

Sharing 9-1-1 Video Call Information between Dispatchers and Firefighters During Everyday Emergencies

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ABSTRACT

In North America, people phone the number 9-1-1 to obtain emergency services. In the near future, such services will incorporate new communication modalities such as video calling where callers can show visuals of the emergency to call takers. This information can then be shared between dispatchers and first responders such as firefighters. We conducted an exploratory study with dispatchers and firefighters to understand how 9-1-1 video call information should be shared with firefighters while enroute to an emergency and what benefits and challenges it would create. Our results show that video call information can help firefighters gain more accurate information about an emergency, provide location specifics, pre-plan strategies, and mentally prepare for the situation while traveling to it. Yet there are design tensions around what and how much information should be shared with firefighters by dispatchers, and, in turn, what video information is shown to firefighter crewmembers.

Author Keywords

Emergency calling; firefighters; dispatch; video call; video conferencing.

CSS Concepts

• Human-centered computing → Empirical studies in HCI

INTRODUCTION

In North America, people experiencing an emergency situation can phone the number 9-1-1 and be connected with an emergency call centre. They share information about their situation with a call taker and a dispatcher relays the information to a first responder (e.g., fire, police, ambulance) who attends to the scene. In the coming years, emergency calling services in Canada will move towards Next Generation 9-1-1 (NG911) and include support for text messaging, video calling, and the sharing of photos or videos between callers and 9-1-1 call centres [13][14][46]. In turn, this will involve new ways of sharing information between 9-1-1 dispatchers and first responders. Studies have looked

at 9-1-1 video calling between call centres and call takers [45][53]; however, there has yet to be any research that explores how systems should be designed to support NG911 information sharing between dispatchers and first responders. There is a variety of research that explores media sharing between firefighters and dispatch/call centres [7],[37]. This work focuses on ongoing information exchange about a situation while first responders are working, where media is often captured by professionals, such as the first responders (e.g., fire commanders) [7]. Thus, there is a research gap when it comes to understanding how media captured by citizens and shared with 9-1-1 call centres can be viewed and acted on by first responders, such as firefighters.

In this paper, we focus on the needs of firefighters who are responding to ‘everyday’ emergency situations and receiving information from a 9-1-1 dispatcher. By everyday emergency situations, we are referring to what are typically small-scale emergencies called into a 9-1-1 call centre on a daily basis, such as car accidents or small house fires. This contrasts emergency response in crisis situations that are typically less frequent and often require large units of first responders over a prolonged period of time [45]. Our emphasis is on the future exchange of video call information because it offers rich visual information about a situation. For example, one could imagine a future where a person makes a call to 9-1-1 to report an emergency and uses a video call—somewhat akin to a Skype or FaceTime call—to communicate with the call taker. When the dispatcher shares information with firefighters about the emergency situation so they can attend to it, the dispatcher is able to send live video, video clips, or images from the caller, in addition to their current practice of sharing textual information. Thus, the media being shared has been captured by a citizen who may not have much experience in doing so.

We conducted an exploratory study with 9-1-1 dispatchers and firefighters as a form of requirements analysis for the design of systems that can allow firefighters to receive and view 9-1-1 video call information. The goal of our study was to understand: what benefits and challenges 9-1-1 video call information might introduce to firefighters; and how video information systems should be designed for firefighters to view and receive 9-1-1 video call information from dispatchers. Our study emphasizes information exchange while firefighters are enroute to an emergency as we have found that for everyday emergencies, this is the most critical

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time for information exchange with 9-1-1 call centres. It is also the time period in which a call centre in our region would typically keep the caller on the line and continue to receive video call information from them.

Our results show that video call information from 9-1-1 callers could be very valuable for firefighters in order to understand an emergency, pre-plan tasks, and mentally prepare oneself while they are enroute to the emergency. Yet there are design tensions around who controls the access to video call information and its curation. Dispatchers presently curate the information that is shared with firefighters, however, firefighters wanted to see and know about more details. This suggests design opportunities for exploring lightweight interactions for video review while traveling in the firetruck. It also raises questions around the present information workflows between dispatchers and firefighters.

RELATED WORK

Emergency Call Centres and Dispatch

When people phone 9-1-1, a call taker asks them a series of questions [23][38][63] and records this information in a Computer-Aided Dispatch (CAD) system [45][60]. This is then dispatched to a first responder [45]. Dispatch information is not always accurate and highly dependent on what a caller tells the call taker [23][61]. Call taking can be a challenging endeavor as call takers must acquire information from frantic callers [4][61][62][64] as well as those with language barriers [1][25]. Given these problems, call takers try to take control of the call in order to gather information in a systematic way, through a series of predetermined questions [45][55]. Call takers sometimes hear about traumatic situations in calls that are not easy to forget [1][6][39][52]. A study of 9-1-1 call takers showed that video calls would be valuable for seeing injuries and location details, yet call takers were sometimes concerned about seeing traumatic situations [45]. Call takers also wanted to be able to direct the camera work of the caller, in order to capture specific things in the scene [45]. A complementary study of 9-1-1 callers found that they would be willing to give up control of what to capture on video providing they had given consent [53]. Research on the use of video calls between ambulances and hospitals found that video would be valuable in order to alert hospitals as to the types of situations they were about to have to deal with [5]. Hospitals have also been found to desire more visual information about patients during transportation to the hospital [65].

