MULTI-AGENCY CRISIS RESPONSE COORDINATION SYSTEMS

REQUIREMENTS ANALYSIS FOR A CONTEXT-AWARE MULTI-AGENCY EMERGENCY RESPONSE SYSTEM

By

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ABSTRACT

Society faces many natural and man-made disasters which can have a large impact in terms of deaths, injuries, monetary losses, psychological distress, and economic effects. Society needs to find ways to prevent or reduce the negative impact of these disasters as much as possible. Information systems have been used to assist emergency response to a certain degree in some cases. However, there is still a lack of understanding on how to build an effective emergence response system. To identify the basic requirements of such systems, a grounded theory research method is used for data collection and analysis. Data from firsthand interviews and observations was combined with literature and analyzed to discover several emergent issues and concepts regarding disaster response. The issues and concepts were organized into four categories: i) context-awareness; ii) multi-party relationships; iii) task-based coordination; and iv) information technology support, which together identified the needs of disaster response coordination. Using evidence from the data, these factors were related to one another to develop a framework for context-aware multi-party coordination systems (CAMPCS). This study contributes to the field of emergency management as the framework represents a comprehensive theory for disaster response coordination that can guide future research on emergency management coordination.

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This study is dedicated to those brave men and women who work on the ground and selflessly help others during times of great urgency.

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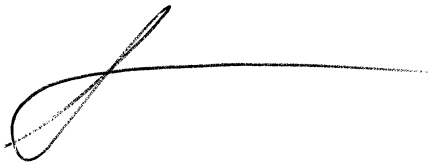
To my countless other friends, family, and colleagues, I also acknowledge your support and words of encouragement along the way. Thank you very much.

Sincerely,



Steven Way

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LIST OF ABBREVIATIONS

ANI/ALI	Automatic Number Identifier/Automatic Location Identifier
AVL	Automatic Vehicle Location
CAD	Computer Aided Dispatch
CBRNE	Chemical Biological Radiological Nuclear and Explosive
EMS	Emergency Medical Services
EOC	Emergency Operations Center
FEMA	Federal Emergency Management Agency
GAO	Government Accountability Office (United States)
GPS	Global Positioning System
GT	Grounded Theory
HAZMAT	Hazardous Materials
ICT	Information Communication Technology
IS	Information System
IT	Information Technology
MDT	Mobile Data Terminals
MoH	Ontario Ministry of Health and Long Term Care
PPRR	Prevention-Preparedness-Response-Recovery
RMS	Record Management System

CHAPTER ONE :: INTRODUCTION

> "We kept asking, 'where is the federal government?'" This was a common remark made by citizen and responder alike in the days after Katrina paid an unwanted visit to the Gulf Coast.
>
> *-- Fischer et al., 2006*

> Katrina exposed serious problems in our response capability at all levels of government, and to the extent that the federal government didn't fully do its job right, I take responsibility. I want to know what went right and what went wrong.
>
> I want to know how to better co-operate with state and local government, to be able to answer that very question that you asked: are we capable of dealing with a severe attack or another severe storm? And that's a very important question.
>
> *-- President Bush[1] on Hurricane Katrina*

1.1 Disasters, Response and Information Systems

Disasters have a large impact on society and can affect our world in a number of ways. They range in form from sudden-onset natural disasters such as tsunamis, hurricanes, forest fires, floods, mudslides, earthquakes, volcanoes, and ice storms, to slower developing natural disasters such as droughts and famines, to man-made events such as terrorist attacks, nuclear meltdowns, and large power outages, to biological disasters such as pandemics. They cause death, injuries, monetary losses, psychological distress and trauma, and can have a profound economic impact (Peek & Mileti, 2002).

Within the last ten years the world has experienced thousands of disasters killing hundreds of thousands of people and affecting hundreds of millions more. In 2011 there were 302 reported disasters killing almost 30,000 people[2]. The largest had 19,486 dead and missing resulting from the earthquake and tsunami in Japan. In 2010 an earthquake in Haiti resulted in a confirmed 222,570 dead and missing with an unconfirmed figure of 316,000 provided by the Haitian Prime Minister[3]. Hurricane Katrina struck the Gulf Coast of the United States in 2005 causing the death of 1,322 people, displacing hundreds of thousands of people, and having an economic impact of approximately $120 billion[4]. From 2001 to 2010 the average number of deaths per year as the result of a natural

[1] BBC News, *In quotes: Bush on Katrina*, http://news.bbc.co.uk/2/hi/americas/4252906.stm
[2] http://www.unisdr.org/files/24692_2011disasterstats.pdf
[3] http://www.unisdr.org/files/17613_rectoversodisasters2010.pdf
[4] http://www.unisdr.org/files/24692_2011disasterstats.pdf

disaster was 106,887 with the number of affected people averaging over 230 million per year for the same period[5].

When disasters do occur, society is compelled to respond but it is not easy. A typical disaster response has characteristics such as, "great uncertainty; sudden and unexpected events; the risk of possible mass casualties; high amounts of time pressure and urgency; severe resource shortages; large-scale impact and damage; and the disruption of infrastructure support necessary for coordination like electricity, telecommunications, and transportation. This is complicated by factors such as infrastructure interdependencies; multi-authority and massive personal involvement; conflicts of interest; and the high demand for timely information (Chen, Sharman, Rao, & Upadhyaya, 2008)." These contextual conditions are frequently different from the traditional business crisis which makes emergency management much more difficult to plan, places different stresses on decision makers, and requires different tools to aid in the response.

When disasters occur it is often local emergency responders and private citizens that are first to react. First responders try to rescue threatened or affected people and limit the impact of an event on people's lives. Citizens may form emergent groups to offer support and resources to affected communities and responders (Drabek & McEntire, 2003). However, disasters with a greater scope usually require more complex coordination efforts, as larger crises tend to require a greater number and variety of responders.

Recent history indicates our society continues to struggle with disaster response. A poor disaster response can have very severe consequences resulting in additional and otherwise preventable loss of life, property damage, and suffering. Responses to disasters such as Hurricane Katrina in 2005, and the earthquake in Haiti in 2010 have been viewed with mixed opinions by the international community.

The response to Hurricane Katrina in the United States triggered several investigations to identify the problems and opportunities for response improvement as the Federal Emergency Management Agency (FEMA) was inadequately prepared to coordinate response efforts (United States Government Accountability Office [GAO], 2007a). Problems included delays in providing aid to thousands of people in need, particularly those at the New Orleans Superdome[6].

In Haiti, US operations were not designed well to coordinate response efforts, and were hindered by the organizational response structure as they struggled to coordinate response efforts for an estimated 1000 to 2000 international humanitarian agencies in severely damaged infrastructure conditions (GAO, 2010e). Robbins (2010) described in a New York Times article many of the problems in the response including: materials sent to Haiti that could not be offloaded due to a lack of personnel at the airport; planes were stranded at the airport due to a lack of fuel; and limitations on the transportation of aid materials to areas of need due to a lack of adequate transportation. The presence of major

[5] http://www.unisdr.org/files/24692_2011disasterstats.pdf
[6] http://georgewbush-whitehouse.archives.gov/reports/katrina-lessons-learned/chapter4.html

response challenges was summarily established in a study by the Active Learning Network for Accountability and Performance in Humanitarian Action (ALNAP) and the United Nations Evaluation Group (UNEG) which observed no less than 45 disaster response evaluations had been conducted by organizations and nations to assess and improve the coordination of their humanitarian response in the future (Haver, 2011).

The ineffective handling of disaster response is often attributed to coordination problems. Coordination challenges arise in the management of diverse technical, social, and organizational communication networks that emerge from the interaction of the responders (Seeger, 2006). Furthermore, pre-existing procedures are often discarded in favor of dynamic and multi-disciplinary responses in order to adapt to constantly evolving situations (Kapucu, 2005). These challenges can greatly affect the overall effectiveness of the response effort of emergency personnel. The effective management of communication and coordination activities has been seen to minimize damages and loss of life, with poor management having negative repercussions. (Seeger, 2006)

A breakdown in communication and coordination is described as a major problem in the emergency response effort to the 9/11 attacks which led to ineffective decision making for command and control (National Commission on Terrorist Attacks Upon the United States [NCTAUUS], 2004). Specifically, firefighters responding to the World Trade Center fires were not equipped with the same quality of communication equipment as the police force. While police were aware of the impending collapse of the World Trade Center towers and communicated a fallback to officers in the vicinity, poor coordination and communication with fire officials led to over 150 firefighters within the towers being neither unaware of the imminent danger nor even capable of receiving communication, which contributed to their deaths.

The use of computers has been shown to improve the capacity of disaster response by improving the ability of emergency management agencies to coordinate complex intergovernmental systems (Drabek, 1991). This improvement was dependent on the level of computer integration with the organization. Several types of tools have been proposed and deployed in the past to improve various disaster response and coordination problems as well (Mick & Wallace, 1985; Stephenson & Anderson, 1997; Turoff, Chumer, Van de Walle, & Yao, 2004). However, even with the use of many different information systems in disaster response, problems with coordination remain.

With recent technological advances in information systems and mobile computing, can we improve information systems to support improved disaster response and coordination and reduce a disaster's impact on society? What are the characteristics that future information systems should possess for improved disaster response and coordination?

The continuing problems with disaster response efforts, the impact of disasters on society, and the opportunities for information systems use to aid in disaster response creates the motivation for this study.

1.1.1 Defining Disasters and Emergency Management

Dozens of definitions of what a disaster is have been proposed and debated since the first studies began almost one hundred years ago. In 1998 an entire book was dedicated to discussing perspectives on "What is a Disaster?" (Quarantelli, 1998), with a subsequent follow-up edition in 2005 revisiting the discussion and providing "New Answers to Old Questions" (Perry & Quarantelli, 2005).

The definition adopted for this study comes from The United Nations Office for Disaster Risk Reduction (UNISDR). It defines a disaster as a "serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources."[7]

A disaster occurs as a result of a hazard. The UNISDR defines a hazard as a "dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage." Not all hazards will become a disaster as the disruption of society is a major determinant.

If an information system can be used to decrease a society's exposure to hazards, or improve a society's ability to function during a hazardous event and enable the better management of resources, then information systems can improve a society's ability to cope with a disaster and decrease its overall impact. The application of the information system would occur during disaster management operations. It could be argued that such systems would reduce a community's vulnerability to disaster. This would fit in well with the call by McEntire, Fuller, Johnston, and Weber (2002) for invulnerable development for communities. Invulnerability is described as a limitation of the frequency and severity of emergencies and disasters through liability reduction and response capacity building. Vulnerable communities could be prone to disasters or have limited response capabilities should they occur.

The term disaster management, usually referred to as Emergency Management, is another term whose definition is debated amongst the practitioner and academic communities (Drabek, 2004; McEntire, 2004). In 1978 the State Governors' Association in the United States introduced *Comprehensive Emergency Management* (CEM) as a disaster management policy framework encompassing Mitigation, Preparedness, Response, and Recovery strategies, with Prevention sometimes used interchangeably with Mitigation (Crondstedt, 2002). Emergency management is generally accepted to be the use of multidisciplinary policies and tactics to mitigate, prepare, respond, and recover from a disaster or disaster threat to society. Its purpose is to reduce the impact of disasters on human lives, property, and the environment.

[7] UNISDR Website, http://www.unisdr.org/we/inform/terminology

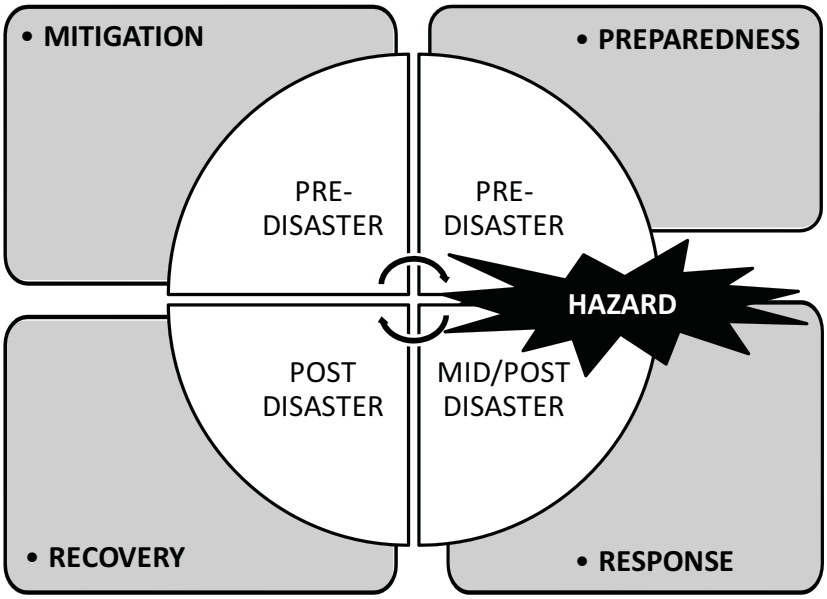

Figure 1. Stages of disaster management

Disaster management is a continuous cycle of well adopted different stages consisting of Prevention or Mitigation, Preparedness, Response, and Recovery (PPRR) (Peek & Mileti, 2002; Petak, 1985) and is represented in Figure 1. The Mitigation phase refers to policies and activities whose purpose is to prevent or minimize risk to society from a hazard. Preparedness refers to developing response and management plan capabilities prior to a disaster to create a more effective disaster response. Disaster response, considered the most studied phase of a disaster, consists of actions performed immediately before, during, and after a disaster to save lives, minimize property damage, and enhance disaster recovery. The recovery phase traditionally refers to short-term restoration activities to key supporting infrastructure, and long-term reparations and recovery of damaged infrastructure and the return to normal society.

Emergency Management Information Systems (EMIS) are systems designed to support and provide information to emergency managers and responders which enable more effective planning, operational control, and personnel management decisions to the prevention, mitigation, preparedness, response, and recovery to disasters.

1.1.2 Disaster and Information Systems Research in Academia

The field of disaster research is a well established field with several academic and practitioner conferences and journals dedicated to related research. Dedicated journals to the research field include *Disasters, Journal of Emergency Management, International Journal of Emergency Management, Disaster Prevention and Management*, as well as several practitioner oriented journals such as the *Australian Journal of Emergency Management* and the *DomPrep Journal*.

The first systematic disaster research ever published is considered the dissertation by Prince (1920) which studied social change after the Halifax explosion of 1917. Initial disaster research that followed was in the stream of human ecology which examined the interaction of nature with human society (Peek & Mileti, 2002), but grew to include natural hazards research and several other fields as disaster research became recognized as a multidisciplinary topic (Perry, 2007).

While research into disasters evolved, perspectives on disaster response changed. Disaster response, once considered an exclusive function of local municipal first responders, grew in scope and several different humanitarian aid organizations started providing support in addition to first responders. This phenomenon led to a growth in disaster coordination research designed to address complex disaster responses requiring multiple different responders, charitable agencies, and levels of government (Borton, 1996; Mooney, 1987; Taylor, 1986).

Coinciding with many of these response changes, studies on the benefits and uses of information technology in disaster response began to grow in prominence. Recommendations were made for a variety of supporting systems including *Decision Support Systems*, and *Expert Systems* (Belardo, Howell, Ryan, & Wallace 1983; Drabek, 1991; Guha-Sapir & Lechat, 1986; Mick & Wallace, 1985; Walter, 1990).

While the role of IS in disaster response was discussed in several dedicated emergency management journals, IS-related journals such as *Group Decision and Negotiation* and *Institute of Electrical and Electronics Engineers* (*IEEE) Intelligent Systems* have dedicated special issues on emergency preparedness and response.

Disaster response and emergency management tracks are also usually featured in several major mainstream academic IS conferences such as the Americas Conference on Information Systems (AMCIS), the International Conference on Information Systems (ICIS), and the Hawaii International Conference on System Sciences (HICSS). Joint disaster and IS researchers have also created a dedicated conference entitled *Information Systems for Crisis Response and Management* (ISCRAM) which is an annual event that draws multi-disciplinary academics from the IS, Computer Science, and Emergency Medicine communities, as well as practitioners such as government emergency managers.

Research into the application of IS to emergency management remains an important field and continues to develop. Frameworks have been proposed to improve the understanding and requirements of emergency management information concepts and systems. For example, Yuan and Detlor (2005) identified the major task requirements and associated key issues for intelligent mobile crisis response systems which include: monitoring and reporting; identification; notification; organization; operation; and assessment and investigation. Turoff et al. (2004) made design recommendations for a dynamic emergency response management information system (DERMIS) and identified specific system and design requirements based on nine premises (Appendix C). Abrahamsson, Hassel, and Tehler (2010) identified four main challenges to the analysis and evaluation

of emergency response systems; the use of value judgments for evaluation, the complexity of emergency response systems and the context in which they operate, the validity of the information upon which analysis and evaluation is based, and the limiting conditions under which the system was operated and is being evaluated. Van de Walle and Turoff (2008) have also discussed many recent advances and challenges in both individual and group decision support systems (DSS) for emergency situations.

However, in general it appears that much of the research into the field is devoted to systems design examples and case studies. The emphasis of much literature appears to be on the actual technology applied or on specific cases which limits the contribution of much of the IS related disaster response literature. Logically, the adoption of any concepts or observations which are limited in scope can translate into inappropriate tools or methodologies that can have life-threatening consequences if used by practitioners. A stronger emphasis on theory development and application for the field is required to improve the development of useful tools and methods.

Franco, Zumel, Blau, Ahyhens-Johnson and Beutler (2008) express similar concerns when addressing the limitations of research being produced in the *Information Systems for Crisis Response and Management* (ISCRAM) community. The lack of a deep multidisciplinary dialogue about what constitutes scientific evidence, the domination of case study methodology and the lack of alternative methods to build the confidence in causal and generalizability claims, and little effort to analytically or inferentially generalize from data to a theory of disaster management are shortcomings of much ISCRAM research. "[A]nalytic generalisation from findings of multiple case studies to a broader, overarching theory of disaster management remains largely absent from the discussion, which seems to be a missed opportunity given the unique centrality of the ISCRAM community in this transdisciplinary research space." (Franco et al., 2008)

McEntire (2004) also calls for critical thought on theoretical concepts, and realistic perspectives on contributions as two of the three ways to overcome the challenges of developing Emergency Management Theory. "If our theory is based on faulty assumptions, the conclusions will inevitably be problematic. On the other hand, if our premises are grounded in reality, we will more likely be able to generate theories that will have practical application. Thus, another goal of theory should be to understand the barriers to change and how things can be different so that the means to progress can be more easily identified and implemented."

A lack of adequate generalizable theory represents a gap in ISCRAM literature that can be addressed with a more systematic and rigorous approach to theory development.

1.1.3 Research Goals and Objectives

The goal of this study is to use a systematic and rigorous scientific methodology for the identification and examination of the factors influencing multi-party disaster response. By conducting a systematic review of the response problems encountered, a better theoretical understanding of emergency response coordination is achieved. Furthermore,

much of the extant IS research and tools designed to support response efforts focus on decision making functions of managers, and less so on rescue operations. However, responders are responsible for implementing the plans of managers and experience the challenges firsthand. Therefore, this study will include responders' roles in response processes.

This research calls for an exploratory research method. It seeks to identify the factors that influence the effectiveness of crisis response, identify the issues with current support systems, and identify the requirements for an ideal response support system down to the operations level.

With an understanding of the supporting research fields, objectives for this study include an improved understanding of: i) the tasks performed during crisis response, ii) the information and communication systems used, iii) the relationships between the tasks, people, and systems for disaster response, iv) the performance of coordination, and v) the relationships between tasks, people, systems and performance associated with disaster response systems used by emergency responders.

In summary, the objective of this research is to develop and validate a comprehensive theoretical framework for disaster response that is based on the analysis of data grounded in realistic exercises and actual emergency environments.

To achieve the objectives of this study, a grounded theory research methodology was chosen, relevant literature was reviewed, and qualitative analysis was performed on the data to conceptualize contributing factors in emergency response. A theoretical framework was then established to aid in the design of support systems for emergency response.

1.2 Significance of the Research

Studies into disaster response coordination include general commentary (Mooney, 1987; Taylor, 1986), case studies (Borton, 1996; Kapucu, 2005; Kapucu, 2008), frameworks, and scenario-based studies (Chen et al., 2008; Sagun, Bouchlaghem, & Anumba, 2009). Salmon, Stanton, Jenkins, and Walker (2011) conducted a case study of multi-agency coordination where they applied the Event Analysis of Systemic Teamwork (EAST) framework on a joint civilian-military training scenario.

Shen and Shaw (2004) have provided one of the few studies which examines the application of IT to managing emergency response coordination. In their study, Shen and Shaw created a conceptual model based on the application of Task-Technology Fit Theory (Goodhue & Thompson, 1995; Zigurs & Buckland, 1998) and Coordination Theory (Malone & Crowston, 1994). They established the theoretical coordination mechanisms for emergency response and created three propositions for the application of IT.

None of these prior studies addresses the gap of creating generalizable theory which is grounded in data and desirable for the further advancement of Emergency Management and ISCRAM research (Franco et al., 2008; McEntire, 2004). This study seeks to fill the gap by exploring the issues and requirements in crisis response and identifying factors to improve the use and adoption of information systems in the field during crisis response.

The circumstances surrounding a disaster response are influenced by the disaster scenario, responder behavior, as well as available technology. Using grounded theory, socio-technical issues are identified which influence crisis response. A new theoretical perspective on disaster response and the use of IS in disaster response is presented which is grounded in real data from a broad range of different disasters, with different scopes, occurring at different periods, over a wide area, and involving different demographics. This creates generalizability for the proposed theory over and above specific case studies. System design requirements are then proposed for future disaster response systems.

In summary, this study is significant to researchers and practitioners in Emergency Management as it addresses an identified gap by using a rigorous and systematic method to create a generalizable theory for emergency management -- specifically disaster response.

1.3 Chapter Outline

This study is presented in eight chapters.

Chapter Two of this study reviews much of the supporting theoretical background that is used to inform this research. The background information is used to support the interpretation and analysis of data prior to framework development.

Chapter Three of this study discusses the research methodology used. A discussion of how the methodology was chosen is provided, along a description of the steps followed from the methodology.

Chapter Four describes the data collection process. This includes a description of the participants as well as descriptions of how data were collected and managed for analysis.

Chapter Five demonstrates how concepts were compared and analyzed from the collected data and with other data sources. Emergent themes and concepts are supported by representative examples taken from the data for each concept.

Chapter Six discusses the framework formulation and system requirements for a proposed context-aware multi-agency response system.

Chapter Seven then examines existing support systems using the framework to consider the generalizability of the study.

Chapter Eight is the last chapter. It discusses the final conclusions and the contribution this research study makes, as well as the limitations and future research possibilities of this study.

1.4 Summary

In this chapter the impact that disasters have on society has been discussed. Millions of people around the world are affected by hundreds of disasters annually. Despite the many years of living with hazards all around us, society remains vulnerable as more disasters are documented.

Information systems have been previously shown to improve the effectiveness and efficiency of decision making processes in business. They are also employed at different degrees in emergency response by first responders and other emergency personnel, but many of their potential benefits in disaster response have yet to be realized.

An overview of the state of emergency management and information systems research identified substantial case-based and design science studies. However, an opportunity existed to generate a holistic theoretical perspective on information systems applied in disaster contexts. This study generated a generalizable theory for disaster response which can be used to identify and analyze information systems requirements for future disaster response information systems.

CHAPTER TWO :: THEORETICAL BACKGROUND AND FOUNDATIONS

2.1 Introduction

The purpose of this chapter is to explore prior literature that informs the general understanding of emergency response from the responder's perspective. A grounded theory methodology is used in this study which discourages detailed *a priori* literature reviews so that research is not biased during the analysis and conceptualization process (Glaser & Strauss, 1967). A non-committal literature review (McCallin, 2003; Urquhart & Fernandez, 2006) enables researchers to sensitize themselves to various concepts without imposing the application of those concepts on the data. Only after the development of a theory based on the data does the application of *a priori* theory influence the analysis of concepts, interpretation of results, and modification of the developed theory as long as it fits with the data. In other words, the relevance of the literature review is determined from emergent concepts (Hekkala & Urquhart, 2013). An initial literature review to inform this study considers research in the fields of disaster management and response, multi-party coordination, inter-organizational information systems (IOIS), situational awareness, and context-aware computing.

2.2 Theoretical Underpinnings

2.2.1 Crisis Management and Response

Traditionally, emergency management was perceived as a function of law enforcement and fire personnel with additional support provided by public health and civil defense organizations (Petak, 1985). Emergency management was ignored by public administrators who were responsible for government policies. However, as society became more technologically dependent, and the responses to disaster grew in complexity, there was a shift in the priority and perspective of emergency management such that emergency management is now a central public administration activity that works in conjunction with the operational components. Emergency management is a consideration at all levels of government from municipal to national.

There has been an argument that emergency management should adopt risk management principles (Salter, 1997). Risk Management has been defined as the systematic application of policies, procedures, and practices to the tasks of identifying, analyzing, assessing, treating, and monitoring risk (Standards Australia/New Zealand, 2009).

As a practitioner, Salter argues that the perceived shift from an internal agency to a community-centred focus such that reactive responses to hazards by single agencies are becoming proactive partnerships to address vulnerabilities. With this shift there is a transition from response management to risk management, and from a limited range of services, to intelligent resource allocation based on risks (Salter, 1997).

While the Prevention-Preparedness-Response-Recovery (PPRR) model may appear outdated with a shift to risk management, it is argued the PPRR model belongs as part of the risk management approach in the treatment of risks (Crondstedt, 2002). Traditional

risk management treatment strategies of avoidance, reduction, sharing, and retention fall under the activities of prevention, preparedness, and response of the PPRR model. According to Crondstedt (2002), the adoption of risk management methodologies encourages risk treatment selection based on criteria of efficiency, effectiveness, and economy.

Whether the traditional PPRR model is used, or some form of Risk Management model that incorporates PPRR, a disaster still has a response phase. The response phase is characterized by dynamic situations with uncertain conditions, either a lack of or too much information, and a requirement for time sensitive decision-making.

While there is much research on the nature of a disaster, on the whole, emergency management and crisis response are ill-defined multi-disciplinary fields using a broad context to organize research. Research in crisis response varies from psychological responses, societal responses, scheduling issues, to coordination issues and more. Much crisis response research deals with identifying the challenges in the context such as best practices for communication (Seeger, 2006) and management (Quarantelli, 1997b), or focuses on elucidating features and coping mechanisms of a specific disaster in context. The literature on coordination, which may use scientific methodologies to perform research, tends to focus on practical applications and ignores theoretical applications that can contribute to the future academic study of the field.

More recently a field of research coined *crisis informatics* has evolved to focus on empirical study as well as socially and behaviorally conscious information computing system development and deployment when studying crisis situations (Palen, Vieweg, Sutton, Liu, & Hughes, 2007). This field draws from information, disaster, and technical sciences.

2.2.2 Multi-Party Coordination

Coordination theory is also an ill-defined multidisciplinary field of research. Malone and Crowston (1994) illustrate the challenges in defining coordination by providing a summary of several different definitions of coordination they found in the literature. They also summarize several different coordination results from selected research fields.

The challenges in coordination theory come from the myriad of various contextual issues that can affect coordination. Typical coordination challenges in disaster response can be amplified by coordination activities requiring numerous organizations at various levels of a response with varying concerns and jurisdictional issues. Coordination theory can be characterized as a group of individual and multi-disciplinary theories on how coordination of diverse systems can occur (Malone & Crowston, 1994) where coordination is defined as a harmonious interaction between actors (Malone & Crowston, 1990).

From a knowledge-based view of the firm, coordination is the fundamental task of the firm in order to maximize the efficiency gains from specialization (Grant, 1996). The argument Grant (1996) uses is that transferring knowledge is not as efficient as

integrating knowledge so coordination becomes a priority. In emergency management, this perspective is used to explain why agencies have specially trained teams or units (such as Hazardous Materials (HAZMAT) teams, CBRNE teams, Cliff Rescue teams, etc.) to respond to special situations. It is more efficient to train a few specialized teams as opposed to having each member of a service trained in the exact same skills for every possible work scenario at great expense.

Coordination consists of goals, activities, actors, and interdependencies and is defined as the management of interdependencies between activities to achieve a goal (Malone & Crowston, 1990). Sample dependencies for coordination have been summarized as shared resources, producer/consumer relationships, simultaneous constraints, and tasks/subtasks. Common example processes to manage those dependencies are budgeting, tracking, scheduling, and goal selection. By identifying the coordination processes associated with dependencies it is possible to manage the coordination processes, with group decision making and communication being two key processes that should always be well managed due to their almost universal importance (Malone & Crowston, 1990).

Previous research has studied emergency response coordination with information systems (Shen and Shaw, 2004). In the study, emergency response coordination dependencies were generalized as sharing, flow, and fit while task-system fit theory was used to link system attributes with management mechanisms of structure, and processes specific to the study's example.

2.2.3 Inter-organizational Information Systems

Some define inter-organizational information systems (IOIS) simply as a system being used by two or more organizations (Chatterjee & Ravichandran, 2004), while others view an IOIS as a system that has been designed with the input of several organizations and is then deployed by several organizations, with the member organizations sharing some common characteristics but otherwise having their own distinct characteristics (Hekkala & Urquhart, 2013). A typical example is the lengthening of supply chains and a corresponding extension of ERP systems throughout the chain. IOIS projects tend to try and standardize information systems across regions and countries.

The purpose of IOIS has been summarized as to improve communication efficiency and enhance storage and processing capabilities (Chatterjee & Ravichandran, 2004). The principle behind IOIS is that enhanced communication enables more efficient matching of supply and demand to supply and demand needs, as well as resulting in better monitoring of suppliers (Chatterjee & Ravichandran, 2004).

Research into IOIS is generally split between those studying the economic and efficiency bases of inter-organizational relationships, and those considering social and behavioral bases (Chatterjee & Ravichandran, 2004).

2.2.4 Situation Awareness and Context-Aware Computing

Situation awareness is a human state of knowledge achieved by the perception of environmental elements within time and space, a comprehension of their meaning, and the projection of their status in the near future (Endsley, 1995). The process to achieve situation awareness is called situation assessment and includes the acquiring or maintaining of situational awareness.

Situation awareness can also be associated with teams whereby each team member has specific knowledge of the situation required to perform their function. The knowledge team members have may be known only to them or there may be overlap of situation awareness knowledge. Situation awareness has been linked with decision making and performance although there may not always be a direct relationship (Endsley, 1995). Much of the situation awareness research was initially conducted with the military, air force pilots in particular, to understand how pilots behave or what actions should be performed within a given context in order to achieve the goals of the pilot (Endsley, 1995). Situation awareness research has expanded to more general applications of operating in complex environments for both military and civil contexts.

Context from an IS perspective has been defined as the set of environmental states and settings that determines an application's behavior (active context) or characterizes the conditions in which an application event occurs (passive context) (Chen & Kotz, 2000). As an extension, context-aware computing is the use of context in performing computing processes. Specifically, context-aware computing has been defined as both active and passive context-awareness where active context-awareness is the automatic adaptation of application behavior by an application when context changes; and passive context-awareness is the presentation of context information.

Context-aware computing is generally linked to mobile computing because of two trends in information and communications technology: i) a constantly increasing processing power with shrinking portable computers, and ii) a growth of wireless communications with increasing bandwidth availability (Chen & Kotz, 2000).

While mainly devoted to location-based awareness, context-aware applications have the potential to incorporate sensors and measure environmental conditions to identify many low-level contexts (temperature, orientation, time, etc.) and then combine them using artificial intelligence to develop higher level complex contexts (Chen & Kotz, 2000). While there are some studies on implementations of context-aware computing, the novelty of the field yields an overall lack of research on the effectiveness of context-aware computing.

