Organizational Coordination in Extreme Events: A Case Study of October '06 Snowstorm in Western New York

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Introduction

Increased attention has recently been directed towards extreme events and their response management. Emergency events such as natural disasters and manmade accidents are characterized by their rare occurrence and the high risk of negative consequences if decisions in response to the emergency are slow, uninformed, or inadequate (Ajenstat et al. 2007). As emergency management typically involves complex network of tasks, resources, and actors, coordination emerges as a critical management aspect which should be used to address the embedded interdependencies for smooth and efficient response operations (Turoff 2002).

Coordination is a specific form of decision making wherein the problems associated with the different possible responses are interdependent (Malone 1994; Malone et al. 1990). Challenges ranging from limited information, unpredictable development, short time windows, and high risks all threaten the response organizations in their ability to make rapid and sound coordination decisions. The governmental reports of coordination in recent rare events, such as 9/11 attack and Hurricane Katrina, reveal enormous failures, calling for further research to improve coordination practices (Townsend 2006).

This paper investigates research questions which include (1) *how is coordination managed in extreme events, (2) what procedures and mechanisms are typically utilized for coordination decision making, and (3) what are the current practices of information systems for coordination support?* Utilizing a case study of response coordination in one large scale natural disaster, this paper provides a rich account of organizational coordination in extreme events with in-depth details on coordination problems, management structures, coordination processes, and the role of technology in supporting decision-making processes.

The paper is organized as follows. The proceeding section reviews the existing literature of coordination. Then, we introduce the case research methodology employed for data collection. This introduction to our methodology is followed by a detailed description of coordination management in the case under study. Next, we discuss the lessons learned in coordination decision making. The last section summarizes the contribution of this study.

Background

This section summarizes the coordination literature and prior, related research on information systems. Coordination is “managing the interdependence” (Malone 1994). By focusing on the flow of wzzork, materials, and objects, Thompson defines interdependence in terms of work flow with the forms of being pooled, sequential, and reciprocal (Thompson 1967). Van de Ven et al (Van de Ven et al. 1976) and Rao et al (Rao et al. 1992) further suggest *team* or *concurrent* interdependence, which refers to situations wherein the work is undertaken jointly by unit personnel who diagnose, solve problems, and collaborate in order to complete the work. Emergency responses typically represent the above interdependences as they involve complex response tasks, resources, responder personnel, and information flows. These entities are likely to be physically dispersed across geographical boundaries and/or jurisdictional municipalities. Unlike a normal event, the interdependence in an emergency context undergoes rapid changes when new entities join the response organization or when existing entities are dismissed, modified, or restructured throughout the course of the response to cope with the incident development.

Prior studies have identified a rich volume of mechanisms addressing the interdependencies. The mechanisms may include standardization, planning, mutual adjustment, and routine (Galbraith 1973; Malone 1994; Thompson 1967). These mechanisms, static or dynamic, prescribe how the decisions will be made to solve the problems associated with interdependencies. From the perspective of information processing, these mechanisms vary in their information bandwidth and richness (Galbraith 1973). Considerations of social structure, conflict, information quality and quantity, cost, technology, and task all have a role in determining when individual mechanisms may be preferred (Galbraith 1973; Shapiro 1977; Van de Ven et al. 1976; Victor et al. 1987).

Despite increasing interest in the organizational coordination of extreme events, little is known about how to effectively make coordination decisions in trying conditions. It remains unclear whether, and to what extent, the conventional wisdom is still valid in abnormal circumstances (Petrescu-Prahova et al. 2005). Although recent studies have explored the coordination decision making in contexts such as software development, new product design, supply chain management, where there exists moderate levels of velocity of change, uncertainty, and pressure, further research is necessary (Montoya-Weiss et al. 2001; Piplani et al. 2005; Raghu et al. 1998; Simatupang et al. 2004). Moreover, there is a lack of awareness about the current practice of information technology in emergency management coordination. Aside from a few attempts (Chen et al. 2005; Mendonca et al. 2007; Shen et al. 2004), emergency coordination support has not been the focus of IS research (Currion et al. 2007; Fiedrich et al. 2007; Manoj et al. 2007; Simon et al. 2007).

