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Multi-organizational Emergency Response Management

– A Framework for Further Development

Christian Uhr

Doctoral Thesis

**Department of Fire Safety Engineering and Systems Safety
Lund University**

2009

Multi-organizational Emergency Response Management – A Framework
for Further Development

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LUCRAM (Lund University Centre for Risk Assessment and Management)

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Abstract

This doctoral thesis suggests a framework for how multi-organizational emergency response management can be understood. A method for collecting and analyzing data on individuals and their interactions has been developed and tested. The method is rooted in social network theory and facilitates further exploration of the complexity associated with responses to emergencies in which various resources from different segments of the society are engaged. Furthermore, in order to build a framework for understanding, the concepts of command and control, coordination, emergence, and trust are elucidated and related to empirical analyses. A synthesis of empirical analyses and literature studies is presented as a model to show how multi-organizational emergency response management can be better understood by studying interactions between individuals. Interactions are prerequisites for coordination of activities. Such activities can be both planned and emergent. Both the manifestation of an interaction and the actual coordination activity are influenced by normative ideals and interpersonal trust. The system designers and emergency response managers should acknowledge this complexity and develop strategies to harmonize the local adaptive behavior of a multi-organizational emergency response system.

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Summary

When a society is struck by an emergency such as a flood, a forest fire, a storm, or a pandemic, various resources are brought to bear to meet various needs. Such resources build an emergency response system. An emergency response system can include not only governmental organizations but also organizations such as religious communities, private organizations, the media and emergent groups. This thesis and international research show that emergency response management does not always follow prescribed plans. Analyzing formal organizations is not the most effective way to analyze such behavior. This thesis improves the knowledge on how emergency response systems are managed. An important assumption is that empirical understanding is a prerequisite for the development of normative ideas.

This thesis, based on five research articles, is the result of a five-year research process that included both literature studies and empirical analyzes. By suggesting a method for data collection and data analysis, presenting important concepts used in various management discourses, and analyzing empirical findings, I present a framework for understanding multi-organizational emergency response management from a systems perspective.

The method for data collection and analysis is rooted in theories on social networks and renders possible analysis of various types of interactions that emerge in an emergency response system. The method is based on the respondents' own interpretations of whom they were in contact with, how important the particular contacts were, and how often they communicated. The snowballing method reveals the various individuals involved in the response system studied. Both the data collection process and the analysis of the data are facilitated by various software such as NetDraw.

Four concepts that are relevant for understanding of the problem area, based on literature studies and empirical studies, have been selected for further elucidations: *command and control*, *coordination*, *emergence*, and *trust*. They are all common in management discourses, yet they are also obscure since they carry multiple meanings. A broad literature study implies that the concept of command and control can be approached from two slightly different perspectives. The "traditional" approach to command and control emphasizes the importance of a central authority for a successful outcome of an operation. The "contemporary" approach to command and control acknowledges system phenomena such as self-organization, the informal networks, and central authority. Apart from the two approaches, heavy criticism against the concept as such has been identified. The

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critics believe that the concepts of command and control are unrealistic starting points for discussing management. An elucidation of the concept of coordination is concluded with a suggestion that the concept has a broad meaning that deals with managing interdependencies among activities to achieve an overall goal. This thesis suggests that coordination is conducted in context specific networks and that coordination should not be seen as an opposite to command and control. Empirical analyses are presented to show how coordination can be studied from a network perspective. The examples show that coordination in complex response systems can be distributed and that coordination does not always take place as planned. Various variants of the concept of emergence have been used in the literature to denote ad-hoc behavior, behavior that does not harmonize with plans. The empirical studies presented in the thesis show how emergent phenomena can be studied. Because the concept of emergence is ambiguous, researchers should use the term in a more precise way. Different approaches to the concept are considered. Emergent behavior can partly be explained by interpersonal trust. The concept of trust is elucidated through literature analyses and an interview study. Trust is considered to be an important dimension, a latent system condition, that influences how emergency response management is performed, affects how interactions are formed, and the effectiveness of the communication.

The different parts of the thesis are synthesized into a model. The model reveals how multi-organizational emergency response management works. Multi-organizational emergency response management can be better understood by studying interactions between individuals. An interaction is always preceded by a need. Interactions can lead to coordination of activities, i.e. the managing interdependencies between activities in order to achieve an overall goal. Such process can be both planned and emergent. Both the manifestation of an interaction and the actual coordination are influenced by normative ideals and interpersonal trust. Coordination can lead to coordinated activities that in their turn influence new needs. Empirical studies presented together with studies on international literature show that centralization is an unrealistic approach to how management in complex systems should be performed. Emergency response management should be based on the knowledge that adaptation in complex systems derives from adjustments made by the system's local parts. An important challenge is to design system solutions so that harmonization among various local behaviours can be achieved. Such development demands a concrete discussion on goals for coordination on higher system levels.

Sammanfattning

När ett samhälle drabbas av en oönskad händelse i form av exempelvis en översvämning, en storm, en omfattande brand eller en pandemi så engageras olika typer av resurser för att möta de olika hjälpbehov som uppstår. Resurserna utgör vad man kan kalla för ett responssystem. Ett responssystem består inte bara av organisationer tillhörandes den offentliga förvaltningen, utan också av organisationer och personer som kan härröras till exempelvis näringsliv, trossamfund, ideella föreningar eller media och som utifrån skeendets beskaffenhet får betydelsefulla roller i hanteringen av den oönskade händelsen. Studier som presenteras i denna avhandling, tillsammans med internationell forskning, visar att nödlägeshantering i praktiken inte alltid harmonierar med vad som är förtänt och att formella organisationer inte fungerar tillfredsställande som ramverk för att förstå den komplexa ledningsstruktur som uppstår i samband med multiorganisatorisk respons. Denna avhandling har som syfte att förbättra förståelsen för hur ledning (i denna sammanfattning används ledning som ett överordnat begrepp som motsvaras av engelskans management) i ett responssystem bestående av ett konglomerat av olika resurser går till. Ett centralt antagande är att sådan förståelse är en viktig förutsättning för utveckling av idéer om hur ledningsarbete bör utformas i framtiden.

Avhandlingen är baserad på fem stycken artiklar och är ett slutresultat av en fem år lång forskningsprocess där litteraturstudier varvats med empiriska analyser. Arbetet har resulterat i en metod för empiriska studier, en analys av i ledningsdiskurser vanligt förekommande koncept, samt olika undersökningar av multi-organisatoriska responser i en svensk samhällskontext. I slutet av avhandlingen presenteras ett ramverk som ett slutgiltigt sammanfattande resultat. Denna kunskapsyntes är avsedd att fungera som underslag för framtida utvecklingsarbete.

Den utvecklade metoden för datainsamling och analys utgår ifrån teorier om sociala nätverk och möjliggör studier av olika typer av interaktioner som uppstår mellan individer i ett responssystem. Proceduren för datainsamling baseras på respondenternas egna tolkningar om vilka andra personer de har haft kontakt med, hur betydelsefulla dessa olika kontakter varit och hur ofta kommunikation har skett. Genom en så kallad ”snowballing” kan många olika resurser identifieras och inkluderas i det studerade responssystemet. Datainsamlingsprocessen sker med hjälp av ett webbverktyg där respondenten själv loggar in på en hemsida och fyller i formulär med olika frågor. Dataanalysen sker sedan med hjälp av verktyg som NetDraw och annan för ändamålet programmerad mjukvara.

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Fyra koncept som är relevanta för helhetsförståelsen av problemområdet har analyserats och relaterats till empiriska studier. Bakgrunden till urvalet av de fyra begreppen är att de är vanligt förekommande i litteraturen och i diskussioner om ledning, men samtidigt ofta diffust definierade. De fyra koncepten är: *command and control*, *koordinering* (coordination), *emergens* (emergence) och *förtroende* (trust). Eftersom jag inte finner ett helt lämpligt översättningsalternativ har jag valt att i denna sammanfattning inte översätta begreppet *command and control* till svenska. Avhandlingen presenterar på ett övergripande sätt hur begreppet *command and control* används i litteraturen och gör en uppdelning mellan ”traditional *command and control*” och ”contemporary *command and control*” där den förstnämnda varianten lägger stort fokus på betydelsen av en central auktoritet och ”top-down styrning” av hanteringsresurser, medan den senare inkluderar en mer problematiserad bild av den komplexitet som ett responssystem uppvisar. Utöver uppdelningen i dessa två innebörder har jag observerat ett starkt kritiskt förhållningssätt till konceptet som sådant. Analysen av *command and control* bidrar till förståelsen för de normativa ideal som påverkar hanteringen av oönskade händelser. Empiriska studier stödjer teorin om att ”traditional *command and control*” är en dålig approach när det kommer till ledning i komplexa system. Resultatet av analysen av begreppet *koordinering* visar på att det kan betraktas som ett brett begrepp som föreslås avse den problematik det innebär att hantera interdependenser mellan olika aktiviteter med syfte att uppnå ett överordnat mål. *Koordinering* föreslås kunna studeras genom analyser av de kontextspecifika nätverkskonstellationer som uppstår mellan individer i ett responssystem. Studier som redovisas i avhandlingen visar att *koordinering* kan ske distribuerat och emergent. Avhandlingen motsätter sig uppfattningen om att *command and control* och *koordinering* är varandras motsatser. Olika begreppskonstruktioner innehållandes konceptet *emergens* används ofta i internationell litteratur för att beskriva ”nya” lösningar på problem, dvs lösningar som inte direkt kan relateras till vad som på förhand planerats. Konceptet är dock komplicerat och rymmer olika betydelser beroende på inom vilken vetenskapstradition det används. *Emergens* kan relateras till begrepp som självorganisering, adaptation, och ”bottom-up management”. Internationell forskning har sedan länge belyst emergenta fenomen vid hanteringen av katastrofer. Med hjälp av den i avhandlingen föreslagna metoden för empiriska studier konstateras att även vid hanteringen av mindre händelser (händelser som inte i vardagligt tal skulle framställas som katastrofer), såsom svavelsyrautsläppet i Helsingborg 2005 eller branden i en latexfabrik i Forserum 2007, framträder hanteringslösningar som inte direkt kan relateras till normativa ideal i form av exempelvis planer. En förklarande faktor bakom de observerade fenomenen rymms i förtroendebegreppet. Både litteratur och

Sammanfattning

empiriska studier visar att förtroende har betydelse för hur multiorganisatorisk respons utformas. Förtroende visar sig påverka både hur interaktioner etableras och hur kommunikation mellan individer utformas.

De olika delarna av avhandlingen genererar en syntes som presenteras i form av en modell med syftet att öka förståelsen för hur ledning i multiorganisatoriska sammanhang fungerar. Modellen utgår ifrån att koordinering sker genom interaktioner mellan individer och att man genom att studera sådana interaktioner kan få mer kunskap om hur ledning i responssystem. Koordineringsaktiviteter föreslås vara både förplanerade och emergenta. Både etableringen av kontakterna, som en grundförutsättning för koordinering, samt själva koordineringsarbetet influeras av normativa ideal och förtroende.

Empiriska studier tillsammans med analyser av inom området befintlig forskningslitteratur visar att centralstyrning är en orealistisk lösningsmodell på hur ledning i komplexa responssystem bör utformas. Nödlägeshantering bör utgå ifrån kunskapen om att adaptation i komplexa system bygger på lokala anpassningar till en situations dynamik. En viktig utmaning är att designa systemlösningar så att harmoni mellan olika lokala anpassningar effektivt kan uppnås. En sådan utveckling kräver bland annat en konkretiserad diskussion om mål för koordinering på höga systemnivåer.

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Preface

All work presented in the thesis is carried out within the framework of the project “Improving Emergency and Crisis Management” funded by The Swedish Rescue Services Agency (SRSA) and the Swedish Emergency Management Agency (SEMA). At the beginning of 2009, the two agencies (together with the Swedish National Board of Psychological Defense) were replaced by a new consolidated authority, the Swedish Civil Contingencies Agency (MSB), which also serves as my present employer.

It is Midsummer’s Eve at the time of writing. There is something very special about Midsummer’s Eve. As far as anyone can remember, we have celebrated the summer solstice. Some people believe that midsummer plants have miraculous healing powers and they pick them on this night and place them in their hair. Others light bonfires to protect against evil spirits that roam freely when the sun turns southwards again. Swedes are normally smashed on schnapps and are doing the frog dance around an inverted flower-adorned phallus. But I... I sit on the third floor in a brick building designed during the darkest years of architecture, surrounded by concrete and try to recapitulate what I have done the past five years. It might sound like the definition of misery, but actually it is not. Somewhere between the faded curtains a ray of satisfaction hits my forehead. A feeling of cheerfulness has suddenly appeared though the final deadline is approaching at frightening speed.

There are many persons who have helped me to put myself in this situation. I am honestly very grateful for what you have done for me (after all, Midsummer’s Eve happens every year and I can always do the frog dance on my way back from the printing service on Monday). In various ways you have all guided, inspired and supported me in my work with this thesis.

First of all I would like to thank my three excellent supervisors Kurt Petersen, Lars Fredholm and Henrik Tehler. Kurt, you personify professionalism and compassion at the same time. Lars, I owe you so much. Ever since the first day I took my first faltering steps to become a researcher you have been the normative ideal affecting me in many ways. You are just an enormous bank of infinite knowledge and humility. If you ever need assistance with modern technology, I’ll stand by. Henrik, it is always a pleasure to work with you. Your intellectual capacity never stops amazing me. I’m glad that you not only are my colleague, but also my friend.

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Olof Ekman, your support in this process cannot be underestimated. It has been great working with you and I hope we will continue this cooperation.

I would also like to express my gratitude to Wendy Saunders in Australia for all her support. Thank you for your care and friendliness during my time down under!

Thank you all my colleagues and friends at Lund University. The milieu at the Department of Fire Safety Engineering and Systems Safety is truly inspiring and generous. I will never forget how the coffee breaks could go off the rails and end up in academic revelations, sometimes bizarre, sometimes brilliant. A special thanks to Robert Jönsson who, as the chairman of the department, has supported my work and invited me to take part of the great atmosphere that embodies the workplace.

Without the positive attitudes shown by my colleagues at MSB, the writing of this thesis would not have been possible. I'm very grateful for all kinds of support. Contact persons I have had – Samuel Koelega, Petra Vesterlund, Lise Ekenberg, Louise Mvinyipembe and Johan Gert – all deserve recognition and thanks for their professionalism and their ability to unravel all the administrative complexities involved in a project of this type.

Finally, I would like to thank my family and friends for directly or indirectly have supported my efforts to put the thesis together.

Lund, Midsummer's Eve 2009

Christian Uhr

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1 Introduction

Emergency response is an intricate art where harmony meets chaos and where skill meets the challenge in a subterranean complexity of connections and conditions. The unthinkable can become reality in a dynamic context made up by a violent flow of uncontrolled energy, nature, and society. Among other things, emergency response situations are associated with technologies, cultures, values, and politics, with interpretations and subjectivity, and inevitably with personal emotions. The nature of emergency response management is truly multifaceted. From an academic perspective, these characteristics make research within the field both heterogeneous and fascinating.

Indeed, empirical behavior in emergency response situations is complex, but it is assumed here that this complexity can be better understood. This thesis represents a multidisciplinary descriptive approach to emergency response management in multi-organizational environments. One important governing thought is that normative ideals – e.g., ideas about how emergency responses should be carried out and how emergency response systems should be designed – should include adequate understanding of empirical behavior.

1.1 Reader's guide to report

This thesis is based on five research papers presented chronologically in the appendix. First, this thesis introduces the research field and presents the research aim and the research process on which the results are based. Then the research contributions are summarized and discussed. Finally, future implications are suggested.

Background

The background defines the area of interest, explains the motives behind the research, and leads to the research aim and the research questions governing the work. Since emergency response management can be described as a relatively new, broad, and multidimensional research field, the research focus presented here needs to be accurately framed.

Aim and Research Questions

The aim and research chapter emphasizes research questions and how they relate to the results.

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Research Approach and Methods

This chapter, to address the research questions, explains the methods used: literature reviews, interviews, observations, and social network analysis. These methods are described and different examples are provided to explain further the research approach.

Research Contributions

This chapter summarizes each of the five papers on which this thesis is based. At the time of writing, three of the papers have been reviewed and published in scientific journals and two have been submitted for publication. Given that all papers except “Emergency response coordination from a social network perspective” (Uhr, 2009) are co-written with others, the main contributions made by the author behind this thesis are also explained. Answers to the research questions are then suggested.

General Discussion

Under general discussion the results and the methods are examined and future work suggested.

Conclusions

In the conclusions the main points of this study is summarized.

This doctoral thesis is one of the outcomes from the research project “Improving emergency and crisis management” financed by the Swedish Rescue Services Agency (-09) and the Swedish Emergency Management Agency (-09) and is conducted within LUCRAM (Lund University Centre for Risk Analysis and Management).

In 2007, the author presented the licentiate thesis “Behind the Charts –Exploring Conditions for High Level Emergency Management”. Three of the papers included in the licentiate thesis (Mapping an Emergency Response Network, Uhr & Johansson, 2007; Trust Among Decision Makers and its Consequences in Emergency Response Operations, Uhr & Ekman, 2008 and Analysing Emergency Response Systems, Uhr, Johansson & Fredholm, 2008) are presented in this thesis’ appendix in their latest versions (all published in scientific journals) and included in the research contributions section. Since the licentiate thesis is a part of a five years’ research project there are similarities between the backgrounds, research aims, methods, results and discussions described in the two theses.

Although the doctoral thesis can be seen as an advancement of prior work, it does not cover all the results from the research project. Therefore, the reader is given references to Uhr (2007) and other publications. At the time of writing, the author has contributed to the following papers either as a first or as a second author.

Appended papers

- Uhr, C. and Johansson, H. (2006). Mapping an Emergency Management Network, Published in *International Journal of Emergency Management*. Vol. 4, No. 1, pp. 104-118.
- Uhr, C. and Ekman, O. (2007). Trust Among Decision Makers and its Consequences in Emergency Response Operations, Published in *Journal of Emergency Management*. Vol.6, No.3, May/June 2008, pp.21-37.
- Uhr, C., Johansson, H. and Fredholm, L. (2008). Analysing Emergency Response Systems. Published in *Journal of Contingencies and Crisis Management*, Vol. 16, No. 2, pp 80-90.
- Uhr, C. (2009). *Emergency Response Coordination from a Social Network Perspective*, Paper for publication, Submitted
- Tehler, H., Uhr, C., Ekman, O. and Fredholm, L. (2009). *Groups and Key agents in Emergency Response Systems*, Paper for publication, Submitted

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Other related publications

- Uhr, C. and Johansson, H. (2006). *Mapping an Emergency Management Network*. Conference paper, Presented at CNIP, (International Workshop on Complex Networks and Infrastructure Protection), Rome, 28-29 March, 2006
- Uhr, C. and Fredholm, L. (2006). *Theoretical Approaches to Emergency Response Management*, Conference paper. Presented at TIEMS (The International Emergency Society), Seoul, 22-26 May, 2006.
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2 Background

2.1 What is emergency response management?

Although differences and similarities between such terms as emergency, crisis and disaster could be discussed in detail, an approach will be taken here of indicating simply that emergencies, crises and disasters are all distressful situations in which series of events have or can have very negative consequences for human beings, societal functions or fundamental human values. The course of events then is such that they result in loss of human life and/or in harm to health and/or property and/or to the environment as well as lead to immediate existential difficulties and/or in the neglect of legal or constitutional rights to name various types of consequences that can ensue.

In the text I will refer mainly to “emergency” and “emergency responses”, but in conjunction with various references from the literature such terms as crises and disasters will also be employed and be explained further to the extent called for, in order to provide an adequate basis for analyzing and discussing the events involved. Emergency management is commonly divided into four phases: *mitigation, preparedness, response* and *recovery* (McEntire, 2007). These phases are closely related to each other and are sometimes hard to separate. McEntire (2007) means that the word “phases” may be misleading and could be substituted with for example “functional activities” (p. 4). In this thesis the term response is related to activities undertaken to eliminate or reduce an emergency agent (also called a disaster agent), e.g. the fire, the flood, the disease, the conflict etcetera, and its immediate negative consequences.

When an emergency situation occurs various societal resources become involved in the response. These resources can be found in an *emergency response system*. (defined by Uhr, Tehler and Fredholm, 2008, as the assembled resources in a society that are engaged to take action against an emergency agent and reduce the negative consequences following such an agent.) Thus, the emergency response system is constituted by numerous elements such as individuals, groups of individuals, formal organizations, communication devices, vehicles, hoses and stretchers, laws and regulations, knowledge, culture as well as their dynamical relations. Such constitutions logically have a complex character (see Uhr, 2007) and grasping both detail and a complete wholeness in theoretical reasoning and empirical studies is reasonably very problematic. Ashby (1956), a renowned scientist interested in complex system theories, writes that “any suggestion that we

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should study all the facts is unrealistic”. (p. 40) He continues, “What is true is that we should pick out and study the facts that are relevant to some main interest that is already given”.

This thesis focuses on management in environments consisting of several formal organizations that have to work together to meet various needs that emerge in an emergency response situation. The word organization can imply different things and does not necessarily reflect a formal structure, although such a perspective is common in the field of emergency response management. Organization is here referred to as a non-random arrangement of parts interconnected in a manner as to constitute a system indefinable as a unit (www.businessdictionary.com). This approach reflects some of the complexity dealt with in this thesis. An emergency response involves dynamic structures of interacting individuals that do not always harmonize with formal organizations. This thesis assumes that management is associated with individuals, their actions and interactions, and how these individuals harness complexity (Axelrod & Cohen, 2000 and McEntire, 2007) in a dynamic emergency response system to meet various needs.

2.2 General Problems Associated with Multi-organizational Emergency Response

Studies of emergency response processes have highlighted various types of problems frequently occurring during operations conducted under demanding conditions. Fredholm (1996, 1997) has examined this subject from a variety of different perspectives, finding emergency response management lacking in many areas. After a discotheque fire (63 deaths) in Gothenburg 1998, a Swedish Board of Accident Investigation (2001) found various weaknesses in the emergency response. The Board suggested that measures should be taken to improve the capability of response management. Sweden was also one of many countries that suffered from human losses when the tsunami struck Asia in 2004. SOU 2005:104 found problems similar what Fredholm identified although at a different administrative level. Internationally, the aftermath of Hurricane Katrina (2005) has scarcely escaped anyone. This situation involved many problem areas that could be related to the examples referred to above. Various managerial problems appears to be common to all of them and possibly to be universal.

An emergency agent, such as a flood or a forest fire, does not automatically adapt to boundaries decided by humans. It can affect various geographical regions and several segments of the society at the same time. Responses to emergencies involve formal organizations that are specialized in such missions (e.g., fire

brigades, health care, police, and military personnel) and also other local, regional, and national agencies and organizations that normally operate on a day-to-day basis with emergencies and crises. To a certain degree, administrative borders influence the effectiveness of the responders. Apart from formal organizations, one can identify permanent or temporary clusters of individuals who also are working in the response context. Several of the difficulties encountered have been identified in the literature and concern the problem of adaptation of management functions (here seen as components in formal organizations in which individuals work with influencing the system to achieve various goals) in relation to an event and its dynamics. The structural complexity created by different types of organizations having to operate, sometimes individually and sometimes jointly, to respond to an emergency in an effective way calls for advanced and adaptable management. In a large emergency, a single commander does not oversee the conglomerate of resources. Moreover, in such a complex environment, bureaucratic as well as cultural differences come into play when the rescue services, the police, health care personnel, and the military all have to operate side-by-side with other official agencies, with NGOs (non-governmental organizations), politicians, single individuals, emergent groups, and the like.

2.3 Introducing the Research Problem

This chapter introduces the research problem to the reader before the presentation of the research questions. For a more thorough description of the research approach, see chapter 5.

Ideas on how emergency response management should be carried out can be found in various literatures. An overall impression is that these ideas take structures of formal organizations and “chains of command” as starting points for discussions, that they to a high degree are based on a mix of tradition and “common sense”, and that the scientific foundations for the normative reasoning sometimes are weak. The soundness of simplifications and the validity of the assumptions can be further discussed. Examples of literature that critically reflect existing normative management ideals include Quarantelli (1988), Drabek and McEntire (2003), Drabek (1985), Comfort (1999), Denis, (1995), Neal and Phillips (1995) Takeda and Helms (2006), Wise (2006), Buck, Trainor, and Aguirre (2006), and Mendonca, Jefferson, and Harrald (2007).

Formal organizations, formal structures, and bureaucracies are here treated as similar concepts. Robey and Sales, for example, see an organization’s structure as

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defining “the expectations for each role and the connections between each role” (1994, p.9 as cited by Kuldeep, 1996, p. 6). (Robey and Sales’ approach to the concept of organization is thus not as wide as the definition suggested in 2.1). Early literature discusses the insufficiency of formal structures as framework for discussing empirical behavior: “Too often it is assumed that the organization of a company corresponds to a blue print plan or organization chart. Actually it never does” (Roethlisberger and Dickson, 1939).

Research (Uhr, 2007) shows that emergency response, even if the situations studied were not “disasters” with hundreds of casualties or severe environmental consequences, but major responses involving several formal organizations, entailed ad-hoc solutions and information exchange that crossed formal organizational borders in dynamic complex network-like patterns that were not represented in formal organizational charts. This does not mean that the pre-planned structures had no influence on the response processes. However, they are poor starting points for empirical analyses. Understanding such networks and the context in which they exist is seen a key for understanding emergency response management. Such understanding is crucial when it comes to developing ideas on how response management should be carried out.

When endeavoring to understand multi-organizational emergency response management, one can hardly avoid coming across concepts such as command and control (C2) and coordination. “Understanding”, as employed in this thesis, includes analyses of a subject in a context and this context needs to be grasped somehow. As earlier research suggests, although these two concepts are very common, they are ill defined; i.e., they have many meanings are used in a diffuse manner, issues that needed to be resolved in my own project to profit from previous research and to analyze my own results in relation to others’ findings and ideas.

During the explorative research process, I discovered literature discussing similar phenomena –empirical behavior that did not correspond to bureaucratic order or written plans – as I had discovered in my early investigations of emergency response systems. Clearly, other researchers had examined such behavior. For example, Quarantelli (1988) writes that “there often is a big gap between what was planned and what actually happens in a major disaster crisis” (p. 374). In the research literature, departures from plans and procedures were often discussed as emergent phenomena; however, when digging deeper into this concept, it became marred with abundance.

Background

Early interviews with emergency responders (Uhr, 2007) indicated that “ad-hoc behavior”, such as behavior that did not correspond with the written plans, could partly be explained by trust. However, the concept of trust was vague. To incorporate it into pragmatic management discussions, it needed to be further analyzed in the context of emergency response. Thus, to generate a framework for analyzing empirical data, the concepts of command and control, coordination, emergence, and trust needed to be elucidated.

When using a systems approach to understand multi-organizational emergency response management, identifying what system level to study is essential. In the beginning of the background section, it was indicated that studying all aspects of a system is unrealistic and that limitations must be made. This study looks at the system-level where individuals and their relations are seen as the key elements in the systems studied. This does not mean that other “system resolutions” are ignored. For example, groups of individuals and formal organizations can be discussed as relevant system elements. However, they are not used as starting points in the analysis, nor does the study enter deeply into individual cognitive processes and subdivide individuals into further connected elements. Cognitive processes are here seen as processes taking place in a “black box”, i.e., the relevant outputs (the results of the processes).

Although many scholars have contributed to the scientific community with various analyses of multi-organizational emergency response, only parts of the complexity associated with the subject have been unveiled so far. Based on interpretations of empirical behavior and literature findings a new framework for understanding was called for. Such framework could be seen as a piece in an enormous puzzle reflecting an intricate reality.

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3 Aim and Research Questions

This research assumes that increased understanding of empirical behavior in emergency response situations improves the prerequisites for appropriate design of systems and principles of effective management. If we do not understand how the emergency response system works, we can hardly understand the fundamentals for management in it: we will not know what “knobs to tweak” to generate the best results. To this end, this thesis aims to understand emergency response management. Thus, the general question guiding the research can be presented as follows:

How can emergency response management be better understood?

Although the research questions presented here also could be interpreted as objectives, such ontological quandaries are not within the scope for this presentation. In this context, “better” means improving the understanding of the complexity associated with studied subject. To gain such an understanding, we need to conduct empirical studies.