In practice, various forms of Information and Communication Technology (ICT) systems are deployed in emergency management activities from planning to rescue operations. Usually customized or adapted forms of existing information systems, emergency management information systems have been designed to manage information relevant for managing emergencies and response. Dispatchers working away from the front lines in

emergency services commonly use Computer Aided Dispatch (CAD) systems, Record Management Systems (RMS), and radio communication systems to dispatch personnel to where they are needed, while responders commonly have more limited information and communication systems, using portable radios and, less commonly, mobile data terminals (MDTs) to receive information and aid in the execution of job tasks.

When larger disasters occur, other software may be activated by dispatchers or emergency managers such as special contact databases, and incident management software for EOC support. Two software packages known to be used by EOCs are WebEOC[8] and E-team[9]. These software systems may aid in contacting groups that can assist in a disaster response, gather and provide situational awareness of any known disaster details, and identify and track the major activities being performed by responders.

Emergency management does have a broad multi-disciplinary background. Any of the aforementioned research areas may contribute to a final emergent theory, or there may be areas of research not yet mentioned that may appear to have a greater influence on disaster response. However, from the outset of this study it is reasonable to anticipate possible influences from the fields of emergency management, coordination, inter-organizational information systems, and situation awareness in multi-agency disaster response. Having general knowledge in these areas provides sensitivity to relevant information when beginning the data collection process.

2.3 Summary

In this chapter the reasoning for a non-committal literature review was provided. In order to develop theoretical sensitivity yet not bias the analysis of future collected data, a high level survey of literature was conducted. Without assuming the type of theory that would emerge from the data, a high level review of perceived relevant literature was conducted in the fields of crisis management and response, multi-party coordination, inter-organizational information systems, situational awareness, and context-aware computing. These research areas provided a broad range of information on the types of issues that would be potentially encountered when collecting and analyzing data.

[8] http://www.esi911.com/esi/
[9] http://www.nc4.us/eteam.php

CHAPTER THREE :: RESEARCH METHODOLOGY

3.1 Introduction

As stated in the first chapter, coordination continues to be a problem during disaster response and there appears to be a lack of generalizable theory in information systems literature that describes the situation. This study seeks to answer general exploratory questions such as *how* and *why* type questions. How is coordination performed in emergency and disaster response? Why does coordination remain an issue with disaster response? How can information systems aid in disaster response? In the process of addressing these questions, this research includes the social and cultural contexts along with the technical contexts in understanding participant interaction with different coordination information and communication technology systems. Together, the exploratory nature of the study and the contextual information to be studied indicates a qualitative-based research methodology is preferred over quantitative research methods initially developed to study natural phenomena in natural sciences (Myers, 1997).

Furthermore, a stated objective of this research is to develop a theory. The remainder of this chapter is dedicated to describing the methodology selection process, and then describing the method implemented to gather and analyze data prior to developing a theory.

3.2 Methodology Selection

There are generally four qualitative research methodologies in the field of IS: i) action research, ii) case study research, iii) ethnography, and iv) grounded theory (Myers, 1997). Each of these qualitative methodologies serves a different purpose and can support different philosophical perspectives. The underlying philosophical perspective of the study follows the philosophical assumptions of the researcher (Myers, 1997). Table 1 summarizes the differences amongst the methods, with further descriptions, and an explanation of the selection reasoning following.

3.2.1 Action Research

Action research is a collaborative qualitative research method where the researcher works with study participants to address the practical concerns of participants and the goals of social science (Myers, 1997). It can be positivist, interpretive, or critical (Myers, 1997). However, action research is non-generalizable and limited to the context in which it was performed, making it an applied methodology of primary interest to practitioners, and less so to academics (Jones, 2009).

Table 1. Summary of qualitative IS research methods

	Action Research	**Case Studies**	**Ethnography**	**Grounded Theory**
Philosophical Perspectives	Positivist Interpretive Critical	Positivist Interpretive Critical	Not Applicable	Interpretive (post-positivist)
Data Collection Sources	Primary	Primary sources (no observations) Secondary	Primary	Primary Secondary
Data Collection Method	Iterative collection and analysis	Linear collection and analysis	Linear collection and analysis	Iterative collection and analysis
Analysis Method	Integrated researcher	External researcher	Integrated researcher	Integrated or external researcher
Study Result	Actions with limited context	Theory with specific context	Descriptive data of context	General theory

3.2.2 Case Study Research

Case studies are the most common form of qualitative research in IS and provide an approach for empirical studies of how practitioners seek information, and generally address *how* problems focusing on the description of real-world phenomena, usually in specific examples with specific context (Jones, 2009; Myers, 1997). Data is usually collected from interview data and secondary sources such as documents (Myers, 1997), and follows a linear and single sequence of data collection and analysis. Defining a suitable case to study may be challenging, as would identifying a suitable practitioner to study in the case, with any observations specific to the participants and generally not representative of some larger population (Jones, 2009). As a result, the case study findings are usually limited in value and difficult to generalize.

3.2.3 Ethnography

In ethnography, researchers place themselves in the lives of the participants and seek to study a phenomena in the social and cultural contexts of the participants (Myers, 1997). While this appears to align with the objectives of this research, the output of an ethnographic study is not an explanatory or predictive theory, but rather a rich and full description of the particular setting (Jones, 2009). This makes a philosophical perspective difficult for ethnographies as they only provide descriptions. There is no prior hypothesis to test or expected theory generation. This is not the desired output for this study.

3.2.4 Grounded Theory

According to Glaser (1992), a co-creator of grounded theory, "the grounded theory approach is a general methodology of analysis linked with data collection that uses a systematically applied set of methods to generate an inductive theory about a substantive area... That is all, the yield is just hypotheses!"

Grounded theory (GT) is a research methodology increasingly common in IS for developing context-based, process-oriented descriptions and explanations of phenomena (Myers, 1997). It was the methodology used in the 1993 MISQ paper of the year examining the use of CASE Tools and their effect on organizational change (Orlikowski, 1993). Its name represents both a methodology and the output of the process. GT is a method of discovery that generates a theory grounded in reality (Glaser & Strauss, 1967), and is not forced or reified with concepts that do not relate to the data (Glaser, 1992). It can be both a rigorous qualitative and quantitative methodology that explores *how* and *why* problems using a systematic method of gathering and analyzing data based on the data itself (Myers, 1997). The method seeks to explain as well as describe and may implicitly give some degree of predictability in certain circumstances (Corbin & Strauss, 1990).

The GT approach allows flexibility with data collection and analysis as researchers seek patterns in the data they collect. Most phenomena are perceived as continually changing in response to conditions, so GT methods incorporate change in phenomena through comparative analysis with previously collected data (Corbin & Strauss, 1990). Furthermore, participants have the ability to make choices in response to encountered conditions and GT attempts to identify relevant conditions, how participants respond, and the consequences of participant responses (Corbin & Strauss, 1990). The theory emerges from the data as researchers continually collect, analyze and compare new data with previously collected data.

Data collection for GT can include interviews, observations, documents, video tapes, newspapers, letters, books -- anything that may address questions raised in the study (Corbin & Strauss, 1990). Collected data can be uniformly coded for analysis regardless of the original format of the data (Glaser & Strauss, 1967, pp. 161-184).

Debate has categorized grounded theory into different forms called classic or *traditional* grounded theory, extended or *evolved* grounded theory, and constructivist grounded theory (Mills, Bonner, & Francis, 2006). Traditional grounded theory is used to describe the work of Glaser, while evolved grounded theory refers to the work of Strauss and Corbin, and constructivist grounded theory emphasizes Charmaz's positioning. Table 2 summarizes the main comparative differences as put forward by Mills et al. (2006), and Breckenridge, Jones, Elliott, and Nicol (2012). The argument as to whether forms other than classical grounded theory are actually grounded theory is a result of methodology changes or framework additions that classic grounded theorists perceive to take away from the emergence of theory from the data (Glaser, 2002).

Table 2. Summary of grounded theory forms

Difference	Traditional	Evolved	Constructivist
Ontological and epistemological perspective	Any, emerges from data	Relativist pragmatist	Relativist subjectivist
Theoretical sensitivity	Start with blank slate and accumulate data	Gather data to stimulate reflection on existing data	Gather data to stimulate reflection on existing data
Treatment of literature	Prior review can inhibit and bias analysis	Prior review can stimulate thinking about how to analyze data	Prior review can stimulate thinking about how to analyze data but must focus on interest of participants.
Coding and diagramming	Open, theoretical, and constant comparative	Open, theoretical, axial, conditional matrices, and constant comparative	Open, theoretical, and constant comparative with narrative of participants present in coding and analysis
Identifying the core category	Emerges from data	Start with a gut sense about the research	Start with participants' sense about the research

Related to this debate is the challenge GT often has overcoming misconceptions and misunderstanding of the methodology by *formed* researchers who have years of qualitative data analysis experience using other methods with which they may have developed loyalty (Glaser, 2009). Experienced researchers are often concerned about framing the research such that a literature review gives a researcher theoretical wisdom (Glaser, 2009). However, it is argued that a requirement for prior theoretical framing hinders the emergence of patterns from the data as researchers continually compare data back to preconceived notions (Glaser, 2009) .

The perspective by Glaser is that GT is ideally performed by *unformed* novice PhD researchers who have not yet developed a predisposition towards other qualitative data analysis methods (Glaser, 2009). Furthermore, a literature review is discouraged at the proposal phase of a study is it may be a waste of time and may be counterproductive to theory generation (Glaser, 1998, p. 69). A knowledge of relevant literature is still required, but it is merely deferred until later in the research process at the final output, because without it the contribution of the research to the substantive area cannot be assessed (Glaser, 2009).

Grounded theory is the most suitable methodology for this study as it is both exploratory in nature and ideally suited for theory development. The substantive area of research is

new and this methodology's characteristics for selection fit the desired output of the study.

3.3 Methodology Steps

GT methodology can be summarized as an iterative and integrated process of data collection, analysis, coding, and conceptualization which culminates in theory generation. Figure 2 provides a visual overview of the methodology used in this study with key terms and processes described in the remainder of this section.

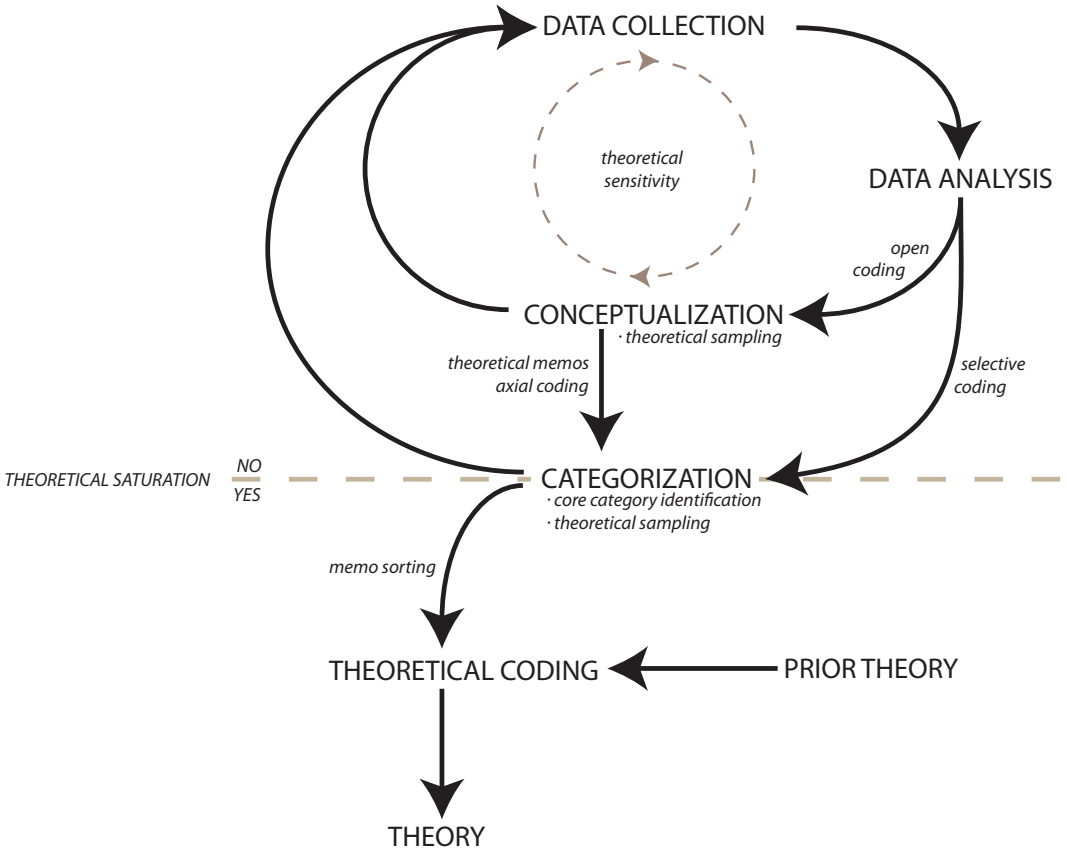

Figure 2. Visualization of the grounded theory method used

3.3.1 Data Collection

Data collection is directly tied into data analysis from the outset, which is counter to other forms of qualitative research where all data must be collected first (Corbin & Strauss, 1990). Analysis is necessary as it directs future information gathering activities and questions through the development of theoretical sensitivity.

Theoretical sensitivity is a term used to describe the ability of the researcher to conceptualize and formulate a theory through the constant comparison of new data with prior data (Glaser & Strauss, 1967). Developing theoretical sensitivity is demonstrated as a researcher progresses from asking open questions, analyzes and processes the

responses, and learns to focus more specific questions on areas of relevance and importance on future data collection processes (Giske & Artinian, 2007).

Theoretical sensitivity in this study was developed as data were collected and analyzed from the observation of the tasks, contextual operating environment, and the conditions under which emergency responders performed their work. It was then further developed through the incorporation of data from disaster response literature.

In this study, initial data collection occurred during embedded ride-alongs with police, firefighter, and paramedic emergency responders. In addition, data collection occurred at emergency dispatch call-centers with direct observation of call-taker and dispatcher activities. In these situations, data were collected and analyzed based on observations of employee tasks, interactions, communication, use of technology, and contextual information related to coordination. Additional emergency management participants were interviewed at their offices and included Community Emergency Management Coordinators, senior management from first responder agencies, and management at regional EOCs and the regional government ministry of health which was responsible for ambulatory oversight.

Data were recorded using pen and paper notes and, where permitted, a digital audio recorder. Open and semi-structured interviews were used with participants to gather data regarding their tasks, interactions, communication, use of technology, and perceptions of context during emergency response. Open interview questions evolved after initial introductory interviews and observations to refine and target data topics of relevance.

Data collected in written notes and audio recordings were transcribed into electronic format and were stored in Word document format on an encrypted USB data storage key. Where possible, this information was then imported into NVivo software. NVivo is a software tool to aid in qualitative data analysis. It is capable of linking to media sources, or importing several different media formats, which then enables indexing and searching of all documents together to identify common keywords and phrases. It also permits the coding of passages in documents, and the creation of relationships between codes. Codes may be sorted based on the source type or other categories, or the passages from all the different sources for a particular code can be output to confirm similarities. How NVivo was used is described in the next chapter.

3.3.2 Data Analysis and Conceptualization

During the data analysis phase the existing issues of disaster response were identified and catalogued into concepts using a process known as *open coding* (Corbin & Strauss, 1990). As data continued to be collected it was either organized into existing identified concepts, or new concepts were created.

As the number of concepts in a study grows the analysis becomes more abstract (Corbin & Strauss, 1990). Concepts pertaining to the same phenomenon emerge and are grouped into categories based on similar identified characteristics.

In addition, *theoretical memoranda* were created to explore relationships between concepts as they emerged by systematically recording patterns, thoughts, questions, relationships between interviews, emerged themes, and concepts and themes found in supporting literature (Martin & Turner, 1986; Corbin & Strauss, 1990; Giske & Artinian, 2007). Memos permit the recorded exploration of relationships by researchers without biasing the raw data itself. Theoretical memos are performed at both a low-level and higher-level of abstraction (Martin & Turner, 1986).

In this study, the low-level memos were used to immediately add an extra layer of abstraction from the data. Patterns in the memos were grouped to help identify the emergence of categories. The term *axial coding* is used to describe the process of creating relationships between categories that fit the data (Corbin & Strauss, 1990). For example, when considering resources to be used for disaster response, a few of the open coded concepts that were encountered included resource request, received resource quality, resource quantity, and resource appropriateness. These were axial coded into a category of resource management. Higher-level memos were used to record this level of abstraction and the ideas supporting the categorization.

Eventually, a common theme can be determined from amongst the categories which identify the core category. The core category is the central phenomenon of the study that is recognized by its ability to answer questions such as: What is the main analytic idea presented? How would I conceptualize my findings in a few sentences? How do I explain the variation between and among categories? (Corbin & Strauss, 1990). The core category may emerge early in the research but usually emerges in later phases of the study. It is the central category around which all other categories appear to be related.

Selective coding is the process used to unify emergent categories and sub-categories around the core category (Corbin & Strauss, 1990; Giske & Artinian, 2007). When using selective coding, emphasis is on the categories indicated by the data which directly relate to the core category. Therefore, as observations and data continue to be gathered, data are only coded if it is directly relevant to those categories. This helps direct data gathering to achieve theoretical saturation of data.

As concepts were repeatedly present (or absent) in data collection they are incorporated into an evolving theory (Corbin & Strauss,1990). The concepts, and not the actual data, were then used to develop the theory. As required by GT methodology, the concepts remained based on the data collected.

3.3.3 Theoretical Sampling

Theoretical sampling in GT is about establishing samples of concepts, and their properties, dimensions and variations, and not about having a broader range of participants (Corbin & Strauss, 1990). For example, this meant that sampling was of i) the incidents, events, and happenings of the crisis response environment, ii) the conditions that facilitated, interrupted, or prevented the ability to coordinate response, iii)

the manner in which coordination response is observed, and iv) the consequences of the response that result.

As abstraction of concepts and categories increased, the evolving theory became more generalized, not necessarily to a broader population, but to the conditions that the theory addresses (Corbin & Strauss, 1990). In other words, as theory developed, it was abstracted to a higher level making it more applicable to general crisis response, but not necessarily more general to the population at large.

3.3.4 Empirical Validation and Theoretical Saturation

The research process of data collection and analysis is repeated until a point where theoretical saturation occurs. Theoretical saturation is the point when no new categories or properties emerge from the collection of new data (Glaser & Strauss, 1967). Until that point, constant comparisons need to occur between new incidents and previous incidents (Corbin & Strauss, 1990). This helps to guard against bias by challenging current concepts against new data (Corbin & Strauss, 1990). It also helps identify patterns and variations which must be accounted for, and helps develop and verify hypothesized relationships among categories which can then be revised as required (Corbin & Strauss, 1990).

To achieve the validation and achieve theoretical saturation, local crisis response operations were repeatedly visited to collect data through observations and interviews. Data from existing literature was also incorporated for comparison and analysis. When the categories became static the next step was theoretical coding.

3.3.5 Theoretical Coding

Theoretical coding is the process where the concepts covered in the categories are related together in a clear and distinct way to represent the theory (Giske & Artinian, 2007). Open and selective coding will have identified the concepts and any dimensions and variations within them. The use of memos will have organized thoughts and observed patterns in the data, organized categories of data, and identified relationships in the categories of data. Memo sorting at this phase of the research helps identify all of the concepts covered by the categories contributing to the core category (Giske & Artinian, 2007). This assisted in a clear and distinct coding of the theory that was generated from the data itself, is representative of the data, and has been validated by the data.

As a result, this step met the objective of developing a theory on context-aware multi-party coordination systems, while theoretical saturation was used to verify and validate the theory.

3.4 Role of Literature

Initial literature was reviewed and included as data later in the data collection cycle, in alignment with grounded theory methodology where "[t]he literature is not forgotten or ignored, it is put in proper sequencing of GT research phases" (Glaser, 2001, p. 139). Prior literature, including theoretical contributions, were also evaluated which helped

refine the emergent theory. This literature is discussed in the analysis and theory proposal chapters and is also used to assess the contribution of this study to both practitioners and academics.

3.5 Summary

This chapter provided an overview of what methodology was chosen to conduct the study and why. A qualitative study was established based on the exploratory nature of this research. The qualitative methods of action research, case study, ethnography, and grounded theory were compared based on several criteria and grounded theory was determined to be the most suitable method due to the desire to create a generalizable theory. The grounded theory variants were evaluated before the classical method was selected. The methodology process was then described and included data collection, analysis and conceptualization, theoretical sampling, theoretical saturation, empirical validation, and theoretical coding. Lastly, how literature was applied in this was mentioned as it use in grounded theory studies differs from other methods.

CHAPTER FOUR :: DATA COLLECTION

4.1 Introduction

In this chapter the participant recruitment and data gathering processes are explained. A breakdown of data sources is also provided to illustrate the breadth of perspectives that were collected. Lastly, a breakdown of the applied data collection methods outlines how data were collected.

4.1.1 Data Collection Approach

With grounded theory studies, everything is considered data and the researcher is encouraged to collect rich versatile forms of data (Glaser, 1978, 1992, 1998). For this study data collection was designed to deliver a comprehensive perspective on emergency response processes to try and capture the apparent complexity of disaster response. To achieve this, data sources were selected to study response issues that exist in regular emergency responses which may be compared to response issues in larger disasters. This process took place in two phases. The first phase was the collection of firsthand data using in-person interviews, direct observations of responders in the field, and direct observations of responders performing multi-agency training exercises. The second phase of data collection used alternative sources of data previously gathered by other researchers or media sources including prior academic studies, government investigations, media sources, and documentaries.

The two phases of data collection provided very different but relevant sources of data for use. Firsthand data collection permitted interaction and follow-up lines of questioning in an unstructured manner that were not available with secondhand data sources. Furthermore, direct observation provided additional insight and triggered additional questions to arise from the experience of the operating environment that were relevant but may not have otherwise been studied during secondhand data collection.

Secondhand data collection was used to ensure theoretical saturation and provide additional samples from data collection to address any experience gaps from primary data collection that arose from participants with limited participation in larger scale disasters. Secondhand data collection also provided theoretical saturation for a general theory with the inclusion of data collected from disasters which occurred in different parts of the world where different operating conditions exist. Together, the two sources of data collected in different phases provided complementary data that supported the emergent theory in this study.

4.1.2 Data Collection Tools

The required equipment for this research was acquired prior to the start of data collection. A digital recorder was used to capture interview data where permitted. An encrypted USB storage key was used for storing notes, contact information, and digital recordings of conversations. Notes using pen and paper were also used to record interview responses and to note observations during data collection sessions. Computing equipment was used

for dissertation development as well as theory development. Specifically, qualitative data analysis software, QSR NVivo 9 (NVivo), was acquired to store data that was collected, track notes or ideas that emerged from observations and data analysis, and to store reference data from other digital sources. NVivo was also used to organize the data into concepts and identify emerging themes throughout each iteration of the data collection and analysis cycle. Other expenses incurred included independent transcription services for some audio recordings, and travel to various locations around the province to collect data.

4.1.3 Timeline

The study was submitted for review to the university ethics review board on June 11, 2009. Anonymity of participants was perceived as the greatest concern due to the potentially sensitive nature of the operating environments that were to be encountered. There was only one minor clarification to the application confirming the ability of participants to anonymously withdraw from the study despite their employer's prior written approval. Final ethics approval for this study was received from McMaster University's research office on June 29, 2010. Data collection for this project started in the summer of 2010 shortly thereafter and concluded in the fall of 2011. Data collection was hoped to conclude within twelve months but delays in scheduling with participants extended the collection timeline. In addition, collection of data with one agency required a background check which took several weeks to clear, further delaying data collection.

4.2 Phase 1 - Firsthand Data Collection

Firsthand data may be considered very rich in that the medium used conveys much more information to researchers than can be collected using secondhand data. This particular firsthand data is also valuable as it provided a standard operating baseline for responders, and allowed identification of common problems that emerge during routine coordinated responses outside of special disaster cases. Unlike secondhand literature sources, additional information is available as researchers are able to observe and record responder reactions, interactions, and behavior which may otherwise be absent from other interview and descriptive data.

Furthermore, firsthand data collection and observation permits the exploration of other related avenues of thought that contribute to the responder operating environment including tasks and behaviors that are routinely performed with little thought by responders, which would less likely be mentioned during interviews.

4.2.1 Semi-Structured Interviews

Emergency response occurs in a dynamic environment with various processes and techniques dependent on the responding agency and the processes followed. As such, a general list of questions were asked to interview participants in order to guide responses to the topic being studied. Interviews were conducted with different levels of personnel from immediate responders to agency chiefs. While the interview questions guided initial responses, tangential questions that were relevant to the study were pursued as they

emerged over the course of the interview. A list of the guiding interview questions is provided in Appendix A.

4.2.2 Communication Center Observations

In addition to interviews, data were also collected from several shifts at communication centers for police and EMS. During these observation sessions an open interview of call takers and dispatchers usually took place between calls, and observational data regarding coordination of responses was recorded using pen and paper. Observational data included data on communication center setup and communication methods, as well as data collected from conversations overheard amongst emergency callers, call takers, dispatchers, and responders. Listening to caller-call taker and responder-dispatcher conversations was facilitated through the use of headsets allowing a one-way flow of audio with a disabled microphone so listening was unobtrusive.

4.2.3 Ride-Along Observations

During ride-alongs, EMS and Police responders were observed firsthand during their normal shift of work. During these periods unstructured interviews were conducted with the participant responders, usually shift supervisors, as well as observation of their interaction with dispatch, colleagues, and other agencies should an incident occur during the course of their work. The types of incidents attended included multi-vehicle collisions, injured and ill citizens, vehicle fires, theft, etc.

4.2.4 Multi-Agency Training Exercises

There was an opportunity to observe three multi-agency training exercises of different magnitudes. One exercise involved the response to an active shooter on a university campus. A second exercise involved the response to multiple shooters at an elementary school with multiple victims and secondary threats. The last exercise involved a multi-community, multi-jurisdictional, multi-agency exercise requiring responses to a multi-stage terrorist attack on a community with dozens of victims in need of rescue from a primary attack, and the threat of secondary and tertiary crises arising. During these exercises data were collected from observation of the emergency operation centers, or observation of responders in action with interview opportunities occurring during and post exercise where feasible.

4.3 Participants

Study participants for firsthand data sources were chosen from the typical set of first responders. These typical agencies include Fire Services, Emergency Medical Services, and Police Services. These groups are agencies the general public assumes are responsible for responding to all emergencies affecting society.

From preliminary discussions with members of these services, other agencies influencing disaster response at different scales were identified and they were selected to participate in the study as well. These agencies included health ministries, hospital emergency managers, and emergency managers from local to regional levels,

Using these participants, this study was able to incorporate the necessary input from key emergency response coordination agencies responsible for responding to disasters in the region where the study was conducted. The participants in the firsthand data collection phase were from police, fire fighting, EMS, and community emergency management organizations responsible for various aspects of emergency response operations in nine different geographical jurisdictions throughout Southern Ontario from the municipal to provincial level. They ranged in role and seniority from responders in the field, to dispatchers in call centers, to community coordinators, and to chiefs or deputy chiefs. Professional experience ranged from six months on the job to over twenty years working in emergency response.

Within the past two to three decades there have been several smaller scale disasters in the geographical jurisdictions served by these responders including large chemical fires, a major explosion, train derailments, tornadoes, pandemic scares, major snow storms, and major power outages. For all of these disasters, authorities have had to coordinate their responses.

Figure 3. Firsthand data collection territory

Table 3. Firsthand interview and observation participants

Agency	**Positions**	**Collection Method**		
		Interview	*Ride-out observation*	*Training observation*
Fire Services	Chiefs	●		●
	Deputy Chiefs			●
	Program Specialists	●		
	Firefighters		●	
Police Services	Chiefs			●
	Superintendents			●
	Sergeants	●	●	
	Operations Managers	●		●
	Police Officers		●	●
	Dispatchers	●	●	
Emergency Medical Services	Chiefs	●		●
	Deputy Chiefs	●		●
	Operations Managers	●		
	Continuous Quality Improvement Manager	●		
	Supervisors	●	●	
	Paramedics	●	●	●
	Dispatchers	●	●	
Municipal Manager	Community Emergency Management Coordinators	●		●
Regional Emergency Management	Deputy Chief	●		
	Interoperability Specialist	●		
Health Ministry	Operations Manager	●		
	Manager of Land Ambulances	●		

In total, 48 emergency professionals from the area were interviewed and directly observed, in addition to dozens of supporting personnel that were observed during various data gathering activities of semi-structured interviews, responder ride-alongs, communication center observations, and multi-agency training exercises observations. Data was gathered at a time that was preferred for participants. This included several night and weekend shifts for the various agencies, in addition to early morning shifts for the start of multi-agency training exercises.

The cumulative amount of time spent collecting firsthand data was 75.75 hours, broken down in Table 4 according to collection method and agency studied. There were three joint training exercises that involved at least two agencies, but usually involved many more agencies and internal special teams. A description of the exercises is found in Appendix B.

Table 4. Firsthand data collection mix (in minutes)

Agency	Interview	Observation	Total
Police	255	1500	1755
Fire	75	0	75
EMS	450	1410	1860
Other	135	0	135
Joint exercises	0	720	720
TOTAL	915	3630	4545

4.3.1 Participant Incentives

All of the participants worked for the public service and were participating in the study during their normal work hours. There were no incentives promised for participation. If the opportunity arose and where it was appropriate, simple refreshments such as coffee and a snack, or on occasion a few lunches were paid for by the researcher as a reward for participation.

4.3.2 Participant Recruitment

Upon receiving formal ethics clearance to conduct the study, previously known contacts were approached via telephone to discuss the research. The known contacts, in addition to providing valuable data, were also very helpful and provided referrals to relevant personnel at several key organizations. The known contacts permitted sharing their names in order to gain access to new leads. The referrals included Police, Fire, and EMS contacts in addition to supporting provincial agencies aiding in crisis response. Initial contact and discussions for recruitment took place using voice Skype, telephone, e-mail, and fax communication methods. After initial contacts were made, ethics documentation was distributed to these contacts either via e-mail prior to discussion or in person upon meeting them. Once an informed understanding of the nature of the research and explanation of the voluntary requirement for participation was achieved, it was then

further explained what information was sought from the particular participant and their engagement was confirmed. Signed participation forms were acquired where possible, but many participants who were willing to participate would not sign the form as they wished to remain anonymous. One agency produced their own participation form to sign as a researcher. The first leads to respond were municipal EMS and Police contacts.

Police Services

In order to secure Police approval to participate in the study, approval had to be sought up the chain of command. A police service covering a large jurisdiction was approached through a contact form on their website. They responded via e-mail within a couple of days and a phone conversation was arranged with a potential participant. In this case, the participant provided a referral to a research liaison at the headquarters that provided guidance through the ethics approval and research process for their organization. Their main concern was that their legislated FIPPA requirements for protection of data were followed. The liaison facilitated the approval process and a visit at headquarters was arranged where a research agreement was signed in the presence of the Superintendent. A successful police background check was also required to conduct research within the organization. Upon approval, data were collected from members of the police force using interviews, communication center observations, and ride-along observations. Data were collected from several regions from various detachments in addition to central headquarters.

