ePlan Multi-Surface: A Multi-Surface Environment for Emergency Response Planning Exercises

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ABSTRACT
Emergency response planning is a process that involves many different stakeholders who may communicate concurrently with different channels and exchange different information artefacts. The planning typically occurs in an emergency operations centre (EOC) and involves personnel both in the room and also in the field. The EOC provides an interesting context for examining the use of tablets, tabletops and large wall displays, and their role in facilitating information and communication exchange in an emergency response planning scenario. In collaboration with a military and emergency response simulation software company in Calgary, Alberta, Canada, we developed *ePlan Multi-Surface*, a multi-surface environment for communication and collaboration for emergency response planning exercises. In this paper, we describe the domain, how it informed our prototype, and insights on collaboration, interaction and information dissemination in multi-surface environments for EOCs.

Author Keywords
crisis management; cross-device interactions; emergency management; emergency operations; emergency; gestures; mobile devices; multi-surface environments; peripheral interactions; risk communication; tabletops;

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
Large scale emergencies and disasters highlight the vulnerability of modern society to collapses of infrastructure that is crucial to daily life (e.g. roads, phone service, and electricity). A significant challenge with emergencies also arises from the different types that can occur, from unplanned events like natural disasters, train derailments, and chemical spills, to planned large-scale events like the Olympics and the World Cup.

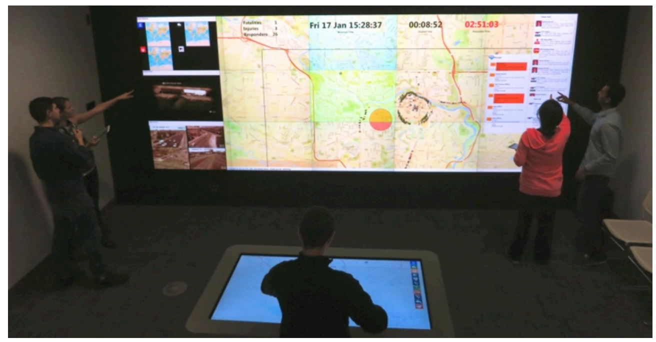

Figure 1 – Users collaborating in the ePlan Multi-Surface environment

Events such as the 2013 floods in Southern Alberta, as well as other recent major events and natural disasters have resulted in significant efforts by authorities worldwide to investigate how information and communication technologies (ICT) can both facilitate and improve upon existing emergency planning and response capabilities. These technologies are primarily found in emergency operations centre (EOC), where trained personnel need to make informed decisions in situations that can be both stressful and highly volatile while information is uncertain and incomplete.

For EOC personnel, a primary challenge is the number of information sources and amount of data that needs to be analyzed and continually monitored during an emergency. These sources include personnel in the field (e.g. firefighters, police, emergency medical services (EMS) or military) or third party sources (e.g. newspapers, television channels or citizens). As Van de Walle noted, “accurate and timely information is as crucial as is rapid and coherent coordination among the responding organizations. [23]”

For each information source, there are different protocols before information can be exchanged effectively in the EOC and between personnel. The source of information determines how it can enter the EOC (i.e. via video, audio, or text). A traffic or incident camera could live-stream into the EOC, tweets could arrive via text, and information from ground-personnel may arrive via text messages, by phone or

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radio. EOC personnel need to ascertain the importance, authenticity, and accuracy of the information. Emergency personnel report through their chain-of-command, reporters (print, web, television and radio) may have their information fact-checked before broadcast, while citizens may live-tweet, post updates, or send emails as an emergency unfolds. When the EOC receives information updates from their personnel, reporters, or citizens, they may also need to monitor developing traffic congestion, incident cameras, and operational decisions that are continually made.

Multi-surface environments (MSE), are environments that contain multiple heterogeneous devices (e.g. tablets, wall displays, tabletops) that are spatially aware of each other, as well as the users in the environment [18]. This provides an environment amenable to emergency response planning in multiple ways.

