	5.22 %	29.79 %	38.90 %	19.42 %	4.49 %	*1 648*
Data plans/data limits	4.96 %	6.89 %	24.12 %	33.13 %	26.90 %	3.99 %	*1 654*
Subsidy for personal smartphone (insufficient or no subsidy)	18.04 %	5.24 %	10.30 %	10.30 %	24.92 %	31.20 %	*1 641*
Outdated/old	1.81 %	4.75 %	26.84 %	38.33 %	20.88 %	7.40 %	*1 662*
Subpoena possibility for personal smartphone	10.53 %	7.26 %	14.16 %	19.67 %	37.71 %	10.65 %	*1 652*
Policies about usage	2.19 %	5.29 %	18.72 %	37.63 %	27.78 %	8.39 %	*1 645*

Table 65 FF device problems question results: Tablets

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Internet connection	5.38 %	11.92 %	48.85 %	27.69 %	4.23 %	1.92 %	*260*
Glare	3.85 %	9.23 %	46.15 %	29.62 %	10.38 %	0.77 %	*260*
Battery life	3.86 %	9.27 %	40.54 %	33.59 %	11.97 %	0.77 %	*259*
Logins/passwords	5.81 %	6.59 %	39.92 %	31.78 %	13.57 %	2.33 %	*258*
Interoperability	4.23 %	8.46 %	34.23 %	33.08 %	13.08 %	6.92 %	*260*
Durability	5.38 %	8.46 %	30.77 %	38.85 %	15.77 %	0.77 %	*260*
Report writing	2.71 %	8.53 %	29.46 %	32.56 %	13.57 %	13.18 %	*258*
Touchscreen	2.31 %	2.69 %	25.77 %	38.08 %	30.38 %	0.77 %	*260*
Size/bulkiness	1.15 %	3.46 %	15.77 %	41.54 %	36.15 %	1.92 %	*260*
Weight	0.00 %	2.71 %	10.85 %	38.37 %	46.12 %	1.94 %	*258*

Table 66 FF device problems question results: TICs

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Price: too expensive	20.80 %	19.20 %	16.80 %	9.60 %	13.60 %	20.00 %	*125*
Battery life	7.94 %	13.49 %	32.54 %	26.98 %	19.05 %	0.00 %	*126*
Small screen	7.94 %	14.29 %	26.98 %	26.19 %	20.63 %	3.97 %	*126*
Size/bulkiness	7.38 %	13.93 %	27.05 %	27.87 %	19.67 %	4.10 %	*122*
Outdated/old	7.14 %	8.73 %	22.22 %	28.57 %	23.81 %	9.52 %	*126*
Durability	4.03 %	6.45 %	15.32 %	42.74 %	31.45 %	0.00 %	*124*
Accuracy of information	0.00 %	4.00 %	16.00 %	51.20 %	28.00 %	0.80 %	*125*

Table 67 LE device problems question results: Body cameras

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Battery life	10.71 %	9.69 %	37.76 %	25.51 %	14.80 %	1.53 %	*196*
Placement/location on body	7.22 %	11.34 %	34.02 %	24.74 %	21.13 %	1.55 %	*194*
Price: too expensive	19.39 %	17.86 %	15.31 %	7.14 %	12.76 %	27.55 %	*196*
Falling off	5.73 %	8.85 %	32.29 %	28.13 %	22.40 %	2.60 %	*192*
Durability	9.28 %	6.70 %	30.41 %	29.38 %	22.68 %	1.55 %	*194*
Using/tagging recorded video data	9.84 %	9.84 %	22.28 %	25.91 %	25.91 %	6.22 %	*193*
Size/bulkiness	6.22 %	7.77 %	25.91 %	20.73 %	34.20 %	5.18 %	*193*
Video transfer/storage	9.74 %	4.10 %	22.56 %	23.59 %	32.82 %	7.18 %	*195*
Interoperability	2.06 %	3.09 %	28.35 %	31.44 %	27.32 %	7.73 %	*194*
Turning on/off	4.15 %	7.25 %	20.73 %	35.23 %	29.53 %	3.11 %	*193*
Video quality	4.66 %	5.18 %	16.58 %	32.12 %	37.82 %	3.63 %	*193*
Outdated/old	3.08 %	4.62 %	13.85 %	24.62 %	38.97 %	14.87 %	*195*

