Multi-Surface Systems for the Emergency Operations Centre of the Future

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Abstract
A persistent problem in dealing with emergencies is the efficient and effective coordination of effort. Organizations and personnel must collaborate, but despite the emergence of new technologies, emergency operation centers (EOC) see limited adoption of new approaches. Most existing EOC tools are designed for single users and have little support for collaboration between users, involving multiple devices. A multi-surface environment (MSE) is able to address some of these problems, while facilitating the future integration of technologies, devices, and personnel. The potential for MSEs to transform existing EOCs and improve emergency management led us to develop concepts for the Emergency Operations Centre of the Future, or EOC-F.

Author Keywords
Multi-surface environments; emergency response; cross-device interaction; mobile devices; tabletop.

ACM Classification Keywords
H.5.2 [User Interfaces]: Graphical user interfaces (GUI), Input Devices and Strategies, Interaction Styles. H.5.3 [Groups & Organization Interfaces]: Collaborative computing, computer-supported cooperative work.

Introduction

Emergencies, crises, and disasters happen when people least expect them to. Some notable examples include: earthquakes in Christchurch, New Zealand (2011), tsunamis in Japan (2011), flooding in Calgary, Canada (2013), and a missing plane in Malaysia (2014). To respond to these disasters on a city level, organizations such as the Fire Department, Police Department, EMS and others work together within a co-located emergency operations center (EOC). Crisis management teams that meet face to face in emergency situations also exist in major corporations and public organizations. These teams have specific needs but their technological support is very limited. There are significant opportunities to utilize new technologies to provide a more effective response to emergencies.

An improved response has substantial cost savings potential, both for the public sector as well as for industry. The costs of the Southern Alberta floods in 2013, earthquakes in Christchurch, and tsunamis in Japan are estimated to be $5 billion, $18 billion USD, and $35 billion respectively. While the cost reductions coming from a more effective handling of the crisis are hard to estimate, even small percentage gains can lead to large savings – not even talking about potential benefits for reducing injuries and casualties.

Emergency Operations Centre of the Future (EOC-F) is a collaborative project between the University of Calgary and C4i Consultants Inc. to explore and prototype emergency operation planning and operation tools. The goal of this project is to investigate how analytics-based, spatially-aware multi-surface environments (MSE) can support teams managing emergencies in an EOC.

Related Work

There are a number of challenges when designing an EOC, with respect to data access, communication, equipment for different scenarios, and the roles of people using the equipment [5]. To address these concerns, we propose an EOC designed within a multi-surface environment (MSE). Creating these environments is difficult and integrating traditional software is a challenge for the design of MSE applications [3]. While some researchers have explored emergency management applications on individual devices, we are unware of any research that has used and evaluated MSEs for emergency management purposes.

CoMap facilitated collaborative situation analysis and planning in crisis management teams [2], but the use of specially designed proprietary paper [12] is quite limiting in an emergency situation.

Other applications such as CERMIT [9], CoTracker [4] and uEmergency [10] make use of interactive tabletops for emergency management, but none of these applications have been integrated into a larger MSE nor did they integrate with commercial emergency management software.

To ease the design and creation of an MSE, many tools and frameworks have been developed [1, 6, 7, 8]. None of these applications have been successfully integrated into a MSE for emergency management. Our Society of Devices (SoD) Toolkit is another MSE framework [13]. Its flexible extensibility of integrating

new devices and sensors makes it suitable for supporting an MSE EOC.

Next Generation EOC

Adaptable, mobile, scalable

Emergency Operations Centre of the Future (EOC-F) (Figure 1) is an investigation into how analytics-based, spatially aware multi-surface environments (MSE) can support teams managing emergencies in an Emergency Operations Centre (EOC). Emergencies are often unique, and an EOC has to handle a diverse variety of scenarios. Similarly, EOCs can range from small localized teams to much larger collaborative efforts, situated in dedicated buildings or deployed as a mobile response. EOC-F aims to support existing users of emergency response technology, while extending this support to smaller organizations through cloud-based services.