First, by providing different areas for information triage (Figure 1), an MSE allows for different information sources to be viewed on different devices. Tablets can be used for personal, private workspaces from which personnel can privately communicate with colleagues. Tabletops serve as a semi-public collaboration and cooperation area, and large wall displays serve as information radiators that publicly aggregate information from multiple sources.

Secondly, because MSEs are spatially aware (devices and people are tracked), it can support the sharing of information between these public and private devices through spatial interactions. For example, flicking or pouring information can occur such that it is context aware. A flick directed towards a wall without the wall display will not send information whereas a flick towards the wall display will render information on the device.

As Seyed *et al.* [19] highlight, "significant research has been done into different types of interactions, as well as collaboration for multi-display environments; however, very little work has gone into exploring multi-surface environments with real industrial partners." As part of the effort to validate these interactions in commercial environments, we explored collaboration and communication for multi-surface environments in the context of emergency response planning, the domain of our industry partner.

In this paper, we present *ePlan Multi-Surface*, a prototype for an EOC of the future that harnesses a multi-surface environment to enable tablets, tabletops, and a large wall display to interact with one another to create a connected communication environment. We also discuss the space of multi-surface environments and interactions in the context of EOCs and challenges presented during implementation.

BACKGROUND & RELATED WORK

Emergency Response Planning

Emergency operations centres (EOCs) are central environments that allow for people from multiple organizations to gather for emergency planning exercises, during emergency events, or during the recovery phase after an emergency event. An EOC can be found in both public and private enterprises who need to conduct planning exercises on an on-going basis to ensure preparedness in emergency situations [15]. In these emergency-planning exercises (Figure 2), multidisciplinary teams of experts collaborate to define how they should prepare or respond to various scenarios [22].

When emergency responders are training for the different scenarios, they conduct one of two general types of exercises: tabletop exercises and live exercises.

Tabletop Exercises

Tabletop exercises are based on the simulation of a realistic scenario and are either real-time or on an accelerated time. They can be run in a single room, or in a series of linked rooms that could simulate the division between responders who need to communicate and be co-ordinated. People involved in these exercises are expected to know the plan and they are invited to test how the plan works as the scenario unfolds. This type of exercise is particularly useful for validation purposes, particularly for exploring weaknesses in procedures [9].

Live Exercises

Live exercises are a live rehearsal for implementing a plan, and can be particularly useful for testing logistics, communications, and physical capabilities. They are a useful training tool to help build experiential learning by having

Figure 2 – Images from tabletop emergency response planning exercises from A) FEMA Operations Supervisor in planning session (Image courtesy FEMA/George Armstrong), B.) FEMA cross-border tabletop exercise (Image courtesy FEMA/Eilis Maynard) C.) US Navy command and control center afloat (Image courtesy US Navy/ Bobby Northnagle)

participants develop confidence in their skills and by providing experience on how it would be to use the plan's procedures in a real event [9].

Personnel & Artefacts

In both real and simulated emergency situations, the EOC provides a key liaison role between municipal officials, external resources and policy makers. To help EOC staff coordinate emergency response with other key stakeholders and personnel, clearly defined principles are used, typically called the Incident Command System [8].

Paper-based maps and documents are commonly used in both exercises (Figure 2) where they are referenced and annotated. Depending upon the situation, responders (e.g. police, EMS, and hazardous materials (HAZMAT)) communicate with people both inside and outside the room. It is vital that people inside the room have the most current information to form a common operating picture (COP) – a *"continuously updated overview of an incident compiled throughout an incident's life cycle from data shared between integrated systems for communication, information management, and intelligence and information sharing."*[1] A COP helps to support decision-making, and to also to ensure that personnel in the field are working with current information.

Tabletops and Surfaces

Emergency response planning is comprised of many important tasks, from detecting and monitoring the emergency to the deployment of resources and communication management [3] [10]. Emergency response planning is also inherently a peripheral process [2]; critical information about an emergency can arrive from numerous sources (e.g. first responders, reporters, or online sources) and information processing and analysis are typically done in parallel with the primary emergency response-planning activity [2] frequently with interruptions [7].

