Emergency Management Task Complexity and Knowledge-Sharing Strategies

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Disasters such as Hurricane Katrina and the 9/11 terrorist attacks have made crisis and emergency management a top priority for policy making and management at all levels. While each crisis or emergency situation is unique in some aspects that are difficult to determine before it actually occurs, all such situations, whether natural or manmade, are unpredictable and threaten high-value priorities such as life, financial well-being, and physical infrastructures.

Emergency management tasks are inherently complex and dynamic, requiring quick knowledge sharing for effective decision making and coordination among multiple individuals and organizations across different levels and locations. Unfortunately, there is a general lack of understanding about how to describe and assess the complex nature of emergency management tasks and how knowledge-sharing strategies can improve emergency management task performance. This article discusses the role of emergency operations centers (EOCs) and how emergency managers can improve their task performance by understanding and managing the dynamic interplays between task characteristics and knowledge-sharing strategies.

Our observations are drawn from a multiyear, multimethod collaborative research project between Florida International University and the Miami-Dade EOC in Florida. Since 2006, our team has studied EOC tasks and organizational structure, knowledge-sharing strategies for emergency management, and subsequent performance through interviews, review of EOC documents, focus groups, and surveys. We also participated in EOC activations and in several-day-long simulation "drills" — exercises designed by the EOC in which all participating organizations and agencies simulate emergency events. These simulation drills are based on prior emergencies and are used to practice coordination and response activities required to accomplish the emergency management tasks.

Our observations indicated that, while emergency management tasks are highly complex, the Miami-Dade EOC is successful in effectively and efficiently responding to emergency situations. The EOC's success can be largely attributed to its personnel's utilization of appropriate knowledge-sharing strategies according to the nature of the complexity of those emergency management tasks. The emergency managers with whom we have interacted in the last few years all agree that attempts to better understand the characteristics that determine task complexity can aid the effective management of emergency events. Furthermore, they recognize that the successful completion of these tasks requires appropriate coordination and knowledge-sharing strategies among multiple actors and organizations across different levels and locations.

EOC CHARACTERISTICS

The state of Florida is currently considered one of the most effective states in the US with regard to emergency management. The State Emergency Response Team (SERT) has identified 18 types of hazards that pose an emergency threat to Florida, including wildfires, thunderstorms, tornadoes, lightning, flood, terrorism, drought, heat waves, hurricanes, cold, animals, nuclear accidents, hazardous materials, cyber attacks, information warfare, aircraft, and bombs. The Miami-Dade County Office of Emergency Management (OEM) is the lead agency in an emergency event, and the EOC is the site where all relevant government agencies and other organizations come together to carry out the emergency management operations. The EOC thus represents a temporary organization that is triggered by an emergency event and is composed of various personnel with specialized expertise and skills from different organizations.

Figure 1 depicts the floor plan and the facility setup of the EOC. The large array of organizations is organized into branches such as the Public Safety Functional Group, the Human Services Functional Group, and the Infrastructure Functional Group; neighboring counties' emergency management liaisons, municipality EOCs, the Air Force Reserve Base, and the Federal Emergency Management Agency (FEMA) participate as well. Many

