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An Emergency Centre Call Taker Task Analysis*

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Abstract. In the context of a project on the roll-out of the Next Generation 911 (NG911) emergency call system, we conducted a task analysis of call takers at an emergency call centre. Much of the emergency response literature focuses on *disaster response*. In contrast, our article is focused on *day-to-day emergencies*. To map out the call takers' tasks, we analyzed training documents and conducted semi-structured interviews. We found that call takers send high priority incidents to dispatch with just enough information for dispatchers to send first responders to the incident. Call takers then enter the remaining required information. Regarding the roll-out of NG911, we identified risks relating to the operational impact of multimedia with disturbing content, and the localization of smart phones. We also touch on artificial intelligence approaches that could be employed to increase call taker efficiency and protect centre staff from disturbing multimedia content.

Keywords: Emergency call centre · 911 call taking · Task analysis · Next generation 911 · NG911.

1 Introduction

Much of the emergency response literature focuses on disaster response [8, 9, 22, 23]. In contrast, the focus of this article is primarily on day-to-day emergencies (such as automobile accidents) rather than disasters (such as a hurricane). There are several differences between emergency response and disaster response that affect tasks, workflows, and roles. These differences make it difficult to generalize findings from disaster response to emergency response. This study of day-to-day operations of an emergency call centre therefore contributes to an underrepresented literature.

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Emergency call centres (ECCs) receive phone calls from members of the public in need of, or witnessing a need for, first responders. These first responders could be police officers, firefighters or paramedics. ECC staff members who receive calls from the public are *call takers*, while staff members who direct first responders to the location of the incident are *dispatchers*.

ECC staff performance is critical since a delay of a few seconds can mean the difference between life and death [33]. The first step in improving the call takers' performance is to understand their tasks. Once the tasks are well described and understood, we can determine where technology can increase the call takers' efficiency. In this article, we describe the call takers' tasks in a particular ECC, namely Québec City's ECC, which is managed by the Québec City Police Service (SPVQ).[1]

This task analysis was conducted in the context of a research project on the roll out of Next Generation 911 (NG911). NG911 is a migration of the US and Canada's emergency calling system from the landline (switched voice data) telephony network to an internet (IP) network. This migration will provide new capabilities, such as the ability to process multimedia and Internet of Things sensor data [4].[2]

2 Method

We employed two data collection techniques: we reviewed documentation from the ECC and we conducted semi-structured interviews of ECC staff.

For documentation review, we were provided with three documents, all of which are training manuals. The first was the centre's call-taking training manual. The second one was for computer assisted call dispatching. Finally, the third training guide provided alternatives to police response (e.g. municipal services calls, precinct police station, etc.).

For the semi-structured interviews, a set of questions was prepared ahead of the interviews and additional questions were asked as needed during the interviews, in order to help refine our understanding of the work practices of the Québec City 911 centre.

For data representation, we used a hierarchical task analysis [10] method inspired by MAD [29] and its enhanced version, MAD* [28].

The constructors ALT, LOOP, PAR and SEQ explain the links between activities and sub-activities shown in figures 2 and 3. Their meaning is as follows:

- ALT = alternative tasks: different ways to execute a same task.
- LOOP = cyclical tasks: tasks that must be repeated several times.
- PAR = parallel tasks: executed simultaneously or in any order.
- SEQ = sequential tasks: which must be executed in order (left to right).

[1] In Canada and the United States, ECCs are typically refereed to as Public Safety Answering Points or PSAPs [4, 17].

[2] While the 911 system in both the US and Canada is being transitioned to an IP network, national and local agencies in each country maintain final approval and control of over the roll-out timelines [6, 17].

2.1 Participants

For this analysis of the call centre, we were able to conduct seven one-hour semi-structured interviews, with a total of five different consenting operators of the call centre. All the participants were interviewed during their normal work hours and were thus being paid to participate in the study. This study, which involves human subjects has been approved both by the SPVQ and the Research Ethics Board of the National Research Council Canada (protocol 2020-116), which follows the Tri-Council Policy Statement [3].

2.2 Recruitment

The names, roles and email addresses of potential recruits were provided by SPVQ management. Email invitations were then sent to them in several rounds along with information about the project and the consent form. Since all the process was online, participants returned a signed consent form via email. Five participants consented to participate in the study, out of 69 invitations.