In the HCI research literature, emergency response planning is a well-explored area, with several different technologies (e.g. tabletops [3]) being used to assist in these tasks, as well as information management, collaboration, and efficiency [10]. However, common rules on interactions to improve collaboration are scarce as the interactions and interfaces are heavily impacted by the domain and the system's purpose. As highlighted by Bortolaso *et al.* [3], co-locating people around a device does not mean that the collaboration will be improved: the trade-off between simplicity and functionality must be evaluated multiple times during the system's development.

uEmergency is a forest fire simulation system running on a very large-scale interactive tabletop [16]. This tabletop's dimensions (381 x 203cm) allow several users to collaborate using the system concurrently while considering personal space (local and private workspace) and a global space (shared among all users and synchronized through a button). Users can interact with the system using a digital pen or touch gestures. It is possible to translate and resize a map using gestures with one and two fingers, respectively; to perform annotations dragging and dropping markers from a menu into the map; and changing the simulation's time point through a slider available on each personal workspace. Since all users are sharing on a physically large tabletop, collaboration is improved through visual cues from each user's actions.

Besides digital pen and touch gestures, physical tokens are also used in disaster planning systems on tabletops [12]. They act as input, changing simulation parameters according to their physical position above the tabletop, and provide feedback through images projected on them. The manipulation of physical tokens to interact with emergency systems has reduced the learning curve of these systems.

While many of these systems utilize single tabletops or other devices and show a benefit in emergency response situations [3], they do not consider peripheral interaction scenarios where multiple users interact with each other on tablets, tabletops, and wall displays. Concurrently, these users are also analyzing and receiving different sources of information while conducting their emergency response planning exercises.

This provides an opportunity for the exploration in using multi-surface environments that contain multiple heterogeneous devices (e.g. tablets, wall displays, tabletops) and which permit a variety of different tasks and interactions (e.g. "flicking" to different screens) [18]. This may be due to interface design, physical constraints such as orientation or screen size, or device constraints. The research space of multi-surface environments is well explored and significant research has been done in examining different ways in which interactions can take place [6][17][18].

The collaborative nature of emergency response planning and the presence of multiple and heterogeneous devices in a room provides an opportunity for the study and experimentation of different types of gesture-based and peripheral interactions in the emergency response domain, described in this work by ePlan Multi-Surface.

EPLAN MULTISURFACE

We developed *ePlan Multi-Surface*, in collaboration with a military and emergency response simulation software company, C4i Consultants Inc.[2] (C4i), located in Calgary, Alberta, Canada. Not only did C4i provide feedback and ideas on features for the prototype, but they also provided the

[1] FEMA- https://www.fema.gov/pdf/emergency/nrf/nrf-glossary.pdf

[2] C4i - http://www.c4ic.com/

company's desktop simulation engine, ePlan, which we integrated with the prototype.

This section summarizes the design considerations for the prototype and its features.

Design Considerations

While working with C4i, we continually discussed and iterated on features that supported three main design elements. These features were inspired by features requested by C4i, or were features that we were looking to test in another domain outside of oil and gas [19].

Privacy Levels in a Shared Environment

We endeavoured to create spaces where personnel in the room from the police, EMS, and HAZMAT could make notes and control how and when they shared information with colleagues from the other services in the room. For example, we wanted the support the ability of the police to discuss and share information internally, make necessary revisions, and then share information with EMS and HAZMAT teams. Taken together, the needs of the personnel and the affordances of the devices, we looked to support the user's ability to keep information private on the devices before publicly disclosing it.

Information Integration

There are multiple sources of information coming into an EOC from sources like the news media, Twitter[3], traffic cameras, incident cameras, personnel from the field, and from personnel in the room. In addition, through the simulation software, we had entities (buildings, people, and vehicles) that we were tracking on a large map to ensure we knew what was happening to the common operating picture (COP).

To reduce the information burden on personnel in the room, we sought a way to consolidate information from these sources so that users could focus on decision-making while knowing that the COP was updating in real-time. As we describe later, the large wall display acted as an information radiator where people could turn when seeking an update to the overall situation. This feature is in stark contrast to the tablets which displayed the local situation for each role independently.