Research Approach

Case research is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident (Yin 1994). As a solid research methodology, case research is widely adopted by IS researcher (Dube et al. 2003). The abundance of case research has developed a systemic methodological framework. We follow the work of Benbasat et al (Benbasat 1987), Eisenhardt (Eisenhardt 1989), Lee (Lee 1989), Yin (Yin 1994), and Dube and Pare (Dube et al. 2003), all of whom have strong influences on the conduct of case study research in IS field. The current research takes a single-case study approach. Despite the typical criticism, the single case study is by far the most frequently utilized format of case research (Dube et al. 2003) and it is deemed rigorous when the relevant methodological concerns are addressed properly (Bonoma 1985; Ragin 1999; Yin 1994). In this regard, we follow the guidelines proposed by Lee (Lee 1989) who demonstrates how to make controlled observations and deductions as well as how to allow for replicability and generalizability when using a single case. That is, natural controls or verbal propositions, among others, are practiced whenever possible.

The current research is an intensive study of coordination decision making in response to the *October Snowstorm* in western New York, 2006. The case study involves an entire configuration of individuals, organizational structure, and advanced information technology inside the Incident Command System (ICS) set up at Erie County, New York. From a site selection standpoint, the October ’06 Snowstorm proves to be an ideal case to study as it meets the general site selection criteria for a single-case design proposed by Dube and Pare

(Dube et al. 2003). The tremendous media coverage of this particular incident, the unique attributes of the disaster and its complex impacts, and the fact that key actors can be located for interviews all point to the necessity to study this particular case site. As suggested by Yin (Yin 1994), the authors conducted a pilot case study four months prior to the launch of the main case study. Through interviews and onsite observations, the pilot case helps the authors determine the appropriate unit of analysis, refine data collection instruments, and familiarize researchers with the phenomenon.

To begin our data gathering, we first consulted published reports on the October ’06 Snowstorm. We found more than 100 articles published in national and local media, either online or paper based printouts. We also contacted the ICS managers who assumed key decision roles for incident coordination during the response to the incident. These contacts are executives (e.g., chiefs and commissioners) of emergency services from multiple municipalities as well as across county, city town, and village levels of government. Over a two month period, we conducted multiple rounds of filed research in the format of on-site observations, semi-structured interviews, and further document reviews. The data collected includes 500+ pages of internal reports, action plans, fact sheets, email correspondence, and 100+ pages of interview transcripts.

