CERMIT: Co-located and Remote Collaborative System for Emergency Response Management

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Abstract

For Emergency Response Management (ERM) personnel the processes of reaching common ground, a common operational picture (COP), and a common understanding of an emergency situation are of key importance. We present a concept and a system, called CERMIT to support co-located and remote actors in organizational ERM training and work practice. CERMIT is based on a shared geographical representation of the emergency situation. The goal of this project is to create a tool to better support so-called information loops and situation awareness among ERM actors. Each involved actor can contribute data to the representation, creating a common operational picture. Relevant data ranges from field unit reports to headquarters commands. A group of ERM domain experts gave input to our design choices. Our prototypical system consists of a multi-user tabletop interface and mobile devices. The up-and-running tabletop interface is based on the tracking of light pens while the emulated mobile devices utilize a touch screen stylus. Changes made on the tabletop interface are reflected on the mobile devices and vice versa. Networking software to connect tabletop and mobile devices has been partly realized.

1 Introduction

We have developed an integrated collaborative system for Emergency Response Management (ERM) designed to facilitate the collaboration between headquarters members and dispatched field units (fire fighters, medical staff, field engineers, etc.). In emergency situations involving multiple authorities, individuals and groups are mostly restricted to collaboration using only phone or radio. Employing newly available technologies including interactive multi-user tables and mobile devices with GPS may improve collaboration, for instance, among co-located headquarters experts and remotely located field units. The aim of the work presented is to create a tool to better support information loops (Carver, 2007) and situation awareness (Camp, 2000)(Endsly, 1995) among ERM personnel.

There are three phases of ERM: i) pre-incident phase for training, maintenance, and simulation; ii) during incident phase for incident response coordination and reporting; and iii) recovery phase for coordinating rebuilding, and revision (Chen, 2008). While the kind of system we suggest here can be of use in all three phases, our work is mainly focused on pre-incident and recovery training. For a system to be useful during incident we assume that severe test criteria must be met; this would be going beyond the current scope of our research.

The first section of this paper defines the research problem including a real-life scenario emphasizing practical requirements that our concept and system is designed to handle. The related work section separately focuses on cognitive, collaborative, and multi-modal aspects of ERM. The systems requirements section draws mainly on insights from the related work; it is also inspired by needs derived from the real-life scenario. The system realization section starts out by briefly showing how design is guided by our six requirements. The same section goes on to present more details about software and hardware aspects of stationary and mobile in-house realizations. A video demonstration of realized tabletop interaction and emulated mobile interaction is offered as well[1]. Feedback from subject-matter experts is presented in the final section. The paper concludes with a discussion and outlook.

2 Co-located and Remote ERM: Problem Statement

According to van Laere et al. (2007), one of the most critical points in ERM is that "[problems arise] where the differences between everyday organization and crisis organization are largest (municipality director, information group)". A so-called Management and Information Group (MIG) only assembles in an emergency situation, so its members are not used to collaborating closely in a team. The group has the responsibility to train for such occasions, and it is possible to facilitate this task with the help of Computer Supported Collaborative Work (CSCW) systems. In our scenario there are two groups: i) field units dealing directly with an emergency situation, and ii) members of the MIG coordinating field unit operations.

Ashdown et al. (2007) examined the multitude of collaborative and human-computer interaction challenges that arise in system architectures where collaboration is asymmetric. They described a number of factors including the user's physical environment (headquarters vs. field), their organizational role (coordinators vs. operators), and the technology that can be used in each environment (large tabletop vs. small mobile device). Accounting for these factors is critical when designing a system that can facilitate effective collaboration, especially in chaotic environments.

