Examining the Role of Human and Technical Infrastructure during Emergency Response

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ABSTRACT

Infrastructures—both technical and human—are critical components of emergency response, helping to facilitate and shape both formal work practices and the improvisational work that individuals and organizations take part in as they address emergent challenges during unpredictable events. This research explores the relationships between infrastructure and collaborative work in this context, at a time when the infrastructures themselves are rapidly changing and/or under pressure to change due to the introduction of new technology. We interviewed 17 emergency workers from region that had recently experienced a major emergency response. These interviews illuminate weaknesses in some of the systems designed to support the information and communication needs of emergency workers, and demonstrate emergency workers assembling their own ICT infrastructures using familiar off-the-shelf tools like social media platforms and shared Google documents. These findings also highlight the importance of human infrastructure in supporting improvisation and collaboration among emergency workers.

Keywords

Computer supported cooperative work (CSCW), emergency response, , human infrastructure, improvisation

INTRODUCTION

Every crisis is unique; hazard type, geographic location, infrastructure vulnerability, culture, timing, and a host of other factors play a role in shaping how a crisis unfolds. From the perspective of emergency response, the varied nature of crisis events creates difficulty with preparation and planning (Ley et al., 2012). Just as every emergency is distinct, the response effort to each emergency—though informed by plans and preconfigured relationships—has unique features and results in distinct configurations of organizations and actors.

A fire in a transit tunnel, for example, might involve the fire department, transportation authority, utility companies, and the police department, and each organization would be notified as the situation evolves and their involvement becomes necessary. As a situation escalates, managing the response between these different organizations requires more coordination. Eventually, one or several emergency operations centers (EOCs) are activated to manage communications and coordination, acting as a centralized location for agency representatives.

Training and formal procedures provide a framework for many types of response, but the diversity of such emergencies make it difficult to prepare for all contingencies. In such cases, the emergency workers must improvise to find solutions to their problems. Improvisation can take different forms, from adopting new tools to using

informal communication strategies, but is nevertheless necessary for effective emergency response.

In this research we explore the relationship between technical infrastructures, communication, collaboration and improvisation. We analyze the interconnectivity between software systems and human relationships, and how these infrastructures can support improvisation and communication among emergency workers. In this paper, we will first explore the related research, followed by the methods of our interviews. Then we will present our findings, a discussion about the results, and the implications of our work for designers.

BACKGROUND

Pressures related to Adoption of New Technologies

Governmental organizations can be slow to adopt new technologies due to institutional resistance of various kinds. For example, regulations surrounding privacy and security often do not keep pace with the dynamics of new technological paradigms, like social media (Bertot *et al*., 2012). This resistance applies especially to the incorporation of ubiquitous, web-based technologies into the formal work practices of emergency responders. Hiltz et al. (2014) note that emergency responders face significant barriers—including regulations as well as requisite expertise and training—to utilizing tools like social media in their work. In addition to issues regarding existing regulations and policies, there are functional concerns—i.e. due to the time and safety-critical nature of emergency response work, it can be difficult to experiment with new technologies, which is often a critical step for introducing them into a workflow.

However, the landscape of emergency response is shifting. Though resistance is clearly present, emergency workers feel pressured—by their own communication needs and the needs of their various publics—to adopt these new tools. As the research here will show, the infrastructures that support emergency workers, both in their formal roles and their informal collaborations and improvisations, increasingly incorporate a diverse array of technical tools and systems. These range from centralized systems designed specifically for disaster response organizations to off-the-shelf tools like Google documents and social media platforms. For many emergency workers, there are both pressures and challenges surrounding the adoption of new tools and systems. Individual organizations might encourage, or even mandate, that members begin using certain systems, and collaborations between organizations may necessitate convergence around a particular tool or set of tools. In both cases, gaps in an individual's technical expertise may limit their ability to fully utilize new systems—and therefore constrain their ability to fulfill their role or to step outside their role to improvise.