The October ’06 Snowstorm and Incident Coordination

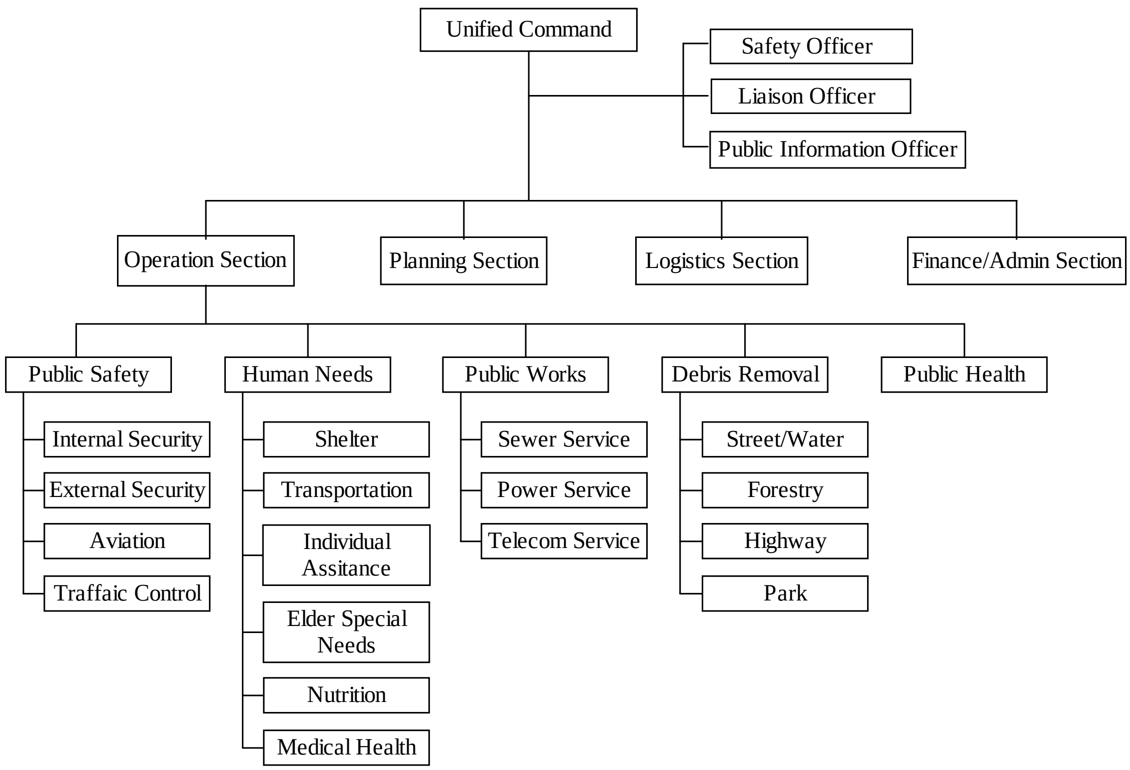
This section presents background information about the organizational coordination of the response to the October ’06 Snowstorm. It highlights the major coordination problems, organization structures, and coordination process in decision making.

On October 12, 2006, a lake-effect snowstorm hit the western New York area with record breaking snowfalls. The snowstorm downed scores of tree limbs and toppled power lines, leaving about 1,000,000 people without electricity in western New York for up to 10 days. The combination of melting snow and rain showers overnight also resulted in flooding hazards. Flood watches were issued and a response was launched in multiple counties. On October 13, Governor George Pataki declared a state of emergency for Erie, Genesee, Niagara, and Orleans counties. On October 20, President George W. Bush signed a Major Declaration for Individual Assistance (IA) and Public Assistance (PA) for the above four counties along with Health and Medical (HM) for all counties in New York State. A 105-mile stretch of the New York State Thruway from Rochester to Dunkirk was closed on the morning of October 15 because of the snow. Local municipalities also issued numerous traffic bans. This incident was a devastating event.

Table 1. Summary of risks in October '06 Snowstorm

Large scale impact	Over 73 local municipalities in western New York with a population of over 1 million people were affected
Huge damage	Estimated loss of more than $500 million as estimated to date. A total of 17 storm related deaths, 151 hospitalizations, and 177 injuries were reported
Multiple hazards	Snowstorm, power outage, water outage, water pollution, broken traffic, and floods
Critical infrastructure interdependence	Hospital, food, shelter, power, communication, and transportation

Erie County was the most impacted area in the October Snowstorm. This case study is focused on incident coordination inside Erie County. Erie County specifically plays a regional role of managing and supporting county-wide emergency responses through interactions with local, State of New York, and federal government agencies (Whetham 2006). In the event of the October '06 Snowstorm, Erie County set up an Incident Command System (ICS) to oversee and direct the county wide (1 city, 17 towns, and 6 villages) incident management. The command staff was located at Erie County Emergency Operations Center with an emergency response team, at full operation, which totaled in excess of 200 individuals (Whetham 2006). The response organizational structure is captured in Figure 1. For the sake of simplicity, we only delineate a small portion of the complete organizational structure, yet this chart still sufficiently reveals the complexity involved.



Note: The Planning Section, Logistics Section, and Finance/Admin Section have their own sub-structures fully established.

Figure 1. A Partial Illustration of ICS Organizational Structure

Coordination decision making at Erie County was highly challenged by the complexity involved.