A real-life scenario, here a snowstorm, may show how multiple authorities must establish and ensure efficient functionality of-non-routine ways of collaboration. In such a scenario roads to vital community buildings such as hospitals, police stations, and fire departments may be blocked. In order to free up these roads, assist stuck vehicles, and repair damaged electricity lines, units such as snowplows, fire fighters, ambulances, and maintenance engineers must be coordinated. The coordination of units from diverse authorities depends on a common understanding of the emergency situation and the correct interpretation of incoming information (Camp et al., 2000). These units collaborate by means of a system dedicated to create the COP shared between them and the MIG at the headquarters. In our proposed system, members of the MIG can issue commands through the tabletop interface. These commands become visible to all selected actors connected to the system, allowing for a common understanding of the emergency situation. In this way, for example, the ambulance coordinator and their drivers would be informed if fire fighters reported a road blockage and are approaching the location to remove it. The coordinator and drivers

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[1] http://www.t2i.se/pub/media/sigrad_2009.wmv

Figure 1: *Left: typical example of a Common Operational Picture (COP) from a contemporary Navy scenario (courtesy of the U.S. Naval Research Laboratory). Right: Coast Guard sailors at chart table about mid-20th century (courtesy of The Mariners' Museum / CORBIS).*

would also be informed as soon as this obstacle has been removed and the road is open again. Although such information could also be transferred via an audio channel, it can be more intuitively accessible when graphically inputted and visualized. This is particularly relevant when multiple obstacles or other information of interest have to be taken into account for proper MIG decisions.

In the example given above, and in other scenarios such as a flood or a fire, members of the MIG engage in co-located collaboration to maintain control of the emergency situation. The field units rely on remote collaboration with one another and the members of the MIG, in order to solve the problem at hand. In such a setting, it is critical to achieve a Common Operational Picture (COP) (Adam, 2008) and a common understanding among the participants (see also Fig. 1). We suggest that employing multi-user tabletop technology together with a system to provide live data from mobile devices can assist in this task.

3 Related ERM Research

Several kinds of issues must be dealt with in ERM. Typical challenges are the involvement of multiple-authorities, massive human involvement, conflicts of interest, and the high demand for timely information. "To support fast response during complex incidents, responders must make rapid coordination decisions, which pose constraints on their capabilities to analyze coordination problems and explore the solution domain" (Chen, 2008). Next, we examine previous research into related cognitive, collaborative, and multimodal issues.

The development of common ground in groups carrying out emergency management planning was empirically investigated by Convertino et al. (Convertino, 2008). They consider common ground to be mutual knowledge, beliefs, and assumptions. Based on a paper-prototyped study of collaboration on maps around a tabletop, they pose and partly answer a set of driving questions, such as: i) what is the evidence that common ground increases as groups collaborate, ii) how are dialogue structures affected, and iii) how do groups similarly develop process- and content-related common ground? Among other things, we can learn from their study how the development and quality of common ground can be made operational and measured. Such measures may prove useful when examining common ground achievements in a collaborative computer-supported system. Since these studies focused on paper maps around a tabletop, they give only limited guidance for the user interface requirements and technical realizations as presented in this paper. However, at a higher level of abstraction, we found that a set of requirements for an interactive ERM system has been suggested with three main categories: building a picture, understanding the picture, and changing the picture in a goal-oriented fashion (Carver, 2007).

Besides these cognitive guidelines on teamwork in an emergency situation, more guidance for collaborative aspects of ERM can be found. In one example, based on a real-life case, open source software for disaster management was produced (Jain, 2007). This example pointed out that timely access to comprehensive, relevant, and reliable information provided by effective information systems is critical to humanitarian operations. In this context, the modular and highly standardized system, DisasterLAN [2], was suggested (Chen, 2008). Aiming to support the development and sharing of a Common Operational Picture (COP), the system collects, tracks, and reports Geographical Information System-based (GIS) incident information and resources. Hancock et al. (Hancock, 2006) examined geographically distributed teams that share information both in real-time and asynchronously. They found that "when such sharing is through groupware, change conflicts can arise when people pursue parallel and competing actions on the same information". They pointed out ways to assure that a system and its users maintain a consistent view of shared information across time and distance. Furthermore, significant numbers of software systems can be found in the field of emergency simulation. As a standard for integrated ERM simulation, a set of major data elements was suggested, including areas, building-structures, chronology, demographics, and hazard-effects (Jain, 2007). The scenario introduced in this work will have a small set of data elements, partly related to field unit reports and partly to headquarters commands.

