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Emergency knowledge management and social media technologies: A case study of the 2010 Haitian earthquake

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ABSTRACT

The US response to the 2010 Haiti Earthquake was a large effort coordinated by three major agencies that worked in tandem with the Government of Haiti, the United Nations, and many countries from around the globe. Managing this response effort was a complex undertaking that relied extensively on knowledge management systems (KMS). For the first time, however, US government agencies employed social media technologies such as wikis and collaborative workspaces as the main knowledge sharing mechanisms. In this research we present a case study developed through action research of how these social media technologies were used, what influences they made on knowledge sharing, reuse, and decision-making, and how knowledge was effectively (and at times ineffectively) maintained in these systems. First-hand knowledge of the response is used, offering strategies for future deployment of social media and important research questions that remain regarding social media as knowledge management systems, particularly for disaster and emergency management.

1. Introduction

Managing knowledge is paramount for organizational survival and effectiveness in turbulent, fast changing environments. Organizations responding to disasters (both those that affect them directly and indirectly) are compelled to operate in such environments. Yet disaster response often presents a completely unique situation that traditional knowledge management systems (KMS) are not optimally configured to support. Governments, aid organizations, business, and individuals alike face unique KM challenges when responding to a disaster such as the 2010 Haiti earthquake. Communication and information systems in affected areas may be degraded or unavailable. Tasks may be out of the ordinary or emergent. Resource constraints may require new ways to think about existing responsibilities and functions. Knowledge availability varies more extremely than in normal situations—that is, sometimes little information will be available with which to make informed decisions; other times, multiple reports with conflicting information may necessitate increased information processing capabilities. Finally, decision-making must occur in a compressed timeline since faster than usual response is needed to stabilize a dangerous situation, prevent further losses, and begin reconstruction. Knowledge management systems that will be useful in a disaster response must be flexible enough to handle unexpected situations yet robust enough to be reliable in degraded or complex environments.

Social media is emerging as an important technology for disaster response. Social media consists of tools that enable open online exchange of information through conversation and interaction. Unlike traditional Internet and communication technologies (ICTs), social media manage the content of the conversation or interaction as an information artifact in the online environment. For example, wikis are a social media in which co-authors collectively build textual and visual websites. Google Docs (http://www.docs.google.com) manages documents, spreadsheets, and other files in a cloud computing environment which allows registered users to upload and share documents and changes from anywhere with internet access. Video and photo-sharing websites such as YouTube (http://www.youtube.com) and Flickr (http://www.flickr.com) use videos and images (respectively) to create social interaction. Social network web sites such as Facebook (http://www.facebook.com) represent links and nodes in the network through conversation threads. While these social media have been widely adopted publicly, organizations are only recently realizing their potential (Awazu & Desouza, 2004; Yates, Wagner, & Majchrzak, 2010).

Disaster response may be the ideal environment for 'proving the worth' of social media as a serious knowledge management platform. Social media's value is predicated on frequent contributions of small knowledge chunks in various forms that are easy

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to acquire, share and, use. The information currency of disaster response is increasingly text messages, images, short videos, blog posts, and web links—all encapsulated knowledge chunks. Social media's strengths are in supporting ad-hoc network formation bringing together various players with different expertise and contexts, and providing some level of common ground between them. Disaster response typically involves a coordinated response between individuals and agencies that in fact have different functions, expertise, and contexts. Finally, social media is designed to create order from chaos, using media as an artifact around which knowledge is organized in clusters, such as comments on blog posts or tags on images. Decision makers in disaster response require knowledge contributions to be highly contextualized because environments are fluid and misunderstandings are common. In short, it seems that social media are inherently flexible yet have the robust knowledge structures that are closely aligned with how knowledge is gathered, shared, and employed in a disaster response.

The goal of this research is to test the above assertions. The 2010 Haiti earthquake was an unspeakable tragedy for which the world mobilized an incredible response. For the first time ever, the U.S. Government relied extensively on social media to coordinate knowledge and action between cooperating response agencies including the U.S. Agency for International Development (USAID), the U.S. State Department, and the U.S. armed forces. The authors were given an unprecedented opportunity to participate in and study this coordinated response, and to understand how social media technologies were employed during the response to effectively manage knowledge.

This article describes our observations of how social media were initially introduced in the response, how they matured, and how they evolved as critical knowledge resources for decision makers as the situation 'on the ground' in Haiti evolved. Responders were forced to deal with lined-up jumbo jets at the airport waiting to deliver supplies and aid workers, shortages of medical supplies, prison escapes, and contaminated wetlands (among other problems), on top of their primary mission of humanitarian aid. Not all the lessons learned with respect to social media were positive. Effectively maintained, social media eliminated linear, manually intensive knowledge sharing processes typical of past response efforts and permitted localized 'crowdsourcing' (Howe, 2008) of ideas from numerous experts simultaneously. Ineffectively managed social media however were abandoned, grew unwieldy, and increased workloads for already over-taxed responders.