Inter-Device Communication

Earlier we mentioned that communication was an important part of emergency response planning scenarios as there are multiple people in the room representing different organizations. When building this prototype, we were concerned with not only permitting the creation and dissemination of information between people in the same organization, but also people from different organizations.

Through the use of the MSE-API[4], we can support the sharing of information between the devices in the room through gestures (flick and pour) to reduce the users' burden in determining how to share information from their devices. Instead, users could focus on collaborating after they were able to establish a COP.

Usage Scenario

Throughout our iterative development process with C4i, we also grounded our development efforts with a mock incident created and validated by C4i with emergency response personnel. This incident is a train derailment in downtown Calgary, releasing a hazardous material.

Step 1: Emergency Alert Issued

At first, the head of the EOC (the 'chief'), the chief of the fire department in the case of the city of Calgary receives information in different mediums (text, email, and phone) from various sources (police, EMS, and HAZMAT) about an emergency event – the train derailment in the city's downtown. The chief then determines the type of emergency that is occurring and issues a local state of emergency alert to the city. While the chief is making his determinations, other EOC personal in the room are often interrupted with new information or are performing tasks simultaneously due to the evolving nature of the emergency.

Step 2: Response Representatives Assemble

After the alert has been issued, the relevant response personnel assemble in the EOC, and depending upon the severity of the event, these representatives may include members of the fire department, EMS, police, power companies, or the public works departments.

Step 3: Emergency Response Plan Execution

During the emergency response plan execution step, which lasts until the end of the emergency, numerous types of interactions occur. This session is the most critical component of an emergency response, as significant coordination and planning are done. This is where the chief would get the current status of the train derailment, set the evacuation radius for the spill, set roadblocks. Then, by triaging information from personnel in the room, the chief would share the updated COP with city officials and members of the public.

This step would be where, in the tabletop exercises mentioned earlier, the people involved in the exercise would be expected to know the plan to test how the plan works as the scenario unfolds. In the case of a live exercise, the personnel may test logistics, communications, and physical capabilities of the personnel. Executing the plan numerous times would help build experiential learning by having participants develop confidence in their skills. At the end of this step, a report is typically generated that summarizes the emergency and the contributions of the personnel involved.

[3] Twitter – http://www.twitter.com

[4] MSE-API - https://github.com/ase-lab/MSEAPI

Figure 3 - An overview of ePlan MultiSurface. (a) Highlighting the ePlan Multi-Surface environment, with different roles collaborating in an emergency scenario (green represents EMS, red represents fire, blue represents police and orange represents HAZMAT). (b) The wall display application and it's different components. (c) The tabletop application. (d) An iPad running in the EMS mode.

THE PROTOTYPE

To fulfill *privacy levels*, we created applications that catered to the privacy affordances of the three devices. The iPad, as a handheld device, was the most private, the tabletop application, as it has a limited amount of space around its surface and orientation, operated semi-privately where users can only see the screen if they were around it, while the wall display was a fully public space visible to all participants in the room.

We constructed three iPad applications to support roles for the police, EMS, and HAZMAT whereby they could make notes and share information with other personnel in the same role. This enabled the police, for example, to make and share information with other police members, alter those plans, and then finally share the plans with people from EMS, HAZMAT, and the rest of the room.

To support *inter-device communication* (communication between the room's iPads, tabletop, and wall display), we sought an API that would provide tracking of both people and devices. Furthermore, the API had to use low-cost sensors that could cover a sizable room [1] so that we could satisfy a requirement from our industry partner when showcasing the prototype to emergency management agencies in the area. We decided to use the MSE-API in its iteration that permitted the integration of multiple Kinects to cover a larger surface area as it provides gesture-initiated inter-device communication to track both people and devices in the room.

We supported *information integration* differently in all three applications:

The *iPads* are used for individual planning activities, and since we worked with both iPads and iPad minis, we built an application suitable for both dimensions[5]. The iPad applications integrated annotations and the entities from the ePlan simulation, and was able to send information to either the tabletop or wall display (Figure 3d).