The general research question reasonably has room for many alignments and can generate many different answers. Therefore, the problem needs to be further specified. This study endeavors to improve the understanding of how management in emergency response systems (including different types of resources) is conducted. In an emergency response that involves formal agencies, private companies, military resources, religious communities, victims, volunteers, and the like, no formal unified hierarchy, similar to what can be found in a traditional military organization, can normally be identified. The first explorative analyses of emergency response conducted within this study indicated that managers during the response interacted in network-like patterns. Formal organizational borders were frequently crossed and ad-hoc solutions not reflected in formal plans and procedures seemed to be used. The interpretation of such empirical behavior was also supported in the literature. Formal organizational structures, or traditional chains of command, are seen as insufficient frameworks for descriptive analyses of multi-organizational emergency response management.

We assume the management in an emergency response system is constituted by interactions among individuals and that by analyzing patterns of such interactions empirical behavior can be better understood. This perspective means that the main interest in this study is directed towards a system level describing several

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entities, in this case individuals and the links among them, as opposed to a description of individual cognitive processes. Based on the reasoning above, a main research question can be formulated:

How can management in an emergency response system be better understood by analyzing interactions among individuals?

The question presupposes that empirical studies must be conducted. Based on the explorative process adopted, to answer this question two conditions need to be satisfied: (1) a method for collecting empirical data is required (2) and concepts relevant for analyzing and discussing the empirical findings and emergency management in general need to be elucidated. Therefore, two specific research questions are presented.

3.1 Specific Research Question 1

If the general aim with the research conducted is to better understand emergency response management, a method for analyzing empirical behavior needs to be identified. A systems approach has been employed and it is believed that an appropriate approach is to delimit the studied systems to consist of individuals and their interactions. Before any such data can be analyzed, the data needs to be collected. To obtain valid conclusions about management in an emergency response system, information from as many individuals as possible should constitute the basis for empirical analyses. Identifying all individuals involved in management activities during a response can be difficult. Official reports and articles in media are examples of documents that can help guide such an enquiry; however, they cannot be expected to be exhaustive sources of information. Also interviews with central decision makers could lead to valuable insights, but it is not realistic to presuppose that single interviews lead to a comprehensive understanding of how patterns of interactions among individuals during a response have emerged. A method is needed that allows the researcher to collect data from many respondents and at the same time detects new respondents that should be included in the study. The studied research literature pays little attention to the problems of collecting data on various interactions among individuals in emergency response systems. Even when techniques for analyzing relations among individuals in general are presented, no studies use a combined method to investigate management in this particular context. This reasoning leads to the specific research question 1:

Aim and Research Questions

How can data that describes interactions among individuals involved in management activities in an emergency response system be collected and analyzed on the basis of the following requirements?

- *A high level of active participation among individuals engaged in management activities during the studied response is essential.*
- *The analyses should aim to include not only official decision-makers but also any individual involved in management activities during the studied response.*
- *The description and the analysis method should facilitate studies of non-hierarchical structures and should have the ability to cover both top-down and bottom-up considerations.*
- *The method of collecting, managing, and analyzing vast amounts of data needs to be viable.*

“Non-hierarchical structures” are structures that are not based on an administrative/bureaucratic order. “Both top-down and bottom-up considerations” means that various types of management processes are acknowledged, not only orders from designated commanders but also information from anyone, irrespective of formal function, that influences the behavior of a response system in a relevant way. A “viable” method is a method that is feasible from a practical point of view.

3.2 Specific Research Question 2

The research behind this thesis includes literature studies. Initially, this study aimed to increase knowledge about emergency response management in general and about empirical behavior in multi-organizational contexts in particular. Concurrently, with the emerging need for a method for data collection and analysis, I developed a theoretical framework that could be used when discussing empirical findings.

Command and control and coordination are frequently used concepts among both scholars and practitioners, however, when listening to discussions and comparing

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various publications and documents, it becomes evident that they stand for different things depending on the person employing them and what tradition she or he represents. One could claim that not only are the concepts marred with multiple meanings, they are also used as “matters of course” without further explanation and precise definitions. Although command and control and coordination are seen as obscure concepts, they can hardly be avoided in emergency response management discussions. Based on interpretations of various management discourses, it is here suggested that command and control is a principle predominantly associated with a normative reasoning, i.e., ideas on how things should be designed and performed. Although this thesis has a descriptive orientation (its main focus is on how things are carried out), such concepts need to be elucidated. The empirical behavior in an emergency response system is not separated from normative ideals. Formal organizational frameworks and various pre-planned procedures among other things influence individuals. Thus, understanding multi-organizational emergency response management includes understanding of central management ideas. Furthermore, the importance of communicating the research results cannot be neglected. It is here believed that such processes are facilitated by using an already adopted language, but at the same time highlighting its shortcomings and suggesting an academic vocabulary with improved precision, such as when discussing empirical behavior relating to normative ideals. Coordination seems to be discussed both as a management principle (normally not explained in detail) and as a concept describing actual management processes. The beneficiaries of this research most likely represent many different academic and practical traditions and contribute to the broad heterogeneous field of emergency response management. Therefore, it is necessary to understand the key-aspects of the two key-concepts command and control and coordination.

As mentioned above both the early empirical studies conducted within the research project and the research literature indicated that responses to emergencies are not always carried out according to pre-existing plans and procedures. Just as command and control and coordination appeared to be central management concepts in normative discussions, the concepts of emergence and trust appeared to be important when discussing empirical behavior. In accordance with command and control and coordination, emergence and trust were considered obscure but important concepts. Literature, mainly sociological research, describes empirical behavior and make use of emergence as a reoccurring empirical phenomenon that can be seen as inconsistent with some normative ideals. Emergence in an emergency response management context early

became an important theoretical concept acknowledged in the descriptive research effort. However, when studying literature on emergence in complex systems, various dimensions were discovered. During discussions with emergency responders representing several different formal organizations, trust emerged as an interesting concept that could be used for explaining some of the unplanned behavior. Trust is a complicated concept. When related to the systems approach, trust needs further elucidation in an emergency response context.

A broad understanding of these four concepts command and control, coordination, emergence and trust and how they are used in the literature reasonably facilitates further discussions. Therefore, a second specific research question is formulated:

How can the concepts of command and control, coordination, emergence, and trust be interpreted in an emergency response context and how can the concepts be related to studies on interactions among individuals in an emergency response system?

The two questions presented are thus interrelated. Empirical analyses of emergency response management and the process of communicating the research results gain from an understanding of the commonly used concepts and how they are used. Conversely, the empirical results could facilitate discussion on their meaning.

3.3 Limitations

The descriptive approach does not incorporate cultural aspects of emergency response management nor does it include an age or gender perspective even if these dimensions are relevant. With one exception (the study on trust), the empirical data presented originates in a Swedish context. All cases represent relatively limited emergency situations, i.e., situations not normally labeled as disasters or catastrophes from a societal point of view. Under the discussion section, it is argued how the results can be relevant for studying and discussing emergency response management in different types of situations. The research has been in progress for five years and the main priority has not been to generate a large database. An extensive database would definitely be valuable for the research process, but time and research resources have restricted such ambitions.

The exploratory process has resulted in a need to elucidate certain concepts that are commonly used within the discourse. Not all concepts are discussed. It is

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possible to raise the question why some concepts are dealt with and some are not. The guiding principle has been to pay attention to concepts that repeatedly have emerged both in discussions with scholars and practitioners and in various literatures relevant for the research objectives. Hence concepts about descriptive reasoning on emergency response management need to be identified. Moreover, the elucidations conducted are broad and do not aim to cover all possible detailed aspects of the concepts, but rather they present interpretations on their meaning and bearing in multi-disciplinary discussions on emergency response management.

4 Related Research

This section reviews research areas that influenced the research process. The interdisciplinary field of emergency response management brings together various researchers, from mathematicians and physicists to psychologists and sociologists. Thanks to the Internet, the availability of literature is vast, a resource that allowed the use of publications representing many fields. From the early beginning to the end of the research process, the explorative research approach guided the search for relevant literature. However, the research process did not start as a blank page. My multi-disciplinary background as an engineer with complementary studies in behavioral and social sciences has most likely affected the process.

Given that multi-organizational emergency response management includes interactions among various individuals in an emergency response system, sociologically-oriented literature has been given considerable attention. Research contributions from established disaster researchers such as E.L. Quarantelli, T.E. Drabek and D.A. McEntire have played an important role in the process of understanding empirical behavior. They recognize the complexity associated with multi-organizational responses and problemize the field from a sociological point of view. Although they mainly concern responses to major disasters, their analysis of empirical behavior harmonize with the studies conducted and have motivated the development of the method suggested.

This thesis is also influenced by ideas on complex systems presented by well-recognized systems scientists such as W.R. Ashby and J. Holland. L. Comfort, adopting the complex systems approach, has produced relevant research. More precisely, ideas on complex systems have influenced how I have dealt with the complexity in an emergency response system. There seems to be a harmonious relationship between what could be seen as general complexity research and more sociologically-oriented research.

Complex systems are here believed to be better understood through network analysis. Social network theory – especially work by S. Wasserman, K. Faust, and D. Krackhardt – is central to improving methods for collecting and analyzing empirical data and serves as a conceptual touchstone for emergency response management. Several researchers – such as T.E. Drabek, D. Gillespie and R. Colignon, J. Scanlon and M. Petrescu-Prahova and T. Carter – use network approaches to investigate emergency response management. However, such network approaches are normally based on one type of relationship; i.e., different

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aspects of interactions are not considered. Furthermore, the problems associated with the data collection process are seldom reflected.

Research addressing management in complex environments has been given considerable attention within the military field. Although there are differences between military, civil-military, and civil operations, theoretical approaches to management are related to the content in this thesis. S. Atkinson, J. Moffat, D. Hayes, and R. Alberts, researchers within the CCRP (Command and Control Research Programme), have influenced the work due to their conceptual reasoning that brings together ideas on complex systems and social networks in a management context. Such research has provided me with a valuable input on how to theorize this intricate subject. In addition, this research identifies important dimensions of the problematic concepts introduced in 2.3. To avoid confusing the reader, this thesis takes into consideration that today command and control can be seen as synonymous to “management and decision making” (Skyttner, 2005, p. 413) and that the concept does not have to be associated with rigid and mechanistic formal authority structures characterized by strong centralization of decision making. When command and control is used as a term indicating such system characteristics, I label it “mechanistic” or “traditional” command and control.

5 Research Approach and Methods

This section describes the research process and the research methods. The exploratory process means that there was little known about the matter at the outset of the project. In the beginning, I adopted a rather holistic approach towards management in multi-organizational responses.

The initial interviews, including broad questions aimed to understand conditions for management in complex environments, indicated that emergency response processes were partly characterized by ad-hoc solutions, solutions not to be found in plans or procedures. At the time (2004-2005), a severe flood followed by a devastating storm –“Gudrun”– had triggered a complex of managerial problems. Both the flood and “Gudrun” struck several regions in southern Sweden. The response processes involved several official civil organizations and different administrative levels of these as well as private industry and business, military personnel, and volunteers. Since the events occurring affected a large area and generated a variety of acute needs, the actors involved need to coordinate their efforts as far as possible while maintaining a high degree of improvisation. This provided suitable cases to begin investigating. Several interviews were conducted with decision makers associated with the response activities. These interviews identified areas of particular interest and provided a rough conception of how actors communicated and how managed the efforts in the complex systems.

This insight led to the idea that a social network approach could shed light on multi-organizational responses. However, the initial attempts to map networks of decision-makers based on data collected in interviews with representatives from formal organizations were problematic. Relationships among different formal organizations were identified, but such knowledge was insufficient. I wanted to know how individuals interacted and looked beyond the bureaucratic perspectives. It became clear that to identify “manually” and conduct interviews with all individuals active during a response was almost impossible, at least very hard. Parallel to the interviews, a literature search was carried out. The research literature supported the early empirical findings indicating ad-hoc behavior in emergency response. Moreover, I found support for the network approach.

The next step aimed to improve the methods for collecting and analyzing data. To facilitate this process, I analyzed literature on social network analysis and studied scientific publications that focused on emergency response. The literature did not show a uniform theoretical approach to the subject. Instead, the literature review

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revealed various disharmonious normative ideas and concepts lacked precise definitions. To advance a better understanding, I defined both empirical behavior and frequently used concepts. The literature on multi-organizational emergency response that was studied in parallel with these processes referred to similar phenomena. Several researchers refer to concepts such as the improvisation (e.g., Wachtendorf, 2004), emergence (e.g., Neal and Phillips, 1995, Scanlon, 1999, Drabek & McEntire, 2003) and self-organization (Comfort, 1999) to describe phenomena that do not correspond to or are not included in formal plans and procedures.

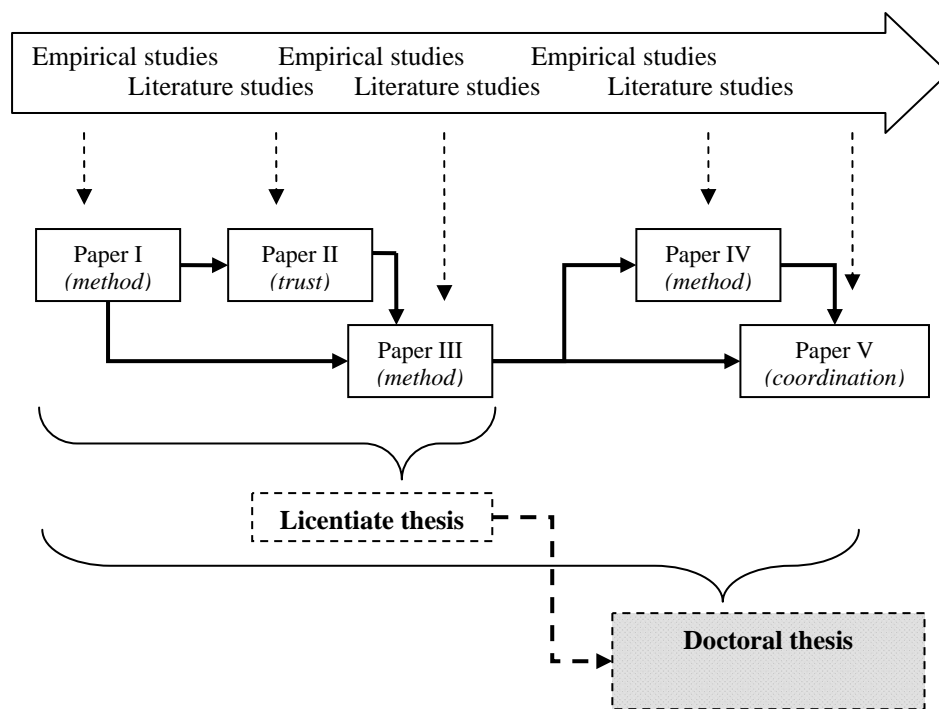


Figure 1

Figure 1 shows how the different papers forming the base for this thesis relate to each other and the explorative research process. It was early realized that a method for collecting and analyzing data on interactions among individuals was needed. Paper I suggests such a method. In Paper I, the initial interviews with professional responders and the studies conducted to test the method indicated

that the concept of trust influenced how the networks were formed. Paper II elucidates the concept and discusses possible consequences in an emergency response context. Literature studies conducted in parallel with the writing of Paper I motivated a development of the analyzing methods suggested in Paper I. Paper III proposes new methods for analyzing emergency response management from a systems perspective. At this stage, a licentiate thesis was submitted. The licentiate thesis is based on Paper I-III and a conference paper discussing different approaches to the concept of command and control (Uhr and Fredholm, 2006). Moreover, the thesis develops other concepts relevant to emergency response management, such as the concept of emergence and self-organization. Subsequent to the licentiate thesis, new empirical network data was collected. During this time, the studies on emergency management literature and literature on network analysis inspired further development of the tools presented in Paper I and Paper III. Paper IV suggests further methods for network analysis with a focus on groups and key agents. Papers I, III, and IV presents the methods for analysis and more literature on management that elucidated aspects of coordination. Paper V analyzes how multi-organizational coordination can be analyzed from a social network perspective.

This study used four methods: literature studies, interviews, questionnaires, and social network analysis. Empirical findings have influenced the literature search and literature findings have influenced the empirical studies. This approach narrowly focused the study. This work aims to develop a tool for data collection and data analysis. The tool has been tested in several empirical studies and has resulted in improved understanding of empirical behavior. Since this particular method is seen as a research result by itself, it will be explained under research contributions.

5.1 Literature studies

The literature studies were conducted to address the following aims:

- to understand the research area,
- to focus the research questions,
- to plan the data collection approach,
- to clarify the meaning of the terms, and
- to identify a proper theoretical framework.

5.1.1 Delimiting the Search

To talk about delimitations in single searches conducted would not be appropriate because the process is a continuum where new knowledge generated new questions and no apparent differentiation between different phases has been made. The initial formulations of the research problems guided the search process. In the very beginning of the project, when attention primarily was directed at a general understanding for the research area, broad variables such as emergency response were used to perform compute-aided literature searches. When the structure of the research problem to be dealt with emerged, based both on the literature findings and on empirical findings, the demarcation of the search variables became more explicit. For example, the concept of command and control, a frequently used concept in emergency response literature, had no consistent definition, a finding that generated new specific search processes based on questions that arose. Variables such as command and control were combined in the computerized search with terms such as criticism. This “funnel principle” was a typical characteristic for the search processes. A broad initial approach that improved the prerequisites for a review rendered more specified searches depending on the findings.

In studying publications in areas normally separated from the area of emergency response, but where the content might still be applicable, an overall picture of the area under discussion was sometimes hard to grasp. The multidisciplinary nature of emergency response as an area of knowledge could make it difficult to find apt delimitations of the literature search if the question at issue was insufficiently clear. For example, ideas on complex systems could be useful theoretically in connection with the approach to emergency response (Drabek & McEntire, 2002). After a broad search of complex systems, numerous of publications were identified; however, because the aim of the research concerns primarily emergency management, only ideas on complex systems in a broad sense, not detailed mathematical models of it, were of interest. The term “complex systems” was combined with such variables as emergency response and disaster to delimit the search results. This approach, however, would not guarantee that all relevant publications would be covered. The exploratory approach employed in the thesis aimed to develop an applicable theoretical framework for the research questions considered. There may be theoretical lines of reasoning not previously considered in connection with the emergency response but potentially applicable to it. Any aim of being exhaustive in a literature search of this type can be regarded as futile. The literature search sometimes concerned a particular author or an entire volume

of a specific journal. This could result in concrete ideas regarding matters of research interest.

5.1.2 Search Forums and Credibility of the Sources

Most of the literature was found using electronic databases such as ELIN at Lund University. ELIN is Lund University Library's database of electronic publications including both articles and complete issues of journals. Other sources were reference libraries, local libraries, and search engines such as Google Scholar. The forums for finding literature also included conferences, seminars, and everyday contact with colleagues.

A critical evaluation of the credibility of the literature has been made. According to Depoy and Gitlin (1994, p. 93), a rule of thumb used by many researchers is to search for articles that are not more than five years old. Even if emergency response is an area in which interest is growing, the number of publications included is relatively limited. I found it necessary, therefore, to use a wider time span. The contents of early publications need to be related to modern conditions in order for their validity to be adequately assessed. In the area of disaster management (in which response activities are included), certain authors give the impression of being highly credible today. E. Quarantelli, T. Drabek, and D. McEntire are examples of researchers of this sort. They are often cited in the literature, despite some of their publications being more than 25 years old. Also, in other areas, such as network and systems theory, the work of some authors is often cited. For example, the basic reasoning of W. Ashby from the 1950s is fundamental for a discussion of systems theory and cybernetics. The work by N. Contractor and P. Monge on networks are examples of authors who are often cited. I felt that I developed sensitivity to which authors were credible mainly on the basis of the number of times they were cited.

5.2 Interviews

Two types of interview approaches were adopted. The first, "initial interviews", and the second, "later interviews", have both similarities and dissimilarities. All the initial interviews were conversations or discussions, although questions, both general and precise, were prepared in advance. The later interviews had a more narrow area of interest, but were still flexible in their configuration. Every interview was semi-structured. My gradually developing skills in conducting both types of interviews probably affected the data collection process as a whole. I

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conducted 16 semi-structured interviews and conducted many “conversations” with various emergency managers; these interviews and conversations probably influenced the research process.

5.2.1 Selection of Participants

Since the initial interviews aimed to explore emergency response, the selection of participants was influenced by my background knowledge of the subject and the availability of persons with the practical experience who desired to participate. At the outset, colleagues and my supervisors contacted potential participants. Of special interest were persons with management functions in organizations such as the fire brigades and the county administrative boards and persons in lower administrative positions. Persons with coordinating functions were of special interest. The initial interviews related to emergencies that had occurred recently and to the interviewees’ interpretation of what had gone well or badly in the response process. Such an approach contributed to a common understanding of emergency response processes in large-scale emergencies. In the later interviews, the aim and disposition of the interviews became more distinct, which led to a more specified selection of participants. The early interviews and the study of incidents involved and the response reports generated a broad range of contacts at different administrative levels in the world of professional emergency managers. The availability of participants and their interest in taking part represented restrictions on the data collection process during the research as a whole. An Australian study, for example, partly relied on existing contacts and a basic understanding of the local, regional, and national emergency response systems, which made the selection more limited than it should have been in Sweden.

5.2.2 Locations

The locations at which interviews took place varied. I wanted to find neutral locations where colleagues would not interrupt or interfere. Many of the topics taken up in the interviews could be considered sensitive for the person who was interviewed and for the organization. During an interview, biases not connected with the content and formulation of questions could occur. An example of such bias is how the formal role of the interviewer or the interviewee influences the dialogue. Neutral locations could reduce such a bias. A few of the interviews, both during the initial interviews and the in the later interviews, were conducted in real emergency situations in which the locations could not be chosen. In spite of these

limitations, neither the “relation bias” nor any of the specific places where the interviews were held appeared to have had a significant effect on the results.

5.2.3 Interview Structures

Semi-structured interviews give the researcher and the respondent more flexibility than conventionally structured interviews and give the researcher the opportunity to follow up particularly interesting avenues of discussion, encouraging the respondent to provide a fuller picture (Smith, 1995). Before each of the interview situations, an interview guide was prepared. Before any of the specific questions at issue were brought up, I attempted to create a comfortable atmosphere by conversing about the respondent’s day-to-day work and his or her role in the response system. The purpose of the study was explained and information about the research project, ethical aspects of it, and concerns regarding anonymity were presented. Normally, the interview revolved around an emergency that had occurred before the time of the interview. I started the interview by asking how the respondent reacted and how he or she understood the situation and the response processes. Many respondents gave the impression of being very engaged in their occupation and interested in sharing their view of how emergency response works.

In the initial interviews, two quite straightforward questions shaped much of the interview process. From the respondents’ perspective I asked these questions: What worked well and what worked poorly in the response from a managerial point of view? I also asked them to describe their important internal and external interactions with other persons. At this stage, I encouraged them to describe the structure of interactions from their point of view and from an overall perspective. These questions represent a basic structure in the interview schedule that was complemented by other related questions concerning important decisions that were made and by whom.

In the later interviews, a more detailed area of interest was considered. Paper II provides a representative example of such an interview approach using the concept of trust. As in the initial studies, a similar introduction (using general questions to open the dialogue) to interviews was used. The questions concerning a concept – i.e., trust – and its consequences began with a broad perspective, and then moved to a more specific level in which trust was related to emergency response management. Even if these interviews were formalized, an opportunity for improvisation and digressions remained. An average interview of the latter

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type was about 40 to 90 minutes. These estimates include the introduction and the final discussion.

5.2.4 Data analysis

Most the initial interviews were recorded and notes were taken, but complete transcriptions of every interview were not conducted. My interpretations of the interviews corresponded to what research colleagues had noted during interviews and seminars with decision makers in similar functions. The transcriptions that were made and notes taken during this phase have been useful in later stages of the research process.

Paper II exemplifies how some of the later interviews were carried out and analyzed. The focus for this interview study was to better understand how practitioners relate to the concept of trust and its consequences in emergency response. Transcriptions made from the recordings have been structured into matrix forms where the answers could be compared and examined. A principle influenced by the Grounded Theory approach was adopted and facilitated a structured process of analysis that included identification of emerging themes in the interview material. This means that all the answers to a question were literally spread out on a table. Then, keywords or sequences of words about the subject of interest along with their contexts were extracted. If some words, or essences, occurred several times, they were gathered into one special group, or a theme. Thereafter, the themes were analyzed in order to identify sub-themes. (See examples in Paper II).

5.3 Questionnaires

To collect the network data, I used a web-based questionnaire. The questionnaire used two questions to gather qualitative data that could be analyzed either on its own right or in relation to the network. This type of questionnaire makes it possible to collect data from a large number of informants, but has the restriction of representing summarized impressions. The questions that were used focused on the subjective notions from a comprehensive standpoint on what the informants regarded as factors connected with successful and with unsuccessful management. Unreserved approaches like this are regarded as suitable complements to more specific queries. In addition, the possibility of adding optional comments was given. In light of the exploratory approach employed in the thesis, these comments (often vague formulations) helped to identify

conditions present in the real emergency response. As in Paper I, themes emerging from the data were identified later in the analyses. For example, similar answers to open questions were analyzed and the interpretation of the essence of the very meaning was summarized in one theme.

5.4 Social Network Analysis

Although social network analysis appears to be a very promising approach, few methods to collect data and validate it exist. Such a method is presented under research contributions in detail. The social network analyses facilitate a system understanding that makes it possible to analyze how different parts relate to each other in different ways. Comprehensively, the process can be described as a sequence that begins with an identification of individuals, in this case, individuals involved as managers in an emergency response system. These individuals are then asked to provide information about relational data among other things, e.g., data that has to do with their different type of relations to others during the response. They are also asked to identify new individuals relevant in the particular study. When a complete network has emerged, it becomes possible to analyze the data. This approach suggests methods for how to perform such an analysis. For example, the analysis can focus on structures or individual positions in a network (see Paper IV). The networks are all based on the individual's own interpretations. In other words, I as a researcher have not modeled a network; the network is based on the sum of individual interpretations made by the participants.

During the research process, the different techniques employed have complemented each other and validated the results. Results of the interviews and interpretations of the conversations with single responders were compared with results of the network analyses and the questionnaires. For example, interviews indicated that particular individuals were boundary spanners, serving as communication hubs between two formal organizations. Such findings have been verified through network analysis showing links of interactions. Also contradictions have been identified. Paper III analyzes answers to questions (non-relational data) included in a web-questionnaire. Some of the respondents meant that "the response organization was difficult to understand" and some described it as "perfectly clear." The respondents were also asked to rate the communication and the ratings ranged from "poor" to "excellent." Very likely the responders referred to different parts of the complex response system from many different

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standpoints. This finding indicates the intricate problems involved in analyzing and, above all, evaluating such a system.

6 Research Contributions

This section begins with summaries of the five scientific papers in chronological order. Four out of five papers were co-written with other authors. The summaries are complemented by clarifications describing the authors' different contributions. Answers to each research question are then suggested under "Results". These answers can be seen as having a condensed disposition and share many references to the five papers. The presentation of the research contributions involves a reasoning that is partly based on existing theories and ideas that are synthesized into a body of knowledge. For example, the development of the method for collecting and analyzing data originates from ideas on systems thinking and social network theory. The elucidations of the four concepts are mainly based on existing contributions from various research fields. This means that the answers to the research questions partly contain summarizations and quotations deriving from existing research from various fields. To clarify what is "new" rather than mere recapitulations of other works, every section ends with a summary of how the particular research has contributed to the synthesized understanding of multi-organizational emergency response management.

To keep pace with improved understanding of the problem area, new knowledge generated a demand for adjustments of previous formulations that can be found in the early papers. In other words, in the exploratory process new knowledge can influence how the researcher relates to old knowledge. Such adjustments are noticeable in the presentation of the results.

6.1 Summary of Scientific Papers

Paper I – Mapping an Emergency Management Network (Uhr & Johansson, 2007)

The paper presents the initial results from an analysis of an emergency management operation concerning the release of 16,000 tons of sulfuric acid in the city of Helsingborg, Sweden. The authors conclude that the emergency management organization included a significant amount of individuals who were not part of any plans, such as boundary spanners and individuals who were not part of any of the involved formal organizations but who still played important roles during the response. The paper underscores the need for a method that can be used to collect data that can be used in network analyses of emergency response management. Such network analyses can be seen as alternatives to analyses that use formal organizational structures as starting points for management discussions. For example, research should address problems such as secrecy, the meaning of relationships, and dealing with a considerable amount of data. A central research result is the suggested method for mapping various relations between agents that have been involved in an emergency response. The method is based on combining a web-questionnaire with telephone interviews to provide an efficient way of collecting large amounts of information concerning the agents involved in a response. The resulting networks of agents enable various network analyses such as identifying important agents and groups, analyzing the correlation between certain relations between the agents, and studying the temporal development of the network. Furthermore, the study presents the initial results from an analysis of the emergency response to the sulfuric acid spill in Helsingborg, Sweden. The authors conclude that the emergency management organization included a significant number of agents who were not part of any plans. These agents included boundary spanners and agents who were not part of any of the involved organizations, but who still played very important roles during the operation.