2. Information systems for disaster response

Knowledge management is not a new concept for agencies involved in disaster response. Since each disaster is unique and presents entirely new environmental, geographical, political, economical, and sociological concerns, it is normal for responders to build new knowledge structures on the fly to capture important information for later reuse. Previous research has shown that in times of disasters, people and organizations improvise and adapt to cope with their new condition and environment (Wachtendorf, 2004). Disaster response often draws on common capabilities however, such as transportation systems and experts such as doctors and social workers, thus knowledge systems typically are organized such that this knowledge may be quickly adapted and reused for the new response effort. Finally, responders are used to consolidating information quickly and presenting it to decision makers with the authority to re-task necessary assets (Crandall, Parnell, & Spillan, 2010).

For example, consider the case of the USNS Comfort, a floating hospital ship operated by the U.S. Navy and sent to Haiti during the response. The initiative to task the Comfort stemmed from identification of several factors unique to the Haiti response—many hospitals in Port-au-Prince (the capital city which was severely damaged by the earthquake) were destroyed. Haiti is on the island of Hispaniola, which makes it remarkably accessible for evacuating patients to a ship-based hospital. The Comfort, sailing from Baltimore, MD, could arrive in Haiti in time to do significant good (weighed against substantial cost) since triage efforts had begun to identify patients who needed operations that could not be easily done in makeshift medical facilities constructed by aid agencies on the ground. Thus knowledge of the particular circumstances was important for identifying the need for the Comfort's services. On the other hand, the Comfort has been used in other disaster response efforts, such as the 2004 Indonesian tsunami. Significant organizational knowledge of the Comfort's role and capabilities had been captured which allowed her to act quickly when tasked for Haiti. And naturally, actual deployment of the Comfort only occurred after knowledge of the situation and the Comfort's capabilities were communicated succinctly to decision makers.

2.1. Disaster management systems

The traditional information management model for disaster response is centralization. In the past, responders have relied on information systems that manage knowledge in silos, with the rationale that consolidating unique disaster circumstances, reconciling it with existing organizational knowledge, and presenting a useful summary for decision makers required specific expertise. Responders are typically organized as a team with a number of functional areas or 'desks' that work in parallel, each focusing on a particular expertise (Turoff, Van de Walle, & Hiltz, 2010). This organizational structure is iteratively applied—thus the U.S. armed forces, for example, has functional areas for the Army, Navy, and Air Force, and each of those has more granular functional areas, such as 'logistics' and 'medical'. Civilian response agencies operate similarly. For example, the State of Maryland Emergency Management Agency (MEMA) has a response command center in which each functional area such as the Department of Human Resources (DHR) has a desk. These response teams employ knowledge management tools, some of which are disaster specific and some of which are not, such as e-mail systems and file servers.

Server-based disaster management software such as the free and open-source Sahana Disaster Management System (http://www.sahanafoundation.org), and many proprietary tools support this structure. By organizing information into silos or functional areas, it is much easier to gather 'the right information' especially when it arrives piecemeal and from a variety of sources. For example, Sahana includes separate for tracking relief supplies and for locating missing persons. While getting information in to these functional areas can be a laborious process, making use of that information to make decisions is often even more manually intensive.

The traditional collaborative model for emergency management is the face-to-face meeting. Different functions independently build knowledge for their role and then present a concise version in a meeting with decision makers. Knowledge is acquired and presented in cycles determined by the frequency of these meetings. Little cross-flow of knowledge from one functional area to another occurs in between. Each functional area focuses their energy on acquiring knowledge pertinent only to their area. Turoff et al. (2010) suggest that face-to-face and distributed virtual teams using this model of organizational collaboration may not leverage the social aspect of disaster information exchange and therefore may not be flexible or robust enough to effectively and efficiently manage resources during times of crisis. A disaster often can be viewed as not only one large emergency, but multiple 'mini-crises' or catastrophes that emerge over a period of time (Hiltz, Van de Walle,

& Turoff, 2010). To respond to these multiple events, response organizations must have the ability to adapt to a dynamic situation through coordinating communication and actions by multiple functional areas, and encouraging cross-boundary communication between groups with different tasks and roles.