- Agencies under coordination: all the local response organizations at the levels of county, city, town, and village, State Emergency Management Office, State Health Department, State Highway Authority, Federal Emergency Management Agency, Coast Guard, Activity Military Duty, Army Corps of Engineers, National Guard, National Grid, New York Electricity & Gas, and Red Cross, National Weather Service, Southern Baptist Disaster Relief, and AmeriCorps

- Tasks under coordination: public safety and security, transportation, food and shelter, information and telecommunications, public works and engineering, public assistance, individual assistance, environment protection, resource support, public health and medical services, hazardous materials disposal, energy restoration, public information dissemination, and education.
- Resource under coordination: strike teams, food, water, medical supplies, shelters, snowplow, water tankers, debris removal tools, and generators
- Information under coordination: situation report, resource request, incident action plan, weather forecast, public announcement and advisory

The command staff deems the ICS as the foundation to emergency coordination as it provides the overarching structures (Whetham 2006). Evolving from the 1970s, ICS is now a national standard for emergency management (DOS 2004). As we observed from the case of the 2006 snowstorm, ICS facilitates the response coordination through five major schemes: (1) it constructs a clear organizational hierarchy that directs both information and decision structures; (2) it breaks down organizational goals into micro structures where specialized personnel may excel in operations and decision making; (3) it prescribes general roles, responsibilities, and accountabilities for decision makers at each organizational layer and position; (4) it standardizes the skills, functions, and input/outputs of internal structures to allow for smooth and interconnected operation; and (5) it establishes the protocols of reporting, meeting, and cross-boundary adjustments for fast coordination.

More detailed response operations are coordinated through the use of Incident Action Plans (IAP) which outline the measurable strategic operations to be achieved. During each one of the operation periods (06:00-18:00 and 18:00-06:00), the Planning Section of ICS developed an IAP that was to be implemented for the next operation period. Key components of the IAPs designed for this incident included control objectives for the incident (sometime alternatives as well), the weather forecast for the period, safety messages, organization assignment lists, division assignment lists, communications plans, medical plans, incident maps, and traffic plans. Through IAPs, response operations were coordinated in the following ways: (1) the same overall assumptions, goals, and objectives were set straight for all the participating agencies, (2) a situational awareness of the incident progress and predictions, (3) a mutual awareness of the contact, status, and operations of other agencies in supportive roles, and (4) detailed task assignments, workflow schedules, resource allocation schemes, and dedicated communication channels in place.

To manage the heavy interdependency such as those of critical infrastructures, ICS established complex decision making processes that strongly emphasized a high level of collaboration. Between ICS and external key stakeholders, the command staff made conference calls to all the town, mayors, and supervisors twice a day to communicate with each other about the situation and their progress. Through consensus building processes, the meeting established the overall direction for the response and prioritized the critical operations. Inside ICS, all the sections joined together for decision making on critical issues. Take IAP development for example. The Chief of Planning Section met with representatives from Operation, Logistics, and Finance/Admin sections at least once per each operation period to discuss IAP development. During the meetings, representatives discussed the plans, shared opinions, and made note of individual concerns or needs so that the plans could consequently be improved with advocacy. Once updated, the IAP was submitted to the Unified Command who discussed and argued its pros and cons before finalizing it for implementation. Decision making rules in these meetings included reliance on protocols, epistemic contestation, joint sense making, cross-boundary intervention, and voting.

Technology Support from DisasterLAN

The organizational coordination at EOC was leveraged by advanced information systems such as DisasterLAN (www.disasterlan.com). DisasterLAN is a workflow-based, commercial, off-the-shelf software purchased by the State of New York and made available to all the municipalities including Erie County. It replaced the conventional "paper-pencil" based management approach with digitalized information flow and (semi) automated decision support and thus it assisted the EOC with coordinating the management of the entire incident. Key functions of DisasterLAN include call center service, incident status board, integrated message broadcasting system, asset management tool, contact management tool, and numerous reporting and task management tools (Geographics 2007). These modules offered a wide range of support for coordinating the emergency management efforts. We summarize the actual performance of DisasterLAN in Table 2.