Through other agencies an introduction was made to a municipal police force for a larger community in the province. Although initial meetings were promising, the police service initially declined to participate because of a perceived lack of value to their organization from the research. However, encouragement was provided to try again in several months as there was turnover taking place within senior positions. Several months later participation through observation was secured in two multi-agency exercises involving the services.

Other opportunities to observe police activities from a different region took place during a large-scale multi-agency training exercise. No formal approval was required for their direct observation as general approval was received from the coordinators of the multi-agency event who had received approval from all participants prior to the training exercise.

Fire Services

Fire department contacts were generally more difficult to approach for a number of reasons. Initial challenges occurred from a lack of available research collection opportunities as not all fire services allowed ride-outs. In addition, an opportunity to observe a large scale disaster training exercise was declined from a fire service because of new leadership and a perceived fear of being observed by an outsider while demonstrating substandard performance. However, interview opportunities for fire services were afforded by a chief of a large community as well as a representative from a provincial fire authority. Like the police, fire service participation also required

permission from the chain of command. While embedded observation time never occurred, different fire services were observed in two multi-agency training exercises that they participated in as well as during multi-agency responses that occurred during ride-along shifts with EMS.

Emergency Medical Services
EMS was very supportive of the research and leads were very helpful in arranging full access to their personnel and technology. EMS response is legislated and controlled by the Ontario Ministry of Health and Long Term Care (MoH), so the ministry was approached for approval and information. The ministry did not need to grant formal approval as, although a central communication infrastructure and guidelines are provided by the province, most EMS operations are managed locally by municipalities so in most cases permission was sought from individual regions. Interviews at several levels and locations were permitted in addition to communication center observations, ride-along observations, and observations from multi-agency training exercises.

Supporting Provincial Agencies
Through the early background interviews with known contacts, it was learned that there are a few other key organizations involved in emergency response to larger scaled disasters and disasters with specific causes. Some of these agencies included Ministry of Health and Long-term Care (MoH), the Ontario Fire Marshall's Office (OFM), and Emergency Management Ontario (EMO). Arranging participation with these organizations only required their permission and not a formal research plan as ride-outs or other direct observation of personnel were not being conducted within these provincial agencies. Leads in these organizations were contacted and they permitted interviews to be conducted. A visit to the provincial EOC was arranged during an interview.

In addition to the agencies mentioned above, interviews took place with two community emergency management coordinators (CEMCs). CEMCs are personnel that are employed by municipalities or regions that help liaise and coordinate with other municipal resources and the province should an emergency need arise.

Overall, participants and leads were very supportive of the research plan and agreed to interviews to collect background information on crisis response coordination. In most cases, the leads also happily provided contact to additional leads, and all interviewed participants agreed to follow-up questions should the need have arisen.

4.4 Phase 2 - Secondhand Data Collection

Data were also collected from secondhand sources to supplement the data collected from interviews and observations. The use of secondhand documents takes advantage of other people's observations and provides more data from relevant environments while eliminating the need for direct observation of those environments.

Furthermore, unless researchers are in the field during a disaster, it is nearly impossible to directly observe large scale disaster rescue efforts. The infrequency of large scale

disasters, the complexity of relationships amongst responding agencies, and the urgency of response makes observation of response very difficult, and also makes it difficult to interact with responders to gather data. It is usually necessary to interview responders after the response has concluded. Secondhand sources provided convenient access to relevant information from people who were at a disaster or interviewed responders to a disaster.

The documents used for secondhand data sources provide very detailed and valuable information which were gathered by credible agents and research institutions. By limiting data to credible sources there is an expectation that the data collected is factual and is an accurate representation of the conditions of the disaster response. These data are therefore suitable to incorporate into this study.

The secondhand data sources also cover a much broader variety of situations, addressing a variety of issues, and representing events that took place over a span of several years. Data of this breadth would also be very difficult to gather firsthand. The variety of secondhand data enables the identification of commonalities amongst several otherwise separate disasters and responses.

Secondhand sources reviewed included newspaper articles, internet reports, books related to disasters, documentaries, and quick response research reports, and government reports.

Internet searches initially performed using both Google Scholar (http://scholar.google.com) and regular Google search (http://www.google.com) were used in order to identify potential secondhand data sources. Search terms included "multi-agency coordination", "crisis response coordination", and "disaster response coordination". Other related derivations that may have arisen from preliminary search results were further used to perform searches for relevant material. Scanning newspaper websites for relevant and timely news articles was also performed. When search results led to an electronic database or directory of potential resource materials, searches were performed on the materials contained or articles were skimmed for initial relevance. Identified articles of interest were then stored in electronic PDF format where possible.

The second hand sources were examined for data only. Any theoretical propositions or conjecture made by authors was ignored. Statements of fact and observations of environmental conditions as well as communication and behavior amongst responders and decision makers were considered as data.

4.4.1 Secondhand Data Sources

The main second hand data sources that emerged from the search process were Quick Response Reports from the Natural Hazards Center of the University of Colorado at Boulder, and reports from the United States Government Accountability Office (GAO).

These two sources were mainly used for the secondhand data sources as they are two existing repositories of high quality data covering several disasters over several years in several locations.

Specifically, the Quick Response Reports are a series of studies that gathered data during and shortly after a disaster. Frequently, a team of researchers would travel to the location of a disaster and interview the responders or city professionals to gain a better understanding of how that particular disaster was being managed, while other times responders and officials were interviewed after the event.

The GAO is an independent agency that works for the United States Congress. Commonly referred to as the "congressional watchdog", the GAO examines how the US government spends taxpayer's dollars and performs a variety of tasks including auditing agency operations and reporting how well government programs and policies are meeting their objectives. The GAO developed several reports on the performance of governmental agencies responding to several disasters affecting the United States, or where participation of the United States was required at locations around the world.

Table 5 and Table 6 contain a summary of the number and types of different sources used. These sources covered disasters such as major hurricanes, tornadoes, tsunamis, terrorist attacks, ice storms, pandemics, floods, and earthquakes.

Table 5. Secondhand data collection mix

Secondhand Source Types	**Number of Sources**
Quick Response Reports	21
GAO Reports	37
Documentaries	10

Table 6. Events, years, and locations in secondhand data

Event	Event Year	Country/Region
Hurricane Fran	1996	USA (North Carolina)
Hurricane Georges	1998	Dominican Republic
Earthquake	1999	Turkey (Marmara)
Tornadoes	2000	USA (Fort Worth)
9/11 Terrorist Attack	2001	USA
Wildfires	2002	USA (Colorado)
Earthquake	2004	USA (California)
Hurricanes Ivan and Charley	2004	USA (Florida)
Earthquake and Tsunami	2004	Indian Ocean
Hurricane Katrina	2005	USA (Gulf Coast)
Tornadoes	2007	USA (Florida)
Tornadoes	2008	USA
Earthquake	2010	Haiti
H1N1 Pandemic	2010	USA

4.5 Data Cleanup and Organization

Once observational and interview data were collected, the notes were transcribed into a Word document electronic format for easier manipulation. This also included any permitted audio recordings of interviews. The first hand data and any identified second hand data sources that were collected in PDF format were then imported into NVivo qualitative analysis software.

The data to be extracted from the sources were objective facts and statements. However, memos were also created from instances of collected data which were used to explore relationships, describe impressions of the research or participants, and identify emergent themes. These memos were created and stored in Word document electronic form and imported into NVivo.

The conceptualization process involved merging, clarifying, and splitting, and eventually categorizing the concepts that were represented in the data. The purpose of this process was to define distinct individual concepts that had no overlap with other concepts yet

were fully represented and supported in the data. Because of the repetitive cycle between conceptualization and analysis, this process is described in further detail in the next chapter on data analysis.

4.6 Summary

In this chapter the data collection process for this study was described. Data was collected in two phases consisting of firsthand data in the first phase, and secondhand data in the second phase. Data collection was an iterative process, with analysis occurring after each collection session and being used to direct subsequent data collection sessions. Over 75 hours of firsthand data was collected from dozens of emergency responders and related emergency managers across Southern Ontario during interview, ride-out observation, and training exercise observation sessions. In the second phase, data was collected from close to 70 documented sources including US Government Accountability Office reports, Quick Response Reports from the Natural Hazards Center at the University of Colorado at Boulder, and film and television documentaries, which together covered disasters from around the world. The collected data was entered into a software program that supported qualitative analysis and conceptualization which is discussed in the next chapter.

CHAPTER FIVE :: DATA ANALYSIS

5.1 Introduction

This chapter is divided into several parts. First, a description of the common disaster response actors, processes, and technology used is described as provided by participants. This provides the background context for the remainder of the analysis. These agencies usually performed specific roles in the response process and required coordination efforts with responders. Together the typical responding agencies and tasks provide much of the information to consider when analyzing disaster response coordination. The next section offers a description of the data analysis process used for concept development, and is followed by a description of what major category emerged from the analysis. Lastly, the lower-level concepts that emerged from data collection and analysis are organized into the emergent categories or themes and are described as they contribute to the theory development in the next chapter.

5.2 Actors, Processes, and Technology

Many assumptions about the processes of routine emergency operations and the level of integration amongst first responders are frequently misunderstood. As a result, it is necessary to provide a common understanding of the general operating processes and the actors involved in this study prior to the development of any new theory.

An initial overview of general emergency management literature describes many of the challenges and processes that take place during emergency response. The literature also lists the numerous actors that may contribute to a disaster response. In this study, participants were also a valuable source of information since they described the general response processes and identified the agencies with which they usually interact.

While the specific responders, organizational hierarchies, processes, and equipment may vary around the world, general feedback on types of personnel, processes, and activities that are required during an emergency were gathered and documented. As a result, the understanding of processes and actors during emergency response processes helped identify research areas that informed this study , and enabled the development of concepts that are consistent with current operating norms.

5.2.1 Response Agencies and Volunteers

For most people, emergencies are a dramatic shock to everyday life, but for first responders it is part of their everyday routine. There are several agencies that people associate with regular emergency response processes -- local police, firefighting, and emergency medical services are the most common. Occasionally, even on a smaller scale, an event may occur that will require the engagement of municipal departments and ancillary support organizations such as utilities and infrastructure support companies. As events increase in scale, complexity, and resource requirements, regional government emergency management professionals, government ministries, national emergency management professionals, non-governmental organizations, military, and other

Table 7. Disaster response actors and responsibilities.

Group	**Typical Responsibilities**
Police Services	• search and rescue • crowd control • public safety • responder safety • counter-terrorism/counter-criminal activities • basic first aid (if required)
Fire Services	• firefighting • search and rescue • basic first aid • damage prevention • Chemical Biological Radiological Nuclear and Explosive (CBRNE) cleanup
Emergency Medical Services	• first aid • medical transportation • responder medical support
Local Emergency Management Professionals	• small-scale disaster response planning • inter-agency coordination and resource acquisition • public communication
Regional/National Management Professionals	• larger-scale disaster response planning • inter-agency coordination and resource acquisition
Government Ministries	• medical support and field hospitals • public communication • specialized department support
Military	• counter-terrorism activities • security • engineering support • additional man-power and equipment support • transportation • medical support and field hospitals
Non-Governmental Organizations (NGOs)	• mass casualty management • resource distribution to public • first aid services • shelters
Other Organizations and Utilities	• infrastructure support • resource provisioning
Emergent Groups and Volunteers	• search and rescue • resource provisioning • first aid • notification and public communication

supporting organizations may be called upon to respond if necessary. Volunteers may also come together and lend aid in times of need (Quarantelli, 1988). Table 7 provides a summary of the types of responders as well as their typical responsibilities as provided by study participants giving background descriptions. A more detailed description of each group follows.

Police Services
During emergency responses, police frequently have the primary roles of securing and protecting the public. This usually requires cordoning off an area to prevent non-responders from entering a dangerous area, or protecting responders from interference by non-responders. Depending on the nature of the emergency, police may have an active role in the cessation of criminal activities, or participate in search and rescue activities to find or track down missing individuals. Identification of victims or persons of interest may also be a task performed by police services. Many police personnel have basic first aid training to help those in immediate need when more appropriate medical aid is absent.

Fire Services
The role of fire departments is primarily firefighting, but it is also frequently one of rescue. The range and variety of rescue depends on the nature of the pressing threat, and the experience, training, and equipment available to the rescuers. This role can lead to tasks such as extraction from a building or extraction from vehicles, trains, planes, and other precarious situations such as cliff sides. In addition to rescue tasks, fire personnel will also be responsible for preventing the spread of any chemical or fire damage that may result from a disaster. Fire personnel may also perform first aid on injured people.

Emergency Medical Services (EMS)
In some jurisdictions the role of EMS is a joint role with Fire Services where EMS personnel may perform many of the same rescue tasks that Fire Services personnel perform, with the exception of extinguishing fires. In other jurisdictions, paramedics have more advanced medical training and do not perform rescue operations; they operate independently of fire services. EMS personnel generally offer first aid assistance to those who are injured or ill, and stabilize for transportation to hospitals those who are more seriously injured or ill. In many circumstances, EMS will provide a supporting role to police or fire services in case any of those responders get injured performing their job. It is common for paramedics to attend a fire scene in a support role for firefighters who may succumb to physical threats and stresses encountered during the response effort. With police and other special units, it is becoming more common for paramedics to be trained to tactically respond with those special response units in order to support them should anybody get injured during the response.

Local Emergency Management Professionals
Local emergency management professionals usually have a role in establishing community response plans. They are not traditional responders, but coordinators that are engaged when an emergency becomes of sufficient magnitude to affect the safety of a segment of the community and the scope of an incident requires a larger multi-agency

response. Such disasters may threaten or utilize a disproportionate number of local resources, and may require a coordinated response from several functional areas, departments, or jurisdictions within a community or the greater region. Local emergency management professionals are responsible for liaising with higher regional or national emergency management professionals to provide status updates, interact with other agencies such as social services or community health services, and to secure necessary resources that may not be available locally. Local emergency management professionals may also be responsible for organizing communication of information to the public, although the actual information is usually communicated from commanders in the police, firefighting, or EMS departments.

Regional/National Emergency Management Professionals
Regional and national emergency management professionals have a role in establishing broader regional or national emergency response plans. These organizations frequently monitor major emergencies as they transpire within their operational jurisdiction and may pre-alert agencies to a pending call to action. However, they usually are not involved in community responses unless a state of emergency is declared at the community level. In those situations these professionals act in the role of coordinators and facilitators for interfacing with various organizations that have the resources, training, or personnel required for an effective response and work to connect these resources with the local response effort where required. These professionals are also responsible for managing and coordinating information and resources across a broader area, as more than one municipality may be involved in a disaster response.

Government Ministries
Government ministries may be called for assistance depending on the nature of an emergency. Energy departments may get involved in nuclear response cleanup while environment ministries may oversee a chemical cleanup. In situations having numerous casualties and risks to public health such as pandemics, health ministries may play a role.

Health ministries may also play a role in managing EMS. While in many jurisdictions EMS services are managed directly by hospitals or private subcontractors, in other jurisdictions they are managed centrally by a health ministry. The same ministry may also be responsible for managing or regulating hospitals. Depending on the nature of an event, and specifically those that have a large number of injuries and fatal casualties, the health ministry will establish protocols to manage patients, assign the medical care providers required for response, as well as allocate medical resources and supplies that may be required to perform a disaster response.

Military Personnel
The military may be called upon on occasion to aid in a disaster response. Usually self-sufficient, the military may take on several roles during a disaster response ranging from transportation provisioning for search and rescue missions, transportation of critical resources for responders and non-responders alike, providing additional manpower for recovery operations, establishing temporary power and communication infrastructure,

providing security to responders and non-responders due to a breakdown in regular law enforcement, or setting up field hospitals and temporary camps to help victims of a disaster.[10]

In some situations the military may also assume control of ports or airspace to aid transportation centers suffering from damaged infrastructure. Also, the military have additional information resources they may be willing to share with other responders (Transnational Information Sharing Coalition [TISC] Joint Capability Technology Demonstration [JCTD]).[11]

Non-Governmental Organizations

NGOs or charitable organizations may have experience responding to large numbers of people in need. Typical roles provided by NGOs include food, shelter, and clothing acquisition and distribution where required, medical care and medicine provisioning, mass casualty management, and grief or trauma counseling. Many of these organizations setup and operate independently inside regions of great distress, or they may have established relationships with governments and may have agreements to assume part of the response role so that other response agencies have their resources freed for other tasks. The International Federation of Red Cross/Red Crescent Societies are a group of national NGOs that specialize in disaster response. They frequently have pre-established agreements with different nations to offer humanitarian aid and mass casualty management during disasters.

Other Organizations and Utilities

Public utilities or local community organizations may also be called upon during a crisis response. The range of services required can vary widely depending on the nature of the emergency and the required response. In situations where damaged or active utilities are a threat to responders and the public, utility companies may need to shut down power before restoring services. This can occur with damaged or downed power lines, or broken water mains that need to be shut down to prevent flooding areas. However, it is more likely that utilities need to restore damaged power, communications, or water operations so that responders and non-responders have what they need to carry out their duties or simply to survive. Other non-traditional organizations may be called upon to provide food, power, shelter, or equipment for responders and non-responders due to the overloading of traditional resource providers and supply channels. Retail outlets may make water and food available to the public, or they may provide goggles, masks, and gloves to responders such as retailer reactions during the 9/11 attacks in New York (Weber, McEntire, & Robinson, 2002). Lastly, some organizations may have specialized skills and equipment that may be required during the response so they may be called in to assist. Construction companies with heavy lifting cranes may be required to remove large

[10] http://www.cbc.ca/news/canada/story/2010/01/13/f-disasters-military-dart.html

[11] http://www.globalresearch.ca/a-haiti-disaster-relief-scenario-was-envisaged-by-the-us-military-one-day-before-the-earthquake/17122

pieces of broken buildings e.g. during the response to the mall collapse in Elliott Lake, Ontario.[12]

Emergent Groups and Volunteers

In times of need a group of individual volunteers may self organize to try and meet community needs. There is usually a lack of professional support available which triggers the formation of emergent groups (Quarantelli, 1988). These groups may contact other responders to inform them of their availability to assist, or they will do what they can independent of a formal response effort. Individuals may also contact authorities and volunteer their time and resources as well. The volunteers and groups may participate in any range of activities they feel addresses the current local needs of the community (Drabek & McEntire, 2003).

5.2.2 The Response Process and Escalation

Besides describing the actors involved in emergency and disaster response, the study participants also provided information on how emergencies escalate to a disaster. The response process outlined in Figure 4 is used to describe the response with and without prior advanced warning of a pending disaster.

An initial disaster response will vary depending on the information that is provided to emergency call-takers. Advanced warning and alert systems may notify emergency responders of a pending emergency, but it is usually the public that first informs call-takers of an emergency event. Such was the situation in Goderich, Ontario where an uncharacteristic series of alarms were triggered by a tornado which led to automated phone calls to police by security companies (Police Participant, personal communication). Phone calls are commonly received at a central call-taking center, commonly run by police, before they are routed to the appropriate response agency. No information is collected on the call prior to routing. Once routed, dedicated agency call-takers collect information on the caller and the type of emergency requiring a response. This information is routed to a dispatcher using a computer aided dispatch (CAD) system.

[12] http://www.cbc.ca/news/canada/story/2012/06/26/f-timeline-ellliot-lake-mall-collapse.html

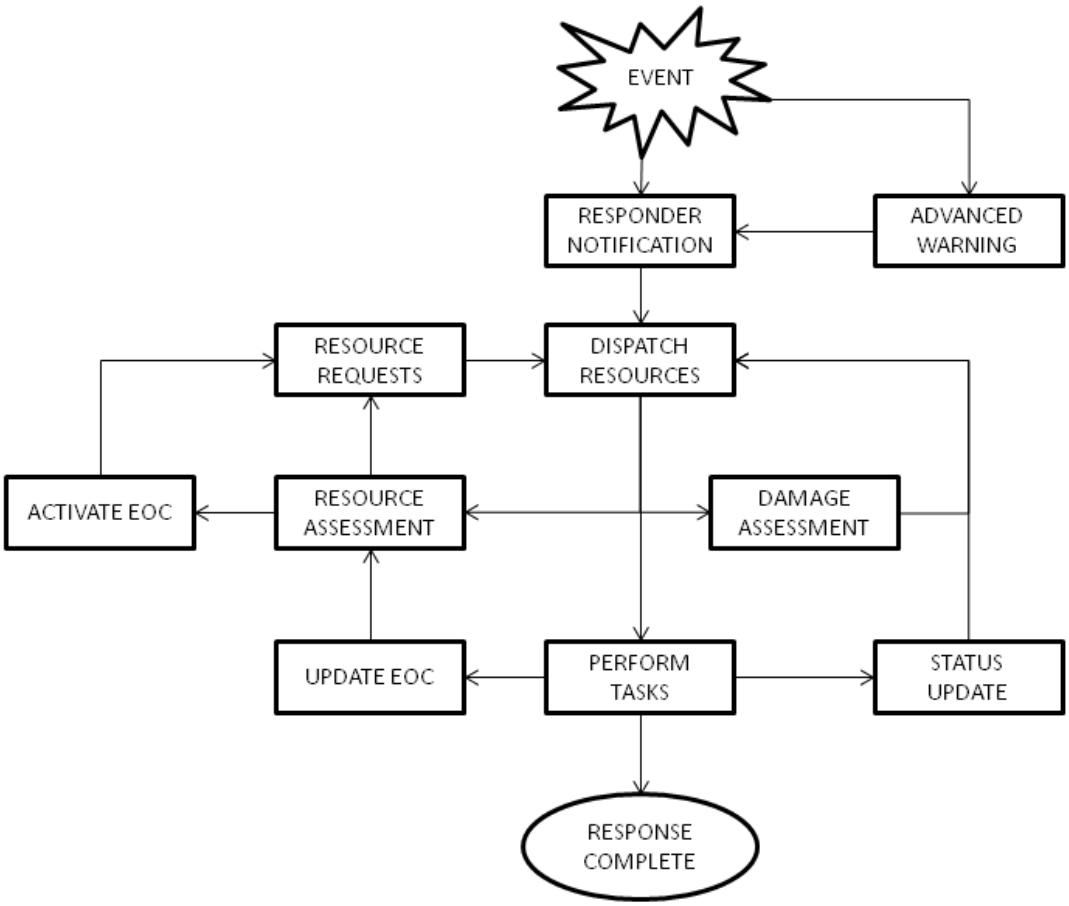

Figure 4. Emergency response and escalation process

If a single call is received, a limited number of resources will be dispatched to the scene of the emergency. Similarly, if a single call is received indicating a large response is required then a limited response may be dispatched until the size of the emergency can be verified through a damage or risk assessment. However, if several calls are received indicating a major problem then more resources are likely to be dispatched. Certain types of emergencies will trigger a joint response with other agencies, so those agencies will need to be notified by dispatch or dispatch supervisors.

As resources are dispatched to a call, the emergency dispatcher will quickly assess the remaining resources available to cover the region or territory being monitored, or to assist in an emergency should a situation escalate. As a demand for specific resources grows from calls into dispatch, or from requests from responders on scene, dispatchers will communicate with agency supervisors in the dispatch centers to request more resources. Pre-arranged mutual aid agreements may be engaged, specific agency support teams may be engaged, off-duty or on-call responders may be called-in to assist, or neighboring regions may be informed of a shortage and additional resources will be requested.

If there is an advanced warning of a possible threat to community safety, then responder managers may pre-arrange additional supporting human and material resources if they are available, and they may instruct emergency dispatchers to pre-position responders nearby to potentially affected areas, or to engage in disaster prevention or mitigation activities according to an emergency response plan. As the disaster commences, the dispatchers will then use information from responders, as well as information from call takers to instruct responders on the appropriate course of action to be taken. Once again, as demand for resources grows, the dispatcher assesses the resources available to respond, and may arrange additional resources with the aid of supervisors.

Depending on the scale and nature of a disaster, dispatchers may be specifically assigned to manage responders tasked with the emergency response, while other dispatchers manage routine operations outside of the event.

Requested support that arrives on scene may be managed by the dispatch of the requesting agency if communication equipment is compatible and pre-arranged agreements permit. However, in most circumstances the requesting dispatch will be communicating via telephone with the supporting dispatch, which will then communicate via radio to their responders to coordinate response.

If there is a joint command established in a staging area, then that command will assume operational control of the local response, and dispatch will fall back to a supporting role to manage resources and provide information as requested by scene command.

If local command determines an emergency is of sufficient scope, they may request the activation of a local emergency operation center (EOC). With the engagement of the EOC comes additional support in coordinating the acquisition of resources from non-traditional supporting agencies and jurisdictions. If a hazard has a broad effect across a region then local EOCs will engage other municipal, and possibly regional support that may require the activation of a regional EOC. A hazard of sufficient scope from the perspective of regional EOCs could escalate and require activation of a national EOC.

If there is advanced warning of a threatening event that is of sufficient scope and impact then higher level EOCs and disaster response plans may be engaged to protect the public and plan for the response during and post-event.

At that point in time, the disaster response effort should be fully engaged by responders and decision makers at all levels. Responders will complete specific response activities as required based on decision making priorities and context information regarding the disaster.

As tasks or the disaster situation changes, responders, dispatch, local joint commands, and EOC members are to be updated. Finally, as the major response tasks are completed, the disaster response effort concludes and long term disaster recovery can begin.

5.2.3 Emergency Response Tasks

Because of the complexity and nature of issues brought about by disasters, it is extremely difficult if not impossible to pre-determine all of the specific tasks that may be required during an emergency response. However, from participant feedback and supported by literature sources it is possible to identify the major categories of response tasks. These tasks may have varying urgencies depending on the nature of a disaster. They also encompass a series of smaller situation-specific activities that may be performed by one or several agencies in order for a task to be successfully completed. The major tasks are: i) acute security and protection; ii) acute search and rescue; iii) mass medical treatment; iv) acute damage mitigation; v) resource acquisition and allocation; vi) mass casualty management; vii) communication with community; viii) disaster escalation mitigation; and ix) infrastructure restoration. These tasks are described below along with a description of common activities that may be required in order to complete them.

Acute Security and Protection

Imminent threats to citizens or responders may occur during a disaster which can create a heightened need to protect people or responders. This protection could involve the prevention of non-responders from interrupting the response process, keeping non-responders safe by barring them from areas of danger, routing citizens to safe locations and securing evacuation routes, or escorting responders to areas having a risk of violence. In extreme cases of criminal or terrorist threats security and protection activities could entail the elimination of threatening parties. Activities addressing security and protection are usually managed by police or military personnel.

Acute Search and Rescue Activities

After a disaster occurs there is frequently an immediate and urgent concern to find and rescue victims of the disaster, remove them from harm's way, and obtain any medical attention they require. Depending on the nature of the disaster, these search and rescue operations are usually performed by fire services, police services, or specialized search and rescue personnel while EMS services treat victims on site or transport victims who require medical attention to the appropriate medical facilities.

Mass Medical Treatment

While deaths can occur in large numbers, even greater numbers are usually injured and require medical attention during and following a disaster. Depending on the urgency of injuries and availability of medical personnel, the injured will be triaged and either treated on site or transported to hospitals for care. In some cases temporary hospitals or field hospitals may need to be established to manage the needs of those injured. EMS responders may provide basic care as well as transportation to hospitals for those more seriously injured while medical personnel will manage the hospitals. Police, Fire, and any responder group with first aid capabilities may also assist in more limited immediate capacities until proper medical treatment is available.

Acute Damage Mitigation
While search and rescue activities are important, sometimes a disaster event may cause immediate damage and destruction to property, or may place an immediate potential risk to people's lives. With damage mitigation, responders seek methods to prevent or limit the likelihood or severity of risk to the local population. For example, an earthquake could cause a building's infrastructure to weaken, or it could cause a fire that was putting a neighbouring building at risk. In these cases, responders will seek to prevent the spread of property damage where possible, or they will arrange for the support or destruction of destabilized property. In another example, a person infected with an extremely contagious and life threatening virus may be isolated and quarantined, while others who may have been exposed to the individual are also quarantined for a period to prevent the potential spread of an infectious disease. Activities addressing physical threats are usually performed by fire services with the support of engineers where required, while EMS services usually manage medical threats.

Resource Acquisition and Allocation
A lack of available resources is what often turns a routine emergency response into an emergency for responders as they scramble to acquire enough resources for the response. This can affect all types of responders and usually involves a shortage in special equipment, personnel, resources or any combination for the response. In addition, a disaster may create a need for more common resources for both responders and non-responders alike such as food, shelter, and clothing. During periods of flooding, for example, water sources may become contaminated so fresh water will be a necessity for both responders and non-responders to consume.

Mass Casualty Management
Particularly devastating disasters can cause the death of dozens, hundreds, or thousands of people in a very short time which may overload traditional casualty management mechanisms. Exposure of the population to decaying corpses can lead to the spread of disease and infection. As a result, managing dead bodies becomes a priority. In addition to removing bodies to prevent the spread of disease, bodies also need to be identified so that families may put their loved ones to rest properly. Mass casualty management may be managed by NGOs such as the Red Cross, or other local medical personnel.

Communication with Community
Information exchange with the media and community is an important part of disaster response. Responding agencies are able to keep the population informed of the response plan, and any precautions non-responders should take to stay safe. Often it is the public media which has better communication channels so responding agencies must manage their relationships with media to ensure the latest and most accurate information is provided to the population.

Disaster Escalation Mitigation
It is possible that an initial disaster may trigger future potential problems. When this is determined, decision makers may hold back resources or assign personnel to tasks of

secondary damage mitigation, secondary security and protection, or secondary resource and acquisition activities in order to mitigate future threats to the population. For example, an earthquake may cause severe damage to the infrastructure of a city and cause many injuries to citizens. If the earthquake originated in the ocean, response to earthquake victims may be delayed until any threat of a potential tsunami has eased. An early response could lead to the loss of responder lives and worsen the overall disaster response. Disaster escalation mitigation activities may involve one or many responding agencies.

Infrastructure Restoration

Many disasters knock out key supporting community infrastructure such as power and communication. Restoring the damaged infrastructure with short term solutions is often a priority for emergency managers because the infrastructure is needed to assist in the response process, as well as to prevent an escalation of the disaster for those in the community who need the infrastructure to survive, or who need the infrastructure to protect sensitive resources. For example, an extended power outage for a hospital could put stored medications at risk if they spoil because refrigeration units shut down. Damaged communication infrastructure will limit the coordination activities of responders until a work-around is in place or the infrastructure is repaired. Infrastructure repair is usually managed by community departments, public utilities, and private corporations responsible for managing key infrastructure, although some responder agencies may have workarounds at their disposal such as police or military services setting up temporary communication systems.

5.2.4 Information Flows in Multi-Agency Responses

With an understanding of response escalation processes and typical tasks to be performed by responders, it is also important to consider how information flows during a multi-agency emergency. A typical response organization such as police, fire, or EMS may have several operating groups or departments within the organizational hierarchy. These groups will have an internal chain of command as well as integrating with the organizational chain of command. Information flow within groups of an organization will usually flow in two directions, from bottom to top of the chain of command, and from top to bottom. The nature of the information flows may be different where upward flows are usually more information oriented such as situation updates, and downward flows are more action oriented communications such as orders.

Intra-organizational communication within the same agency may also take place via inter-group communication. These inter-group communications are usually bi-directional and horizontal across organization structures and consist of information updates and requests for assistance. Official communication between groups is usually limited to official liaisons within the organizational chains of command and can occur at one or more levels of inter-group hierarchies.

When responding to a disaster event, several organizations may be involved, which can complicate communication. The responding authority will have responsibility for

managing the response effort, but may require the assistance of several organizations to do so. In such circumstances, information flows move from intra-organizational communications to inter-organizational communication.