2.2. Social media, wikis, and collaborative tools

Social media is one emerging technology with the potential to allow for the flexibility, adaptability, and boundary spanning functionality demanded by response organizations for their information systems. Sutton, Palen, and Shklovski (2008) demonstrated the ability of social media technologies to have the ability to not only coordinate widespread communication and strengthen information flows, but also be flexible to the changing needs of the responders. Social media technologies have been previously used in disaster response, yet very little research has been conducted examining their impact on knowledge management, and specifically knowledge sharing and use amongst the respondent organization. This paper provides a unique look and the benefits (and drawbacks) of social media technologies during a recent disaster, the 2010 Haitian earthquake.

Boyd and Ellison (2007) define social media as "web-based services that allow individuals to (1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system" (p. 1). The difference between these technologies and other standard forms of ICTs are users are able to make their views, perceptions and knowledge public via the system. This forms ties with other individuals who may have similar interests, needs or problems. While networking may not be the primary motivator for their use, these technologies allow knowledge sharing through the creation of knowledge networks.

Critical to this notion of networking and knowledge sharing is the ability of people to collaboratively create content and knowledge. Furthermore, users are able to create semantics and taxonomies to organization and store this information for retrieval (Hendler & Golbeck, 2008). These technologies provide users with the ability to respond quickly to changes in the information and the environment, and provide flexibility, adaptability, usability and customizability in both the system and the information. Social media "support the creation of informal users' networks facilitating the flow of ideas and knowledge by allowing the efficient generation, dissemination, sharing and editing/refining of informational content" (Constantinides & Fountain, 2008, p. 231).

2.3. Knowledge sharing through social media in disaster response

Carlile (2004) presents a framework of knowledge sharing which potentially explains how users rely on social media functions as described above to more expediently and efficiently share knowledge in a disaster. Called the 3-T framework (for transfer, translate, and transform), this model illustrates how information boundary objects are utilized by organizations to span three forms of boundaries: syntactic, semantic, and pragmatic. A syntactic boundary requires two parties develop a shared syntax or language in order to communicate. A semantic boundary occurs even when a shared syntax is present, but differing interpretations or understandings of the knowledge create contrast in how the knowledge is interpreted by two parties and the absence of a mutual understanding. Pragmatic boundaries occur when knowledge is directed towards a specific practice and require common knowledge regarding the practice in order to be shared. These boundaries assume knowledge can be embedded in practice, actions or routines. The objects (which are not necessarily physical or tangible objects used to span these boundaries) perform three corresponding tasks: knowledge transfer, translation, and transformation. Traditional KMS employment in disaster response makes it difficult to study knowledge management across these boundaries since such exchange occurs typically in a manual fashion (e.g. through liaison officers or chains of command), or not at all. Social media have the potential to shortcut these traditional routines by connecting responders more directly and providing access to each others' knowledge stores.

Social media provide access to what Van De Walle and Turoff (2007) refer to as the 'human element' in disaster response. Comfort (2007) additionally notes that the 'common operating picture' requires interdependence and knowledge sharing by thinking individuals, not reliance on hierarchical information structures. Social media use typifies this access and decentralized interdependence (Awazu & Desouza, 2004). Wikis, online community forums, and blogs create instant feedback loops as knowledge recipients are able to immediately share their reactions with the author and other readers—in some cases, requesting clarification or additional information to help them overcome knowledge boundaries. Photo and video-sharing websites, as well as socialized news and weblink websites feature not only user-generated content, but also other users' tags—metadata that creates instant and situation-specific ontologies that again facilitate knowledge transfer across boundaries. Thus research suggests that what social media enable is not just information availability, but rather contextual information that responding organizations and the public alike may use to make sense of the available information.

Previous research on social media use in emergency management and disasters has primarily focused on the community or individuals impacted by the crisis. The role of online communities and their ability to support emergency preparedness and response (Palen, Hiltz, & Liu, 2007) including emergency response grids (Jaeger et al., 2007) have previously been examined, including the need for cross-boundary collaboration (Mendonca, Jefferson, & Harrald, 2007) and design needs for public facing systems (Carver & Turoff, 2007). However, no studies exist that examine the role of social media applications and technologies used by organizations responding to disasters. This paper takes an action research approach to illuminating how social media can be used in order to manage knowledge during an emergency. It focuses primarily on two social media used in the US government response: wikis, and collaborative technologies such as SharePoint. It should be noted that other social media were used in public forums including social networks, blogs, and photo-sharing websites. How these media were used to support the public response is outside the scope of this research, but remains an important area of study.

3. Methodology

Because of the unique access offered in this case we under took a participatory action research strategy (McIntyre, 2008; Mehra, Bishop, Bazzell, & Smith, 2002). Action research involves the research making active contributions to the community while undertaking the research. While critics of action research observe that researchers embedded within a study may compromise their objectivity, proponents of the approach acknowledge that researchers often bring their own expectations and political aims to their research. By shaping the phenomenon being studied, action researchers offer unique insights that outside researchers may not observe.