A stationary EOC setup may include a wall-sized display, tabletop, digital whiteboard, and a number of tablet devices (Figure 3). One or more Microsoft Kinect

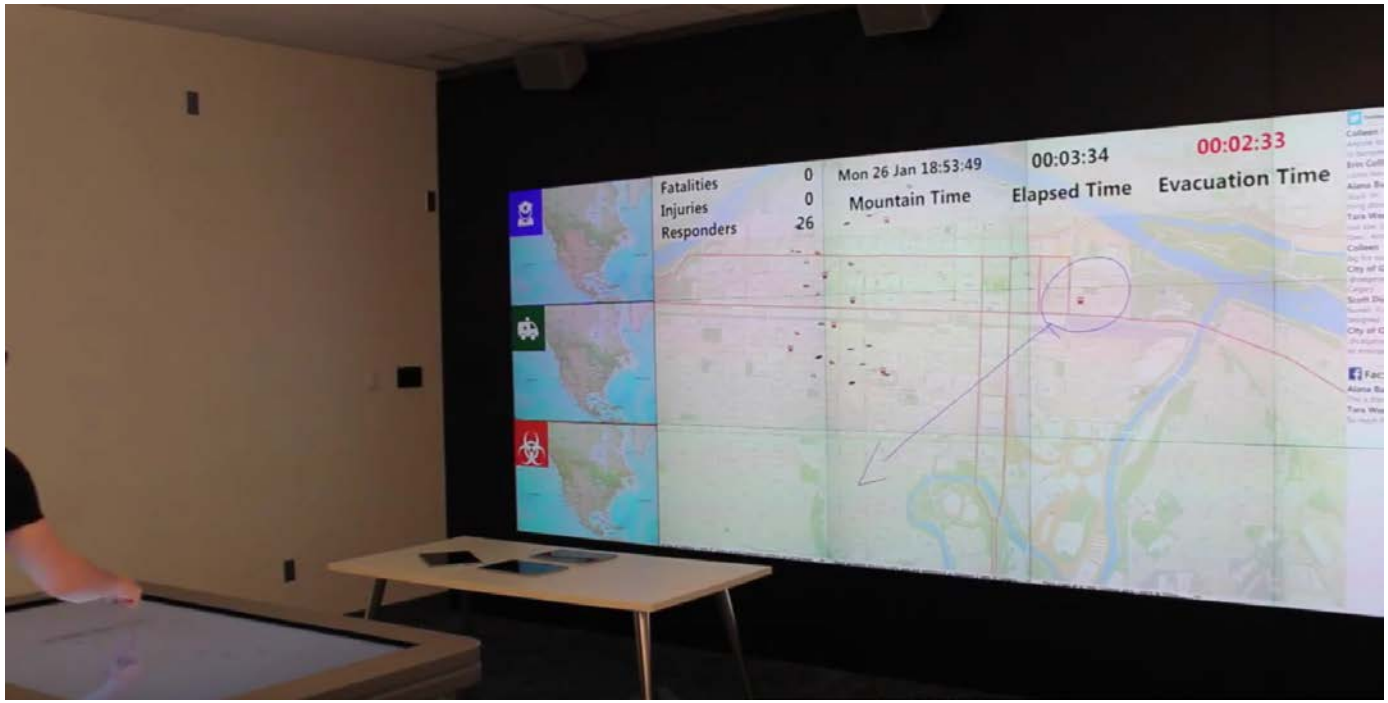

Figure 1: Emergency Operations Centre of the Future (EOC-F).

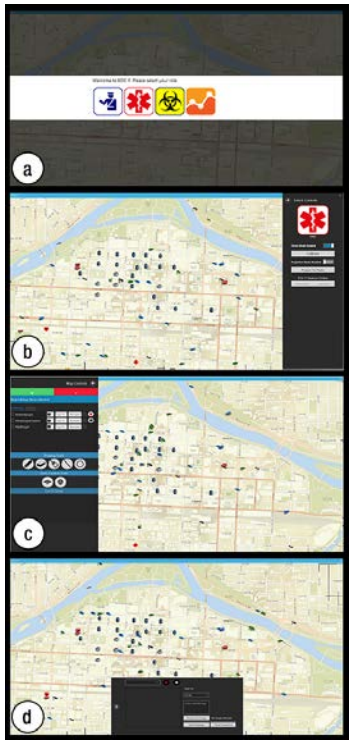

Figure 2: Various screens of the tablet device; a) Role selection screen, b) General device settings, c) Annotation and planning tools, d) Video and texting tools.