Table 68 LE device problems question results: Desktop computers

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Software updates/upgrades	3.71 %	8.89 %	41.97 %	33.51 %	10.45 %	1.47 %	*1 158*
Logins/passwords	4.73 %	7.91 %	40.93 %	36.20 %	9.80 %	0.43 %	*1 163*
Outdated/old	5.76 %	12.04 %	31.21 %	31.38 %	15.74 %	3.87 %	*1 163*
Internet connection	1.80 %	4.28 %	38.61 %	43.41 %	11.39 %	0.51 %	*1 168*
Software crashes	1.72 %	5.24 %	37.03 %	41.92 %	12.20 %	1.89 %	*1 164*
Price: too expensive	7.52 %	11.06 %	22.82 %	22.90 %	15.47 %	20.22 %	*1 157*
Interoperability	1.73 %	2.68 %	27.74 %	43.65 %	18.93 %	5.27 %	*1 157*

Table 69 LE device problems question results: Earpieces

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Audio quality	2.47 %	4.94 %	38.27 %	40.74 %	8.64 %	4.94 %	*81*
Volume	6.25 %	7.50 %	31.25 %	30.00 %	20.00 %	5.00 %	*80*
Price: too expensive	11.11 %	12.35 %	19.75 %	17.28 %	16.05 %	23.46 %	*81*
Fit/falling out	5.00 %	6.25 %	31.25 %	32.50 %	17.50 %	7.50 %	*80*
Durability	3.66 %	6.10 %	28.05 %	36.59 %	17.07 %	8.54 %	*82*
Battery life	3.70 %	6.17 %	22.22 %	16.05 %	12.35 %	39.51 %	*81*
Outdated/old	6.33 %	10.13 %	13.92 %	17.72 %	29.11 %	22.78 %	*79*
Wireless (bluetooth pairing, etc.)	1.23 %	4.94 %	6.17 %	13.58 %	9.88 %	64.20 %	*81*

Table 70 LE device problems question results: Fingerprint scanners

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Capture of fingerprints	5.00 %	5.00 %	30.00 %	45.00 %	5.00 %	10.00 %	*20*
Price: too expensive	5.26 %	5.26 %	15.79 %	5.26 %	21.05 %	47.37 %	*19*
Quality of fingerprints	0.00 %	0.00 %	25.00 %	40.00 %	20.00 %	15.00 %	*20*
Receiving fingerprint results quickly	5.00 %	10.00 %	5.00 %	25.00 %	30.00 %	25.00 %	*20*
Sending fingerprints	5.00 %	5.00 %	10.00 %	35.00 %	30.00 %	15.00 %	*20*
Outdated/old	5.26 %	5.26 %	5.26 %	15.79 %	31.58 %	36.84 %	*19*
Battery life	5.00 %	0.00 %	10.00 %	5.00 %	25.00 %	55.00 %	*20*
Interoperability	5.00 %	0.00 %	10.00 %	35.00 %	20.00 %	30.00 %	*20*
Glare	0.00 %	0.00 %	10.53 %	26.32 %	26.32 %	36.84 %	*19*
Logins/passwords	0.00 %	0.00 %	10.00 %	30.00 %	35.00 %	25.00 %	*20*
Size/bulkiness	0.00 %	0.00 %	5.26 %	15.79 %	36.84 %	42.11 %	*19*

Table 71 LE device problems question results: Laptops

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Internet connection	5.71 %	10.78 %	52.43 %	22.41 %	6.77 %	1.90 %	*473*
Logins/passwords	6.98 %	11.63 %	38.05 %	27.91 %	13.32 %	2.11 %	*473*
Software updates/upgrades	5.08 %	10.81 %	37.50 %	29.87 %	13.35 %	3.39 %	*472*
Battery life	7.37 %	8.21 %	37.47 %	26.32 %	18.11 %	2.53 %	*475*
Price: too expensive	11.75 %	11.97 %	24.79 %	17.31 %	13.68 %	20.51 %	*468*
Software crashes	3.81 %	6.77 %	34.67 %	36.15 %	15.86 %	2.75 %	*473*
Outdated/old	6.79 %	10.62 %	25.90 %	31.21 %	19.96 %	5.52 %	*471*
Interoperability	4.28 %	4.93 %	33.83 %	29.98 %	20.13 %	6.85 %	*467*
Glare	3.17 %	7.61 %	31.50 %	32.14 %	23.04 %	2.54 %	*473*
Power source/recharging issues	3.38 %	6.77 %	31.92 %	32.77 %	21.99 %	3.17 %	*473*
Size/bulkiness	5.30 %	7.20 %	25.21 %	27.75 %	28.18 %	6.36 %	*472*
Durability	5.08 %	5.30 %	24.15 %	34.75 %	27.97 %	2.75 %	*472*
Weight	3.00 %	5.14 %	17.56 %	32.76 %	31.26 %	10.28 %	*467*