Moreover, multimodal research has been done on how to reliably access and distribute key information in an emergency situation. Rauschert et al. (Rauschert, 2002) examined how speech and gesture recognition can be coupled with a knowledge-based dialogue management system for storing and retrieving geospatial data. They showed how a multimodal, multi-user GIS interface might benefit collaborative work on large screen displays. Also, Streitz et al. (Streitz, 1999) showed that non-hierarchical meetings could be supported well by a horizontal interactive surface like a table rather than by a vertical display. Wigdor el al. (Wigdor, 2006) pointed out the importance of users in a shared horizontal workspace being able to work on their particular sub-tasks without interfering each other. One potential answer to a sub-set of Wigdor's requirements was offered by Ganser et al. (Ganser, 2006) with their InfrActables system. On the InfrActables tabletop system multiple users can interact simultaneously on a back-projection display. Their system identifies and recognizes the position and orientation of multiple devices. It also enables the devices to communicate their statuses to the application that the user interacts with. Hence, InfrActables makes it possible to configure complex interaction devices for direct manipulation with buttons, sliders, and other input capabilities. The tangible tools offered in InfrActables are much like those previously used at a chart table (Fig. 1, right). Such complex uses call for a consistent and potentially standardized vocabulary like, for example, MacMillan et al.'s data elements (MacMillan, 2004). Finally, models and experimental data describing text entry in mobile (Dietz, 2001)(MacKenzie, 2002) and tabletop interfaces (Hinrichs, 2007) may also provide guidance in our work. For instance, to enable useful scribble writing on a Portable Data Assistant (PDA), it should support a refresh rate of at least 10 Hz (Dietz, 2001).

In summary, proven cognitive, collaborative, and multimodal requirements exist for use in ERM. Numerous software products for emergency situation training do exist. However, little or no research can be found on how existing tabletop interaction systems can be utilized for co-located teamwork in ERM, or how the underlying information can be accessed and distributed more easily by the use of mobile devices.

[2] http://www.disasterlan.com

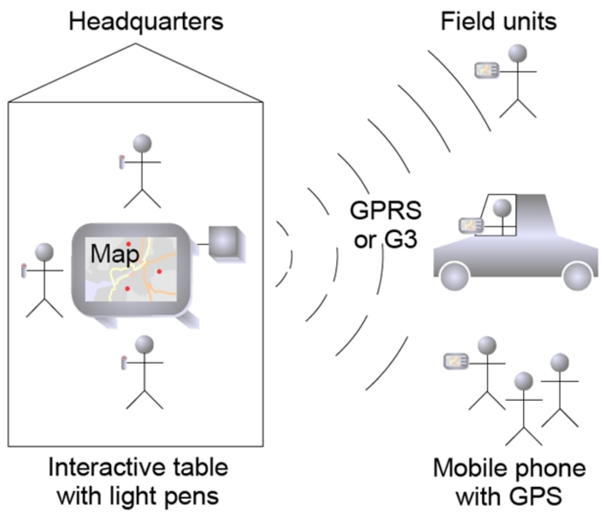

Figure 2: *System overview where experts located at the headquarters collaborate on a tabletop interface.*

4 Systems Requirements

Drawing upon the problem statement, the representative scenario, and the analysis of the related work, we argue that close collaboration among the members of the MIG and the field units is crucial in reaching a COP. One such realization is the chart table as used, for example, in military or naval environments (Fig. 1, right). Typically, multiple users gather around the chart table to coordinate the actions to be executed in the emergency situation. A ”table setting encourages collaboration, coordination, as well as simultaneous and parallel problem solving among multiple people” (Shen, 2006). Hence, we derive the first set of system requirements (R1-R4):

- The representation of the COP has to be intuitively understandable (R1) to the members of the MIG and all other persons involved.
- The COP can only be achieved by combining the knowledge of multiple users, (R2) each operating in their special field
- The different field units coordinated by members of the MIG may be concentrated in a small part of the displayed emergency area. Thus, the system needs to allow multiple simultaneous interactions (R3) in small physical spaces (R4) that represent these parts of the emergency area.