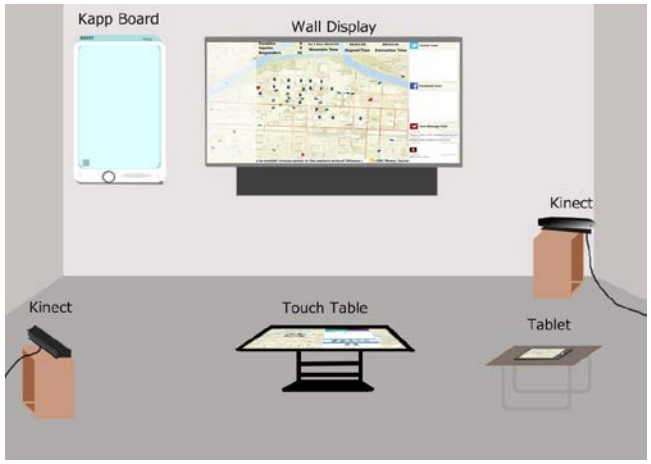

Figure 3: Typical setup of EOC-F.

sensors enable proxemics interactions within the EOC, something discussed in more detail later.

The wall display (Figure 4) is intended to provide information that can be easily interpreted, increasing awareness of the emergency situation. It is instrumental in understanding a Common Operating Picture (COP). Information from the COP can be shared with field personal. A common reference point creates a shared understanding of basic and vital information among EOC operators. The information is aggregated from various streams, including social media.

The tabletop (Figure 7) is the central collaborative space for decision makers, and provides an interactive map of the emergency site. Operators can draw up response plans with the annotation tools, and directly interact with field units by controlling them on the tabletop map. For example, hazard sites could be marked up, before an evacuation zone is created. Field

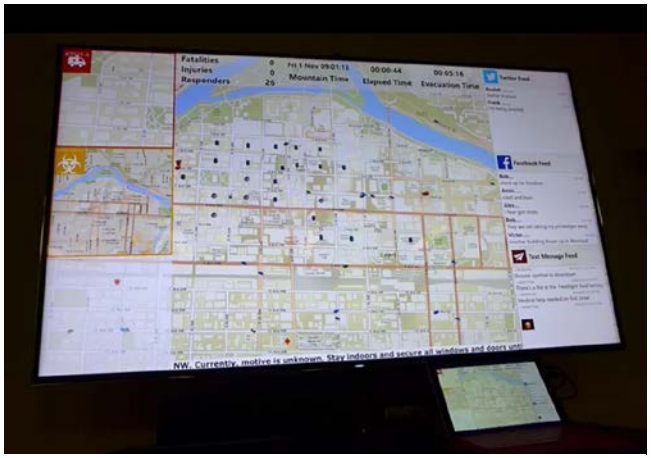

Figure 4: Wall display sharing information from the Common Operating Picture (COP).

units inside the evacuation zone are automatically routed to outside the area, while units outside the zone will be routed around it.

The digital whiteboard (Kapp Board) provides a familiar planning tool present in existing EOCs, but is digitally integrated to quickly distribute information to other devices. Information on the whiteboard can be viewed on the tabletop, or sent to field operators to communicate key objectives and planning details.

The tablet (Figure 2) is the mobile device of EOC-F, and can be used both within the EOC and out in the field. Similar to the digital table, users are presented with an interactive map and planning tools. However, tablets are role-dependent, and provide different tools suited to the user's role. A police officer using the tablet could place roadblocks, while a HazMat specialist could create regions around chemical spills and annotate it with

Figure 5: A *flick* gesture from a tablet to the tabletop [11].

Figure 6: A *pour* gesture from a tablet to the tabletop [11].

relevant information. Plans drawn on tablets remain private and role-specific until they are explicitly shared publicly, to reduce information clutter. The tablet also supports communication between field responders and the EOC, through video calls and SMS texting capabilities.

Any number of wall displays, tabletops, and tablets may be connected simultaneously, making the EOC easily scalable. In a mobile EOC, the wall display and tabletop can be replicated on the tablet, making it possible to deploy EOC-F with as little as three tablet devices.

Spatial awareness, proxemics interactions

Based on prior research on gestures and interactions in emergency response environments [11], EOC-F currently supports several novel interactions. EOC-F is a spatially-aware system: the system knows where users and devices are in a physical space and can used this knowledge to enhance interactions with data.

The two basic gestures are *flick* and *pour*. The *flick* (Figure 5) can be performed on a tablet device by swiping either towards or away from the user. The user can simply point their tablet at another device (wall display, tabletop, or tablet) and perform a *flick* to send or receive information. For example, *flicking* across the room towards the tabletop will allow the tabletop to display the same map location as the tablet.