The unit of analysis for this case study was a two-week period of participation by one of the authors with the U.S. Air Force Chief of Staff's Crisis Action Team (AFCAT). The AFCAT is organized, trained, and equipped to gather information and provide facts and informed

opinion to the Chief of Staff and other Air Force leaders who in turn advise their superiors. For the Haiti response, the primary missions of the AFCAT were to ensure that aid was flowing to Haiti as needed; that military units in (and in support of) Haiti were properly resourced; that military and civilian leadership had the most accurate and up to date information possible with which to make decisions; and to coordinate information with other agencies involved in the response in an efficient manner. The AFCAT consisted of a team leader, a team executive officer, and representatives from twenty different functional areas that included public affairs, airfield operations, personnel, and logistics, among others.

One of the authors, a U.S. Air Force reserve officer, was called in to participate as a Communications and Information Technology functional expert to the AFCAT. While serving a series of 12 h shifts, the author helped configure social media tools used by the AFCAT (and other responding agencies) and also collected research data on how the response effort itself unfolded from the perspective of knowledge acquisition, sharing, use, and maintenance (Awazu & Desouza, 2004).

3.1. Background on the 2010 Haiti earthquake

Haiti is an island nation in the Caribbean, on the western side of the island of Hispaniola. Gaining independence in 1804, it has grown to a population of over 9,000,000. Haiti is the poorest country in the Americas, with a GDP of $7 billion, or $1,317 per person and ranks 149th out of 182 countries on the United Nations Human Development Index. Foreign aid currently contributes 30–40% of the nation's budget, and their foreign debt is estimated at $1.3 billion. Haiti's political history is a series of dictatorial ruler ships, coups, and more recently democracy, with recent elections placing Rene Preval as president. Haiti has a long history of severe natural disasters, such as hurricanes and earthquakes. Situated on a large fault line and in the path of many Caribbean hurricanes, the nation's poverty has prevented much progress and development in this small country.

On January 12th, 2010 at 4:53 p.m. a magnitude 7.0 earthquake struck Haiti, the strongest quake measured on the island in over 200 years. The earthquake caused widespread damage to the densely populated capital city Port-au-Prince, with an estimated 230,000 killed, 300,000 injured, and over 1 million people left homeless. Most of the major government buildings were destroyed, including the Hotel de ville, the Palais des Justice, and the Presidential Palace. Additionally, the major port in the city and the international airport were severely degraded; no shipping could safely enter the port due to collapsed piers and debris, and at the airport while the runway was operational the control tower and support buildings were totally destroyed or unusable.

3.2. US and international response to the earthquake

Although the United Nations maintained 9000 troops in Haiti under MINUSTAH (a French acronym for the UN mission to Haiti), the earthquake destroyed the MINUSTAH headquarters and the United Nations Development Programme building. Many of the UN troops were dispersed about the country at the time thus were unable to quickly reconstitute as a relief force. Numerous aid agencies operated in Haiti at the time of the earthquake; however most also lost infrastructure and unfortunately many aid workers were killed or injured. The United States was more fortunate in that its embassy was undamaged and its personnel were able to quickly establish contact with the Government of Haiti and resources in the United States, initiating a response effort. Within hours, search and rescue teams were enroute from all over the world. Recognizing that the United States would take a major role in the response, it was agreed early on that the U.S. Agency for International Development (USAID) would coordinate the humanitarian response, the U.S. State Department would spearhead any diplomatic issues, and the U.S. Department of Defense would 'carry the load' of the response itself—in terms of supplies, personnel, and information. Since the research participation for this study was with the Air Force, a Defense component, most of our observations are therefore concerned with knowledge gathered and exchanged for accomplishing the relief effort itself.

After the initial international response, the impact of the relief efforts could be clearly seen. Over 2.4 Million bottles of water and 3.4 Million meals were distributed, along with 70,000 households given shelter materials. 9000 U.S. troops remained on the island, and assisted in the evacuation of 16,000 U.S. Citizens, including approximately 700 adoptees. U.S. troops were also responsible for treating 34,900 injured, which included performing 625 surgeries.

Issues that still remained only weeks after the response included restoring capabilities at the sea port which was only able to handle approximately 1500 containers a day (25% load). Debris removal required additional help from military engineers, and commercial flights began to resume limited service as of February 19th. Most importantly, care for the civilians remained a priority, which included stabilizing the medical situation and extending aid to mental health and trauma support.