Since the members of the MIG may not be directly aware of the dynamic changes in the emergency area, they will rely upon information from the units in the field. This information is gathered and processed in so-called information loops (Carver, 2007). With this observation the second part of the requirements can be established (R5-R6):

- The mobile units must have access to and be able to manipulate the COP. Therefore, a mobile interface (R5) is required.
- A shared view (R6) for both field units and members of the MIG is required to issue and receive commands, to display the current COP, and to allow intuitive modifications of it. (Private views may be combined with shared views.)

GPS mobile devices give field unit actors access to the same map as shown in the tabletop interface. Due to the sensitivity of emergency management, reliability and security may pose additional requirements. While our contribution is a proof-of-concept, concentrating on fulfilling the requirements (R1-R6) outlined above, a future system would also have to be reliable and secure.

5 System Realization

The development of the prototypical system involves an interactive tabletop set-up together with several mobile devices as shown in Fig. 2. The COP is displayed, jointly authored, and edited by all connected actors with one of the device types, i.e. using a light emitting pen on the table (Figs. 4-7, 9) or a stylus on the mobile device (Fig. 8). Field units each operate a mobile device; experts at headquarters jointly operate an interactive tabletop system. The tabletop system allows multiple simultaneous interactions by means of light pens. A map with items representing obstacles, routes, and units is displayed on the mobile devices and on the table. Each device in the system receives updates on dynamic data such as positions of units or modifications of items. This way, both the tabletop and the mobile devices are able to take part in authoring the COP.

Our system design is based on a shared geographical representation of the emergency situation. Specifically, this is a map of the disaster area enriched with additional symbols representing the current emergency situation. Each involved actor can add data to the representation such as the location and geographical shape of a flooded area or a route cleared for units, thus contributing to the COP. Some of our design steps were guided by a group of ERM subject-matter experts. Besides input from the ERM experts, we designed a system (Figs. 2-3) to fulfill the requirements (R1-R6) as following:

- Intuitively understandable (R1) Building upon the established metaphor of a chart table, we chose to design the representation of the COP as a digital map displayed on a tabletop interface. Following the tabletop interaction metaphor (Forlines, 2007), the actors in the MIG can issue commands by means of a pen and visualize them on the tabletop
- Multiple users (R2), multiple simultaneous interactions (R3) The tabletop system is designed to support multiple users, each identified by a pen with a specific color. We support multiple simultaneous interactions by allowing all users to manipulate objects on the COP either using the tabletop system or the mobile devices
- Small physical spaces (R4) If two or more units are close to each other in the COP, tabletop interaction with their graphical (or iconic) representations may become difficult touch contact with the surface is required. By combining touch and remote pointing through the use of light for tabletop input (Piazza, 2007) the system overcomes this limitation.
- Mobile interface (R5), shared view (R6) The system is designed to support information loops and situation awareness by integrating mobile interfaces, through which field units can access and manipulate the COP. The COP is designed to be a shared view among all persons. This is maintained by frequently updating the information presented on the local device with changes on any other device

The prototypical system we have realized consists of a multi-user tabletop interface (fully implemented), mobile devices (emulated), and networking software (partly implemented). Input to the tabletop interface is based on the tracking of light pens (Piazza, 2007). The multi-user tabletop interface and the mobile devices are realized as two subsystems. Fig. 3 shows these subsystems and the data-flow between them as well as their base technologies. The