Status: Published in International Journal of Emergency Management, Vol. 4, No. 1 pp. 104-118, 2007

Author's contribution: Main writer, identified the needs for an improved method for data collection, structured the problems that had to be solved, designed the data collection method, participated in the process of finding methods for analysis, and performed the data analysis.

Paper II – Trust Among Decision Makers and its Consequences in Emergency Response Operations (Uhr & Ekman, 2008)

Paper II elucidates the commonly used concept “trust” and explores how it affects the behavior of an emergency response system. In this paper, trust is framed as an important concept for understanding emergency response management. Based on a literature review, several approaches to the concept of trust are presented. Moreover, on the basis of a literature review and six interviews with Australian emergency response practitioners, this article discusses relevant characteristics of trust and its consequences in emergency response. Trust could generally be described as a relation between a trustor and a trustee where the expected behaviour and competence of the trustee in a specific context, estimated by the trustor, is a central core in the concept. Trust can influence the effectiveness in communication between different decision makers and how networks are formed. Consequently, trust might affect the effectiveness, flexibility, and adaptation capability in the response system as a whole. The content emphasizes the need for further development of descriptive analysis of the processes underlying the formal charts and documents to understand authentic conditions and further develop valid normative theories for emergency response management.

Status: Published in Journal of Emergency Management, Vol. 6, No. 3, pp. 21-37, 2008

Author’s contribution: Main writer, conducted the fundamental literature review, conducted the data collection, and performed the data analysis.

Paper III – Analyzing Emergency Response Systems (Uhr, Johanson & Fredholm, 2008)

Paper III includes a development of the method used for understanding emergency response presented in Paper I. The improved method for analysis, which aims at achieving a better understanding of emergency response management, adopts a systems perspective, using various relationships that exist or develop between persons belonging to those organisations that are part of the emergency response system. Results of a study of such an emergency response system are presented and discussed in order to demonstrate how the method can be employed. Paper III also discusses concepts such as systems, emergence and trust that are relevant in the context of interest. Both literature and earlier empirical findings indicate that responses sometimes depart from existing plans when adapting to an event and its consequences. In Paper III qualitative and quantitative data have been analysed mutually and the results of such analyses indicate that the studied response included emergent behaviour. The empirical analyses also show that the individuals involved in the response meant that factors such as problems in getting an overall picture and receiving relevant information contributed negatively to the operation. A factor that appeared to contribute to a well functioning response was the knowledge of other people. This finding relates to the concept of trust in emergency response. The results imply that further development of methods for analysis is needed.

Status: Published in: Journal of Contingencies and Crisis Management, Vol. 16, No. 2, pp. 80-90, 2008.

Author's contribution: Main writer, collected the data according to the method presented in paper I, participated in the improvement of methods for analyses, performed analyses of qualitative data, and performed the analyses of network data.

**Paper IV – Groups and Key Agents in Emergency Response Systems
(Tehler, Uhr, Ekman & Fredholm, 2009)**

Paper IV further improves the methods for analyzing emergency response systems with a focus on groups and key agents. Groups of agents formed during emergency responses have been discussed previously in the literature. This paper presents a new way of identifying such groups in emergency responses that involves the use of social network theory. This method provides the opportunity to identify groups based on the interactions between the agents that participate in the operation. These groups can then be compared with the formal organizations and conclusions can be drawn regarding the tendency of agents from the various organizations to mix with others to form new groups during an emergency response. A measure of this tendency is suggested. Besides facilitating the identification of groups, the use of social networks also allows measurements of how many other agents a specific agent has had contact with during the operation. This allows for the identification of the agents that were central in the operation and the agents that had many interactions with other agents. I label such agents key agents. Furthermore, a hypothesis implying that the distribution of the number of interactions a specific agent has had during a response follows a heavy-tailed distribution, possibly a power law is proposed. This distribution may be because the network of agents grows, i.e., all agents do not become involved in the operation at the same time, and that the new agents included in the response are more likely to establish contact with agents that have more contacts with other agents than with those with fewer contacts. This developed approach to emergency response analysis is exemplified by performing an analysis of the response following a fire in a factory in Forserum, Sweden.

Status: Submitted

Author's contribution: Co-writer, supervised the data collection process, developed the theoretical perspective utilized, and participated in the development of methods for analysis and in the analyses of the empirical material.

Paper V – Emergency Response Coordination from a Social Network Perspective (Uhr, 2009)

Paper V illuminates the concept of coordination in an emergency response context. Coordination is commonly used in emergency response discussions focusing on management in multi-organizational contexts where no single chain of command exists, i.e. situations in which no formal authority at the top of the system can give order to all the resources active in the operation. This paper suggests that coordination can be considered as a broad concept that can include various strategies for dealing with interdependencies in complex systems. The paper argues that coordination can include both elements of traditional command and control and bottom-up activities such as self-organization. Three studies examined responses to emergencies conducted in Sweden to illustrate how coordination can be analyzed and understood from a social network perspective. In these studies, certain network relations, such as communication intensity and perceived importance, are used as proxy attributes that indicate coordination. The interpretations of network data imply that coordination activities were distributed among the individuals active in the operations. In other words, coordination was not performed by individuals with only “formal coordination functions.” Moreover, coordination was partly characterized by emergent behaviors. Finally, the empirical analysis implies that emergent behavior can be positively related to high complexity and vice versa. The network approach and the empirical findings are critically discussed. Although parts of the results of the analyses can be supported in research literature, the results should not be generalized. This paper concludes that social network analysis can be a useful tool for analyzing and understanding the complex nature of emergency response coordination, but further studies need to be conducted to facilitate improved normative suggestions on emergency response management.

Status: Submitted

6.2 Results

It is assumed that in order to better understand the subject area the research focus needs to be directed at both empirical conditions and normative ideals influencing how responses are carried out. Initially, a method for how to analyse management in an emergency response system is suggested, i.e. an answer to specific research question 1 is provided. This presentation is followed by summarizations of the elucidations of the concepts identified as relevant for understanding the problem field. The elucidations contain analyses of the concepts based on literature reviews and further suggest how they can be related to empirical findings. This approach answers research question 2. Finally, I synthesize the findings is to address the main research question.

Generally, when examining complex systems, research should focus on the interactions between the various agents the system (Axelrod & Cohen, 2000). The literature presents many options on how to analyze an emergency response system. Often, the literature looks at how the different parts of the system and the organizations belonging to the system interact. Comfort and Haase (2006) present such an analysis. They analyze the content of the news reported in New Orleans around the time of the disaster and study one network of organizations that interacted during the response to the disaster. Using a systems perspective, they investigated the elements (organizations) involved and their interactions representing the system in question.

Although this thesis considers the (formal) organizational level, its main object is the individual level. Borell and Johansson (1996), in referring to Barnes (1954), state that societal events cannot completely be analyzed by studying only administrative systems and production order. They identify a third system, a network, with diffuse borders and without a formal coordinating mechanism: “Drabek, Leik and their colleagues argue that social networks are key types of social units that respond to disasters and that they are definable and interpretable in their own terms” Kreps (1984, p. 314). The network approach breaks through various formal structures and their normative influence on the results, providing satisfactory material for various analyses. O’Tool considers clusters of individuals, such as organizations, as follows: “Networks are structures of interdependence involving multiple organizations as parts thereof, where one unit is not merely the formal subordinate of the other in some larger hierarchical arrangement” (1997, p. 45). Network models appear within discussions in various fields, such as information technology, business administration, political science, sociology, and

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criminology, sometimes as a conceptual term, sometimes as concrete schemes of physical artifacts and their connections, and sometimes as something in between.

6.2.1 Addressing specific research question 1

How can data that describes interactions among individuals involved in management activities in an emergency response system be collected and analyzed on the basis of the following requirements?

- *A high level of active participation among individuals engaged in management activities during the studied response is essential.*
- *The analyses should include not only official decision-makers but also any individual involved in management activities during the studied response.*
- *The description and the analysis method should facilitate study of non-hierarchical structures and should have the ability to cover both top-down and bottom-up considerations.*
- *The method of collecting, managing, and analyzing vast amounts of data needs to be viable.*

6.2.1.1 *Data collection*

Paper I begins with identifying and discussing three problems that are identified and must be considered in collecting data for a network analysis: the problem of handling a considerable amount of data, the content of the relations, and secrecy. A complete network of emergency response agents could be very large. It is reasonable to expect hundreds of agents involved in some of the more severe emergencies and since one agent easily can have connections to ten or more other agents, one can expect that a large amount of information needs to be collected. Also, if one is interested in more than one type of relation, which is likely, the amount of information called for is still greater. If one needs to conduct interviews with all of the agents to determine the relations they have taken or have with each other, it is evident that the workload can be considerable. A

computerized collection process is one way to handle the problem of collecting a large amount of data of this sort, but using web-based questionnaires, for example, could have disadvantages such as possible loss of data due to technical problems and unfamiliarity, the risk of technical bias, and problems associated with jurisdictional restrictions. Nevertheless, due to its practical advantages, I selected a web-based questionnaire connected to a database.

In the data collection process, the participants of the study need an understanding of the content in an agent-to-agent relation. To create a valid network, consistency in this perception is preferable. However, subjectivity regarding this matter cannot fully be eliminated and this needs to be kept in mind throughout the process of analyzing the data. An example of a relation used in the analysis is what is termed contact. It could be problematic for the agents to understand what exactly “contact” means. If an agent has talked only briefly with another agent during the response, for example, should it be classified as contact? The main reasons for including the contact-relation are to get an idea of which agents had little or no contact with others during the response and to provide a way of identifying new agents who participated in the operation. Thus, the aim is to have a “weak” definition of contact, meaning that any exchange between two agents of information or resources related to the response is classified as a contact-relation; if an agent has exchanged information with another agent about something that is not related to the ongoing operation, then it is not considered to be a contact-relation.

To rationalize the data collection process, the database allows participants to sign in and submit the information required for a network analysis. This process involves storing information concerning the agents and their relations, a fact that could cause harm to both individuals and to organizations if the information were made public. It needs to be handled with care. Moreover, sensitive information might be recorded which could be in conflict with the current regulations. In Sweden, the principle of free access to public records has a strong influence on what guarantees of secrecy can be given to participants in studies like this. Complete confidentiality would be desirable to generate greater accuracy of information obtained. Unfortunately, this is not an option; the participants need to sign an agreement in which they clearly indicate that they understand that the information they provide will be stored in a database. In addition, they are informed that if anyone would like to study the information, they will be allowed to do so. This could, of course, reduce the agents’ willingness to provide information. It is not possible to completely eliminate this problem. Storing

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personal particulars, especially without approval, is also problematic. If an agent refers to another agent who does not yet exist in the roster, it is necessary to store temporarily this data in a veiled roster (a roster only visible to the person responsible for the study). The persons should then be contacted for approval before they are transferred to an open roster.

A method of collecting network data was developed based on the problems identified above. Figure 2 summarizes the four phases of this method. See Paper I for a complete description.

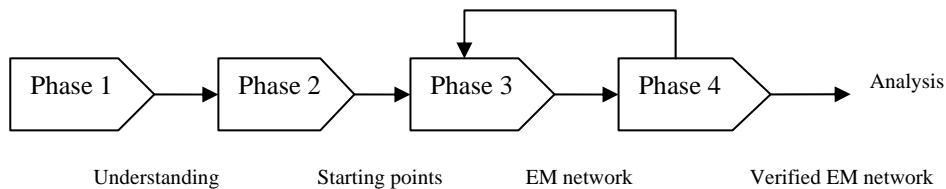


Figure 2

To investigate a network of agents, a basic understanding of the course of events is necessary (pre-study phase). By analyzing documents from different formal organizations, this basic understanding can be obtained. This work is the first step in identifying the starting points for the actual mapping process performed in phase 3. The starting points are those agents with whom the snowballing process begins (in phase 3). At this point, a rough outline of the limitations of the network is needed. The results of the pre-study are used to identify key persons (phase 2) within the organizations who participated in the emergency response. Large-scale crises can require time consuming operations involving staff turnover, a situation that increases the number of possible agents to start with and complicates the data collection process. Records showing information flows, such as phone lists, were extracted from decision support systems. Notes in the minutes can be helpful and provide valuable information regarding the time when a specific agent was active in the operation. This approach also helps identify sub-groups—i.e., groups with similar geographical representation and frequent internal communication—and find desirable starting points. The agents identified in phase 2 constitute the starting roster of agents or the first-order zone (Wasserman & Faust, 1999). The first-order zone is followed by a second, where the agents in the first-order zone are asked to refer to new agents and so on. Phase 3 used a web-based questionnaire

that included a starting page on which the participants use a personal username and a password to gain access to the main page. After being informed about secrecy regulations and how the data will be used, the participants can create their part of the network using the existing roster. Additional names can be added if the roster is incomplete. The agents also provided personal information and information about their involvement in the emergency response, such as the hours they worked in the operation, their organizational position, and their main tasks. They also had the opportunity of adding personal comments. The information was then saved in a database used as the basis for analyzing the network. At some point during this snowballing process, the number of new agents that were added to the network drops; i.e., the agents who are referred to by new agents are already present in the roster. When this happens, the boundaries of the network have been reached and the roster of agents is complete. To assess the validity of the network, a fourth stage, which is a kind of verification process, followed. Since the roster is expected to grow very quickly, it should contain the names of almost all the agents after the third- or fourth-order zone has been passed. Nevertheless, one can expect a few agents to be added still late in the process. A second contact with all the agents should be established so as to confirm and possibly add or change relational data. This task involves reviewing the final roster and making possible changes in the information that has been provided. Verification also involves making a second contact with a selection of agents on the basis of their position in the network.

Results confirm the difficulty of contacting every agent involved in the management of an emergency response situation. To collect data from all identified agents in a network, if the network is large, is unrealistic. Some possible respondents are hard to reach, some forget despite several reminders, and some have various reasons for not wanting to participate. To address this issue, Paper IV suggests a completeness measure. Comparing the number of agents active in a study with the total amount of agents in the network can be misleading for judging the validity of the results. Several of the individuals that participated in the studies constitute a “core” in the networks, and each of these agents are involved in multiple relations, the in-relations. Many of the individuals that did not participate in the study have only one or very few in-relations. Although an individual who has few in-relations might be very important to a specific agent, it is unlikely that such an agent is crucial to the response as a whole. Therefore, relations are used to measure the completeness of our network. By dividing the number of relations between individuals active in the study with the total number of relations, we achieve a useful completeness measure.

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6.2.1.2 Analyzing the Data

When analyzing the end result of the process described above, two categories of data are distinguished: quantitative and qualitative. Aware of this division being a simplified one and of the fact that quantitative approaches also include qualitative elements, the types of data analyzed can be said to have characteristics that could place them in either category, although for simplicity's sake they are placed in only one of the two. Relations of the data of both types to the system components of agent (node, person, etc.) and relation (link, connection, etc.) could be shown. Agent data, or agent attributes such as identity, age, organizational membership and period of activity together with relational attributes, such as degree of importance to one and type of friendship, are examples of quantitative data that form different types of networks. Agent attributes, consist of more detailed answers to questions such as: "What do you think functioned well during the response?" or "What do you think functioned poorly?" These are regarded as qualitative. Data of these two types differ with respect to the perspectives from which they were considered. The section below describes methods for analyses of the quantitative material, systems analyses.

The analyses of network configurations conducted can be divided into two types. Focus on individual positions in a network and focus on groups or clusters in a network. By calculating the closeness centrality (Wasserman & Faust, 1999, p. 184), it is possible to gain an understanding of which agents that could be considered the most "central" in a particular network. Calculating the closeness implies that one calculates the length of the shortest paths between all agents. The agent that has the shortest path on average compared to all other agents is the agent who is the most central person. Another way of identifying central agents is to calculate the actor degree prestige, which is the number of links (relations) that lead to a specific agent (Wasserman & Faust, 1999, p.202). Calculating the actor degree prestige of a certain relation, such as "important contact" (see Paper II and 4), will provide a measure of which agents are most often selected as an important contact by the other agents in the network. In Paper IV the concept of key-agent is introduced. The term "key-agent" primarily relates to the network of relations, not to the actual emergency situation. Paper IV discusses the principle of preferential attachment and power-law distribution (Barabási & Albert, 1999 and Atkinson & Moffat, 2005).

There are several ways to identify groups in social networks (Wasserman and Faust, 1999). Paper IV uses divisive hierarchical clustering. With the complete network as a starting point, the least connected parts of the network are

successively identified. The relation connecting these parts is then removed. When this procedure is repeated the network will start to break up into groups of nodes. To do this, an algorithm introduced by Newman and Girvan (2004), which has proven to be both efficient in terms of computer time and reliable in terms of identifying relevant groups in networks, is used. To measure whether the groups' constitution is strong or not, the concept of modularity is used (Paper IV). The Newman-Girvan algorithm can identify groups of individuals from different organizations working together. As shown in Paper V, such groups can be very heterogeneous. This type of group analysis is valuable when identifying emergent groups in response systems. Paper V also presents another way of analyzing groups of interacting individuals. By placing agents who share the same formal organization in one particular group, another perspective on inter-organizational interaction can be provided.

Dynamics is an important condition in an emergency response system. At this stage, the problem of how to incorporate dynamics in the network analyses is not completely solved. Using the agent attribute "active in the operation between t1 and t2" (such attribute is actually collected in the empirical studies, but not used in the analyses) may be effective.

The complexity of emergency response management is not well captured by formal organizations.. Analyzing interactions among individuals provides an empirical understanding of the conditions. The method suggested acknowledges the four prerequisites: (1) a high level of active participation among individuals engaged in management activities during the studied response is essential; (2) the analyses should include not only official decision-makers but also any individual involved in management activities during the studied response; (3) the description and the analysis method should facilitate the study of non-hierarchical structures and should have the ability to cover both top-down and bottom-up considerations; and (4) the method of collecting, managing, and analyzing vast amounts of data needs to be viable. The method for collecting data makes it possible to reach many respondents. The Internet is a common tool at most workplaces and the respondent's contributions are immediate. The database becomes a "living" document and easily accessible. Compared to traditional interviews or paper questionnaires, the web-questionnaire is very effective. By using the principle of "snow-balling," it becomes possible to identify various responders and not only responders associated with formal response organizations such as volunteers or victims. Thus, the researcher does not design the systems analyzed. The basis for the systems derives from the resources constituting it. The

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method for collecting, managing, and analyzing data is viable. The amount of data is vast, but thanks to software such as MS Access, NetCalc, and NetDraw it is manageable. It would be unrealistic to deal with such data with pen and paper as the only technical aids. In addition, the method is not considered to be rigid, but flexible and open to alterations. Considering the prerequisites, I was unable to find an alternative approach.

Summarization of research contributions:

A systematized approach for collecting empirical data on individuals and their interactions has been developed and tested.

The data derives from the individuals' own interpretations of their relations in particular response

The approach facilitates analyses based on various types of relations, not only on communication.

Various tools for analysing network data are proposed and tested. It is suggested that analyses of various groups and so called key-agents lead to a better understanding of empirical behaviour in multi-organizational emergency response management.

6.2.2 Addressing Specific Research Question 2

How can the concepts of command and control, coordination, emergence, and trust be interpreted in an emergency response context and how can the concepts be related to studies on interactions among individuals in an emergency response system?

The answer provided below is mainly based on condensed extracts from Paper II and 5 and chapter 5 in Uhr (2007). Both academics and practitioners frequently use the concepts of command and control (C2), coordination, emergent phenomena, and trust. They have become important tools for describing different aspects of emergency response management. For example, command and control and coordination are often used to describe different managerial approaches. In civil contexts, command and control has to a certain degree become a representation of “strict hierarchical systems.” Several researchers and practitioners regard command and control as an unrealistic management ideal in a civil multi-organizational environment. Instead, they see coordination as a more realistic approach. However, the concepts are often used without precision.

Sociologically-oriented literature often refers to the concept of emergence when describing empirical behavior in emergency response systems. Emergence seems to stand for “non-planned” or “ad-hoc” behavior, phenomena discovered in the early stages of the research process. When studying emergency in literature not dealing with emergency response in particular, the concept of emergence becomes obscure. Other concepts such as self-organization (see Uhr, 2007) and self-synchronization are identified as processes related to emergence although they are not examined in this thesis.

Trust is often mentioned as an important condition for effective management. The initial interviews conducted within this research project indicated that “trust” partly explains why some contacts during operations were established. Trust can be seen as a condition that causes ad-hoc behavior although a research review reveals that the concept is ambiguous.

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6.2.2.1 Command and Control

Command and control and its amalgams are imprecise concepts with multiple meanings (Arbuthnot, 2008). In this thesis, I view command and control as a principle even if many amalgams – such as C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance) – have been developed to expand its meaning and adapt to the changes in other fields. The concept of command and control is changing with the emergence of new adversaries challenging the system and new technologies supporting it (Rosen, Grigg, Lanier, McGrath, Lillibridge, Sargent and Koop, 2002). Since command and control research is vast, detailed explanations on various aspects will not be provided. The objective has been to examine it from a broad perspective so as to understand how scholars from various traditions approach the concept.

Without doubt, there has been a strong military influence on conceptions of how society should prepare for and respond to different types of civil crises. A threat must be taken care of in one way or another irrespective of whether it stems from the actions of a hostile actor or from a natural disaster. Some theorists make no distinction between civilian and military command and control. In “Command and Control in Civil Emergencies” (Edit, 2003), the editor writes that civilian command and control is virtually the same as the military version. The same elements are present. However, important differences between the civil and the military contexts are obvious. For example, military forces can actively take the initiative, whereas civil emergency actors are “reactive” even if principles of feed-forward sometimes are adopted during the response. The response is still a response, however. A large civil response can involve various actors with completely differing organizational structures and cultures as compared with the more homogeneous character of one or many military forces.

Two approaches to command and control have been identified. The first approach can be regarded as the “traditional.” Several definitions representing this approach are listed below.

Command and control is characterized by “*clearly defined objectives, a division of labor, a formal structure and a set of policies and procedures*” (Schneider, 1992).

The following definition of command and control comes from the U.S. Department of Defense Dictionary of Military and Associated Terms (2002).

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“The exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities and procedures which are employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission.”

Skyttner (2005, p. 413), noting the military origin of the terms, cites Coakley (1991) when defining command and control:

“In general terms, Command and Control is everything an executive uses in making decisions and seeing that they are carried out; it includes the authority accruing from his or her appointment to a position and involves people, procedures, equipment and the executive’s own mind. A Command and Control process is a series of functions, which includes gathering information, making decisions and monitoring results. A Command and Control-system is a collection of people, procedures, and equipment which support a Command and Control process”

In the “traditional” approach, the top-down perspective is consistent throughout the entire system. Command and control in this approach is normally centralized and orders and instructions are explicit, often to the point of detailing not only what is to be done but also how, when, and with what means. In the present case, traditional Command and control emphasizes a vertical information flow with information flowing up the chain of command and orders and instructions flowing down.

A second approach to Command and control has been identified. The Marine Corps Doctrine Publications (1996) in chapter 1 discusses the behavior of a complex system as a system with reciprocal action and feedback. Rosen et al. (2002) describe “detailed” and “mission” Command and control as extremes along a spectrum of command structures. This view of Command and control has several important features that distinguish it from traditional Command and control. The authors regard a military organization as an open system that interacts with its surroundings rather than as a closed system focused on internal efficiency. The feedback loop makes command and control a continuous, cyclic process and not a sequence of discrete actions. The action-feedback loop also makes command and control a dynamic, interactive process of cooperation. Finally, the most important characteristic of this approach is that this view does not regard the commander as being above the system, exerting command and control from the outside; the commander does not act as a chess player moving the chess pieces as he wishes, but acts as an integral part of a complex web of

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reciprocal influences. The authors end the section by saying, “It is unreasonable to expect command and control to provide a precise, predictable, and mechanistic order to a complex undertaking as war.”

Alberts and Hayes (2003) support the idea that command and control can represent different approaches to management. They use command and control as a framework for their discussions in which they include concepts such as complexity, social networks, self-organization, and emergence. Publications, such as “the Agile Organization” (Atkinson and Moffat, 2005) from CCRP (the Command and Control Research Program), represents a modern approach to management in complex systems, an approach that does not rely on mechanistic top-down arrangements and acknowledges bottom-up activities. In “Agility, focus and convergence: the future of command and control” (2007), Alberts actually suggests that the concept of command and control should be replaced with “focus and emergence.” Skyttner (2005, p. 413) makes the important observation that command and control is being used more and more in a civilian framework in a manner synonymous with “management and decision-making.”

At this stage, one can conclude that there is one “traditional” and one “contemporary” approach to command and control. The first approach relies on formal a bureaucracy describing a clear division of labor, a formal structure, and a set of policies and procedures. All the resources rely on a central authority with predetermined structures and procedures and the power to influence subordinates in detail to achieve the operational goal set by the authority. This approach assumes that the available resources act within formal boundaries and that the set of resources are somewhat “controllable.” The second approach problematizes the field of management and tones down the possibilities for one central authority to govern the management processes. Words such as complexity, emergence, and self-organization describe the context in which management takes place. A main difference between the traditional and the contemporary approach to command and control is that the latter acknowledges the problems of dealing with complexity whereas the first does not. Another way to put it is that traditional command and control aims to defeat “the chaos” often associated with multi-organizational response management through rigid command structures, while contemporary command and control aims to “ride on the edge of chaos, exploiting the leverage that this might allow” (Atkinson & Moffat, 2005, p. 98). Clearly, the traditional approach uses the intent of one central authority as starting point for management discussions, but it is uncertain if the contemporary

presupposes that only “one single governing operational intent” dominates the management context.

Some disaster researchers and organizational theorists have a negative view of command and control as a basis for disaster management or as a basis for management in general. Drabak and McEntire (2003), Comfort (1999), Denis, (1995), Neal and Phillips (1995) Takeda and Helms (2006), Wise (2006), Mendonca, Jefferson and Harrald (2007), Seddon (2005) and Wheatley (1997) formulate their criticism of command and control in different ways, but the core in their criticism is similar. Quarantelli (1998), a sociologist and disaster researcher, believes that in many countries there is a strong tendency to assume that the best model for disaster organizational preparedness and management is what has been called a “command-and-control model.” This model takes from the military that a top-down, rigidly controlled, and highly structured social organization as the model for disaster purposes; however, according to Quarantelli, direct studies in disaster areas have not only shown that command and control models are seldom organizationally viable, but also are poor models for disaster planning, even if they could be implemented in the real world. He argues for the relevance of what he calls an “emergent resource coordination model” instead of a command and control model. Rather than attempting to centralize authority, he feels it to be far more appropriate to develop an emergent resource coordination model. The problem is one of coordination, not of control. (However, the concept of “control” is not clearly defined.) Quarantelli implies that disasters have implications for many different segments of social life and of the community, each with its own pre-existing patterns of authority and each with the need of simultaneous action and autonomous decision-making. This makes it impossible to create a centralized authority system. Quarantelli argues that we ought to leave aside the fact that the command and control model is more fiction than fact even in the military area. It is not the way armies, navies or air forces actually operate, especially not in conflict situations, stereotypes and group mythologies to the contrary.