4. Social media, wikis, and collaborative tools used for the Haiti response

The AFCAT had recently shifted to a Microsoft SharePoint information infrastructure but had never used this infrastructure in a response. The platform could be considered 'social' as it provided several key functions of social media: it allowed web pages to be created 'on the fly' by anyone on the team (although in practice this was not done—since the legacy system was not configurable in any way therefore most individuals did not know they could create any pages until later in the response effort). Further, all contributions were tagged with the contributor's name and contact information. Anyone who had a comment or additional information would know exactly who to contact for more information, or how to contextualize their response if they had information to share. Using SharePoint also changed the social dynamic of the response effort. Past efforts were very linear. Working in a 12-h cycle, each functional area gathered information from various sources that was used to create a long PowerPoint briefing presented to senior leaders at the beginning of each successive 12-h shift. Each presentation would create formal and informal tasks that the next shift would accomplish and the results would be folded into their PowerPoint slides for the next brief. Most of the staff learned what others were doing only when listening to the briefings as there was little cross flow of ideas during the 12-h shifts, despite physical proximity (i.e. all individuals were located together in one large operations center).

If knowledge sharing within the AFCAT was minimal, it was traditionally even lower with agencies outside of the staff. Most inter-agency knowledge sharing was accomplished through formalized liaison officers whose main function was to coordinate knowledge back and forth between, for example, the State department and the military. This arrangement has advantages—namely liaison officers become experts in who to consult in both organizations for the 'right' information, how to prioritize interagency requests, and how to translate knowledge across the knowledge boundaries between the organizations (Carlile, 2004). However, relying on an explicit liaison also creates a knowledge bottleneck thus less sharing occurs than what might be shared if better knowledge sharing mechanisms were available.

By switching to SharePoint, the AFCAT now had mechanisms available that would support enhanced knowledge sharing

between functions on the staff and directly with other staffs. In addition to SharePoint, the various agencies involved in the response also developed Haiti-specific wiki pages. Using a common government MediaWiki platform (http://www.mediawiki.org) called Intelink, any agency could develop a shared website (accessible to any user with Intelink access). While SharePoint sites were therefore primarily oriented toward sharing knowledge within a staff such as the AFCAT, wikis were oriented toward the relief effort as a whole. Used in tandem, these social media fundamentally changed how knowledge was acquired, shared, applied, and maintained in comparison to response efforts of the past.

4.1. Knowledge sharing using social media

Social media facilitated knowledge sharing in two ways, by increasing knowledge reuse within a staff and by eliminating the reliance on formal liaison structures (both in terms of personnel and systems) between staffs. Within a staff, whereas before the majority of knowledge was shared during formal briefings (when little conversation was possible and little insight into 'how' knowledge in each function was acquired and built), now each staff member had complete visibility into how their colleagues were managing knowledge. This included access to their sources, identifying when different functions were working on the same problem from different ends (something that occurs frequently), and finding materials that could easily be repurposed for other needs. For example, one of the author's tasks was to build a comprehensive picture of the communication and information system availability for the responding units. At first the information was built in a tabular form, but as new sites in Haiti, the Dominican Republic, and Puerto Rico were added the table quickly became too difficult for senior leaders to digest. Additionally, it was not a useful format for others to share knowledge. The airfield operations staff member was building a similar report about airfield radars and equipment status in the same areas. From looking at maps that others had generated from Google Maps and posted online the author created a method for displaying the information geographically instead of in a table, however none of the maps available depicted the entire Caribbean area around Haiti. The author requested a new map that was quickly added, and both communications and airfield operations adopted the same map to depict their information. The format was so successful (partly because reusing the same map for different purposes created a common context for decision makers) that it was adopted for displaying other information such as fuel stores and personnel movements.

The other major advantage offered by using social media in the response was in the advantages gained from bypassing or eliminating formal liaison structures used previously to share knowledge between different agencies. Besides translating knowledge from one domain to another, the liaison's most valuable function was brokering knowledge sharing requests (Wenger, 1998). Typically, the problem was not so much that staff in one agency were not allowed to access knowledge from another, but that it would be practically difficult for them to know who, what, where, and how to access that knowledge. Social media facilitated this awareness. Since a common platform was utilized for the wiki pages, a user who could log in to one page could access all of them and search directly for the information needed. For example, early in the response the US Secretary of State Hillary Clinton flew to Haiti and announced her intention to bring home a planeload of American citizens in Haiti when the earthquake hit. Awareness of this event came from formal liaisons. However, it became apparent very quickly that additional information about this event was needed. No one knew if the American citizens being evacuated by the Secretary of State would be injured or not, and hospital facilities were set up in some Florida cities but not everywhere that Americans had been evacuated. Also, the U.S. Military controlled access into the Port-au-Prince airport (at the time, although control passed back to the Government of Haiti after the first two days), but the military had no control over where the Secretary's plane would go back to in the U.S. The U.S. Department of Homeland Security had coordinated immigration entry points at a few airports and Air Force bases in the southern U.S., but it was not clear that anyone had the authority to direct the Secretary's plane to one of these bases. Finally, the military and aid personnel in Haiti were concerned that the Secretary would have adequate transportation and security in Haiti, which was still a fluid and volatile environment at the time. Most of the information needed to answer these questions was available from documentation posted on State Department, USAID, and U.S. Military wikis without each agency having to make specific requests for it. When information was not readily available, lists of contacts were posted allowing functional representatives to directly contact counterparts in other agencies.