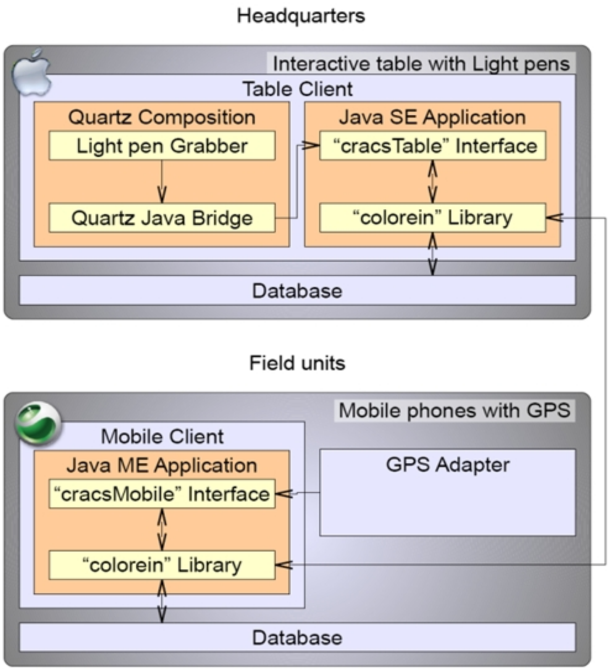

Figure 3: *CERMIT headquarters and field unit software architecture: headquarters actors use the interactive table client consisting of a Quartz Composition, a Java SE Application, and a shared database (top). Field unit actors use mobile clients consisting of a Java ME Application, a GPS Adapter and the same shared database (bottom).*

prototypical flooding scenario in a central city area is shown in an accompanying video [1].

5.1 Headquarters Tabletop Software Architecture

This component can be used for co-located collaboration of multiple headquarters members. A member can enter text by means of a simple virtual keyboard and can also use the light pen to create, manipulate, and delete items. The MIG user interface allows its users to enter relevant information into a map being displayed on the table. In the following, the software components are briefly described. The table client is constructed out of two software components: a Quartz Composer 2 composition and a Java SE Application. The Quartz composition includes the two following plug-ins:

- Light pen Grabber The purpose of this plug-in is to track the multiple light pens used as interaction devices, which are based upon the Ortholumen system (Piazza, 2007). By reading the size and shape of the light spot, the plug-in can provide the distance and orientation of the light pen with respect to the tabletop surface. Position and color are used to identify the point of interaction and distinguish between different pens.

- Quartz Java Bridge This plug-in provides an interface to the Java Standard Edition (JSE) application described below. It is based on the Java Native Interface (JNI) technology running the application in a separate process.

The Java SE application consists of the two following plug-ins:

- cracsTable Interface: The cracsTable Interface integrates the colorein Library into a JSE application and provides auxiliary libraries for networking (JXTA) and data storage (Derby).

- colorein Library: This library provides the functionality and Graphical User Interface (GUI) to allow collaboration of multiple persons in the COP. It is implemented as a Java 1.4 application based on the Abstract Windowing Toolkit (AWT) technology.

Inspired by the properties of a chart table, the table displays visible obstacles and other objects with relevance to ERM workers. Users can create and manipulate objects in the COP through menu operation. Users can name and tag objects by entering text or numbers using a simple virtual keyboard. From a single user's point of view, input on the tabletop and the mobile display is very similar. On the table the elliptic or circular spot cast by the handheld light pen controls input; on the mobile client the stylus controls input. In the table menu selection and object manipulation is triggered by a light flash; on the mobile client this is triggered by stylus touch. A tabletop use case where an ERM worker reports a flood covering a certain area is shown next. In three steps the user creates an obstacle object (Fig. 4), labels the object (Fig. 5), and then defines the shape of the area (Fig. 6). These steps and more, including two users collaborating on the table, are shown in a video recorded demonstration[1].