2.3 Procedure

Our objective was to map out the tasks performed by the call takers, including the conditions under which, and the order in which, they performed them. Essentially, our main objective was to construct figures 2 and 3. In addition, a secondary objective was to determine the call takers' difficulties.

In keeping with our objectives, we analysed the three training documents [30, 31, 36] and conducted the interviews in search of the steps taken by the call takers. Once we identified a step, we documented it, confirmed it through other interviews and by relating it to the documentation. Finally, the information presented both in the flowcharts and in the figures of this report was validated by a supervisor of the 911 centre to ensure its accuracy.

All the interviews were conducted by using the Microsoft Teams video-conference application. Nothing was electronically recorded and a team of two or three people interviewed the participant during each session, generally with one or two asking questions and the other one taking notes.

Because of the COVID-19 pandemic, all the data collection, recruitment and interviewing activities were conducted remotely and online.

3 Results and Discussion

3.1 Organizational Context

The ECC's organizational structure and workflow (Figure 1) provide a context to situate the call takers' tasks in the broader ecosystem.

Citizens dial 911 to reach the centre. These calls are received by the call taker. Most of these calls are about emergencies requiring an immediate response. Some calls require police or firefighter response, but are not considered urgent

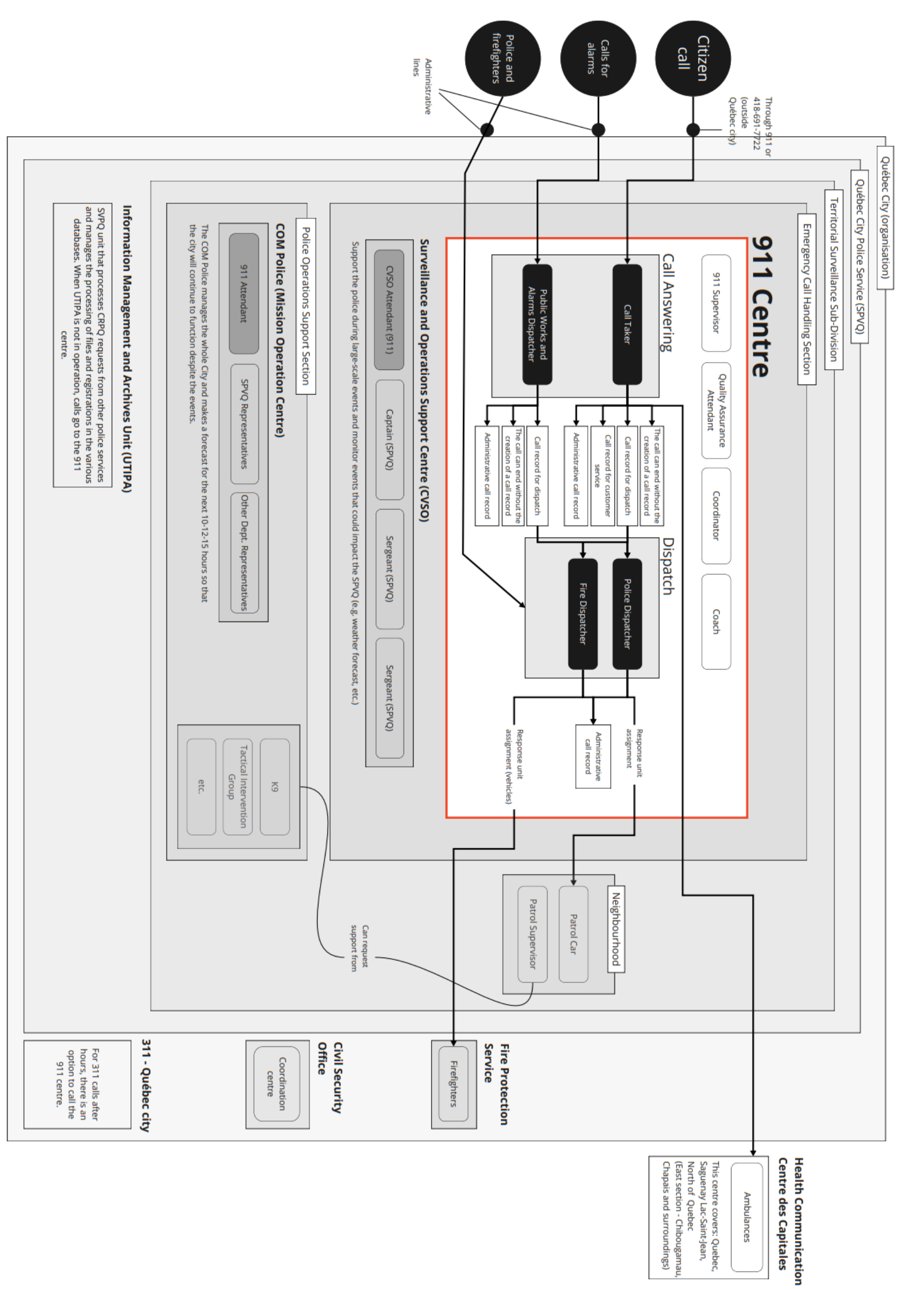

Fig. 1. Emergency Call centre Broad Context. The figure shows that the various actors of the 911 centre all have direct relationships through the call record.

(reporting a break-in that occurred earlier, for example). Some calls relate to other municipal services (parks and recreation, for example).

The centre also receives calls (and instant messaging texts) from police and firefighters who need additional information about an incident to which they are responding, and calls regarding alarms. These calls come in through special administrative lines rather than through 911. They are handled by police and fire dispatchers or the public works and alarms dispatcher instead of the call taker.