The *tabletop* is used to integrate the role-specific (police, EMS, HAZMAT) plans into a comprehensive whole. Its information integration was based on its size, orientation, and location at the centre of the room. It was constructed to display ePlan's desktop simulation entities, and support the annotation on all three of the police, EMS, or HAZMAT layer. It was also able to receive information from the iPads, and send information to the wall display (Figure 3c).

The *wall display* is used to share factual information about the situation as well as the agreed upon plan. With both the largest screen and the most public device, the wall display showed different information sources simultaneously (Figure 3b). This figure shows how Twitter, ePlan's desktop simulation entities, live traffic cameras, news feeds, annotations, and messages were integrated. In addition, since it was not touch-enabled, it was a receiver of information from both the tabletop and iPads.

As mentioned above, not only did the devices afford different privacy levels, but their screen sizes also afforded different information integration requirements.

Infrastructure

As shown in Figure 3, *ePlan* is a multi-surface environment comprised of a number of components: A large, high-resolution wall display (Figure 3b); digital tabletop (Figure 3c); multiple Microsoft Kinects[6], multiple iPads; and, a laptop with the ePlan desktop simulation software.

The MSE-API framework provides device location and orientation that results in a spatially aware environment, and it was used to provide inter-device communication and multi-surface interactions with the aid of multiple Microsoft Kinects. Custom applications were created for the iPads, tabletop, and high-resolution wall display.

C4i's ePlan simulation software, which is used during training exercises, stores information about entities (e.g. people, vehicles, and buildings), their location, and their routing information on a backend ArcGIS[7] server, allowing the tabletop, tablet, and wall display to receive the same information as the desktop software updates the simulation. In addition to the simulation information stored on an ArcGIS server, the police, EMS, and HAZMAT planning layers for the iPads, tabletop, and wall display were also stored on separate ESRI's ArcGIS layers.

Tabletop

We built the tabletop application with the idea that it is a collaborative space where one or more users gather to discuss information before an action is taken and shared with the room. Users can create annotations on one of the police, EMS, or HAZMAT layers before relaying that information to the field. At the same time, the tabletop merges these three layers onto one map so that the chief can see a future COP before sharing that information with the entire room through a touch-enabled gesture to send the information to the wall display.

iPad

The iPad applications were created to support three different roles – police, EMS, and HAZMAT. These three roles are operated by independent chains-of-command, and thus we created three independent layers on which annotations are created to support the collaboration amongst personnel from that organization. By separating these tools in role-specific user interfaces, we expect to reduce the cognitive burden for the people using the iPads so that they can focus on their own

[5] iPad dimensions - https://www.apple.com/ipad/compare/

[6] Microsoft Kinect - www.xbox.com/en-CA/Kinect

[7] ESRI ArcGIS - http://www.esri.com/software/arcgis

job and are not be burdened with filtering away UI options that are not relevant for them. Reducing the tool set can be important to reduce errors in high-stress situations (like emergencies). All three application provide some common functionality that permits the user to change the emergency response planning scenario update frequency, annotate shapes and lines, as well as toggling between a street or map view. Each iPad application operates on an independent, private ArcGIS layer so that police annotations and entities are not merged with either the HAZMAT or EMS layers.

Wall Display

This application consolidates information from eight different sources onto a 9600 x 3600 high-resolution wall display as seen in Figure 3b:

(1) Shows the areas under review by the three iPad application;
(2) Represents a camera showing a live-feed from the incident zone;
(3) Represents the area where traffic cameras are live-streaming into the EOC;
(4) A ticker showing news headlines from the area;
(5) The map overview showing the entities (people, buildings, vehicles, etc.) from C4i's software along with annotations and other information shared from the tabletop and/or iPad applications;
(6) Lists the messages that have been received by the EOC;
(7) Live Twitter feed from people or organizations are being followed by the software; and,
(8) More detailed information about news items that are scrolling through in (4).

Overall, the wall display is used as an information radiator to share factual information about the situation as well as an agreed upon plan.