Infrastructure and Improvisation in Emergency Response

Researchers in the emergency response context explain that every disaster is unique; the very nature of crisis suggests unplanned-for contingencies (Mendonca *et al*., 2007; Mendonca, 2007; Ley *et al*., 2012). In the aftermath of an emergency event, inevitably, there will be emergent collaborations and improvisation, as people work rapidly to address novel problems with the resources at hand, both technical and human (Dynes, 1970; Mendonca and Wallace, 2007; Kendra and Wachtendorf, 2003). Improvisation in the disaster content occurs both among informal actors (Kendra & Wachtendorf, 2003; Tierney et al, 2001) and formal responders (Mendonca *et al*., 2007; Ley *et al*., 2012). For formal responders, improvisation takes place both within individual organizations and across organizations (Ley *et al*., 2012). Increasingly, information communication technologies (ICTs) play a role in supporting the work that emergency responders do, including the improvisation work that takes place within and between organizations.

Examining improvisation among Jazz musicians, Crossan (1998) explain that shared goals and a structure that guides actions according to a shared set of rules are important for effective improvisation. Applying this conceptual understanding to the realm of emergency response, we can view the underlying structure that guides action in this context as one that includes many distinct, yet interconnected components—e.g. formal procedures and hierarchies, rules and regulations regarding information sharing across organizations, shared understandings and norms, as well as technical systems (the tools and platforms that structure work and enable communication). Improvisations, it can be assumed, are facilitated and shaped by these underlying structures—even as they often occur in the gaps of formal plans and procedures.

The various structures that shape improvisation can be examined as *infrastructure* (Star and Ruhleder, 1996; Star and Bowker, 2002), and in this research we investigate the infrastructures of emergency responders as well as their infrastructur*ing* activities (Star and Bowker, 2002; Pipek and Syrjänen, 2006; Pipek and Wulf, 2009)—the work they do to design their own technical, artifactual and social infrastructures. Star and Bowker argue that the metaphor of infrastructure as something that lies underneath things and something upon which other things operate begins to fall apart when we examine the "multiple, overlapping infrastructures" that inevitably exist within any intersection of technology and organization (2002). Though we align with their vision of multiple, intersecting and integrated infrastructures, we also believe that these infrastructures inevitably shape behavior, and that this conception of infrastructure and infrastructuring provides a valuable lens for examining both the formal work and improvisation activities of emergency workers.

At this intersection of technology and improvisation lie key challenges. Describing technology use within organizations in general, Star and Ruhleder (1996) note a simultaneous need for both customization and standardization. This seemingly paradoxical need may be especially critical within the emergency response context, where the need to improvise means that the technical infrastructures must be flexible enough to allow different users (with different technical skills as well as different roles in the response) to fulfill their varied responsibilities, and at the same time support intra- and inter-organizational communication, collaboration, and information-sharing (Mendonca, 2007; Mendonca *et al*., 2007).

This research explores the relationships between infrastructure and improvisation in emergency response, at a time when the infrastructures themselves are rapidly changing and/or under pressure to change.

METHOD

For this study, we interviewed 17 emergency workers through 12 interview sessions. Four interviews were conducted as group interviews—i.e. with multiple workers at the same time. This was due to time and access limitations for individuals who worked closely together. Each interview session lasted approximately one hour and consisted of a series of semi-structured interview questions, which were followed by a contextual inquiry. The interview protocol was developed by the researchers The contextual inquiry focused on eliciting discussion of available tools and systems, including communications software and hardware, room layout and design, documents, and other relevant artifacts. During each interview researchers recorded observations, taking field notes and photos. We received permission to record audio for ten of the interviews, and we later transcribed using targeted transcription. This process involved the researchers listening to each recording, noting themes among the interviews, and transcribing relevant sections word-for-word.