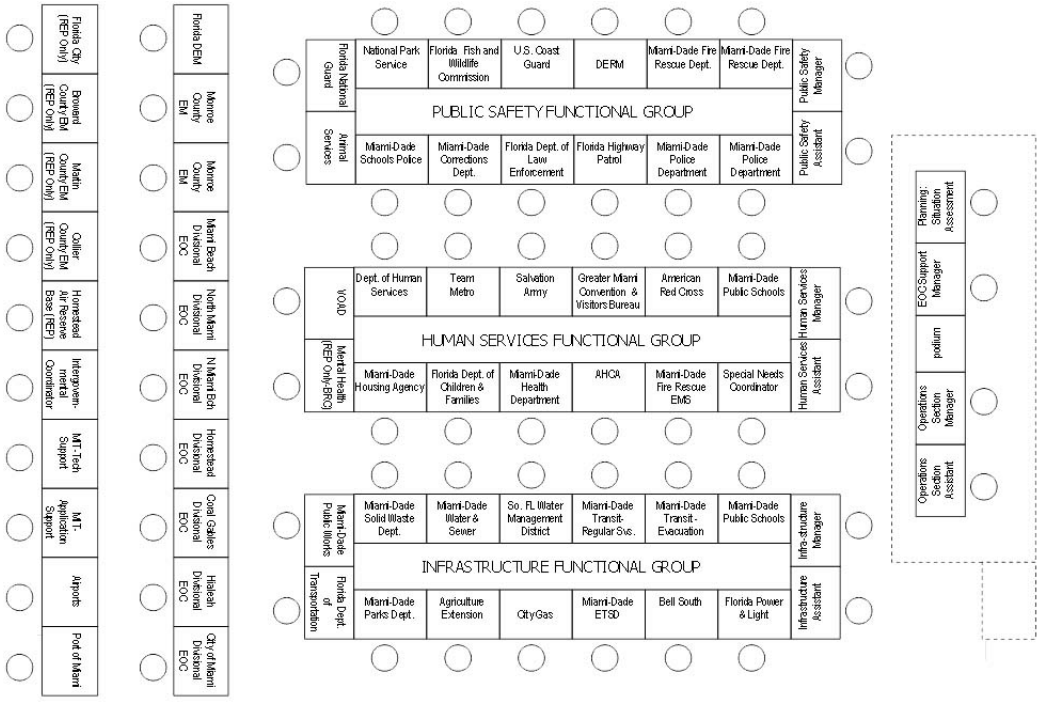

Figure 1 — Miami-Dade EOC activation floor plan.

other agencies are likewise called upon following an emergency event.

COMPLEXITY CHARACTERISTICS OF EMERGENCY MANAGEMENT TASKS

Two complexity characteristics can be used to describe emergency management tasks:

1. Structural complexity
2. Dynamic complexity

Structural complexity refers to the inherent complexity of the task, and it captures the type and number of the various task components (such as time and location of the incident and the personnel, equipment, and organizations involved), as well as the interdependencies among the components. It is composed of two dimensions: *component complexity* and *interactive complexity*. Component complexity represents the multiplicity of the task components (e.g., number of people assigned, variety of organizations represented, computer systems accessed and used, machines required, variety of resources required to complete the task). Interactive complexity represents the degree of interactions and interdependencies among the task components (e.g., the interconnectedness of the people and different organizations participating in a given task).

Dynamic complexity refers to the aspect of the task that involves the decision maker, and it captures the ad hoc and unpredictable nature of the task. It is composed of three dimensions: *task non-routineness*, *task difficulty*, and *task significance* (see Figure 2). Task non-routineness represents the unexpected and novel events and exceptional circumstances associated with the task. Task difficulty represents the degree to which the information required to perform the task is missing or equivocal, thus leading to conflicting interpretations. Task significance captures the immediate priority and potential impact of the task.

KNOWLEDGE-SHARING STRATEGIES

Because of the significant amount of information and knowledge needed for quick assessment and decision making, emergency management requires intense knowledge identification and sharing across the diverse organizations involved. As shown in Figure 3, knowledge-sharing strategies in the emergency management context can be viewed from two perspectives:

1. **Knowledge-sharing purpose** — exploration versus exploitation
2. **Knowledge-sharing mechanism** — personal interactions versus written documents

Knowledge sharing can serve one of two purposes. Knowledge *exploration* refers to situations where discovery of new knowledge is required because there is no existing knowledge for performing the task at

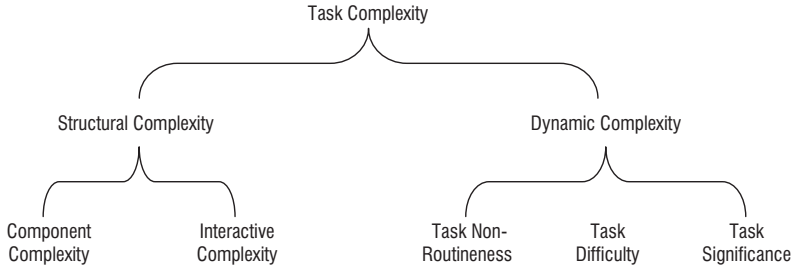

Figure 2 — A framework of emergency management task complexity characteristics.