Ignoring any technical components to inter-organizational communication, the identification and communication amongst disaster stakeholders intensifies the complexity of the response. Not only must organizations manage information flows internally, they must now consider the information that should be shared with other organizations, whether or not they should share that information, who is entitled to the information, and how are they going to communicate the information. Organizations frequently have liaisons that are responsible for information exchange with other organizations, although who those people are may vary depending on the organization being communicated with, and people may only be sharing information from one group within one organization, to another group within another organization.

5.3 Data Analysis Process

The data collection process described how collected data were transcribed or collected in electronic format and then it was imported into the qualitative research software NVivo. Once in NVivo, documents were analyzed and coded for concepts. Concepts were passages of data or key observations that indicated or stated the actions performed during response. In addition, any motivational information expressed by responders for why actions were performed was also coded.

Any perceived explanations for the motivations of responders were tracked in the creation of memos. Memos also tracked any perceived relationships that emerged amongst concepts.

In NVivo, concepts were created and tracked using the software's Nodes capabilities. Nodes permitted identification and grouping of concepts. When a particular passage of data was encountered which was thought to influence emergency response coordination in any manner, a new node was created and a name was given to the node to represent a general concept contained by the data. Some data passages could convey multiple nodes and the software allowed the creation of several nodes within a data passage. If the data passage resembled a previously identified node, it could be also be coded as belonging to the previously identified node. In this way the nodes were used identify low-level concepts. These nodes were further grouped into a hierarchy for more abstract groupings. NVivo also permitted the visualization of relationships amongst nodes.

Figure 5 is an excerpt from a document which illustrates how stored data in NVivo software were analyzed and NVivo software tools were used to highlight examples and code the concepts they represent. Authors' opinions were not coded so as not to bias interpretation of the open codes.

PROGRESS

When compared to the findings of earlier studies, this evaluation of the response to Hurricane Georges shows evidence of improved relief operations. Areas witnessing progress include an immediate declaration of the disaster, the distribution of appropriate and usable aid, a higher degree of coordination among humanitarian actors, increased experience and training of relief workers, and the integration of humanitarian assistance and development. These issues will now be discussed in order.

Immediate Declaration of the Disaster

This investigation reveals that the Dominican government quickly declared a state of emergency after the disaster and likewise established a curfew that same night to prevent any social disturbances that might have arisen.49 Respondents also noted that numerous government agencies started to work right away to clean up the debris that Georges left and to provide relief to its numerous victims.50 Furthermore, those interviewed observed that political officials did not delay in requesting assistance from the international humanitarian community.51 Thus, the government did acknowledge the disaster as well as its need for help from outside sources.

response speed
declaration of emergency status
escalation mitigation
response speed
resource request
multi-agency communication

The Distribution of Appropriate and Usable Aid

Findings about the nature and provision of aid in this research project are not conclusive as many of the respondents had no comment on such questions or were not aware of any difficulties in this area.52 It appears on the surface though - in spite of minor and normal problems that could arise in any large relief operation - that donors and relief providers were "much more conscious" about what they were giving to the victims of Hurricane Georges.53 Four examples support this view. First, while a few of those interviewed asserted that there was too much clothing being provided,54 the greater number did not mention an excess of any other particular type of aid.55 A Program Manager for the United Nations even doubted that an overabundance of relief was possible.56 Second, although there was one reported case of diet medicine showing up in relief supplies,57 there was no additional evidence of aid being sent which was not requested. This is probably due to the fact that non-governmental organizations relay pertinent information to prospective donors.58 Third, and despite the fact that a truck delivered contaminated water to a shelter,59 there were no further reports of unusable aid. In fact, some respondents were impressed by the quality and condition of the aid that was arriving.60 Forth, there was agreement among those interviewed that the aid was appropriate for the disaster context. This could have been due to the fact that donors attempt to communicate frequently with victims and their representatives in disaster areas,61 or also because some non-governmental organizations receive money from international donors and are able to buy the necessary goods and supplies locally.62 Only one respondent replied that he had seen relief that was inappropriate for the disaster context (i.e. winter coats in a tropical climate).63 Therefore, it appears that aid was generally beneficial to the victims of Hurricane Georges.

received
resource quality
demand assessment
resource quantity
supply assessment
resource appropriateness
information sharing
received
resource quality
resource appropriateness
needs assessment
multi-agency communication
resource acquisition
resource conversion
resource inappropriateness

A Higher Degree of Coordination

The low level of collaboration among various agencies and organizations has long been a criticism of relief operations, and the respondents' view of Hurricane Georges in this study was not significantly different. For instance, a Program Development Specialist for USAID stated that everyone in the public, non-governmental and private arenas was doing their own assessments of the disaster.64 A Red Cross official stated that the Civil Defense did not advise them of where the shelters were going to be located.65 Also, a respondent stated that some organizations were working alone in various parts of the country.66 Yet the interviews of this study also indicated that coordination was a significant feature of the relief operation after Hurricane Georges. As an example, officials from foreign nations worked closely with the Dominican government to help fulfill victims' needs.67 Non-governmental organizations in the Dominican Republic interacted with other domestic and international disaster relief agencies.68 Local social groups and other humanitarian organizations were in constant contact with emergency managers in the Dominican Republic.69 Government officials received assistance from businesses in the private sector.70 Churches consulted with the Civil Defense and non-governmental organizations.71 Finally, churches, humanitarian agencies, and governments were exchanging information and assistance with counterparts and/or various branches of their respective organizations.72 It is probable that coordination was more prevalent in the response to Hurricane Georges than in the relief operations of 20 years ago. Respondents felt for the most part that "it is impossible to work without collaboration" as coordination facilitates the sharing of resources (i.e. information and supplies) and minimizes the duplication of effort.73

work duplication
damage assessment
response authority
insufficient notification
agency independence
response authority
international
resource sharing
multi-agency/multi-national
communication
resource sharing
multi-agency communication
multi-party information and
resource exchange
information sharing
resource sharing
work efficiency

Figure 5. Open coding sample excerpt from Weber, McEntire, & Robinson (2002)

Table 8. Theoretical memo sample from Figure 5 excerpt (Weber et al., 2002)

Concept	Open Code	Memo
Declaration of Emergency Status	Declaration of Emergency Status	Emergency status appears to play a very important role in emergency response. Its declaration triggers different protocols and response behaviours. It informs the public that special rules are now in effect. It is also a required condition for some international organizations to provide resource assistance. Without an emergency declaration, some agencies will not be able to assist.
Task Performance	Response Speed Escalation Mitigation Work Duplication Work Efficiency	The ability to complete a task in a timely and effective manner, and the output of the task execution influences the overall perspective on task performance. Several of the open codes can be grouped into such a concept of Task Performance. Successful execution of disaster mitigation tasks as part of a response will minimize potential problems from worsening the disaster situation, which is a positive result. Mitigation actions themselves may or may not require the coordination of several parties. In addition to the effect of the action, how quickly a task is accomplished, and how resources are utilized will also influence task performance. A quicker response is generally better, while the proper allocation of resources on completing tasks can also be used to assess task performance. Work redundancy can inhibit response capabilities by over-utilizing resources, while efficient work by responders leaves resources available for other tasks.
Resource Management	Resource Request Received Resource Quality Resource Quantity Resource Appropriateness Resource Inappropriateness Resource Acquisition Resource Conversion International Resource Sharing Resource Exchange Multi-party Resource Sharing Resource Sharing	The management of resources, such as acquisition and allocation, are important contributors to disaster response since local resources are frequently destroyed or insufficient to supply the needs of the public and responders. Resource appropriateness, which can be summarized by resource quality and quantity are necessary to ensure that the available resources are applicable and sufficient for the situation. Resource sharing amongst response agencies is also a method of acquiring and allocating resources. The codes could be represented more simply by a concept of resource management.
Multi-Agency Communication	Multi-Agency Communication Multi-National Communication Multi-Party Information Sharing Multi-Party Information Exchange	Communication and sharing of information amongst responding agencies appears to be an integral component of disaster response. It is used intra-organizationally, and inter-organizationally for information sharing amongst several stakeholders.
Damage and Victim Needs Assessment	Needs Assessment Damage Assessment	The importance of identifying the damage to society and needs of society appears to be very important to disaster response. The assessment information is used to determine the level of response and the type of resources required to help victims and prevent the escalation of a disaster.
Resource Availability Assessment	Demand Assessment Supply Assessment	Knowing the current resources on hand and available for response seems to be important information as it helps determine what quantity of resources need to be acquired over what is on hand in order to address victim needs. Knowledge of the resources can also minimize wasted effort on managing too many resources or unnecessary resources. Damage and victim needs assessment information combined with resource availability assessment would appear to identify a resource gap to be filled during response.

Notification	Insufficient Notification	Notification of key stakeholders appears to influence disaster response. It prepares agencies for actions and informs them of the situation. A lack of notification of leaves responding agencies unprepared.
Response Authority	Response Authority Agency Independence	Response authority was often implied. Jurisdictional authority to the government was implied due to the interaction with foreign nations. Some agencies chose to act independently in some locations, while in other locations there was an implied dependence on authority to provide information and guidance.

Table 9. Exploring relationships sample from Figure 5 excerpt (Weber et al., 2002)

Themes	Conceptual Relationships	Memo
Contextual Information	Damage and Victim Needs Assessment Resource Availability Assessment Declaration of Emergency Status	Damage and victim needs, resource availability, and emergency status are all pieces of contextual information that responders need when planning a response. This information affects how tasks go about getting accomplished if protocols change due to the emergency status. It also affects what agencies will need to be involved in the response, and what resources will be required, and if there are enough resources to meet the needs of the response.
Multi-Agency Relationships	Multi-Agency Communication Notification Response Authority	Communication amongst agencies and the notification of agencies to situations and plans seems to affect overall disaster response. These activities would seem to be controlled by any established hierarchy or response authority amongst responding agencies. Grouping these concepts into a category called multi-agency relationships would address their common elements. Relationships establish how the agencies communicate with one another, who needs to be informed, and what information should be shared with different stakeholders as directed by those in authority or through an established response structure.
Task Management	Resource Management Task Performance	Managing the resources required to respond to a disaster, and the effectiveness in which tasks are performed appear to be related to overall task management. The ability to act quickly without the proper resources might cause problems with the response, whereas quick action with proper resources can be seen to improve response or mitigate damage. Task management incorporates the performance of activities and the management of resources in order to complete tasks.
Coordination	Contextual Information Multi-Agency Relationships Task Management	A higher level relationship appears to be emerging where the integrated management of information, relationships, and activities are responsible for overall disaster response effectiveness. Coordinating the exchange of information amongst agencies for planning responses and the execution of tasks with proper resources appears to enable more effective disaster response.

Table 8 demonstrates the thought processes that occur during the development of theoretical memos. Memos continue the analysis process by abstracting relationships amongst codes to a higher level. In theoretical memos, open codes are organized and grouped into concepts. Any perceived relationships between concepts are explored and used to inform future data gathering processes.

In time, themes or categories may emerge from the relationships amongst concepts and these are also explored through the use of memos. This is shown in Table 9, which was generated from the analysis of Table 8. Eventually, a core category emerges which is the major theme represented in the data for the phenomenon. In this study, multi-party coordination emerged as the major theme when examining disaster response. The last row in Table 9 shows how coordination emerged as the core category from the conceptualization of the sample in Figure 5. It was supported by the sub-themes that emerged in the memos.

Figure 6 shows a screen capture image from NVivo of how coding would is performed and represented in the software. The top half of the screen represents all of the different sources of data that have been imported into the software, while the bottom center of the screen represents the detailed notes from one data collection source, and the bottom right of the screen would list any nodes present in the data source and have a bar to correspond with the location of a node in the data. Passages of data that have been coded with a node are shown as being highlighted.

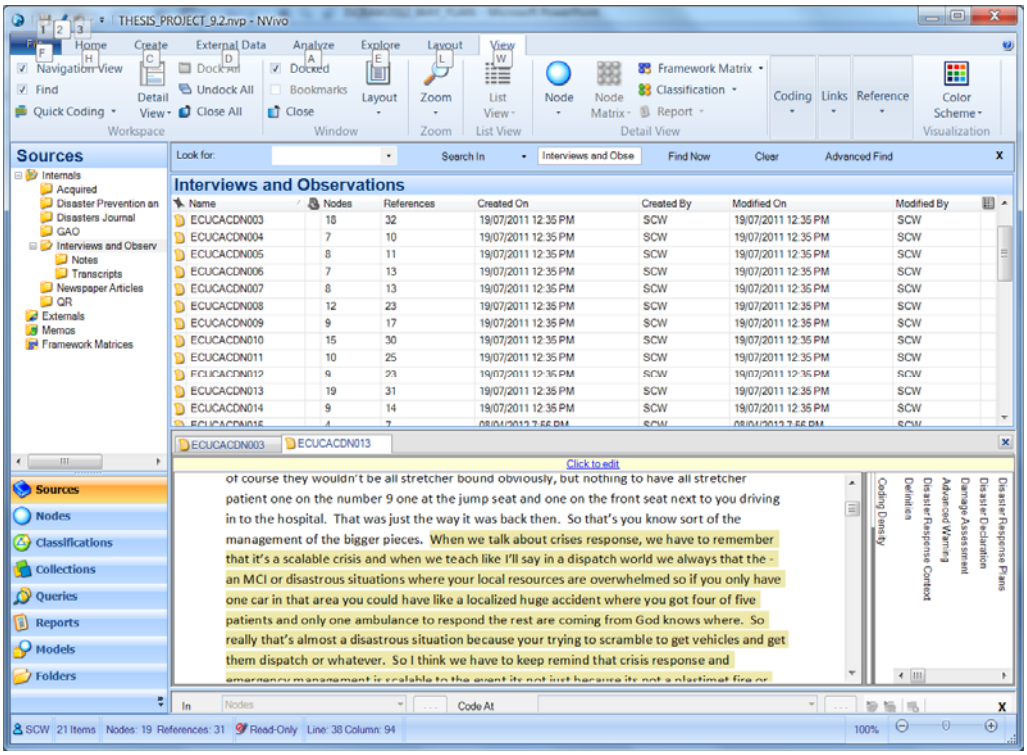

Figure 6. Coding data into nodes in NVivo

Figure 7 shows a screen capture image from NVivo of how nodes were organized into different hierarchies. The software allows nodes to be nested such that some nodes encompass other nodes at different levels as they emerge. For example, a node on Emergency Support Technology could have a sub-node of Attitudes toward Technology, and Financial Funding. In turn, the node on Financial Funding could have a sub-node on Costs. The hierarchy facilitated the progression of abstraction from low-level to higher level concepts.

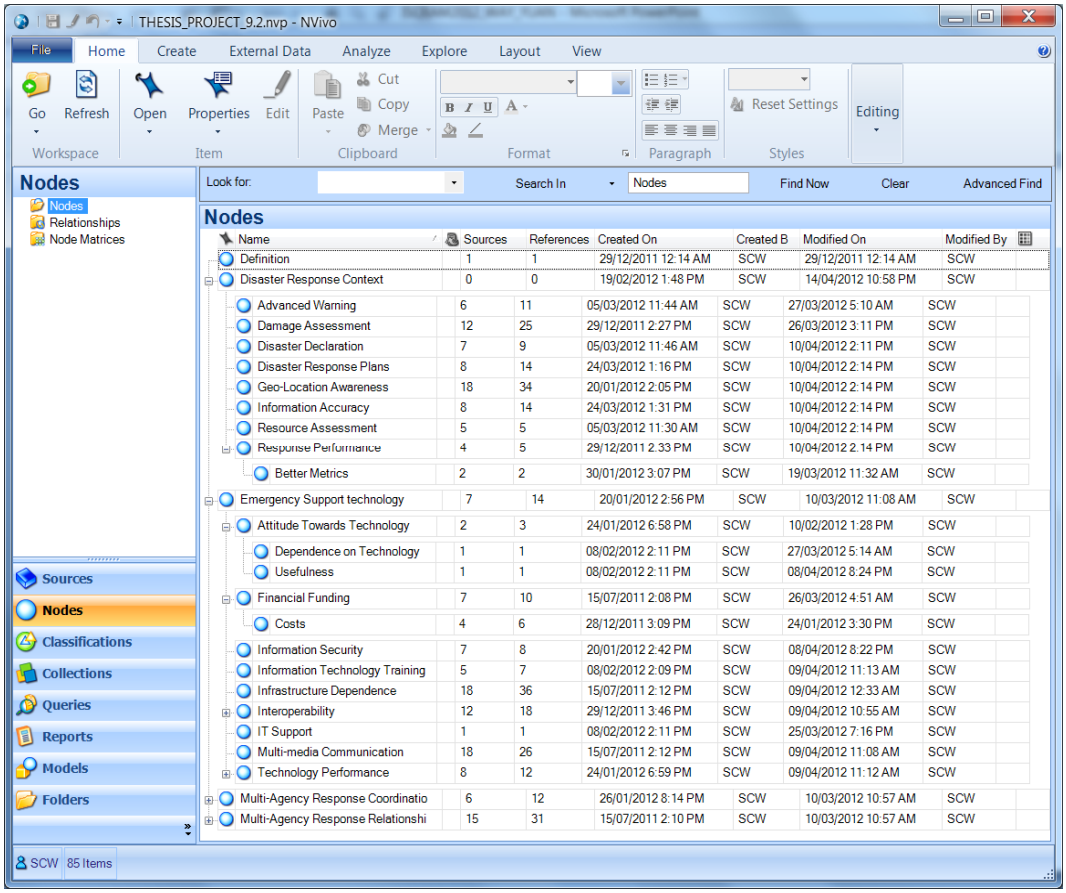

Figure 7. Developing a hierarchy of nodes in NVivo

Once preliminary concepts were identified, there were several iterations of review, discussion, and refinement of the nodes to ensure the coding of data was consistent and accurately described the different data. During this process related concepts were reviewed and discussed with other academics and professionals within the emergency response community. Upon agreement the node name was changed to match the final concept.

5.4 Concept Analysis and Theme Identification

From the very beginning many participants expressed jesting humour when posed with questions regarding how the different agencies worked together and shared information when responding to disasters. Responses such as, "What coordination?" and "We don't share information!" were quickly and freely given which seemed to indicate that multi-party information sharing and coordination was something that could be improved upon. With the continued exploration of emergency response issues relevant concepts emerged and were organized into four major categories revolving around the larger central theme of effective coordination as no one area dominated emergency response. Figure 9 outlines the core category of the study, the related selective codes, and the contributing concepts to each category. The categories were determined through identification of the concepts that either positively or negatively influenced the characteristic of disaster response coordination depending on how they were managed. The next section describes the emergent categories in greater detail along with their contributing concepts and how they were identified.

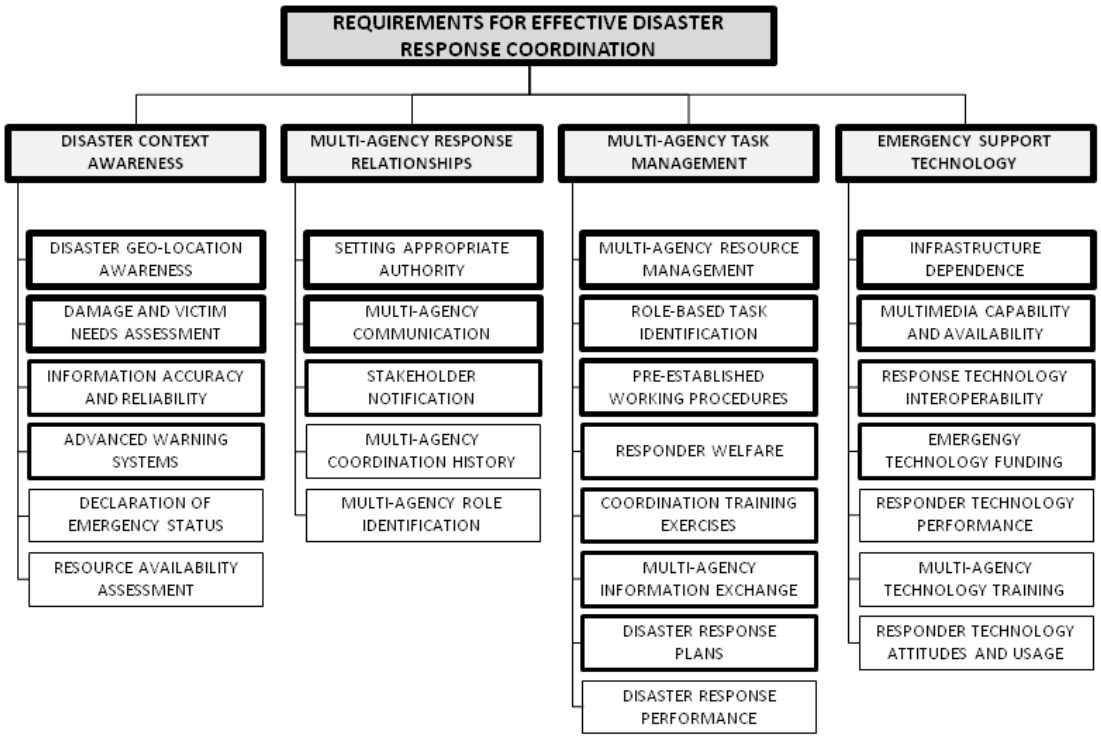

Figure 8. Emergent concepts and their relative prevalence in data

5.5 Emergent Categories and Concepts

The four categories that emerged are Context-Awareness, Multi-Agency Relationships, Task Management, and Emergency Support Technology. Figure 8 provides a graphical illustration of the core category, factors, and supporting concepts from the data. The concepts which influence these factors are ordered with respect to their apparent priority to responders as indicated by the prevalence of the concepts present in the response data. Border thickness around the concepts also reflects a relative importance as present in the data.

5.5.1 Disaster Context-Awareness

Upon speaking with study participants the importance of situational awareness was immediately emphasized which was reinforced with the literature. Data supported the common understanding that a disaster is made up of several dynamic and complex contexts which vary depending on the viewpoint and perspective of many different stakeholders in the regions affected by a disaster. Information context provides important details of a situation such as where is the risk, who is at risk, what are the causes of risk, who is available to respond, when did the event occur, what is the rate of environmental change, and much more. The data indicated an understanding of as many key contextual elements of the situation as possible is necessary for responders and decision makers to plan the most effective and efficient response. However, this contextual information must be of high quality to avoid information overload and confusion. Furthermore, a lack of information could lead to problems. The emergent concepts leading to the category of disaster context-awareness are summarized in Table 10 with more detailed descriptions and examples following.

Table 10. Emergent concepts for the disaster context awareness category

Category	Concept	Description
Disaster Context Awareness	Geo-Location Awareness	Location-based information relating to a hazard, victims, and resources
	Damage and Victims Needs Assessment	Assessment of the magnitude of the damage to the environment and people used to establish the required resource and response
	Information Accuracy and Reliability	The closeness to reality and trustworthiness of information on which to base response decisions
	Advanced Warning	An alert to society providing timing and impact information pertaining to a hazard
	Declaration of Emergency Status	The call for priority action by authorities for emergency response
	Resource Availability Assessment	Quantitative and qualitative information on resources available for response

Disaster Geo-Location Awareness

Location-based information related to the disaster and response is perhaps the most frequently requested contextual information sought by responders and decision makers. In this study, Geo-Location Awareness is the identification of real-world geographic location information on events, resources, stakeholders, and points of interest relative to a disaster and the response. In certain situations relative locations are sufficient, but actual location information provides more contextual information for responders and decision makers. Potential and actual location-based data on disaster events, victims, damages, responders, resources, access routes, operations centers, shelters, and search and rescue grids is used to modify the behavior of responders, victims, and other affected parties. When combined with available temporal and environmental change information, responders are able to prioritize and plan for the most appropriate response. An unavailability of location-based information can lead to poor decision making, negatively affect resource planning and logistics, and lengthen response times.

The importance of geo-location information is illustrated by its influence on the response efforts to two different disasters. During the 911 response in New York City,

> GIS was used to re-map the changed geography of Manhattan. This included the creation of base maps of Lower Manhattan and affected buildings, as well as

> search and rescue grids, utility outages, and the altered nature of the transportation system. These maps were not only used to document the impacts of the hazard and identify affected people and places, but they also aided in resource allocation for rescue worker deployment and getting affected people to the proper services. (Thomas, Cutter, Hodgson, Gutekunst, & Jones, 2002)

When responding to Hurricane Katrina,

> [m]any of the responders were not local and therefore did not know how to get around Baton Rouge, New Orleans, and surrounding areas. The Louisiana State Police frequently needed New Orleans road maps for troopers who escorted buses on rescue missions. Due to the high volume of their requests, one of [the] volunteers went to the local bookstore to buy all of the New Orleans road maps. Using GIS to create these maps was a duplication of product, since it already existed. However, it was not too long before Baton Rouge stores ran out of New Orleans road maps. (Curtis, Mills, Blackburn, & Pine, 2006)

Damage and Victim Needs Assessment

Damage and Victim Needs Assessment is the determination of physical and psychological damage to the environment, infrastructure, and population, and the determination of corresponding response requirements to prevent disaster escalation. An accurate and timely assessment of the damage caused by a disaster, lives lost or people injured, and any secondary threats to people or property are critical to an efficient crisis response. The information provided from the assessment is used to plan the response activities and aid provisions required by those injured or at risk. Other information such as the location of need and any damaged infrastructure will also influence how aid is routed or administered. Poor damage assessments lead to a misallocation of resources, puts responders at risk, and can delay overall response. The US response to Hurricane Andrew stressed the importance of damage assessment in crisis response.

> FEMA relies on state and local governments to identify services needed from the federal government once they have determined they cannot adequately meet their own needs. In practice, their request for federal assistance must specify the type, amount, and location of the needed services. State and local governments were unable to do this because of the overwhelming nature of Hurricane Andrew, causing delays in services. (GAO, 1993a)

Study participants also emphasized the importance of damage assessments. One EMS responder recounted a day when he was sitting at a dispatch desk and the 911 emergency phone rang. The call taker explained to him that there was a train derailment. As a dispatcher, he immediately needed to know if it was a passenger train or not. The derailment occurred in a relatively remote community and there were not a lot of ambulances in the area so he needed to know the extent of damage. He also needed to know information such as if the track or access roads were blocked, if there was a diesel fuel leak, how many people were injured. His major concern was how to transport all the

injured people to the hospital. The only way to establish the level of the response required was to understand the amount of damage and the number and type of injured at the scene.

Information Accuracy and Reliability

Information accuracy and reliability is another major influence on coordination that was expressed in the literature and by responders. Information accuracy is the degree of closeness of acquired information to actual information, while reliability is the consistency of the information received from multiple sources. Sources of information for a disaster response can be numerous, such as victims, responders, the public, environmental sensors, or the media. The accuracy of information that is reported to decision makers can alter a response greatly. Inaccurate information can have severe consequences such as causing confusion, a misallocation of resources, and leading to poor decision making from a misallocation of resources or inappropriate response plans causing delays. As a result, as much accurate and consistently corroborated information as possible is beneficial for a multi-agency disaster response.

In New Orleans during the Katrina response, press reports of looting and violence had responders on high alert causing them to avoid the downtown area. A volunteer medical responder in New Orleans shared,

> we drove over the infamous bridge one evening to go to see who may need some medical attention and we were immediately surrounded by scary people pounding on the ambulance. We locked our doors; they had a crazed look in their eyes. We didn't get out, we just slowly backed up until they stopped, then we turned around and left. The next day we went in with some support (National Guard) and then helped them. We then realized what was going on. Those pounding on our vehicle the night before were going through drug withdrawals. They saw the ambulance and assumed we would have something they could shoot themselves up with to get high and stop the withdrawal symptoms. They weren't intending to harm us; they were desperate for the drugs they could not now buy since they were cut off from their dealers. Everything here is just one hell of a mess. Reporters see some things, make assumptions, and come to the wrong conclusions about what is really going on, which only makes it worse. (Fischer et al., 2006)

Information accuracy and reliability also affected the response to the nuclear reactor problems in Japan following the earthquake and tsunami in 2011. During the Fukushima nuclear meltdown in Japan, the Japanese prime minister was not receiving accurate information from Tepco (Tokyo Electric Power Company) which operated the plant. A history of scandal and cover-ups in regulatory safety filings led to distrust in the reliability of information received from Tepco and delayed the response to the nuclear disaster. Only when the prime minister went to the step of placing a trusted advisor into the Tepco headquarters did information accuracy and reliability improve in the nuclear response (Onishi & Fackler, 2011).

Advanced Warning Systems

Early warning awareness of potential disasters can vary greatly in duration depending on pre-event indicators and monitoring capabilities. The awareness of an impending event often affects emergency preparedness in potentially affected communities, and can trigger the engagement of disaster response plans. Poor early warning systems will leave people and responders unaware of the timing or severity of potential disasters and increase the likelihood of a more severe impact on the public and on response capabilities.

Prepared communities will have an action plan ready to implement and may have resources stockpiled and responders standing by for when the event occurs before initiating a response. For an unexpected event it is typical for calls to begin arriving at emergency call taking centers from observers, or from automated monitoring systems or sensors such as security alarms. As calls are received, they are usually entered into an incident tracking system which dispatchers use to determine who needs to be notified for response.

With the response to Hurricane Katrina, FEMA was able to use advanced warning systems to see the threatening storm develop and pre-plan a response. FEMA positioned resources and response professionals in neighboring states for post-disaster assistance to local responders. Unfortunately, any pre-planning for the response with the advanced warning was altered as the severity of the damage and destruction to infrastructure such as roadways was not anticipated and limited their ability to respond in a timely fashion (Fischer et al., 2006).

An improvement to response was observed during a later disaster when advanced warning systems prompted a different response from the government. In August 2012, Hurricane Isaac was once again threatening New Orleans as well as other parts of Louisiana and Mississippi. Once again FEMA used advanced warning systems to monitor the development of the threatening storm. In this case, United States President Obama declared a state of emergency prior to the disaster arriving which enabled the coordination of several FEMA response groups ahead of the disaster[13].

What has been observed over time is a trend by governments to use advanced warning systems to pre-enact response plans. Responders have been pre-positioned, the public has been informed of the threat, and declarations of emergency have be called prior to the onset of the hazard to minimize the overall impact on society.

Declaration of Emergency Status

In many jurisdictions, financial relief from higher levels of government, or assistance with resources managed by higher levels of government are not available to local response efforts unless a declaration of emergency is made. For many of the potential response teams that are managed by higher levels of government, their funding is dependent on a declaration of emergency. In the United States, "preparatory activities are

[13] http://blog.fema.gov/2012/08/isaac-update-6-august-30-recap.html

not explicitly authorized until the President has issued a disaster declaration... Federal agencies may fail to undertake advance preparations because of uncertainty over whether costs incurred before a disaster declaration will ultimately be reimbursed by FEMA (GAO, 1993e)."

In addition to releasing funds for an emergency, a declaration of emergency may also modify operating procedures for decision makers and responders and affect the legislation that governs the actions of responders and volunteers. Roles and responsibilities of leadership to disaster responses may also be influenced by declarations of emergency.