Empirical analyses (see Paper V) of response operations involving several formal organizations support the idea that the traditional approach to command and control is a poor management strategy due to the complexity built up by among others things the situational dynamics, numerous personal interactions, and various administrative borders. It is also a poor framework for descriptive discussions since it does not represent the behavior of all the resources active in a response. Figure 3 demonstrates a network of agents active in a response to a

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discharge of sulfuric acid in Helsingborg in 2005 and the contact relations that were mapped. The size of the nodes corresponds to the amount of relations that are directed to them (in-degree). It shows that the interactions among the individuals are outspread, or distributed, in the network. If the individuals operate according to a traditional command and control structure, the communication would not be as distributed as the illustrations show. For example, the chief of the fire brigade (19) did not only communicate with her subordinates or with individuals at similar positions in other formal organizations. The information flow cannot be seen as vertical. Instead it flows “in all conceivable manners.” It is also shown that the response was not arranged only according to written plans and procedures. There were several examples of ad-hoc solutions and bottom-up activities inconsistent with the traditional command and control ideal. For example agent 47 is assigned with an in-degree that was equivalent to, and in some cases even higher than, than the on-scene commanders who generally are considered as very central for response operations. Agent 47 (employed by the fire brigade) occupied no formal role in the formal organizations. Instead, due to his knowledge of different people, he had a free role (supported by the chief of the fire brigade) with the aim of supporting coordination. Agents 34 and 37 were commanders in a “chemical staff function” that to a high degree was initiated and designed by the two well-recognized experts themselves. There were no detailed plans for such establishment. The commanders’ “official mandates” were not equivalent with, e.g., the on-scene commanders. Still 34 and 37 showed a high in-degree in the network presented and according to interviews the decisions made in this function influenced the operational alignment of the response.

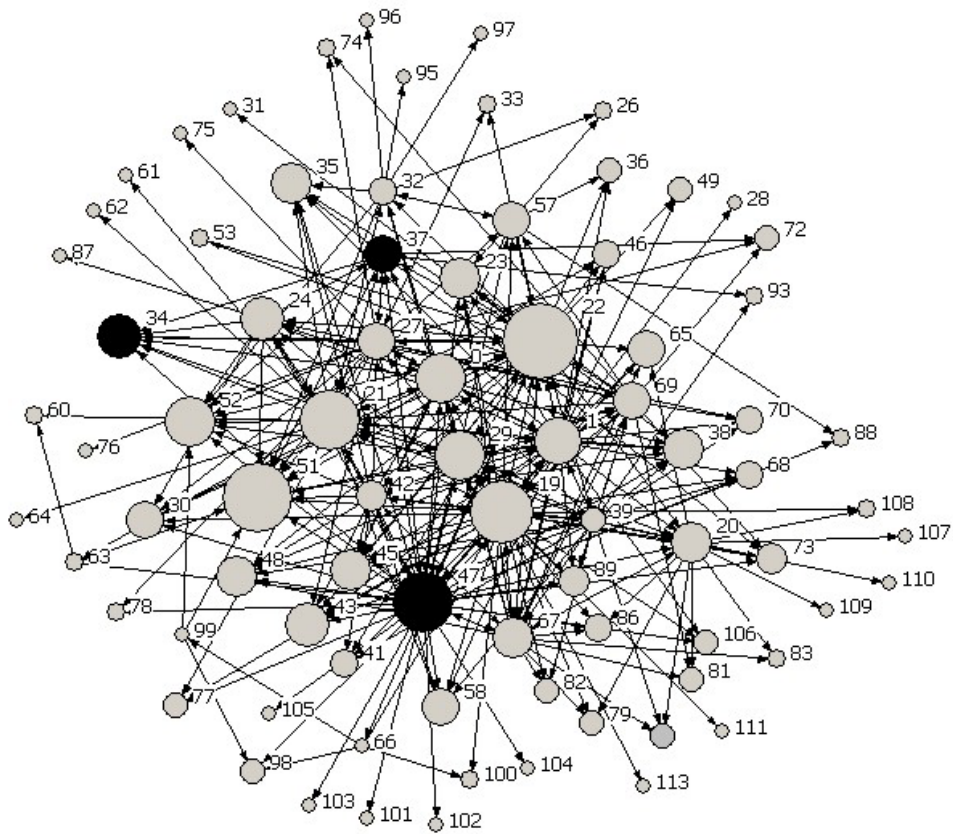


Figure 3

Summarization of research contributions:

The concept of command and control has been elucidated from a broad perspective and related to the context of emergency response management. It is suggested that one can distinguish between two different approaches to command and control:

- One “traditional” approach which emphasises the role of a central authority at the top of a hierarchical command and control system
- One “contemporary” approach which acknowledges the complexity and the bottom-up behaviour in an emergency response system and that such system cannot be controlled from the outside.

It is also concluded that several scholars show a very negative attitude to the concept as such. Their criticism seems to a high degree be focused on the components of “traditional” command and control.

The studies conducted within this research show that “traditional” command and control is an insufficient starting point in normative discussions since it does not acknowledge empirical behaviour. Resources active in a response do not automatically adapt to bureaucratic structures or predetermined procedures. It is suggested that the “contemporary” approach to command and control and the critical discussions acknowledge such empirical behaviour.

6.2.2.2 Coordination

Several researchers suggest that an important part of emergency response management is to coordinate available resources (Quarantelli, 1988; Boin, Hart, Stern & Sundelius, 2005; Wise, 2006 and Wybo & Latiers, 2006). Coordination in the context of emergency response is an important but understudied research issue (Chen, Raj, Raghav & Shambhu, 2008, p. 73). Quarantelli suggest that there is a “lack of consensus among organizations concerning the meaning of coordination” (1988, p. 382). The modern emergency management discourse often seems to use the concept when discussing activities that involve several formal organizations that operate “harmoniously” in one way or another. Brehmer (2008) discusses complex operations (meaning operations involving several formal organizations and in combinations that cannot be predicted). He proposes that the challenge in such operations is to achieve the amount of harmonization in the operation that is required to solve efficiently all the missions.

Paper V elucidates the concept of coordination and suggests how coordination can be studied from a social network perspective. Malone and Crowston suggest a definition of coordination:

“[t]he act of managing interdependencies between activities performed to achieve a goal” (Malone & Crowston, 1990).

“...if there is no interdependence, there is nothing to coordinate. . . . Interdependence between activities can be analyzed in terms of common objects that are involved in some way in both actions” (Malone & Crowston, 1990, p.6).

A similar approach to coordination is suggested by Malone and Smith:

“The additional information processing performed when multiple, connected actors pursue goals that a single actor pursuing the same goals would not perform” (Malone & Smith 1988).

Comfort writes:

“Coordination means aligning one’s actions with those of other relevant actors and organizations to achieve a shared goal” (2007, p. 194).

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Klein suggests:

“Coordination is the attempt by multiple entities to act in concert in order to achieve a common goal by carrying out a script they all understand” (2001, p.70).

Hage, Aiken and Marrett talk about coordination as:

“. . . the degree to which there are adequate linkages among organizational parts, i.e., among specific task performances as well as among subunits of the organization, so that organizational objectives can be accomplished” (1971, p2).

Thus, coordination can be seen as something that does not necessarily have to involve many different *formal* organizations. In this thesis, the concept of coordination is associated with all types of organizations including formal bureaucracies and informal network structures.

To better understand coordination, one needs to reflect on the goal as an important component in the discussion on coordination. Coordination reasonably has to have a purpose and this purpose can be to achieve some overall goal or decompositions thereof. It is relevant to discuss the precision associated with formulated goals. Malone and Crowston (1990) contend that situations where actors, at least partly, have conflicting goals are almost universal and that conflicts are common. When analyzing coordination, the collective behavior of the actors must be evaluated in terms of how well it achieves some overall goal (Malone & Crowston, 1990): “Even when a group of actors has strong conflicts of interests or belief, they may still produce results that observers would judge to be ‘good’ or ‘harmonious’” (Malone & Crowston, 1990, p. 2). In a situation where many formal agencies, volunteers, and private companies act together, they may have different goals on the operational level, i.e., the police in a given situation want to evacuate a block, healthcare organizations want to provide medications, the fire brigade wants to control a fire, and so on. Such different operational goals can be seen as decompositions of an overall goal. An example of an overall goal can be the return to a functional society or to protect life, property, and environment. Harmonizing operational goals on various system levels to achieve efficiently the overall goal is here seen as an essential component in coordination. Coordination is not necessarily a top-down driven process where one authority solely determines the overall goal and its compositions. Operational goals reasonably develop from local perceptions of a dynamic environment.

Paper V discusses coordination on various system levels. Coordination on an accident scene where several fire fighting units have to operate jointly in order to extinguish a fire can be seen as coordination on a low system level and the goal to efficiently extinguish a local fire is a subset of an overall goal as exemplified above. A low system level can involve a high resolution of system elements but covers a more finite segment of the resources involved in the response. If a major emergency affecting many parts of a society (such as a flood, pandemic or earthquake) occurs, various formal organizations need to coordinate their objectives on a high system level. Most probably priorities need to be assigned, resources need to be shared and activities must be synchronized. Coordination on a high system level is associated with a holistic approach and a deep understanding of the complexity characterizing the entire context (see Paper III), and understanding of the meta-level (Wybo & Latiers, 2006). However, overall coordination in a community disaster of any magnitude is problematic. (Quarantelli, 1998)

NSF-IRIS, a report by the NSF-IRIS Review Panel for Research on Coordination Theory and Technology, suggests that coordination means “the operation of complex systems made up of components.” This thesis supports this approach and advocates that emergency response operations represents dealing with complexity and that there are many managerial approaches of doing this. Here, coordination can involve both emergent behavior (here indicating new, novel ad-hoc characteristics including self-organizing processes) and strict mechanistic command and control processes. Coordination is sometimes used as a polar opposite to command and control, but from the perspective employed in this thesis “traditional” command and control is a possible component in coordination processes.

I have concluded that coordination is a broad concept that involves dealing with complexity. Malone and Crowston’s (1990) approach captures a central aspect detectible in many other attempts to define the concept. Managing interdependencies between activities performed to achieve an overall goal can be seen as a central part of coordination. An overall goal does not have to be associated with an overall authority or management function. Coordination can be related to both normative and descriptive discussions. Coordination is sometimes referred to as a normative idea on how to manage multi-organizational responses. It can also be related to the management processes taking place in emergency response systems. When discussing coordination on a high system level, on a meta-level that includes systems of systems, it is important to relate coordination

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activities to some kind of overall goal. Paper V presents how coordination in emergency response systems can be studied from a network perspective. Coordination can be studied through analysis of so called proxy-attributes, or indicators. Figure 4 below exemplifies how communication intensity and perceived importance are used as such attributes for analyzing coordination. All individuals are grouped according to their formal organizational belonging. The network in Figure 4a represents relations of grade 3, 4, and 5 where 5 indicates “contact of decisive importance.” Each respondent also estimated communication intensity. In Figure 4b communication relations showing “more than 5 occasions” are illustrated. The illustrations show that there is no single “coordinator” within every formal organization that takes care of all horizontal interactions with other formal agencies.

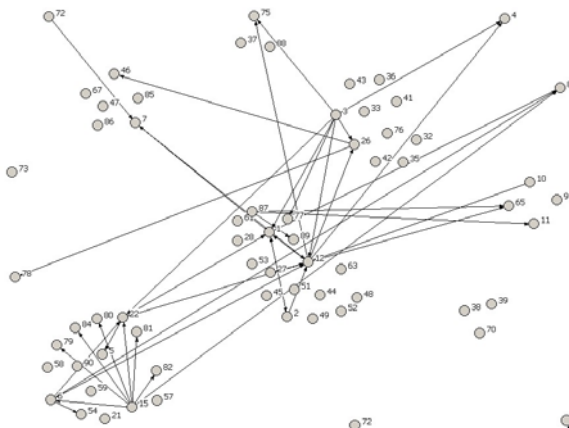


Figure 4a

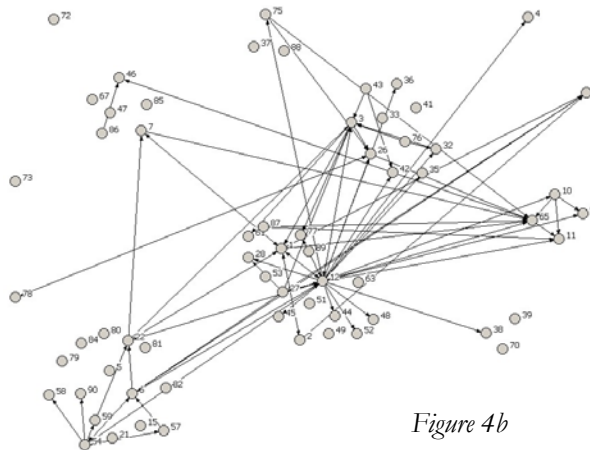


Figure 4b

Research Contributions

The data analyzed in Paper V indicate that coordination in multi-organizational emergency response operations can be distributed (coordination is not only associated with certain “hubs” in the networks) and emergent (the structures indicating coordination did not fit within the framework of the formal organizations). Furthermore, the empirical studies presented in Paper V suggest that such behavior is positively associated with high complexity.

Summarization of research contributions:

The concept of coordination has been elucidated from a broad perspective and it is suggested that:

Coordination in an emergency response system has to do with managing interdependencies between activities in order to achieve an overall goal. Discussions need to pay attention to how such a goal can be formed and how it can be achieved.

There are various means for managing interdependencies between activities in order to achieve an overall goal. Exercising authority can be a method applicable in sub-sets of an emergency response system. However such approach is not realistic when the level of complexity increases.

Coordination can be studied from a social network perspective by studying influences among individuals through proxy-attributes.

Empirical analyses suggest among other things that coordination in multi-organizational emergency response is distributed among individuals and not only associated with predetermined coordination functions.

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6.2.2.3 Emergence

The word emergence has become overloaded with an abundance of different meanings (Brunner & Klauninger, 2003). Sawyer's publication in the *American Journal of Sociology* "Emergence in Sociology: Contemporary Philosophy of Mind and some Implications for Sociological Theory" (2001) treats emergence as a "slippery concept" (p. 551). Neal and Phillips (1995) write that "[e]mergent social structure reflects the spontaneous, ad-hoc development of organizational structure" . . . "Emergent groups are a form of collective behavior (i.e., spontaneous ad-hoc entities)" (p. 330). Scanlon cites Quarantelli (1993, p. 74) who suggests that emergent phenomena "always have an element of new, novel, non-traditional or non-routine" (1999, p. 2). This does not mean that there are system conditions in a pre-disaster situation that cannot be traced and understood. Drabek and McEntire cite Stallings and Quarantelli (1985, p. 84) and their description of emergent groups where they write "emergent groups can be thought of as private citizens who work together in pursuit of collective goals relevant to actual or potential disasters but whose organization has not yet become institutionalized" (2003, p.100).

Drabek and McEntire (2003) also conceptualize emergence as including both new behavioral structures and the norms and values that guide the participants who produce them. According to the authors, the literature reveals that emergent phenomena most likely occurs when the needs connected with a disaster are not met by established organizations and that emergent phenomena are frequently conducive to a quicker and more effective disaster response. Drabek and McEntire (2002) argue that disasters by their very nature lead to emergence. Dynes (1970) discusses "emergent groups" as being groups that diverge from what is normal. He provides the examples of ad-hoc formations of persons from different organizations that convene to co-ordinate their efforts. The method for data collection and data analysis thoroughly presented in Paper I, 3, and 4 can be seen as technique for analyzing emergent behavior from this perspective. The example below (Figure 5) shows network clusters of individuals active in a response to factory fire in Sweden 2007. The clusters, or the groups, are calculated by a Newman-Girvan algorithm applicable when detecting communities in complex systems (Paper IV). The relations used for performing this analysis are relations showing perceived importance of grade 2, 3, 4, and 5 (out of 5). Thus, the figure shows clusters of agents based on interactions and not on formal organizational belonging. The largest group is heterogeneous; it consists of agents belonging to various formal organizations. The group configuration is ad-hoc and context dependent.

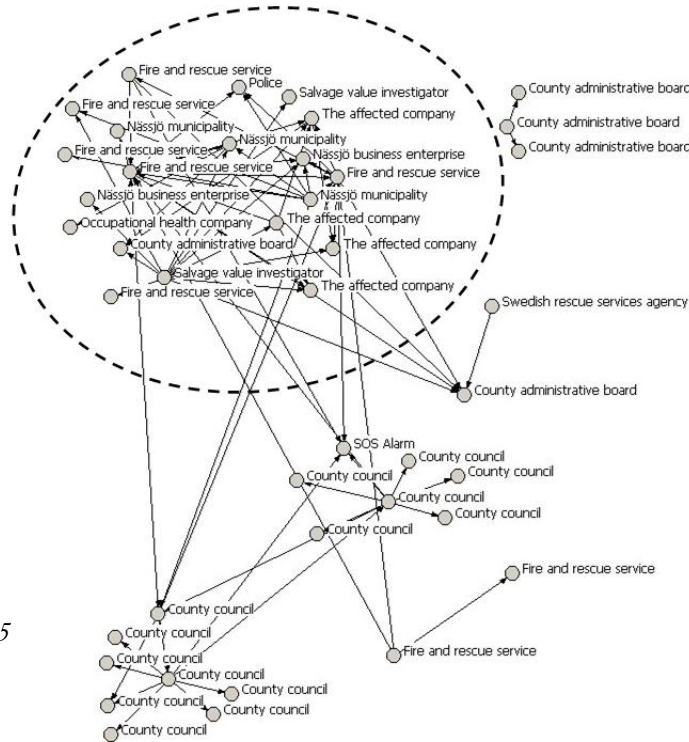


Figure 5

Brunner and Klauninger maintain that one has to “draw a line between emergence as a mere synonym of everyday language words like appearance or growth on the one hand, and emergence as the fundamental concept of emergent theories in philosophy on the other hand” (2003, p. 23). The concept of emergence can be confusing. In this thesis the emergency response system is considered a complex system. Complex systems are often described as systems characterized by “emergence” or “emergent properties”. In system science, emergence is a phenomenon observable on a high system level, but generated on a micro level. According to De Wolf and Holvoet, emergence includes two important characteristics: “a global behavior that arises from the interactions of the local parts, and that global behavior cannot be traced back to the individual parts” (2004, p. 3). Holland (1998) problematizes the area in “Emergence: from Chaos to Order” in line with this definition. De Wolf and Holvoet (2004) relate to what they consider to be the most important characteristic mentioned in the literature: the micro-macro effect. Micro-macro effects “refer to properties, behaviors, structures, or patterns that are situated at a higher macro-level and arise from (inter)actions at the lower micro-level of the system” (DeWolf & Holvoet, 2004,

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p. 4). Emergentism is a form of non-reductionism, but penetrating the subject creates philosophical quandaries far too sophisticated to be dealt with in this thesis. Reductionists sometime argue that with sufficient time and use of sufficient computing power, everything can be reduced and be explained by a few laws of particle physics (an approach not to be confused with determinism). Some social scientists use antireductionist arguments in opposing the reductionists' theories when they claim that constitutive patterns of organization in social systems arise through social interaction and that their explanation cannot be reduced to laws operating at other levels of analysis (Smith & Stevens, 1996).

When using emergence in descriptive discussions, one must bear in mind the multifaceted aspects of the concept. If emergence is used as a term indicating something new, novel, or ad-hoc, one should reflect on what it relates to. It seems that emergence from this perspective often refers to a behavior that does not correspond to what is written in planning documents. The micro-macro effect is most likely a characteristic that can be related to emergency response systems, but one must consider how such knowledge can be transferred into normative concepts. For further considerations on emergence and how it can relate to the concept of self-organizations, see Uhr (2007).

Summarization of research contributions

The concept of emergence has been investigated from a broad perspective and it is suggested that:

When studying emergency response management from a systems perspective the concept of emergence can relate to two slightly different qualities.

- Emergence could indicate that a phenomenon, or system behaviour, is “new”, “ad-hoc”, “non-planned”. Such behaviour is common in emergency response operations and could be studied from a social network perspective. From a systems perspective it is seen as a necessary part of local adaptation. However it could also be maladaptive to the overall goal. Managing such behaviour is an important part of emergency response management. The method for analysing interaction among individuals can be utilized in order to analyse emergence.
- Emergence can refer to a system quality, or property, that appears on higher system levels and derives from local adaptation by the system’s parts.

The approaches do not have to be contradictorily, but it is important to bear in mind that emergence can have slightly different implications. It is here advocated that the concept needs to be employed cautiously.

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6.2.2.4 Trust

There are reasons to believe that trust not only can influence how the interactions between individuals are formed but also influence the performance of the emergency response system. LaPorta et al. (1997) conclude that several studies point to trust or social capital determining the performance of social institutions. Research shows that there is a clear tendency toward informal co-operation forms and that even normal organizations become more network-like (Arwidsson & Christofferson, 1991). Arwidsson and Christofferson note that the development is from hierarchies to networks and that networks demand trust. Mishra argues that trust has a “positive effect on the degree to which sufficient resources are developed to deal with the crisis in a timely fashion by enhancing decentralization, undistorted communication, and collaboration” (1996, p. 20). Decentralization is to some degree necessary in emergency response organizations for dealing with complex situations. Gambetta (1988) argues that trust enables cooperative behavior and Miles and Snow (1992) maintain that it promotes adaptive organizational behavior, such as network formations. The importance of trust in effective responses to crises is also claimed by Meyerson, Weick and Kramer (1996) who say that “trust facilitates rapid formulation of ad-hoc work groups” (as cited by Rousseau, Sitkin, Burt & Camerer, 1998, p. 394). Kramer (1999) concludes that trust enhances individuals’ willingness to engage in various forms of spontaneous sociability, although in complex and often unexpected ways. In “Emergent Phenomena and Multi-organizational Coordination in Disasters: Lessons from the Research Literature,” Drabek and McEntire (2002) also consider the concept of trust in this context.

Trust is a subjective concept and scholars such as Mayer et al. (1995), Blomqvist (1997), Rousseau et al. (1998) and Costa (2003) all consider there to be a lack of clarity in the concept. Blomqvist (1997) reviews the concept from the perspective of social psychology, philosophy, economics, contract law, and market research and concludes that “the weak conceptualization of trust is partly due to the fact that trust is always specific, i.e., the context matters” (p. 283). Gambetta (1988) regards trust as being one of the basic variables in any human interaction, which of course makes it complex. Rousseau et al. stress that “trust is not a control mechanism, but a substitute for control. Control comes into play only when adequate trust is not present” (1998, p. 399). According to Barbalet (2005), trust must be characterized by dependency and therefore vulnerability. Consequently, it is not a means of control at all.

Costa (2003) believes that “the willingness to be vulnerable” is one of the most cited definitions of trust. Barbalet notes that “most treatments define trust in terms of a confident expectation regarding another’s behavior”, but argues that this does not cover the whole mechanism of trust since “it leaves out the essential component of a self-referential confidence in the subject’s own judgment as well as a confidence concerning the other that is in any case dependent less on the other’s qualities and more on the subject’s appraisal of them” (2005, p. 5). Concepts such as trustworthiness and confidence can easily be confused with trust (see Paper II).

In the first study, using the tool for mapping and analyzing individuals in an emergency response system, friendship relations were mapped. Friendship is a type of relation that is difficult to define but is clearly connected with trust. During the development of the mapping procedure, the relation between trust and friendship were not completely discussed, which resulted in ambiguity when interpreting the results. Trust can be seen as being a component of a friendship relation, but since trust is context-dependent, there are certainly areas when a friend may not be trusted due to the lack of specific qualities for some particular task.

Kramer (1999) summarizes and discusses trust in organizational theory. He concludes that there is an increased interest among scholars in exploring how the concept affects such processes as inter-organizational cooperation, coordination, and control. In an organizational setting, trust can be seen as a form of social capital that has constructive effects on increasing spontaneous sociability between organizational members and facilitating adaptive forms of deference toward organizational authorities. Brehmer (2008) acknowledges the important of trust in a complex operation. He believes that without trust a decentralized management system is impossible.

Interviews were made to supplement the literature findings and to expand, test, and structure the specific hypotheses concerning the potential consequences of trust in the present context. All interviews were conducted in the outskirts of Melbourne in Victoria, Australia. Possible cultural differences between emergency response personnel in Australia and in Sweden were borne in mind. At the same time, the nature and problems of emergency response are to certain degree universal. This research uses empirical references from many different countries and much of the theoretical reasoning in the literature assumes transferability. The

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conclusions drawn from the interviews are moderate in the sense that they indicate and suggest, not state in any absolute sense, generalized conclusions.

A generic interpretation of the transcribed interviews in Paper II maintains that the constitution of trust has to do with expectation about the other:

“...you would expect that a person would do what you want them to do...”
(Respondent II).

The discussions of trust all ended up in an example, real or fictive, where the concept of trust could be substantiated. As suggested by the literature the responders meant that trust was very context dependent. The qualities of the trustee was discussed and experience, competence, skills and reputation emerged as important factors when judging if a person was to be trusted for a certain task or not.

Effectiveness of communication was mentioned as a consequence of trust. Respondent V expresses this clearly:

“...the enthusiasm and the speed that is carried out might change depending on the relationship.”

Preference was another category, or sub-theme, uncovered during the interviews. All the respondents noted that trust was the main reason they contacted others irrespective of formal organization structure. They also declared that flexibility and adaptation were necessary for a response system and that the decision makers need to have flexibility regarding the different solutions to a problem. This sometimes includes using contacts based on trust rather than formality.

“At the end of the day my role is to glue an incident and the quicker I can do that the better for all concerns, so I’ve been looking for the right experts...”
(Respondent III)

During the interviews, the idea of distrust as something that impinges in a negative way on a situation or on the response system as a whole was used by many of the respondents in the examples they gave. Lack of experience or incompetence promotes distrust according to the respondents. I oppose the idea, however, that trust and distrust are polar opposites, arguing instead that it is possible to both trust and distrust someone at the same time, reflecting the view

Research Contributions

presented above that trust is task and context specific. A subtler attitude that came to light when examining some of the transcriptions from the interviews was that there seemed to be a link between “not-having-the-same-opinion” and distrust. Concurrence within or between authorities is probably an observable phenomenon, even in an emergency response context, although this is not dealt with in the thesis.

The concept of trust between individuals in an emergency response situation has many similarities with trust in general, but because of the context dependent nature of it, there is the need to explain the specific circumstances that comprise the emergency response and the specific factor of risk. Risk in an emergency response involves the person who trusts the other, the person he or she trusts, and often a third party, where the situation may also be life threatening for all three. Risk and vulnerability are not objective, rational, and measurable values, but properties of the trustor and trustee, related to the context. An emergency response, involving a certain set of actors, escalating from non-life threatening to life threatening, is by the same set of actors likely to be perceived as carrying more risk than before.

Möllering’s proposed definition of trust harmonizes with the interpretations of the interview material: “trust is an ongoing process of building on reason, routine, and reflexivity, suspending irreducible social vulnerability and uncertainty *as if* they were favorably resolved, and maintaining a state of favorable expectation towards the actions and intentions of more or less specific others” (Möllering, 2006, p. 111).

Whereas established networks often seem to be based on history based trust (see Paper II and Kramer, 1999) between the actors involved, some emergent networks seem to work along different sets of trust, at least to a degree. An emergent network may consist of or include individuals who do not share a history or have “predetermined” opinions on others. It is suggested that the successful integration of such new and unknown agents into a network during an emergency response relies on trust of the sort corresponding to the concept of Swift Trust (Meryerson et al., 1996).

Summarization of research contributions:

The concept of trust has been elucidated and related to the field of emergency response management.

From a systems perspective trust may be studied as a context-dependent directed link attribute between two different individuals in a network, based on the estimation of intentions and the competence of the other. The mechanisms behind trust include a self-referential confidence in the trustor's own judgement concerning the trustee's qualities.

On the basis of the interviews trust seems to be able to improve effectiveness in communication and thus reasonably to improve operational action, be a decisive factor or an incitement for individual interaction and (hence) constitute a basis for functional networks of various individuals active in a response operation. Trust can be a latent and important condition for functional informal networking processes. Distrust, in contrast, can be a major barrier to effective coordination and can clearly affect in a negative way how internal procedures are carried out.

6.2.3 Addressing the Main Research Question

How can management in an emergency response system be better understood by analyzing interactions among individuals?

This section addresses the main research question by summarizing the answers to the two specific research questions. To understand management in an emergency response system, both normative ideals and empirical behavior need to be considered. Normative ideals do to a certain degree shape the frameworks for empirical behavior and the latter in turn affects normative ideals. However, the initiative behind the contributions presented in this thesis is based on the notion that normative ideals need to take knowledge about empirical behavior into further consideration to progress the development of future system designs.

A method for collecting and analyzing empirical data has been suggested. Moreover, elucidations of various concepts relevant for building a germane contextual framework have been provided. Figure 6 shows how interactions among individuals can be seen as a key for understanding management in an emergency response system. The section below aims to explain its components and how they relate to each other.