Importantly, these interviews took place between three and eight weeks after the Oso landslide, a major regional disaster that caused dozens of fatalities and resulted in the extended mobilization of local, regional, and national emergency response professionals in a coordinated response. Several of the interviewees participated in that response, and even among those who were not actively involved, there was a heightened awareness at the time of the need for collaboration across organizations.

Participants

Interviewees were contacted predominantly through snowball and convenience sampling—though some were found through official websites—and each worked for an organization within Washington State. We recruited participants based first on their association with a local or regional emergency response organization, and second on their familiarity with communications systems, protocols and technologies used by their respective organizations. This sampling resulted in a diverse group of emergency workers that spanned a wide range of roles and organizations. Participants included Public Information Officers (PIOs), Coordinators for operations, planning, and communications, and Strategic Advisors. The affiliations include the City of Seattle, the State of Washington, and regional government agencies and private organizations.

Participant Communication Flow Map

To better understand their role in their respective information systems, participants were asked early in the interview to draw a communication flow map—i.e. a network illustration representing their communications during a recent

emergency event. The maps are similar to concept maps, but with a focus on personal networks and communication, and grounded in a specific event. Participants placed themselves in the center, and drew connections to nodes that represented the organizations or job roles with whom they communicated. They were asked to "think aloud" and describe the nature of each connection and label the communication method in the diagram.

These communication flow maps grounded the remainder of the interview, providing researchers with a quick, visual representation of emergency communications. Because these networks varied widely for each participant, the visual modeling helped researchers understand complex human and technical relationships referred to later in the interview. As we illustrate below, mind maps also helped situate each organization and individual within the larger context of regional emergency response systems and infrastructure.

Analysis

We used a grounded, interpretivist approach for our analysis of the interviews. We first employed thematic analysis with the interview materials, photos, and related documents to develop a common set of themes. Subsequently, we returned to the observations and audio recordings to identify additional content related to those themes and to transcribe relevant sections and quotes.

FINDINGS

Analysis of these interviews surfaced several interrelated themes, including widespread negativity towards rigid, centralized systems developed specifically for emergency response, and increasing inclusion of off-the-shelf tools into formal work practices. Below, we describe how many emergency workers assemble diverse technological infrastructures from ubiquitous ICT devices (e.g. mobile phones) and available online platforms (e.g. social media and shared documents). We then explain how these personalized infrastructures present new challenges to improvisation and collaboration, and describe emergency workers' strategies for coping with them.

Though our study initially focused on opportunities for designing and building ICT solutions for emergency workers—i.e. tools to facilitate communications during emergency response efforts—our interviews revealed the importance of human relationships and activities in supporting these technical systems. In the following section we explore not only the tools themselves, but also the interdependence of technical applications and human relationships in effective emergency response.

Assembling Diverse Technological Infrastructures

These interviews reveal a number of overlapping tools and technologies used by emergency workers to facilitate response efforts. For many interviewees, these technical infrastructures include a centralized system designed specifically for managing emergency response, as well as a periphery of other ICT tools and platforms that they utilize to meet specific information and communication needs. Analysis of this information ecosystem shows some convergence among the types of tools emergency workers are most willing to use, why they choose these types of tools, and how these tools complement or complicate existing human relationships and information sharing strategies.

Barriers to Adoption and Use of Dedicated Emergency Management Systems

Recent pushes for transparency and inter-organizational collaboration have lead to the adoption of large, centralized software systems for emergency management and situational awareness. The two most mentioned packages from our interviews were Intermedix's WebEOC and a customized version of 4QTR's ViewPointe, referred to as C.O.P. (Common Operating Picture). Although the programs have different focuses, both offer a variety of features for searching and filtering information to make relevant information easier to find. Our research surfaced several key barriers to adoption and effective use of these systems within interviewees' organizations.