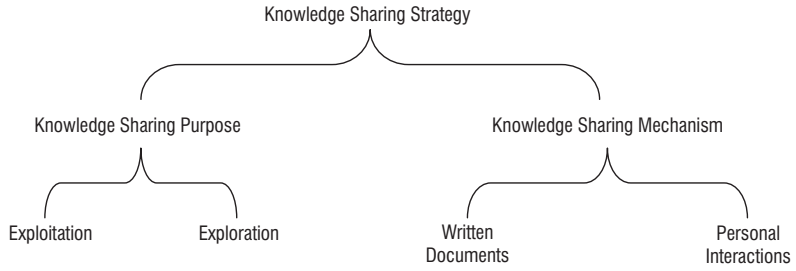

Figure 3 — A framework of emergency management knowledge-sharing strategy.

hand. Exploration activities often include search, variation, risk taking, experimentation, play, flexibility, discovery, and/or innovation. Knowledge *exploitation* refers to a directed search and utilization of existing knowledge. Exploitation activities often entail refinement, choice, production, efficiency, selection, implementation, and/or execution.

Two knowledge-sharing mechanisms can be used in emergency management: *personal interactions* and *written documents*. Knowledge sharing through personal interaction is appropriate for knowledge that is difficult to codify and hard to formally articulate in writing. Such tacit knowledge often resides in individuals based on their experiences and social context. Knowledge sharing through written documents is appropriate for explicit knowledge that has been formally codified and written down in the form of planning guidelines, standard operating procedures, best practices, lessons learned, and/or after-action reports.

FINDINGS AND LESSONS LEARNED

1. EOC tasks are highly complex and at risk of failing because of the inherent dilemmas of dealing with the conflicting dimensions of task complexity.

In order to effectively assess and distinguish the complexity dimensions and levels of different EOC tasks, we developed a set of frameworks and assessment tools. In general, the tasks undertaken at the EOC are complex based on both their structural complexity and their dynamic complexity. A typical EOC activation during the hurricane season calls upon more than 300 personnel from more 50 organizations. The personnel from each organization possess specialized expertise in a particular aspect of the emergency management process. Differences in the personnel's background and expertise make information exchange not only necessary, but also difficult. Because of the large number of personnel and organizations involved and the ways they are all interconnected, structural complexity represents one of the most critical complexity dimensions of emergency management tasks.

In addition to the high structural complexity, EOC tasks are generally high in dynamic complexity as measured by task non-routineness, difficulty, and significance. Because each emergency event could manifest itself with a new set of characteristics (e.g., hurricanes could have different levels of wind speed or precipitation), each event could essentially be unique and introduce a new set of challenges. Decision makers could thus face new tasks that require actions and procedures that are not routinely performed and yet demand immediate response because of the high level of task significance. For example, during Hurricane Katrina, emergency responders in Miami had the task of dealing with the sudden collapse of the SR836 overpass bridge in construction between 87th and 107th Avenues. This emergency task was non-routine, as emergency crews had never dealt with an overpass collapse before. Because

the task was essentially new, the non-routine information that was required for decision making may have been unavailable or may have conflicted with other pieces of information.

The different complexity dimensions can be organized into a progressive complexity hierarchy based on their relationships and relative priorities. One of the most significant challenges emergency managers face is managing the conflicting demands imposed by the different dimensions of task complexity. Tasks that are high in both non-routineness and difficulty require EOC managers to take the time to understand the task circumstances as thoroughly as possible before committing to a particular approach or course of action, yet because of the urgency and high impact of the emergency event, EOC personnel are pressured to respond to the disaster event as quickly as possible.

2. Despite the high levels of complexity, EOC tasks are completed successfully because of effective knowledge sharing.

Effective knowledge management depends on appropriately managing the interplays among task complexity characteristics, knowledge-sharing purposes, and knowledge-sharing mechanisms. Managers often share knowledge for exploitation purposes through written documents and systems when they are dealing with component complexity, which tends to be limited to a particular knowledge area. In contrast, when dealing with interactive complexity (which tends to be more unstructured and more likely to cross organizational boundaries), managers often share knowledge for exploitation purposes through personal interactions in order to utilize knowledge that managers in other organizations already possess.