Inside the ECC, communication regarding incidents between people in the roles mentioned above occurs primarily through the call record — a computer-based record containing important and relevant information about an incident. However, they also use Microsoft Teams as a secondary system.

In addition to roles that are directly involved in communications about an incident, call centre staff also have management and training roles: supervisor and coordinator, quality assurance attendant, and coach. These roles are not directly involved in incident processing. Most ECC staff perform several roles depending on their experience. Only those with the least training are exclusively call takers.

The ECC as an entity communicates with several other units and organizations:

- Police units.
- The Surveillance and Operation Support Centre (CVSO) for police operations requiring coordination.
- Firefighters.
- Ambulance dispatch (Health Communication Centre des Capitales).
- External services (like utility companies).

3.2 Call Taker

Call Taker is the entry-level role that every staff member of the call-centre can perform. As indicated in figure 1, a call taker's main responsibility is to interactively process a 911 call.

The call taker's main tasks are:

1. Answering the call.
2. Identifying the ECC, to notify the caller in case the 911 call was routed to the wrong ECC.
3. Identifying the incident type.
4. Locating the incident.
5. Determining which type of response is required.
6. For police and firefighter response,
   (a) Assigning a response type and priority code to the incident.
   (b) Entering the code and any relevant information into the digital call record.
   (c) Submitting the call record, which is then sent automatically to the appropriate dispatcher (police or fire).

7. For paramedic/ambulance response,
   (a) Transferring the call to the Health Communication Centre whose catchment area includes the incident location.
   (b) Monitoring the call to determine whether a police/firefighter response is also needed.
8. For municipal service requests, referring the caller to the relevant municipal department.

The call taker workflow shown in figures 2 and 3 and the following description provide more detail as well as the relationships between these tasks.

