

Emergency Response Coordination and IT support: Contingency and Strategies

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ABSTRACT

This article explores the emergency response coordination phenomena and discusses the response contingency that impacts coordination performance. The authors synthesize the prior literature and examine the critical issues of coordination task analysis, coordinator relationship management, response pre-planning, psychological coping, and information system designs. The multi-dimension lens highlights the interactions and dynamics between tasks, actors, and technologies and suggests the importance of contingency in determining the emergency coordination performance. The paper contributes to the theory development and information system design in the research of emergency response.

INTRODUCTION

Emergency response is the process of gathering resources and acting upon the problems immediately during and after a critical incident (Shen and Shaw 2004).

Emergency incidents may be either natural or man-made cases such as traffic accidents, fire and explosion, floods, tornado, earthquakes, nuclear or biological attacks, chemical leakage, and cyber attacks. As emergency incidents pose immediate threats to human lives and prosperities, an effective and efficient management of

incident response is critical to alleviate the losses and bring the community back to normal. Emergency management is an organized social response and it involves complex network of tasks, resource, and actors (Turoff 2002). The performance of emergency response coordination therefore plays an important role to address the embedded interdependencies in the response entities and to enable effective response consequently. Coordination in emergency response, however, is under a variety of challenges. The limited information, unpredictable development, short time windows, high risks and impact all make coordination difficult to manage. Due to such factors, the emergency response coordination is far away from successful and the observations of coordination failures are well documented in the response to 9/11 and Hurricane Katrina (Townsend 2006).

In this paper, we examine the during-incident coordination management and propose the coordination strategies. The paper draws on the prior literature on organizational science, strategic management, and psychology to construct a nomological network that explains the emergency coordination. In particular, we investigate four critical issues including coordination task analysis, coordinator relationship management, response pre-planning, and psychological coping that are most relevant to the coordination in emergency context. We further study the role of information system in facilitating coordination during and after critical incidents and we suggest the appropriate system designs.

The paper has four sections. The next section describes the conceptual background and reviews the relevant literature. We then describe the proposed

research model which predicts the emergency coordination performance. We conclude the paper with a discussion of the contribution, limitations, and directions for future research.

CONCEPTUAL BACKGROUND

Emergency response coordination is a complex phenomena and it introduces a number of research issues related with the design of effective coordination strategies (Turoff 2002; Turoff, M et al. 2004; Van de Walle and Turoff 2007). In this section, we explore and discuss interdependencies, coordination mechanisms, coordinator relationships, and psychological coping. We argue that their interactions and contingency may predict the coordination performance. The discussion of research issues facilitates the construction of nomological network (Cronbach and Meehl 1955) for emergency coordination phenomena and it lays the theoretical foundation for the research model to be presented in the next section.

Prior literature suggests that coordination implies arranging a set of objects (such as tasks, responsibility, capability, and information) for the fulfillment of one overall goal (Thompson 1967; Malone and Crowston 1994; Simatupang, Wright et al. 2002). As the objects are interconnected with degrees of dependency, coordination translates to the management of the interdependencies as the core issue (Malone 1994). By focusing on the flow of work, materials, and objects, Thompson (Thompson 1967) defined interdependence in terms of work flow with the forms of being (1) pooled or independent, (2) sequential, and (3) reciprocal. Van de Ven et al. (Van de Ven, Delbecq et al. 1976) suggested one more work flow format as “team work flow”

which refers to situations where the work is undertaken jointly by unit personnel who diagnose, solve problems and collaborate in order to complete the work. In team work flow, there is no measurable temporal lapse in the flow of work between unit members, as there is in the sequential and reciprocal cases; the work is acted upon jointly and simultaneously by multiple personnel at the same point in time. Similar concept is suggested by Rao et al. (Rao, Rajagopalan et al. 1992) as “concurrent interdependence.” Examples of team/concurrent interdependence in organizational units include group therapy sessions in mental health units, a sports team playing a game and the concurrent engineering processes. Typical emergency response involves complex response task flow, resource, responder personnel, and information flow. These entities may be physically dispersed in different geographical locations across jurisdictional municipalities. In addition, the involvement of response entities may also have temporal spread. Emergency coordination designs and schedules tasks, utilizes the resources and responders, directs information flow for situation awareness and decision making, and assigns jobs, responsibilities, and accountability among the participating agencies for smooth and efficient operations (Lee and Bui 2000; Bui and Sankaran 2001). Shen and Shaw (2004) summarize emergency response interdependencies as sharing (e.g., resource sharing), flow (e.g., role delegation, perquisite, and sequential scheduling), and fit (e.g., capability fitness, tradeoff of response efforts, and goal capability). These interdependencies capture the dynamics between activity and actors.