Figure 4: *Tabletop interaction I: a light emitting pen on the map generates the main menu to create and interact with the COP. Menu items are New Obstacle, New Unit, New Waypoint, New Route, and New ShapeNode.*

5.2 Headquarters Tabletop Hardware

The tabletop hardware client deployed is based on the Ortholumen system (Piazza, 2007), a light pen-based tabletop interaction system. A video presentation [3] of the Ortholumen system with a complete navigation of Google Earth accompanies the original work (Piazza, 2007). A web-cam sitting underneath a horizontal translucent screen tracks the pen's light, which is projected from above onto the screen (Fig. 7). The elliptical light spot cast by the pen informs the system of pen position, inclination, and direction. The system output is then projected back onto the same screen. The fixed parts of the set-up consist of a table holding a translucent screen, a projector, a mirror, a web-cam, and a pair of neutral gray linear polarization filters. The filters are in front of the projector and the camera, having an orthogonal orientation to one another. This prevents the camera from being blinded by the hotspot of the projector, which is reflected on the screen. The light emitting pen used to interact with the system is a battery operated LED. We also

[3]http://www.t2i.se/pub/media/2007-Piazza-Fjeld-Ortholumen.mov

Figure 5: *Tabletop interaction II: a new name for an object (here a new obstacle) is entered by means of a virtual on-screen keyboard Pen Grabber and sent through the Quartz Java Bridge is processed to create, edit, or remove items. Currently, the library includes items for obstacles, routes, and units. Items are displayed on Google Maps.*

Figure 6: *Tabletop interaction III: after creation, shape nodes have to be attached to the object representing the obstacle delimiting its area.*

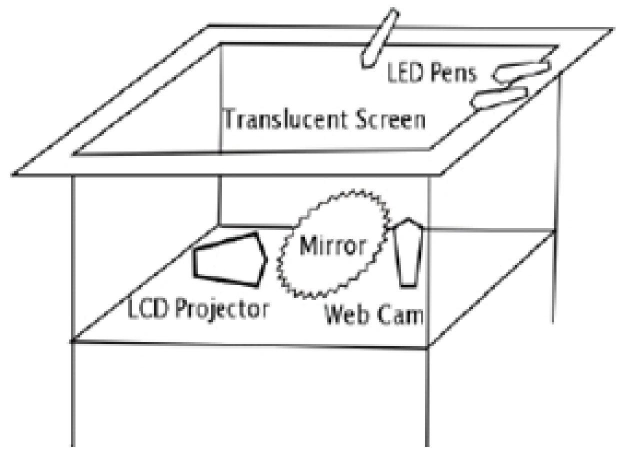

Figure 7: *Headquarters hardware: table with translucent screen, LCD projector, mirror, web cam, and LED pens.*

tried an unfocused laser with similar results. Standard consumer quality hardware was employed to build our proof of concept system. Since the devices emit randomly oriented light, they are still visible to the camera, with the linear polarization filter.

5.3 Field Unit Mobile Software Architecture

The emulated mobile client provides full featured interaction with the system. It caches the data to allow interaction even during periods of network disconnection and employs the same colorein Library as the tabletop client. The colorein interface integrates it into a Java Mobile Edition (JME) application and provides mobile libraries for networking (JXME) and data storage (Derby).

5.4 Field Unit Mobile Hardware

The mobile client has been developed on Sony Ericsson P1 emulators (Fig. 8). The P1 smart-phone can be supplied with an extension to read positional data from the Global Positioning System (GPS).

6 Feedback from Subject-matter Experts

The design process was partly informed by related work and projects, and partly by discussions with a few EMR domain experts. As we reached the system design stage we wanted to present our results and collect feedback from a wider community of domain experts, some of them being potential users of the CERMIT system. We compiled a list of approximately twenty expert candidates located in four different countries. Our aim was to examine subjective value-of-use, so we chose to use an online survey to get feedback. We solicited each candidate by e-mail to complete the anonymous survey and followed up after three weeks by e-mail again. The e-mail consisted of three items, each offered as a URL: i) a brief PowerPoint presentation, ii) a video presentation, and iii) a list of ten questions. After four weeks the survey was closed and the results were analyzed. Nine individuals had answered some or all of the questions. Table 1 summarizes the ten questions and collected results.