Needs

An interaction, as perceived in this research, must be preceded by a need. A need can be seen as the motive behind any interaction. Quarantelli (1997) discusses agent- and response-generated demands. Agent generated demands are those that are specific to the agent (the flood, the fire, the hurricane etcetera). An agent-generated demand could be what skills and equipment that are needed for search and rescue (Rotanz in Rodriguez, Quarantelli and Dynes, 2006). “Response generated demands are more general and basic involving communications, continuing assessment of emergency situations, mobilizations and utilizations of human and material resources, coordination (the most important of all agent- and response generated demands), and control and authority” (Rotanz, p. 472 in Rodriguez, Quarantelli and Dynes, 2006). Brehmer (2008) harmoniously considers “the internal” and “the external” aspects of needs of management. The model below concerns “response-generated” or “internal” needs. Moreover, needs are related to subjective contextual interpretations made by individuals engaged in an emergency response system. Different kinds of needs, how they emerge and how they relate to the concept of goal, can be discussed thoroughly; however, this is not within the scope for this thesis.

Interactions

Interaction is seen as a prerequisite for coordination activities: “Interaction patterns shape the events in which we are directly interested” (Axelrod and Cohen, 2000, p. 63). This thesis proposes how interactions can be studied as relations among individuals, i.e., not preliminary between formal organizations. The respondents in the empirical studies were initially asked to indicate whom they were in contact with given that the other was estimated to be of any importance for the person’s behavior at the time of an operation. Such contact relations were supplemented by relations indicating perceived importance and communication frequency. By analyzing various patterns of interactions among individuals, an improved understanding empirical behavior from a systems approach is achieved.

Normative Ideals

Normative ideals expressed in bureaucratic structures and preplanned procedures can be important influences on how the interactions are formed and how coordination is carried out. For example, normative ideals can provide a manager with recommendations or “rules” guiding what contacts that should be established and what type of information that should be shared in certain situations. The research presented here suggests that normative ideals influence the empirical behavior in an emergency response system, but do not dictate it. The elucidation of the concept of command and control (6.2.2.1) exemplifies how normative ideals can be analyzed.

Interpersonal Trust

Empirical studies conducted within this research project strongly indicate that interpersonal trust affects how contacts in an emergency response system are formed and how coordinating activities are carried out. Trust can be studied as a relation between two individuals in an emergency response system. Normative ideals and trust are not seen as polar opposites. However, sometimes there is a disharmony between the two. Trust can be a dominant force and lead to ad-hoc solutions, e.g., departures from the administrative borders described in the normative ideals. Such departures do not have to be negative for the outcome of the response; they can be seen as parts of an adaptive behavior.

Coordination

Coordination, understood as the act of managing interdependencies between activities in order to achieve an overall goal, is seen as a central part of emergency response management. Coordination can be understood by analyzing patterns of

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interactions among various individuals in an emergency response system. Such studies show that not all interactions in an emergency response, and thus not all of the coordination activities carried out, harmonize with what can be found in plans and procedures. Earlier research supports these findings. Faraj and Xiao (2006), for example, found that coordination practices among fast response organizations were highly emergent and that they cannot necessarily be specified. Figure 6 illustrates that coordination can be both preplanned and emergent. Preplanned coordination follows the normative ideals manifested in plans and procedures. Emergent coordination is characterized by ad-hoc solutions that differ from what is planned. Coordination can be discussed in many ways. Petrescu-Prahova and Butts (2005), for example, discuss institutionalized versus emergent coordination. They suggest that emergent coordination in crisis situations is not strongly contingent on responder training or formal organizational structure.

Dynes and Aguirre (1979) discussed coordination from a formal organization perspective and suggest that organizations can be coordinated by plan and by feedback. Coordination by plan is based on “pre-established schedules and programs directing and standardizing the functioning of organizations” (p.2) and coordination by feedback “is centered in the transmission of new information so as to facilitate the mutual adjustment of parts” (p.3). They also note that the two types of coordination are ideal constructs. Coordination by plan can be related to preplanned coordination and coordination by feedback can be related to what has been described as emergent coordination. Normative ideals and trust are two important conditions that influence how actual coordination is carried out and coordination is a combination of preplanned and emergent behavior.

Activities

Activities refer to the actual efforts needed to achieve a common goal. These activities could be practical activities such as building temporary walls to prevent flooding, but it could also mean negotiating a common operational goal. In the latter example, the overall goal would be to formulate jointly a common operational goal. In a dynamic and uncertain context, where old decisions influence new ones, coordinated activities generate new needs. Thus the process should be seen as a loop.

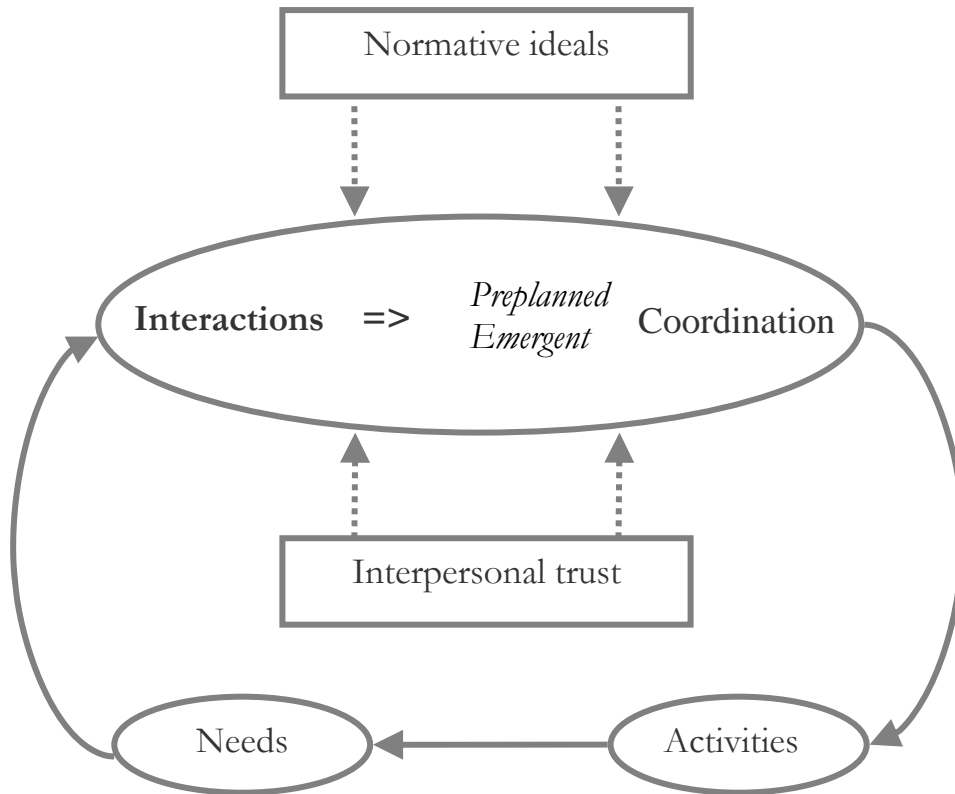


Figure 6

The model illustrates how the issues dealt with in this thesis constitute a whole. This synthesis improves the understanding of management in an emergency response system. Moreover, even if the model can be supplemented through further analyses of the complex subject area, its present design illuminates important aspects of empirical behavior and can thus serve as a basis for future developments of normative ideas.

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To sum up: Multi-organizational emergency response management can be better understood by studying interactions between individuals. An interaction is always preceded by a need. Interactions can lead to coordination of activities, i.e., the management of interdependencies between activities to achieve an overall goal. Such process can be both preplanned and emergent. Both the manifestation of an interaction and the actual coordination is influenced by normative ideals and interpersonal trust. Coordination can lead to coordinated activities that in their turn influence new needs.

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7 General Discussion

The following chapter begins with discussing the method for collecting and analyzing data. It then continues with a discussion on the concepts elucidated and a general reflection on the subject of multi-organizational emergency response management based on the synthesis of the findings. Finally, future implications are suggested.

The main idea governing the study has been to describe emergency response management in multi-organizational contexts and to suggest how it can be better understood. An explorative research process uncovered that the issue should be approached from a systems perspective. Ryan writes that “the result of over half a century of systems thinking is not a general theory of organization, but a loosely connected set of techniques, where each technique contributes some insight on the temporal and spatial structures of organized complexity” (2008, p. 30). Ryan’s conclusion harmonizes with my approach to the research presented here. That is, studies have contributed new insight on the complexity associated with multi-organizational emergency response management. The method for data collection and analysis can be seen as a tool for holistic studies on emergency response management.

An emergency response system is considered to be dynamic. However, at the time of writing, few attempts have been made to employ the suggested method for studying such aspect. Two attempts have been made to split up the studied responses into different phases and study how the structures change. This technique needs to be further explored. Furthermore in the data collection process the agents’ have been asked to estimate when they became “involved” in the response and when they “ended” their efforts. Such data could be seen as a basis for partly studying dynamics.

Important to note is that not only relational data can be, and have been, mapped through the method suggested. As shown in Papers I, III and IV, data describing for example how the respondents interpret certain situations, or how they rate the success of the particular response, are other types of data that contributes to the understanding of emergency response management. Employing web questionnaires for collecting data can generate data records useful for various types of analyses. An interesting aspect not covered in this thesis concerns gender. The contexts studied are predominantly associated with males and masculine culture. By analyzing relations showing perceived importance or communication

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frequency, a gender aspect of emergency response management could be revealed. The development of the method is not complete, but a pragmatic platform has been suggested. There will always be room for further improvements. Future efforts might suggest other relations or agent attributes that should be mapped and analyzed.

When studying literature on emergency response management, one can hardly avoid coming across the different concepts dealt with in this thesis. Many disciplines and academics and practitioners with various backgrounds have not agreed on a common vocabulary. One can argue that there are other concepts that should have been chosen, for sure, and it is always possible to critically ask why I made this choice. However, during the research process the concepts emerged as relevant to understand and to make use of in discussions with others. No statistical analysis proving how often they occur in literature or in conversation has been conducted. The choice has been based on subjective interpretations; the explorative process and my understanding of the problem area suggest this to be rational. An important aim with the elucidations has been to summarize different approaches used in analytical discussions. By grasping various aspects of the concepts, it will become easier to profit from diverse research literature and management discussions. This thesis strongly advocates that both academics and practitioners should define what they mean when using the concepts.

I have shown that command and control does not necessarily imply a mechanistic top-down oriented system perception that does not recognize the complex behavior in an emergency response system. (However, the negative attitudes about anything labeled “command and control” seem to be very hard to overcome. This is a problem in view of the fact that progressive research is conducted, but labelled as “command and control research”, and therefore automatically rejected by some researchers and practitioners.) Command and control can also refer to management principles in complex systems that cannot be controlled from the outside. I have not discussed the components of command and control in detail. Control is definitely an important concept on its own and a concept treated within various research disciplines. Six (2007), for example, discusses bureaucratic control and value-based control. Bureaucratic control is based on “the establishment and utilization of formal rules, procedures and policies to monitor and reward desirable performance” (Das and Teng 2001, p. 259 as cited by Six, 2007, p. 302) and value-based control “relies on the establishment of organizational norms, values and outcome” (Das and Teng, 2001, p. 259 as cited by Six, 2007, p. 302). The latter approach seems to be less

“mechanistic” than the former and probably also conveys and supports adaptive behavior. Another interpretation of the concept is “the capacity to focus on the critical tasks that will bring the incident to a non-destructive, none-escalating state” (Comfort, 2007, p. 195).

The concept of coordination is marred with ambiguity and cannot simply be referred to as an “alternative” management principle. The question of “Who’s coordinating whom?” or the turn of phrase of “Everybody likes to coordinate, but no one wants to be coordinated” are definitely relevant. In many management discussions, coordination seems to refer to methods for dealing with multi-organizational environments where no single authority possesses the power to dictate the conglomerate of systems active in a response. This thesis suggests that coordination is a very broad concept that has to do with harmonizing activities to achieve an overall goal. Thus coordination does not only have to mean joint consensus driven decision making where individuals representing different formal organizations sit at a table and agree on what needs to be done. Sometimes coordination is discussed as an absolute good but “There can be relatively effective organizational responses in disasters without a high degree of coordination” (Quarantelli 1988, p. 383).

Even if no one can dictate the system from outside, certain subsystems included in the response system have room for exercising authority and make use of traditional command and control. From this perspective, giving order within a single organization can be a means for harmonizing activities to achieve an overall goal. Goals can be seen as a prerequisite for management. Without a management goal, management appears to be meaningless to discuss. This thesis has not thoroughly dealt with the issue on how goals and coordination activities relate to each other. However, this subject needs to be discussed when designing future normative ideals. Identifying management goals for single formal organizations can most likely be done. For example, the highest ranked commander can decide the operational goal of a military organization. However, identifying management goals common for a whole response system consisting of resources from many different segments of a society can become problematical. Paper V suggests that manifestations of such overall goals can be found and manifested in a country’s constitution. I also suggest that overall goals can be related to common values, yet there is no guarantee that all responding resources accept such goals. In an international context, where resources from many countries sometimes need to operate side by side in very complex settings consisting of thousands of different organizations, overall goals are difficult to enumerate. Coordination in such

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environments can be very arduous and maybe impossible: “The larger the scope of a disaster and the greater the number of responders, the less the likelihood of success of any overall organizational coordination” Quarantelli (1988, p. 382). Irrespective of how one approaches the concepts of command and control and coordination the problem associated with management goals are important to discuss. Klein, Feltovich, and Woods (2004) believe that the foundation for “coordinated activity is the Basic Compact or intent to work together to align goals and to invest effort to sustain common interests” (p.32).

Emergence as used by many scholars interested in disaster studies represents ad-hoc structures and behavior that differs from plans and procedures. The empirical studies conducted and presented in Paper I, 3, 4, and 5, although they concern situations with less magnitude than the disasters examined in other research literature, support the notion that emergence is common and detectible in responses. By employing a social network approach when examining empirical behavior in emergency response system, verifications of emergent behavior can be attained. Emergent behavior during response operations might possibly be affected by various pre-emergency arrangements, but one central authority cannot reasonably govern it. In other words, in a complex emergency response system consisting of many different resources, emergent behavior is likely to occur whether we like it or not. Such understanding is inevitably relevant to include in the process of designing emergency response systems. Emergent behavior is a key to adaptation. Since all major responses can be seen as unique events, the ability to adapt is essential. Having said this, it is very important to emphasize that all emergent behavior does not need to be functional from a holistic perspective. Goals set up on a local level may conflict with an overall goal. A challenge for emergency response managers working on high system levels is to influence the behavior of the local parts to achieve satisfying results. Emergence is a slippery concept that also can focus on qualities appearing on higher system levels in complex systems. The analyses of the emergency response system presented in this thesis do not pragmatically expound this perspective; however, since the emergency response system is considered as a complex system emergence with the latter meaning, it can be a valuable concept for further reflection. The “multiple meanings” of emergence are seen as problematic since it can be confusing when discussing management from in an interdisciplinary context.

The concept of trust has emerged as a component of emergency response that should not be ignored. Indications that trust or trust-like phenomena could be a system element that affects how the networks of decision makers are established

and change over time, generating a need for a reflective analysis of this vague concept. Reviewing the literature with the aim of substantiating suggestions regarding the concept and the consequences of trust that could be applied directly within the area of emergency response confirmed earlier interpretations of interviews and the discussions with decision makers. For some, and perhaps for everyone, it may be obvious that both trust and distrust affect the performance of social institutions. Thus trust can be regarded as an important factor in a systems approach to the emergency response. Just as the concept of networks should be substantiated and discussed more precisely, it is important that trust is approached from a scientific perspective. Analyzing trust involves interpretations of observed data, which can range from being rather diffuse to being fairly clear, but having a theoretical and conceptual basis for guiding the study of trust can contribute to the validity of the results. Sometimes control and trust are discussed as opposites (Six, 2007); i.e., control comes into play when there is a lack of trust. However, when describing normative control there is an “overlap between normative control mechanisms and trust-building in the form of socialization, interaction and training leading to a better understanding of each other and shared values” (Six, 2007, p. 302). Improving the understanding of trust and its consequences can be useful, if not entirely necessary, for the development of sound normative ideals. Perhaps “trust-building” is a preparedness activity that is at least as effective as hammering home plans and procedures. Drabek (1985) discusses the importance of viewing community disaster planning as a process and not as a product: “where managers approach this task within a process framework, the roles and relationships among the responding participants were clearest and coordination frequently was highest” (p. 88).

The model in 6.2.3, serving to explain a synthesis of the research, can be used for understanding and discussing multi-organizational emergency response management. As stated in the results section, I do not claim that the model is detailed, i.e., it does not include every single aspect of emergency response management. For example, as already pointed out, needs can be discussed and systematized in many ways. Moreover, the relation between normative ideals and needs is not reflected: it serves as a basis for understanding multi-organizational emergency response management from a systems perspective. And importantly, it draws on formal organizations as a starting point: it is a simplified interpretation of a complex subject, aimed to facilitate the understanding of such complexity by structuring parts of it in a mental model. As earlier noted, I believe that ideas on how emergency response should be designed and conducted need to be based on empirical understanding. The synthesis is thus not only seen as a descriptive

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framework but also as a basis for development. From such perspective, I regard it as normative since it suggests how the complexity associated with the subject should be approached. Despite my partly critical reflection on how the concept of “emergence” is employed in emergency management research, I choose to make use of it in the figure. The reasons for doing this are that it is recognized among many emergency management researchers and the possibilities to problematize the concept are not necessarily negative. This might generate valuable analytical discussions. Moreover, based on my contacts with practitioners in Sweden, I interpret the concept as “neutral”, not an emotionally charged concept. I believe that words such as “non-planned,” “non-routine,” or “ad-hoc” are associated with negative emotions and that such conditions could be unhelpful in progressive discussions.

This research does not suggest new normative ideals, but rather it provides an input for such suggestions. The results presented here show that management resources do not automatically adjust to formal frameworks decided by bureaucrats and “management experts.” Many forces come into play in an emergency response. All of these cannot be determined in advance. Discussing structures of commanders and subordinates and rules and regulations is not simple. Emergency response management is not only about the exercise of formal power through administrative systems. In order to improve the society’s capability of responding to emergencies (including catastrophes, disasters, and crises), emergency response managers need to better make use of and deal with what can be seen as “bottom-up behavior”, local adaptation. Management discussions today still focus too much on the function of a central authority. Structures for “top-down management” are needed and centralization cannot completely be rejected as something bad. However, a reasonable prerequisite for effective emergency response is local adaptation based on local rationality. “Local rationality means that what people did made sense to them at the time, given their knowledge, their goals, and their understanding of the situation at the time.” (Croskerry, Cosby, Schenkel, Wears, 2008, p. 82). Managers should focus on harmonizing the behavior of the system’s parts and not enforcing the operational will of a superior commander. McEntire (2007) discusses what he calls “a traditional model” and “a professional model.” The traditional model can be related to what I have concluded about the traditional approach to command and control. The professional model agrees with what I consider to be a realistic approach to management in multi-organizational contexts. Among other things McEntire writes, “[e]mergence cannot be prevented. . . . hierarchical and top-down relations among all responding entities are sometimes impossible when multiple

organizations respond to disasters. . . . departures from emergency operations plans are to be expected at times and will often prove to be beneficial” (p. 97). Even if such an approach is “preferred among many scholars” (p. 95), it seems like the traditional approach still has many supporters. I hope that the research presented here can contribute with a frame for understanding why the professional model should be advocated and further developed and integrated.

Do exercises capture the complexity of real emergencies? In an exercise no real lives, no real property, and no real environment are at stake and the willingness to cross administrative borders is possibly not particularly high, due to the risks involved – for example, departures from plans are being regarded as failures – or due to the practical limitations – the college friend who was strategically talented when it comes to brush fires sits in another town and is not included in framework of the exercise. Exercises are perhaps a good way to come to know the weaknesses and strengths of an information system and of individual capabilities. They do also help responders to become familiar with procedures. However, do they have the potential to stimulate the creativity that may be necessary in a real response system and process?

7.1 Aspects on Validity

Since the literature that was reviewed comes primarily from the United States, contextual factors obviously had an affect here. t'Hart writes, “[d]ifferent rules of the game apply, different structures of decision making are in place and different cultural expectations about the roles and responsibilities of the public and private sectors may prevail” (1997, p. 208). Nevertheless, many problems, characteristics and phenomena observed by foreign researchers are also present in Sweden. An exploratory literature search aims at achieving an understanding of the empirical results that led to certain findings in the literature. From this perspective, the observations could be seen as a validation of the international literature and vice versa. For example, the empirical studies conducted supported earlier research findings that ad-hoc behavior is a recurring element in emergency response management.

Another matter that should be considered is that of the possible biases in different steps of the research process. Bias is, according to Depoy and Gitlin (1999), a potential, not intentional or unavoidable influence on the result. Selection processes that unintentionally favor certain groups are mentioned as such a bias. The initial interviews with the decision makers who were accessible following the

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flood situation in Småland in 2004 were characterized by use of a broad exploratory approach. In the late interviews, which were concerned specifically with trust, the selection of participants was based on accessibility. The only exception to this is the snowball approach used in the network studies in which those responding emerged after being referred to by other participants in the study. Because of the exploratory approach adopted and the diversity of participants taken from a variety of organizations, a possible selection bias should be borne in mind, but should not be seen as negating the research results. Another bias, one that probably is more critical, involves the questions. My interviewing skills became refined in the course of the work and the data processing and data analysis also became more structured. My awareness of my own role in the research process has also increased. It is certainly a balance one should maintain to strengthen one's hypotheses and to be exploratory at the same time. This problem arose first after clear hypotheses had been built up and by that time the interview skills were (thanks to experience and literature studies) improved. Still, there are unavoidable situations in which my enthusiasm and commitment may have formed the way the respondents expressed themselves in one way or another. Many of the interviews involved use of a semi-structured approach, but some of the questions were value-laden and closed (cf. Smith, 2004). An associated problem is that when as an interviewer I dealt with abstract topics, such as ability to adapt, various matters may have been unclear to the person being interviewed. In such discussions the subject could answer in any way he or she considered appropriate. When conducting an analysis of qualitative data, I regard myself as part of the research process and I am aware of the subjectivity of my interpretations of someone else's interpretations. The interdisciplinary approach to the research the thesis represents and its inclusion of methods in areas including those of design, programming, calculating, interviewing, and literature studies makes it difficult for me to lay claim to use of one clear and simple approach.

7.2 Implications for Future Research

Throughout the development of the method for analyzing interactions among individuals in emergency response systems, three empirical studies have been conducted. Although the studies have contributed to the understanding of emergency response management, the primary objective with these empirical studies has been to test the method and to find ways to improve methods. The method is considered to be dynamic; the basic design allows for the improvement of analytical tools. Further research should strive for such development. Additionally, more empirical studies need to be conducted. Normative reasoning

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on how emergency response management should be carried out would benefit from more general conclusions on empirical behavior. Thus a database of network studies on management in responses to emergencies would be very valuable.

The synthesis of the research presented here can be supplemented with additional analyses and thus be expanded. For example, the concepts of need should be reflected and related to a discussion on goals. Can all resources in a response system, consisting of a conglomerate of organizations, norms, and values, actually agree on an overall goal? How specific can goals be formulated and by whom? How should goals be reflected in normative ideals?

Many researchers believe that one single authority cannot dictate a multi-organizational response. In a democratic society, no one has the legal mandate to give direct orders to everybody involved in response activities. Even if the societal system would allow such a function, it is not realistic to believe that a single individual could possess the cognitive ability to perform such tasks. It is more reasonable to believe that management needs to be distributed in the system and that managers need to make use of various means to influence the system's behavior. A comprehensible discussion on how high-level coordination can be and should be carried out is needed.

Moreover, related to what is written above, it is important to develop the discussion on criteria for success. What characterizes good or poor emergency response management? Who makes this appraisal? Media? Scientists? Professional response organizations? Politicians?

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8 Conclusions

This research is based on the assumption that there is a lack of empirical understanding of how multi-organizational emergency response management is carried out and that such understanding is essential when developing normative ideas. A common starting point when discussing emergency response management is formal bureaucracies, or chains of command. However, such structures are insufficient starting points for empirical analyses due to the fact that they only describe a certain dimension of an emergency response system. Management is a process that takes place through interactions among individuals and to understand empirical behavior such interactions need to be studied.

A method, rooted in social network theory, aiming to collect and analyze data on individuals and their interactions, has been developed. The networks generated are based on the participants' own estimations of which individuals they found to be of great importance for their work or who they interacted with frequently. By analyzing different structural aspects of such networks, it becomes possible to study empirical behavior such as various group constellations. Moreover, boundary spanners, key-agents, and other phenomena can be identified. Empirical data has been used to reveal what happens behind the formal charts of bureaucracies.

To better understand multi-organizational emergency response management, the method has been complemented by an elucidation of four concepts that are associated with multi-organizational emergency response management: command and control, coordination, emergence, and trust. Individuals in an emergency response system do not act without influence of pre-existing ideas on how management should be carried out. Understanding such ideas is important when examining empirical behavior. Furthermore, such understanding is essential when comparing empirical behavior with predetermined ideals.

Command and control and coordination are concepts often used in discussions among academics and practitioners. However, their obscure nature can lead to confusion and possibly restrict innovative discussions. Command and control can be approached from a traditional horizon where a central authority and a clear chain of command are central and necessary characteristics of a management system. Another approach to the concept acknowledges the complexity of modern response systems and incorporates ideas on such things as informal networks and self-organization. From this approach, no commander can steer the

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system from the outside. Coordination is sometimes referred to as a management principle, practical when no single authority can be identified, such as in complex response systems. Based on literature findings, this thesis suggests that coordination has to do with harmonizing activities, or harnessing complexity, to achieve an overall goal. This approach is broad and can include elements of traditional command and control. Command and control and coordination are not seen as polar opposites. Therefore, pragmatic models describing how coordination should be performed are needed. Such models need to deal with the problem of identifying an overall goal for coordination. The methodology proposed for how to analyze interactions among individuals in an emergency response system can facilitate a better understanding of how coordination activities are carried out and manifested in network structures.

Emergence, or emergent behavior, is an important concept that relate to the complexity of an emergency response system. Every emergency situation is somewhat unique. The resources found in an emergency response system need to show an adaptive behavior to meet different emerging needs. Emergence is primarily treated within the context of emergency management as a concept describing “novel,” “ad-hoc,” “unplanned,” or “spontaneous” behavior. It is necessary to incorporate knowledge about emergence in preparedness activities as well as in response management. Emergent behavior can be influenced through rules and regulations; however, it cannot, and should not, be eliminated. Emergence is seen as an important part of functional adaptation. Emergent behavior can be analyzed through studies on different network configurations. From a general systems approach, emergence can also refer to the appearance of system properties appearing on higher system levels, but springing from local adaptation. Although such an approach is given limited attention in this thesis, it is regarded as an interesting approach useful in theoretical discussions.

Trust can be seen as an important system condition, or a “catalyst”, for emergent behavior. Generally, trust may be understood as a context-dependent directed link attribute between two different agents in a network based on the estimation of intentions and the competence of the other. The mechanisms behind trust include a self-referential confidence in the trustor’s own judgment concerning the trustee’s qualities. Trust is an important condition for effective coordination and “building” interpersonal trust should be seen as an important part of preparedness activities.

Empirical analyses demonstrate that even in responses to emergencies of “less magnitude,” emergency responders cross formal bureaucracies and practices ad-

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hoc management in their efforts to meet various needs. Such behavior cannot routinely be judged as incorrect since it is a part of system adaptation. However, complete autonomy among the resources in an emergency response system is not advocated. Local adaptive behavior can be maladaptive on a higher system level. Management in an emergency response system has to do with harmonizing local activities. Harmonizing activities, here described as coordination, cannot be done only by exercising authority. Individuals performing different activities can be influenced by several different means. Together, the different research contributions presented in this thesis generate a synthesis, or a body of knowledge, that can be employed in descriptive analyses and when developing normative ideals.

On the following page I have summarized the conclusions in seven bullets.

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- Multi-organizational emergency response management can be better understood by analyzing individuals and their interactions from a complex systems approach.
- A method for how to collect and analyze such data has been developed and tested. The method is rooted in social network theory.
- To facilitate analyses and discussions on multi-organizational emergency response management, the concepts of command and control, coordination, emergence, and trust have been broadly elucidated.
- A model suggesting how multi-organizational emergency response should be understood on the basis of a systems perspective is presented.
- The empirical analyses conducted show that emergency responses generate context specific network constellations of interacting individuals. Such networks do not always harmonize with the normative ideals and can partly be explained by the concept of trust.
- Management in a multi-organizational emergency response system cannot be based on the notion that one central authority can “control” all the resources engaged in a response. The system is complex and dynamic and cannot be fully identified before an emergency situation.
- Future normative development should acknowledge that the behavior in complex systems is partly based on local adaptation.