There is a vast extant of literature that addresses the issue of coordination

interdependencies. The mechanisms include standardization, planning, mutual adjustment, scheduling, synchronization, notification, sequencing, tracking, routine, etc. (Thompson 1967; Malone 1994). Prior research posits that the proposed social structure, conflicts, information, cost, technology, and task as important determinants to the exercise of different coordination modes (Galbraith 1973; Van de Ven, Delbecq et al. 1976; Shapiro 1977; Victor and Blackburn 1987). Coordination mechanisms may change depending on the type of interdependency (Bailetti, Callahan et al. 1994; Adler 1995). The emergency management literature main focus on two overarching coordination mechanisms: (a) structures and (b) processes (Shen and Shaw 2004; Chen, Sharman et al. 2005; Petrescu-Prahova and Butts 2005). Structural coordination refers to the emergency response organizational structure such as Incident Command Systems (ICS) and Emergency Operation Center (EOC). ICS prescribes the typical on-site emergency response management and coordination practices while the EOC portrays the counterpart at a higher position of the chain of command such as the city or state levels (DOS 2004; Prizzia 2006). Formal organizational structure prescribes the structures of decision roles, responsibilities, accountabilities, communication and reporting mechanisms, response policies, contacts and boundary spanners (DOS 2004). On the other hand, the procedural coordination mechanisms refers to the approaches and activities which outlines the coordination processes. For example, the emergency response Standard Operation Procedures (SOP) details the coordination steps, conditions, and strategies such as priorities, routines, work flow, resource deployment, meetings, etc. The establishment of structural and procedural

coordination mechanisms facilitate the coordination design in terms of quality and responsiveness.

Findings from existing emergency response studies highlight the importance of human aspect in emergency coordination design. As an organized activity, emergency response typically involves multiple responders, agencies, and authorities to collaborate and coordinate their response actions. This mix has the potential to introduce conflicts during coordination. These conflicts include varying objectives and incompatible cultural values stemming from differences at both the individual and organizational level. The management of coordination therefore has to carefully address the potential issues with the relationships involved. Van de Ven and Walker (Van de Ven and Walker 1984) suggested that the coordination relationship typically experiences creation, growth, and decline. Bailetti et al. (Bailetti, Callahan et al. 1998) posited that coordination structures (configuration of actors and shared work objects) help manage the coordination relationships. Gittell (Gittell 2000) pointed out that responsibility management is important to relational coordination. Another human aspect of coordination relates to the psychological coping in emergency response coordination. The psychological coping with stress, anxiety, frustration is likely to emerge as critical incidents pose pressures which result in a highly stressful environment to the response coordinators. The psychological stress may negatively impact on coordination decision making and coordinator social interactions. The issue of psychological coping during disasters has been studied several researchers and there is now some literature (Flin, Strub et al. 1997; Paton and Flin 1999). Despite the

existing literature this area remains largely understudied and much needs to be done especially as it relates to Post-Traumatic Stress Disorder (PTSD) in the aftermath of emergencies and disasters.

THEORETICAL DEVELOPMENT

In this section, we examine the set of factors that may impact performance of a coordination activity in the context of critical incidents. We specifically examine the role of coordination relationship, pre-planning, psychological stress, task complexity, and information technologies and present a theoretical model which describes the dynamic interactions. A number of research propositions are also described in this section. The pre-planning, relationship, and psychological coping may be categorized as internal factors while the task complexity and IT support may be regarded as external factors.