Table 2. DisasterLAN Support to Coordinating Emergency Management at EOC

Module	Level of Support	Performance Highlights	Emerging Issues
Call Center *Logs requests, offers, and reports; prioritizes, assigns and tracks calls, searches and generates reports*	High	Provided a centralized information repository to enable global situational awareness; transformed data for reduced semantic and structural inconsistency; routed information only to relevant agencies so as to reduce information overload	Unexpected changes and ambiguity of information routing policy introduced unnecessary delays in system operation
Status Board *Presents up to date incident information, messages, weather, photo, and video*	High	Provided a common operational picture of the current emergency management for all agencies involved; presented comprehensive information for decision makers; aided evaluation process of disaster	Lack of integration support of data such as power grid and GIS

		management effectiveness so far	
Streaming Video *Captures IP-based video from the scene of the incident and provides critical infrastructure*	Low	Provided visualization (rich medium) of incident development and response operation status for monitoring and analysis	Lack of sources for video data; limited bandwidth of video stream transmission
Reference Library *Stores reference documents, response plans, and images of supportive web sites*	High	Provided domain specific knowledge to improve decision making quality in a timely manner; established the foundations for decision improvisation	Lack of pre-loaded data, missing certain reference materials
Security Management *Manages user/group account and privilege*	High	Achieved data access control by implementing "need-to-know" policy for information security	Lack of intuitive ways to manage user/group accounts
Contact Management *Manages organizational and personnel contact*	Medium	Provided centralized repository for permanent and temporary response personnel/group; aided establishment of communication among personnel	Lack of preloaded data; lack of enforced policies for periodical contact updates
Preplanning *Manages organizations and personnel needs*	Medium	Provided predesigned plans for emergency mitigation and recovery	Lack of preloaded data; lack of plans for long term operation
Weather Center *Presents weather bulletins and radar imagery*	Medium	Aided the analysis and planning of weather dependent operations such as power restoration and environment	Lack of data richness of weather information
Chat and Broadcast *Enables instant messaging for one-to-one or broadcast*	Medium	Facilitated internal information sharing and exchange; improved interpersonal/group communication for decision making	Abandoned by some managers who prefer face-to-face communication or phone
Incident Action Plan *Develops, distributes, and archives incident specific operation plans*	High	Ensured clear management objectives by using ICS informed planning schemes; aided decision making through information infusion and integration techniques	Implemented during the response process and was not available to the mangers at the beginning
Situation Report *Develops, distributes, and archives incident specific situation reports*	High	Assisted the internal information sharing among related stakeholders; reduced the development effort and expedited the information sharing	Interface not easy to use

Table 2 suggests that DisasterLAN provided an overall satisfactory performance in supporting coordinated emergency management during Snowstorm ’06. It established a collaborative platform for distributed individuals/groups/organizations to share information, make decisions, and consequently synergize response capabilities. While there were many successful aspects of DisasterLAN, there are still a number of issues valuable for research analysis and practice design. Table 2 suggests directions for future improvements in organizational process/policy design, infrastructure support, system maintenance, ease of use, and user adoption. It is, however, important to note that some issues (e.g., organizational ones) are inherent in the nature of emergency situations and are unlikely to be fully addressed by any system design. Others, such as infrastructure issues, require the investment in a supportive computing environment by the local government.

Lessons Learned from October ’06 Snowstorm

The incident coordination of the October’06 Snowstorm is concluded as being successful (Whetham 2006). Through further review of the incident management, we summarize the lessons learned in decision processes and decision making for organizational coordination. These lessons provide valuable opportunities to reflect on the current practices and to improve management strategies design and information system development. As indicated in Table 3, we summarize the key lessons learned along dimensions of people, process, and technology. Due to the page limit, we present a brief discussion on example lessons.