While the first five questions were of a general nature, the last five questions concerned the CERMIT system (Table 1). The first question (Q1) asked for the background of the subjects. The following four questions concerned the usability of tabletop interaction (Q2), tabletop interaction in support of interdisciplinary collaboration (Q3), combined tabletop and mobile interaction in support of interdisciplinary collaboration (Q4), and combined tabletop and mobile interaction in support of EMR (Q5). The next two questions examined the system's utility for general EMR (Q6) and for the three specific phases of ERM: i) pre-incident phase for training, maintenance, and simulation, ii) incident phase for response coordination and reporting, and iii) recovery phase for coordinating reconstruction, and revision (Q7) [4]. The three final questions were open-ended and intended to collect sector-specific knowledge from the subjects. Question eight examined the subjects' views of the main risks, shortcomings, and challenges (Q8). The next question asked which tabletop input system they viewed as the most promising: touch-sensitive input [11], handheld pointer-based input (light/laser), or both (Q9). Finally, the subjects were asked whether they knew of any other commercial system offering functionality similar to CERMIT. If yes, they were asked for the product name and web link (Q10). All answers concerning utility (Q2-Q7) could be rated from 1 ("very useful") to 6 ("not useful at all"); the in-

Figure 8: *Field unit mobile hardware: the mobile client was developed on a Sony Ericsson P1 emulator. In the future realization, input will be done using a standard stylus.*

Figure 9: *Tabletop system with two users and mobile device, both display showing same object.*

termediate rankings (2-5) were not labeled. All questions also offered the option: "do not know". In addition, it was possible to leave a question unanswered. In Table 1, the average values only utilize numeric rankings; the number of answers (n) counts all answers: numeric and "do not know". Unanswered questions are not counted.

The survey results (Table 1) are based on a mixed set of domain experts (Q1). The experts are positive about the benefits of using tabletop and combined mobile tabletop interaction (Q2 - Q5, 2.0, 2.1, 2.0, 1.8). While combined mobile tabletop interaction is judged to be particularly useful for ERM (Q5, 1.8), the CERMIT system ranks slightly below this (Q6, 2.3). This may be explained by the answers to Q8 and Q9. For each of the three phases of ERM (pre-, during-, and after incident), CERMIT is judged to be useful (Q7, 2.2, 2.2, 2.8) but more so for pre- and during-incident phases than recovery. System risks, shortcomings, and challenges (Q8) repeatedly cited network issues as an answer. Also, the role of domain experts in system development was judged to be of prime importance. As for alternative forms of tabletop interaction (Q9), experts seem to prefer the combined use of touching and pointing. However, some arguments for only a touch-sensitive tabletop were recorded. This reflects the current market, which has seen several touch-sensitive tabletops offered over the past few years [11]. To our and the domain experts' (Q10) knowledge, no system offers tabletop pointing as in CERMIT, nor combined tabletop pointing and touch-sensing.

7 Discussion and Outlook

We have presented early research into the combination of a tabletop interface with mobile devices for field use to better support co-located and remote ERM collaboration. Firstly, we provided a proof of concept to collaboratively create and display a COP in complementary ways such as tabletop and mobile devices. The COP serves as the basis of a common understanding of the emergency situation. It is designed to enhance the team cognition process (MacMillan, 2004) and thereby increase situation awareness (Camp, 2000) among all participants. Our prototype is affected by the common limitations of most tabletop approaches. The orientation of the tabletop interface is normally geared towards a single user point of view. Privacy issues arise when users collaborate on a shared interface but do not want to share all their information. Also, there may be the need for a user to access information that is not useful for other users. Doing this on the shared interface can obstruct the access of other users to the COP. To deal with the privacy issues concerning user collaboration, we consider adopting some concepts from Sugimoto et al. (Sugimoto, 2004) blending individual PDAs into a collaborative tabletop space. Design concepts suggested by Wigdor et al. (2006) may also help in blending shared and private views.