Dealing with dynamic complexity — with its high levels of task non-routineness, difficulty, and significance — is another story. Because of the lack of existing knowledge and the urgency in responding to a novel situation, managers share knowledge primarily for exploration purposes and depend mainly on personal interactions rather than searching written documents and systems.

One of our most interesting findings is that, while personnel more often engage in knowledge exploitation (seeking and reusing existing knowledge) than exploration (creating new knowledge), they are more apt to do so through personal interactions than by searching written documents and/or systems. Indeed, the greater the difficulty of the task at hand, the more likely they are to shift to sharing knowledge through personal interactions rather than using prescribed mechanisms such as operating procedures and documents. We have found that explicit knowledge stored in written documents and systems is more suitable for dealing with lower-order complexity such as component complexity within a particular specialty area, while tacit and/or integrated knowledge sharing through personal interactions is more suitable for dealing with high-order emergency task complexity.

3. The EOC organizational structure and facility configuration provide an enabling physical setting for effective knowledge sharing.

Given the high interactive complexity and task significance of emergency management tasks, the successful completion of these tasks depends less on individual managers possessing the specialized knowledge required to deal with component-level complexity and more on managers from different organizations coordinating effectively to share the knowledge needed to handle the higher order of task complexity. This is no small feat, as emergency managers must search as much information as possible, identify available alternatives, and then coordinate the large number of diverse and interdependent organizations to make immediate decisions. The temporary nature of the various organizations' involvement in the EOC and the high turnover of personnel in the different organizations further exacerbate the difficulty of managing the high interactivity and significance of EOC tasks. Effective knowledge sharing would not happen without the well-ordered organizational structure of the EOC and the physical proximity of the actors in the facility.

The EOC is the site for all emergency management operations and functional responsibilities. Many assumptions usually made in the organizational context with regard to issues such as resource planning, communications, chain of command, and so forth may not hold true in the EOC setting. During an emergency, the participation of representatives from different organizations is transitory. Communication mechanisms could be instituted formally, but the stressful conditions during an emergency might cause the participants to revert to informal means of communication. For similar reasons, the chain of command at the EOC might be construed to be fluid and evolving.

The EOC is organized under the guidelines of the Incident Command System (ICS) within the National Incident Management System (NIMS),[1] the first standardized management approach that attempts to unify US federal, state, and local lines of government in times of emergency response activities. One of the management characteristics of the ICS is an organizational structure that develops in a top-down, modular fashion

based on the size and complexity of the incident, enabling the assembly of the diverse organizations needed to manage complex emergency events into a temporary but highly fluid and effective organization like the EOC. When situational complexity increases, the organization is able to expand from the top down, adding functional responsibilities as required. For example, one of the procedures adopted at the Miami-Dade EOC is to ramp up (or down) the activation level depending on the severity of the disaster event, thereby increasing (or decreasing) the personnel and resources available for the emergency response operation.

Effective and efficient knowledge sharing among multiple managers from diverse organizations also requires colocation in one facility, with an appropriate communications and information exchange network setup. The EOC central command room is designed and furnished in special ways (see Figure 1). Three large, elongated tables are arranged in the center of the room; each table is equipped with 14-16 workstations and corresponding chairs, with two stations at the head of each table. A nameplate for each of the various organizations and agencies is neatly displayed at each workstation, which is also equipped with a computer, two telephones (one conventional, and another customized), and several manuals and instruction sets. One end of the room has seating arrangements for 8-10 people in each of two rows; the other end has a raised platform for four section managers and a podium with a microphone lending an aura of authority and orderliness. There are four ceiling-mounted monitors, and each of the adjoining walls is fitted with four television screens.

Flash back to 29 August 2006. We were in the EOC central command room observing the whole activation procedure for Hurricane Ernesto. The workstations were then manned by the representatives of the various organizations and government agencies and by regional EOC representatives. The heads of three tables were occupied by the Miami-Dade EOC functional branch managers (Public Safety, Human Services, and Infrastructure Functional, respectively), who also periodically updated the status boards on the overhead monitors. The television sets were muted but linked us to the outside world through different broadcast channels. "Task complexity," "knowledge sharing," and "emergency task performance" were no longer empty words or academic terms. They had sprung to life in this activation room, and as we became aware of the gradual deterioration of the weather conditions outside, we realized there was serious work to be done. The faint buzz of telephone discussions, the chatter of computer keyboards, and the furtive glances at the television screens conveyed an ambiance of anxiety and apprehension, yet we could sense the urgency and intensity of purposive knowledge sharing through written documents and systems at each station and the ad hoc gatherings of people exchanging ideas and making decisions. The EOC central command room setup manifested the ICS-guided modular organizational structure and afforded the physical networks for effective knowledge sharing.