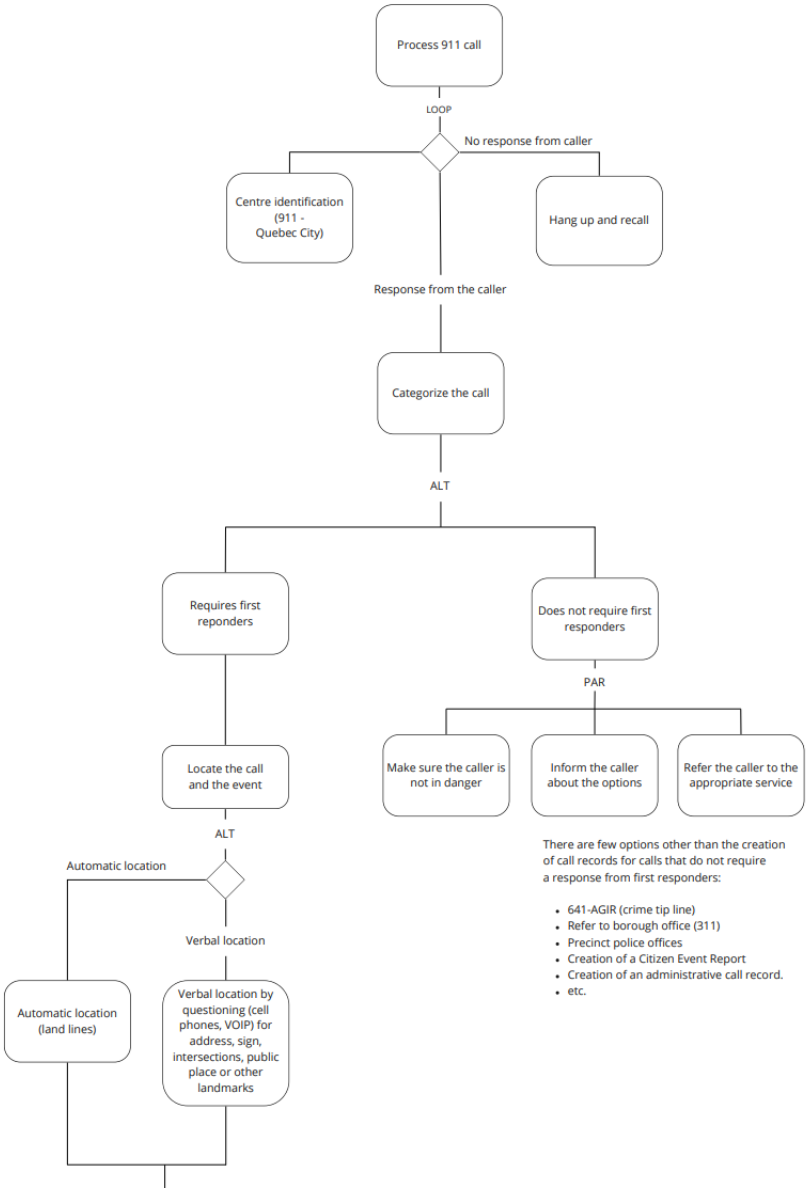

Fig. 2. Call Taker Workflow, Part 1. The first part of the call taker's workflow. The second part is displayed in Figure 3. ALT = alternative tasks: different ways to execute a same task. LOOP = cyclical tasks: tasks that must be repeated several times. PAR = parallel tasks: executed simultaneously or in any order. SEQ = sequential tasks: which must be executed in order (left to right).