Firefighting and First Response

There has been a large amount of research on firefighting practices, primarily focused on procedures at the scene of an emergency. The role of firefighters has changed over the years from responding to just fire emergencies to include a broader set of first response work such as attending to motor vehicle accidents or injuries (e.g., heart attacks, falls) [23]. Firefighters' work practices are highly structured and roles are hierarchical [12][16][29][59]. When arriving at a scene,

firefighters first survey the scene to size it up [29]. High ranked commanders and officers relay instructions of what to do to subordinate firefighters in person or over a shared radio communication channel [12][29][59]. Radio communication involves a shared vocabulary amongst firefighters and firefighters must actively listen to see what information is important for them to know [16][59]. This is part of maintaining situation awareness, a moment-to-moment understanding of what is happening and how this information should be acted upon [1][16][19][59]. When fighting fires in the front line, situation awareness can be challenging to maintain because radios are difficult to use while wearing fire gear [17]. Background chatter on radios can also be distracting, firefighters can draw conclusions too quickly based on what they hear, and there can be temporal misunderstandings about what is being done [26]. Researchers have investigated new designs and systems to help improve firefighting work while actively fighting fires. For example, designs have focused on virtual reality training for fighting fires [36][58], simulation games [58], clothing to measure physiological data and assist firefighting tasks [15][51], head-worn depth and thermal cameras for seeing in buildings [1], and large displays for task assignment and management [29].

More closely related to our focus, there is research on media-sharing between firefighters and emergency dispatch centres. During crisis management, first responders found value in seeing video of a situation for themselves while it was ongoing [37], though we do not learn about specific details around what would be relevant to show in photos/videos or how it should be recorded (e.g., camera location, camera work). Media from citizens during a crisis was also found to be valuable yet raises concerns around information overload from first responders receiving too much media [37]. During the response to an emergency, short videos from incident commanders have been found to provide valuable contextual information for other crewmembers [7]. Histories of text message archives have also been found to be important for understanding changes over time [8]. While valuable, this research focuses on the ongoing response to a situation with a heavy emphasis on crisis situations, rather than our focus of traveling to and handling everyday emergencies. Moreover, media is captured by first responders themselves, rather than everyday people calling 9-1-1; this is our focus.

Video Calling and Streaming

Outside the realm of emergencies, many people rely on video calling to support both personal and work communication [3][10][32][35]. Despite the benefits of video calling, people face privacy concerns including showing oneself on camera in unflattering ways [11][22][34][43] or streaming video of bystanders in public [54]. Video calls using mobile devices have been found to require careful camera work in order to adequately show the remote viewer a scene [30][40][47][48]. By camera work, we are referring to the continual reorienting of the camera's direction and zoom levels to provide an ideal view of the scene to remote viewers [27][31][49]. This act is

often difficult for people to do because they are trying to think about what the remote person would most like to see [27][30][49]. In turn, remote users often want more control over their own view and to be able to gesture at things [30]. There is also a desire for better spatial context [30][34].

To overcome these challenges, design work has focused on combining or providing multiple camera views [44], 360-degree cameras to shift the focus of the camera work to the remote viewer [56], and drones to provide an aerial view of a scene [31]. Researchers have also explored the live streaming of events by amateurs, including performances and social events [33][57]. Again, camera work was shown to be a challenge along with differences between the goals of amateur video streamers and remote viewers [20][21][50]. Multiple camera views were again suggested as possible solutions [20][21][50]. Our work is similar in that we explore how everyday people share video of a scene with remote users, albeit the kinds of situations being shared (emergencies) are different. We explore topics of camera work and mobile video views as it relates to firefighters receiving video call information captured by 9-1-1 callers.

USER STUDY

The goal of our study was to understand: what benefits and challenges 9-1-1 video call information might introduce to firefighters; and how video information systems should be designed for firefighters to view and receive 9-1-1 video call information from dispatchers. We explored this in two ways. First, we conducted observations in 9-1-1 call centres to understand dispatching practices. Second, we interviewed firefighters about their work while traveling to an emergency scene and needs around video call information. Our study was approved by our university research ethics board.

9-1-1 Dispatch Observations

We conducted observations of 9-1-1 call taking and dispatch activities in three call centres within Canada. These included one call centre that handled a rural population of approximately 130,000 people; a centre handling a medium-sized city and surrounding rural areas of approximately 100,000 people, and a centre handling a city with approximately 1.4 million people. All three centres received and dispatched calls to firefighters as first responders. We spent between 7 and 10 hours at each of the call centres where we sat next to call takers and dispatchers, listened in on calls and dispatches, and observed regular work practices. Here we focused on understanding what information was collected from callers; if and how information was filtered and recorded within the CAD system; and, what information was shared with first responders and how.

As part of our observations, we directly observed and talked with 11 call takers / dispatchers who handled fire-related emergencies. Some performed both roles, while others performed either a call taker or dispatcher duty on its own. We talked with four of these participants at sporadic moments throughout our observations. The other seven we were able to talk with away from their call taking/dispatch

duties in a private room, in addition to our time observing them while working. Conversations lasted approximately one hour. Participants comprised of 10 women and 1 man; the large number of women reflects the high proportion of female workers at the call centres. Participants' ages ranged from the early 20s to late 50s. Our conversations focused on understanding why participants performed particular work activities in the way they were done, e.g., why was certain information recorded and not other information? how did they decide what to share with firefighters? We also asked about challenges with information acquisition.