Finally, one of the most significant benefits of knowledge sharing was that reuse eliminated significant duplication of effort. One of the major functions the U.S. Air Force provided was overhead reconnaissance. Full motion video devices were distributed by the military to the Government of Haiti, U.S. Embassy personnel, and aid agency representatives. At the same time, hundreds of digital images taken by aid workers and military personnel in Haiti were posted on wikis for all to use for various purposes, from public relations to analyzing road conditions to parachuting in pallets of supplies in aerial deliveries. Not only did the social media make this information available, but it let those who controlled it know *how* others found it useful through their comments. It helped responding agencies make the most of their capabilities by being responsive to requests, and by combining information from different sources to create more consolidated and knowledge-rich stores.

4.2. Knowledge application using social media

Decision makers usually found visual presentation of information the most effective format, since a visual medium can be constructed by layering different knowledge sources successively onto a common context or orientation. An example of how this was done is the World Food Program's decision to organize aid distribution in Port-au-Prince into 16 strategically placed distribution points. This issue is particularly indicative of the complexity of the disaster response. First and foremost, the decision of where to place distribution points depended on where aid was needed. But there were other considerations. Supplies were building up at the airport, at Cap Haitien in the north where ships offloaded, and in the neighboring Dominican Republic, but transportation to potential distribution sites was a problem due to damaged and debris-strewn streets. A third concern was security. Although the populace in general was calm and orderly, escaped prisoners, pockets of looting, and thefts from relief convoys (some made by armed assailants) meant that security was necessarily a concern in where distribution points would be located. In the past, gathering this information would have necessitated several agencies working independently, continuously coordinating information and decisions back and forth in either a time intensive, labor intensive or time and labor intensive process. In this case, however, the information was simply available. Plans were built quickly using available information from wikis and posted status reports.

4.3. Challenges maintaining social media technologies

An important and significant aspect of how social media were employed was how the knowledge structures were built and evolved. With SharePoint, initially the site was not used as a collaborative space but as an easily updated record of events. Materials were developed offline, e-mailed or placed in shared folders on a

file server, and once briefs were completed they were uploaded to SharePoint to ensure everyone had access to the 'complete' brief. Working materials such as images and other documents were not maintained in the SharePoint space however. Within the first days of the response, however, as staff became accustomed to using SharePoint, its use was expanded. Senior leaders had their own accounts and became more actively engaged in the knowledge creation process and could do so at any time, not just at 12-h intervals. As new tasks emerged, adding new folders, a task list, contact lists, and links to other SharePoint pages altered the SharePoint site.

How additional structure was created to manage knowledge varied depending on the staff and some strategies were more successful than others. The most successful model was to have administrators design an initial site structure and provide simple, manageable suggestions for how others should use the site. In fact, a particularly useful idea was for an administrator to create a simple how-to document and post it right on the SharePoint home page, so newcomers could learn how to create their own folders and share knowledge. Administrators for other staffs attempted to create a complex structure from the beginning, by creating a hierarchy of file folders that mirrored the various staff functional areas and briefing tools used. This resulted in a SharePoint site replete with folders but with no content. Surprisingly, this site utterly failed. Since the users had not developed the file folders themselves, they were unsure where to add their knowledge. Also, since the tasks and even the tone of the response changed as days passed, a pre-built structure imposed an artificial knowledge classification on users that they did not like. This was an unfortunate and unanticipated negative consequence of using social media.

With wikis, the most significant knowledge management challenge was the extent to which the wikis grew unchecked – and unwieldy – as more and more users added knowledge yet little shaping of the knowledge ensued (Yates, Shute, & Rotman, 2010; Yates, Wagner, & Majchrzak, 2010). In one instance, for example, 400 images were added, some with descriptive filenames but some without, and all in need of descriptive metadata. Additionally, as more and more news stories were published, links were added to each creating a comprehensive yet unstructured section of the wiki documenting popular press reports. The wikis used quickly became an embarrassment of riches, and without common naming conventions it became difficult to find specific knowledge. Users quickly learned to tag contributions with explicit dates to distinguish old from new knowledge. Although a key function of wikis is that new knowledge overwrites old (but old versions are maintained in a revision history), in this case it was rare that any information would be overwritten or combined since the purpose of the wiki was not only coordinating the response, but also capturing lessons learned over time. As of this writing, one of the primary wikis involved had been accessed over 35,000 times and updated over 1000 times, thus in the highly fluid timeline of a disaster response it may be that access to knowledge is more important than how it is structured.