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Appendix

10 Appendix

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Appendix – Paper I

Paper I

Multi-organizational Emergency Response Management

Mapping an emergency management network

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Abstract: We present a web-based method for mapping various relations between agents that have been involved in an emergency response operation. The method is based on combining a web-questionnaire with telephone interviews and it provides an efficient way of collecting large amount of information concerning the agents. By using the resulting network of agents it is possible to perform various network analyses such as identifying important agents and groups, analysing the correlation between certain relations between the agents, and studying the temporal development of the network. Furthermore, we present initial results from an analysis of an emergency management operation concerning the release of 16.000 tons of sulphuric acid in the city of Helsingborg, Sweden. We conclude that the emergency management organization included a significant amount of agents that were not part of any plans, such as boundary spanners and agents that were not part of any of the involved organizations but still played very important roles during the operation.

Keywords: emergency management, social network analysis, computer-based data collection

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1 Introduction

In an emergency or crisis situation one is likely to find a complex pattern of interacting agents (persons) within and between organizations responding to the crisis. This pattern could be regarded as a social network containing certain agents such as fire-fighters, policemen and medical staff. Various relations between the agents, such as whether they know each other, have been shown to be important to the effectiveness of an organization when responding to a crisis (Krackhardt and Stern, 1988; Nishigushi and Beaudet, 1998). Krackhardt and Stern (1988) argue that friendship-relations in an organization enhance cooperation and since adapting to a crisis requires cooperation it is valuable to have such relations in organizations dealing with a crisis situation. They also suggest that in the course of the crises it is advantageous for an organization to have more such friendship links between subunits in the organization than within subunits. Other authors such as Granot (1999) and Mulford (1984) have also noted the importance of social connections between people of different organizations when responding to crises.

Recent crises in Sweden, such as the discharge of 16 000 tons of sulphuric acid in the central parts of the city of Helsingborg on the 4th of February 2005 and the storm Gudrun, which struck southern Sweden on the 8th of January 2005, have also indicated that various relations among emergency response personnel are important. More specifically, in both disasters it was evident that agents sought co-operation with agents they knew, even if that meant going outside the formal plan. Due to this phenomenon agents were given tasks not planned for in the contingency plan and some agents became important bridges between different organizations, so called boundary spanners (Mulford, 1984).

Furthermore, it also resulted in the fact that people from outside the involved organizations got involved in the crisis management simply because they had access to

an important knowledge/resource and knew someone within the involved organizations.

Understanding interactions and various relations between agents involved in an emergency response operation seems vital in order to understand the dynamics of such an operation. Most of the results by which the success of an emergency response operation is measured can be regarded as emergent properties of a complex adaptive system consisting among other things of the agents of the involved organizations. Thus, the measures used to judge whether a particular emergency response operation is successful can seldom be attributed to a single agent or a small group of agents but are instead emergent properties of the system as a whole. For example, the number of people that are brought out from collapsed buildings in a search and rescue operation following an earthquake and the time it takes to get them out could be valid measures of the success of such an operation. It is not often that the result in terms of number of rescued people can be explained by the actions of one or a few agents. Instead it is the result of the collective actions of many agents, such as fire fighters, policemen, K-9 units and volunteers, and therefore the number of people brought out is an emergent property of a system of agents (people) and artefacts (e.g. equipment). In order to comprehend complex adaptive systems it is vital to understand the interactions among the agents in the system (Axelrod and Cohen, 2000). Therefore, this paper is aimed at presenting a method for mapping various relations between agents participating in an emergency operation, e.g. senior commanders, chief officers and administrative managers. Furthermore, we also present the empirical results from an analysis of one of the crises referred to above, namely the discharge of sulphuric acid in Helsingborg.

The paper starts by discussing some of the problems of mapping various relations between agents that have been involved in a crisis. Then a description of the proposed method is given and its practical application is discussed. Thereafter some analyses that can be performed using the results from the mapping method are presented. The paper concludes with a discussion about the findings from the initial analysis of the release of sulphuric acid in Helsingborg and about the practical applicability of the suggested method.

2 Problems when mapping agents and their relations

The process of collecting information concerning relations among agents involves difficulties that must be considered and managed. During the development of the method presented in this paper we found methodological and phenomenological as well as technical and jurisdictional problems when trying to map the relations between agents. We use three categories to describe these problems: The problem of handling a considerable amount of data, The content of the relations, and Secrecy.

2.1 The problem of handling a considerable amount of data.

A complete network of emergency response agents could hypothetically be very outsized. It is reasonable to expect hundreds of involved agents in some of the more severe emergencies and since one agent easily can have connections to ten or more other agents, one can expect that a great amount of information needs to be collected. Furthermore, if one is interested in more than one type of relation, which is likely, the amount of information increases further. Assuming that one needs to perform interviews with all agents in order to find out about their relations, it is evident that the work load can be considerable.

One aspect of the data collection process that is related to the amount of data that needs to be collected is the question of which agents to include in the network. Mead (2001) suggests that the boundaries of a network should, if possible, be established before the data collection begins. In the present context it would mean that the agents that were involved in the emergency response activities should be identified before the process of investigating their relations starts. Doing this will probably be difficult since our experiences from analysing the release of sulphuric acid and the storm Gudrun indicate that a number of important people are not included in the written documents relating to the crises. Therefore, before the data collection activities begin one can only have a rough estimate of which agents who are to be included in the network. One can, for example, have a good idea of which organizations that participated in the emergency response activities and one can define the initial network as all the agents belonging to one of the organizations, and who participated in the response operation. This initial definition of the network can then be expanded using a snow-balling approach [7], which implies that agents who belong to the initially identified organizations can refer to agents that participated in the emergency response activities but who do not belong to any of those organizations. The idea is to use information from the agents to expand the network, i.e. if one agent identifies a new agent who is not part of the present network, then the new agent is included and if that agent in his turn identifies new agents the network continues to expand. This method is to a certain degree "borderless" since all the participants of the study cannot be predetermined as when examining friendship-relations within a collage class or communication flow within a company. Consequently the amount of data can become cumbersome to deal with. Since the ties between the agents consist of different persons' judgments of which contacts they found important, predetermined boundaries could bias the study and hinder growth of a "total network". Instead we consider the network to be complete when the agents that are added to the network do not provide names of agents that are not already included in the network. At that point it is very unlikely that there exist agents or organizations that have performed important tasks during the emergency that have not been identified by *anyone* of the agents included in the network. Of course, if only one or a limited number of agents are chosen as the starting points for the

snowballing process the risk of missing important agents increase, and therefore identifying agents from a variety of different organizations to start the snowballing process from is very important.

A computerized collection process is one way to handle the problem of collecting a large amount of data, but using, for example, web-based questionnaires could mean disadvantages such as increased loss of data due to technical problems and unaccustomedness, a risk for technical bias, and problems associated with jurisdictional restrictions. Nevertheless, we have found that a web-based questionnaire connected to a database is probably the most practical way to deal with the collection of the data. One benefit of doing this is that the information is immediately available for analysis without having to translate the results from, for example, a recorded interview. Furthermore, we have found that the combination of interviewing the agents over telephone and letting them work with the web-questionnaire at the same time provides a time-efficient way of collecting data and it allows the researcher to check that the agents understand the meaning of the questions.

2.2 *The content in the relations*

In the data collection process the participants of the study need an understanding of the content in an agent-to-agent relation. Consistency in this perception is preferable, in order to create a valid network. However, the subjectivity regarding this matter cannot fully be eliminated and one must bear this in mind throughout the process of analysing the data.

Agents can be linked to each other by a wide range of ties. For example, ties related to an evaluation of one agent by another (e.g. expressed friendship, liking or respect) or behavioural interaction (talking together, sending messages) (Wasserman and Faust, 1999). In broad outlines, in this study we construct our networks on the basis of four types of relations; *contacts*, *important contacts*, *friendship* and *formal relation*, which all constitute the basic element of the relations. At the initial step of the collection process the agents are asked to name all other agents with whom they have had contact with during the emergency response. This process results in a quickly growing roster of names since an agent is likely to be in contact with a significant number of other agents during a severe emergency.

It could be problematic for the agents to understand what “contact” mean. If, for example, an agent has only briefly talked with another agent during the response operation, should it be classified as a contact? The main reasons for including the *contact*-relation are firstly to get an idea of which agents *did not* have any contact during the response operation and secondly provide a way of identifying new agents that participated in the operation. Therefore, the aim is to have a “weak” definition of contact, which means that *any* exchange of information or resources related to the response operation between two agents are classified as a *contact*-relation. However, if

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an agent has exchanged information with another agent about something that does not concern the ongoing operation, then it is not considered to be a *contact*-relation. To exemplify the relation, let's consider the contact between an on-scene commander and a chemical expert when an accident involving some kind of poisonous gas has occurred. The chemical expert provides the on-scene commander with valuable information regarding the emergency and therefore the chemical expert probably becomes an important contact according to him or her. The chemical expert might also have discussed other things than the emergency response operation in question with other people than the ones engaged in the operation, but those contacts should not be included in the network.

Another relation between agents that can be problematic to understand is the "stronger" *contact*-relation, *important contacts*. The "importance" is related to how important the agent in question was for the ability of the agent in question to perform his/her tasks during the response operation. An obvious difficulty with this relation is the definition of importance. It is highly likely that agents will interpret it differently. Some might, for example, provide a list of basically all agents that they have interacted with whereas others might not think that any other agent was important to him/her. The aim of asking the agents for the *important contact*-relation is to identify the most important agents in the emergency management network. This is described further in the analysis section of the present paper. In trying to limit the impact of the difficulties we suggest that one has a detailed definition of what is meant by "important" and that the agents are only asked to name the three most important agents.

During interviews with decision makers who have been involved in the chemical accident in Helsingborg there was a great variety regarding what the agents considered to be an adequate number of contacts. Some were focused on colleagues, some on traditional response organizations and some even included family members. In addition to the problem of explaining to the agents what is meant by "contact" one needs to consider whether the agents might be influenced by friendship, prestige or pressure to tell others what they want to hear and thus distort the information. The organizational culture and the cultural context where the organizations exist could probably influence the frankness of the agents. Some individuals could be expected to be "important" thanks to their position in the organization and will possibly be regarded as an important contact "routinely". Another situation which could cause a conceivable source of error is if there are conflicts between individuals, groups or whole organizations which might have an effect on how the actual circumstances are reported. The potential problems discussed above need to be considered when collecting information regarding relations between agents. In interview situations there is scope for clarification, when handling quantitative data there is not. Therefore it is preferable if the person conducting the analysis can interview the agents at the same time as they are providing information regarding their relations.

Since friendship or trust-relations have been suggested to be important when organizations are forced to deal with a crisis (Krackhardt and Stern, 1988), it is interesting to measure this relation between members of the emergency response network. When measuring the friendship-relation we use a modified version of the classification used by Krackhardt and Stern (1988). They classified the friendship-relation in terms of five categories: “trust as a friend”, “know well”, “acquaintance”, “associate name with face”, and “do not know”. We employ one additional category which we call “trust as co-worker”. Thus, we distinguish between whether two agents are personal friends, which we regard as the highest level of trust, and whether they trust each other professionally. Therefore, an agent within the emergency response organizations might trust another agent but might not be a personal friend of that agent, which would imply that the relation could be classified as “trust as co-worker”. Furthermore, agents that work together and know each other might not trust one another and therefore their relation would be described as “know well” or “acquaintance”. During interviews with agents involved in the emergency management operation associated with the release of the sulphuric acid in Helsingborg it became apparent that it is important to distinguish between the categories “trust as co-worker” and the relations “know well” and “acquaintance”. Some agents explained that they sought help from agents outside the formal organization because they “knew that he/she could be trusted”.

It might happen that agents do not know each other before the crisis but become acquainted during the emergency activities. In the present study we focused on relations that existed between agents *before* the crisis. The friendship-relation does not appear to be as problematic to understand for the agents as the contact-relation, especially not when one can interview the agent at the same time as he/she is providing the ranking of the relations. Therefore, it is useful to perform a telephone interview at the same time or directly after the agent has filled in the web-questionnaire.

2.3 *Secrecy*

In order to rationalize the data collection process the database allows participants to sign in and submit the information required for a network analysis. This process involves storing information concerning the agents and their relations, a fact that could cause harm to individuals and organizations if the information was made public and it must therefore be handled with care. Moreover, sensitive information could be recorded which could be in conflict with the present regulations.

In Sweden, the principle of free access to public records has a strong influence on what guarantees of secrecy that can be given to participants in studies like this. Complete confidentiality would be desirable in order to generate more accurateness to the given information. This is unfortunately not an option and the participants must sign an agreement in which it is clearly shown that they understand that the information

they provide will be stored in a database and that if anyone would like to study the information they will be allowed to do so. This might cause a problem since it might reduce the agents' willingness to provide information. It is not possible to completely eliminate this problem. However, we provide the agents with assurances that the information they provide will never be published without first showing them the content of the publication, and that sensitive information never will be published in a way that it is possible to identify which agents the information pertain to.

Storing personal particulars, especially without approval, is also problematic. If an agent refers to another agent that not already exists in the roster and has accepted the handling of the personal data, it is necessary to temporarily store this data in a veiled roster. The persons should then be contacted for approval before they are transferred to an open roster.

3 Method

A method for the mapping of emergency management networks has been developed based on the analysis of the potential problems presented above. The method consists of four phases, which are described below.

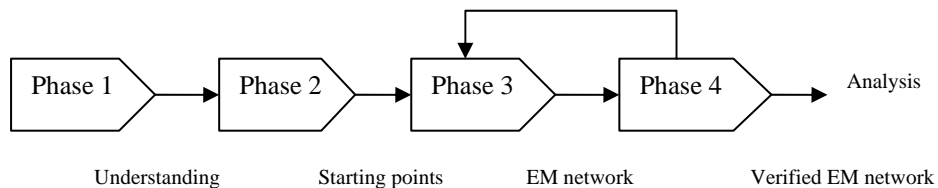


Figure 1

3.1 *Phase 1 – The pre study phase*

A basic understanding of the course of events in a crisis is essential in order to investigate a network of agents from different organizations. In the case of the discharge of sulphuric acid in Helsingborg several documents from different organizations, such as the fire brigade and other authorities, have been produced. By analysing these documents, a basic understanding of the crisis, the response activities and the structure of the responding organizations was established. This is the first step to identify starting points for the actual mapping process in phase 3. Starting points are agents from whom the snowballing process begins (in phase 3) and since our purpose is to cover a complete, or at least as near complete as possible, network of emergency response agents it is important to identify a variety of organizations or clusters of

agents to be used as starting points. Private, voluntary and official organizations with different tasks, not only operative, should be included. In the Helsingborg case the local fire department had a central role, but a wide range of organizations were involved in emergency response activities. Some of these organizations did not have direct contact with the fire department and therefore they might not be included in the network if one only used the fire department as a starting point for the identification of agents.

3.2 *Phase 2 – Identifying starting points*

The result of the pre study is used to identify key persons within the organizations that participated in the emergency management operation. In the Helsingborg study, depending on the extent and diversity of an organization's role in the response operation, we used one or several key persons within the organizations, to identify the agents that should be the first ones to be included in the network.

As mentioned above, the fire and rescue services played a central role in the operation and consisted of a compound organization with a number of functions. In addition to the personnel from the fire and rescue services in Helsingborg personnel from adjacent districts were also engaged in the operation. The fire and rescue service organization was made up of subgroups with different tasks assigned to them. One task of such a subgroup was to decontaminate vehicles and equipment in a secure area, a task that they could perform almost autonomously, e.g. they did not need the on-scene commander to tell them exactly what to do. Another subgroup within the fire and rescue services was a group located near the collapsed tank that had the task of controlling a possible secondary discharge. There were many such subgroups (not only within the fire and rescue services) and since we are using a snowballing approach it is important to identify the major subgroups and select agents in order to start interview with these subgroups.

Large scale crises can require time consuming response operations with staff turnovers which increase the number of possible agents to start with and complicate the collection process. Records showing information flows such as phone lists, extracts from decision support systems and notes in the minutes can be helpful and give valuable information regarding the time when a specific agent was active in the operation.

3.3 *Phase 3 – The snowballing process*

The agents identified in phase 2 will constitute the starting roster of agents or the first order zone (Wasserman and Faust, 1999). The first order zone is followed by a second where the agents in the first zone are asked to refer to new ones and so on. Due to the

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problems discussed in the preceding section we chose to use a database connected to a web-questionnaire for the collection of the information concerning the relations among the agents. The main reason for this was that it made the processes more efficient since we could interview the agents over telephone and at the same time provide them with a visualisation of parts of the network. Furthermore, the analysis of the information could be performed directly using the database, and therefore we did not need to spend time on converting the data to a suitable format. In practice, the agents identified in phase 2 were contacted and asked to participate in the study. After having received their approval we performed interviews with them and at that time we collected the information necessary for constructing the network.

The web-based questionnaire includes a starting page where the participants use a personal username and a password to get access to the main page. After being informed about secrecy regulations and how the data will be used, the participants can create their part of the network using the existing roster. Additional names can be added if the roster is incomplete. The agents are also asked to provide information regarding themselves and their involvement in the emergency management operation, such as at what hours they participated in the operation, which organizational position they occupied, and what their main tasks were. They also have the opportunity to add personal comments. The information is then saved into a database that constitutes the basis for the analysis of the network.

At some point during the snowballing process, the number of new agents that are added to the network will drop, i.e. the agents that are referred to by new agents are already present in the roster. When this happens the boundary of the network has been reached and the roster of agents is complete.

3.4 Phase 4 – Verification

In order to assess the validity of the network, a fourth stage which is a kind of verification process is carried out. Since the roster is expected to grow very quickly it should contain the names of almost all agents after the third or fourth zone has been completed. Nevertheless, one can expect that a few agents will be added late in the process. A second contact with all the agents should therefore be established to confirm, add or change given relation data. This task involves reviewing the final roster and making possible changes of the information that the agent has provided.

The verification also involves a second contact with a selection of agents on the basis of their position in the network. Agents who are centrally placed within the network, i.e. agents who have been referred to as important persons by many others (see next section). These agents are of special interests in this type of study. More profound studies, such as in depth interviews, can be performed with them.

4 Analysis of the network

In an emergency management operation it is interesting to investigate which agents are at the “centre” of the operation. In emergency management operations, similar to the one in Helsingborg it should, intuitively, be agents within the fire and rescue services, but there might also be others that play a central role. One way of analysing the centrality of agents is to use methods from social network analysis. More precisely, one can calculate the actor closeness centrality (Wasserman and Faust, 1999, p.184) of the agents in the network based on the *contact*-relation. Since the *contact*-relation is a directed relation (from one agent to another) one needs to verify it during phase 4, which implies that if one agent indicates that he/she has had contact with another agent who has *not* indicated that such a contact existed, one needs to find out whether there actually has been any contact between the two of them or not. When the network has been validated in this way, the *contact*-relation can be treated as an undirected relation between the agents. Calculating the closeness implies that one calculates the length of the shortest paths between all agents and the agent that has the shortest path on average compared to all other agents, is the agent who is the most central person in the emergency management network.

Another way of finding the central agents is by calculating the actor degree prestige which is the number of links (relations) that leads to a specific agent (Wasserman and Faust, 1990, p.202). Calculating the actor degree prestige of the relation *important contact* will provide a measure of which agents are most often selected as being an important contact by the other agents in the network.

Although actor degree prestige can give valuable insights into which agents were among the most important ones, it has some shortcomings when applied in the present context. Since actor degree prestige does not provide any indication of *who* chose a specific agent as an important contact, one might encounter situations in which one agent receives a high degree of prestige but has only been chosen as being important by rather unimportant agents. Intuitively, the more important agents that indicate that a specific agent is important, the more important that agent should be. A measure called rank prestige (Wasserman and Faust, 1999, p.205) facilitates this and therefore it is useful when analysing the most important agents in the emergency management operation.

In order to understand more of the dynamics of an emergency management operation one can study the formation of groups within the network of agents. If, for example, those groups correspond to the formal organization or the emergency preparedness plan, one can conclude that the operation was performed more or less according to the expectations of the involved organizations. However, if there are numerous groups that were not included in any planning document and did not correspond to the formal organizations, the operation has been performed in a more ad hoc manner. To study group formation, we suggest that one uses the *contact*-relation

and employs the algorithm suggested by Newman (2004). However, instead of only measuring the *contact*-relation as a binary relation, one could measure how many times the agents had contact during the operation and use weighted networks to identify groups (Newman, 2004). This would probably give a better indication of where different groups in the network are, but it would also involve more work when collecting the data.

Analysing the correlation between two types of relation in the network could also be useful; especially the correlation between the relations *important contact* and *friendship* is interesting. Such an analysis can be performed using the technique suggested by Krackhardt (1987). This type of analysis can help us to shed light on the question whether agents in an emergency network tend to think that persons they know within the organizations in question, are more important to them than people they do not know. Since the initial interviews (phase 1) regarding the Helsingborg crisis suggested that some agents assigned important tasks to agents that they knew/trusted, it would be interesting to see whether the correlation between the two relations (*important contact* and *friendship*) is high. Furthermore, it would be interesting to investigate the structural differences of the network at different times. One could use the methods discussed by Monge and Contractor (2003, p.68) to perform an analysis of the correlation between, for example, the *important contact*-relation in the early stages of the emergency and the same relation but at a later time.

The agents can provide information regarding which time period(s) they were active during the crisis and if their relations to the other agents changed from one period to another it is thus possible to observe the temporal changes of the network structure. Analysing the changing network patterns and comparing them with the changing needs due to the emergency can give valuable insights when trying to understand the response system's adaptation capability.

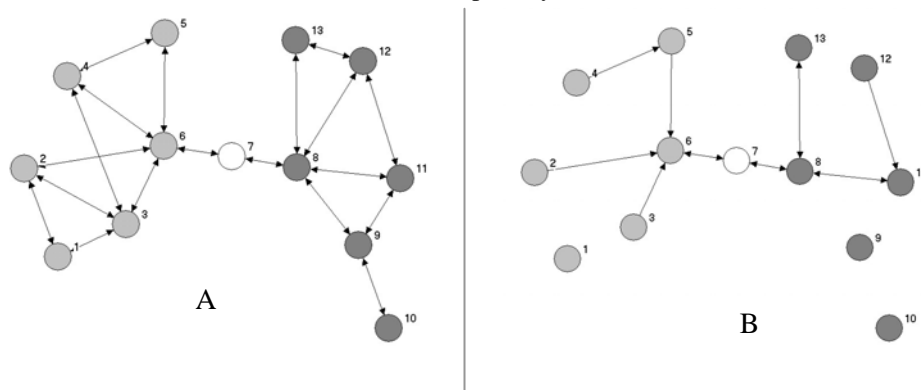


Figure 2 Illustration of two types of relations in a demarcated network.

Figure 2 illustrates two examples of a demarcated network containing agents that belong to three organizations (illustrated by the colour of the nodes). The relations shown in the network called A is the *contact* relation. Agent 6, 7 and 8 have the highest closeness centrality and agent 7 serves as an example of a boundary spanner. The network called B is made up of the same agents, but the illustrated relation is *important contact*. If no links are originating from an agent, then none of the agents that are illustrated in the picture are classified as important contacts according to the agent in question. The most important agents in terms of actor degree prestige is agent 6 followed by agent 8.

4.1 *The release of sulphuric acid in Helsingborg*

The development of the method for mapping a network progressed in conjunction with the empirical studies of the chemical accident in Helsingborg. Accidents of this extent are likely to generate an abundance of evaluation documents that become useful for the understanding of the course events and the complex of managerial problems. This section is a short summary of the results from mainly the first and the second phases in the data collection procedure. Internal as well as independent reports have been studied and interviews with key persons have been conducted. In addition several starting points in different organizations have been identified and in some cases interviewed about their contacts.

Early in the morning on the 4th of February 16 000 tons of sulphuric acid leaked out from a cistern on an industrial estate near a residential area. The sulphuric acid aerated the ground under another cistern and the risk for a second collapse was imminent. Moreover, the acid release resulted in the formation of a gas cloud that spread over a large geographic area. When the local fire and rescue service arrived, they realized that the operation was to become very demanding. Initially, it was problematic to get an idea of the extent of the gas cloud since it was still dark, which meant that the initial decisions regarding the operation was made in a context of high uncertainty. During the assessment of the situation, additional units along with experts on chemical accidents joined the organizations and a local management network structure began to emerge. Commanders from different fire brigades established general principles for the operation and formed the initial rescue operation. An early decision was to pump the acid into the dock, despite the risk of causing environmental damage. Sulphuric acid demands special protective suits and the rescue workers had to be replaced continuously due to the difficult work. Equipment, like pumps and hoses, were worn down fast. Therefore, logistic functions were of great importance.

In addition to the problems of handling vast amounts of toxic substance and the potential danger of a second discharge, the municipality had to deal with residents who did not have access to their homes and workplaces along with the massive need of information. Since effective co-ordination and co-operation were essential for solving

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the problematic situation, the information flow became considerable. One can identify several conflicting goals during the operation. A tactical problem was whether to dump the acid into the harbour or not. Further spread of the toxic substance could be limited by pumping it directly into the ocean, but at the cost of probable environmental damages. After the emergency operation was over, experts concluded that the environmental damage was limited. However, that information was not available to the commander during the operation. Other conflicting goals were identified between different authority centres. Residents and companies, who were affected by the measures taken by the fire and rescue service to rope off adjacent areas lost their access to their homes and workplaces, which resulted in both economical and emotional quandaries.

In addition to the pre-planned coordination functions some agents, regardless of their organizational belonging, acted as information carriers between different parts of one organization or between different organizations. The agents' personal contacts made this important task easier. Decision makers realized that this quality was related to the individuals and not to their situation as commanders or experts. Consequently problems arose when these agents had to be replaced. Replacing and appointing agents at important and central functions was to some extent a procedure affected by friendship relations.

The complex response process holds a number of ad-hoc influenced solutions where new agents from various organizations became important resources in unplanned processes. Many of these contacts were established owing to the central decision makers' interpersonal connections.

5 Conclusions

Mapping interactions and relations between agents participating in the management of a crisis situation is important in order to understand the dynamic development of the emergency response system. An emergency response system could be described as a system containing both agents who are trying to mitigate the effects of the crisis and the resources (artefacts) that those agents use.

In the present paper a method for mapping various relations between agents in an emergency management network has been presented. The method is based on using a web-questionnaire connected to a database in order to collect the information regarding the relations between the agents. Using the web-questionnaire in combination with telephone interviews provides a time-efficient way of collecting large amount of relational data.

The network of relations between the agents that participated in the emergency management operation in question can be analysed in a variety of ways so as to provide information on issues such as who the central agents were, which important groups were formed during the operation, if the contacts between the agents concurred with

the formal organization etc. Hopefully, such analyses can facilitate the understanding of the complex adaptive systems involved in an emergency management operation.

Using the proposed method an initial analysis (phase 1 and 2) of an industrial accident involving the release of 16.000 tons of sulphuric acid in the central parts of the city of Helsingborg has been preformed. We conclude that there were agents who acted as boundary spanners and facilitated the exchange of information between organizations in a way that was not pre-planned. Furthermore, there were agents from outside the formal emergency response organizations that became involved in the operation primarily since they knew persons within the organizations and had some knowledge/resource of value to the operation.

The decisions made, regarding the practical aspects of the emergency management operation, appear to some extent have been driven by a “bottom-up” process in which a group of commanders situated close to the accident site made decisions that affected the operation as a whole. Moreover, the structure of the emergency management organization that was built up did not fully agree with the pre-planned structure. Thus it seems as if it, at least partially, was created in an ad hoc manner.

The conclusions regarding the Helsingborg operation are at present only based on the interviews and the documents analysed in phase 1 and 2 (see the Method section) and it will be interesting to see whether the upcoming analysis of the complete emergency management network will provide evidence that agree with these initial conclusions.

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Appendix – Paper II

Paper II

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Trust Among Decision Makers and its Consequences in Emergency Response Operations

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Abstract

In an emergency response operation trust can have an influence on the efficiency in communication between different decision makers and how the networks of these decision makers are formed. Consequently, it might affect the efficiency, flexibility and adaptation capability in the response system as a whole. Trust could generally be described as a relation between a trustor and a trustee where the expected behaviour and competence of the trustee in a specific context, estimated by the trustor, is a central core in the concept. On the basis of a literature review and interviews with Australian emergency response practitioners this article discusses relevant characteristics of trust and its consequences in emergency response. The content emphasizes the need for further development of descriptive analysis of the processes underlying the formal charts and documents to understand authentic conditions and further develop valid normative theories for emergency response management.