We kept detailed notes of our observations and conversations, noting the actions of the call takers/dispatchers. We then conducted open, axial, and selective coding on our notes. Open codes related to the ways that information was collected from callers, how it was recorded in the CAD system, challenges that existed, and how information was dispatched to firefighters. Axial codes grouped open codes into categories such as contextual information, curation, situation awareness, and targeted sharing. Our selective coding identified the main themes across our data. We report these in conjunction with results from our firefighter interviews, described next.

Interviews with Firefighters

Next we conducted interviews with firefighters to understand information exchange from their perspective. We recruited firefighter participants through word-of-mouth by talking with firefighters in our university's city location. This built on connections we had with local firefighters through past work. Twelve males agreed to participate in the study. All were from the same suburb of a major metropolitan city in Canada. The large number of male participants reflects the high proportion of male firefighters in the city. In 2016, the estimated population of the suburb was 525,000 people. The city's fire service has 15 fire halls strategically located throughout the city and a department size of 400+ firefighters. Participants in our study were stationed at both urban and rural fire stations within the city.

It is important to note that the call centres from our 9-1-1 dispatch observations did not dispatch to the fire halls where we interviewed firefighters; this was due to access issues with call centres and firefighters. Nonetheless, the data from both areas suggests that practices were very similar between regions and groups. Thus, we do not see this as a major limitation for the work.

All participants had responded to fires, motor vehicle incidents (MVIs), and medical emergencies, as well as, in special cases, hazardous materials response (HAZMAT). Six of the participants were of rank 'firefighter,' the lowest rank in the fire service. Two participants were drivers, a special type of the firefighter rank, and drove fire trucks to and from incidents. Two participants were 'officers,' a senior rank that includes supervisory work during an emergency call. Within the officer rank, there are additional ranks, such as Lieutenant and Captain, based on experience. The final two

participants were retired and had taken on all three of the aforementioned roles throughout their career. The two retired officers we interviewed had 30-36 years of service experience and at least ten of those years of service were in the position of an officer. The retired officers had retired within the last ten years. Participants' experience ranged from 6 months to 36 years of service and ages ranged from 25-75 years of age. All participants had at least some experience in making video calls in their personal lives.

Semi-structured interviews were conducted at the firehall before / after participants' shifts had finished in order to tie interview questions to the context of work as much as possible. For retirees, we met during their availability. Interviews lasted 60 to 90 minutes. We were unable to conduct observations or interviews *during* work time given a high unpredictability of people's availability and the emergency nature of the work. Interviews were done individually away from other firefighters in private so that each participant could openly express their opinion. Several participants requested to be interviewed at their home or a local coffee shop for additional privacy. Interview questions focused on two areas:

1. Existing Practices: We asked about current work practices from the moment a call came in to the fire hall until the completion of the emergency response. We also asked about what types of information they received from dispatch and needed for medical emergencies, motor vehicle incidents, and fires and what worked well and not so well about the receipt of this information. We purposely tried to ground all questions in actual situations that the participants experienced. For example, we asked, "Tell us about the last call you were involved in. What information did you receive about it? What happened?"

2. Future Situations: We probed about future technology usage where we asked about firefighters seeing video call information. Here we explained that a 9-1-1 call taker/dispatcher would have a video call with an everyday citizen—somewhat akin to a Skype call—and video or images from the call could then be sent by the dispatcher to the firefighters for them to view while driving to the scene.

We asked participants about the benefits they thought that video call information might bring, the disadvantages of video call information, what kinds of camera views they felt would be best/worst, where they would want to see video call information in their existing software/hardware, possible privacy concerns, etc. Because participants were largely speculating about a technology that was not yet available to them, we ground their thoughts in specific cases of 9-1-1 calls. For example, we asked, "Tell me about a recent fire you went to. If you were able to receive video or images from dispatch, what would you want to see beforehand? Why? What would you not want to see? Why? How would you want information to be relayed to you? How would video/images benefit you, if at all? What challenges do you foresee for both first responders and the public?" We

repeated these questions for the different types of emergencies that participants dealt with (e.g., fire, MVIs, HAZMAT). Throughout this interview stage, we also probed participants about other possible sources that might provide video information of an emergency beyond the 9-1-1 caller. For example, several participants brought up the idea of video footage from drones.

All interviews were audio recorded and fully transcribed. Our analysis included iterative review of our interview transcripts and open, axial, and selective coding stages. We produced four main categories of findings focused on general work practices, behaviors during the receipt of call information presently, uses for video within dispatch information, and viewing and sharing video information. The former two groups focused on current work practices and the latter two groups focused on future practices with video dispatch information. Within current routines, our codes included subgroups such as private information (known only by the officer), public information (known by all firefighters on the crew), information accuracy, planning, dynamic information, and emotional responses. For future needs, our codes included subgroups such as camera work/views, safety concerns, privacy concerns, private information, public information, information accuracy, and access control. Selective coding revealed main themes around contextual understanding, camera work, safety and privacy, information viewing and sharing, and inaccurate and conflicting information. We focus on these in our results sections next. We report quotes from firefighter participants with F#.

RECEIVING INCIDENT INFORMATION

Our observations showed that when a person calls 9-1-1, the call taker at the emergency call center asks a series of questions and records the information about the incident in their CAD system. Once the caller can provide no new information, they are let go by the call taker. While the call is taking place, dispatchers see the incident's information in their own CAD system. They then radio a particular fire station with the information.