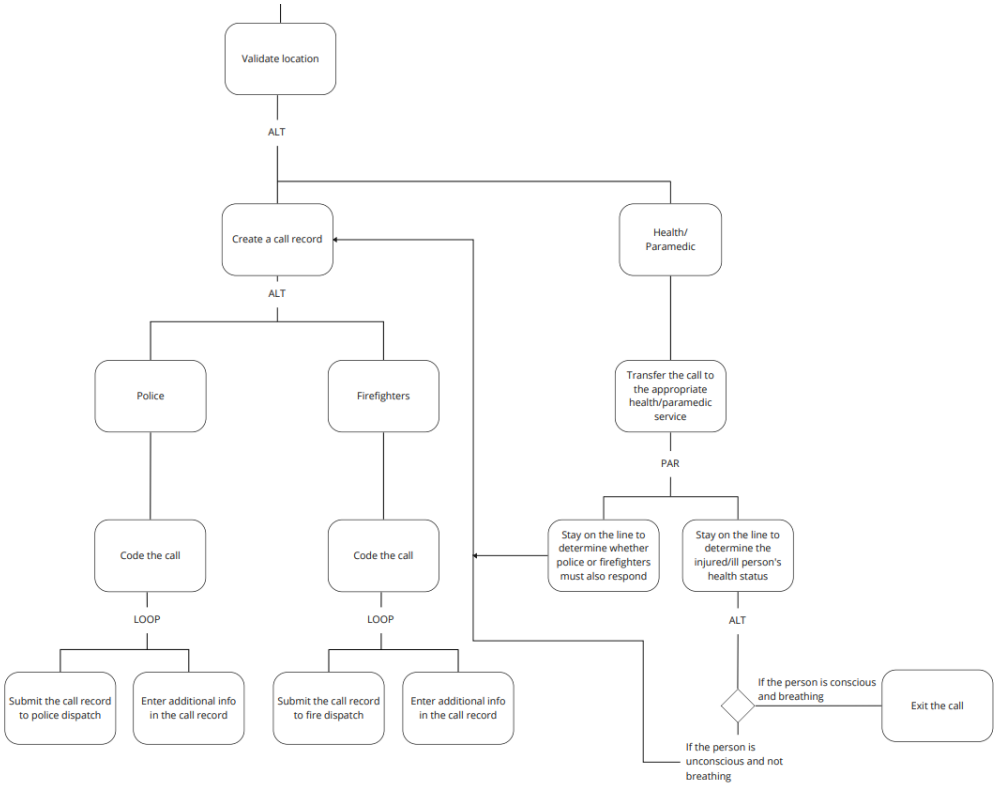

Fig. 3. Call Taker Workflow, Part 2. The second part of the call taker's workflow. The first part is displayed in the Figure 2 above. ALT = alternative tasks: different ways to execute a same task. LOOP = cyclical tasks: tasks that must be repeated several times. PAR = parallel tasks: executed simultaneously or in any order. SEQ = sequential tasks: which must be executed in order (left to right)

As such, the first thing a call-taker does when answering a call is to identify the service. The call taker says "911, Québec City". It is necessary to alert callers about which ECC they have reached because calls are sometimes routed to the wrong ECC. This could happen if, for example, a cell phone caller is in a neighbouring catchment area near the border of Québec City's catchment area and her call is picked up by a cell tower *inside Québec City's area*. Similar problems can occur with both static and mobile IP-based (VoIP) calls and multi-line telephone systems. Technological enhancements to increase the precision of location information have already been deployed in many areas in North America. Additional enhancements are being deployed within the current 9-1-1 framework, and will continue in the NG911 framework [5].

The caller is then questioned to collect all the required information to categorize the incident type. The incident type will determine which service should

respond. There are also codes to be used when multiple services are required. Identifying the service type is a common call taker task across ECCs [15, 22].

As in other ECCs, not every call is an emergency [15]. For example a report of a stolen car is not an emergency. The call taker must collect sufficient information to determine whether the call relates to an emergency and more generally, determine the call's response priority [15, 32]. For calls that do not involve an emergency, the call taker may refer callers to a crime tip line or the local police station. In some cases, the police wants a record of the call, but there is no need to dispatch officers. The call taker then creates a *administrative* call record that is *not* routed to dispatch upon submission.

It is not always easy for call takers to obtain the required information as callers may be, for example, mentally ill, very young, or witnesses calling from a location away from the incident. Of course, this problem is not unique to this ECC [15].

Incident type and priority are embedded in the incident type code assigned by the call taker. This code can be revised later. In the Québec City's ECC, this revision is often performed by dispatchers rather than the call takers themselves. Each code is composed of three to six letters, with the exception of a *COVID-19* code. There are 100 codes in total to be memorised by the call taker. Fire-related incident have only two levels of priority which are 1 (high – visible fire or smoke) or 2 (low), while police codes have seven priority levels.

For the type of calls that require police or firefighters call takers locate the emergency, enter the collected information in a call record and submit it to the system so that it is automatically sent to the appropriate dispatcher (police or fire) for further validation and eventual dispatch of the first responder unit(s). It is important to note that for emergencies, as soon as the call takers have the location and the incident type code they submit the call record to enable dispatchers to send units quickly. Further information is added to the call record after submission.

In case of health-related calls, they are transferred directly to the appropriate Health Communication Centre, but call takers stay on the line to ensure that the person is conscious and breathing and determine whether there is a need for police and/or firefighters. If the person is not breathing and/or is unconscious, a call record is created and a police unit is sent immediately to perform resuscitation. If police and/or firefighters are required (for traffic accidents for example), a corresponding call record is created.

When both firefighters and police are required to respond to an incident, the call taker enters a multi-service incident code. The system then automatically creates linked call records: one for police and one for firefighters. Moreover, the information entered by the call taker in one of these linked call records is automatically added to the other call record. If paramedics are also required, the call is then transferred to the Health Communication Centre.

Multiple call records can also arise when several callers are reporting the same incident. This has become more common with the advent of mobile phones. Now, several witnesses to an incident can all report it to 911 at about the

same time. Fortunately, the software automatically notifies call takers of other recently submitted call records with the same or nearby location information. This allows call takers to delete the record they are creating and switch to a previously created record for the same incident. The call takers can then add information to the original call record. Similarly, several related incidents (for example, someone committing multiple assaults across different locations) will result in several call records. However, call takers can link these records manually through a (virtual) button.