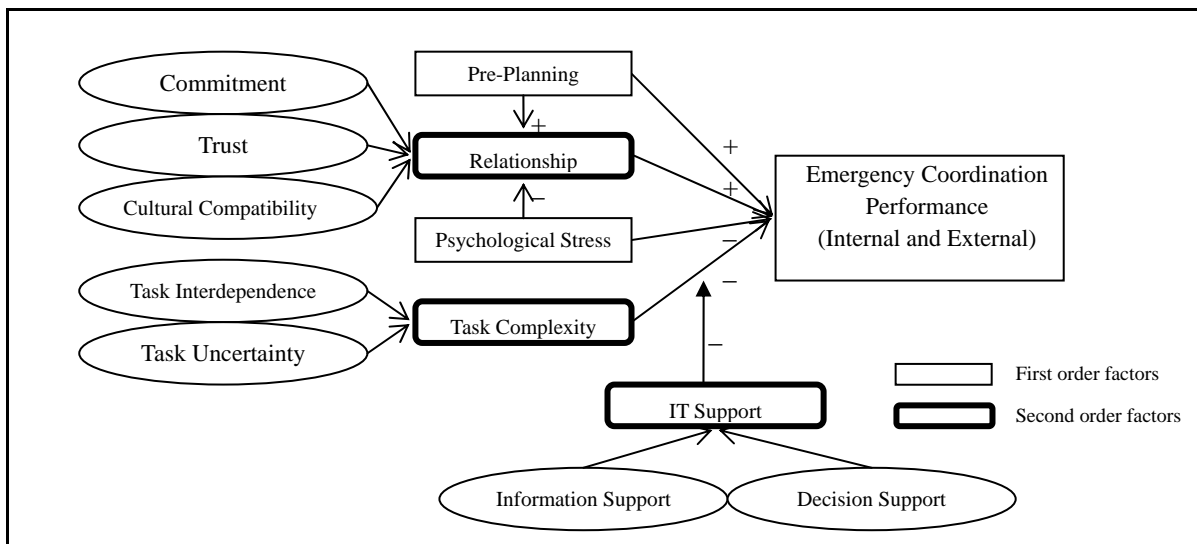


Figure 1 Conceptual Model for Emergency Coordination

Coordination Relationship

Coordination relationship is considered as one important factor to ensure cohesive and efficient emergency coordination process (Comfort, Ko et al. 2004). O'Toole et al. (O'Toole, O'Toole et al. 1972) pointed out that the success of coordination with a network of individuals is heavily dependent on relationship within the network that facilitate coordination action. In the study of coordination among government agencies, Post (Post 1935) acknowledged the importance of the relationship between the coordinators "otherwise, division of authority and irresponsibility will result." When coordination is initiated among individual agencies such as Fire, Police, and Emergency Medical Service, the relationship may not be tightly coupled by structural authority as usually exists in vertically integrated hierarchies (Van de Ven 1984). Coordination research has identified a number of threats to coordination relationship. Moss-Kanter (Moss-Kanter 1994) pointed out that "rational arguments coupled with technical feasibility are not sufficient to consummate the collaborative alliance." He suggested that the socio-political issues such as personal chemistry, compatibility between the parties, culture, philosophical, and strategic grounds determine if the alliance will come into existence and mature (Moss-Kanter 1994). Kumar and van Diesel (Kumar and van Diesel 1996) point out that a managerial culture with an adversarial view of extra organizational actors can also result in opportunistic behavior by one or more participants in the coordination (Kumar and van Diesel 1996). When the relationship is not perceived as equitable by the participants, the coordination will eventually fail. Prior research suggest that coordination relationship is multi-facet construct including dimensions such as commitment, trust, and culture

compatibility are tightly related to the emergency coordination phenomenon (Goles and Chin 2005).

Exchange theory suggests commitment as important in the coordination relationship to achieve the norms of equity (Dwyer, Schurr et al. 1987; Fontenot and Wilson 1997). Dwyer et al. (Dwyer, Schurr et al. 1987) described commitment in relationship as a “pledge of relationship continuity between exchange partners”. Fontenot and Wilson (Fontenot and Wilson 1997) formally defined commitment as the willingness of the parties to exert effort and devote resources in order to sustain ongoing relationship. A high level of commitment in the coordination relationship therefore would encourage the participants to contribute individual capabilities into solving the coordination problem, and achieve a good coordination outcome. The commitment is most salient in the emergency response where the risks and threats are widely observed. The commitment of the coordinating parties would positively encourage the coordinating parties to set aside their varying views of opinion and their pursuit of self-regard interest according to (Townsend 2006).