Our firefighter participants explained that when a new incident comes in, a tone goes off in their firehall alerting the firefighters that they have an incoming call and the basic information is relayed over a loudspeaker that all the hall's firefighters can hear. This includes a basic classification of the call so firefighters know if it is a fire, motor vehicle incident (MVI), an injured or trapped person, or HAZMAT. Firefighters quickly grab the necessary equipment for the type of call and then board the fire truck. For example, for fire calls, they will don their fire protective clothes, but for injury-related calls they will typically not.

The initial dispatch is usually very kind of general...when it first comes over the loudspeaker at the hall, or over the radio, will just be something simple like 'a rescue.' – F9

In our participants' fire halls, firefighters typically worked in teams of four per truck. This included one driver, one officer

who sat next to the driver in the truck, and two firefighters who rode in the back of the truck. The exception was rescue trucks that were stationed in busy parts of the city to respond to medical calls and act as backup resources. These trucks contained only a driver and an officer. On the trucks, the driver and officer decide on the best route to get to the incident. The front passenger seat of the truck has a laptop next to it. Officers look at the CAD system running on the computer periodically while driving to the incident. It will continually update with new text information as the call taker adds information during the call with the 9-1-1 caller. For example, in the case of injuries, this might include the patient's age, gender, and specifics of the injury.

When the officer receives information on the firetruck, he decides what information he thinks is pertinent for the other firefighters on the truck to know about. He then shares it with them over the radio while they are driving. Typically, information about the injury type or type of fire are shared. Officers will also relay strategy to the firefighters that is specific to the call's incident. Information may also be shared over the radio from the dispatcher, which all fire fighters on the truck can hear. This often involves repeating information that has already been typed into the CAD system, but saying it verbally in case the officer did not have time to read it. The officer can ask the dispatcher additional questions if needed.

We learned that the entire process of traveling to the scene and acquiring an initial understanding of the situation happens very quickly. For severe fire calls or MVIs, depending on the location, it can take a fire truck as little as two minutes to arrive on scene. For less severe incidents, firefighter participants said that they usually arrived within eight minutes because they did not need to travel with lights and sirens. This allowed them to travel more safely and avoid additional accidents. Thus, the time period where information was received from dispatch was very small when traveling to an incident, but extremely important. We found this was also the only time period in which the 9-1-1 caller was on the call with the call centre. Thus, it was generally the only period of time in which new information was shared by a dispatcher.

INFORMATION CHALLENGES

Our interviews and observations surfaced several challenges that were experienced in relation to sharing and understanding information about the emergency while firefighters were enroute to it. We describe these next where we detail how video calling might benefit the situation.

Information Inaccuracies

First, we learned there were tensions over what information dispatchers provided and how valuable it was to the firefighters. The call takers and dispatchers in our study talked about information acquisition from callers as an iterative process where they learned more and more as the call went on. They wanted to share information quickly with firefighters so that they could know what they were going to be heading into, but the call takers and dispatchers

understood it was often incomplete information. As such, they tried to provide new updates as quickly as they could but they were limited based on what a caller was telling them. Our call centre participants explained that they tried to share only specific details of the emergency situation, selecting what they felt could help first responders understand the situation best. They felt that firefighters had limited amounts of time and would not want to know a lot of detailed information. Details that might be heard in the 9-1-1 call such as background information about what was happening at the time of the incident (e.g., a family picnic) or how panicked the person is would often not be shared. Thus, there was a clear information filtering process.

When we interviewed firefighters, they very clearly valued the information they received from dispatch, yet they described challenges with the information as sometimes they felt it was inaccurate. They explained that they would sometimes be traveling to the scene and not fully knowing what was upcoming. When they would arrive there, the nature of the injury or what was happening was not always what was described in the CAD system or radioed by dispatch. They noted that they felt this was a result of the caller, however, and not the dispatchers. Accurate information was very important as it helped judge the seriousness of the call and how fast the firefighters needed to respond. Several firefighter participants talked about information being highly dynamic, which meant details could quickly become inaccurate. They said that although the time needed to get on scene is a matter of minutes, this time period is long enough for fires to escalate from small kitchen fires to large house fires. In the case of MVIs, the amount of change was seen as being less dynamic, however, changes to injuries could also change largely (e.g., amount of bleeding). They felt dispatchers were not always able to provide such dynamic updates on the situation.

A lot of the times we do get inaccurate information on patients...A lot of the times the information we get isn't necessarily ... its not live information. It's a little bit delayed in that ambulance gets it, then it goes to our dispatch. – F4

In contrast to what the dispatchers were sharing, firefighters talked about the benefit of having access to more data about the situation. For example, they talked about the value of being able to see live video from a caller, if 9-1-1 video calls were available for them to see. They felt that live video could help them understand the origins of fires, which would help better fight the fire in its present situation. Several participants also talked about wanting to be able to move forward or backward in a video feed to see the progress of the incident (e.g., look at the origin of the fire and how it grew). Rather than have dispatchers as the filterers of information, they felt they had additional expertise that made it valuable for them to see the raw information from the call.

Location Details

The call takers and dispatchers in our study most often received location details from the caller automatically as

landline phones sent their location. Mobile phones typically shared a location range of several metres, but this could be larger depending on the accuracy of the GPS. The call takers verified location information with the caller, including the address and any visible landmarks, and would share it with the firefighters while they were enroute. Yet the firefighters in our study explained that they often wanted more details than the location information they were given. This included the type of building, the side of the street when it was a complex street situation, and details about the specific location within a property. This information was currently not provided by the dispatchers and it was felt to be difficult to relay via text or verbal descriptions. It was also not always easy information to get from callers.