Table 72 LE device problems question results: License plate readers

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Ability to accurately read plates	0.00 %	13.64 %	45.45 %	36.36 %	4.55 %	0.00 %	*22*
Price: too expensive	23.81 %	9.52 %	19.05 %	0.00 %	14.29 %	33.33 %	*21*
Receiving results quickly	4.55 %	13.64 %	27.27 %	27.27 %	22.73 %	4.55 %	*22*
Range	0.00 %	0.00 %	40.91 %	36.36 %	18.18 %	4.55 %	*22*
Outdated/old	0.00 %	9.09 %	27.27 %	18.18 %	36.36 %	9.09 %	*22*
Interoperability	0.00 %	4.55 %	27.27 %	36.36 %	18.18 %	13.64 %	*22*
Power source	0.00 %	4.55 %	22.73 %	22.73 %	40.91 %	9.09 %	*22*

Table 73 LE device problems question results: MDTs/MDCs

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
CAD (computer- aided dispatch)	1.75 %	5.70 %	55.41 %	29.97 %	3.22 %	3.95 %	*684*
Using while driving	7.76 %	11.86 %	36.60 %	25.48 %	13.32 %	4.98 %	*683*
Logins/passwords	6.88 %	6.15 %	40.56 %	32.50 %	11.57 %	2.34 %	*683*
Outdated/old	9.46 %	10.77 %	29.26 %	25.76 %	17.18 %	7.57 %	*687*
Price: too expensive	14.91 %	15.79 %	16.08 %	9.65 %	8.19 %	35.38 %	*684*
Glare	1.03 %	6.19 %	38.79 %	37.46 %	13.27 %	3.24 %	*678*
Mapping/navigation	7.06 %	8.38 %	27.35 %	29.71 %	11.62 %	15.88 %	*680*
Lack of portability	11.93 %	10.75 %	19.73 %	29.75 %	19.59 %	8.25 %	*679*
Interoperability	2.65 %	5.74 %	33.73 %	38.88 %	12.52 %	6.48 %	*679*
Size/bulkiness	4.83 %	10.54 %	23.28 %	28.26 %	18.89 %	14.20 %	*683*
Durability	1.03 %	3.40 %	23.49 %	46.97 %	20.24 %	4.87 %	*677*

Table 74 LE device problems question results: Microphones

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Audio quality	0.00 %	11.57 %	47.11 %	31.40 %	9.09 %	0.83 %	*121*
Outdated/old	12.10 %	4.84 %	25.81 %	19.35 %	24.19 %	13.71 %	*124*
Placement on body	4.84 %	7.26 %	27.42 %	30.65 %	23.39 %	6.45 %	*124*
Price: too expensive	14.52 %	12.10 %	12.10 %	8.87 %	17.74 %	34.68 %	*124*
Cord	3.25 %	8.13 %	26.83 %	34.96 %	21.95 %	4.88 %	*123*
Falling off	0.00 %	4.80 %	30.40 %	35.20 %	24.80 %	4.80 %	*125*
Durability	0.82 %	4.92 %	23.77 %	39.34 %	28.69 %	2.46 %	*122*
Talk button location	2.42 %	0.81 %	13.71 %	37.10 %	41.94 %	4.03 %	*124*
Talk button size	1.61 %	0.81 %	12.10 %	32.26 %	49.19 %	4.03 %	*124*

Table 75 LE device problems question results: Pagers

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Outdated/old	25.00 %	0.00 %	50.00 %	0.00 %	25.00 %	0.00 %	*4*
Battery life	0.00 %	0.00 %	50.00 %	0.00 %	25.00 %	25.00 %	*4*
Falling off	0.00 %	0.00 %	50.00 %	0.00 %	25.00 %	25.00 %	*4*
Price: too expensive	25.00 %	25.00 %	0.00 %	0.00 %	25.00 %	25.00 %	*4*
Size/bulkiness	25.00 %	0.00 %	25.00 %	25.00 %	25.00 %	0.00 %	*4*
Durability	0.00 %	0.00 %	25.00 %	25.00 %	25.00 %	25.00 %	*4*