Both systems aggregate information from multiple organizations, provide logging and searching functionality, and attempt to increase situational awareness. In the case of WebEOC, the system acts primarily as the official log, but also includes task management and resource request features. However, even with a system designed specifically to accommodate this type of work, the volume of information from multiple organizations and departments can be

problematic.

> *I3: Back in the old days, it was 'if only we had more information'. That's completely turned on its head. Now we have way, way, way too much information coming in. So you have to have a human in the loop that can intelligently triage the information for you.*

I3 stated that during busier periods their organization often needed to assign people entirely to monitoring WebEOC in an attempt to keep others updated. They also had a person dedicated to simply joining duplicate tasks and closing outdated tasks, just to keep the system manageable for other members. Similar problems with finding information were also echoed about C.O.P. (I6).

The issue of *perishable skills*, which can slow response, exaggerates this problem. Not only do the emergency workers need to filter and find relevant information within the system, they *have to remember how to use the system*. Without regular usage and training, people forget how to perform basic tasks. All of the state, regional, and local government officials were trained to use WebEOC, but the rare calls-to-action limit their regular interaction and therefore their facility with the system. Even a long-term emergency manager mentioned difficulties finding information and functionality.

> *I2 : Where are my templates? Where are my plans? In WebEOC, you can't find them, and [emergency response] is very much about how you're organized.*

WebEOC provides a lot of configurability, but doing this required significant time investment, and was difficult to do for all organizations. The problem of perishable skills was so problematic that one of the city organizations migrated away from it for their EOC. As described later, they shifted to the social media platform, Yammer, instead.

Supporting Informal Communication

In many cases, effective collaboration is maintained not through centralized tasking systems, but around them—i.e. through informal or "back-channel" communications. Previous research shows that informal communication is important for supporting emergency response in general (Peterson and Besserman, 2010), and that it plays a critical role in facilitating improvisation (Ley *et al*., 2012). Our findings affirm this view, and highlight the relationship between back-channel communication and ICT tools and systems.

Several participants reported backchannel information sharing through face-to-face communication or personal phones to be an important aspect of their work. A few remarked that they occasionally utilized these backchannels to purposefully circumvent the official communication tools (e.g. the centralized systems described above). Outside of the EOC, informal communications networks improve safety for emergency response workers. Certain regulations may limit the types of information that can be formally shared across organizations, and informal communications provide a workaround for sharing critical information. For example, in responding to a fire, police may want to warn other responders about ongoing investigations in the area:

> *I7: He may tell me verbally, 'you know what, just as a heads up for you, throughout the next week, just be careful [about a specific safety concern]'*

Informal communications are often facilitated by existing personal relationships between responders at different organizations, as one emergency manager noted:

> *I3: There's the informal notification […] and that's just the personal relationships that exist. This job is all about people. I've been doing this for [over 30 years], and that informal notification system is one of the fastest, most effective systems around.*

These comments imply that human relationships—not just technical tools and software—play an important role in the success of emergency response operations. Yet personal relationships and communication channels have to be established before an event for informal communication to flow. Several of our interviewees indicated that they purposefully cultivate these relationships to develop trust and establish these channels:

> *I6: Day in and day out, before the emergency, I am networking at any conference, at any training. I have done site visits. You make those relationships. I host every year at least four if not five networking events, where it's either bringing in a guest speaker … or we'll have some basic training*

Back-channel networks are clearly critical to both safe and timely emergency response efforts between organizations, and while the importance of these "information notification systems" based on human relationships may seem obvious, current ICT solutions do not (or perhaps cannot) support or take into account this type of communication. Although large, standardized applications are built to enhance interoperability, emergency workers routinely circumvent these applications in order to communicate effectively. In some cases, workers may be avoiding these tools due to design failures of those specific tools, but in other cases, it may be that some kinds of communication between responders are not appropriate for formal communication channels. The latter observation suggests that a multi-tool approach is not necessarily a marker of a failed system, but a strategy for successful collaboration and improvisation.