Usually if it's at a house, we know that it's going to be inside the house, but if it's a patient down for instance, it's nice to know where is the patient? Is he in the middle of a field? Is he in the middle of a busy street? Is he up a tree? You never know, just a patient down, you don't know where he is. – F8

Firefighters also said they wanted to know site-specific details that would help them know where and how to park upon arrival. For example, they wanted to know the location of fire hydrants so that they could park the fire truck within a necessary distance from them. Firefighters felt that knowing these details ahead of time could help them to strategize what direction to come into on a street. This could seemingly save only a short amount of time (e.g., seconds or minutes), but this time was often critical. Three firefighters also talked about complex streets that contained medians and large volumes of traffic traveling in each direction. They felt that video or pictures of a location could provide valuable information to help plan their approach, providing that such media was recently captured or 'live.'

Task Preparation

Firefighters talked about challenges with task preparation while they traveled to the emergency. They told us that they would often preplan in their head as to what they might do, or recite what the particular emergency steps were for the given situation. Many were highly familiar with processes such as CPR or steps to treat specific injuries, yet they wanted to mentally recite them as a way to focus. Other tasks were sometimes more demanding and, even though they contained routine actions, the firefighters would have to apply their training to the specific context of the call. For example, firefighters talked a lot about MVIs and how to rescue people from cars. However, the locations of where the cars were and how accessible the people were within the car were often very different across emergency calls.

There's all kinds of things that could come into play. If they're wedged upside down in a ditch, your first thing might be breaking the back window and going through there. Or if you can't do that, you might need a shovel, just start digging the sides of the bank away...if you knew ahead of time, what you had, you have time to think of these things and what your

Plan A, Plan B, Plan C is before you get there. So that would be good. – F1

It was clear from our observations and conversations with the dispatchers that the kinds of information that the firefighters needed in order to mentally prepare for an emergency were not something that the dispatchers were able to provide. The information from dispatchers was not always detailed enough. In contrast, firefighters felt that video or images of the actual scene could help them to figure out how they might rescue a person in a given situation. In the case of fire, they felt that they could begin to judge distances between areas around a building and within a building itself. Videos showing specific injuries were felt to be valuable so that the firefighters could think of what equipment they would need ahead of time (e.g., stabilization board). Videos of MVIs could let them figure out rescue plans ahead of time.

Scene Size-Up and Hazards

When arriving at a scene, firefighters described the first activity they performed as scene-size up. When the crew arrives at the scene, the driver finds an appropriate place to park. The officer performs a size-up of the scene and gives orders to the firefighters of what to do. A size-up is defined as an overview of a situation including hazards, number of people involved, and severity of the incident. Sometimes multiple trucks go to a scene. In this case, the first truck arriving would be responsible for the size-up. The firefighters explained that the kinds of things they needed to look for were not something that was possible for dispatch to tell them while they were traveling to the scene because it included a lot of situational information (e.g., what information was important depended on the situation). Our observations of call centres confirmed this as the dispatchers did not get enough information about an emergency scene to know all aspects related to size-up.

Firefighters explained that video call information could be valuable for sizing up the scene while they were enroute to it as they could likely see many of the things that were a part of their normal size-up activities. They also felt they could identify any obvious hazards that they may need to pay attention to. Such hazards could affect their route to the specific location of the incident (e.g., down power lines) and if they had the right amount of vehicles, or the right crew (e.g., HAZMAT) and equipment (e.g., 'jaws of life'). Even if the dispatchers could see the video call themselves, the firefighters felt that dispatchers may not be trained to notice or understand such specifics within a 9-1-1 video call, but the firefighters' additional firefighting training would allow them to do so.

CHALLENGES WITH VIDEO INFORMATION

We probed participants about the various ways that video call information might be shared by dispatchers with the firefighters. Within these conversations, several themes emerged around how video call information would need to be shared, how systems would need to be designed, and what challenges would need to be overcome.

Information Viewing and Sharing

First, the firefighters in our study made it very clear that 9-1-1 video call information that was relayed by the dispatcher to them would need to be viewed exclusively while on the truck and traveling to a situation. The time spent in the fire hall before leaving was too short, and, once arriving at the scene, participants all said that video information provided little extra value because they were focused on the situation at hand. Yet the driving context raised issues around the ability to actually look at a video screen in a moving vehicle. Firefighters noted that the truck was often moving very quickly and, given its large size, was prone to bouncing. This meant that it could be hard to look at a small screen. Currently, the laptop screens onboard in the cab were considered to be relatively small (e.g., a 15 inch display) for viewing and firefighters said they would have to look closely to inspect the screen and see what was happening in a video.

Our screens are just little, I don't know what they are, probably 15 inch screens...And you are in a moving vehicle, so nothing's very stable. You're bouncing on a seat and you're on route, so you gotta take that into consideration. You're not just sitting in an EZ Boy looking at TV. It's gotta be pretty clear for you to make decisions. That's one consideration. – F1

There were mixed reactions over who should be able to see the video on the fire truck. The two drivers in our study very adamantly did not want to have access to view video call information, nor did they think they needed to. They said that their focus was solely on driving and they did not want to be distracted for safety reasons. The six firefighter participants who rode in the back of the truck all said that they wanted to see video call information during the drive. It was seen as a valuable resource to understand the scene and mentally prepare, both psychologically and task-specifically. Yet they were cautious that they did not want to be overloaded with information during such a short time span. There were also concerns about getting tunnel vision and overly fixating on what they saw in the video information. Thus, in some cases, they felt like getting information filtered by an officer could help.