Each call taker has five computer displays, four of them for the RAO (computer assisted dispatching) and one for the phone-related data. Figure 4 below illustrates an instance of a call record with fictitious information. The location information and the incident code is in the top left corner. Information about the caller is below. Most of the left half of the display is for comments from the call taker or dispatcher to provide additional contextual information to the first responders who have access to the call record. The right side of the displays holds button for certain situations that may arise, such as the need to link several call records. The police and fire assistance buttons are used primarily by the dispatcher when first responders at the scene request assistance.

The alarm buttons relate to the fire response. The greater the number of alarms, the more fire response units are needed. Moreover, a large response will typically require the distribution of fire response units throughout the city so that no area is left without units nearby. Typically, the call taker will enter an alarm value of 1. It is the dispatcher who adjusts the number of alarms in consultation with the firefighters on the scene and the dispatcher also initiates and oversees the redistribution of fire response units when required.

Finally, ECC staff, first responders and some allied staff (see Figure 1) have the ability to add attachments to the call record. The attachments could be documents, images, audio or video files. In the call record user interface, the button for adding attachments is located on the far right.

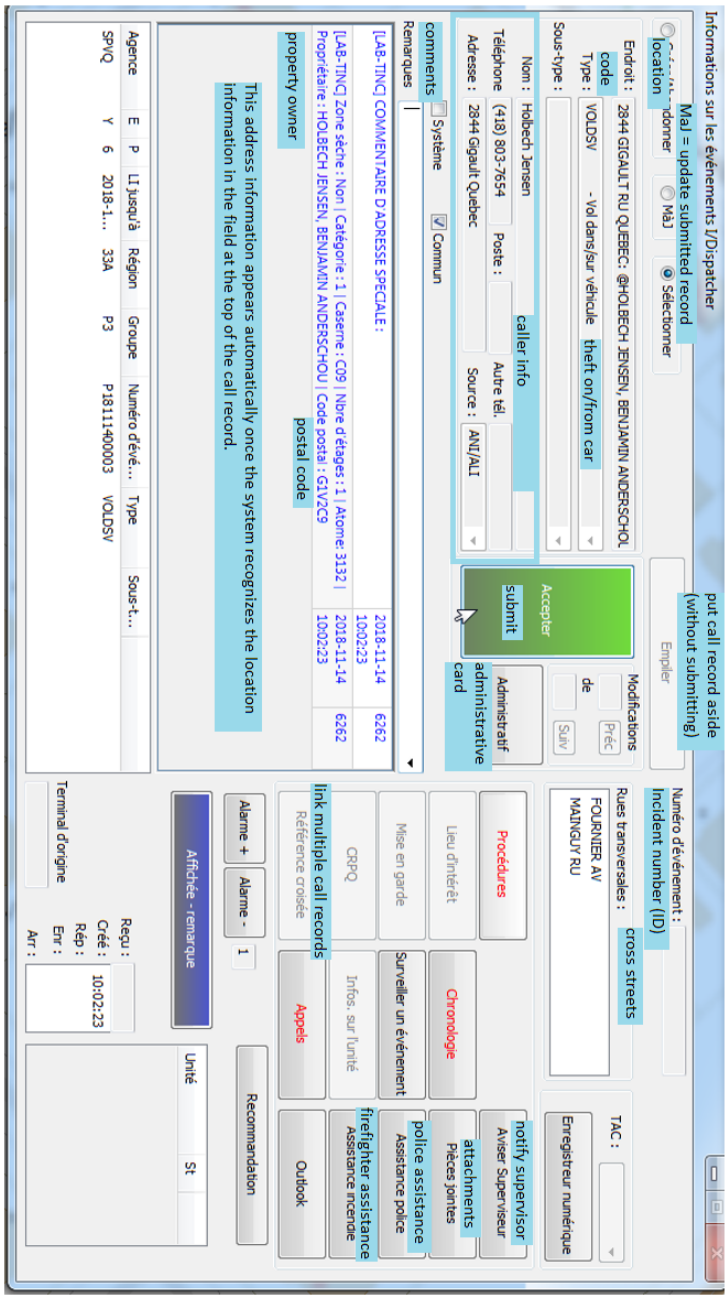

Fig. 4. Call record as displayed on the call taker's computer screen. English translations are provided in black text on a teal background. They are *not* part of the call taker's display.