1 Introduction

This article is based on a literature review and a series of interviews conducted in parallel. The authors have carried out the literature review with the aim of finding theoretical interpretations of the concept of trust separately, a method that generates a higher degree of validity to the findings. These individual findings have been discussed on several occasions. The interviews were constructed, conducted and analyzed by the first author alone, but later re-examined with the second author. At the end of this article the two parts of the study are merged in the discussion. As a result of this production structure the section that focuses on the interviews uses “I” instead of “we” in the text.

1.1 Background

The relationship between different professional emergency response officers and decision makers can be described in a number of ways. One of the most common ways to describe such a relation is to refer to a person's organizational position, such as a colleague at the same hierarchical level, a colleague who is subordinate or superior to the referred person and so on. The relationship could also exist across organizational borders, like when different commanders from different fire stations have to operate on the same accident scene, or when commanders (or other decision makers) from different organizations have to coordinate their efforts. (See Uhr & Johansson, 2006)

Another type of relationship is the relation that is based on trust. This type of relation is by logical reasons hard to capture when analyzing a formal organizational chart. However, a trust-relation could be very important for the formation of decision makers when there is a flexibility to create an ad-hoc organization, such as when a major emergency situation occurs and many actors from different sections of the society are involved. In an "every-day situation" such a traffic accident or a small house fire, the predetermined formal organizational forms are often relatively clear, but when extrapolating the situation the borders can become more obscure and the normative organizational frameworks do not provide sufficient foundation for extensive analysis of the response process. Preparation activities like planning and exercising procedures support the aim of enabling an effective organizational build-up in case of an emergency, but there must doubtlessly be enough flexibility in the organization to adapt these to current unfolding situations. Trust could therefore, even in "minor" emergency situations, have an impact on how the structure (both the formal and the informal) of decision makers, or for that matter how the distribution of work within the "ground staff", emerges.

Mishra (1996, p. 20) argues that trust has a "positive effect on the degree to which sufficient resources are developed to deal with the crisis in a timely fashion by enhancing decentralization, undistorted communication, and collaboration." It is reasonable to believe that decentralization to some degree is necessary in emergency response organizations when dealing with complex situations. Detailed and centralized Command and Control (discussed by Uhr and Fredholm, 2006) is by many scholars (Drabek & McEntire, 2003; Quarantelli, 1998 among others) viewed as a poor theoretical foundation for efficient emergency response management and according to these discussions decentralization is necessary. Mishra's (1996) hypothesis that undistorted communication within an

organization will increase the speed and degree to which adequate resources are developed to solve a crisis, could be seen as an applicable assumption in the context of emergency response management. One could claim that the hypothesis is not applicable if the emergency or crisis “occurs outside the system boundaries” of the response system – however, it is a matter of defining system perspectives and when considering the response system as a part of an effected community, the reasoning is relevant. Comfort (1994) (2006) discusses the emergence of collaborative partnerships in disaster response and Robinson, Berett and Stone (2006) present research on the development of the collaboration of response to Hurricane Katrina and uses the phrase “disaster response networks” when describing parts of the response system. Kock (1991) contends that trust is an important attribute when discussing industrial networks. Network and network theories could be used as central conceptions when theorizing emergency response and are also discussed by Uhr and Johansson (2007) and Uhr and Fredholm (2006). There is no doubt that collaboration and co-operative behavior are important elements in demanding response processes. Furthermore, Gambetta (1988) argues that trust enables cooperative behavior and Miles and Snow (1992) maintain that it promotes adaptive organizational behavior, such as network formations. Adaptation in a multi-agency response is thoroughly discussed by Comfort and Kapucu (2006). Kapucu (2006, p. 221) suggest that “individual public emergency managers, nonprofit managers, and business sector managers should provide before-the-fact incentives and information to promote interorganizational networks” in order “to foster interorganizational communication and the trust that enables interorganizational network coordination in emergency management response operations...”. The importance of trust to effective responses to crisis is also claimed by Meyerson, Weick and Kramer (1996) who say that “trust facilitates rapid formulation of ad-hoc work groups” (as cited by Rousseau, Sitkin, Burt & Camerer, 1998, p. 394). Kramer (1999) concludes that trust enhances individuals’ willingness to engage in various forms of spontaneous sociability, but in complex and often unexpected ways. LaPorta, Lopez-de-Silanes, Shleifer and Visny (1997) conclude that several studies, including those in Diego Gambetta (1988), as well as studies by James Coleman (1990), Robert Putnam (1993), and Francis Fukuyama (1995), argue that trust or social capital determines the performance of social institutions. In Wachtendorf’s dissertation “Improvising 9/11: Organizational Improvisation Following the World Trade Center Disaster” (2004) trust is related to the improvisation processes that are verified in response operations and is described as “essential to any improvisation process” (p. 186).

1.2 Aim

This article aims to explore and bring substance to the concept of trust when used as a descriptive formulation in the context of emergency response. In particular the study attempts to describe the essence of trust in important informal relations between decision makers within (or between one or more) emergency response organizations, and answer the research questions below. By informal relations we mean the type of relation that exists in a social context where different agents (people) act. These relations are not generally manifested in a formal organizational description. The article aims to exemplify how different decision makers view the concept of trust and its importance for the structure of the ad-hoc networks of agents formed in response to an emergency or crisis. It is hoped that the findings will stimulate further discussion about the empirical conditions that form a complex response organization.

1.2.1 Research questions

On the basis of what is stated above three research questions have been identified:

- *How do different scholars interpret the concept of trust and how is it applicable in the context of emergency response management?*
- *How do decision makers in an emergency situation understand the meaning of trust? (not related to the relation between a professional and a “victim”)*
- *In what ways can trust affect the structure of the organization that emerges as a response to an accident and what other relevant consequences can it bring?*

The aim is subsequently NOT to devise an explanatory theory for trust in general but to add to the knowledge its meaning so that the concept can be used for example when discussing relations, such as friendship relations, and their value in an emergency response network (see Uhr & Johansson, 2007).

1.3 Methods

In order to answer the first research question a literature review was carried out. In parallel, six interviews with professionals working in the field of emergency response management were conducted. These interviews are meant to supplement the literature findings and provide a more concrete and solid picture on how the concept of trust could be used in the context of emergency response.

1.3.1 The literature search

Most of the literature was found through electronic data bases like ELIN at Lund University. Other sources were reference libraries, local libraries and search engines like Google Scholar. The forums for finding literature also include conferences, seminars and everyday contact with colleagues at the workplace. Different search combinations were used to find relevant literature. *Trust* was combined with words like *emergency*, *crisis*, *disaster response* as well as with organizational concepts like network and co-operation. With the purpose of finding possible discussions on definitions, *trust* was also combined with *definition*, *meaning*, and etcetera. A critical evaluation of the credibility of the literature was conducted. This was done mainly by cross-examining different authors' chains of argument and conclusions, as well as how these fit with their chronology of publication. Another straightforward way of judging credibility was to see if the authors were frequently cited by others.

1.3.2 The interviews

The results are based on our interpretations of the data rather than the only truth about it. This interpretive approach has been used when analyzing the data and is derived from the structural idea in grounded theory. Willig (2001) explains that evaluation criteria such as objectivity and reliability are hard to justify in partly relativistic approaches and reflexivity issues, as the acknowledgement of the researcher and how his or her perspective and position have shaped the procedure, is a better dimension of the quality criteria. Since the final objective is not to develop a theory, but to understand and suggest how the concept of trust could be given substance in the context of emergency response management, the grounded theory approach will not be appropriate. However, the organization of the interview material has followed the principle steps in this established method. The themes and the sub-themes emerging from the process are presented in the findings section and discussed in the following section.

Selection of participants

The selection of interviewees in this particular study depended on the availability of individuals, at a specific time and place, in the population of interest – emergency response organization professionals. By and large the selection was limited to Melbourne and surrounding areas in Victoria, Australia. As a foreign Swedish researcher I relied on different contacts who could guide me to individuals happy to contribute to the study. After the initial phase of the research process had been carried out and the first contacts interviewed, new ones emerged

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without third party interference. Emergency response involves numerous of different types of organizations but I was primarily looking for individuals with experience from decision making and organization build-up processes in civil emergencies. People from the fire services (both volunteers and professionals), first responders from the health care system, the police, other community services and the civil part of the military organizations were of interest. An effort was made to reflect the balance between homogeneity and heterogeneity in the selection. All the participants had experienced real emergency situations of some magnitude, all were men in their fifties. Variations between the participants were mainly due to different education background and daily work tasks in their respective organization. The representation correlates with my earlier experience of decision makers in senior positions. Most of them are men and have been in the profession for several years. One thing that could have bearing on the validity of these results when using them to define the meaning of trust among first responders, and how it affects the work processes, is the possible cultural discrepancy between organizations in different regions and nations. Another aspect of the selection relates to the nature of the information. It is clear that ways of verbally expressing abstract concepts, such as when discussing the complex structure of interacting decision makers, varies. All participants were engaged by the topic and were willing to share their experiences which resulted in informative data, albeit articulated in diverse ways. A theoretical selection, normally used in grounded theory, was not used, although the cyclical work process acknowledges it, simply because of the rather clear-cut opening research question. For this study six interviewees were chosen according to their similar formal position (e.g. senior commanders) and their estimated experience in working with “real” emergency responses as well as with emergency planning and exercises.

Sample method

The data collection was based on semi structured interviews carried out between October and December 2006. The choice of using this interview method allowed flexibility in adapting the questions to fit the interviewee and individual ways of assessing questions by discursive processes. Since the interpretation of the word trust and how it affects work processes among emergency responders is influenced by many things, such as cultural aspects and reflexivity, the interviews had to be flexible to the circumstances. At the same time I felt it desirable to use a thematically structured approach to reduce bias influence and be able to sort the data in an effective way. As an interviewer I was aware that my interpretation of trust and its consequences in organizational processes could affect the outcomes of the interviews, and in order to eliminate this bias I attempted to assume a non-

judgmental and permissive attitude. Of course, the interpretations are not entirely free from distortion but the awareness of reducing the influence on subjective bias has possibly contributed to more credible results. In an introduction the purpose of the study as well as ethical issues regarding the use of the collected material was explained to the participant. Moreover I presented myself as an interviewer, described my background and talked generally about how the Swedish emergency response system is arranged. This created a relaxed and friendly atmosphere that simplified the interview process and reduced some of the barriers that by experience sometimes exist between academics and practitioners. The first questions asked were of more general character like describing current and previous job positions, organizational structure, role in a major emergency or disaster situation and practical experience. To gain understanding of how words like adaptation and organizational flexibility were understood I then asked participants to tell me if they thought they could possibly change the organizational structure in order to adapt to certain needs. There is a logical correlation between organizational flexibility, adaptation and trust as an influence on how emergency response processes are carried out. Here I explained that I defined adaptation in a way that could not be found in pre-planned procedures and documents and therefore was not clearly authorized by superiors. These questions were followed by more specific questions about trust but still not associated with an emergency or crisis situation. Here I wanted the interviewee to present a general understanding of trust. This could later in the analysis be compared to the picture of trust in a more specific context. A typical question at this stage was: “How do you understand the general meaning of trust?”. In some cases I added follow up questions to extend the answer. This part of the conversation was followed by more precise questions on how trust could affect the structure and the work processes in the organization and interactions with other response organizations when it came to coordination, cooperation and joint command. At this stage the dialogue was formed in different ways, mostly because of the fact that the respondents used a particular event to illustrate their answers. More often than not I formulated questions like “Have you experienced situations where you contacted “trusted” people instead of people that should be contacted according to administrative procedures?” to enable the informant to give substance to their reflections. Finally I asked if they thought that trust had an effect on preparation processes like planning.

The locations selected for the interviews varied from the interviewee’s office, their home, to my office. All of the interviews took place where colleagues and superiors could not interfere or directly influence answers of more sensitive

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nature. The setting in all of the cases could be regarded as reasonably neutral. I did not find the status balance an issue. All the interviews were recorded and transcribed in a text editing program, printed and reviewed. The initial conversations were not recorded for two reasons: It could have a negative outcome on the comfortable atmosphere that I found important to create. Additionally this reduced the total amount of collected material. An average interview lasted approximately one hour and 15 minutes and contained 30 to 40 minutes of recordings. In the transcription process some extraneous words were ignored.

Analysis method

The transcriptions were later analyzed individually and the answers to the comprehensive questions were fitted into a matrix to simplify the process of identifying themes and sub-themes. Absolute objectivity in this type of exploratory analysis is impossible to achieve and my own interpretation of the data material inescapably forms the results. The awareness of the negative consequences of bias has expectantly contributed to more valid results. During the analysis the interview questions were the dominant aspect when labeling the main themes. The sub themes emerged directly from comparisons with the discussion following questions related to the main themes. Some representative quotes given by the responders were used to support the sub themes and give form to their meaning.

1.3.3 Reflection

The empirical section in this article has a clear interpretive approach and the search for meaning and understanding of different concepts and phenomena among a limited group of practitioners has the purpose of bringing body to a discussion on trust in the emergency response context. To start with, our hypothesis based on earlier findings is that trust is a condition capable of influencing the structure and the working process among professional decision makers. There are many aspects of trust and I needed to establish a definition that could be applied most of all to the work of developing methods of analyzing the management aspects of emergency response. My own conceptions and preconceptions probably affected both the interview and the analysis processes. Without saying it directly, the interview situations embodied my hypothesis that trust is important for the outcome of response operations. The interest we showed in the conversations that corroborated this, most likely stimulated the respondent's reasoning, and when indications on the contrary occurred I might not have expanded the interview enough. Since the main focus of the interviews

was to bring substance to the concept and the consequences of trust rooted both in empirical findings and literature the way the respondents expressed themselves was essential. Words, meaning and understanding are not necessarily equivalent and perhaps more follow-up questions would have provided me with deeper understanding of the meaning. At the same time the time limit during the interviews with these busy men forced me to restrict the discussion. This reasoning highlights the difficulty of being as neutral as possible. I have a preconceived notion of how to behave to gain respect and mutual confidence. The emergency service is still a very male-dominated domain and we had an expectation that issues like this might be communicated in a particular manner. Two of the interviews were carried out during an operation. Even though the situation was fairly static there was an amount of tension that is not present in a normal office setting. During the data analysis and the categorization process we were influenced by my previous understanding of trust and its consequences derived from earlier studies and the findings in the literature. In my own day-to-day life I would probably use words like competence and expectation to describe trust. This understanding has remained during the whole process even where further abstract dimensions have been added. A larger number of participants would possibly benefit the empirical material and more attention could be paid to these results. At the same time interviews and analysis are time consuming activities and the aim of the interviews was to supplement the literature findings and relate the discussions to emergency response management. The choice of participants was fairly randomized and I had no previous knowledge of their opinions about the questions at issue.

2 Trust as described in the literature

Earlier interviews with decision makers in three major disasters in Sweden (The Flood situation mainly in Småland 2004, the Storm “Gudrun” 2005 and the discharge of 16 000 tons of sulphuric acid in Helsingborg 2005) indicate that personal knowledge of individuals and their characteristics mattered when the network shaped patterns of decision makers and other important agents emerged. Quotations such as “I knew him since before so it was easy to call him to make up plans” occurred as explanations of why some different important contacts were established in the early phases of the response processes. This type of statement suggests that links between decision makers are not merely constituted by official administrative components, but contain a complex of relationship data. Trust is a subjective concept and has different meanings for different people depending on the situation. Scholars like Mayer, Davis and Schoorman (1995), Rousseau et al (1998), Costa (2003) and Blomqvist (1997) all state that there is a lack of clarity in

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the concept. Blomqvist (1997) reviews the concept from the perspective of social psychology, philosophy, economics, contract law and market research and concludes that “the weak conceptualization of trust is partly due to the fact that trust is always specific, i.e. the context matters.” (p. 283). Gambetta (1988) says that trust is one of the basic variables in any human interaction which naturally makes it complex. Nevertheless, trust seems to be a word that could be useful when trying to describe the unofficial relationships between people in organizations operating in environments with high uncertainty.

Rousseau et al (1998, p. 295) write that “trust is not a behavior (e.g. cooperation) or a choice (e.g., taking a risk), but an underlying psychological condition that can cause or result from such actions.” They also stress that “In a sense trust is not a control mechanism, but a substitute for control (p. 399). Control comes into play only when adequate trust is not present.” According to Barbalet (2005) trust must be characterized by dependency and therefore vulnerability. Consequently it is not a means of control at all. These statements could be viewed in accordance with the scholarly criticism (Drabek & McIntyre 2003, Fredholm & Uhr 2006, Quarantelli 1998 among others) on Command and Control as a theoretical base for emergency management.

The attempt to find similarities between different interpretations of the meaning of trust results in the discussion about the apparent inclusion of a risk component (Rousseau et al, 1988). According to Costa (2003) “the willingness to be vulnerable” is one of the most cited definitions. Barbalet (2005, p. 5) notes that “most treatments define trust in terms of a confident expectation regarding another’s behaviour”, but argues that this does not cover the whole mechanism of trust since “it leaves out the essential component of a self-referential confidence in the subject’s own judgment as well as a confidence concerning the other that is in any case dependent less on the other’s qualities and more on the subject’s appraisal of them.” This leads to the question of how one should understand words such as confidence and trustworthiness and their relation to trust. Confidence as a feeling has to do with an expectation of the future and its object is not primarily self or other, but it is not the same as trust since there is a difference of attribution between them (Luhman, 1990, cited by Barbalet, 2005). The basis of trust “is the feeling of confidence in another’s future actions and also confidence concerning one’s own judgment of another. Thus there is a double confident within trust” (Barbalet, 2005 p. 13). In a similar way trustworthiness can be regarded as a part of the concept of trust. When discussing trust among professionals in an emergency response situation it is useful to talk about a trustee

(trust giver) and a trustor (trust taker). Barbalet (2005) maintains that the trustworthiness of the trustor is only a part of the context of trust giving and only becomes real when it is accepted by the trust giver. Furthermore he argues that it could never provide conclusive grounds for trust and never constitute sufficient evidence for the reasonableness of trust when it is given. However, discussions with the decision makers referred to in the Swedish studies imply that the interpretations and the use of the word trust often focus on the qualities of the trustee. Friendship is another type of relation that is hard to define but has a clear connection to trust, or vice versa. Trust could be seen as a component in a friendship relation, but as trust is context dependent there certainly are areas when a friend may not be trusted due to the lack of specific qualities for a certain task

Mayer, Davis, and Schoorman (1995) propose a model of trust in which they review factors that lead to trust: ability, benevolence, and integrity. In their conceptualization the task- and situation-specific nature of ability is regarded. This approach harmonizes with the interpretations of the discussions with the decision makers involved in the response processes following the three crises referred to above. Trust in colleagues' and interorganizational partners' abilities was mentioned as a factor when "choosing" contacts that were established during the response process. Words like "expertise" or "competence" are used by researchers (Mayer et al, 1995). Benevolence is the second factor that leads to trust. Mayer et al (1995) define benevolence as the perception of a positive orientation of the trustee toward the trustor and the word is used by other researchers like Giffin (1967) and Deutsch (1960) among others. Finally, integrity is identified as a third factor underlying trustworthiness.

Kramer (1999) summarizes and discusses trust in organizational theory. In the introduction of his article he concludes that there is an increased interest among scholars to explore how the concept affects processes like interorganizational cooperation, coordination and control has arisen. In the context of organizational settings trust can be seen as a form of social capital with constructive effects on increasing spontaneous sociability among organizational members and facilitating adaptive form of deference to organizational authorities. Under the line "Trust as Choice Behavior" (p. 572) Kramer means that conceptualizing trust in terms of choice makes it an observable behavior. Furthermore, he summarizes two different images of trust as a choice; trust as a rational choice and relational models of trust. Hardin (1992) cited by Kramer (1999) notes that a rational account of trust includes the thematic elements of knowledge – that enable a person to trust another – and the incentives of the trustee to honor or fulfill the

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trust. Relational models of trust suggest that trust “needs to be conceptualized not only as a calculative orientation towards risk, but also a sociological orientation toward other people and toward society as a whole” (Kramer 1999, p. 573). Hardin (1992) also suggests conceptualizing trust as “...a three-part relation involving properties of a truster, attributes of a trustee, and a specific context or domain over which trust is conferred”... “[A] three part theory of trust would thus afford adequate attention to both the calculative and relational underspinnings of trust.” (Kramer, 1999, p. 574).

Kramer (1999) finds several bases of trust within organizations, such as *Dispositional Trust*, *History Based Trust*, *Role-Based Trust*, *Rule-Based Trust*, *Category-Based Trust* and *Third Parties as Conduits of Trust*. For our purposes, the first five of these categories are of particular interest. *Dispositional trust* refers to the considerable differences between individuals, believed to origin from early trust-related experiences. *History based trust* is the cumulative result of two or more independent actors interactions and may thicken or thin depending on the outcome. Kramer suggests that when this type of trust is not possible, such as in large organizations or when time is limited, substitutes are often sought or utilized. Such substitutes may be trust based on *roles*, *rules* or *categories*. *Role-Based Trust* is a form of depersonalized trust that relies on information that a person has a certain role or position in an organization. Kramer (1999), referring to Barber (1983), Dawes (1994) and Meyerson et al. (1996), points out that it is not the person in the role that is trusted, but the system of expertise that produces and maintains the behavior that is appropriate for that particular role. *Rule-Based Trust* concerns the shared understanding within an organization regarding the norms, values and beliefs that guide individuals to a trustworthy conduct and behavior. Kramer (1999) observes that when reciprocal confidence in members’ socialization and continued adherence to a normative system is high, mutual trust can become “taken-for-granted”. *Category-Based Trust*, finally, refers to trust based on information on a person’s membership in a social category or organization.

Kramer (1999), referring to Brewer (1996), also concludes that shared membership in a group tends to attribute positive characteristics such as honesty, co-cooperativeness and trustworthiness towards other in-group members. Möllering (2001 and 2006) rejects the rational choice perspective and argues that trust goes beyond rationality. Möllering, inspired by Giddens (1991) recognition that “trust differs from weak inductive knowledge in as far as it ‘presumes a leap to commitment, a quality of “faith” which is irreducible” (Möllering, 2001, p. 410),

uses the expression “leap of faith” to describe this intangible quality of trust, an interesting perspective that we will touch upon again in our discussion.

Studying trust in physicians and medical institutions, Hall et al. (2001) find support for the notion that trust develops quickly, based on other factors than history of interaction: “Surprisingly, the length of a doctor-patient relationship or the total number of visits is only weakly associated with trust...” This indicates that patients form their impressions relatively quickly and that trust does not depend greatly on how well patients know their doctors (Hall et al., p 628). An explanation for the observations of Hall et al. may be found in the concept of Swift

Trust, introduced by Meyerson, Weick and Kramer in 1996. Meyerson et al. (1996) suggest that temporary mission specific teams develop interpersonal trusts that differ from traditional history based trust. These forms of trust, labeled *Swift Trust*, may have characteristics that borrow from some or all of Kramer’s (1999) earlier mentioned substitutes for history based trust. According to Meyer et al. (1996), Swift Trust applies to trust within temporary teams whose existence, like those of an emergent emergency response organization or network, is formed around a common task with a finite life span. Such teams consist of members with diverse skills, a limited history of working together and little prospect of working together again in the future. The tight deadlines under which these teams work leave little time for relationship building. Because the time pressure hinders team members developing interpersonal relations, members import expectations of trust from other settings. Thus, individuals in temporary groups initially use category-driven information processing to form stereotypical impressions of others. The authors mean that trust is then maintained by a highly active, proactive, enthusiastic, generative style of action. Whereas traditional concepts of trust are based on interpersonal relationships, Swift Trust is initially based on broad categorical social structures and later on action. Because members start out with imported trust rather than developed trust, the level of trust may be highest at the initial stages of the co-operation: “Expectations defined in terms of categories are especially likely as people have little time to size up one another (Fiske & Taylor, 1991). Categories invoked to speed up perceptions reflect roles, industry recipes, cultural cues, and occupational- and identity-based stereotypes.” (Meyerson et al. 1996, p. 174.)

Meyerson et al. (1996) further suggest that the emergence of Swift Trust is related to three main factors; *vulnerability*, *confidence* and *risk*. Members in a group carry a certain degree of vulnerability, i.e. potential to be subject to unfavorable behavior

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from others. Heterogeneous groups are likely to contain varying vulnerability. For example, people with lower *rank*, or *status*, are more likely to be vulnerable than equals. Swift Trust is more likely to emerge if all are equally vulnerable. Confidence relates to how assured a person feels about predicting the behavior of others in terms of *favourable/unfavourable*. Meyerson et al. (1996) further argue that Swift Trust is most likely to emerge if a group shares a 50/50 confidence about predicting the behavior of others, as they are then more inclined to look for positive signals from the other members of the group. The final factor, risk, is said to build Swift Trust by group members showing willingness to risk *failing*, which in turn encourages the rest of the group to do the same. (Meyerson et al. 1996).

Following the introduction of Swift Trust, several studies have attempted to develop the concept. The majority of these have focused on virtual teams in commercial settings, such as Jarvenpaa & Leidner (1997), who concluded that "...trust in virtual teams appears to be somewhat depersonalized, but perhaps not as depersonalized as described in Meyerson et al.'s swift trust (1996). Also, trust may be initially created rather than imported, via communication behaviors in global virtual teams." (Jarvenpaa & Leidner, p. 812). To our knowledge, there is only one non-virtual *a priori* study of Swift Trust in a non-virtual temporary group setting – Lester (2006) examined how leaders can accelerate follower attributed trust in leaders and found support for the existence of Swift Trust as well as indications that it contains an affective component. We feel that Lester's (2006) findings support our view on trust as a multidimensional, contextual and task related construct.

Since this article is focused on the context of emergency response management the concept of trust here is likely to be understood as a constituent of conceptual ideas about leadership, cooperation, coordination etc. The importance of trust and the way that responding agents form network-like structures has not been given the same attention as research on trust in the field of economics, trust in the relation between patients and professionals or trust from a political or media perspective.

3 Empirical findings

During the analysis of the interview data several themes and sub-themes emerged. The themes were identified through systematically studying the transcripts and arranging the core responses to the recurring questions in a matrix. The themes are presented in Table 1, which is followed by a presentation and discussion of the information that supported them.

Table 1

Theme	<i>Sub-Theme(s)</i>
<p>The constitution of trust</p> <p>Qualities of trustee (Why they are trusted)</p> <p>Consequences of trust relationships</p>	<p>Expectation Context dependency</p> <p>Experience/Competence/Skills Reputation</p> <p>The effectiveness in communication Preference Networking</p>
<p>Flexibility and adaptation</p>	

Themes emerged when analyzing the interviews

3.1 The constitution of trust

3.1.1 General constitution

As mentioned in the literature review, the concept of trust is hard to capture, and means different things for different people in different situations.

“...includes respect...is also understanding that they have the competence to actually carry out tasks and finally the trust is actually that that person will give me due respect, credibility etc in return.” (Respondent I)

“...you would expect that a person would do what you want them to do..” (Respondent II)

“Basically someone who you can rely on” (Respondent III)

“..if they keep the word if they say they are going to do something then you can rely on that thing. “ (Respondent III)

Expectation appears to be central when discussing the meaning of trust. All of the respondents focused during the interview on competence as one of the main factors that constitute trust, which is in line with what Barbalet (2005) contends is a common definition among theorists. The expectation that the trustee will do what he or she says or indicates he or she will do was a frequent description. Talking about trust in a general way gave rise sometimes, to an abstract dialogue between me and the respondent that necessarily had to be focused.

3.1.2 Context dependency

Since the concept of trust is difficult to grasp, most of the respondents preferred to give examples, real or hypothetical, whereby discussions on trust could be applied. It became clear that a person may be trusted in one situation but not in another. It is hard to say if trust among emergency response managers clearly could be described as something non-generalizable because it is built on elements like the trustee's competence, a key factor that probably could be applied in many other contexts. Nevertheless, an emergency response environment puts relatively unique demands on individuals and their capabilities.