The trust is regarded as another important component in relationship and is defined as the expectation that the other party will act predictably, will fulfill its obligations, and will behave fairly even when the possibility of opportunism is present (Zaheer, McEvily et al. 1998). Klepper suggested that trust enables risk-taking and it reduces conflicts in the collaborative work (Klepper 1995). Trust between exchange partners may positively affect joint actions, which essentially involves the parties carrying out the focal activities in a cooperative or coordinated way. Trust therefore is

a critical factor in the emergency response coordination where high risks are embedded. When the interest of the parties are aligned, trust helps the parties to reach the most effective coordination arrangements by assuming responsibilities and risks (Zaheer, McEvily et al. 1998). The individual emergency response parties can then count on each other to reach the coordination goal through the beliefs about the good intentions, concern, competence, capability, and reliability of partners.

Morgan and Hunt defined *cultural compatibility* in an relationship as the extent to which the parties can coexist with each other's beliefs about what values, behaviors, goals, and policies are important or unimportant, appropriate or in appropriate, and right or wrong (Morgan and Hunt 9914). Kumar and van Diesel suggested that the cultural incompatibilities in a relationship may be a stumbling block (Kumar and van Diesel 1996). They also suggested that culture compatibility has a great impact on the collaborative outcomes. As the emergency coordination task involves a high level of risk and may cause huge economic or social impacts, the culture value, such as risk taking or risk aversion, of coordination parties may exercise a major influence on whether the coordination can reach a mutual agreement in coordination designs.

Based on the literature it appears that coordination relationship may have a positive impact on the emergency coordination performance. We paraphrase this observation as Proposition 1.

Proposition 1: The greater the extent to which the coordination relationship is characterized by trust, commitment, and cultural compatibility, the better the emergency coordination performance

Research in emergency response and coordination, however, is in lack of appropriate metric of coordination performance measurement. Prior coordination research has developed coordination coherence and soundness as general measures (Georgopoulos and Mann 1962; Cheng 1983). We synthesize the prior emergency response literature and suggest that emergency coordination may be measured from both internal and external evaluations. Internal evaluation may include (1) coordination cost in managing the interdependencies and it may be measured by calculating the involved manpower and IT resources and (2) time spent for coordination design and implementation. Meanwhile, coordination may be measured through feedbacks from external entities such as victims satisfaction and losses in terms of human life and property damages. Therefore, internal measurements focus primarily on coordination efficiency while the external measures focus on coordination outcomes.

Pre-Planning

As with any group activity, emergency coordination requires pre-plans to prepare coordination designs for potential problems in emergency incidents. Pre-planning plays an important role in facilitating the coordination process and outcome (vanFenema, Pentland et al. 2004). Pre-planning in forms of plans, procedures, and established process is important according to both (Rao, Rajagopalan et al. 1992; Malone and Crowston 1994). The plans identify a list of possible scenarios,

coordination problems, and alternative coordination mechanisms for the optimal arrangement (Dawes, Birkland et al. 2004). In essence, the pre-plans prescribe the coordination arrangements to be taken and the approaches to decompose the overall coordination goal into pieces where individuals may handle and accomplish. When plans are in place, the coordination task is simplified by searching the knowledge space and by finding the right match between the available plans with the pending tasks. The plans, procedures, and process also define the roles (Cheng 1983). Information processing theory posits that pre-planning reduces the requirement of information consumption and consequently enhances coordination performance. Prior studies in emergency response found that plans of response procedures, mutual aids, and preventative mechanisms help reduce the operational risks, manage the time pressure, cope with the disruption of infrastructure failures, and direct the multi-authority participations (FEMA; Townsend 2006). The National Incident Management Systems suggest pre-planning as a key component in emergency response and coordination management (DHS 2004). It is also important to recognize the limitation of pre-planning as it may not work well in unstable and unpredictable scenarios (Van de Ven, Delbecq et al. 1976). Flexible adaptation, modification, and improvisation are important remedies for coordination in such scenarios (Mendonca, Beroggi et al. 2001). Despite of these limitations, pre-planning is widely accepted to have a positive influence on incident coordination. Hence, we paraphrase this as Proposition 2:

Proposition 2: The level of pre-planning will be positively correlated with

emergency coordination performance.