4 Performance Metrics

For the call taker, there are two important performance metrics: time to submit the call record to the system, and quality of the information entered into the call record. Keep in mind that the call taker may submit the call record *before* entering all the mandated information. If so, the rest of the information would be entered *after* the record is submitted. Call takers follow this workflow so the dispatcher can send first responders to the scene as quickly as possible.

Indeed, in the case of a fire emergency, no more than 90 seconds must elapse between the call reception and the moment at which the units are dispatched, in accordance with North American National Fire Protection Association standards [25]. In the case of a police dispatch, the target dispatch time depends of the priority of the incident. For a priority 1 incident, the target dispatch time is 1 minute. For a priority 2 call, the target dispatch time is 3 minutes. Of course, these metrics conflate the call taker's response time with the dispatcher's response time.

The call taker must also transfer medical emergency calls to the Health Communication Centre des Capitales within 1 minute [19].

In addition, regulations specify the types of information that the SPVQ ECC must enter into into each call record [19].

To assess call taker performance changes following a change in their computer system, we would measure the time between call reception and the submission of a call record that has sufficient information for the dispatcher to send first responders to the scene. For more accurate diagnosis of performance problems we would also measure the proportion of times the call record information is insufficient for dispatch. In addition to that, we would have to measure the proportion of incomplete call records.

5 Call Taking Challenges

Our task analysis revealed some of the challenges faced by call takers. These challenges provide opportunities to develop software that will better support call takers. Below, psycho-social issues, location information, computer assisted coding, and question support are discussed.

5.1 Psycho-social Issues

One of their difficulties is obtaining relevant information from callers who are having difficulty providing it, because they are too young, they are too upset, or they are suffering from mental issues (also reported in [15]).

Similarly, call takers reported that 911 call taking can be psychologically taxing (also reported in [15, 37]). In addition to dealing with emergencies involving injuries and severe property damage, ECC staff can be exposed to disturbing images, audio or video. In the SPVQ ECC's system, first responders, ECC staff,

and some allied staff have the ability to append files to the call record (see figures 1 and 4). There have been a few instances of staff seeing disturbing images appended to the call record and having to take time off as a result. The increased prevalence of camera-enabled smartphones, web-accessible CCTV surveillance, and social media simply increases these risks. Moreover, the coming NG911 system is intended to transmit images and video [4, 34], making exposure to troubling images and video even more likely.

5.2 Reliable Location Data

The 911 system typically provides ECC call takers with accurate caller location data. This saves time because it is much faster to simply confirm a location than to first obtain the location from the caller and then confirm it. Before the advent of the cell phone, location data was provided automatically through landlines. Obviously, cell phone location could not be provided in the same way. At first, there was simply no location provided. Later, the location of the cell tower receiving the call was provided, but this was often inaccurate to the point of the call being routed to the wrong ECC.

For several years now, the enhanced 911 system has been providing ECCs with the GPS coordinates of the cell phone making the 911 call. The regulations have required the coordinates to be increasingly more accurate. However, the Québec City ECC still experiences difficulties will cell call localization. In some cases, especially in urban areas, the GPS coordinates are still not sufficiently precise (having an error of up to 800 meters) to support an efficient response. Buildings with several floors are even more problematic since localization data does not indicate the floor from which the call originates. In response, service providers are beginning to provide the height of the cell phone to make it easier to identify the floor [5, 12, 13, 35].

However, even if all calls provided an accurate caller location automatically, the call taker would still have to confirm the location of the incident with the caller. The reason for this confirmation is that the caller is not necessarily located at the same place as the incident. For example, someone could be calling from a car about an incident they saw while driving, or someone from a high rise could be calling about a fire in another building.

In the NG911 context, location would again become a problem if social media (twitter, messenger, for example) were used to contact the ECC. Smartphone users can turn off location tracking both in general and for specific apps [2, 24]. Consequently, the location of a user who turned off his location tracking would be unavailable to the ECC. Remedying this problem would require software changes in the mobile device operating system, the social media app, and some coordination with the ECCs so that the mobile device software can recognize the recipient of a message as a legitimate ECC.