Integrating "Off-the-Shelf" Applications into Formal Response Efforts

Our exploration of the complex ICT ecosystems of emergency workers shows an increasing number of off-the-shelf applications integrated into existing emergency response processes. For example, social media platforms have been broadly adopted by almost all of our interviewees. TweetDeck and HootSuite—client applications that enable monitoring of personal accounts and public posts on Twitter and Facebook—were the two most commonly mentioned pieces of software. Every participant indicated that their organization uses social media primarily to advance notifications of incidents, such as the Oso slide, and to improve situational awareness.

While social media were often integrated into communications strategies, a few interviewees described how they were incorporating off-the-shelf tools into operations as well. Two of our interviewees work as emergency managers for a large state organization with close ties to its local city infrastructure. The organization has its own police staff, 911 call center, and EOC, but instead of adopting a large, centralized system for coordinating their work, the organization opted to develop its own collaborative logging and communication system through Google Apps, a suite of free, cloud-based applications. Although many factors affected this decision, the interviewees noted that Google Apps was readily available, familiar, and easy to use. In describing the choice, one participant said, "we wanted something that'd be easy for people to figure out without a lot of training." Long lapses between EOC activations caused emergency workers to forget how to use complex software systems. Outside familiarity with these applications helped emergency workers avoid relearning tools.

Another interview revealed a city organization transitioning from an application designed specifically for emergency management to Yammer, a publically available social media platform. This interviewee cited multiple reasons for migrating, including "the fact that Yammer kind of looks like Facebook." The participant noted that his workers applied their personal experience with Facebook to quickly and intuitively grasp the functionality of Yammer. Utilizing familiar platforms helps avoid the issue of perishable skills, as worker have no trouble remembering how to use tools that they routinely use for other activities.

Human Interoperability

A major finding from this study revealed a critical component of communication work within emergency response efforts to be human interoperability. Similar to systems and technological interoperability, human interoperability focuses on ensuring successful communication of important information between two parties. In describing their activities and communication flows during a response effort, several interviewees highlighted work they do to ensure important information makes it to the appropriate people in an appropriate form. Human interoperability involves a person actively facilitating communication with an awareness and understanding of cultural differences and technical limitations of the receiving party. This work involves seeking, filtering, managing, and translating information so it can pass across the inherent gaps that exist between responders, between organizations, and between response organization and their publics.

Often, the gaps that must be bridged are technical, where one system is unable to communicate with another system—or when information is available in some place and some format, but it is not easily integrated into the tools and practices at hand. To bridge these gaps, workers are consistently appropriating tools to address specific needs—for example, firefighters using Google Maps on personal devices to aid response (Ley et al, 2012). Similarly, eight interviewees also mention adopting smart phone apps, social media applications, and web applications, like Google Maps. This software bridges gaps in their official infrastructures. In these situations, the information may be available or an information-processing activity may be possible, but only through a specialized

tool. People with the right tools and expertise provide—or *perform*—the interoperability for the underlying information. Human expertise in the tool is leveraged to find specific information relevant to a situation, and to communicate that information back to their teams. And yet, with response workers assembling their own infrastructures from available tools, new technical gaps—or issues of communication between applications—may form, requiring additional (human) work to bring information together again.

> *I6: The key thing for me is we can have multiple tools and systems, as long as the relationships are built where we can share information and then issue the alerts.*

Our research highlights socio-technical gaps as well as technical ones. As individuals continue to use their preferred applications, they develop specific kinds of expertise that may not be shared across others in their collaborating groups. For example, describing work with GIS experts to create a map, one participant said:

> *I3: It's really hard to work with GIS people, they are such subject matter experts that you get this disconnect between the average responder […] who is trying to get a map made […] and sometimes what is produced is not what they wanted.*