I think it would be helpful for everybody to have a view on it. Ultimately, I do like having the captain's input on it into what he's deciding on his wall. I think it would be beneficial for everybody to see the information opposed to just one guy being able to see it. I think it would be good for everybody to see it. – F3

The four participants who were currently officers or had taken on this role in the past said that their role in the front of the truck was to help the driver navigate, read information on the laptop's CAD system, and relay pertinent information to the other fire fighters on the truck over the radio. They cautioned that they did not want to be too distracted by a video feed such that it might take them away from their ability to help the driver navigate. This meant that they would have to be able to quickly glance at a display screen and

acquire the necessary information. Two participants expressed hesitation about having the rest of the firefighters on the truck see the call information. The officer's role was described as being very purposeful: he needed to figure out what was pertinent for his crewmembers to know, and then relay it in a calm manner. Thus, the officer acted as an information filter that would help direct his crew in the right manner, rather than have them come up with their own plan about how to handle a call.

The guys in the back basically do what I tell them and so, for them to have information is irrelevant...I want them to do what I want them to do. We go to a fire and I'm lookin' at a screen and I see what I want...I've seen notes for so many years, that I can read between the lines. And it would be the same with video...For someone, say, it's their first month on the job and they see some video footage, they might be panicking, 'cause it's not enough information for them, or whatever, or they think it's worse than it is. It might just create anxiety for someone that's new to the job. – F1

Camera Work

Firefighters talked in detail with us about the types of camera views and camera work that they felt would create the best information for them. Two firefighters said that callers should pan around a scene with their mobile phones to provide an overview, or that CAD systems might be able to stitch together video from multiple callers' phones to create a 360-degree view. This would help with scene size-up while enroute. Five firefighters talked prominently about the high value that they would get from seeing elevated views of an area, including 360-degree views of an entire scene. These participants talked about having drones fly above a scene to capture such aerial views.

If you had a drone do a 360 around it or something, or multiple videos so that you can see all the way around the incident before you get there, it would just help us identify more hazards ahead of time, and potential problems, and potential victims, and potential solutions to those problems. – F9

Nine firefighters talked about close-up views, in particular, to see injuries or vehicles in order to see if somebody was trapped inside. Several said that it could be difficult to acquire such close-up footage if the situation was spread across an area, like a multi-vehicle car accident.

Seeing a nice a close up of just the arm would help...because we could see that he's got a big dog bite on his arm, but you can also see maybe he's got, like I said, puncture wounds on his abdomen or both arms are bit. Or, maybe he's got half his chin missing, but he doesn't even know, so it would be good to see the whole, yeah, the whole patient I guess. – F8

There were also concerns raised by both firefighters and call takers/dispatchers about whether a 9-1-1 caller would have the necessary camera work skills when using their mobile phones in order to capture the aforementioned details, e.g., the ability to frame the video, zoom in and out, etc. This

could be the case because people do not frequently call 9-1-1 so it may be a new experience for them and they would not have built up training in capturing such video on their mobile phones. The call takers and dispatchers felt it would be important to be able to guide the caller in terms of what to capture.

Participants also felt that a 9-1-1 caller may be less familiar with technology. For example, one firefighter said that older adults may not know how to use a video call on a mobile phone. Many firefighters talked about the value of 'good' camera work and commented that they did not want to see a lot of irrelevant information since they had such little time already when traveling to the incident. This could cause information overload and make it hard to assess what is relevant. For example, one firefighter talked about not wanting to see 'a lot of sky' or other features of the scene not related to what was actually happening because callers did a poor job of orienting their phone's camera. This could slow down their ability to acquire the necessary information from video clips or live video.

I guess what I wouldn't want to see is something that is not related to the incident. They're showing water flooding out of the basement or something. I don't care about that. I'd rather see what's going on at the incident. So, non-pertinent information, I guess. – F7

Video shot during the night time on a mobile phone was noted by one participant as being particularly challenging to decipher even if it did focus on relevant information. There were also concerns by two participants that a person calling 9-1-1 may not be comfortable getting up close to somebody who was injured and capturing possibly gory information.

Safety and Privacy

Seven firefighters talked about serious safety concerns related to the person shooting the video and providing it to the 9-1-1 call centre. There was a general sense that this person could be putting themselves in harm's way by trying to get good footage or footage that was requested of them by the 9-1-1 call taker. They did not want to have additional emergencies to take care of at the scene because the caller became injured as well. Firefighters said this could be difficult for the caller to know, or even the 9-1-1 call taker to alert the caller about, because hazardous materials can be hard to spot and identify. Fires can also easily and quickly escalate. There was even a question of which was more helpful, providing video to 9-1-1 call centers or physically helping an injured person (e.g., giving CPR).

There's a lot of things that you can't see necessarily through a screen that could potentially get that guy into trouble or he could become part of the problem... Maybe the car is on fire or if there's a fuel leaked all around. He's walking around in it to get a better video picture, I don't know if that's going to be a good thing. – F3

Both firefighters and dispatchers said that there may be serious privacy issues that could come with capturing video

of others in public spaces using a mobile phone (e.g., bystanders, an injured person) when they did not want to be captured or did not know they were being captured. They felt this could easily compromise what video 9-1-1 callers were able to capture or be comfortable in doing so. On one hand, they felt that because situations were emergencies, privacy issues were less of a concern. Yet, because the severity of the situation was subjective, people in the general public may have differing views about whether their privacy rights were superseded by the supposed emergency-nature of the situation. For example, one firefighter talked about respecting people who had passed away and not capturing videos of dead bodies. He related this to their current practices of immediately placing a tarp over a dead body at the scene of an accident out of respect.