The multimedia roll-out for NG911 appears to centre on Real Time Text (RTT) [7]. RTT is similar to the text message service we currently use on mobile phones except that, with RTT, the recipient can see every character the sender types in *as it is typed*, as opposed to having to wait for the sender to send the

message. In addition, RTT allows voice communication on the same call as text messaging. Eventually, RTT may also allow callers to send video [11]. RTT is currently available on iPhones through the accessibility settings [1], and on some android phones [18].

5.3 Computer Assisted Coding

When people are required to generate and enter a code for an event, a natural assumption is that coding can be supported by software, either through automatic coding or Computer Assisted Coding (CAC). With CAC, the system generates one or more codes and the coder validates or selects the appropriate code. Automatic coding generates and enters the code automatically without requiring user validation.

A few features of 911 coding make it difficult for any automated system to improve coding performance.

First, there are only 100 codes, 51 of which are high priority (priority 1 or 2). Consequently, it is fairly easy for call takers to learn, memorize, and recall the codes.

Second, for high priority incidents, especially fires, call takers will often enter the code and send the call record to dispatch before entering any additional information besides location. This allows first responders to get under way as quickly as possible. After additional information is added to the call record, the dispatcher updates the firefighters over the radio, while police typically access the call record on their computers. In such cases, the incident code is entered before any information that could be used to determine the code is entered into the call record. Consequently, a CAC or automatic coding system that depends on information in the call record would be unable to generate a code for such high priority events. The incident responses that are the most important to speed up would therefore not benefit from CAC or automated coding. As a result, it would therefore be challenging to develop a *useful* automated coding or CAC system.

5.4 Question Support

In our NG911 project, we are attempting to support the call taker's collection of *relevant* information from the caller. We intend to combine a knowledge base of the incident codes with speech recognition and Natural Language Processing (NLP) to suggest questions for the call taker to ask the caller to more quickly and more accurately determine the incident code. For high priority incidents question guidance is unlikely to be helpful for submitting the call record to dispatch because the call record is submitted with so little information. However, in such cases, the call taker remains on the call to collect the additional information required by government regulations [19]. This additional information may also result in a modification to the incident code. Question guidance, if successful, would be useful in this context.

6 Conclusion

A few descriptions of call takers' and dispatchers' tasks can be found in the literature, even though these publications focused on another topic [14–16]. In general, our findings regarding the call takers' tasks are very consistent with the tasks reported in those articles, though more details are provided here.

One important observation is that high priority incidents are submitted to dispatch as quickly as possible so that first responders can be sent to the scene as quickly as possible. Call takers then update the call record with additional information from the caller, and this new information is conveyed to the first responders. As discussed earlier, this workflow has design implications for building an efficient and effective ECC computer system.

Another issue that should considered in ECC system design is regulations and standards. The SPVQ centre is regulated by the province and the 911 infrastructure by the Canadian federal government. The centre also follows North American National Fire Protection Association standards [25]. Centres in other areas will be subject to different regulations and may follow different standards such as the National Emergency Number Association (NENA) standards [26].

Note also that organizational structures differ markedly across ECCs. In Québec City, the ECC handles all incoming calls but transfers health-related calls to the ambulance service (but may still dispatch police to the incident). In contrast, for example, some centres may answer all 911 calls, but then transfer each call to the appropriate agency for call taking [27]. A variety of other arrangements are also possible [14, 22, 27].

To support the call taker we will explore the use Artificial Intelligence (AI) to suggest questions for the call taker to ask the caller to obtain all the required information as efficiently as possible. This could help the call taker fill in the calling record more efficiently *after dispatch* in high priority incidents, and *before dispatch* in lower priority incidents.

We will also explore the use of AI to support the ECC with the roll-out of the next generation 911 network (NG911). NG911 is expected to increase multimedia communications to the ECC. This could disrupt ECC operations by exposing staff to disturbing images and videos. We intend to explore the use of AI-based image analysis to detect such media and provide users with a trigger warning before displaying the media.

One design method we did not discuss above but may prove useful is the GOMS (Goals Operators Methods Selection) approach. GOMS is a method for analyzing user goals and behavior often in the context of using a computer system. The GOMS method can be used to evaluate computer user interface designs to optimize certain performance metrics [21]. If the case of an ECC, some relevant metrics would be time to submit a call record, quality of the information entered into the call record, time to dispatch. Since the GOMS approach has been found to accurately predict user performance times with different user interface designs [20] and response time is quite important in ECC operations, GOMS could prove useful to design an ECC user interface that reduces performance times.

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