This problem can be exaggerated when these experts communicate mostly with experts in their field. It becomes difficult for them to know which terminology is difficult to understand for novices, and how to effectively communicate with people who do not share their level of expertise. Language is often a problem in these situations, but sometimes these issues can stem from barriers between organizational cultures. Common language can help, but transitioning to this can take long periods of time as this participant noted:

> *I7: We used to all have our own ten-codes, and nobody knew anyone else's ten-codes. We worked for years and got rid of the ten-codes, and now we're speaking a common language, but there are still different challenges that have to do with the different culture and nature of the job.*

This participant then remarked that even with the adoption of common language, cultural barriers of communication still exist. Like technological interoperability, exact translations are often not possible. In the case of communication, the reliance on natural language makes the process difficult to automate through standardized communication processes.

Some level of standardization is needed to ensure a base level of communication, but human interoperability may still be necessary. A focus on supporting human interoperability may increase as personal technology use becomes more accepted practice and the diversity of tools and expertise used in an emergency response increases. This diversity may be healthy for enabling improvisation in situ. If the diversity of cultures and tools is important, then the question shifts to how best to support this in practice. Our interviews indicate that some members of the emergency response community are beginning to actively coordinate their tool use and share expertise, building a shared infrastructure between events so it can be leveraged for improvisation during events.

DISCUSSION

This research describes the work of emergency workers taking place with a complex ecosystem that integrates tools, practices, expertise, and personnel. These interviews also demonstrate emergency workers acting as *infrastructurers*—as designers of their own infrastructures (Pipek and Syrjänen, 2006)—assembling the tools, developing the expertise, and enacting the changing practices. Inevitably, these tailored infrastructures result in distinct arrangements of tools and practices across and even within organizations, creating barriers for integrating data outputs and coordinating action.

Interviews with emergency workers in the wake of a major regional event demonstrate some of the specific challenges related to technology use, collaboration and improvisation—as well as some of the strategies for overcoming these challenges—at a time when emergency workers are increasingly incorporating a range of different ICTs into their practices. Our interviews show some responders consciously (in many cases) developing the personal connections to do inter-organizational work. This finding speaks to the importance of "human infrastructure" (Lee et al., 2006) in emergency response work, demonstrating how it plays a critical role in emergency response work.

Examining Improvisation through the Lens of Human Infrastructure

In examining the cyberinfrastructure of scientific collaborations, Lee *et al*. (2006) highlight the human aspect of infrastructure—or *human infrastructure*—describing how personal networks augment collaboration "… by organizing access to information and human/technical resources" (p. 488). This concept of human infrastructure encourages us to look at the relationships and understandings between emergency responders that enable them to converge around certain tools or work to overcome gaps in expertise and/or tools. Importantly, human infrastructure and technical infrastructure are not separate concepts or even separate constructs, they are instead interrelated, deeply integrated, and mutually constituting; one shapes the other. But highlighting the "human" aspect allows us to focus in on the human relationships that enable collaboration and improvisation.

Participant Communication Maps as a Tool for Revealing Human Infrastructure

Our method of data collection helped to reveal the human elements of the infrastructures that support emergency responders' work. We began each interview by asking participants to draw a communication map, a conceptual diagram of their information and communication flows. Interviewees were asked to narrate as they drew nodes for other people or organizations they communicated with and label the modality of the communication. Using these maps as an interview tool, we were able to elicit specific details about the social connections and communication modalities from each participant. The drawing provided an explanatory artifact for participants, and may have encouraged them to focus on some of the interpersonal connections in their workflows. It later became a vital resource for our analysis of each interview, allowing us to record and recall specific aspects of both the technical and human infrastructure. We believe these "communication maps"—or participant-generated network diagrams—may be a useful tool for future studies of complex systems, helping researchers better understand both the social networks and the organizational boundaries between individuals.