Multi-Surface Interactions

Earlier we described the general steps that people working in an EOC might take when executing the train derailment emergency response plan. Next, we highlight interactions in our multi-surface prototype for that same usage scenario:

Step 1: Emergency Alert Issued

In the first stage, the chief is stationed by the tabletop and receives updates from personnel in the room through a one-finger flick (or pour gesture) that transfer information from their iPads to the tabletop where the chief can triage the information. Simultaneously, the wall display updates with information from local traffic cameras, news feeds, and Twitter.

Step 2: Response Representatives Assemble

Personnel from the police, EMS, and HAZMAT gather in the room with private iPads containing information about their people and vehicles in the field, possible routing information for ground personnel, and preliminary plans for their people. These EOC representatives may then share relevant information using flick or pour gestures at their discretion or use the information from other representatives in their own assessment for allocating their resources during the emergency.

Step 3: Emergency Response Plan Execution

In ePlan multi-surface, emergency response personnel are collaborating and consuming new information rapidly using iPads, while also simultaneously trying to keep track and manage the emergency through the wall display and digital tabletop. Representatives can share information from their iPads to the tabletop – where it can be triaged with the chief and other representatives – using a one-finger flick (or pour gesture).

If the same person wanted to share the information with the entire room, they could use a two-finger flick to share that piece of data with the large wall display. The wall display allows everyone in the room to see the information; the tabletop is used to assist in collaborative emergency response planning; or other iPads are used to facilitate communication between different representatives. While personnel are sharing information with others via multi-surface interactions, information from other sources (news feed, traffic cameras, and Twitter) are updating the wall display to ground on-the-floor discussions.

PROTOTYPE CRITIQUE AND DISCUSSION

Getting feedback from users in the emergency management planning domain is extremely critical. As we worked closely with domain experts from C4i Consultants Inc., we asked them to continually provide feedback through the various stages of our collaboration, including the prototype that is presented in this work. The goal of this feedback is to discuss the potential of multi-surface environments and applications to their domain as well as to brainstorm future research. The feedback received is presented below in general themes.

Interactions and Gestures

As with other applications that have been developed by our group in the oil and gas domain [19], we started from the gestures and interactions defined in prior work [14]. Our group of users from C4i, however, gave mixed reviews to the gestures – point & flick, pour, and pull – that we implemented in the prototype. Point & flick along with pull gestures received positive reviews as *"natural gestures"*, however the pour gesture whereby the user takes the iPad and rotates the screen so that the iPad screen faces the tabletop was thought to be cumbersome and *"not natural"*.

Our users repeatedly referenced *"natural gestures"*, focusing on the ease of use and learnability of the interactions. During emergency response, there are users who regularly work in the EOC, and there are others who will come to work there during the emergency [8]. As described during one of the interviews *"On a typical day, the EOC houses 25 staff. At the height of the recent Calgary flooding, Burrell (city of Calgary fire chief) estimated nearly 200 people were working in and around the ops room [13]."* In the case of the city of Calgary, irregular EOC personnel come from "the city's business units, along with agencies like Enmax (the local power company), ATCO (a local natural gas provider), Alberta Health Services, and industry groups" [13]. Our interviewees also mentioned that the gestures needed to be easy enough to learn simply by a user *"peeking over a colleague's shoulder"* and that during these highly-intensive events, users may not be able to remember the difference between a *"three-finger and four-finger swipe"*.

During our interviews, our C4i collaborators also repeatedly acted out gestures that incorporated both the surface of the tabletop and iPad, followed by an in-air movement. This combination of on-device gesture plus in-air gesture felt more natural when they wanted to share content from their device to other devices in the room.

Information Overload

In the city of Calgary, our collaborators noted that police collect video from cameras placed both in the police cruiser along with cameras on the officer's uniform [4][5][20], and with this, and social media sources of information (e.g. Twitter, Facebook, Instagram, Pinterest, Tumblr) that were not available a decade ago, the amount of information could become overwhelming. With this quantity of data, C4i mentioned that maintaining situational awareness is critical in environments like EOCs. Furthermore, they mentioned the need, with the quantity of information at their disposal to "*see [both] the forest and the trees*".