Further, pre-planning may help the coordination relationship as it fosters better understanding and also introduces cohesiveness among the coordinating parties. Prizzia (Prizzia 2006) suggested that pre-planning identifies the roles and job assignments for future coordination jobs. This may therefore greatly reduce the opportunities of role misalignment and job misalignment, which contribute to the conflicts in the emergency coordination process and the damage of coordination relationship. Pre-planning may also involve intensive drills and exercises where the response agencies are invited. Drills foster better understanding not only of tasks and roles but also of strengths and weaknesses of participants. Goles and Chin suggested that the cultures in an relationship may evolve and become more tolerant or accepting of each other's culture as the interactions increase (Goles and Chin 2005). Further, the pre-planning practices facilitates the participators in sense making of each other which develops the understanding of each other and fosters mutual trust and commitment (Bensaou 1997; Lacity and Willcocks 2000). Therefore, a successful management of the pre-planning may consequently help the different parties to create, assimilate, and build up cohesive and smooth interrelationships. And thus, we propose as Proposition 3 that pre-planning would benefit the coordination relationship.

Proposition 3: Pre-planning will be positively correlated with the emergency coordination relationship

Psychological Stress

Coordination in emergency response differs greatly from the coordination of normal activities such as a wedding party. Due to the fact that incidents are highly unexpected in nature and they are of high social and economic impact, the emergency response coordination involves psychological coping issues (Paton and Flin 1999). Paton and Flin (Paton and Flin 1999) suggested that emergency scenarios pose psychological constraints to the coordinators and consequently impact their cognitive capabilities. Among others, psychological stress which concerns the state of mental tension, preoccupation, and agitation is an important issue (Lemyre and Tessier 2003). During the course of emergency response, coordinators may be threatened by the psychological stress resulted by time pressure, desire to achieve acceptable results under conditions of uncertainty, etc. They may also experience stress out of concern for their families who may be in the affected region. This psychological stress may lead to physical and mental disorders (Lemyre and Tessier 2003) or lead to the inability to perform in command positions (Bourdeaux, 2006). Unless properly managed (decompressing, stress relieving counseling, etc) , psychological issues may prevent coordinators from making good decisions. As psychological stress is likely to take place in emergency coordination, it is important for coordinators to detect and control the stress perceived as early as possible. This may also be an issue for peers to spot (Bourdeaux, 2006)

Prior literature has found several factors that may help address the stress under emergency and disaster response (Flin, Strub et al. 1997; Paton and Flin 1999).

Physical fitness or lack thereof (illness or fatigue) effect decision making and emotion. This is particularly true when the incident or the aftermath of the incident protracts over a long period of time. Second, psychological fitness is found to help and it may be cultivated through occupational trainings, exercises and other extrinsic structures such as family support, counseling, etc. Third, positive personality is suggested to help with the psychological coping. Factors such as self-efficacy, locus of control, and tolerance for ambiguity may contribute to better coping behaviors.

We propose that psychological stress will have a negative impact on the coordination performance:

Proposition 4: The level of psychological stress will be negatively correlated with the emergency coordination performance

Paton and Flin found that the group relationship flows dynamically and may be shaped by the emotional states of the participants (Paton and Flin 1999). In line with the psychological research findings, the psychological stress hampers the individual's in the cognitive processing and introduces irrational decision making, which may generate negatives attitudes towards the others on their behaviors and evaluation. When the coordination is managed with the group members highly stressed, it is likely that the distrust, objections, and rebukes may evolve (Paton and Flin 1999). The emergence of the above incoherence due to irrational thinking would threats the coordination relationship consequently. The capability for the coordinators to address the stress, therefore, may cast an impact on the coordination relationship they manage.