Table 3. Summary of Lessons Learned of Decision Making in Coordination

Lesson	Example	Primary Cause	Preventative Solution
People Dimension			
Key decision makers lacked task critical knowledge and expertise	Command staff refused to implement demobilization process in the overall plan	Appointment was made by county executives who were not familiar with emergency operations	Expertise-based personnel selection scheme; pre-incident plans for personnel nominees; database of candidate expertise

Difficulty for decision makers to shift across contexts	Finance/Administration personnel experienced prolonged learning period for working in disaster scenario	Agencies were well trained in normal contexts but not in disaster scenarios	Quick instructions and training to reduce learning; drills of potential participants and stakeholders
Decision makers with incompatible personalities	Few agencies were in conflict over their attitudes toward ICS and certain operations	Agencies were gathered from multiple municipalities	Scheduled orientation process for mutual understanding and opinion exchange; leadership
Process Dimension			
Slow decision making process and ambiguity in decision making roles	In the initial stage, ICS operated with insufficient staff for two days	Inaccurate damage assessment; insufficient planning of decision making	Quick disaster damage and risk assessment; all hazard plans for ICS activation and operation
Diligence of situational awareness for decision making	Multiple municipalities built up 26 shelters without being coordinated in time; they soon ran out of resources	Lack of reporting from the subordinates; lack of situational awareness and supervision of the entire incident response	Enforcement of reporting policies and standard of reporting process; real-time monitoring
Insufficient communication of decision making process and purpose	The general public once misunderstood the power restoration operation as unfair and politically-biased	Ineffectiveness of channels for public information dissemination; lack of feedback mechanisms	Strengthen the process of public information distribution; enhancement of the trust toward government
Technology Dimension			
Decision makers were unable to use advanced decision support systems	Many agencies did not know DisasterLAN or did not know how to use it for help	Unawareness of available technologies; underestimation of the role of information technology; low level of technology self-efficacy	Sufficient education and training; enhancement in easily used decision support systems
Insufficient technology investment	Available computers in EOC met only 75% of the demand	Low priority of technology investment; insufficient financial resources	Increase in the amount and priority of technology investment
Degraded and unfaithful appropriation of technologies	Many used DisasterLAN for purposes other than decision making; the full capability of DisasterLAN as a decision support was not achieved	Lack of appreciation of the computer systems; unfamiliarity with the technology functionalities	Sufficient training on information system; standardize the information usage and put into plans
Unnecessary technology redundancy	Fax was used for information exchange while DisasterLAN was available; fax resulted in many missing/delayed requests	Lack of financial resources for some agencies; unawareness of alternative technologies	Improvement in the level of technologization
Insufficient technological "*readiness*" of decision support	Important decision support modules in DisasterLAN were not installed before the incident	Lack of planning; lack of prediction on what decision support will be needed	Timely maintenance and updates on software; use best of breed technology with full modules

Excessively tight control of technology and restraints on technology contribution	DisasterLAN was managed by EOC; individual municipalities could not alter its usage to support decision making for their own disaster activities	Inaccurate estimate of the incident magnitude; lack of mechanisms to manage user privileges; “local-mindset”	Relaxation of system management policy with the appropriate control and oversight

When *people issues* are concerned, one important lesson revealed in the October ’06 Snowstorm is that key decision makers lacked the task critical knowledge and expertise. An example is the demobilization coordination by the Unified Command (UC) who assumed the ultimate decision making role in ICS. Demobilization is the process of releasing and sending back external response agencies and resources when they are no longer required. It is a standard response procedure for large scale incident response and has a direct impact on other core response processes such as operations and logistics. In the case of the snowstorm, several members of the Unified Command did not understand the concept of demobilization and they looked upon it as a defeating term. The Chief of ICS Planning Section recalled, “*The command staff absolutely refused to implement the demobilization plan. They did not understand what it means. It had been explained several times and until that time some of them were still saying ‘how can we sending people back when some citizens are still without power?’*” Decision making for coordination tasks therefore greatly suffered and a comprehensive response plan could not be established until this issue was addressed.