In the next phase of this project, we envision improvement of the tabletop user interface. We anticipate adding multiple layers of information and working on overcoming limitations due to the single perspective of the tabletop interface. In addition, we want to further investigate the use of unfocused laser pointing technology and experiment with alternative existing tabletop technology (Forlines, 2007) to evaluate the differences in coordinating different units displayed close to each other (R4).

At the same time, our project will also focus on interviews with potential users followed by more controlled studies aiming to capture and determine how common ground develops. These studies will offer empirical data geared towards estimating the project's success in fulfilling the requirements (R1-R6) as well as basic usability criteria. Backed up by the studies of Convertino et al. (Convertino, 2008), we may then approach questions such as how common ground increases as groups collaborate, how dialogue structure is affected, and how groups develop processes and content.

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Table 1: *Survey results collected from nine ERM domain experts. Mean usability and percentages are shown, followed by number of choices per alternative. Usability alternatives were 1 ("very useful") through 6 ("not useful at all"); 2 through 5 unlabeled.*

Q1: in which sector do you work	
INDUSTRY	33%, n=3
EMERGENCY MANAGEMENT	33%, n=3
MILITARY; RESEARCH; EDUCATION (seperate choice)	0%, n=0
OTHER (Answers: Interactive digital signage, city planning office, government)	33%, n=3
Q2: Usability: Tabletop interaction in general?	2.0, n=8
Q3: Usability: Tabletop interaction for interdisciplinary collaboration?	2.1, n=8
Q4: Usability: Combined mobile and tabletop for interdisciplinary collaboration?	2.0, n=8
Q5: Usability: Combined mobile and tabletop for emergency response management?	1.8, n=8
Q6: CERMIT usability for emergency response management?	2.3, n=7
Q7: CERMIT usability for alternative phases of emergency response management?	
PRE-INCIDENT PHASE: training, maintenance and simulation.	2.2, n=7
DURING INCIDENT PHASE: incident response coordination and reporting.	2.2, n=7
RECOVERY PHASE: coordinating rebuilding and revision.	2.8, n=7
Q8: CERMIT: Main risks, shortcomings and challenges?	n=4
"Nice idea... but this always comes down to how effortlessly you can collect and send data from the scene. The challenge is to understand the domain and what the most frequent situations in emergency response management."	
"You do not mention any collaboration with domain experts. This might be a shortcoming."	
"Stability of software and mobile network."	
"The challenge is to understand the domain and what the most frequent situations in emergency response management."	
Q9: Regarding the CERMIT system: The tabletop system may be realized using touch-sensitive input (hands and fingers), handheld pointer-based input (light/laser), or both. Which kind of input do you view as most promising?	
TOUCH-SENSITIVE INPUT (HANDS AND FINGERS)	29%, n=2
HANDHELD POINTER-BASED INPUT (LIGHT/LASER)	14%, n=1
BOTH: A COMBINATION OF BOTH INPUT TYPES	57%, n=4
DO NOT KNOW	n=0
IF POSSIBLE, PLEASE GIVE REASONS FOR YOUR ANSWER	
Reasons for TOUCH-SENSITIVE INPUT (HANDS AND FINGERS)	n=2
"I always know where I keep my fingers... and it provides for direct manipulation (in the true meaning of the word)."	
"Because it's faster (don't have to look for pen, hold it right, keep batteries, etc)."	
Reason for BOTH: A COMBINATION OF BOTH INPUT TYPES	n=1
"It depends on what kind of task that system needs to support. If the system requires frequent editing and drawing input, then a pointer based solution is probably more efficent. In other scenarios touch-sensitive input might be more efficient."	
Q10: Any other commercial system offering similar functionality as CERMIT	n=0