The County of Lambton, Ontario outlines on its website why a county emergency would be declared during or following a disaster:

- It gives the Warden exceptional powers to direct County personnel, resources, supplies and equipment (i.e. suspension of corporate tendering policy);
- It places the Province on notice their assistance may be requested. The Province can procure specialized equipment or activate response teams with specialized training (i.e. HAZMAT (*Hazardous Materials*) or CBRNE (*Chemical, Biological, Radiological, Nuclear, Explosives*)). The Province will cover the cost for the use of such resources if an emergency is declared;
- It implements a business cycle for keeping records of actions, expenditure of funds etc.;
- It covers volunteers under the Workplace Safety & Insurance Board legislation;
- It may provide for the County and local residents to make claims for financial assistance for disaster recovery (if a Disaster Area is identified and declared).[14]

Lastly, when to declare a state of emergency will also influence the disaster response because of the changes in operations it may cause. Confusion over when to declare a state of emergency can affect the response protocols, as indicated when

> Hurricane Katrina showed the need to improve leadership at all levels of government to better respond to a catastrophic disaster. For example, there were problems with roles and responsibilities under the NRP [National Response Plan] and ambiguities about both what constituted an incident of national significance to trigger the NRP and what constituted a catastrophic incident to trigger the proactive response of the NRP's Catastrophic Incident Annex. (GAO, 2007a)

[14] http://www.lambtononline.com/community_emergency_planning

Resource Availability Assessment

Damage and victims needs assessments provide a status report of what the response requirements are, but the responding resources assessment evaluates what human, technical, and materials resources are currently available to the response effort. The difference between the damage and victim needs assessment and the responding resources assessment identifies a resource gap which must be met for an effective response to occur. Several participants shared that an emergency becomes a disaster when there are not enough resources available to respond to the incident. "You have four or five patients and only one ambulance to respond. The rest are coming from God knows where. So really that's almost a disastrous situation because you are trying to scramble to get vehicles and get them dispatched or whatever. (EMS Participant)" A resource shortage creates a need for coordination activities with other agencies to fill the gap.

The proper assessment of resources available for response may also lead to modified resource allocation, scheduling, and resource acquisition activities. During the response to several tornadoes hitting the Fort Worth, Texas area on March 28, 2000, the fire chief used damage assessment information to divide the affected area into eight sectors to be managed by battalion chiefs. After determining that he had committed almost all of his available resources to the response plan, he called up off-duty personnel for additional support that were immediately deployed to the field in small teams as they checked into the central staging area (McEntire, 2001).

5.5.2 Multi-Agency Response Relationships

Participants and literature sources indicated that not only is managing the situation information critical to a response, but also the management of relationships amongst responders. Managing relationships is the second category to emerge. Relationships amongst responders are important for establishing leadership roles, leadership structures, communication mechanisms, and identifying roles performed by responding agencies, all of which contribute to the coordination of a disaster response. Any history of coordination with agencies will also influence response relationships or the establishment of multi-agency relationships. The key emergent concepts that contribute to the theme are summarized in Table 11 and described in the following section.

Table 11. Emergent concepts leading to multi-agent relationships category

Category	Concept	Description
Multi-agency Relationships	Appropriate Authority	Determination of who is in charge and the response hierarchy
	Communication	Communication channels and protocols amongst organizations
	Stakeholder Notification	Identification and notification of who needs to be informed of risks and response activities
	Coordination History	Prior collaboration relationships and contracts amongst responding organizations
	Role Identification	Determination and recognition of organizational roles within response environment

Setting Appropriate Authority

Perhaps the most important concept for multi-agency response relationships contained in the data is the establishment of the appropriate authority. Dependent on the conditions of the disaster situation, it ultimately defines who is responsible for managing the response effort, and who will be held accountable for any problems that arise. It also defines who needs to support the response process at the highest levels. The authority is also the responding party that is usually responsible for establishing the leadership structure and engaging an incident management system (IMS), a tool which provides standardized organizational structures, functions, processes and terminology for use at all levels of an emergency response for participating agencies familiar with the system. Regions or agencies not familiar with the system will require ad hoc protocols and structures to be established to navigate chains of command and perform decision making activities.

Determining the proper authority to manage the entire response, or a portion of the response can be difficult and depend on several criteria. The criteria that are commonly considered are geographical jurisdiction and the nature of the disaster, although any legislated jurisdictional authority would take priority.

Assigning power of one agency over another may lead to conflict. Inter-organizational or political conflicts of interest may challenge the establishment of the appropriate authority and inhibit responses but responders generally try to minimize those conflicts for the benefit of all involved.

The challenges in establishing proper authority played a key role in the response to Hurricane Katrina.

> One critical issue that needs to be resolved in any large, integrated operation is the decision concerning command and control of the forces. This issue had not been resolved prior to Hurricane Katrina and was a subject of discussion during the critical first days after Katrina made landfall. Ultimately, the military took a pragmatic approach to de-conflict the operation with separate active-duty and National Guard chains of command. The federal forces—the active component and mobilized Reserve volunteers—were under the command and control of Northern Command's Joint Task Force-Katrina, while the National Guard forces, including those from other states, were under the command and control of the governors in Mississippi and Louisiana. While response operations were coordinated across the several chains of command, they were not integrated, which led to some inefficiencies and duplication of effort. For example, many responding military units from outside the states were assigned missions within established geographic boundaries, but the Louisiana and Mississippi National Guard units had functional missions that cut across these geographic boundaries. Furthermore, in New Orleans, the geographic boundaries were not the same as the city district boundaries. This made coordination with local responders more difficult. (GAO, 2006a)

Multi-Agency Communication

More often than not, each individual agency has its own communication channels and protocols. Different communication mechanisms were described as yet another influence on multi-agency coordination by participants. In some geographical regions there may be multi-agency communication channels established that allow communal sharing of information. In many cases, individual agencies continue to operate independently with communication flowing along internal lines of communication, and then being shared across agencies at instances of local unified command, or at emergency operations centers. Amongst different agencies, challenges in communication arise from the type of information that needs to be shared. Agencies are usually not aware of the information requirements and responsibilities of other agencies which leads to asymmetrical information sharing.

Regardless of any authority or management structure, the communication mechanisms between agencies need to be clarified so that lines of communication are open. At the local responder level it was observed that frequently EMS and Firefighters have radios for all of EMS, Police, and Fire radio communications. This informal exchange of radios allowed the different services to be pre-alerted to potential assistance as requested by other agencies. The exception to this was the Police force. In the police vehicles, and with dispatch, only the police radio was seen or heard. Agencies that shared radios with one another had the understanding that the radios were for listening only, and were not to be used for communication with the other agencies.

While sharing communication information between responders at the same level is fairly common, it is often less common and can be problematic between responder levels. During Hurricane Katrina established communication channels amongst peer responders

enabled better coordination than communication channels between responder levels. Responders at different levels of response (local, state, federal) complained of coordination between levels of responders.

> Local responders reported feeling that cooperation was very good, "all things considered," among all of the locals. "The problem was between levels; it was impossible to get anything going with the state or the feds." On the other hand, those working from the state perspective suggested "the problem was at both the local and the federal levels. We did fine working with each other, but getting the locals to act in concert with us was mission impossible—ditto for the feds." Those working from the federal perspective conformed to this pattern: "We are fine, they are not." (Fischer et al., 2006)

While there is no explanation for the possible causes of this breakdown in communication between responder levels, it was observed during training exercises that most multi-agency training exercises are planned with agencies at the same level. During scenario SC3 (Appendix B) it was observed that the exercise concluded the moment the disaster was elevated to the provincial level due to a declaration of emergency. Therefore, the multi-agency communication between levels appears to be less frequently developed and is definitely less present in day-to-day emergency response operations by first responders.

Stakeholder Notification

Stakeholder identification and notification is another important factor for managing multi-agent response relationships. Establishing and notifying stakeholders about potential and actual disaster events takes into account those who are or might be directly and indirectly affected by a disaster such as victims, responders, volunteers, resource providers, supporting agencies, infrastructure managers, service providers, and various levels of government. The need for assistance may be real or pending, but notification engages response plans and establishes relationships for a disaster response.

Furthermore, relationships amongst agencies are further maintained through the notification of any changes to the operating or environmental conditions. During two multi-agency training exercises stakeholder notification was witnessed firsthand. In one exercise involving multiple shooters at a primary school, response plans included notification of the school board, acquiring attendance lists and notifying parents of a situation at the school. In addition, the city was notified and they made city buses available for containing and transporting evacuees, and crisis response teams from hospitals including grief counselors were notified to support victims and their families.

In scenario SC3 (Appendix B) the American city's EOC notified the Canadian EOC of the emergency so they could coordinate a response. Because of the location of the incident, federal border services were notified, and the port authority, which is a federal jurisdiction, was also notified. As the exercise played out, plans to notify regional police services were notified to secure evacuation routes, the city prepared for evacuation orders

to notify the public, a state of emergency declaration was decided upon so notification of the other city and the regional EOC were made, and notification of a military response team was made to inform them of events but not to activate them.

Multi-Agency Coordination History

When responding to disasters the response is frequently directed by many agency leaders such as Chiefs or Deputy Chiefs of Police, Fire, and EMS. Often these leaders and their agencies have a familiarity of working with one another from prior training exercises or day-to-day operations which influences the relationships the agencies have with one another. This familiarity can introduce elements of trust or distrust to operations which affect the response. Trust is developed from observed competency in performing activities and working together, while distrust can be developed by perceived incompetency, glory seeking behaviours, and lack of discretion in communicating sensitive information (Fire Participant).

In addition to day-to-day interactions, similar organizations such as Fire departments from multiple regions may have more formal mutual aid agreements which offers resource coverage should one area be overwhelmed by a local emergency. In situations where there are no agreements in place, and there is a lack of familiarity, ad hoc relationships may be needed to establish relationships amongst agencies. The ability or inability to manage ad hoc relationships successfully may also influence the response.

Prior coordination history influenced the response during the 9/11 response to a crashed plane in Pennsylvania.

> For example, the standard operating procedure for an EMS response is that the PSP [Pennsylvania State Police] will respond to the scene to handle security and safety issues as well as investigative matters. The local paramedics and fire personnel have extensive experience working with PSP Troopers and have respect for their capabilities. Likewise, the PSP personnel understand the roles and responsibilities of the local emergency responders. This enhanced the smooth initial response at the site. Once it was determined there were no survivors, the PSP immediately established perimeter security and began to move unnecessary personnel out of the immediate area. They worked cooperatively with the local fire departments who extinguished small brush fires in areas adjacent to the immediate impact zone. As one paramedic put it: "We might have some differences, but when we get to a scene we put all those differences aside and everyone works together." The essential element of this and other conversations was that the local and state responders were familiar with one another and respected the professional capabilities of their fellow responders. They trusted that others would do their jobs in a competent and professional manner. (Grant, Hoover, Scarisbrick-Hauser, & Muffet, 2002)

While 9/11 provided a positive example of managing prior relationships, the response to Hurricane Katrina provided a situation where an ad-hoc relationship between the military and National Guard was handled improperly and led to a challenge with the response.

> Because the military had not specifically planned nor decided which parts of the military response would be handled by the National Guard and which parts would be handled by the active component and mobilized reservists, many of the force flow decisions and integration efforts were ad hoc in the midst of the crisis. Because military plans and exercises had not provided a means for integrating the response, no one had the total picture of the forces on the ground, the forces that were on the way, the missions for which forces had been allocated, and the missions that still needed to be done. For example, National Guard commanders in Mississippi and Louisiana were not prepared to receive the division headquarter elements that were sent from Indiana and Kansas to command the out-of-state National Guard forces that were arriving in the two states from around the country. (GAO, 2006a)

Multi-Agency Role Identification

The identification of roles established early in the disaster response process provides clarity of priorities for responders, and establishes relationship interdependencies to coordinate responses. Role identification may be a bi-product of previous interagency collaboration, or it may simply be a matter of recognized expertise. Failure to identify agency roles can lead to role confusion and a misunderstanding of responsibilities.

During large emergencies it possible to see the early effect of role identification on response processes. One EMS participant described the following typical response details to a large accident involving many vehicles.

> [I]n those cases the police, fire and the paramedic supervisors go to those calls and have to get together and formulate unified command of the scene. Each of them has specific functions. The police are going to be traffic control, fire is going to be rescue extrication, and the paramedics are going to be patient treatment, so they unify their command and then address the incident. (EMS Participant)

Due to the dynamic environments frequently encountered during emergencies and disasters, initial roles may change. Adaptation to dynamic conditions is also necessary for responders. It is common for responding agencies to provide a backup or supporting role, and then switch off to primary or leading agency roles if conditions change or other responders need relief.

This situation occurred during a multi-agency training exercise involving multiple gunmen with multiple victims in a school attack scenario. The response required police tactical response units from two jurisdictions to work cooperatively to secure the school. The team from the visiting jurisdiction had recently received new suspect takedown training techniques. After a brief discussion over which team should be responsible for

suspect takedown, it was determined the local response team would be the lead unit based on jurisdiction, while the outside tactical response team was to play a supporting role. However, shortly before the teams were planning to enter the premises of the gunmen's location a real emergency call occurred requiring the attention of the local tactical response unit. The team was split in half, with half going to the new incident, and half remaining with the current exercise incident. Because of the reduced numbers, it was determined that the roles of the two teams would be reversed and the supporting tactical unit would now become the lead tactical unit (Direct Observation).

5.5.3 Task-based Management

Thus far the impact of environmental information and multi-agency relationships have been discussed in relation to disaster response management. Multi-agency task management examines the actual execution of the response. It considers the supporting activities, task management structures, and factors required to organize, plan, and execute the interdependent tasks that make up a disaster response. The main concepts that influence task management include managing the resources, identifying the tasks based on required roles, following pre-established working procedures, maintaining responder safety and readiness, coordination training exercises, and information exchange. The emergent concepts are for the task-based management category are summarized in Table 12 with descriptions that follow.

Table 12. Emergent concepts for the task-based management category

Category	Concept	Description
Task-based Management	Resource Management	Acquisition and allocation of resources required for response
	Role-based Task Identification	Identification of tasks to be performed based on the roles of the responders
	Pre-established Working Procedures	Prior documented protocols for multi-agency cooperation and task execution
	Responder Welfare	Safety and well-being requirements for responders to maintain response capabilities
	Training Exercises	Practice for gaining response collaboration experiences
	Information Exchange	Information sharing amongst organizations which is influenced by rules, regulations, and cultural elements
	Response Plans	Documented response tasks and priorities based on assumed disaster scenarios
	Task Performance	The measurement and monitoring of task execution in terms of effectiveness and efficiency

Multi-Agency Resource Management

Multi-agency resource management covers several activities that are necessary to perform an effective disaster response. These activities make up many activities related to logistics and include resource acquisition, allocation, distribution, and monitoring of material and human resources across multiple agencies. The activation of pre-arranged mutual aid agreements, where resources from agencies in neighbouring regions can be called on to help when a local shortage occurs, and other support contracts are also included in resource management. The ability to monitor and track resources and determine resource utilization levels can be used to determine the physical location of required resources across multiple agencies as they move around a disaster response theater.

The importance of resources and their management during disaster response was made very apparent during Hurricane Katrina where coordinating a response was extremely difficult.

> Exacerbating the situation, the loss of emergency equipment (e.g., police and fire cars, trucks, ambulances) made it impossible for search and rescue to begin in the immediate post-impact period in those areas affected by the hurricane winds and storm surge. With the loss of equipment, even when roads begin to be cleared, responders were reduced to acquiring what was needed. "If a private car was found usable, we appropriated it for the time being in order to help find and transport those needing care to an appropriate location; we siphoned gas from cars that were destroyed and unusable. Sometimes we appropriated gasoline being brought in; we even appropriated the vehicles of others converging to the site." (Fischer et al., 2006)

Another example from the same disaster illustrates how logistical problems impacted the response,

> Four days after Katrina's landfall, FEMA asked DOD to take responsibility for procurement, transportation, and distribution of ice, water, food, fuel, and medical supplies. However, because FEMA lacked the capability to maintain visibility—from order through final delivery—of the supplies and commodities it had ordered, DOD did not know the precise locations of the FEMA-ordered supplies and commodities when it assumed FEMA's logistics responsibilities. As a result of its lack of visibility over the meals that were in transit, DOD had to airlift 1.7 million meals to Mississippi to respond to a request from the Adjutant General of Mississippi, who was concerned that food supplies were nearly exhausted. (GAO, 2006a)

Role-based Task Identification

Role-based Task Identification differs from agency role identification. With agency role identification the emphasis is on establishing relationships amongst responder agencies to manage the overall macro response, whereas role-based task identification focuses on the interdependencies of required tasks to be completed, and the resources required at a lower micro level.

To highlight this distinction, one participant shared the sentiment that police, fire and EMS responders generally have a small view perspective with no exposure to higher level planning. They are only concerned with their immediate response, not coordinating recovery. Thus, first responders manage the local activities to be performed as a result of the general role provided from the higher relationship level.

To illustrate role-based task identification, the interaction amongst first responders was observed during a local incident response and coordination was observed. During the response to a multi-vehicle collision there was very little spoken communication between the EMS, police, and firefighters on scene. Upon arrival the driver of one vehicle was trapped in a car. Police blocked off the intersection while firefighters used the jaws of life to extricate the trapped victim. EMS personnel stood by casually waiting until they could get access to the victim. Once the victim was made accessible by the firefighters,

EMS personnel jumped to action and secured the victim, loaded the victim onto the ambulance, and took the victim to the hospital. Before departing, the only communication that was spoken between responders was the destination and extent of injuries of the victim which was shared by EMS with police. This lack of communication could have been for a number of reasons such as trust, familiarity with the other agencies, but ultimately each agency understood its role and executed the tasks they were expected to perform in a competent and professional manner.

Sometimes other services don't always understand roles and this can lead to perceived response problems as task priorities are misidentified. For example, during a rideout and observation period a suicide attempt call was received by police and they sought an ambulance for standby. The ambulance was available for a period but then left. This upset the police who were trying to manage the response situation. Police didn't understand that if nobody is immediately injured, then there is no victim and the ambulance can be pulled to another scene where there is a victim. This is the priority for the emergency medical personnel.

Pre-Established Working Procedures

One of the strongest influences on task-based coordination is pre-established work protocols or standard operating procedures (SOP). These procedures often provide the structure for responders that dictates how things should be done, who needs approval, what can be shared with whom, and more. Many individual organizations have SOPs that manage internal operations, while organizations that have a history of interacting with others will have protocols to manage those request-response relationships needed to administer aid or resources. These pre-arranged request-response relationships are referred to as mutual aid agreements. When required in certain circumstances, responder resources from a nearby municipality will be sent to support the local response to a resource-straining incident, or provide backup support for the region should further incidents occur while local resources are occupied. The presence or absence of pre-established working procedures does not necessarily influence overall coordination itself, but the how the working procedures are managed does influence coordination.

For example, the United States has pre-established working procedures for military-civilian assistance but the priorities for each agency may differ and there may not be joint awareness of the differences.

> The National Response Framework broadly calls for DOD and other federal agencies to respond to requests for-assistance from state and local civilian authorities, while DOD's doctrine and guidance specify how the department will review and respond to these requests. However, as DOD and FEMA officials told us, civil authorities have misconceptions about time frames for DOD's process for approving and resourcing civilian requests-for-assistance. For example, DOD's capabilities-based assessment for homeland defense and civil support identified the response timeliness of DOD transportation support—including aeromedical evacuation—as a capability shortfall. The assessment noted that although civil

> authorities have identified a need for DOD transportation support within 24 hours of a catastrophic incident, DOD has limited capability to respond sooner than 72 hours. (GAO, 2010b)

Responder Welfare

The health and safety of responders is usually a priority and consideration at the forefront of disaster response decision makers and emergency managers. Improper equipment, inadequate resources, or situations of extreme danger that responders are ill-prepared for can quickly turn rescuers and responders into victims themselves and compromise a response. In addition, there is also responder fatigue to be managed which requires food and shelter considerations. Not only must current responders be cared for, but any supporting resources and volunteers need to be taken care of too. Lastly, personal issues have the possibility of distracting responders, such as the safety of families, or other financial obligations that responders may be incurring as a result of the disaster. Any of these issues can influence responder availability for tasks and need to be managed.

During Katrina, responders that were self-sustaining were particularly valuable and did not add to the complexity of response. As expressed by one responder,

> "We were overwhelmed with our own needs—inadequate water, food, shelter, transportation, medical care, and so on—and the 'doc-in-a-box' (doctor living out of his car with his own supplies in the back of his car) arrives, then a group of fire fighters arrive, then . . . in each case they come up to me and say 'we are here to serve.' They have this angelic look on their face and want to be of help, but the first thing they ask is 'where can we eat, sleep . . .' and I say, 'you know we are in the middle of a major disaster, right?' I mean, I wanted to appreciate their offer, but they only added to my problems. I needed people and supplies, not people to take care of, as I already had that."... One responder expressed appreciation for those who arrived self-sufficiently: "I could have kissed them. In they came one day and told me what they came prepared to do; I was expecting another housing and feeding burden, but they told me not to worry about that. They came prepared to take care of themselves, as well as care for those who were in need of medical treatment. I thought, 'finally something that works.' God bless them!" (Fischer et al., 2006)

In a separate incident, a tornado that struck a major city illustrated the impact responder welfare had on disaster response.

> One of the major challenges evident during the response was the dangerous condition of the downtown area. As emergency workers entered the disaster site they notified the emergency operations center that the tornado had broken a substantial number of windowpanes. Because many of these panes were hanging precariously from offices in high-rise buildings, a large portion of responding personnel were asked to pull back and suspend non-essential operations until the safety of workers could be ensured. A no-fly zone was also established with the

> help of airport officials so that the loose windowpanes were not disturbed further by overhead aircraft. (McEntire, 2001)

Coordination Training Exercises

Agencies participating in training exercises gain familiarity interacting with response partners in scenarios designed to test how agencies communicate and work together. Scenarios do not necessarily need to be of large scale, but participants use the experiences to identify challenges and weaknesses in the coordinated response, and to practice working with other agencies and adapting response procedures. Failure to enact knowledge learned from training, or infrequent training provides little to no benefit for organizations.

> Collaborative approaches to national security require a well-trained workforce with the skills and experience to integrate the government's diverse capabilities and resources. A lack of understanding of other agencies' cultures, processes, and core capabilities can hamper U.S. national security partners' ability to work together effectively. However, training can help personnel develop the skills and understanding of other agencies' capabilities needed to facilitate interagency collaboration. (GAO, 2010e)

An observed full-scale multi-agency multi-national training exercise scheduled along the border with Canada and the United States illustrated such training. Participants in the Canadian emergency operations center (EOC) were using an online EOC software to test its use in managing the response effort. A prior exercise involving only the Canadian participants had been conducted previously but it was chaotic and described as a "Tower of Babel" as the software was made accessible for all EOC participants to enter incidents. Without a standard process, everybody was entering multiple instances of the same issues with different details and terminology causing confusion for decision makers. From that experience it was determined that only scribes and key individuals for agencies would be permitted to input data. The second exercise was conducted in a calm and orderly fashion with all response incidents tracked in an organized and efficient manner for decision makers to follow and direct responders.

Multi-Agency Information Exchange

Multi-agency information exchange is used to communicate and gather relevant contextual information for the purposes of planning, coordinating, and executing disaster response activities by responders, the public, or the media. Information exchange is established through information control and sharing activities which may be influenced by organizational security, privacy policies, and any legislative concerns that must be maintained. Language differences brought about by cultural influences, lingo differences in terminology, and simple differences in spoken languages may also affect information exchange. The manner in which information is exchanged, such as e-mail or encrypted digital radio will also affect information exchange. Lastly, whether or not a requesting party for information actually needs the information or is justified in asking for it will

also affect information exchange. Recently, social media has taken a larger role in information exchange during disasters.

FEMA-store, an online GIS information repository, was made available to aid in the Hurricane Katrina response.

> Not only did FEMA-Store allow data organization, it also facilitated data sharing. An early problem was the logistics of data sharing from multiagency sources. Initially, some individual files were sent to us via e-mail. This limited the size and security of the information, thus this method only allowed us to accumulate non-confidential information that was small in size. With FEMA-Store, select members of various agencies were provided access to deposit spatial data for our use in the EOC. Access to this resource was limited due to the need to provide security for some of the data sets. Initially, interagency data sharing was an essential component of FEMA-Store for providing the most complete data for the most informed maps and information for decision support. When the Federal Emergency Management Agency (FEMA) mitigation team arrived, however, it also became a resource for their mitigation efforts, which were also facilitated through the CADGIS lab at LSU. (Curtis et al., 2006)

One interviewed EMS participant provided some thoughts on information exchange with police and fire services.

> Before an incident we have no problem sharing policy and procedures and sitting down with them. We would encourage different agencies and departments to actually sit down and chat. We have the regional emergency operation center too. There's all kinds of different things. So, beforehand that's usually not as huge an issue. During it's a little bit more of an issue only depending on what they're asking for. If they're asking for patient information, that is protected by privacy legislation. But we also have to keep mind who's asking,why are they asking, do they tend to have access to that information, what value is it, is there a breach of confidentiality if we actually share that information or are they considered to be continuing the care of that particular patient? There's a whole bunch of questions that we ask in order to be able to do that. If it's policy or procedure or something during the event, again it should not be an issue of sharing that. We will share information post but we technically blank the HIPPA information. They don't need to know a patient name, they don't need to know billing address or whatever. We have to just sort of scrape the data of anything that would give away who the patient was. Other than that we're good. Technically they don't need to know who the patient was.

Disaster Response Plans

Pre-disaster information and preparations influence the response of personnel when an actual event occurs. This information may be used to establish evacuation routes, community shelters, or other response plans such as the engagement of additional

resources. The alignment of actual events with anticipated events can greatly influence disaster response. Furthermore, disaster response plans can trigger faster action as responders and decision makers do not need to re-think established plans, merely execute.

When a training exercise took place that was escalating in scale to the point of declaring an emergency, the decision was made to notify the regional police force to secure a pre-established evacuation route. A route did not need to be planned, only action taken.

During disasters, hospitals may also activate disaster response plans since they must prepare for an influx of casualties. One physician interviewed regarding emergency response plans explained how hospitals are involved in community disaster response plans. Response plans include planning and associated training for CBRNE emergencies. The type of plan implemented depends on the type of event that occurs and the scale. Management may invoke the first stage of the response plan which includes calling in sets of required personnel. As a disaster escalates it could include finding additional resources in the form of people and equipment as it is needed.

Disaster Response Performance

Response task performance is used to provide dynamic contextual data on the success of response efforts so that decisions can be made on an ongoing basis and in the future regarding future task assignments and resource requirements. The two examples below illustrate the importance of providing response task performance information and problems that can occur from improper reporting.

In 1992 the state of Florida was hit by a hurricane.

> FEMA regional officials told us that they knew by the second day after the disaster that the American Red Cross was unable to fulfill its mass care response role. These officials then offered to provide the state with whatever assistance it requested. However, Florida did not immediately request significant amounts of additional mass care because it had the impression that the state/local/volunteer network was doing an adequate job. For example, the state official who managed Florida's emergency operating center told us that the American Red Cross officials informed him that it had established feeding centers in Homestead and Florida City. In fact, Homestead and Florida City--perhaps the two hardest hit areas--did not get such help until the military set up field kitchens there 4 to 5 days after the disaster. (GAO, 1993a)

Similar problems with response performance and its communication occurred during Hurricane Katrina.

> President Bush, on vacation, was briefed on the [Hurricane Katrina] situation and was reportedly assured that all appropriate steps were being taken. While television images showed a starkly different picture, the president rarely watches TV news and practices a management style delegating vast responsibilities. (Fischer et al., 2006)

President Bush was later criticized for his lack of oversight in what was considered a poor disaster response by FEMA.

5.5.4 Emergency Support Technology

While technology is not considered a pre-requisite for disaster response, its presence, absence, or fit may affect the performance of the response. The general use of support technology can be affected by many social, technical, and organizational factors regarding its use and perceived effectiveness. These factors include infrastructure dependence, multimedia communication capabilities, systems interoperability, technology costs and funding, systems performance, technology training and expertise, and lastly, responder attitudes towards technology. These concepts are summarized in Table 13 with detailed descriptions and examples that follow.

Table 13. Emergent concepts leading to the emergency support technology category

Category	Concept	Description
Emergency Support Technology	Infrastructure Dependence	Reliance of technology on infrastructure
	Multimedia Capability and Availability	Ability to communicate in different media formats for responders and decision makers
	Interoperability	Seamless connections and operations across different platforms and organizational boundaries
	Technology Funding	Financial resources available for support technology
	Systems Performance	Effectiveness and efficiency of information systems support required by responders
	Multi-Agency Technology Training	Technology training across organizational boundaries
	Attitudes and Usage	Responders' attitudes and actual use of technology

Infrastructure Dependence

During many large disasters infrastructure such as transportation, power and communication are frequently disrupted. Disruptions can occur from damage, or from overloading. Emergency response communication and information systems that are dependent on the infrastructure may also fail which effects emergency response. The ability to find alternative supporting technologies to restore communication is often a

critical first step in disaster response as decision makers must communicate with responders.

> Hurricane Katrina caused significant damage to the communication infrastructure in Louisiana and Mississippi, which further contributed to a lack of situational awareness for military and civilian officials. Even when local officials were able to conduct damage assessments, the lack of communications assets caused delays in transmitting the assessments... Hurricane Katrina destroyed or severely degraded many commercial landline and cellular telephone systems, and emergency radio systems were oversubscribed, making it difficult to establish necessary connections between officials and responders at the local, state, and federal levels. As a result, it was difficult for officials to gain situational awareness. (GAO, 2006a)

After an earthquake in Turkey in 1999, dependence on infrastructure was also encountered.

> The set of managers universally reported that standard communications were not functioning on the first day after the earthquake, and only sporadically and in very limited areas in days two and three. Electrical power was out, telephone communications were down, the only means of getting information was through short-wave radio... [A]ll 21 managers made strong, qualitative statements regarding their inability to transmit, receive, or access information from other sources during the first three days when communications were largely unavailable. Without the technical infrastructure for communications, coordination of action among the many organizations with responsibilities for disaster operations is extremely difficult at best and painfully inefficient at worst. (Comfort, 2000)

There is continued development of different satellite and mobile communications systems to try and reduce infrastructure dependence. Technologies such as MANETS (mobile ad hoc networks) and TETRA (terrestrial trunked radio) have capabilities to function in the absence of infrastructure through direct communication with other systems in proximity. In addition, cells on wheels (COWs), cells on light trucks (COLTs), and satellite COLTs may be deployed to reduce the dependence on terrestrial networks during exceptionally busy periods or compromised infrastructure (Richtel, 2009).

Multimedia Capability and Availability

The type of communication medium that is used by responders can convey different amounts of information. For example, images or video may be more informative than voice communications. Some of these medium formats may also convey additional relevant contextual information that responders may not otherwise think to communicate. Visual systems may convey body language if communicating, and voice systems may convey stress in verbal communications. In many call centers and EOCs they have

monitors mounted on the walls that are capable of viewing the feeds from local traffic cameras or local news stations to gather more information.

A report by the US government documented motivations for improving multimedia capabilities.

> Some current systems are not designed to send non-voice communications, such as photographs and video. First responders in several of our case study areas described additional capabilities that developing non-voice communications would provide. For example, photographs and video can quickly convey an emergency situation, saving time in response. Related capabilities, such as geospatial mapping, can accurately identify the location of first responders relative to a disaster. Hawaii first responders described an instance battling brush fires when air reconnaissance had to roughly convey its location using voice descriptions compared with a paper map. Some jurisdictions we interviewed are expanding, or planning to expand, their systems' capacity to transmit photographs and videos. For example, first responders in Sacramento, California, have planned to install a digital radio system in their emergency operations center, which would enable both voice and data transmissions. (GAO, 2009b)

A community emergency management coordinator (CEMC) discussed the use of multimedia in certain situations.