We therefore paraphrase Proposition 5 as:

Proposition 5: Psychological stress will be negatively correlated with the emergency coordination relationship

Task Complexity

Emergency response typically involves coordination tasks of high complexity which may affect the coordination performance (Auf der Heide 1989). The increasing level of task complexity increases the demand for coordination, challenges the coordination capabilities, and threatens the coordination performance. Through an information processing perspective, Campbell (Campbell 1988) defined task complexity as emanating from four sources, among which the task interdependence and task uncertainty have received substantial attention in the study of coordination (Van de Ven, Delbecq et al. 1976; Rao, Rajagopalan et al. 1992; Malone and Crowston 1994).

Task interdependence has been recognized as one critical factor in the coordination research. Van de Ven et al. (Van de Ven, Delbecq et al. 1976) described task interdependence as the interconnection and restrictions among the participants in their operations. As we discussed earlier, coordination research has proposed four major interdependencies such as pooled, sequential, reciprocal, and team/concurrent interdependency (Thompson 1967; Van de Ven 1984; Rao, Rajagopalan et al. 1992). Other definitions of task interdependence have also been observed. Kelley and Thibaut developed the interdependence theory which defined the construct of the

interdependence in a complex format (Thibaut and Kelly 1959; Kelly and Thibaut 1978). McCann and Ferry proposed their interpretation of interdependence in terms of the characteristics of the resources exchanged between participants and operationalized interdependences as an additive function of number of resource exchanged, amount of each resource, frequency of transaction, amount of time before loss of resource has an impact on the unit, and the value of the resource to the unit (McCann and Ferry 1979). However, these interdependencies have been criticized for difficulties in application and incomplete (Victor and Blackburn 1987). We therefore focus on the four major interdependence formats in this paper.

The four types of interdependences are theorized to increase the level of dependency in a hierarchical manner: pooled exists before sequential, sequential exists before reciprocal, and reciprocal exists before team/concurrent interdependence (Thompson 1967; Van de Ven, Delbecq et al. 1976; Rao, Rajagopalan et al. 1992). As task interdependence increases, more elaborate coordination mechanisms are required to manage the coordinated units. Specifically, pooled interdependence requires standardization, sequential interdependence requires planning and scheduling, and intensive interdependence requires mutual adjustments (Van de Ven, Delbecq et al. 1976; Malone and Crowston 1994). When the level of task interdependencies increase, it becomes difficult to analyze the coordination problems, identify the proper coordination mechanisms, and to reconcile the coordinators in their visions and interest. The manipulation on one part of the coordination may result in a rippled impact on the many other entities in the disaster management (Beroggi, van Gent et al.

2001).

Task uncertainty, on the other hand, is resulted from the changing nature of tasks and the environment. Task uncertainty refers to the frequency of unexpected and novel events that occur in the conversion process (Van de Ven and Delbecq, 1974). It represents what might be called "stimulus" uncertainty for participants (Perrow, 1970). Low uncertainty means that participants experience considerable certainty about the occurrence of future activities while high uncertainty means that participants cannot predict problems or activities in advance. Simatupang et al. suggested that coordination tasks are more or less uncertain as the task elements are conceptualized as stimuli that vary systematically across work settings and translate into uncertainty for participants (Simatupang, Victoria et al. 2004). Meanwhile, the task environment may generate uncertainty as the activities are non-routine (Tushman, 1978) or constantly changing (Duncan, 1972).

Prior research suggests that the task uncertainty has impacts on the coordination modes (Lee, 2002). Low task uncertainty enables the standardization of coordination operations as structuring and programming are possible (Perrow 1967; Hall 1972). When task uncertainty increases, coordination becomes hard due to the high likelihood of exceptions (March and Simon 1958; Thompson 1967) and to the incurred cost in reorientation for coordination modifications and adaptation. Galbraith (Galbraith 1973) claimed that an increased degree of task uncertainty shifts coordination modes from rules and standards to hierarchical communication and goal setting. In the extreme case, a high level of uncertainty may require that mutual