Our interviewees also described how multi-surface environments and interactions could aid in information sharing where a user could swipe a picture, text, or video from their iPad or tabletop and have that information shared with a wider audience, especially when they compared this to the current situation where users "*go back to my desk to email that information to you"*. One subject remarked that the ease with which information sharing can take place using gestures should also reduce both the number of silos and the amount of information contained in those silos.

Technology Reliability

Throughout our interview sessions, a common concern was the Kinect tracking technology. When working, the three Kinects allowed for the coverage of the room, however, the tracking system would occasionally lose track of users and devices.

Our collaborators at C4i commented that a better system would allow for an AirDrop[8]-like or an *"AirDrop on steroids"* where the user can focus less on whether they are connected, and more on sharing content. Just like cellphones just work (with roaming charges) when people travel internationally, the tracking technology should be pervasive and reliable. They saw no issues in the possible privacy concerns with their suggestion to use on-board cameras on tablets, phones and computers to help track people and devices in the room.

Areas to explore

During our on-going collaboration with C4i, we kept track of items that we were able to implement for our current prototype, and those which could be explored during our continued collaboration. With that in mind, we generalized their feedback into four further themes:

Rate of Data Growth

We are seeing a tremendous growth in the amount of information available to users [21] and this growth is not likely to stop with the increased pervasiveness of cheap sensors that can provide directions to people while navigating New York City [11]. Our collaborators reaffirm this notion, seeing the increased use of metadata in military applications, and are sure that its use will follow into the civilian realm whereby emergency responders would be able to get historical and real-time information on cities, neighbourhoods, and buildings.

This additional information builds a more complete picture of the environment in which personnel in the field are entering. Furthermore, the people in the EOC will be able to simultaneously live-stream cameras from officers [5] and data on their location, foot speed, wind conditions, and fatigue level [11]. C4i indicated that our prototype would need to incorporate this information into information radiators or other applications without increasing the cognitive load on EOC operators.

Using Multiple Senses

In this prototype, we explored a small set of surface-related gestures (swipe, pull, pour, and flick), however our collaborators see the opportunity to augment the prototype with voice-based commands and haptic feedback. One interviewer commented how Siri[9] can function in busy, noisy locations, and thus sees an opportunity to add voice-base commands to the gestures. Moreover, currently when a user attempts to send information to the wall display or tabletop, they get feedback on the screen indicating whether it succeeded or failed. Alternatively, C4i suggested that we provide haptic feedback indicating the success or failure of these gestures so that the user need not look at their screen as they move about.

Security

As with any technological system, security cannot be an afterthought, however, it was something that we did not explore due to time and complexity. C4i indicated that should we explore security, we must examine *information security*, *device security*, and *personal security*. C4i considered information security to be how we secure the information (picture, video, or text); device security was related to whether a phone, tablet, or computer was secure enough to be authorized to be on the network); and, personal

[8] AirDrop - http://support.apple.com/kb/HT4783

[9] Siri - https://www.apple.com/ca/ios/siri/

security was about whether the person should be in the room. Each of these areas would present an interesting path to explore in future work, particularly in the context of multi-surface environments.

"Newness" of technology

A final comment made during our interview related to the new EOC that was opened by the Calgary Emergency Management Agency (CEMA) in 2012 [13]. *"Though the city of Calgary's EOC was recently opened with new technology, the moment it opened the technology was actually old"*. These are critical, highly stressful environments that require that systems work – failure is not an option. The technologies that we developed (and used) during the prototype do not fit the reliability criteria of an EOC yet, however it can be used to draw requirements and commentary from EOC users who are working with older technology.

CONCLUSION

In this paper, we presented our prototype, *ePlan Multi-Surface*, a multi-surface environment for emergency response planning exercises that was designed with domain experts from C4i Consultants Inc. We discussed challenges such as collaboration, interaction and information dissemination in multi-surface environments for EOCs. We also presented a preliminary prototype critique and discussion about its utility for the domain.

Our future work involves extending the prototype and continuing with a more complete evaluation of the system and its impact for emergency response planning exercises. We believe that the emergency response domain is an ideal candidate for further exploration of multi-surface interactions and technologies in real-life applications as this domain stresses systems differently than applications in other domains.

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