> There is no formal process. We have had incidents of flooding where someone has been down on the scene and the supervisor has taken pictures and emailed them. Then we brought them up in the EOC to give them a perspective of knowing there actually is a foot of water in the basements because people weren't believing the fire incident commander. He was saying, "There are new waterfalls on the escarpment. There's a lot of water here." So we have done that and it has been very useful in the past. ... In chemical HAZMAT type fires it has been able to assist the ministry. The environment rep we had in the EOC in that case could even just look at the smoke and say, "You know, you should be worried," or "You shouldn't be." They could do just a quick assessment on it. There is no formal process for them to do that. I know in our teleconference [anon] was talking about [tablet computers] and snapping things and sending it to the EOC and we would love that or video streaming. We do not have that capability right now.

System Interoperability

The ability to communicate amongst agencies depends on social interoperability from understanding procedures and languages, as well as technical interoperability such as information exchange standards between information systems. Most agencies have their own set of information systems, with very few common standards or interfaces between systems which inhibits the ability to share information amongst agencies.

In the United States,

> DOD has identified uncoordinated data and incompatible technology systems as technological challenges to efforts to enhance maritime domain awareness. Without data standards, data such as the date an event occurred can be difficult to communicate, because this information can be recorded in several different ways depending on agency and personal preferences. The National Information Exchange Model is one effort under way to address data standardization. Another effort, the National Maritime Domain Awareness Architecture, is to establish a technology architecture that will allow currently incompatible technology systems to communicate and access common data. (GAO, 2011c)

In addition,

> [f]irst responders continue to use various, and at times, incompatible communications technology, making it difficult to communicate with neighboring jurisdictions or other first responders to carry out response. For example, some fire departments have hesitated to use digital radio systems due to safety concerns, which could create incompatibility with other responders' equipment, such as law enforcement. (GAO, 2009b)

The use of bridging equipment, such as the ACU-1000[15], is available which can technically enable interoperable radio communications between agencies. When deployed, theses systems enable the possibility to simultaneously cross connect radio networks, telephone, and satellite communications systems. Depending on specific systems, these devices often require an extra radio to connect to the bridging system, and the system broadcasts all communication in the system to the participants. However, one firefighter participant expressed concerns with such systems as confidential or sensitive communication is compromised, different agencies use different terminologies, and information overload becomes a problem as participants are listening to all communication over the bridged systems.

Emergency Technology Funding

The ability to fund multi-agency emergency support technology is a challenge for many regions and agencies. Differences in funding mechanisms for various agencies influences technology spending across those agencies such that it is often done individually. Furthermore, the technology costs alone, or the staff required to operate the technology can be cost prohibitive, and was frequently stated as a limiting factor in disaster response. The ultimate result of funding challenges is a lack of availability to possible support tools. During scenario SC3 a United States Coast Guard liaison commented that they have more technology than people to man it or use it because people cost money. Meanwhile, the US city that was organizing the event was using an original version of software that was provided by the state because it could not afford to upgrade to the latest version. There had been approximately 20 version updates since the initial software purchase. The lack of modern software affects the ability of that city to manage

[15] http://www.raytheon.com/capabilities/products/acu1000/

incidences. An integration tool that was being tested during the exercise connected the US and Canadian incident management systems so that both sides could see what information was being logged. The software was well received but the US city needs to negotiate price or funding alternatives as it cannot afford the integration tool it needs. On the Canadian side, the incident management software they use is recent and up to date. It is jointly funded and used by the county, the city, and a large university for incident management.

In some cases as well, even acquiring immediate needed support technology is beyond the means of local authorities. The only way it can be acquired in those cases is with emergency funding from regional or national governments provided a local state of emergency is declared.

This information was expressed in one interview. A firefighter discussed the ideal technological needs for multi-agency response but cited funding as the major problem. Finding municipal partners is cost prohibitive as equipment can be very expensive[16]. A cost of $48.5 million dollars was estimated to be Police, Fire, and EMS on the same system in a region of Ontario[17]. In addition, all responding groups have different sources of funding. Ambulatory services are covered by ministries of health, and ministries of safety fund provincial police and fire services. Police and ambulance services are able to generate income from service fees. However, fire services are considered "a money pit" as they are not able to recover costs by collecting fees. In order to get coverage funding for a disaster from the government it is in the community's best interest to declare an emergency.

Responder Technology Performance

Responders rely on dependable equipment, and technology is no different. Whether it is an information or communication technology, emergency responders must have proven and reliable equipment that is available for use in a timely manner when it is required. Slow or poor performing equipment will inhibit the ability of responders to communicate or perform their emergency response duties.

Emergency professionals also have a keen awareness of information privacy and security as it relates to technology performance. They must trust the information and communication technology they use to share sensitive information securely. Open communication and radio signals are subject to possible interception by the public and media so sensitive information must be communicated using the most appropriate and secure communication mechanisms.

Problems with technology were experienced firsthand during an observation session with an EMS supervisor. A call was received from dispatch where the automated vehicle locator (AVL) for an ambulance indicated it was driving around. However, the crew had

[16] http://www.wcyb.com/news/Change-in-radio-system-fees-coming-for-emergency-responders/-/14590844/19793716/-/ts1oea/-/index.html

[17] http://www.oafc.on.ca/article/price-tag-485-million-put-durham-cops-fire-ems-same-system

reported they were stuck in offload delay so the ambulance should not have been moving. This unexpected ambulance movement hinted at a problem as serious as a stolen vehicle, or maybe an abuse of work time by the EMS personnel. The supervisor hunted down the vehicle location by GPS only to determine it was a phantom movement on the mapping system. A visit to the hospital revealed the vehicle was still in the emergency drop-off lane. The unexpected movement was the result of a technical glitch. If an urgent response was necessary this error could have affected the agency's capabilities.

A different type of technology performance issue occurred in the Marmara region of Turkey in 1999 after the communication infrastructure was destroyed by an earthquake. "Motorola Company distributed Iridium satellite telephones, but these telephones need an open area for clear transmission, and they did not function well for most uses in the disaster environment. (Comfort, 2000)" The city environment limited the performance of the satellite phones.

While these example problems highlighted some of the issues with technology, positive examples of the performance of technology were seen during other disaster responses[18].

Multi-Agency Technology Training

While multi-agency training exercises often focus on inter-agency cooperation, familiarity of multi-agency communication and technology training is often limited such then when a crisis does occur, trained emergency professionals may not recall how the system was used. In addition, coordination may also sometimes entail sharing of equipment. Different agencies may need to be familiar with the operation of that equipment to coordinate responses.

The Early Alert System (EAS) in the United States was designed to help share advanced warning information amongst stakeholders. Amongst other problems with the system, the US government indicated a problem of

> ... inadequate training for EAS participants, both in using EAS equipment and in drafting EAS messages. In 2007, we reported that several EAS stakeholders, including state and local officials, identified inadequate training as a limitation of EAS and cited a need for additional instruction in equipment use and message creation. Our current work indicates that such training is still lacking. For example, a state official told us that users and message originators need additional training to know how to properly craft and initiate a message, especially since emergency managers vary in their level of expertise. Similarly, a number of respondents to our state survey of emergency managers cited a need for training. For example, one state emergency management representative suggested that training courses be established for emergency managers, broadcasters, and cable providers. To address training inadequacies, we previously recommended that FEMA develop a plan to verify that EAS participants have the training and

[18] http://www.ft.com/cms/s/0/c5d3462a-ef38-11e0-918b-00144feab49a.html#axzz2S0sSBrL1

> technical skills to issue effective EAS alerts. DHS agreed with the intent of the recommendation and noted that FEMA would improve training for EAS operators, as well as make the system more user-friendly. According to FEMA, it is currently analyzing and assessing EAS operator training needs, but it has not yet implemented any new training initiatives. (GAO, 2009f)

In 2008 a series of tornadoes struck an unidentified state and NIMS (National Incident Management System) usage was studied as its implementation and training was mandated by the US federal government three years earlier in 2005 (Jensen, 2008).

> I think most of the people hadn't had the NIMS… I think it hurt because it could have been done. They could have done more. Some were new and just hadn't had a chance to get in there and do it...
>
> And, while many interviewees confirmed that they had indeed gone through NIMS and ICS courses, they indicated the time between the training and the event was too long to for them to use it effectively. One respondent noted that it was difficult to remember what needed to be done and how it needed to be done to comply with NIMS since it had been six months since they had gone through NIMS training.
>
> More than one interviewee pointed out that the trainings presented a lot of information at one time and that there was considerable time between the few trainings they had. Interviewees also stated that they didn't have enough opportunity to use NIMS before the disaster. (p. 11)

Responder Technology Attitudes and Usage

Responder technology attitudes influence how technology is used by responders, or if it is used at all. This can create complications if there isn't a consistent level of trust or comfort about using technologies across agencies. Some responders fear there is too much of a dependence on technology which leaves responders incapable of doing their jobs when infrastructure fails despite the capabilities of having non-technologically enhanced response capabilities. Others wish there was more use of technology as it aids in the job. Ideally, the tools emergency responders have should be useful on a day-to-day basis for the responder so that they are confident with using the system when a crisis arises.

One EMS supervisor responsible for dispatch shared a perspective on technology that was implemented for dispatchers working at the call center.

> I was training the dispatch people here. One of my first questions was, "Is technology the answer?" It' was funny to see their answers from the start of the course to the end of the course. I am a big proponent in our Dispatch Center where once a month a platoon has to go down. We take their computers down, their maps down, and they have to do it manually. Each platoon does it three times a year. There are four platoons and each does it three times a year as a

> requirement. It's not a "maybe", it's a "you have to", so they know what to do if the power isn't there. Not all centers do that. It is a requirement here... There are dispatchers in the provincial system that will probably never use paper only because they don't practice paper exercises. They weren't taught paper when they took the course. Here, they have to learn to dispatch on paper before they even touch a computer. And then they have to do it once every three or four months, in a live environment. They know what paper is. They don't like it but they know they have to do it. You can be too reliant on technology. You get lackadaisical – you think the technology will do it for you and you don't check to make sure the technology is correct but it's only as good as what's going into the system and spitting out. So, if there's a flaw in any of the data that was entered, say on the response plans or anything like that, then it's not coming up right on the other end of the deal either and they're not checking to make sure that it's right. Technology can be a help or it can be a huge hindrance.

5.6 Summary

This chapter discussed the analysis process and results of conceptualization from the data sources. The first information to be presented was an analysis of background information provided by participants and supported in the literature. The background information provided contextual information on the actors involved in disaster response, from first responders to NGOs to emergent citizen group volunteers. A typical escalation process of how emergencies transitioned into disasters from the perspective for first responders was then described. The escalation processes followed from notification of a hazard to activation of EOCs and acquisition of additional resources. With an understanding of the actors and escalation process in place, a summary of the types of tasks conducted by the actors during response was then provided. The tasks were described as consisting of several situation-dependent activities that needed to completed in order for the greater task to be accomplished.

This background information contributed to the establishment of theoretical sensitivity for conceptual analysis. The use of NVivo software and its function is the study was then described. NVivo is a qualitative research analytical tool that enabled a centralized store of documents and markup to be performed on those documents to identify and document concepts and relationships present in the data.

The emerged concepts were then presented along with supporting examples from the literature. As extracted from the data, coordination emerged as the major theme and contributed greatly to disaster response. This was determined through the analysis and abstraction of low-level concepts into four higher concepts of context-awareness, multi-agency relationships, task-based management, and emergency support technology. Together, these four concepts related to coordination of disaster response.

CHAPTER SIX :: FRAMEWORK AND DISCUSSION

6.1 Introduction

During the data collection and analysis process several relationships between concepts were observed and explored using axial coding and theoretical memos. To try and establish relationships at the conceptual level would lead to an extremely complex model of the situation. Through abstraction, the concepts were categorized which allowed a parsimonious representation of the relationships amongst categories.

In this chapter the categories and relationships are used to develop a framework for a context-aware coordination system. The results of the analysis were combined with extant literature and theory to finalize the framework. The framework is used in this chapter to identify system requirements to be considered for building a comprehensive and integrated system capable of addressing many of the challenges of crisis response coordination.

6.2 Context-Aware Multi-Party Coordination Framework

Figure 9 represents a context-aware multi-party coordination framework which emerged from the data. In this framework three emergent categories are related to one another through information flows. Previously identified concepts represent internal factors which affect the performance of the category. At the center of the framework is decision-making, which is an integral part of any coordination process.

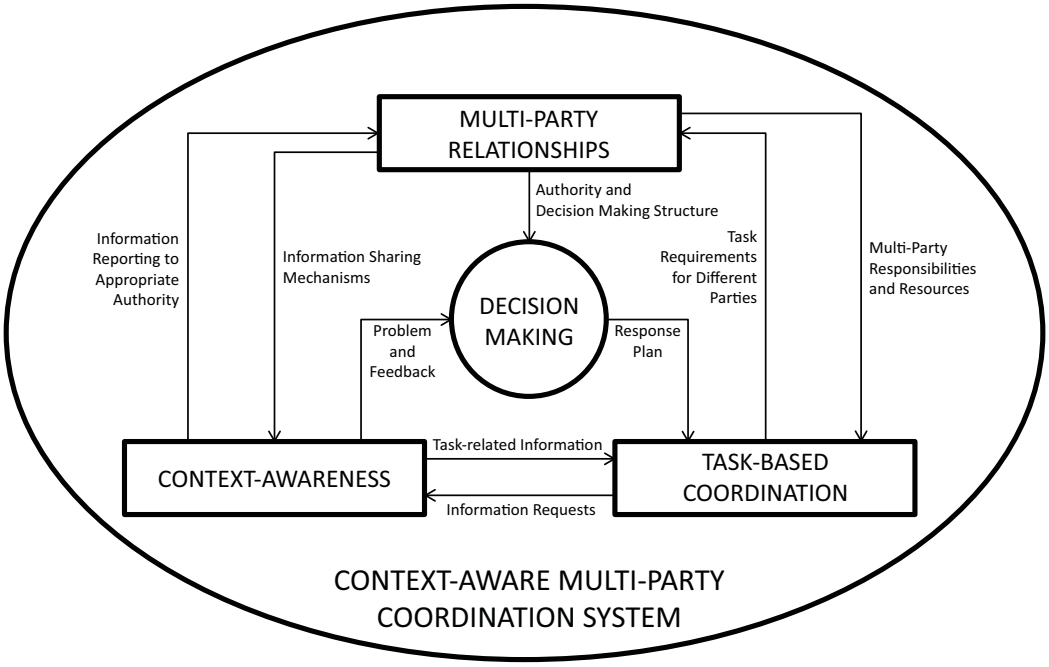

Figure 9. Context-aware Multi-party Coordination System (CAMPCS)

The proposed framework addresses three main types of issues that were encountered in the study. These issues are identified as environmental issues, multi-party issues, and activity-based issues influencing coordination. The NVivo analysis of Figure 8 identifies three components represented as Context-Awareness, Multi-Party Relationships, and Task-based Coordination, to address the three types of issues accordingly. These issues are distinct but interdependent and influence the overall coordination process.

The awareness of environmental issues by agencies helps to determine what problems agencies need to respond to, along with what and how tasks will be performed to address the problem. Similarly, activity-based issues surrounding the tasks to be performed are dependent on the operating environment of responders as well as the agencies available to execute the tasks as agencies frequently have different roles performing different tasks. Finally, different agencies need to work together in order to address complex environmental conditions and must try to provide all the resources necessary to complete any required response tasks.

Disasters often develop rapidly with great uncertainty making it essential to collect situational information in order to take quick and appropriate action. Context-awareness represents the acquisition and type of information required, as well as the information quality.

In addition to understanding the environment, an emergency response often requires the temporary participation of multiple parties with different professions, from different regions, and belonging to different authorities. It is necessary to make sure they can work together and appropriately handle their work relationships. The multi-party relationship component of the framework is therefore used to deal with multi-agency organizational issues.

Lastly, emergency response needs to organize multiple interrelated tasks in order to respond to a variety of events. Task execution may require resource sharing, expertise and activity coordination from different parties. The coordination component of the framework addresses activity-based issues.

There is one other component of the framework that is not visually represented in the model. Emergency support technology, is implicitly applied in the framework through its impact on the interaction between components, and its impact on processes within the components represented in the framework.

The next three sections break down the environmental, organizational, and activity-based issues further and then describes how each component of the framework can help address the coordination issues present in disaster response. The following section describes the role of emergency support technology in the framework.

6.3 Context-Awareness

Understanding the emergency environment is critical to planning an adequate emergency response. Environmental understanding directly influences how people respond to situations. A lack of understanding of the environment can negatively impact the effectiveness of the response.

In addition, responders and decision-makers are also concerned with the quality of the context information received which can also lead to response problems. Lee, Strong, Khan, and Wang (2002) examined several papers discussing the characteristics of information quality and developed a tool to measure it. From an academic and practitioner perspective, Information Quality can be *intrinsic* meaning the quality resides in the information itself, *contextual* meaning the information must be considered in regards to the task at hand, *representational* meaning it can be stored and presented in a way that is interpretable, and *accessible* meaning the information must be available and not kept privately secured (Lee et al., 2002). Information quality profile can effect perceptions of risk, trust, and intention to use in inter-organizational systems and inter-organizational relationships (Nicolaou & McKnight, 2006). In emergency response settings, the trust in quality information influences responder behaviours.

Endsley (1995) developed a model which reflected the observed relationship between information and response performance. Endsley (1995) proposed a model to explain the development of situational awareness and how it translates into action for individuals on a job. In Endsley's model, information on the State of the Environment combines with individual factors such as goals and objectives, abilities, experience, training, and information processing mechanisms to assess the current environment and project a future state. This future state projection leads to decision making and the performance of actions.

Endsley and Jones (1997, 2001) later developed new models for describing team situational awareness and shared situational awareness where team situational awareness consisted of the awareness of all members of a team, and shared situational awareness consisted of only the common situational awareness shared amongst team members. While these models created a relationship between the environment and performance, they are limited in application in this study in that they only represent a small portion of the overall coordination study.

In general, environmental conditions may be referred to as context. Context has several different definitions in literature. A general definition of context for an information system provided by Dey, Abowd, and Salber (2001) is stated as "any information used to characterize the situation of entities (i.e., whether a person, place, or object) that are considered relevant to the interaction between a user and an application, including the user and the application themselves. Context is typically the location, identity, and state of people, groups, computational and physical objects."

In an emergency response setting, context is much more complex as it can be applied to a much broader range of people, places, times, and things with great uncertainty and difficulty to assess. For example, context information for an emergent event can include the nature of an event (i.e., earthquake, tsunami, explosion, etc.), its location, its magnitude or severity of impact, when it occurred, its immediate impact, the potential affected population, the potential affected area, the speed of onset, the duration of effect, and potential triggered secondary events. Decision makers, responders, and citizens are able to use all or part of this context information to plan their responses.

Decision makers, responders, and citizens may also have context information associated with them. Search and rescue personnel context may include where they are, what their role is, what tasks they are performing, what equipment or resources they require, what resources or equipment they are using, when they started their activity, when their status will change, who they are working with, and more. Higher level contexts may include knowledge of where rescuers are in relation to other rescuers, resources, equipment, or security which could provide support if needed, and how long it will take to receive additional support. Information on proximity to victim locations, or search areas to find victims may also be important to rescuers. For victims, context information may include where they are, their health and physiological status, their mobility status, how long they've needed assistance for, or even where they are relative to a physical threat, a safe place, or a search and rescue responder. For decision makers, context information may include what organizations are available to assist, what roles organizations will perform, how to communicate with organizations, what resources are on hand, what resources are required, where resources are deployed, and how resources will get to where they are needed.

Research into the application of geographic information systems (GIS) for decision making has been ongoing for years. Zerger and Smith (2003) provide an overview of dozens of cases of GIS in dynamic environments and identify many challenges to using GIS for real-time disaster decision support. Among the impediments identified in their research are scale and suitability for regional decision making of spatial data, as well as the desire for temporal detail rather than spatial details by decision makers.

The application of GIS in crisis response has grown from the historical application of GIS in disaster response settings and involves the use of mobile and web-based applications along with visualization tools to overlay real-time and historical data on geographic maps (Meier, 2009). During the response effort to the 9/11 terrorist attacks in New York, a GIS was used to track the search and rescue operation and organize the cleanup effort (Thomas et al., 2002). Using the GIS tools, decision makers were able to gather relative location-based information to coordinate rescuer search for survivors, allow heavy machinery to clean up debris, and develop routes of traffic in and around debris. Other equipment was used to identify unstable search areas in the rubble and map those unsafe areas for rescuer awareness. These maps were updated on a regular basis.

Context-aware computing can be used to manage this environmental awareness issue by providing better aggregated, filtered, and processed information for dynamic decision making. In context-aware computing, context-awareness is defined as the set of environmental states and settings that determines an application's behavior (active context) or characterizes the conditions in which an application event occurs (passive context) (Chen & Kotz, 2000). Context-aware computing itself is a set of integrated devices, databases, and services designed to capture, represent, communicate, integrate, query, and support development of a larger context (Mehra, 2012).

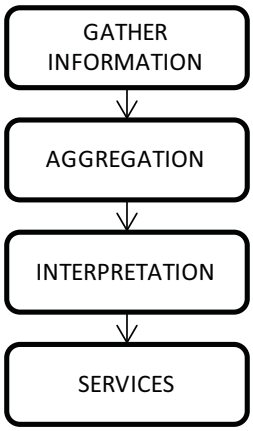

Figure 10. Context-aware computing processes.

Figure 10 highlights the general components of context-aware systems. Information gathering is the collection of contextual data from various monitoring systems and call centers. There is a great effort to add monitoring systems to aid in gathering emergency contextual data. Examples include earthquake monitoring systems, sea-level monitoring systems, satellite observation systems, and weather monitoring and forecasting systems. Public reporting to emergency call-centers is also a major source of environmental data. The reported data may be in several different formats such as voice, images, sounds, text messages, and video. The next function is the aggregation of the information from different sources and organizing and integrating it into a structured data management system. The information can then be used for modeling and interpretation by experts or expert systems. The interpreted results may be used directly by decision makers to plan a response to an emergency. However, with context-aware computing the interpreted results may trigger services or actions such as notification of key personnel, an automated response such as alarms or engagement of backup systems, or the results may be used to respond to information requests.

Many emergency response agencies have systems that perform similar tasks on smaller scales. Automated dispatch is used in some call-centers to automatically notify other agencies to respond to a call if it meets certain criteria. Some agencies have other monitoring, expert, and decision support systems that often operate independently, but an

effective emergency management system can be improved if it has the capability to connect, integrate, understand, and share the information related to an emergency.

Research into context-aware computing has already addressed several of these requirements. Context-awareness uses sensors or other information sources to measure environmental conditions and identify many low-level contexts (location, temperature, orientation, time, etc.) while context-aware applications combine environmental and low-level contexts using artificial intelligence to develop higher level complex contexts (Mehra, 2012). Context-aware computing utilizes both active and passive context-aware applications where active context-aware applications automatically adapt application behavior when new context is discovered; and passive context-aware applications adapt the presentation of information (Chen & Kotz, 2000).

Using context-aware technology can aid in the collection and aggregation of sensory environmental data in several dimensions to provide passive context information to emergency responders. Use of this data can also be combined with real experts or expert systems to better identify the nature and scope of a disaster to interpret more appropriate responses. The context information can also be used to trigger an appropriate action for an active-context application such as responder notification on the changes in the operating environment or availability of resources. Changes in context can also be used in a decision analysis framework for public notifications of disasters (Xu, Yuan, & Ji, 2009). Many modern ambulance dispatch centers already utilize global positioning system (GPS) tracking on their ambulances along with ambulance status tracking in order to select which ambulance should be quickest to respond to an emergency. These systems are called AVL (Automatic Vehicle Location) systems.

The contexts for responders may also be influenced by greater contexts. For example, the response to the nuclear disaster in Fukushima, Japan was not limited in scope to the local proximity of the nuclear power plant. Leaking radiation spread widely into the air and sea influenced by the wind, rain and rivers. Radiation affects the food chain and the human body through exposure to direct radiation and contaminated goods. This information adds additional high-level context information to the response effort.

All of the pieces of contextual data are collected through sensory information, eye witnesses or first responders on scene. Integration of these pieces provides a more complete picture. A geographic information system (GIS) may serve the purpose of disaster information integration (Environmental Systems Research Institute, Inc., [ESRI], 2008; Centre for Security Sciences, [CSS], n.d.) while a crisis memory system can be used to log the chain of events during a crisis along the dimension of time (Turoff et al., 2004). As a response continues contextual information is continually monitored, updated, accumulated and analyzed to further refine and redirect decision making processes, resource requirements, and action plans. During a crisis, those who are dealing with the emergency are flooded with information (Turoff et al., 2004). An emergency support system should carefully filter information that is directed towards actors. A layered crisis communication architecture (CCA) was proposed to validate, filter, interpret, access, and

exchange relevant crisis information (Hale, 2009). As indicated by Turoff et al. (2004), "[e]stablishing and supporting confidence in a decision by supplying the best possible up-to-date information is critical to those whose actions may risk lives and resources (Premise 7 – information validity and timeliness)." With dynamic decision making, a combination of performance feedback and feedforward decision aids are necessary for improved decision making (Gonzalez, 2005). These may be provided by context-aware computing systems.

6.4 Multi-Agency Response Relationships

Disasters or crises are usually beyond the capabilities of a single agency. Responses often require participation from several parties of different professions, regions, and authorities. Some parties may have previous working relationships but many of them may not. To establish and manage working relationships is a prerequisite for effective coordination in emergency response. As pointed out by Turoff et al. (2004), "the critical problem of the moment is the nature of the crisis, a primary factor requiring people, authority, and resources to be brought together at a specific period of time for a specific purpose (Premise 5 – Scope and nature of crisis)."

Unlike well-established contract-based multi-party relationships in routine business operating relationships such as supply-chain management (SCM), emergency response is often a dynamic response that may lead to the formation of ad hoc relationships with responders from different departments, agencies, regions, cultures, or even countries (Janssen, Lee, Bharosa, & Creswell, 2010).

During disasters, the establishment of command centers for emergency response is usually the first priority. Depending on the scope of the disaster, command centers could be activated locally, regionally, nationally, or in multiple locations at the same time. Government chief officers are often directly in charge of the command center in order to have authority to mobilize the resources for emergency response. Without the establishment of appropriate authority, the rescue effort cannot be well organized. For example, in the case of hurricane Katrina, when the storm badly destroyed the coast from Alabama to Texas, many citizens and responders kept asking: "Where is the federal government?" The Federal Emergency Management Agency (FEMA) was supposed to take the leadership role of the federal response for such a large scale disaster but it let individuals and communities act on their own for the first 72 hours (Fischer et al., 2006).

The parties involved in emergency response also depend on the nature and scope of the disaster. Typical individuals responding to an emergency are police, fire, and emergency medical service (EMS) personnel. Responders can also be from several different groups including government ministries, non-government organisations (NGOs), and humanitarian agencies. Lastly, responders may be from other divisions or specialized units within the typical responder agencies, such as firefighters from several fire departments, or tactical response teams and bomb squad units from police services.

All of the various responders have their own responsibilities to consider based on their training, area of expertise, knowledge, tasks, and organizational contexts. These differences can also include legislated requirements on information sharing policies, processes to follow, and communication hierarchies which influence or mandate how these responders operate. For example, an emergency call to a police dispatcher would entail questions the responding officers would need to know about safety such as if there is a weapon on scene, while an emergency medical service (EMS) dispatcher would be more concerned about a victim's medical situation and how to access the victim. The same emergency can generate multiple requests for assistance from different agencies using different contextual data.

In addition to different emergency requirements, the relationships between organizations may vary greatly depending on the history of interacting with one another. Police, fire, and EMS regularly respond to many of the same emergencies giving them an extensive history of working together. Organizations with established relationships have familiarity with each others' policies and procedures making interdependency more routine. Organizations drawn together for the first time may need to establish coordination relationships to overcome an obstacle or achieve a common goal. It is especially true when rescuers are from different regions or countries and from many volunteer organizations. For instance, FEMA and the Red Cross agreed that FEMA should be the primary agency for mass care in the NRF (National Response Framework) because the primary agency should be able to direct federal agencies' resources to meet mass care needs, which the Red Cross cannot do. NVOAD (National Voluntary Organizations Active in Disasters), an umbrella organization of 49 voluntary agencies, is supposed to have a broad role of facilitating voluntary organization and government coordination, but limited staff resources constrained its ability to effectively fulfill its role in disaster response situations. At the time of Katrina, NVOAD had only one employee to make daily conference calls with its members which made for ineffective information sharing (GAO, 2008c).

With multiple organizations also come conflicts of interest regarding the goals and objectives of activities being performed, as well as the overall output of activities. Failure to resolve conflicts of interest amongst parties can negatively affect decision making capabilities. For example, political conflict stemming from mistrust between the Japanese government and Tokyo Electric Power Company (Tepco) was said to be the cause of slow information flow between the two parties and negatively affected the pace of Japan's response to an impending nuclear disaster (Onishi & Fackler, 2011).

The nature of coordination also depends on how agencies and individuals are able to connect with one another and share information or resources. As indicated by Turoff et al. (2004), "[c]rises involve the necessity for many hundreds of individuals from different organizations to be able to freely exchange information, delegate authority, and conduct oversight, without the side effect of information overload (Premise 8 – free exchange of information)." As an example, while SOUTHCOM (U.S. Southern Command) developed an organizational structure designed to facilitate interagency collaboration, the scale of

the Haiti earthquake disaster challenged the command's ability to support the relief effort. SOUTHCOM's support to the disaster relief efforts in Haiti revealed weaknesses in this structure that initially hindered its efforts to conduct a large scale military operation (GAO, 2010d).

Interoperability is the term used to describe the interaction between multiple agencies. Interoperability is the process of maximizing opportunities for the exchange and re-use of information, whether internally or externally, through the management of systems, procedures and the culture of an organization (Miller, 2000). Technical or hard interoperability, the most commonly discussed form of interoperability, relies on technological factors such as hardware, communication protocols, storage, etc. for the exchange of information. Soft interoperability relies on factors such as semantic, human/political, inter-community, legal, and international operability.

Organizations that have more interdependency and are more familiar with one another may have procedures and established relationships in place to connect with the other organization making them more interoperable. For example, Red Cross may have relationships with various levels of government to manage mass casualty situations.

Unfamiliar organizations, in addition to making contact, will need to quickly establish connections with key personnel in order to share information and resources. These new connections are likely to be subject to a lack of trust and other behavioural issues impacting the relationship that established communication channels should have already resolved.

When multiple agencies are responding to an emergency, problems with authority and dynamically changing roles may also occur. As pointed out by Turoff et al. (2004), "[i]t is impossible to predict who will undertake what specific role in a crisis situation. The actions and privileges of the role need to be well defined in the software of the system and people must be trained for the possibility of assuming multiple or changing roles (Premise 6 – role transferability)." During the response to Hurricane Katrina, local civilian authorities sought access to military resources to help with the response, but they did not wish to cede overall control of the response effort to the military. The military role became one of facilitating transportation of people and resources, providing support to responders, and general repair to destroyed infrastructure (Fischer et al., 2006).

The identified multi-agency issues above illustrate that navigation of the inter-organizational issues related to each of the agencies contributes greatly to the overall response. Information systems can be used to overcome or assist in addressing many of these organizational issues. Current information systems within agencies are largely used to maintain a list of key contact information for other agencies which dispatchers may interact with or need to notify. However, with the soft interoperability issues that have been mentioned, there is an opportunity to improve the interactions between agencies with context-aware communication systems.