Articulating a Strategy for Building Human Infrastructure to Support Improvisation

If we consider emergency responders as designers of their own infrastructure, which Pipek and Syrjänen (2006) encourage us to do, then we have already acknowledged that emergency responders construct their own human infrastructures. We should therefore not be surprised to see, as we do here, that some responders employ the construction of networked human relationships as a conscious strategy for supporting future collaborations. Several of the interviewees mentioned the importance of their personal relationships and talked about strategies for "networking" with other responders in the region. But designing this infrastructure goes beyond just developing the relationships. It also involves coming to know and understand each other's roles and areas of expertise, including tool preferences, and designing strategies for reaching collaborators on their own terms (where possible).

In our findings, we describe how some responders are actively serving as bridges across technical and socio-technical gaps between individuals and organizations. This model of the "work" of bridging gaps aligns with a similar view of the members of the distributed crowd functioning as a "human-powered mesh network" to help bridge gaps in technological access and expertise by actively moving information from one platform to another during an emergency response guided by informal actors (Dailey and Starbird, 2014). This human work to bridge gaps between social and technical systems is an important adaptation to the challenge of both maintaining flexible infrastructures and assuring interoperability between different tools, actors and organizations.

Implications for Design and Practice

Our findings provide several implications for designing systems to support workers during emergency response. The overarching theme is about the importance of the broader infrastructure, which includes the human systems and their interactions with the technical systems. Our recommendations here are based on practices that are already in place, and appear to be successful within these systems.

Constructing Human Infrastructures

Each of our interviewees highlighted the importance of social connections for effective inter-organizational response to an emergency event. These social networks were used to informally spread important information about the event and the response efforts. At the start of an event, participants gave informal notifications ahead of the official call-to-action. During an event, they used these same informal channels to draw attention to particular details and help

warn others of potential safety concerns. Training serves to familiarize emergency workers with individuals from other organizations, but may not include the diverse range of actors involved in larger-scale responses. For extended events, like the Oso landslide, these networks helped individuals find regional expertise or just temporary replacements for relieving overworked employees.

Following the recommendations and current practices of many of our interviews, we encourage additional trainings and networking events designed to introduce emergency workers from across the region, and help develop a collective understanding of what tools are being used and who has particular types of expertise. One interviewee hosted regional, inter-organizational skill share events, where one individual introduces new tools and processes to the larger group. These events were often framed as hands-on walkthroughs for beginners to learn new tools, though they also served to extend social ties and to spread expertise with certain tools—as well as knowledge about *who* has expertise with certain tools—across organizations.

Improving Technical Infrastructures

Perishable skills and rare calls-to-action can make remembering how to use complex systems difficult. To help address this, we make a few suggestions for the design and adoption of such systems.

Personal Infrastructuring. One issue that was raised was the difficulty within some organizations of installing custom software or apps. In these cases, emergency workers had become familiar with apps such as Hootsuite or Tweetdeck, but were unable to install these applications when needed during an event. Clearly, security and maintenance are critical in managing these infrastructures, but IT policy makers should consider ways of supporting the development of such personal infrastructures. Flexible, well-communicated policies could help, especially in diverse or large-scale events where new response workers are mobilized and brought in to contribute.

One approach to this could be regular meetings between IT staff and various members to discuss possible new applications being used in response. Regular surveys about software technology use in all of the organizations and regions could also help. We observed many interviewees having installed many apps on their smart phones, both work and personal. These measures may identify potential security risks or infrastructure incompatibilities in advance of an event, and lead to resolving problems before an incident.

Familiarity. System designers consider mimicking familiar layouts, workflows, and terminology of more popular software and tools. The familiarity from such designs could strengthen the recognition of such tools and make them less prone to problems from perishable skills.

ACKNOWLEDGMENTS

We would also like to thank the following groups and individuals for contributing to this project: Megan Torkildson and Jonathan Lee Russo for their work on the project; Andy Davidson and the Human-Centered Design & Engineering Capstone class; the College of Engineering's Capstone Design Fund; and all of our interviewees for their time and energy.

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