In the long term, however, it is unclear how valuable these wikis will remain as a knowledge resource given the lack of structure. A potential limitation with social media like wikis, highlighted in this example, is that shared ownership of the developing knowledge resource may lead to ambiguous management of knowledge for purposes such as long-term storage or records management.

5. Discussion

5.1. Managing knowledge across boundaries using social media

Through the previously described experiences and observations, we have illustrated how social media had an impact on the information and knowledge management routines of the individuals within an emergency response organization. These impacts can be further examined through the lens of Carlile's (2004) 3-T framework, which denotes that knowledge is managed across syntactic, semantic, and pragmatic boundaries.

In the Haitian earthquake case, the social-enabled knowledge management system spanned syntactic boundaries by allowing knowledge to be transferred from one domain to another. This brokering function (Wenger, 1998) not only allowed for the knowledge to flow between different departments and agencies, but also created an awareness of the knowledge, enabling it to be used by others. Furthermore, as stated in the case, the transfer of knowledge significantly eliminated duplication of effort, since no longer were different functions unable to access outside work, as they knew what knowledge already existed.

The SharePoint system was able to span semantic boundaries through translating knowledge, or converting it to a form that was understandable across organizational boundaries. The description of how the reliance on formal liaison structures was reduced through the decreased use of formal briefings illustrates how the switch to information knowledge structures effectively translated the knowledge for better visibility and greater knowledge reuse. As this included the repurposing of knowledge for new and innovative uses, it facilitated the conversion of knowledge in order for it to be used on a greater scale. Secondly, it was determined by decision makers in the organization that knowledge presented visually was more effectively communicated and used than knowledge in a text format (i.e. report, PowerPoint presentation, etc.). Many of the decision makers were able to grasp knowledge comprised from multiple sources and formats more easily, and this lead to better decisions being made, such as when they determined the 16 distribution points for aid and the corresponding security needs.

Pragmatic boundaries were spanned through the social media's ability to transform knowledge. The practices of how knowledge was managed were altered through an enhanced social dynamic created by the system. The 12-h shift system was maintained through the ability of the SharePoint users to transform the knowledge they had collected and utilized during their shift into new knowledge that would meet the needs of the next shift. Furthermore, knowledge transformation occurred when sharing knowledge with external agencies. Not only was the flow of knowledge increased, but also with the help of the Wiki functionality the form of the knowledge was altered to make spanning organizational boundaries more practical. The shared ability of multiple agencies to create and alter pages lead to a transformation of internal knowledge into a more externally friendly content. Finally, users transformed the structure of the knowledge on the SharePoint system through the addition of comments across agencies. Having multiple people involved with the creation of knowledge (including expanding these processes to more senior leaders) and the iterative transformation of knowledge though the conversation created by the comments made the knowledge available and usable to multiple organizations.

This approach to transfer, translating, and transforming the knowledge is done in a cyclical, or iterative fashion. Through this process, the individuals become more adept at creating common knowledge across boundaries and assessing each other's knowledge. SharePoint enabled this iterative capability through the establishment of a simple site structure that was manageable and adaptable to changes in the environment. The system did not limit the ability of users to structure the knowledge and it became commonplace to develop a customized structure that could be shared or altered by others depending on the situation.

In Table 1 we summarize the ways in which SharePoint as a social media helps to span the boundaries found in a typical disaster management situation. Each of the boundary types and their cor-

Table 1
A view of the sharepoint system using the 3-T framework.

Boundary/process	Observation
Syntactic/transfer	Sharing knowledge from different agencies Decreasing the level of duplication of work
Semantic/translate	Increasing knowledge reuse through increasing knowledge visibility Creating visualizations of knowledge for other departments or agencies
Pragmatic/transform	Altering the social dynamic of the knowledge organization Create a bridge to outside organizations and resources Transform knowledge through conversations within the system

responding process were observed in the USAF's use of SharePoint and its social media functions.