Table 76 LE device problems question results: Radios

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Coverage/dead zones	7.45 %	9.21 %	47.53 %	27.42 %	7.38 %	1.02 %	*1 477*
Audio quality	3.31 %	9.92 %	50.74 %	31.65 %	3.78 %	0.61 %	*1 482*
Price: too expensive	23.04 %	20.93 %	16.06 %	7.79 %	8.06 %	24.12 %	*1 476*
Battery life	3.18 %	9.47 %	44.65 %	34.98 %	6.77 %	0.95 %	*1 478*
Radio discipline/etiquette	4.90 %	7.70 %	35.01 %	36.65 %	12.74 %	3.00 %	*1 468*
Size/bulkiness	4.87 %	9.14 %	27.08 %	34.53 %	19.97 %	4.40 %	*1 477*
Interoperability	5.05 %	7.37 %	25.99 %	36.43 %	21.56 %	3.62 %	*1 466*
Outdated/old	8.02 %	8.36 %	21.41 %	25.42 %	25.42 %	11.35 %	*1 471*
Channel switching	2.24 %	6.72 %	27.29 %	39.78 %	22.40 %	1.56 %	*1 473*
Cord	1.92 %	4.79 %	21.41 %	39.40 %	24.90 %	7.59 %	*1 462*
Durability	1.29 %	3.47 %	16.95 %	44.79 %	31.65 %	1.84 %	*1 469*

Table 77 LE device problems question results: Smartphones

Device Problem	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*
Price: too expensive	15.60 %	18.79 %	22.96 %	15.20 %	16.58 %	10.87 %	*1 224*
Logging in (PINS, passwords, usernames, etc.)	3.27 %	8.27 %	35.43 %	33.63 %	17.10 %	2.29 %	*1 222*
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*
Subpoena possibility for personal smartphone	12.55 %	5.74 %	14.85 %	20.18 %	34.78 %	11.89 %	*1 219*
Permission/access to apps	2.95 %	5.49 %	22.52 %	38.00 %	25.88 %	5.16 %	*1 221*
Outdated/old	2.12 %	6.19 %	21.03 %	38.14 %	25.67 %	6.85 %	*1 227*
Subsidy for personal smartphone (insufficient or no subsidy)	14.70 %	4.93 %	8.05 %	10.34 %	26.11 %	35.88 %	*1 218*
Data plans/data limits	3.20 %	4.68 %	18.57 %	30.40 %	37.06 %	6.08 %	*1 217*
Policies about usage	3.03 %	5.07 %	16.20 %	36.66 %	32.65 %	6.38 %	1 222

Table 78 LE device problems question results: Tablets

Device Problem	Always	Most of the time	Sometimes	Rarely	Never	Does not apply	*n*
Price: too expensive	12.05 %	12.05 %	22.89 %	21.69 %	15.66 %	15.66 %	*83*
Internet connection	1.22 %	3.66 %	37.80 %	47.56 %	9.76 %	0.00 %	*82*
Battery life	1.22 %	6.10 %	34.15 %	35.37 %	23.17 %	0.00 %	*82*
Glare	0.00 %	8.54 %	31.71 %	30.49 %	29.27 %	0.00 %	*82*
Logins/passwords	4.88 %	6.10 %	21.95 %	48.78 %	17.07 %	1.22 %	*82*
Durability	3.61 %	4.82 %	20.48 %	34.94 %	36.14 %	0.00 %	*83*
Interoperability	1.22 %	4.88 %	21.95 %	45.12 %	21.95 %	4.88 %	*82*
Report writing	1.20 %	3.61 %	21.69 %	31.33 %	22.89 %	19.28 %	*83*
Outdated/old	3.61 %	2.41 %	12.05 %	44.58 %	30.12 %	7.23 %	*83*
Touchscreen	0.00 %	3.61 %	8.43 %	44.58 %	39.76 %	3.61 %	*83*
Size/bulkiness	0.00 %	2.41 %	6.02 %	36.14 %	51.81 %	3.61 %	*83*
Weight	0.00 %	0.00 %	4.94 %	37.04 %	55.56 %	2.47 %	*81*