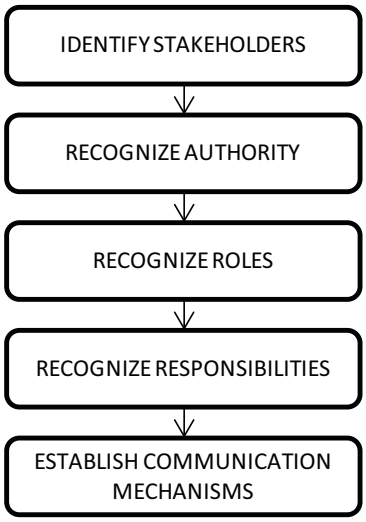

Figure 11. Multi-party relationship management

Figure 11 summarizes a system controlling the relationships between several agencies. This system clarifies the roles, responsibilities, authorities, and information exchange privileges amongst agencies. The roles describe what role an agency plays in the emergency response while responsibilities describes the tasks the agency is responsible for executing. The system also identifies established authority relationships such as the command and reporting structure for the emergency. Lastly, the system establishes information exchange channels and privileges dictating what information should be exchanged with whom through which channel or contacts. This system is dynamically maintained in order to reflect the changes in the emergency situation and responding agencies. It helps address multi-party relationship management issues which helps add control and order to potentially chaotic multi-agency environments.

It is important to point out that many of the issues relating to multi-agency relationships can be reduced to concepts of power. Power researchers generally seek to examine the determinants of network effectiveness in relation to power bases. One study on power pertaining to emergency management (Choi & Kim, 2007) examines changes in emergency management networks with respect to shifting structural-based, resource-based, actor-based, cognitive-based, and political-based power bases. However, the research into specific types of power is outside the scope of this study as it occurs at a lower conceptual level than the analysis of the data.

6.5 Multi-Agency Task Management

Coordination is the last of the key components to discuss. Coordination, consisting of goals, activities, actors, and interdependencies, can be defined as the management of interdependencies between activities to achieve a goal (Malone & Crowston, 1994). Coordination has also been described as the fundamental task of the firm in order to maximize the efficiency gains from specialization (Grant, 1996). With this second

perspective, transferring knowledge is not as efficient as integrating knowledge, thus making coordination a priority. In a multi-agency emergency response setting, coordination is the process of getting multiple parties sharing multiple resources to complete multiple tasks. Coordination can be actor-actor based, actor-activity based, or activity-activity based depending on the type of coordination process, with non-human resources intrinsic to all the forms of coordination (Shen & Shaw, 2004). Chen et al. (2008) provided a coordination framework for emergency response management. Coordination goals, issues, and supporting mechanisms were analyzed along the dimensions of task flow, resource, information, decision and responder in the life cycle of pre-incident, during incident, and recovery phases.

When a crisis does occur, emergency management personnel must maintain effective communication and coordination in order to manage an effective crisis response and minimize damage or loss of life (Seeger, 2006). "Effective response to catastrophic disasters will require that first responders—law enforcement personnel, firefighters, and others first on the scene—have reliable communication systems, including supporting infrastructure, facilities, and staff. Such communication systems would enable first responders to communicate through voice, video, and other information seamlessly among themselves, various organizations, and different levels of government (GAO, 2009b)." Coordination in emergency response is necessary to share critical contextual information about environment conditions, command and control structure, resource availability, process workflows, and task arrangements. This contributes to the decision making process. Coordination is then used to assign tasks, allocate resources, and execute the plan. During a disaster, infrastructure including the roads, electric power supply, and communication networks are often significantly damaged or overloaded due to reduced capacity or high demand. Re-establishing communication networks will be the first priority to facilitate coordination. Usually wireless communication is the first form of communication to be established but an emergency response system should not be designed only based on the use of the most advanced communication infrastructure. For instance in the case of the Marmara earthquake in Turkey in August 1999, standard communications were not functioning on the first day after the earthquake, and only sporadically and in very limited areas in days two and three. Electrical power was out and telephone communications were down. The only means of getting information was through short-wave radio provided by Turkish Amateur Radio Club (TRAC) to relay information among different disaster sites, the Governors' Offices and the Prime Minister's Disaster Operations Center in Ankara. Police and military units also used two-way radio for internal communication with limited relay for urgent messages to other organizations. Satellite telephones were brought in by search-and-rescue teams for limited users. Only on day four was telephone communication reinstated for major areas (Comfort, 2000).

As pointed out by Turoff et al. (2004), "The crux of the coordination problem for large crisis response groups is that the exact actions and responsibilities of the individuals cannot be predetermined (Premise 9 -coordination)." Challenges with coordination begin with different responders having their own specialties and their own methods of

conducting business. Agencies cannot necessarily perform all of the activities, nor possess all the knowledge required during an emergency. As such, they must coordinate tasks and information with others in order to effectively manage an emergency. The ability to share information, request information, and coordinate activities relies on the ability of responder agencies to work within their own organizational contexts and interface with other agencies. The importance of coordination is difficult to assess as its true value can only be described when it fails.

In many circumstances collaboration is minimised at an accident scene. It has been argued that the lack of collaboration at a scene occurs due to uncertainty, asymmetry in information and expertise, and lack of incentives (Berlin & Carlström, 2011). In disaster settings, competition between humanitarian agencies that serve similar needs and seek similar funding sources has also been cited as a factor inhibiting collaboration (Inter-Agency Standing Committee, 2010; Stephenson, 2005). From firsthand participant observation and inquiry, it is argued that the reasoning for a lack of collaboration may be different, at least with first responders. In situations where a lack of collaboration occurs, coordination is still present for each agency to perform their function. Collaboration is not necessary due to familiarity and trust in the other agencies' abilities to perform their function based on prior experiences. There is no perceived need for collaboration.

Coordination may also be a challenge due to hard or technical interoperability issues. Emergency management and communication systems currently in place in most responder organizations are mainly targeted for individual agencies. More often than not, each agency has its own equipment, its own standards, and its own protocols and communication systems which limit interoperability with other agencies. As such, agencies only support those responders which the dispatch center is responsible for managing thus making coordination amongst multiple agencies more difficult.

Coordination is generally facilitated through aggregation and accumulation of public incident reports providing contextual background information, expert systems to assign priority levels to emergencies, notification systems for tiered responses between multiple agencies, identification of available responder resources, location tracking of responder assets, and any historical information on previous events at the location. The emergency management systems also provide connections to local and national databases to provide additional background information if required, as well as a directory of key agency contact phone numbers. The information and functionality provided by these systems enables dispatchers to coordinate the allocation of responders from one agency to an individual scene or several scenes throughout the entire jurisdiction of responsibility. While effective for single agencies, there is an opportunity to extend these systems to support multiple agencies.

There is increasing interest in emergency logistics and humanitarian logistics in operations research (Simpson & Hancock, 2009). Emergency logistics is defined as “the support function that ensures the timely delivery of emergency resources and rescue services into the affected regions” (Danish Refugee Council [DRC], 2008) while

humanitarian logistics is aimed to aid people in their survival during and after a disaster. The focus of disaster relief operations are "to design the transportation of first aid material, food, equipment, and rescue personnel from supply points to a large number of destination nodes geographically scattered over the disaster region and the evacuation and transfer of people affected by the disaster to healthcare centers safely and very rapidly" (Kovács & Spens, 2007). Many theoretical models and optimization algorithms have been investigated. However, to put them into a real emergency operation is still a big challenge (Kovács & Spens, 2009).

During a rescue operation, there is usually a serious resource shortage which may affect the tasks being carried out and requires setting priorities and searching for alternative solutions. Thus resource allocation requires coordination between multiple parties at different levels. For instance, after the Haiti earthquake an enormous amount of resources were sent to the nation from the international community. Unfortunately, many of the resources remained at the airport as the logistical infrastructure was not yet established to offload the resources, warehouse and secure the resources, and transport the resources to where they were needed. Rescue personnel improvised to carry what they could by personal automobiles, or by using secondary gateways from nearby Dominican Republic to get personnel and resources to where they needed to be in Haiti (Robbins, 2010).

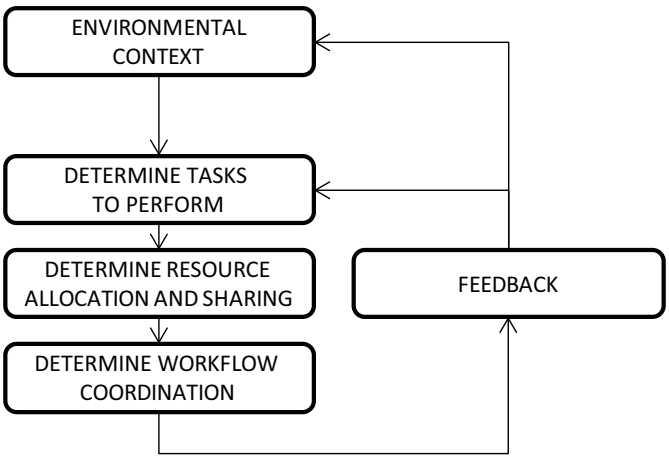

Figure 12. Task-based coordination process

Figure 12 outlines a process flow diagram which can be applied to a task-based perspective on emergency response coordination. First and foremost is an emergency event that occurs. This emergency event provides the awareness trigger to begin collecting and disseminating contextual information to responders regardless of the source. A context-aware coordination system can measure, accumulate, and filter contextual data before notifying key personnel of an emergency and sharing relevant information with key responder personnel and decision makers. Responders to the scene can then gather additional context information and begin to identify the tasks that need to be performed in order to respond to the emergency. The determination of the tasks leads

to the determination of the required resources and agencies to successfully respond to the scene. Resources may include equipment, personnel, or other miscellaneous requirements from within single or multiple agencies. This is another opportunity for context-aware systems to provide resource availability data to key personnel. This resource availability information does not need to be restricted to a single agency, but can incorporate information from other agencies across organizational boundaries with agencies willing to build connections pre-disaster or during the disaster. An assessment of required resources can also be used to identify key contacts and share contextual information with new agencies that may be sought to assist in the response effort. Once resources have been requested, a plan for response is formulated based on the tasks to be completed, the resources available, and the interdependencies amongst multiple responder agencies. The tasks may be performed through workflow coordination activities. Context-aware computing can aid in the connection of agencies, sharing of resources, and sharing of incident information such as the command and control structure and responder roles such that situational awareness is shared amongst agencies and interdependencies are known. During the task execution unexpected situations may occur. This may trigger requests for modification of existing tasks, or requests for new tasks. Task feedback may also affect or become part of the environmental context. Completed tasks need to be reported back to commanders for monitoring purposes and to free up resources. This response process flow is repeated until all identified tasks are completed, the emergency is over, or the response is abandoned. This coordination process involves information gathering, decision making, as well as the execution of processes which is different from previous studies focusing on decision making only.

6.6 Emergency Support Technology

In the proposed framework, technology does not have a required presence in the ability to coordinate. Technology plays an important support role as a moderator for many of the interactions that take place. In many examples provided by the participants and in the literature, the failure of technology did not prevent disaster response coordination, but it greatly impaired it. Some agencies trained for coordination with disabled computer support systems. Information systems have the capabilities of improving disaster response coordination or inhibiting it if there is a dependence on technology that fails.

When present, interoperability is an important concept that contributes to influence disaster support technology can have on response.

Unfortunately, technology in general, and mobile technology in particular has a few challenges with fragmentation. The industry is made of several different service providers and manufacturers which utilize different standards (Yuan & Zhang, 2003). The fragmentation can lead to problems of proprietary systems and difficulties in communication between two parties (Turel & Yuan, 2006).

Emergency management and communication systems currently in place in most responder organizations are mainly targeted for individual agencies. However, the

challenges with fragmentation have not prevented the growth of mobile technologies. Real-time, anytime, anywhere connectivity, voice applications, mobile internet applications, scalability, and potential cost savings all contribute to the growth of mobile technologies in business and user communities (Chen, Chiniwar, Lin, & Chen, 2006). The value propositions for mobile technologies come from mobility and location-awareness and include ubiquitous communication, emergency and time-critical information services, and location-sensitive services (Yuan & Zhang, 2003).

The features and value propositions for mobile technology make the technology ideal to address the needs of emergency responders. For example, internet-enabled mobile devices allow the integration of mobile devices with centralized decision support systems and data warehouses which facilitate better communication amongst responders. This same principle can be used to build and deploy an intelligent mobile crisis response system (Yuan & Detlor, 2005). This functionality is improved from basic voice communication and demonstrates the usefulness that mobile technologies can now offer crisis responders.

Other features that mobile technologies offer include mobile chat functionality which can be used to send text-based communication to subscribed users in an emergency response setting (Goh, Ardil, Fung, Wong, & Depickere, 2003). This feature is capable of seeking out domain specific information for an emergency worker by voice command when requested (Goh et al., 2003).

Current emergency support technologies do not appear to have the capabilities of interacting with social media, but this feature appears to be growing in importance and may become a future standard functionality. The greatest use of social media during disaster response is generally one of sharing information with the public by those in charge of responses, but the growth of social media and the application of crisis informatics and crisis mapping (Liu & Palen, 2010; Meier, 2009) is also enabling the mapping of disaster related social media information which can be used to direct responders to areas of particular concern. Such was the case during Hurricane Sandy (Robertson, 2012a). Generally speaking, however, responders are not yet fully connected to social media to guide their responses as there have been instances of false and misleading information being perpetuated using social media systems (Robertson, 2012b).

6.7 Evaluating the Framework

Up to this point elements of the framework have been described and discussed with the examination of literature pertaining to the category and supported by the data provided by participants and literature. In this section the framework is compared to other systems that discuss related frameworks.

6.7.1 Comparing CAMPCS and GDSS

A central element to the proposed context-aware multi-party coordination systems (CAMPCS) for emergency response is decision making. Throughout the paper, coordination was discussed in conjunction with decision making and planning. Having the proper information would lead to better decision making, and in turn would lead to better action.

Group decision support systems (GDSS) were originally defined as systems that combine communication, computer, and decision technologies to support problem formulation and solution in group meetings. A GDSS aims to improve the process of group decision making by removing common communication barriers, providing techniques for structuring decision analysis, and systematically directing the pattern, timing, or content of discussion (DeSanctis & Gallupe, 1987). The proposed framework however, is significantly different from traditional GDSS and DGSS in terms of the objectives, users, decision contexts, and working environment.

The main objective of GDSS is to improve the process and the outcome of group decision making. GDSS helps group members resolve conflicts and reach mutual agreement. The implementation of the decision is usually not the focus. The main objective of CAMPCS is to support multiparty coordination. Although multiparty coordination may also involve group decision making and negotiation, it emphasizes the management of the tasks of activities performed by the joint effort of multi-parties, such as communication, resource allocation, scheduling, job dispatching, etc. In other words, GDSS is decision oriented and CAMPCS is action oriented.

The users of a GDSS may be a group within an organization or from different organizations. The roles and the relationships of the group members are usually well defined. For emergency response, the participants may be from different authorities, professions, and regions. They come together on an ad-hoc basis and identifying their roles and relationships becomes one of the major tasks.

The decision context for GDSS is often given and well defined. The focus of the group decision makers is on how to reach a better decision. The decision context for CAMPCS is dynamic with great uncertainty and urgency. In a disaster scenario, things change rapidly and decisions must be made immediately. Collecting context information and taking quick corresponding action is critical for saving human life and reducing property damages. Context-awareness becomes an important component of CAMPCS.

The working environment for GDSS is mainly in a meeting room equipped by computers connected through fixed-line communication networks. For DGSS there may be several geographically different locations but the individual locations still generally rely on fixed-line communication networks and are not mobile. The working environment for CAMPCS in emergency response can be for anyone at anytime, anywhere.

Emergency responders have to work on a disaster frontline. Emergency command centers may be temporally established on the frontline of the disaster scene even without a camp.

With the possible and frequently severe damage of communication infrastructure during a disaster, mobile communication is usually the method used to communicate amongst responders and decision makers. Mobile communication is relatively easy to install and mobile devices are most likely used by rescuers.

6.7.2 Comparing CAMPCS and DERMIS

In 2004 Turoff et al. proposed a design for a Dynamic Emergency Response Management Information System (DERMIS). They designed their system using several premises which are shown in Table 14 in Appendix C. All of the premises put forward were supported by the information contained in the collected data to some degree.

Turoff et al. had identified seven software design requirements based on key assumptions of supporting responders, and existing available network and computing technologies. The identified requirements were:

- Extremely easy to learn via training and exercises because it is consistent with the task requirements.
- Useable by people who will have an understanding of their roles and responsibilities in an emergency environment.
- Will focus on a concise and self-evident design demanded by the small screen orientation and the need to minimize learning.
- Will allow the individual users a high degree of tailoring, filtering, and focusing of the interface tailored to their specific roles and responsibilities.
- Will serve to support planning, evaluation training, exercises, and system updating and maintenance between crisis events.
- Will allow the operation of the response function without the need for a single operational physical center except for the operation and backups for the computer hardware and software acting as a server and distributed resource databases for this operation.
- Will be designed as a structured communication process independent of the nature of a particular crisis.

They then set about describing the criteria they would use for the interface design (metaphors, roles, notifications, context visibility, and hypertext) and outlined their general design principles, and supporting design criteria to develop their system. They concluded with an outline of workflow communication processes and meta communication processes.

Using a grounded theory approach, the collected and analyzed data from this study produced a framework that would be largely addressed by the proposed DERMIS system. Some of the conceptual terminology and how information was related differs between the two studies because of the different approaches, but the underlying meaning is similar.

When developing system requirements for a CAMPCS, the three factors of context-awareness, multi-party relationships, and task-based management contribute to effective

disaster response coordination and are considered in addition to the role technology has in coordination. As a result there are additional requirements in a CAMPCS.

6.8 CAMPCS Design Requirements Summary

Quarantelli (1997a) raised ten non-technical issues for a foreseen information technology revolution and its impact on disaster planning and research (Appendix D). The design and application of any such system should consider these concerns to try and avoid any predicted problems. For example, Quarantelli mentioned concerns of technology as an "end" instead of a "means", information overload, loss and outdated information, diffusion of inappropriate information, less non-verbal communication, more difficult intra- and inter-level group communication, adoption of IT fads, the development of adequate social and cultural infrastructures, and computer system-related disasters. Many of these concerns were indirectly mentioned in the premises for the design of a DERMIS (Appendix C) as well as in the data collected from participants.

With many of these concerns in mind, system requirements were created for a general system design, and are not dependent on any particular technology format, platform, or interface. Any CAMPCS system is to be recognized as a tool, not the solution to disaster response coordination. As a tool, its failure should not worsen a disaster. It should enhance response with proper filtering and communication controls preventing information overload and inappropriate information sharing. It should permit multi-media sharing which may actually enhance non-verbal communication through the use of media such as video communication. A CAMPCS should try to leverage communication networks to encourage intra- and inter-group communication and foster the development of adequate social and cultural infrastructures between emergency managers and day-to-day first responders, thereby creating greater cooperation amongst agencies, and trying to discourage cultures of boundaries where first responders are perceived to become less important during disasters compared to dedicated disaster response teams.

After reviewing the emergent concepts which supported coordination, the system requirements were created which fit both the data and the framework. The general requirements highlighted in the DERMIS model generally apply to the high level requirements for a context-aware coordination system. However, the lower level CAMPCS requirements differ in the details.

Summary of Recommendations for Disaster Response Context

An effective disaster response coordination system should meet the following requirements:

1. Sense, monitor, aggregate, and record positional, temporal, environmental, and status-based information on victims, responders, resources, threats, physical assets of interest, dangerous areas, aid regions, damages, and victim needs.
2. Allow for resource availability assessment of gathered information by examining numbers, location, status information, and related dependencies.

3. Provide location-based overlay capabilities of gathered information.
4. Record information provider details.
5. Cross-reference, filter, and aggregate related data reports for accuracy and reliability based on time, source, and number of reports.
6. Alert responders to declarations of emergency.
7. Integrate with external advanced warning systems and monitor for alarming conditions.
8. Integrate, store, and retrieve historical records for analysis and processing.

Summary of Recommendations for Multi-Agency Response Relationships

An effective disaster response coordination system should meet the following requirements:

1. Record and share responding authority information.
2. Record and share agency roles and responsibility in the response.
3. Record and share response structures and chains of command.
4. Propose related stakeholders as established from multi-agency coordination history.
5. Notify identified stakeholders of situation updates.
6. Identify inter-organizational communication personnel, systems, and protocols.
7. Allow for role transferability and responding authority changes.

Summary of Recommendations for Multi-Agency Task Management

An effective disaster response coordination system should meet the following requirements:

1. Identify and share agency roles for complex tasks across agencies.
2. Consume and share information available from Disaster Response Context requirements.
3. Manage and share resources across several agencies.
4. Track, Monitor, and Update disaster response task performance across agencies.
5. Monitor and translate any agency specific language to common language across agencies.
6. Share any agency pre-established working procedures across agencies which control inter-agency coordination behaviour.
7. Share known response limitations related to responder welfare across agencies.
8. Share pre-established protocols from coordination training exercises across agencies.
9. Share disaster response plans from different agencies and stakeholders.

Summary of Recommendations for Emergency Support Technology

An effective disaster response coordination system should meet the following requirements:

1. Limit dependence on fixed infrastructure.
2. Be capable of receiving, creating, and sharing information in several media formats.
3. Utilize common standard architecture, communication protocols, and data models available across agencies.
4. Incorporate structured meta-data language capabilities for dynamic data sharing.
5. Incorporate open licensed technologies as much as possible to limit license fees and technology costs.
6. Perform to agency requirements for speed, durability, and functionality.
7. Have an easy to use visual interface and physical design for ease of training, and for favourable daily-use adoption.
8. Have key functionality be usable for responders and decision makers.

6.9 Summary

In this chapter a framework for context-aware multi-party coordination was presented. In it, the inter-relationships between context-awareness, multi-party relationships, and task-based coordination were described, in addition to their interaction with the fundamental coordination activity of decision making. Context-awareness was demonstrated to provide important decision making information for key stakeholders, while the relationships amongst stakeholders guided the information sharing of that information. Context-awareness also provided context-related information necessary for completing tasks to responders, while identified tasks were a driver for determination of the information required. Evidence indicated multi-party relationships influenced the responsibilities of agencies and the resources available to responders performing response tasks, while identified task requirements were communicated to agencies so that proper determination of required stakeholders could occur. Decision making was based on problem identification and feedback from context-awareness, and incorporation of decision making authority and structure as established through multi-party relationships. The output of decision making was a response plan which determined the tasks to be coordinated to fulfill the plan. The entire framework represented a dynamic environment the related the concepts which emerged from the data and fit the data itself.

Not modeled this framework is the explicit concept of emergency support technology. The role of technology in the framework was explained to be an inherent or implicit aspect embedded in the entire framework. Information systems play a role in communication between the different elements of the framework, such as communicating context information to stakeholders, as well as within the elements of the framework, such as collecting context information from the environment or mapping the relationships amongst participating agencies. Thus, emergency support technology represents tools to enable more efficient and effective decision making and task execution when used appropriately, or it can hinder and impair decision making and task execution if the support technology is ineffective for any number of reasons.

The chapter concluded with a comparison of the framework against prior decision support systems with a purpose of identifying common and differing elements with CAMPCS. The design requirements for a dynamic emergency response management information system proposed by Turoff et. al (2004) were then reviewed with the system requirements of a CAMPCS. While at a higher level there was agreement in the IS requirements, at lower levels the functional requirements of a CAMPCS were different than DERMIS as CAMPCS incorporated a greater emphasis on relationship management, and less reliance on specific technologies which were a component of the DERMIS proposal. The CAMPCS system recommendations were provided under the heading of which concept of context-awareness, multi-party relationships, task-based management, or emergency support technology was addressed.

CHAPTER SEVEN :: EXISTING SYSTEMS AND GENERALIZABILITY

7.1 Introduction

In the previous chapters the concepts associated with disaster response were identified and a context-aware multi-party coordination system framework was developed. Requirements were also identified for the design of a CAMPCS. In this chapter, the practical applicability of the identified design requirements are used to evaluate systems commonly used in disaster response. The theoretical applicability of the framework is then discussed by addressing different qualities of the study.

7.2 Re-visiting Existing Systems

Currently, information technology used by many agencies appears to positively address many issues this study identifies as influencing effective crisis response. Computer aided dispatch (CAD) systems[19] used by first response agencies are used to record initial damage if reported in incident calls, or at least to describe the nature of the emergency. CAD systems also provide details on the location of emergencies and track when calls were made to report incidents. Furthermore, CAD systems also track the provider of initial information in an effort to verify information accuracy and assess information reliability. Integrating roster lineups and maintaining current status updates on the roster is used for dispatching resources and also make it possible to quickly assess current resource availability with tools such as automatic vehicle location (AVL) systems. A screenshot from an AVL system is shown in Figure 13.

Integrated radio communications with the CAD system records audio traffic and is used to share dispatch orders, and also to notify responders of any alerts from advanced warning systems, or declarations of emergency, both of which may modify standard responder processes or behaviour. CAD systems integrated with radio systems will also have access to rarely used multi-agency specific radio channels, if they are available at all.

[19] http://www.intergraph.com/sgi/default.aspx

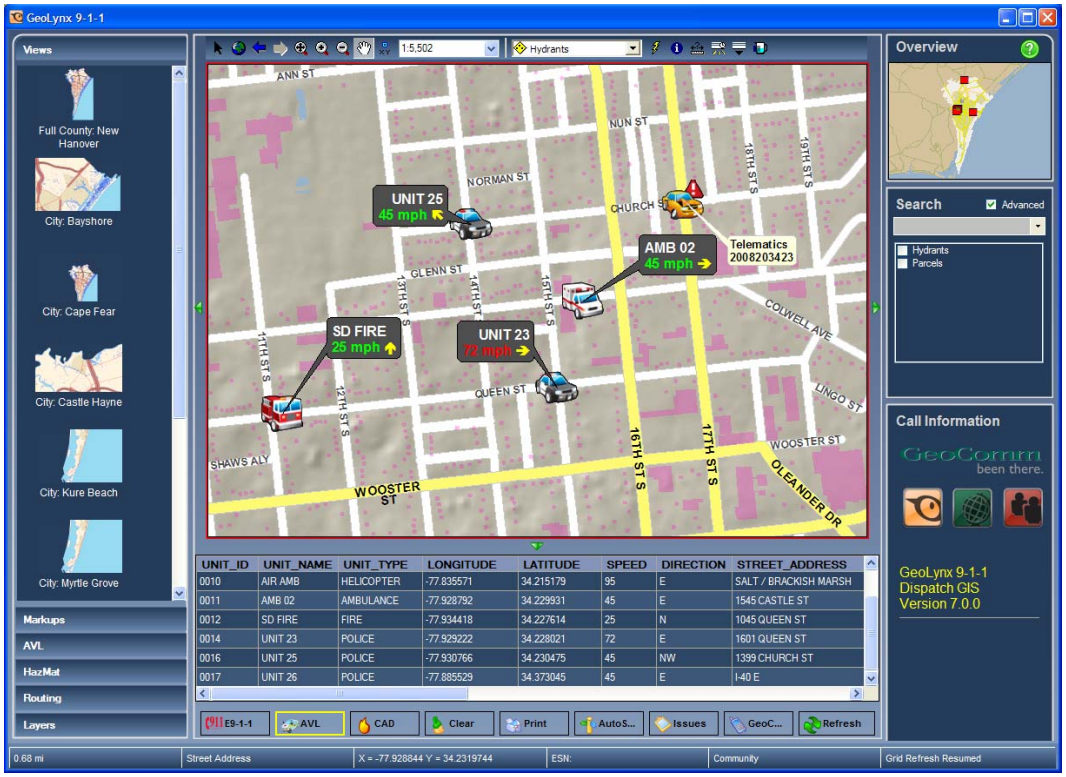

Figure 13. Sample AVL system by GeoLynx[20]

However, these same benefits of the CAD system are only designed for single agency response. If additional resources are called in to assist they cannot be tracked and monitored in the CAD system unless they are part of the duty roster. As such, only members of the same agency are tracked. Tracking incident details and updating an incident with information from multiple callers is also agency specific. Frequently, several callers may call different agencies in response to an incident, but these agencies usually do not share the incident details.

Furthermore, this study also highlights many opportunities to improve the functionality information systems may have in facilitating effective disaster response coordination by further highlighting challenges in response. For the most part there is a strong dependence on technology. When infrastructure is disabled there is often a negative impact on response performance. Unavailable communications and computer equipment means responders must resort to new coping mechanisms with which they may be less familiar. Even if systems do not fail, currently adopted communication and information technology tools limit the type of communication to voice and text unless communication is face-to-face. Video and image-based information containing much richer contextual information is rarely used or available unless events are covered by local press. For interoperability, some of the first responders in the field listen to the radios of other

[20] http://www.geo-comm.com/files/avl1.png

agencies in the region. Responder supervisors will often have the radios turned on as background noise while traveling in their vehicles or at the station. In this manner they can receive one-way situation awareness information to be alerted to potential problems or need before official requests. Otherwise, the information and communication systems for different agencies, even within the same region, are not interoperable and there is usually limited communication between agencies except through dispatchers on the phone, or senior responders on scene.

When responding to larger crises the utilization of new incident management software is more commonly being deployed, with its usage also being incorporated into routine operations for some agencies. These systems, such as WebEOC[21], ETeam[22] and EmerGEO[23], are used to track multiple events and resources as required across a region. When deployed, these systems are generally accessible to representatives of several important responding organizations. Newer tools such as FusionPoint[24] have standard interfaces to a wide variety of tools built in for easy integration and are accessible via the internet. These software tools can integrate GIS packages, incident management software, dispatch software, and more, while also having the capabilities to model hazards such as chemical spills, and earthquakes for example. These software packages support multi-agency resource management, and aid in multi-agency information exchange for users that share system access.

For example, the Multi-Agency Situation Awareness System Information eXchange (MASAS-X[25]) initiative launched in November 2011 by Defence Research and Development Canada - Centre for Security Science, enables the sharing of location-based situational awareness information using open standards amongst first response and emergency management agencies. It is designed as the first step in developing a national MASAS capability.

Users of the system are able to post and consume situational awareness information to and from other registered users of the application (Figure 14). MASAS-X data may also be incorporated into other applications, including ESRI[26] (Figure 15), and EmerGeo.