Two firefighters were concerned that people may continue video recording or streaming past a point at which it was valuable for emergency crews to the point at which it was focused more on sensationalism rather than help. They felt that those who called 9-1-1 using a video call should stop recording or sharing video information once the crew had arrived on the scene. There were concerns about people getting in the way of their work. One firefighter felt that continued video capture of the scene could raise liability issues if the 9-1-1 video caller captured footage that they believed showed malpractice on the part of the firefighters.

Psychological Preparation

Psychological preparation while they were traveling to an emergency was critical for many of the firefighters in our study. Seven firefighters talked about wanting to know ahead of time what type of situation they were getting into as they traveled to a scene so that they would not be shocked when they arrived. The information they received from the dispatchers described what they were about to encounter, yet the specifics of the incident could still vary quite heavily (e.g., how gory the scene was). They were used to seeing very traumatic situations, however, many felt they could be in a better state of mind if they knew more details ahead of time such as exactly what they would see. Several firefighters in our study had calming rituals that they would do enroute to an emergency situation. Video information was seen by many as a means to help such preparations. Of course, this presupposes that the caller is able to acquire such information. Prior work has found that callers may feel uncomfortable capturing details that might be considered gory or hard to look at [53].

Rather than being shocked, especially at two in the morning. A lot of these calls come at two in the morning when you're half asleep. If I had a little bit of pre-warning, as to what I'm going to see and what we're going to be doing when we get there, I think that'd be a little better on my mental and my physical health, too. – F12

In contrast, there were five firefighters who did not want to see traumatic visuals from dispatch. They thought they were already seeing too much when it came to traumatic situations

on scene and gory video information should be limited to avoid further challenges with post-traumatic stress disorder. This is similar to findings of emergency call centres where not all call takers/dispatchers wanted to see visuals of a scene [45].

If there was a fatality, I don't know if I'd want to see that on video and then now I'm knowing I'm going there... It's never good seeing that, but you kind of want to react when you're there. I don't think I'd want to see a burning building with people entrapped in it and seeing video of that. – F5

DISCUSSION

Overall, our study points to the value that 9-1-1 video call information could provide firefighters when they are enroute to an emergency. Yet it also raises important points about the difficulties in designing within this space, and the possible effects on firefighter's work practices and communication exchanges with 9-1-1 call centres.

Viewing Visual Information

Similar to the related work, we found that visuals would be valuable for firefighters to see of emergency situations [7][37]. We extend past research to illustrate the desire for such visual information by firefighters while enroute to an emergency and when the visual information is coming from everyday people who are calling 9-1-1; this contrasts ongoing video acquisition while at the emergency or during a crisis situation [7][37]. The firefighters in our study felt that it would be valuable to see information and this information would extend the capabilities of what dispatchers are normally able to provide. Yet having firefighters view video call information raises challenges. At a pragmatic level, we see that video call information would be desirable within the cab of a firetruck such that it could be viewed by the officer (but not the driver). However, it is clear that this view could easily become distracting for officers who are also trying to help the driver navigate to the scene. This suggests that there would be value in making this view optional such that an officer could turn it on or off, along with ways to quickly glance at it to gain information, rather than requiring long inspections or interactions. Officers may find value in being able to easily move backwards and forwards through the video (scrubbing) in case they want to see key visuals such as the origin of a situation, or key moments in time. Yet, again, this type of interaction would need to be extremely lightweight in order to perform. A large difference between our findings and the related work on mobile video usage (e.g., [30][31][40][49][50]) is that firefighters are under intense time pressures for viewing video.

Past work has illustrated the role that video can play as 'data.' For example, video feeds have been found to let surgical staff predict what tools a surgeon may need next [41]; video media spaces in office settings presented availability 'data' to help colleagues time social interactions with others [9]; and, families use video call 'data' to see how children have grown [35]. Actual video or images from 9-1-1 calls could be used as data for firefighters to mentally

prepare for a situation and plan out a sequence of tasks. While similar to the related research, the difference is that firefighters only have several minutes of travel to think about what they have seen and what they might do at an emergency when they arrive there. In turn, there are also design opportunities to explore how visual information can be presented to firefighters enroute such that it does not cause additional trauma and negative mental health situations, such as Post-Traumatic Stress Disorder (PTSD). This type of challenge is not something seen in the related work where video surfaces as data for understanding contextual information [9][41].

Information Sharing and Curation

Information exchange between 9-1-1 dispatchers and firefighters is currently a curated process where dispatchers select and filter the information that they share with firefighters in an abbreviated manner [45][53]. This workflow and summarization appears important as firefighters have very little time to act and comprehend situations when they are traveling to them. The introduction of 9-1-1 video call data raises questions about how this information flow and curation may work in the future. It would seem pertinent that dispatchers be able to curate the video that they receive from 9-1-1 callers, such that they could highlight or send particular sections of video, or select still frame images to send fire fighters. Yet firefighters wanted to know more information than they were presently getting, and if video was available, they tended to feel that they were the best judges of what information would be important to know given their unique training. This raises a design tension around how to manage video curation and sharing between dispatchers and firefighters. As such, design work could explore ways to support curation by dispatchers, while also allowing firefighters to vary how much information they can see. For example, at a basic level, designs could show the information curated and shared by dispatchers. Firefighters could then have the ability to choose to see more, if they find it desirable in the moment because the curated information feels incomplete. Timelines associated with a video call could also tag or highlight areas to suggest important or graphic content ahead. Beyond design, this also raises implications for the training of dispatchers and firefighters and adjustments to information workflows to incorporate the complexities of managing, curating, and reviewing video information.