adjustments be accomplished by group judgments (Van de Ven, Delbecq et al. 1976). Task uncertainty has also found to be influential on the information processing as well. Daft and Macintosh suggested that the amount of task information required for coordination may increase when task uncertainty and variety raise (Daft and Macintosh 1981). Emergency response involves high level of uncertainty as a result of the unexpected incident nature, unpredictable evolvement, and the unknown impact. The high uncertainty greatly reduces the coordination effectiveness in that the existing coordination arrangement may quickly grow ineffective during the course of response. The re-coordination may be employed while it consumes precious response time and efforts. Meanwhile, the uncertainty of emergency response may contribute to a high waste of the on-going response investment in terms of resource and manpower.

As discussed above, we suggest that the emergency coordination task complexity, reflected in task interdependency and uncertainty attributes, may introduce the difficulty in the management of the emergency coordination. For response tasks with great amount of complexity, the coordinators may be challenged with more cognitive burden and the information required. These may all contribute to the outcome of the coordination process. And thus, we propose:

Proposition 6: The greater the extent to which the task complexity is characterized by task interdependency and task uncertainty, the worse the emergency coordination performance will be

Information technology (IT) has been more and more exercised nowadays to facilitate emergency coordination process in the support of information and decision making (Turoff 2002; Sawyer, Tapia et al. 2004; Turoff, M et al. 2004; Yuan and Detlor 2005; Currion, de Silva et al. 2007; Mendonca, Jefferson et al. 2007; Van de Walle and Turoff 2007). The information support is focused on the enhancement of information quality achieved by the technology while the decision making support helps the individual and group decision making in the coordination process.

Coordination studies suggest that information quality is important to enable efficient coordination (Simatupang, Wright et al. 2002). Piplani and Fu summarized several challenges to information quality as (1) the needed information may not be available because such information may not exist at the moment or may not be captured; (2) the information may be incomplete due to the limited information sources, lack of knowledge about the emerging issues, and the complexity involved in the tasks; (3) the obtained information may not be correct or consistent as it may have been misinterpreted, wrongly reported, or distorted during the transmission or transformation process; (4) the available information may not be usable for lack of suitable information-exchange or knowledge-retrieving mechanisms (Piplani and Fu 2005). Emergency response exemplified the scenarios of these threats as accurate and complete information is rarely available for emergency coordination (Turoff 2002; Carafano 2003). Due to the limited information resources (witness and responders), the information collected in the emergency response is typically of low quality (Manoj and Baker 2007; Palen and Hiltz Liu, Sophia B). Eye-witness accounts of the

scene are often biased by own comprehension, background, recollection and verbalization. Quite often the information reported is also contradictory according to first responders. This may delay actionable decisions as the process of sorting out conflicting information is difficult and time-consuming. The information for emergency coordination therefore is likely to be inconsistent, misleading, inaccurate, and even completely wrong (Anderson 1991; Bannon and Bodker 1997). The lack of information quality may lead to information misalignment as information necessary to support decision-making processes is not readily available, not usable or incorrect. An improvement in the information quality, therefore, may help the coordinators investigate into and analyze the complicated coordination tasks.

Research in emergency response has presented a number of IT solutions to improve information quality for coordination (Botterell and Addams-Moring 2007). Example solutions include wireless mesh networks (e.g., CalMesh - calmesh.calit2.net), sensor networks (e.g., ASPECT - www.epa.gov/naturalevents/flyinglab.htm), geographic information systems (e.g., CATS - cats.saic.com), communication standards (e.g., CAP - www.incident.com/cap), and peer-to-peer communication platforms (e.g., Microsoft Groove - www.groove.net). The ubiquitous techniques which involve the mobile computing devices increase the amount of the available information. The high speed communication channels such as Internet enables the fast transmission of information to reflect the dynamic changes in the coordination tasks and environment. The advanced information fusion, analysis, and minding techniques, further solve the information inconsistency issues and

generate information network for new intelligence (Carver and Turoff 2007; Fiedrich and Burghardt 2007). Such support is most critical for emergency response where the coordination tasks are uncertain and complicated. The information technologies such as artificial intelligence and neural networks may help solve such problems efficiently (Chen, Schroeder et al. 2003).