[21] http://www.esi911.com/esi/
[22] http://www.nc4.us/eteam.php
[23] http://www.emergeo.com/
[24] http://www.emergeo.com/solutions/fusion-point
[25] http://www.masas-x.ca/en/
[26] http://www.esri.com/software/arcgis

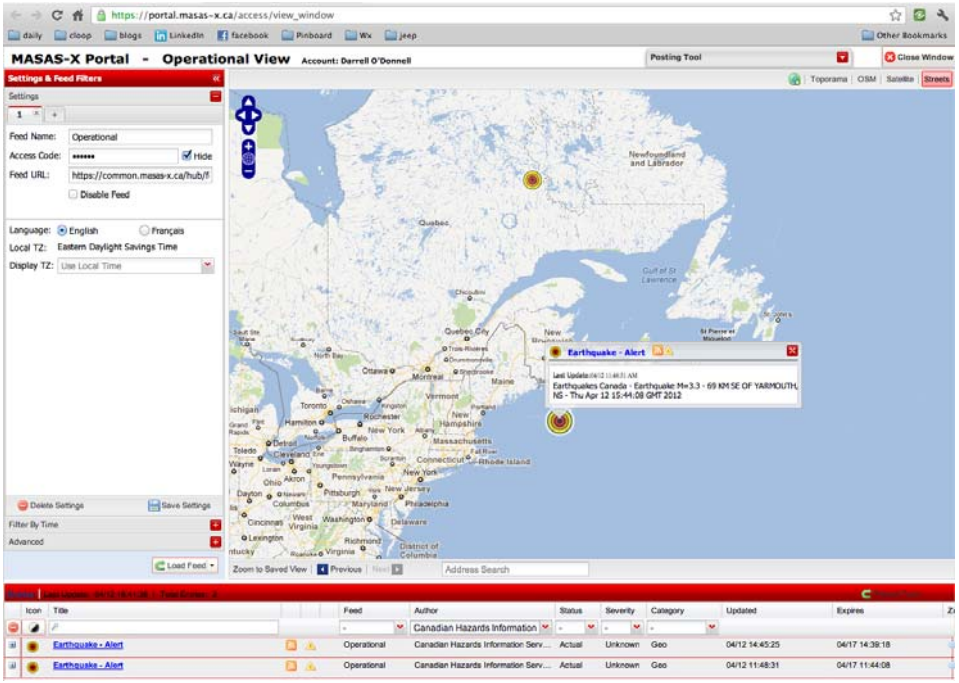

Figure 14. MASAS-X web portal[27]

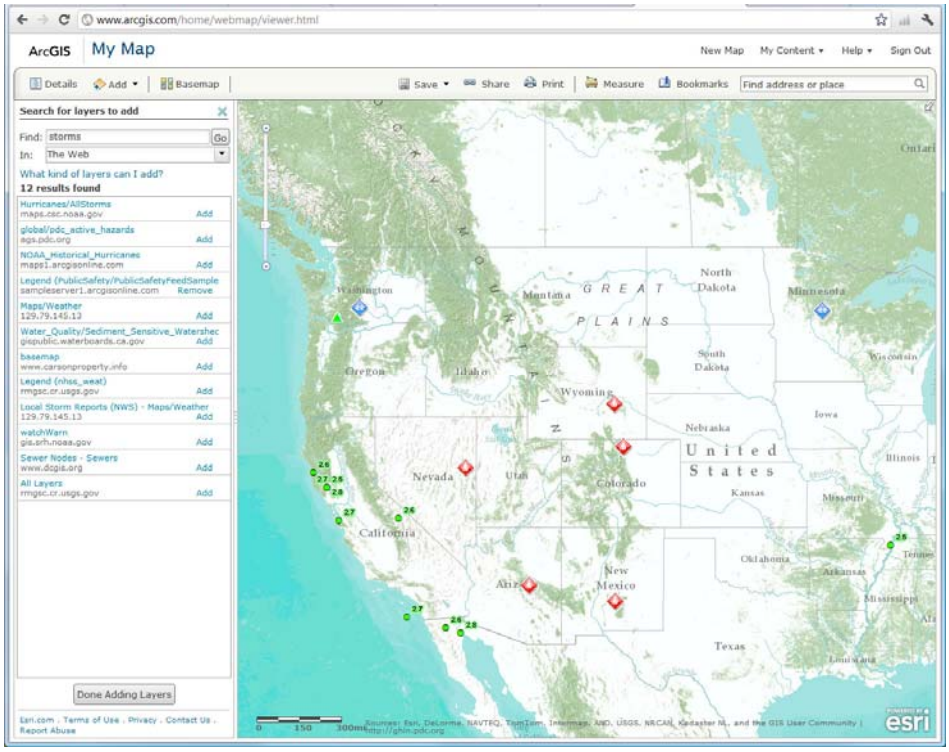

Figure 15. Personal ArcGIS by ESRI with alerts layer added[28]

[27] http://ircan-rican.gc.ca/attachments/4238/Screen_Shot_2012-04-12_at_6.42.13_PM.png

These current situational awareness and GIS support applications consume data from a variety of sources as required. Typically, the software for these applications is licensed by a region or agency, and then they decide what data elements they will consume. Also, users will have the capability to mark their own events into the system as they occur. However, these systems do not export integrated data back to other systems. Events entered into the system will only be shared by users with local network access only. The software itself pulls the various data at different levels from different sources, so depending on the particular view, the source data provider may change. For example, as maps drilldown to smaller geographical regions, local maps are pulled up and displayed to users from a different data source. These software solutions represent an improvement in multi-agency situation awareness.

Even with all of these newer technology tools, the technology solutions available to responders currently do not address nor support many of the non-technical aspects of multi-agency disaster coordination. For example, these systems do not track hierarchical chains of command as they evolve and they do not identify stakeholders and responder roles in different situations. While some CAD tools will have automated notifications of other agencies for tiered response, they are only triggered for programmed circumstances which may not be met by disasters. Modifications or abandonment of pre-established working procedures are not incorporated into the systems, nor is tracking resources from multiple agencies usually a feature of such software.

The four factors of context-awareness, multi-agency relationships, task-based coordination, and support technology that influence effective disaster response this study identifies can be used in a framework to establish the requirements for the development of a context-aware multi-party coordination system. The framework was a natural outcome from the conceptualization of participant and secondhand data.

7.3 Generalizability

7.3.1 Comparing Emergency and Disaster Response

One of the major challenges with this study was one of scale. There is general acceptance amongst the research community that emergencies are different from disasters, and disasters are different from catastrophes, although there is no agreement as to what specifically differentiates the classification of events (Quarantelli, 2006).

Routine emergencies are faced by first responders daily, and therefore fall within normal operations. Disasters are qualitatively and quantitatively different from routine emergencies, with at least four differences easily observed at the organizational level: organizations must relate to more and unfamiliar converging entities; autonomy and freedom of action may be lost due to changing priorities; different performance standards may be applied; and there is usually a closer interface between the public and private sector (Quarantelli, 2006). Catastrophes differ from disasters based on the level of

[28] http://www.arcgis.com/home/webmap/viewer.html

infrastructure damage, the inability of local officials to resume normal operations, the unavailability of help from nearby communities, the disruption of everyday community functions, the social construction of catastrophes by mass media, and the political importance of events (Quarantelli, 2006).

Firsthand data can be difficult to collect for crisis response research as disasters and catastrophes are generally infrequent and unpredictable. In addition, some regions are more susceptible to different forms of disasters than others. In order to capture firsthand observational data of catastrophe response would require fortuitous timing of unfortunate events, available research funds to travel to the area, and pre-established relationships with potential responding organizations in order to have approval and access to observe responders in action. These conditions are unlikely to be achieved successfully. However, studying smaller scale emergencies within communities by local responders was achievable. The challenge then becomes the question of is the data collected at smaller scale emergencies representative of larger scale emergencies? Can these data be extrapolated to larger scale disasters?

Despite the many differences in emergencies, disasters, and catastrophes, it is incorrect to imply that everything is different. Research has not yet indicated the most significant differences, although it appears they are greater as observations move from responder to societal levels. "In the time period right around impact, at the individual human level, the reaction to disasters and catastrophes is remarkably similar and generally good. (Quarantelli, 2006)"

It is argued that firsthand data from local multi-agency emergency response can be used for three reasons. The first is that participants in the study frequently talked about the only difference in response activities between a small emergency and a large catastrophe is the scale. The second is that effective crisis response has been almost universally identified as a bottom-up process to be managed by local crisis response. Third, although the added scale of a disaster dramatically increases the complexity of the response which exposes new issues that responders may encounter less frequently, the challenges and concepts identified from firsthand observation of emergency response align with many of the challenges identified from a larger crisis response.

When considering the argument that the only difference is the scale, the feedback from responders is critical. "When we talk about crisis response, we have to remember that it's a scalable crisis. When we teach an MCI [multi-casualty incident] or disastrous situation where your local resources are overwhelmed and you only have one car in that area, you could have a localized huge accident. You may have four or five patients and only one ambulance to respond. So really that's almost a disastrous situation because you are trying to scramble to get vehicles and get them dispatched. So I think we have to keep in mind that crisis response and emergency management is scalable to the event. (EMS participant, personal interview)" This particular responder was discussing the actual activities performed by first responders. Their actual tasks don't change much at the

lowest levels, but the organizers have new concerns for coordination over and above regular response.

This sentiment is expressed in a second comment found in the data by a responder which sounds contradictory to the argument presented, but it is actually a comment regarding the difficulties of managing the logistics of a disaster response, and not an argument regarding any differences in the tasks performed by responders.

> [T]he logistics just weren't there. We didn't stockpile locally for something of this magnitude. The state was good, but not good enough for something like this, and the feds, oh man, they just weren't there. We all thought a disaster was like an emergency, except that you just raise the level a bit. You know, a disaster is like a big emergency, you just do what you normally do but do it on a bigger scale. We now know it ain't that way. You need real planning by those in the know; you can't run these things with just volunteers, part-timers, and those whose only experience is everyday emergencies. (Fischer et al., 2006)

The second argument is that response is a bottom-up process, so emergency response should translate to disaster response. Response structures tend to change depending on the scale of an event. Waugh Jr. and Streib (2006) discuss the paradox of modern emergency management. Emergency response requires meticulous planning but also needs to be spontaneous. Government hierarchies play a central role but emergency response must also draw on a wide range of community resources which do not fit into traditional hierarchies. Emergency management capacity is built from the ground up, prevention is a local responsibility, and the tools needed to manage hazards often reside with local officials (Waugh Jr. & Streib, 2006). Incident command systems appear to have utility at field operations levels, but are they applicable at emergency operations centers? If local responders are effective at managing multi-party emergency responses, is it not reasonable to assume that they may be better equipped to manage disaster responses? Similarly, if problems exist during routine emergency response, then would it not also seem reasonable to assume that problems would worsen during a disaster? This reasoning is the second motivation for including firsthand data from routine emergencies in the data analysis.

The third reason for including the data from firsthand sources and combining it with the data from secondhand sources is that the concepts that emerged were similar. Both the firsthand and secondhand data sources shared the same core concepts. The only concept which was contained mainly in firsthand data was that of technology funding. Whether this concern was expressed from a general awareness of agency funding sources, or whether it was expressed out of a heightened concern due to general economic and departmental budget conditions is outside the scope of this study. However, it was a concern that was expressed repeatedly from Chiefs down to first responders on scene.

7.3.2 Firsthand vs. Secondhand Data Sources

The firsthand and secondhand sources used for this study represent a broad range of responder types, disaster types, disaster scales, and disaster locations with different management structures and socio-economic levels from regions in wealthy nations to responses to disasters in third world countries.

The incorporation of the secondhand data into this research made this research a form of meta-study. Where the more familiar meta-analysis is a combination of the results of several studies, this meta-study used a systematic method of taking data from several studies and integrating them. Because grounded theory was the methodology used, a meta-analysis would have been inappropriate as it would not have guided any theory development. However, a meta-study is completely acceptable and permitted the development of independent conclusions from the data while ignoring any previous author's analysis.

The use of such a wide-array of data sources covering such a range of disaster scenarios should make the results of this study generalizable to all disasters, disaster response planning, and information systems design for disaster coordination response. Future research that augments the results of this study will only enhance the generalizability of the proposed framework and system requirements.

7.4 Summary

This chapter examined the practical and theoretical applicability of the proposed CAMPCS framework and information system requirements. A summary review of several information systems currently used by responder agencies was provided to identify elements of the framework and requirements that appear to be present in the systems used by many agencies. This review also highlighted many opportunities to improve upon the existing systems. Most agencies purchase specific software that enables the effective management of their individual agency, and may be able to consume information feeds from other sources. However, information sharing problems with other agencies exist which makes multi-agency coordination difficult. Essentially, all of the individual agencies are waiting for information to consume, but very few are sharing. In general, it was readily apparent how the framework and requirements could be used to evaluate information systems.

The applicability of the theoretical framework was addressed with a discussion of generalizability. The more generalizable a study, the more applicable it is in different contexts. The use of different data from day-to-day emergency response activities and from historical disaster response could have been a problem as emergency and disaster responses are accepted to be very different. However, this study focused primarily on the responders, and literature has shown that individual behavior and activities are generally the same in emergencies and disasters. It is only at when considering broader societal impacts where differences are more prevalent. Generalizability in this study was also addressed with the use of local firsthand data sources combined with secondhand sources

encompassed a broad variety of contexts in different regions and different times in different economic conditions. The recurring concepts in the data despite these other differences also reinforced the generalizability of the study.

CHAPTER EIGHT :: CONCLUSIONS

8.1 Introduction

This study set out to provide a clearer understanding of the factors influencing effective of crisis response, the issues with current support systems, and the requirements for an ideal response support system down to the operations level. This was achieved by studying i) the tasks performed during disaster response, ii) the information and communication systems used, iii) the relationships between the tasks, people, and systems for disaster response, iv) the performance of coordination, and v) the relationships between tasks, people, systems and performance associated with disaster response systems used by emergency responders. This chapter begins with a discussion of the contributions and limitations of this particular study and concludes with a discussion of future research opportunities.

8.2 Theoretical and Practical Contributions

Despite the stated limitations of this study, the framework contributes to the theoretical and practical body of knowledge. It fills a stated gap in research, provides reinforcement to an uncommonly used method in IS research, and is applicable to emergency management practitioners.

8.2.1 Theoretical Contributions

This study provides a valuable theoretical contribution for emergency response coordination in general. Previous studies have provided valuable lessons from individual or multiple cases, but no systematic analysis that covers a variety of situations exists which concludes with a series of generalizable concepts and a framework for coordination. This study addresses a gap in generalizable theory that was identified by McEntire (2004) and Franco et al.(2008) by consolidating many observations from case studies into a set of recurring concepts which lead to a framework for disaster response coordination systems.

The proposed framework also provides a new perspective on decision making. It extends traditional decision support into dynamic situations which require a new way of thinking. Prior literature had expanded decision support contexts from individual decision makers, to include personal, organizational, technical, ethical, and aesthetic perspectives (Mitroff & Linstone, 1993). However, this new framework expands the perspectives to include contextual, multi-party relational, and task-based coordination aspects into decision making processes. It necessitates the consideration of other parties' perspectives in developing the best decisions and corresponding actions for multi-party response.

Lastly, this framework highlights new research directions for decision support and coordination studies. Each perspective and the corresponding factors that contribute to the perspective is an opportunity to extend academic knowledge into new modern decision support areas. Like prior advances in technology expanded opportunities for improved DSS design and implementation, the advancement of ubiquitous mobile

computing, environmental sensors, and artificial intelligence encourages the growth and distribution of context-aware computing to aid in decision making and coordination as urgent decisions and actions become based on the latest real-time data available.

8.2.2 Methodological Contributions

This study uses grounded theory which is an uncommon methodology used in disaster research. By successfully demonstrating the application of grounded theory in conducting research in disaster response areas the method can be used to further develop new theories in the field that are applicable in a more general way. This methodology enabled the consolidation of key concepts from much of the extant case study literature available. From a grounded theory perspective, if a new case does not yield any new concepts to the proposed theory, it reinforces the framework and its generalizability. Furthermore, it questions the need for more case studies in the field if nothing new is to be learned.

8.2.3 Practical Contributions

Intuitive thinking led to the identification of concepts from participant data that were supported by literature with examples and recorded interview data. This provides a practical demonstration which reinforces the identified concepts. This study outlines the major areas for focus in disaster response coordination.

Although this study has a stated output of IS design requirements, it did not solely focus on an IS perspective. Other issues were examined in the rescue effort which had an overall impact on effective disaster response coordination. For example, the importance of managing multi-agency relationships, and the identification of tool costs being a concern, are not issues that would typically be addressed in an IS paper. However, the identification of these concepts influences overall system design and contributes new requirements whereby IS systems can aid in addressing the concerns posed in the non-traditional IS concepts to improve overall emergency response efforts.

Related to the last point is the identification of how IS can address the issues presented in crisis response coordination with a context-aware multi-party coordination system. An emphasis on improved data mobility and sharing, and improved relationship management functionality are only two of many important requirements to be incorporated in future systems design for more effective crisis response coordination. This study can be used to prepare guidelines for the assessment of existing coordination systems, and identify gaps in information systems to be filled enabling better disaster response support.

The proposed framework can also be applied to many situations beyond emergency response. Many similar operating conditions exist in large scale events and projects, like the Olympic Games, national and international exhibitions (Meyer, Wichmann, Büsch, & Boll, 2012), and military operations (Louverieris, Gregoriades, & Garn , 2010). The requirements and functionality to support the management of such events can benefit from CAMPCS. Although there may not be the same threat of damage and loss of life,

these events may have planned schedules to follow and need capabilities to effectively respond to unexpected events triggering a complex chain of reactions.

8.3 Limitations

One of the advantages of this study is the use of mixed data sources with real-world observations and literature sources. However, a major limitation is the type of firsthand data that was available. Firsthand data from an actual large-scale disaster context would be the most desirable. This would have eliminated the need to justify the comparison of smaller emergency data to larger disaster response data. However, the concepts that emerged from the secondhand data reflected important issues that were identified by others, sometimes on a firsthand basis. Furthermore, the common concepts that emerged from both sources provides a future research opportunity. Is there a transitional boundary when an emergency becomes a disaster? When does it occur, what factors influence and determine the transition point, and what changes to information systems are required to support the transition?

Another challenge with this study is the lack of a proof-of-concept system design that can demonstrate the system requirements. This limitation also becomes a future research opportunity. An actual system that could be developed, deployed and tested would further validate the framework and system requirements.

8.3.1 Bottom-up Response

Effective crisis response is generally accepted to be a bottom up process to be managed by local crisis response. It is usually local responders on the ground that are performing and executing the immediate local response to a disaster. These responders will be managed by their supervisors and managers. Meanwhile, the complexity of logistics and resource management usually resides at higher levels with the needs determined from local emergency management professionals. Any challenges experienced or identified at a local level during a typical emergency should carry forward, and perhaps even be amplified, when responding to a larger scale crisis. Therefore, firsthand local level emergency response should provide much of the same data as larger disaster.

8.3.2 Similar Concepts

A comparison of the data collected from firsthand data sources to secondhand data sources should yield the same concepts if local emergency response can be used to in a representative fashion to study larger scale disasters. This third reason supports the first two arguments made for the use of local emergency response as a suitable proxy for larger disasters in this study. In this study 26 concepts emerged to help identify the requirements for effective disaster response coordination. Of these concepts, 25 of them were present in the sources used for both firsthand and secondhand data. Only the concept of responder technology attitudes was present in the firsthand data sources only. A simple explanation for this occurrence is that the secondhand data sources used did not inquire or report on responder perspectives on the technology used. However, during direct observation and interviews this topic emerged. The similarity in emergent concepts

despite different data sources should justify the incorporation of both data sources into one study, and should furthermore support the deduction of concepts determined from local emergency response to be representative of concepts that would be present during larger disaster response.

8.3.3 Social Media

The historical nature of much of the secondhand data left a gap in this research in considering the growing role of social media in disaster response. Some interview participants in the study discussed the growth of social media in their communication activities. Specifically, social media was being used a method to push information out to the public. While some emergency managers monitored social media in conjunction with other media outlets to track hazard escalations and response needs, this was a growing area and its importance and impact was yet to be determined. This limitation does represent a possible area for future research.

8.4 Future Research

The systematic analysis and conceptualization of the data identifies future research opportunities in emergency coordination research. Each of the four factors and twenty six concepts identifies issues of relevance in the emergency coordination process which can be studied further. How can information systems be used to improve relationship management, context-awareness, and task-based coordination? For IS researchers, this represents new opportunities in IS research.

8.4.1 Relationship Management

IS research into relationship management offers opportunities for more research into socio-technical and technical areas of relationship visualization, dynamic relationship tracking, and management of dynamic communication channels to improve information flows and situational awareness in dynamic settings. In addition, this study calls for the expansion of research into applications of language translation information systems to support multi-party and multi-national communication and coordination.

Other relationship management issues identified as future research areas include some specific issues that arose in this study related to the interaction and behavior between different levels of response. Peer agencies and the same level, such as municipal, regional, and national, are generally more familiar with interacting with one another. Further research is warranted into the interactions between levels, which seems to be a problem area according to several examples in the data. Another phenomenon that was encountered was the role of geography in day-to-day emergency response as well as disaster response. What if the closest neighbour is from a different country? Further study of the interactions between national neighbours and how relationships are managed is also an area to examine. How would the nature of the relationship between international agencies change if the agency with jurisdictional authority was not best equipped and trained to manage a situation? Furthermore, interoperability amongst

domestic agencies is a growing concern, but what emphasis is being placed on international interoperability? These are all issues ready for further investigation.

8.4.2 Context-Awareness

More research into the areas of context modeling, presentation, interpretation, organization of contextual data, and the use of context by responders are also opportunities to pursue. With advances and ubiquity in mobile technologies, there is an opportunity to study new applications of various information system technologies on different platforms such as wearable computers. Screen sizes and resolutions, innovative interfaces such as eye and gesture control, and innovations in data representation can all be studied to enable seamless IS integration with day-to-day activities emergency responders. The application of sensor networks on personnel, as well as the development of sensor networks based on civilian GPS positions tracked on mobile devices may also enhance search and rescue activities and is an area for study. Yet another application for mobile IS research into context-awareness is the study of alerting platforms with the public. Which alerting mechanisms work best and are most dependable?

8.4.3 Task-based Management

Project management information systems are currently used in non-emergency settings to track and management interdependencies amongst known tasks and resources. Many of these projects are very complex and involve thousands of tasks and resources. IS research into task-based management can be expanded into real-time tracking of dependent relationships between activities, equipment, materials, personnel, and the representation of that information to examine opportunities to enhance disaster response performance. The integration of information systems into everyday response use, and practical implementation of wearable computing, is a further opportunity for research in task-based management. This can also can also bring ongoing research in the Operations Management area of studies that examines emergency logistics, which is also interested in relationship management as it pertains to task-based and resource-based coordination.

8.4.4 Social Media

The last area to consider for further study is the use of social media in disaster response. The field of crisis informatics and crisis mapping has begun research into the use of social networks as predictive agents to gauge disaster severity. For example, more severe incidents are assumed to correlate to an increase in communication amongst users of social media in an affected area. While a new field, new applications incorporating social media and mobile computing represents a research area of growth to consider, especially as responding agencies try to determine response priorities and how best to communicate with the public. While aware of these opportunities, care should be given to avoid fad-based research as its relevance may be temporary.

8.5 Summary

This study presented a recurring problem with response efforts to large disasters and considered the impact information systems may have to improve disaster response. A

grounded theory method was used to pursue an identified gap in research for a holistic theoretical perspective on information systems in emergency management. The data indicated multi-agency coordination was a major theme with disaster response and was positively or negatively affected by context-awareness, multi-agency relationships, task-based management, and emergency support systems. A framework for context-aware multi-party coordination systems was developed which fit the data and led to the development of software requirements for such a system.

This study made several theoretical and practical contributions which were discussed. It addressed the identified opportunity to generate a holistic and generalizable theory on information systems in emergency management. The framework also expanded previous thinking on dynamic decision making by adding new criteria to consider in decision making processes. Methodologically, this study also represented the successful application of grounded theory in information systems research, and not yet another case study. This study's practical contributions included a framework which can be used to analyze existing information systems, or to develop new systems based on proposed requirements. Furthermore, the coordination framework created addressed the need for disaster response, but may also be applied in other business settings such as the organization of large-scale events involving multiple stakeholders.

The limitations and contributions of the study were then presented. One limitation of this study was identified as the type of experiences possessed by firsthand participants compared to the literature. Participants with larger scale disaster response experience would have been ideal, however, their data was deemed just as relevant due to consistent responder behavior in day-to-day emergencies and disasters which was supported by the comparisons of concepts that emerged when data was collected from both types of sources. Another limitation was the lack of relevance of social media in the study. Social media appears to be a growing area of research in the emergency management field but it was not present in the collected data due to the historical nature of much of the data.

For future research, this study identified several new opportunities based on the identified concepts related to multi-agency coordination. Specifically, opportunities exist to study the representation and management of relationships in real-time decision making structures. This appears to be an area of many opportunities for future research. In addition, the modeling of context in information systems for emergency management applications, and the presentation of such data to emergency responders remains a large opportunity. Many design science proposals ignore key usability assumptions identified in this study. The development of new systems that follow the requirements in this study is an opportunity for new design science studies. Another area of study is the management of dynamic processes in an urgent environment as it relates to project management. Many of elements of project management implicitly occur when planning disaster response, but the context is so different and dynamic that the tracking mechanisms do not appear to be in place. Improved task-based management systems are another opportunity for future research as they relate to emergency response. Lastly, the applications of social media and mobile computing in emergency management is a new

field which is a research opportunity to consider. The ubiquity of mobile computing is creating new opportunities for information gathering and dissemination between the public and responders. The behaviors, motivations, and opportunities for future mobile systems and social media use is a growing opportunity for future research.

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APPENDICES

Appendix A - Sample Interview Questions

1. Please provide a brief description of your experience working in the field of emergency management or crisis response.
2. Please describe your role within the organization and what involvement you may or may not have with coordinating a crisis response.
3. Please describe the types of incidents your organization responds to that require a multi-agency response.
4. Please describe the process of an incident response where it becomes apparent that the assistance of other agencies may be required. How is the assistance requested?
5. Please describe any challenges your organization has in responding to an incident that affects its ability to coordinate an effective crisis response. For example, incident size, incident management training, etc.
6. Please describe your biggest concerns with multi-agency coordination.
7. Please describe any challenges your organization faces in coordinating with other agencies.
8. How does your organization share information with other parties during a multi-agency response?
9. Please describe your biggest concerns with sharing information with other agencies.
10. Please describe the challenges your organization faces in sharing information with other agencies.
11. Please describe any perceived concerns that other agencies may have sharing information with your organization.
12. Who is responsible for sharing information with other agencies? At what level does sharing occur ie. responder, dispatch, supervisor?
13. Please describe the tools that your agency uses to coordinate amongst its members and between agencies.
14. Please describe any factors that limit your ability to respond to crisis, share information, and coordinate a multiagency crisis response.
15. Please describe how regularly your agency interacts or coordinates with other agencies during a crisis response.
16. Please describe the types of training your organization offers to assist in coordinating responses with multiple agencies.
17. EMS specific: What can you tell me about offloading delays? Do they impact your organization's ability to respond to crisis? How does your organization coordinate with hospitals, if at all?
18. EMS specific: What can you tell me about an MCI kit? What is their purpose? Are they used? Are field agents properly trained?
19. Please describe your ideal operating environment for responding to crises requiring a multi-agency response.
20. Do you have any other comments you would like to add regarding multi-agency crisis response?

Appendix B - Multi-Agency Training Exercises

Scenario ONE (SC1)
SC1 was a single gunman scenario in a public university setting. The scenario was established between the university and police services. During the scenario, a lone gunman entered a library on the university campus and opened fire on students. An emergency call was placed to 911 from a witness to the attack. The police contacted the university police to coordinate the response. University police met responding units at a pre-arranged entrance to campus where responding officers were notified of the exercise and their real firearms were replaced with mock weapons. They were then escorted to a safe responding proximity by university police. University police provided specialized equipment such as a shield to protect from gunfire, and a bag of tools to gain access to locked facilities if necessary. The police then used the shield to approach the library, enter the building, evacuate those at risk, locate the gunman, and take the gunman down. EMS and fire responded for treatment of the mock victims.

Scenario TWO (SC2)
SC2 was a multiple gunmen scenario in a public elementary school setting. An two gunmen set off an explosion outside of an elementary school and then entered the school and began opening fire on students. 911 was called by administration within the school. A call for response was put out. Emergency Response Unit (ERU) support was requested from the local region and from a neighbouring region. Other resources such as K9 units were notified. A staging area and perimeter was established nearby to plan and coordinate the local response, and keep the public away from the school. Several groups were contacted including municipal transportation, school board administration, grief and trauma support counselors, Fire and EMS services, a media officer, and police liaisons who sat on community boards. The two ERUs identified roles and entered the building. People were evacuated as the ERUs entered the building. One gunman was taken down quickly, while another was isolated in a classroom with students and a teacher in a hostage situation. A throw phone was used for hostage negotiations. Eventually, the second gunman was taken down with gunfire.

Scenario THREE (SC3)
SC3 was a multiple event terrorist attack scenario involving two cities from Canada and the United States. Setup in three phases over two days, only phases one and two were observed. In phase one, an explosion occurred on a passenger barge and ejected riders into the river bordering the two countries. As the response played out, a second explosion occurred in the American city which turned out to be a *dirty* or radioactive bomb. Phase 3 was an environmental disaster as the disabled barge was run aground during towing and leaked a large amount of fuel and oil into the river. The event was initiated by the Department of Homeland Security in the United States. The barge in the river was a tourist barge with up to five hundred passengers onboard. After the explosion, fire and police were notified of the response and the EOC was activated. The explosion took place on the American side of the river. The Canadian fire department notified the

American fire department of its availability to assist. Canadian Border Services Agency were also notified due to border issues, and a liaison with the US Coast Guard was sent to the Canadian city's EOC. WebEOC was used by the Canadian side to track major events. This system had been setup to share information with the American city's EOC. As the response continued and river rescues continued, an explosion occurred in a downtown park of the American city and radioactivity was detected. The Canadian CBRNE team was put on standby. The two EOC's discussed the timing for a declaration of emergency to evacuate civilians and prevent mass panic and evacuation from one city to the other. Other support agencies were notified such as social services for victim and family support at a staging area near the rescue landing site, and provincial police for possible evacuation planning. The provincial EOC was activated. Once a declaration of emergency was deemed necessary the exercise shut down.

Appendix C - DERMIS Design Premises

Table 14. DERMIS design premises by Turoff et. al. (2004)

Dynamic Emergency Response Management Information System Design Premises used by Turoff et. al. (2004)

1. System Training and Simulation: An emergency system that is not used on a regular basis before an emergency will never be of use in an actual emergency.

2. Information Focus: People responding to an emergency are working 14-18 hour days and have no tolerance or time for things unrelated to dealing with the crisis.

3. Crisis Memory: Learning and understanding what actually happened before, during, and after the crisis is extremely important for the improvement of the response process.

4. Exceptions as Norms: Almost everything in a crisis is an exception to the norm.

5. Scope and Nature of Crisis: The critical problem of the moment is the nature of the crisis, a primary factor requiring people, authority, and resources to be brought together at a specific period of time for a specific purpose.

6. Role Transferability: It is impossible to predict who will undertake what specific role in a crisis situation. The actions and privileges of the role need to be well defined in the software of the system and people must be trained for the possibility of assuming multiple or changing roles.

7. Information Validity and Timeliness: Establishing and supporting confidence in a decision by supplying the best possible up-to-date information is critical to those whose actions may risk lives and resources.

8. Free Exchange of Technology: Crises involve the necessity for many hundreds of individuals from different organizations to be able to freely exchange information, delegate authority, and conduct oversight, without the side effect of information overload.

9. Coordination: The crux of the coordination problem for large crisis response groups is that the exact actions and responsibilities of the individuals cannot be pre-determined.

Appendix D - Hypothesized Issues of Technology Revolution

Table 15. IT revolution effects on disaster planning by Quarantelli (1997a)

Hypothesized Effect of IT Revolution on Disaster Planning and Research by Quarantelli (1997a)
1. The probability that the "rich will become richer" in dealing with disasters.
2. The possibility that technology is a "means" will be turned into an "end" in itself.
3. The inevitable information overload problem.
4. The loss of, or outdated, information.
5. The greater likelihood of the diffusion of inappropriate disaster relevant information.
6. The implications of even further diminution of non-verbal communication.
7. Intra- and inter-level group communication will be made even more difficult.
8. The negative consequences of the probable acceleration of fads and fashions associated with computer use.
9. The kinds of general social infrastructures and cultures necessary for the adequate functioning of disaster relevant technology.
10. The certainty of computer system-related disasters.