4. The EOC's information and communication technology tools provide a necessary facilitation environment for knowledge sharing.

The EOC depends on the following state-of-the-art tools to manage emergencies:

- **Written and system documents** for standard operations procedures (SOPs), local response protocols, situation reports, and incident action plans (IAPs) based on past emergency management experiences.
- **Hurrevac**, a software tool developed jointly by the National Hurricane Center, US Army Corps of Engineers, and Federal Emergency Management Agency (FEMA) to track tropical cyclones and provide a continuous flow of information to emergency managers.
- **SLOSH II**, a computer model developed jointly by the National Hurricane Center Storm Surge Group, US Army Corps of Engineers, US Geological Survey (USGS), and FEMA with input from the state of Florida and several local emergency managers, including those from Miami-Dade County. It calculates probable storm surge based on size, direction, and forward speed of a storm.
- **SALT (Storm Action Lead Time)**, a software application developed by the Miami-Dade County OEM and Enterprise Technology Service Department (ETSD) to provide a checklist of pre- and post-storm activities.
- **Snapshot**, a software tool developed by Miami-Dade OEM to provide virtually instant information on damages caused by a storm or flood event.
- **E-Team**, collaborative software for crisis management developed by software vendor NC4.

5. EOC personnel training must go beyond procedural training based on written documents and systems.

The events that trigger emergency management operations are rare and diverse, and there is no single comprehensive plan that can be devised ahead of time to cope with the next incident. Many of the personnel at the EOC for a particular incident may be first-time participants, because emergency events do not have a regular

pattern or schedule. They will doubtless have extensive knowledge and expertise in their particular area of specialty (water management, electric utility, phone services, etc.), but they may not have much experience in dealing with the higher levels of complexity presented by a real emergency event. In addition, this might be the first time they are meeting and working with the other EOC members. This is a challenge because the situation will demand a high degree of interaction, under severe time constraints, between representatives of the different organizations.

While training based on traditional written documents and system procedures will help the "new" participants obtain explicit knowledge about what worked in the past, it does not provide the on-the-spot knowledge-sharing skills that are critical for addressing component and interactive task complexity, task non-routineness, task difficulty, and task significance. The Miami-Dade EOC has adopted regular full-scale emergency simulation drills to train and update emergency management personnel. These have proven to be a pivotal organizational mechanism not only for giving the participants a live experience of dealing with an emergency event, but, more importantly, for enhancing their knowledge-sharing skills.

CONCLUSION

In this article, we have discussed frameworks for describing the complexity of emergency management tasks and knowledge-sharing strategies that enhance performance. The complexity dimensions — component complexity, interactive complexity, task non-routineness, task difficulty, and task significance — represent a progressive hierarchy in terms of the order of magnitude and the priority of actions needed. As we've discussed, the nature and level of the different complexity dimensions of an emergency management task dictate the most effective purpose and mechanisms for knowledge sharing.

In addition to dealing with each complexity dimension, emergency managers must grapple with the conflicting demands of the different complexity dimensions. High levels of interactive complexity and non-routineness require emergency personnel to take time to coordinate and search for new solutions, yet high levels of task significance (urgency and impact) demand immediate actions. As a result, many emergency management actions are "rushed irrational" — improvising in nature — rather than "well planned rational" — following the book. There are no one-size-fits-all solutions or procedures that emergency management organizations can develop *a priori*. Therefore, such organizations must be set up with an appropriate organizational structure, which includes physical configurations and information and communications technologies that facilitate appropriate knowledge sharing in accordance with the complexity circumstances of the specific emergency situations.

ENDNOTE

[1]*National Incident Management System*. US Department of Homeland Security, March 2004 (www.dhs.gov/xlibrary/assets/NIMS-90-web.pdf).

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