The interview suggests that this problem was rooted in the appointment process of key decision makers. The county legislation states that county executives are authorized to appoint incident commanders. As elected officials, the executives were not equipped with sufficient knowledge of emergency responses. They made the final decisions using their criteria and preference, which resulted in the fact that inexperienced personnel occupied the command position. To eliminate this problem, a number of solutions are suggested by emergency managers. For example, it is important to have pre-incident plans for nominees for command personnel in typical disaster scenarios. Second, the nomination criteria should be expertise-based but not rank-based or title-based. Third, it is important to maintain a knowledgebase of local response experts from whom the command staff can be selected when the preferred nominees become unavailable.

When *process issues* are concerned, a valuable lesson learned was related to the slow decision making and ambiguity in decision roles at the early stage of the operation. Soon after the snowstorm hit Erie County on Thursday night, the ICS was activated; however, it was severely understaffed while most positions remained unfilled. In the event of a large scale incident such as this, a curtailed ICS is simply unable to meet the huge demand for collaborative and complex decision making. An effective incident management at the initial stage of a disaster is critical to control the situation and minimize the losses. While many important decision making positions (e.g. Chief of Finance/Admin) were empty, the ICS was functioning at low capability and missed great opportunities in mitigation. It was not until Monday that the county requested additional assistance and a hundred personnel started to arrive. The Chief of Planning Section commented that "*Everybody knows that on Thursday night the things are bad, but somebody needs to push the button and say, 'Look, Friday morning we need all these people to come.' The next time it happens, we hope they will push the button much quicker and the people come here much quicker.*"

The interview suggests that this problem is a result of both ambiguity in decision roles and incomplete information of incident damage assessment. The ambiguous roles of decision makers is reflected by the fact that there exists no clear decision making scheme for the local authorities to assess the response operation. That is, the establishment of decision making roles for a quick response in extreme events was missing from the response plans and from the governmental structure. On the other hand, critical input to decision making such as damage assessment was not fully available. It is a required procedure that all affected cities, towns, and villages submit a preliminary damage assessment (including dollar loss estimate) in the first 24 hours after disaster strikes. This assessment information helps the county determine the incident magnitude and develop a response strategy; however, they did not come in as quick as needed. A number of solutions are proposed by the emergency managers in this regards. The solutions include quick disaster damage assessment through policy and information technology enablers such as *sensor networks*. Second, it is important to establish all hazard plans for ICS activation processes and assign clear decision making roles to related authorities.

In terms of the *technology* used, the snowstorm revealed that decision makers were unable to use the advanced decision support systems. At Erie county, DisasterLAN is the backbone system designated for ICS operation and decision making. During the disaster response, it was found that many of the agencies who joined ICS were not familiar with this decision support system. It took most of these personnel the first day to learn the system with the help from DisasterLAN technological support staff who came onsite. As the Chief of ICS Operation Section put it, "*So, technology is only as good as training of people who are using it*."

The interview found that the reasons for this lesson are threefold. First, some responders greatly underestimate the role of information technology. Although DisasterLAN is provided free access and training to the local responders, not many people took advantage of it. Second, the lack of appreciation for the necessity of computer technology is also a result of low technology self efficacy as most of the responders were not technology savvy. Third, DisasterLAN is not mandated software for the local municipalities to adopt. In a “home rule” state, this certainly results in situations where there is not a uniform awareness of the available technology across the local community. Potential solutions include an increased awareness of technology, sufficient education and training through dry runs and scheduled meetings, and enhancement in the easy of use of decision systems.

Conclusion

Coordination in extreme events such as natural disasters plays a critical role in achieving organizational goals and operational efficiency. The current body of knowledge in coordination, however, is mostly limited to normal contexts. While the conventional wisdom provides limited predictions, it remains largely unknown the extent to which these beliefs are in fact accurate. Through the case study of coordination in one large scale incident, this paper presents some intriguing findings. It shows that the decision making for extreme event coordination is mainly facilitated through (1) organizational structures, (2) collaborative decision making processes, and (3) the contribution of advanced decision support systems. The discussion of lesson learned provides opportunities to extend the coordination literature and develop grounded theories of decision making.

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