We also saw a similar tension arise between the officers in our study and firefighter crew members. The officers felt it was important to maintain a level of control over what information their crew members knew. They felt this would help maintain a sense of calm and protect those with less experience from information overload. This reflects the firefighter organizational hierarchy that we found, as well as that found by others [7][37][59]. However, the crew members in our study who rode in the back of firetrucks tended to want to see more video information, with cautions about information overload and 'tunnel vision.' These

findings suggest design opportunities for exploring ways that firefighter officers may be able to filter and select pertinent visual information to share with crew members, where it might be easy to adjust the amount of information being shared for cases where more becomes desirable. The challenge is that such designs, again, need to involve very lightweight interactions. It would also likely involve additional cognitive loads on officers who would now need to decide what to share. This could be extremely challenging in such a short amount of time and requires cautious design.

Camera Work by Amateurs

One of the main differences between our work and prior explorations of media sharing by firefighters is who is capturing the media. Past work explored firefighters themselves capturing videos while on scene [7], while we have focused on amateur video capture by people calling 9-1-1. This is more akin to people who live stream events and happenings [57]. Yet our study raises questions around the abilities of those capturing 9-1-1 video. Live streaming is often done by those who have an affinity for capturing video and experience in doing so [20][21][57]. When firefighters capture video information, they have a broader understanding of what is valuable to capture. People calling 9-1-1 with a video call will likely be doing so infrequently [45][53], which means that they are likely to have little experience in capturing what could be considered ‘good’ video of an emergency. They may also not be technology-savvy.

Like past work, this suggests design opportunities for those in contact with the 9-1-1 callers—the call takers and/or dispatchers—to help 9-1-1 callers capture valuable video data [45][53]. Our study builds on these suggestions to illustrate the types of video footage that firefighters would find valuable. This includes 360-degree panning of a scene to get an overview, as well as close-ups of specific problems (e.g., injuries, vehicles). We also see the concerns that firefighters have about 9-1-1 callers making the situation worse by capturing video in unsafe situations, or the possible privacy concerns of others. Here there are interesting questions around consent and when it is needed during an emergency (e.g., is it okay to video stream bystanders?). 9-1-1 callers may also not necessarily know when video should not be captured out of respect for the family or victims that have passed away. It could be difficult to distinguish death from serious injury, for example.

Camera work by everyday people may also not be enough to adequately help firefighters. There is a possible role to play for other technologies such as drones that are able to easily get an aerial view of a situation. For example, one could imagine a drone quickly flying to the scene of an accident and sharing aerial video with a dispatcher who relays this to the firefighters as one of the video feeds about the call. Drones could also share video footage directly with firefighter officers. One could even imagine CCTV cameras playing a similar role if they are available. Yet the challenge

with CCTV cameras is that they are stationary and it could be difficult to get the right camera views and angles and it would be unlikely to get the types of close-up video that firefighters wanted. Overall, this suggests there are design opportunities for creating hybrid systems that could, for example, bring together video from a number of different sources, including 9-1-1 callers’ mobile phones, drones, and even CCTV cameras. To date, we see little research that has looked at combining such an array of camera technologies.

CONCLUSIONS AND FUTURE WORK

Overall, our work has helped to open up the design space of Next Generation 9-1-1 calling services, which will be critical as such services move to the use of advanced technologies. We have specifically provided details on the design needs of firefighters when handling and receiving 9-1-1 video call information from dispatchers. This includes the need to review video call information in a lightweight manner while driving to the scene of an emergency, the ability to sometimes see more information than is provided by dispatchers based on their curation efforts, and the ability to select and control which video information is shared amongst firefighter crewmembers.

Our study is limited in that we focused on a relatively small sample of firefighters, in addition to our 9-1-1 call centre observations. Yet our firefighter interviews were in-depth and time-intensive. We also found that our data was saturated around the completion of ten firefighter where we then continued interviewing additional participants. Nonetheless, future work should explore additional demographics, including female firefighters, to understand how their thoughts and experiences may present different views than our participants. Firefighters in our study speculated about a plausible future use of technology where we ground discussions in real work situations. This should be complemented with further design work and field testing of technologies. Our findings are also limited in that we focused somewhat narrowly on video that would be shared by 9-1-1 callers using Skype-like video calling systems. There are a host of other possible technologies that could be incorporated into information sharing practices, such as drones, CCTV cameras in the public, etc. Our work touches on drones, however, future work should more deeply explore drones and other technologies and their possibilities.

Our study was conducted specifically in Canada, though at a general level, our findings likely apply to firefighting practices in Western countries where procedures are relatively homogeneous. Differences could lay in the specific information sharing practices, which could vary. For example, firefighting units will all generally have a chain of command and specific information sharing routines, yet the nuances of this may vary. Thus, our findings on how visual information should flow between individuals will generally apply, but the specifics may vary based on the region and country.

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