IT may also introduce a great amount of *decision support* to the emergency response coordination of complicated tasks (Simon and Turoff 2007). Simon defined decision making as the cognitive process of selecting a course of action among alternatives (Simon 1977). Decision making involves reasoning process which can be rational or irrational and can be based on explicit assumptions or tacit assumptions. As Malone (Malone and Crowston 1994) suggested, coordination processes requires a huge amount of decision making. For instance, the coordination of response resources sharing requires sound decision making to maximize the overall utility and to minimize the opportunities of resource exhaust. In emergency response where the decision making is conducted with stress and time constraint, Klein suggested that the rational decision making may not be favored (Klein 1999). In his book of Sources of Power, Klein found that individuals usual identify only one course of action and follow it if no other reasons can topple this decision.

Information technology has long been an important enabler and support to the decision making in emergency response (Anderson 1991). Example solutions are such as knowledge management systems (e.g., RKBP - www.rkb.mipt.org), incident forecast and analysis programs (e.g., SLOSH -

www.fema.gov/plan/prevent/nhp/slosh_link.shtm), collaborative work systems (e.g., E-Team – www.eteam.com), and command and control systems (e.g., DisasterLAN – www.disasterlan.com). By presenting the relevant information, the proper media, the decision making tools, information technologies are efficient to support coordination decision making processes such as need recognition, information search, and evaluation (Green and Kolesar 2000; Dykstra 2003; Gillis 2003; Shen and Shaw 2004).

The above discussion, therefore, suggests that the IT support may help the emergency response coordinators in managing the coordination tasks. A strong level of IT support may help the coordinators attack the complicated coordination tasks with enhanced information quality and decision making. We therefore argue that the IT may cast a moderating effect on the relationship between task complexity and coordination performance. A high IT support in terms of information and decision support may significant reduce the impact of the task complexity and support the emergency response coordination. Thus:

Proposition 7: The extent to which the IT support is characterized by information support and decision support has a negative moderating effect on the association between task complexity and the emergency coordination performance

CONCLUSION AND DISCUSSION

In this paper, we examine the emergency response coordination phenomena and

discuss the influential factors that contribute to the coordination performance. Through the discussion of a set of research issues in emergency coordination, we develop a theoretical model which captures the roles of coordination relationship, pre-planning, psychological stress, task complexity, and information technologies. The research model illustrates the interaction dynamics and it suggests that the contingency determines the emergency coordination performances. The paper contributes to the theory development of emergency response coordination and it highlights the importance of the information technologies.

This paper however is limited in several aspects. First, we discuss the information technologies only with its interaction on task complexity. We argue that information technologies enable and support information quality and decision making, which consequently mediate the negative relationship between task complexity and coordination performance. Prior research in emergency response suggest a wider contribution of information technologies in pre-planning (e.g., forecast and analysis), relationship management (e.g., group communication), and psychological coping (e.g., emotion detection) (Anderson 1991; Shen and Shaw 2004; Turoff, M et al. 2004; Hegde, Manoj et al. 2006). Due to the scope of this paper which discusses during-incident coordination, we leave the discussion of detailed IT contribution into future study. Second, the coordination performance measurement may be further improved by exploring alternative measurement and metrics. Rathnam et al suggested the concept of *Coordination Gaps* as to measure the breakdowns (such as information transfer and activity progress flow) in a coordination task (Rathnam, Mahajan et al.

1995). Emergency response coordination typically involves hundreds of coordination progresses, the detailed measurements such as coordination gaps may be difficult to utilize. In addition, coordination performance may be measured using 360-degree global assessment where coordination outcome is evaluated from the supervisors, peers, subordinates, and victims of the emergency coordination group (DHS 2006). Third, this paper does not discuss the potential roles of external factors such as political pressures and regulations which may cast impact on coordination performance. In addition, the responders' ability to act and finish assigned coordination tasks is understudied in this article. A bad execution of coordination designs may request for re-coordination and impede the coordination progress.

ACKNOWLEDGEMENT

This research has been funded by NSF under grant 0705292. The usual disclaimer applies.

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