5.2. Challenges to social media use in disaster response

It should be noted that the system also presented challenges to the organization in the way it allowed knowledge to be managed socially. The accuracy of information, which is of utmost importance when managing emergency response, needs to be constantly checked and validated which is very difficult given the amount of data that can flow into these systems. The example given of 400 images being uploaded to the system and not properly tagged is only one example of many, and it had relevantly minor consequences. Consequently, information overload can occur due to the embarrassment of knowledge riches that was observed in this case. This threatens the manageability, usability and perceived value of the system. Organizations must ensure processes or system controls are put in place to monitor and evaluate the information and knowledge being stored and shared.

5.3. The evolution of social media in future disaster response

While social media may have a transformative impact on knowledge sharing in disaster response, responding organizations may be able to successfully leverage these technologies with minimal transformation. Because of their traditional functional silos maintained within hierarchical structures, participating individuals have specific identities. Identity, whether personal or role-based, is an important component of social media since each knowledge contribution 'comes from' and is 'received by' someone. By better leveraging identity management with knowledge management organizations may be able to manage knowledge transfer over boundaries implicitly, by for example, logging which experts view certain files or images and then routing future files similarly tagged (or from the same source) to those experts. Social media may also help these organizations to better identify knowledge boundaries that exist that are knowledge-based rather than functionally based. If each silo maintained a blog that other responders could see it would be easier for decision makers to track parallel tasks and critical choke points simply by identifying which functions were busy at the same time, or if different functions were each receiving the same requests for knowledge from others.

A further impact of social media that has potential for future disaster response is publicly crowdsourcing (Howe, 2008) response information. As more information becomes available from a wide variety of sources, responders will quickly become over-taxed. Whereas the public is often asked for monetary donations, social media would enable individuals to assist responders by tagging photos, creating customizable maps, and offering cultural and other useful background information.

Opening up disaster response systems to the public however creates numerous privacy and security concerns. Person locator systems such as Google's person finder for Haiti (http://haiticrisis.appspot.com/) and similar systems maintained by organizations such as the Red Cross use public information to reunite separated families, yet some fear that criminals could mine these systems to steal identities and take advantage of at risk populations such as children. Even when personally identifying information is masked, expressive information shared online can be used to connect anonymous individuals with their true identities (Yates, Shute, & Rotman, 2010). Others fear that government agencies involved in disaster response might track, catalog, or otherwise invade the privacy of public individuals who do decide to help (McCarthy & Yates, 2010). Thus the implications of publicly crowdsourcing disaster information are not yet well understood.

6. Conclusion

Social media technologies hold great promise for leveraging public participation in disaster response, yet the lessons from this case underscore their advantages when used within formal organizations to support open, collaborative knowledge sharing and reuse. When properly employed, the benefits of social media support are faster decision cycles and more complete knowledge resources. Whether or not these lessons can be duplicated in other crises or emergencies is an open question, as each circumstance offers unique challenges. As these systems mature and are more widely adopted, it is also unclear whether lessons from traditional KMS – recovering from knowledge errors, prioritization of knowledge, dealing with too much information, and long-term storage and retrieval of knowledge – will be important factors.

Our research has begun the investigation of how social media supports disaster and emergency response mechanisms from an organizational level. By viewing the impact of the introduction of social media through the lens of the 3-T framework, we illustrate how social media enables effective knowledge management in a dynamic emergency environment, through establishing coordination methods with various external aid agencies, and how knowledge is transformed in order to be better utilized by individual and decision makers. This emerging technology demonstrated its potential in the response to one major disaster, the 2010 Haitian earthquake through providing a flexible and innovative structure and could be utilized by many individuals, departments and external organizations for the effective acquisition, sharing, use, and maintenance of knowledge.

This paper consists of one case study, yet presents many opportunities for future research on knowledge management, social media, and emergency response by organizations. For example, in knowledge management it would be valuable to understand the differences in flows of emergency knowledge as compared to normal organizational knowledge, including contrasts in barriers to information flow, new aspects of information overload that emerge, and the impact of erroneous knowledge on emergency management. The processes used to prioritize knowledge on disasters should also be investigated in order to not only understand how tacit knowledge affects information use, but also how technologies should support disaster knowledge.

Little research exists on the design of social media and knowledge management technologies for emergency management, including how they differ from other organizational systems with respect to usability, portability, open standards, and durability in a post-disaster environment. How these systems, including social media, factor into the decision-making processes of organiza-

tions would provide the opportunity to extend out understanding of the decision-making models in extreme or high pressure environments. The requirements for the inclusion of community and knowledge sourced from individuals in an organization's knowledge acquisition processes remains understudied, which would necessitate the inclusion of elements such as trust, 'crowdsourcing', and knowledge across vast barriers. Many of these questions could be answered through a multi-case study approach that would compare the use of social and knowledge management technologies across a broad range of disasters. We hope that this research sets the stage for investigating these and other important questions and for more effective and efficient response to disasters and emergencies.

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