The *pour* (Figure 6) can be done by positioning a tablet above a tabletop, and turning the tablet over as if to pour the contents onto the tabletop. *Pouring* is a quick and intuitive way to share information from the tablet to the tabletop, making the information public to the

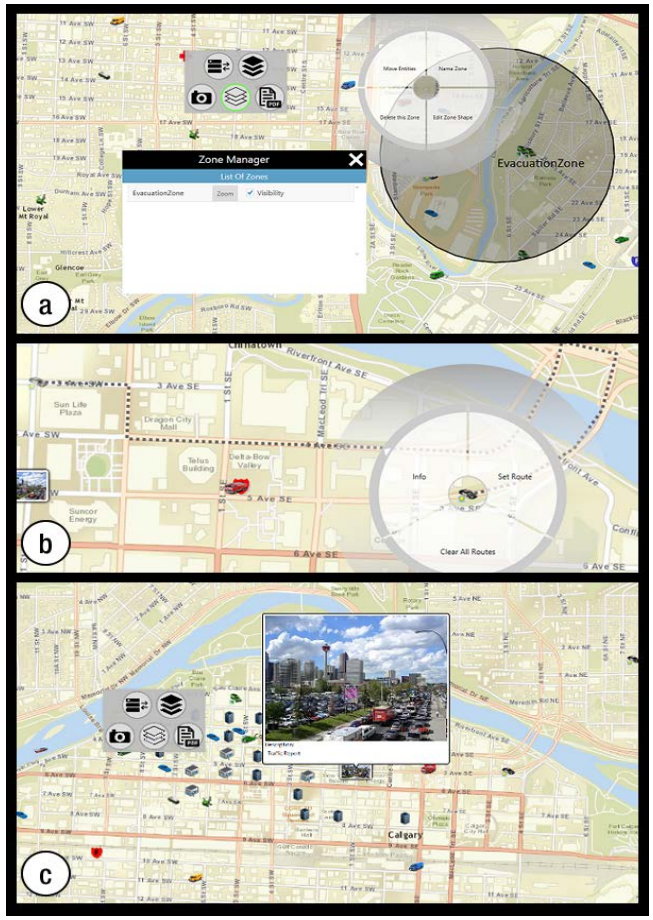

Figure 7: Various tools of the tabletop; a) Zone/region management tools, b) Vehicle routing tools, c) Geotagged images from the field.

EOC. For example, a response plan drawn up by the police is initially only visible to the police, but can be shared and discussed with other roles by *pouring* the plan onto the tabletop.

Spatial-awareness is provided by our SoD Toolkit, and does more than just enabling gestures. Proxemics allow users to take control of the wall display through a tablet. A user can walk up to the wall display, and is then able to modify what information is displayed on it. Another useful example is the sharing of information to everyone around you based on proximity, rather than having to individually share information during a group discussion.

Social Media Analytics
With the proliferation of networked mobile devices, the public have become a vital source of real-time information during an emergency crisis. The public is often able to alert officials to immediate problems, well before any responders arrive on scene. They are a source of situational awareness, and provide a lot of information for relatively limited resources spent. However, the sheer amount of information received becomes problematic when emergencies allow little time for careful and thorough analysis. Social media analytics can help extract the most relevant information, significantly reducing the burden on EOC operators and improving the overall response timeliness.

In EOC-F, social media streams are shown on the wall display. To ensure only useful information is displayed to the EOC, a Social Media Analyst filters through the vast amount of updates before they reach the rest of the EOC. Social media analytics partially automates and accelerates this process.

Augmented Reality for Response Planning
The integration of Google's Project Tango allows cutting-edge interactions with 3D models in augmented reality. Building models are overlaid over the map on the tabletop, and operators can navigate these models by moving the Tango devices in physical space. The integration provides a great opportunity to investigate interaction techniques with geospatial data for multi-surface systems in an EOC.

Conclusion
The development of EOC-F facilitates the investigation of how analytics-based, spatially aware MSEs can support teams managing emergencies in an EOC. We have created a prototype EOC as a multi-surface environment which integrates new technologies to support emergency response. Novel interactions and automated processes support emergency management in time-sensitive emergency situations. As EOC-F continues to be in development, we hope to further support emergency response teams. We will achieve this through innovative software prototypes focused on public safety and emergency preparedness to support next generation EOCs.

Future Work
The EOC-F project will continue to investigate and integrate new technologies in novel ways to support emergency management. To support crisis management teams, we will investigate multi-surface technology, analytics and wearable computing approaches.

Future work with EOC-F includes:

- Continuing investigations on the use of augmented reality in EOC-F as an integral tool for collaboration in an MSE.

- Developing technology for a-posteriori analysis of data gathered during an emergency, and feeding the lessons learned into training exercises.
- Integrating wearable technologies following our ongoing interviews with emergency management personnel.

Investigating projected pixels on the walls and floor space between displays to determine if they can help increase awareness and interactions.

References

1. Chris Burns, Teddy Seyed, Theodore D. Hellmann, Mario Costa Sousa, and Frank Maurer. 2013. A Usable API for Multi- Surface Systems. In *Workshop on Envisioning Future Collaborative Interactive Spaces* (CHI '13).
2. Sebastian Doeweling, Tarik Tahiri, Philipp Sowinski, Benedikt Schmidt, and Mohammadreza Khalilbeigi. 2013. Support for collaborative situation analysis and planning in crisis management teams using interactive tabletops. In *Proceedings of the 2013 ACM international conference on Interactive tabletops and surfaces* (ITS '13). http://dx.doi.org/10.1145/2512349.2512823
3. James R. Eagan, Eric Lecolinet, and Clemens N. Klokmose. 2013. What are Applications in Multi-surface Environments? In *International Workshop on Interactive, Ultra-High-Resolution Displays* (CHI '13).
4. Andreas Kunz, Ali Alavi, Jonas Landgren, Asim Evren Yantaç, Paweł Woźniak, Zoltán Sárosi, and Morten Fjeld. 2013. Tangible tabletops for emergency response: an exploratory study. *In Proceedings of the International Conference on Multimedia, Interaction, Design and Innovation* (MIDI '13). http://dx.doi.org/10.1145/2500342.2500352
5. Morten Kyng, Esben Toftdahl Nielsen, and Margit Kristensen. 2006. Challenges in designing interactive systems for emergency response. In *Proceedings of the 6th conference on Designing Interactive systems* (DIS '06). http://dx.doi.org/10.1145/1142405.1142450
6. Michael Nebeling, Theano Mintsi, Maria Husmann, and Moira Norrie. 2014. Interactive development of cross-device user interfaces. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '14), 2793-2802. http://dx.doi.org/10.1145/2556288.2556980
7. Michael Nebeling and Moira Norrie. 2012. jQMultiTouch: lightweight toolkit and development framework for multi-touch/multi-device web interfaces. In *Proceedings of the 4th ACM SIGCHI symposium on Engineering interactive computing systems* (EICS '12), 61-70. http://dx.doi.org/10.1145/2305484.2305497
8. Michael Nebeling, Elena Teunissen, Maria Husmann, and Moira C. Norrie. 2014. XDKinect: development framework for cross-device interaction using kinect. In *Proceedings of the 2014 ACM SIGCHI symposium on Engineering interactive computing systems* (EICS '14), 65-74. http://dx.doi.org/10.1145/2607023.2607024
9. Tommaso Piazza, Hannes Heller, and Morten Fjeld. 2009. Cermit: Co-located and remote collaborative system for emergency response management. In *Proceedings of Swedish Computer Graphics Association* (SIGRAD '09), 12-20.
10. Yongqiang Qin, Jie Liu, Chenjun Wu, and Yuanchun Shi. 2012. uEmergency: a collaborative system for emergency management on very large tabletop. In *Proceedings of the 2012 ACM international conference on Interactive tabletops and surfaces* (ITS '12), 399-402. http://dx.doi.org/10.1145/2396636.2396710
11. Francisco Marinho Rodrigues, Teddy Seyed, Apoorve Chokshi, Frank Maurer. 2014. Gesture Design and Feasibility in Emergency Response

Environments. In *Workshop on Gesture-based Interaction Design: Communication and Cognition* (CHI '14), 4 pages.

12. Cheryl Savery, Christophe Hurter, Rémi Lesbordes, Maxime Cordeil, and TC Nicholas Graham. 2013. When Paper Meets Multi-Touch: a study of multi-modal interactions in air traffic control. In *Proceedings of International Conference on Human-Computer Interaction* (INTERACT '13), 196-213.
13. Teddy Seyed, Alaa Azazi, Edwin Chan, Yuxi Wang, and Frank Maurer. 2015. SoD-Toolkit: A Toolkit for Interactively Prototyping and Developing Multi-Sensor, Multi-Device Environments. In *Proceedings of the 2015 International Conference on Interactive Tabletops & Surfaces* (ITS '15), 171-180. http://dx.doi.org/10.1145/2817721.2817750