“..in a non-emergency situation it's a totally different ball game..” (Respondent V)

One thing that seemed to impinge on how trust was treated in an emergency response situation was that there is a general expectation of the trustee because of her/his formal position in an emergency response system. The system itself constructs both formal and informal demands on the individuals and in a stressful situation one would suspect that these circumstances create special frameworks for the interpretation of trust. Trusting somebody to repair your car is simply not the same as trusting somebody in a situation where other issues are on stake. One could argue that the difference lies in the risk component of trust which naturally is magnified when life, property and environment are threatened, especially when the trustor's life and health are directly jeopardized, but there might also be other disparities. The following quotes show how some of the respondents wanted to further distinguish between trust in an emergency response situation and trust under other circumstances. Some of the expectations of the trustee may possibly be referred, not to the individual herself, but to the response system as a whole.

“Fire ground trust is not corporate trust” (Respondent IV)

“...in an emergency situation you have to do your job.” (Respondent V)

“...fire services trust each other because they have their role in emergency response and a lot of culture is built up because of that... so there is a lot of trust there...” (Respondent IV)

“...means that you have confidence in the people you are working with and also in the system as a whole” (Respondent IV)

“trust on the fire ground is a different kettle of fish because there is lots of people on the fire ground who I would not trust because I don't believe they know what they are doing” (Respondent II)

“..I do trust them because they are one of our group but also I have seen them work lots of times and they are doing a really good job...” (Respondent II)

This context dependency could be further examined. It is possible that an on-site position implies other characteristics for trust compared to a senior managerial position where activities like coordination are more in focus. The feedback deriving from different decisions is more direct and the characteristics of the trustee will possibly manifest in a more concrete and practical way compared to what occurs at higher managerial levels where long timescales and comprehensive

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goals are more in focus. None of the respondents could be regarded as a representative from the highest command levels but all had some sort of liaison function, which was of interest in this study.

3.2 Qualities of trustee

3.2.1 Experience/competence/Skills

Experience and professional skills were often mentioned as reasons why one person could be trusted for a certain task and not another. During the interviews tasks and their outcomes appeared to be a spontaneous way to apply the abstract concept of trust. If an officer was judged to have the capabilities to perform a certain task (and she or he would do it), there was a trust relation between the trustor and the trustee. Not all mentioned how the trustee viewed the trustor and whether this relationship was included in the concept of trust. There also seemed to be a relatively high confidence in the skills of colleagues and decision makers from other similar response organizations. There were contradictions to this too. See *preference* below.

“What underpins that relationship is competence, capacity and experience...”
(Respondent VI)

3.2.2 Reputation

If the trustor was not able to judge whether someone else could be trusted (or not) by own eyes, reputation seemed to be another way of assess if there was a trust relation or not.

“...could be rank related...” (Respondent IV)

During the interviews this issue was not profoundly investigated but as mentioned above all the respondents expressed confidence in their own systems.

“If people are actually asked to do something from above in a fire ground situation it is never a problem with that” (Respondent V)

Respondent III meant that the professionals should know what they are doing and declared that he initially had this approach to official highly ranked individuals who also showed high self esteem, but it could easily change if the person did not live up to this expectation. The outcome of such a situation could be regarded as

distrust, in these contexts the opposite phenomenon mainly constituted by the contrary factors for trust: bad reputation, lack of experience and incompetence. Bad reputation, both individual and organizational, may well be a dominant barrier when forming a trust relation with an individual. A more subtle attitude that came to light when examining some of the transcriptions, was that there was a link between “not-having-the-same-opinion” and distrust. Criticism from the potential trustee could possibly also be a barrier for trust building.

3.3. The consequences of trust relationships

3.3.1 The effectiveness in communication

Trust among professionals in an emergency response situation, or in any situation, is observably important for the effectiveness in the flow of communication. All of the respondents denote that trust or distrust affects the communication. Of course trust or distrust are not the only two alternatives in a relationship, the amount varies and a relation could logically be viewed as neutral. This was not discussed with the participants, however some used “degree of trust” when describing the consequences of the concept. On the basis of the transcriptions trusting somebody reduces obstructions in communication.

“...the enthusiasm and the speed that is carried out might change depending on the relationship.” (Respondent V)

“..you gonna automatically accept what he says straight away and so..” (Respondent IV)

“A it delays things. B it may lead to making an inappropriate decision. So to me that degree of trust is very important... (Respondent I)

It was interesting to see how the focus of trust shifted from being something in the relation to another to become an expression for something broader. The respondents at times, without being directed, changed positions and adopted the perspective of the one who performs tasks instead of requesting or commanding them. However the constitution of trust seems to be unchanged. The concept of acceptance could be used to describe the positive effect of a trust relation. Acceptance reduces doubt which in turn enhances the enthusiasm and speed of communication, almost certainly something of great importance in stressful environments.

3.3.2 Preference

When asking the question if they had experienced situations in their professional life when trust for another person has been the reason for them to contact him or her instead of another more likely to be contacted according to the formal organization structure, all of the respondents answered yes and sometimes with emphasis.

“Definitely, definitely without doubt” (Respondent V)

“...you go for the person you trust rather than the person...the paper says that you should contact Fred but you go...o yea, but Bill will probably do a better job so you go and see Bill.” (Respondent II)

This might not be a surprise for some, but it certainly is a reality that trust could have an effect on the structure of decision makers in an emergency response situation.

3.3.3 Networking

One of the hypotheses I had when writing this article was that networks built on trust sometimes were important for effective emergency response management. A network built on trust does not necessarily have to be identical to networks built on just formal relations, which make them interesting for empirical studies. In these networks, especially if we regard competence as a key factor for building trust, we are perhaps able to find and analyze more important conditions for effective management. Several of the respondents discussed networks and their importance. They also stated that flexibility and adaptation were necessary for a response system and that the decision makers need to have flexibility towards different solutions to a problem. This sometimes includes using contacts based on trust rather than formality.

“At the end of the day my role is to glue an incident and the quicker I can do that the better for all concerns, so I’ve been looking for the right experts...” (Respondent III)

“If you have an emergency manager, very effective and good, day to day working relationships and networks with people that are directly under you, you generally find that you have a lot more support, information, alternative ways of doing

things. Choices made available to you how you actually can perform the tasks that are required. The better you are at doing this sort of work, the more you realize that you pass a lot of your decisions.” (Respondent V)

3.3.4. Flexibility and adaptation

This theme is an “additional benefit” based on one of the initial questions. I was interested in how the respondents interpreted these often used phrases. The association with the concept of trust and its consequences is apparent. A rigid mechanical structure and its constituent procedures limit the potential for trust as an important condition for the outcome of emergency response procedures by logic and vice versa. For example if the organization does not allow the decision maker to choose whom to contact in a certain situation, then the role of trust as a selective factor loses some its assumed important potential to influence the structure of decision makers.

The respondents in general answered that there is an amount of flexibility in their organization, but at the same time a structured framework. One of the respondents expressed:

“We have done a lot of work the last couple of years to ensure that the structure is flexible” (Respondent III)

Some emphasized that the commander had a lot of authority and therefore was allowed to be creative in different solutions. One stated that you have to work with definite standard operational procedures and therefore it was hard to call the organization flexible. Flexibility in what sense? – is a valid question to ask. Many of the respondents followed the line of reasoning to the accident scene and related flexibility to tactical choices. My intention was more oriented to how the structure in the formal organization could be changed to meet different demands. Some positions in the response organizations are fixed, but others could be added or removed depending on the situation. It appeared to me that both the words flexibility and adaptation need to be anchored to a specific situation with different options of action. At the same time the previous themes suggest that trust can be an incitement for example choosing whom to contact. The organizational structure, or the organization as a system, must consequently be equipped with some flexibility to allow this to happen. The relation between control functions and organizational flexibility or adaptation capability should be further investigated. This theme highlights a problem area, but based on this particular enquiry the respondents representing different organizations all meant that there is

an amount of flexibility depending on the context. One organization had obviously the ambition to officially implement this feature and had also looked at how the structure aligned with other emergency services' structures.

4 Discussion

4.1. The meaning of trust

On the basis of the literature review, the interviews and earlier experience, trust is to be seen as an important phenomenon when discussing emergency response. Generally trust may be understood as a context dependent directed link attribute between two different agents in a network, based on the estimation of intentions and the competence of the other. The mechanisms behind trust include the self-referential confidence in the trustor's own judgment of the trustee's qualities, something that also was manifested by some of the respondents during the interviews. In other words trust as a concept should be focused on how the trustor appraises the qualities of the other and not on the actual intentions and competence of the trustee.

Kramer's (1999) categorization of bases for trust could be applied to the results in the interview study. Based both on the interviews and earlier understanding, history-based trust seems to be central when it comes to how decision makers refer to trust. This also corresponds to the impression we got that there often, but not always, is a personal relation between the trustor and the trustee when discussing trust as a reason why some contact links in response operations were established outside the formal structure or procedure. According to Kramer (1999) trust thickens or thins as a function of cumulative interaction. The expectations about someone's behavior change over time and experience validates or discredits this.

A factual situation where a trust relation is manifested consequently involves a component of vulnerability, and vulnerability involves risk. Many of the respondents expressed that trust in an emergency response operation was combined with particular conditions. It is reasonable to say that the risk component under these circumstances has another character than it has when discussing trust between a car dealer and a buyer.

Risk in an emergency response operation involves the trustor, the trustee and third party and may be life threatening for all three categories. Despite sharing the same physical risk, there may however be a difference between professionals and bystanders. Professionals, expected to perform according to their training, also risk their reputation, whereas bystanders have no such pressures to act other than perhaps morally and ethically. Risk in the car showroom, involving the car buyer (trustor) and the car salesperson (trustee) is different as mainly economical values are at stake, although the perceived vulnerability may be just as great as in a emergency response operation – the professional may have such confidence in themselves, their colleagues and their equipment, that they perceive little risk. The car buyer may be handing over many years of savings as down payment, risking personal bankruptcy if the car turns out to be a bad apple. They are likely to feel that they are taking a great personal risk. As observers we may not agree, but that is beside the point. Risk and vulnerability are not objective, rational and measurable values but emic properties of the trustor and trustee, related to the context. The point here is that neither can any situation be said to, as a rule, carry greater perceived risk than another. Nor is the perceived level of risk necessarily constant throughout the development, culmination and closure of a situation. However, we feel that it is reasonable to believe that an emergency response operation, with a certain set of actors, escalating from non-life threatening to life threatening, is by the same set of actors likely to be perceived as carrying more risk than before.

As mentioned, life, health and environment are sometimes directly at stake in an emergency or disaster situation – the life and health of the trustor, the trustee and other people affected by the situation. Several respondents in the interview study conveyed their trust in their own system and that people in general would do what is expected. Emergency services like the fire brigade could be regarded as a kind of highly reliable organization (Perrow 1984, Weick and Roberts 1993) of good repute depending on the work they do. Depersonalized trust, like category-based trust (Kramer, 1999), probably influences how different decision makers predicate the capabilities and intentions of others. One could claim that, in general, there is a positive orientation towards colleagues and personnel from similar organizational categories, not only depending on familiarities and knowledge about their work procedures, but also depending on the trustees belonging to an organization with high levels of trustworthiness from a societal perspective. At the same time, concurrence and competition could encourage an opposite and negative orientation, something that also came to light during the interviews. Kramer claims that role occupancy sometimes signals both intent to fulfill role

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obligations and competency in carrying them out. This was also noticeable in the interview material. Important to note here is that the respondents represented commanding and comparable positions at relatively high hierarchical levels. In view of the discussion above, we see that Möllering's proposed definition of trust harmonizes with our interpretations of the interview material: "trust is an ongoing process of building on reason, routine, and reflexivity, suspending irreducible social vulnerability and uncertainty *as if* they were favorably resolved, and maintaining a state of favourable expectation towards the actions and intentions of more or less specific others (Möllering, 2006, p. 111)

Möllering suggests that trust is unique in that it requires a leap of faith not required in reason, routine or reflectivity alone. Trust goes beyond these three dimensions and is not an aggregate of the three - suspense has to be added. Möllering explains the role of reason as a passing stage arguing that decisions cannot be made in a strictly calculative way, i.e. when reason ends. Routine is linked to e.g. institutions that we trust, as they enable us to carry out our every day lives without thinking much about it – we take for granted that society will work today too, just like it did yesterday. We trust as a matter of routine. Reflexivity, finally, labels the gradual process of interaction beginning with small steps, in which trust is the outcome (Möllering, 2006, p. 106).

4.2 Swift trust

A set of agents (decision makers) and their trust relations could be seen from a network perspective. Whereas established networks often seem to be based on history based trust between the actors involved, some emergent networks to us seem to work along different sets of trust, at least to a degree. An emergent network could consist or include agents that do not share a history or have "predetermined" opinions on others.

We argue that the successful integration of such new and unknown agents into a network during an emergency response rely on trust that corresponds to the concept of *Swift Trust*. (Meyerson et al., 1996). We find that the respondents reflect the perspective that role based trusts apply to those they have no previous history with. ("fire services trust each other because they have their role in emergency response and a lot of culture is built up because of that... so there is a lot of trust there..." Respondent IV) This corresponds with the Meyerson et al. (1996) theory that individuals in temporary groups initially use category-driven information processing to form stereotypical impressions of others. The Swift Trust is then "...maintained by a highly active, proactive, enthusiastic, generative

style of action...” (Meyerson et al.,1996), a description that applies to emergency responses.

4.3 Consequences of trust

On the basis of the interviews trust seems to be able to improve effectiveness in communication and therefore reasonably improve operational action. It can also be seen a decisive criterion or an incitement for individual interaction and (hence) constitute a foundation for functional networks of various decision makers. These findings correspond to Mishra’s (1996) hypothesis that undistorted communication will increase the speed and degree to which adequate resources are developed to solve the crisis and Miles’ and Snow’s (1992) argument that trust promotes adaptive organizational behavior, such as network formations. Adaptive organizational behavior can be linked to Wachtendorf’s (2004) reasoning on improvisation in which she includes the concept of trust and stresses its importance for effective information distribution. Effectiveness in communication is, without a doubt, of importance when it comes to effective emergency response management. We believe that emerging networks tend to involve as many “known” actors as possible. If this is the case we speculate that it may be crucial that actors are allowed a carefully balanced flexibility that enables them to build and exploit such a network whilst retaining traceability and a clear picture of mandates and responsibilities. One of the questions asked in the interviews was if the respondent felt that there was any flexibility in their organization. The respondents representing different organizations all stated that there is an amount of flexibility depending on the context (One organization had obviously the ambition to officially implement this feature and had also looked how the structure was aligning with other emergency services’ structures.) but we note that they referred to tactical settings only. This suggests to us that such flexibility is not a consciously driven culture on other levels than tactical. If this is true, we find that preparation activities like planning and exercising procedures are likely to support the aim of enabling an effective organizational build-up in case of an emergency, but that it may not be enough to make full use of the potential in emergent functional networks. The organization must also train and prepare for the flexibility needed to adapt to unexpected unfolding situations.

Lack of experience or incompetence are examples of characteristics that promote distrust. These examples could be seen as contrary factors to trust. However, we oppose the view that trust and distrust are polar opposites, arguing that it is possible to trust and distrust someone at the same time based on the supported view presented above that trust is task- and context specific. A more subtle

attitude that came to light when examining some of the transcriptions from the interviews, was that there seems to be a link between “not-having-the-same-opinion” and distrust. Distrust may be a dominant barrier for effective coordination. Distrust may also affect how internal procedures are carried out. Individuals can be disregarded, and burdened with distrust against others who were expected to behave in a certain manner but did not because of lack of mutual trust. This is something that will impinge on future communication in line with Kramer’s (1999) history based trust. These are issues that cannot be solved through more sophisticated information technology or rigid operational guidelines. Trust has also been investigated predominantly from an individual perspective. The result of the trustor’s appraisal for the trustee’s competence and behavior might not be aligned with what should be the most appropriate according to the comprehensive objective of the response operation.

5 Concluding remarks

An interesting question to consider is whether the problems and benefits relating to trust are substantiated in exercises and simulated environments. Individual qualities such as competence may well be manifested, but what could be described as emergent phenomena –like adapted functional networks – expected to appear in real crisis situations, are restricted by the framework of exercises. These types of phenomena are of ad-hoc nature, context dependent and influenced by the trust relation between different individuals from all sorts of professional and non-professional organizations. As both the literature review and the interviews suggest, the context dependency when discussing trust is decisive. Exercises are perhaps a good way to find out about weaknesses and strengths in information systems, procedures and individual capabilities, but have many times not the potential to stimulate the creativity that conceivably is necessary, and also appears, in real response systems and processes –The creativity to overlook predetermined behavior to solve a specific task. Contacting a person from outside the formal response structure because of their special capabilities and trustworthiness could be seen as an example.

This study suggests that the concept of trust among decision makers in an emergency response situation has many similarities with trust in general, but because of the context dependent nature it needs to be given substance in the specific circumstances that comprise emergency response and the specific risk aspect that must be taken into consideration. Trust can be seen as a relation based on the trustor’s appraisal for the trustee’s competence and expected behavior, in

turn partly formed by preceding experience or reputation. The results from the interviews support previous research which implies that trust is important for undistorted information. Trust could be a latent and important condition for functional informal networking processes in emergency response processes. Moreover, there is arguably a link between trust and the flexibility and adaptation capability in emergency response systems. Future research should try to study the possible conflict between trust relations and formal structure and procedures and further examine the consequences of trust related to the needs of effective emergency or crisis response management.

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Appendix – Paper III

Paper III

Multi-organizational Emergency Response Management

Analysing Emergency Response Systems

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Abstract

We suggest a method that can be used for analysing an emergency response system. Both the literature and empirical findings indicate that response operations sometimes diverge from existing plans when adapting to an event and its consequences. The method, which aims at achieving a better understanding of emergency response management, adopts a systems perspective using various relationships that exist or develop between personnel belonging to those organisations that are part of the emergency response operation. Results of a study of such an emergency response system are presented and discussed in order to demonstrate how the method can be employed.

Introduction

When a society is affected by a sudden perturbation in which life, property, the environment or social values are threatened, various organisations become involved in an attempt to reduce the negative consequences of the event in question. The personnel and artefacts involved in a response operation forms an *emergency response system*. To obtain a better understanding of the capabilities of an emergency response system, greater insight into the dynamic processes involved when such a system responds to a perturbation is needed.

Many accounts and analyses of disasters and crises are contained in the literature. Although such accounts can deal with a wide variety of elements of the emergency response system, not all of these accounts adopt a holistic perspective in an effort to understand the performance of the system as a whole. In many cases there are reasons enough for not attempting to perform such a study, since in large-scale crises there can be hundreds of organisations involved in the response. Therefore, data-gathering can be extremely difficult, at least if one endeavours to take account of each of these organisations

separately. Nevertheless, if one aims at increasing one's knowledge of how a system of this sort, which consists of many different organisations, responds to a crisis, one is more or less forced to employ a holistic approach. This is especially true if the interdependencies among the various organisations are strong. One way of dealing with the data-gathering problem is to use data that is easily accessible and does not require that each of the organisations are investigated in detail. An excellent example of this approach is Comfort and Haase's analysis of the emergency response system in New Orleans following hurricane Katrina (Comfort & Haase, 2006). They used content analysis of the news on the hurricane reported in major New Orleans newspapers in order to obtain knowledge concerning a network of organisations that had contact with each other during the hurricane and its aftermath. Their analysis was holistic in the sense that it sought to identify all of the organisations involved in the response and the contacts between them.

Comfort and Haase's approach is consistent with a systems perspective, which involves the view that to understand a phenomenon one needs to take account of the various elements of the system in question and the interactions between them. Another example of such an approach is Comfort and Kapucu's (2006) analysis of interactions among various organisations following the terrorist attack on September 11. We adopt a systems perspective here too in our efforts to understand how an emergency response system meets the needs created by a disaster or catastrophe. However, whereas Comfort and Haase used organisations as their unit of analysis, our approach focuses on the personnel engaged in the response operations and the interactions between them. We believe that our approach has certain advantages as compared to an analysis using the different organisations as the smallest unit of analysis.

First of all, we believe that various phenomena described in the literature, such as emergent groups (Dynes, 1970), the effect of trust on the emergency response operation (Krackhardt & Stern, 1988) and boundary spanners (Mulford, 1984 and Kapucu 2006), can best be studied if one employs the different agents (personnel) as the smallest unit of analysis and adopts a systems perspective. Although it is possible to study these different phenomena without employing a systems perspective, we believe one's understanding of them can benefit from interpreting the actions of the various agents from a perspective that emphasises the importance of the context in which the agent in question operated. For example, although it could be of interest to note that

emergent groups appeared during response operations, it could be of even greater interest to know who participated in these groups, how they related to each other both before and during the response, how they related to the formal response system, etc. To investigate such questions require relational information from various agents, e.g. who had contact with whom.

Secondly, we argue that the use of various agents' accounts of whom they interacted with during an emergency response operation increases the validity of the analysis as compared to the approach of only relying on information from the media or from official statements (e.g. public investigations). There is a risk that some of the interactions between the various agents may not be reported in the media or in official statements from the different organisations. This risk is reduced if one uses the agents' accounts of whom they interacted with in combination with information from the media and from official statements.

In the present paper we present a method that can be used to analyse an operation performed by an emergency response system. The method is based on a systems perspective that takes account of relations, taken or actively utilized during the emergency between personnel belonging to the organisations who were part of the emergency response system. The paper begins with a summary of previous research that is particularly relevant in the present context. We believe that the method we suggest for studying emergency response systems could be useful for studying the phenomena of the type dealt with in those research efforts. Since the method we discuss here has been presented elsewhere (Uhr & Johansson, 2007), the description of the method is relatively brief, our major aim being to consider how we believe the method can be of use in providing an understanding of an emergency response system. Following this account we illustrate the method by presenting an analysis of the emergency response operations following the release of 16.000 tons of sulphuric acid in the central parts of the Swedish city Helsingborg. The paper concludes with a discussion of the limitations and possible future developments of the method.

Emergence, trust and a systems approach

In attempting to understand how an emergency response system adapts to the circumstances of a perturbation that occurs and seeks to alleviate the needs of the affected population one should note the difference between descriptive and

normative models of the emergency response. Normative models, i.e. models of how things should be, have traditionally been heavily influenced by the command and control model (Neal & Phillips, 1995). However, analyses of actual crises have revealed that the descriptive power of that model is weak and that it needs to be complemented by other models (Uhr & Fredholm, 2006). One major area of criticism of the command and control model as a descriptive tool is concerned with its inability to account for the emergence of new or unexpected groups and tasks within the emergency response system (Quarantelli, 1998). In the present context we are interested in trying to understand what occurs when an emergency response system responds to a crisis and therefore such phenomena are of central interest.

Drabek and McEntire (2003), in reviewing literature concerned with emergent phenomena in a context such as the present one, conclude there to be ample evidence for emergent phenomena playing an important role during emergency response operations. They also note that the phenomena of this sort observed are not consistent with the command and control model of how the management of a crisis is conducted. In the emergency management literature, emergence appears to be generally considered as a concept dealing with spontaneity in the sense of its being concerned with structures that decision makers make use of that cannot be related directly to forethoughts such as plans and procedures, see, McEntire (2004), Drabek and McEntire (2003), Scanlon (1999), Quarantelli (1996), Kreps and Bosworth (1993), Kreps (1989), Bosworth and Kreps (1986) and Forest (1978), Dynes (1970), Neal and Phillips (1995) for example. Neal and Phillips (1995) argue that emergence is ad hoc and spontaneous. Scanlon (1999, p. 2) cites Quarantelli (1993, p. 74) who suggests that emergent phenomena “always have an element of new, novel non-traditional or non-routine”. This does not mean that there are systems conditions in a pre-disaster situation that cannot be traced and understood. The concept of emergent phenomena has been dealt with in detail by the sociological oriented literature, in which it has been categorised in terms of various types of emergence (Drabek & McEntire, 2003) within the context of disaster response. Sawyer (2001, p. 551) writes that “many accounts of the micro-macro link use the philosophical notion of emergence to argue that collective phenomena are collaboratively created by individuals yet are not reducible to explanation in terms of individuals”. This harmonizes with a common understanding of the concept summarized by researchers like De Wolf and Holvoet (2004). Emergence is a complicated concept, however, marred by

philosophical quandaries and by vagueness. Brunner and Klauninger (2003, p. 23) observes that the term emergence has become overloaded with an abundance of different meanings and Sawyer (2001) describes emergence as a “slippery concept” (p. 551) in his ambitious attempt to clarify the meaning of sociological emergence. In the light of what has been said here we will focus upon the spontaneous and ad-hoc nature of emergence and direct attention at what we consider to be structures of agents and of tasks that are of a new, novel, non-traditional, or non-routine character leaving questions of micro-macro matters largely untouched.

In the present context, the typology of emergency organisations suggested by Dynes (1970) and the extension of it as summarised by Drabek and McEntire (2003) are of particular interest. Such a typology provides a means of classifying emergent phenomena related to the structure of the tasks performed by various organisations during an emergency. Other emergent phenomena that are of interest are improvisation (Wachtendorf, 2004), self-organisation (Comfort, 1999) and boundary spanners (Mulford, 1984 and Kapucu, 2006). Such phenomena are important to identify and analyse in efforts to understand how an emergency response system adapts to the circumstances produced by a crisis. More precisely, we believe that an increased understanding of such phenomena can be achieved by studying, for example, personnel who participated in the formation of emergent groups and what relations these agents had to other agents both within the emergency response system and outside it. It would also be of interest to study the effects of trust between the various personnel participating in emergency response operations, particularly those who were part of emergent groups or displayed other types of emergent behaviour. Trust can be seen as a latent system condition that affects the manifestation of organisational structures and tasks. Qualitative information stemming from interviews, discussions, reviews of reports and participation in seminars, all of them pertaining to two emergencies that occurred in Sweden during 2004 and 2005 (one flood situation and one storm) indicate trust to have been important for how the emergency response systems involved were structured (Uhr, 2007). Meyerson, Weick and Kramer (1996), who emphasizes the importance of trust in responding effectively to crises, say that “trust facilitates rapid formulation of ad-hoc work groups” (as cited by Rousseau, Sitkin, Burt & Camerer, 1998, p. 394). Miles and Snow (1992) argue that trust promotes adaptive behaviour, such as network formation. Gambetta (1988) maintains that it enables cooperative behaviour and Kramer (1999) concludes

that trust enhances individuals' willingness to engage in various forms of spontaneous sociability. LaPorta, Lopez-de-Silanes, Shleifer and Visny (1997) indicate that several studies show both trust and social capital to strongly affect the performance of social institutions. The importance of trust in emergency management has also been noted by Krackhardt and Stern (1988).

Using agents and their relations for studying various emergent phenomena that occur within the framework of emergency management can be described as a systems approach. A systems approach means that one emphasise the importance of seeking explanations of various phenomena through identifying the elements of the system of interest and their relations to each other. Moreover, one also identifies the relations of these elements to the external environment (that which is not part of the system). Transferring these lines of thinking to the present context would mean the agents involved in an emergent group during response operations being considered to represent the elements of the system, where the relations of interest might be, for example, the extent to which the various agents involved interacted with each other and with agents outside the system during response operations. Analysing such a system could provide valuable insight into how an emergent group functions and how it relates to its immediate "environment", i.e. the other agents involved in the response operations. Studying relations between agents in an emergency response system can be performed by use of methods found within the area of social network theories, see e.g. Wasserman and Faust (1999). The methods for analysing emergencies, however, appear to a large extent to be directed at the organisational level. We believe, nevertheless, that many of the phenomena of interest, such as the neglecting of organisational boundaries, the rejection of plans and procedures, ad-hoc behaviour and the formation of emergent groups, are best studied using agents as the smallest unit of analysis. Examples of earlier analyses of emergencies include Stern's (2000) investigation of the Swedish response to the Chernobyl fallout crisis, Scanlon's (1999) analysis of emergent groups that appeared during the Ottawa Carleton's response to the 1998 ice disaster, Kendra and Wachtendorf's (2001) account of the reconstruction of the Emergency Operations Centre after its destruction in the World Trade Center attack and various others, for example Takeda and Helms (2006), Denis (1995), Wise (2006) and Comfort (1999).

Analysing an emergency response system

At 4:36 AM on February 4, 2005, a cistern on an industrial estate near a residential area in the municipality of Helsingborg in Sweden collapsed. In a short time 16 300 tons of sulphuric acid was discharged. As a result of a reaction of the sulphuric acid with salt water a cloud of poisonous gas spread towards the city. The slush that remained on the ground also threatened other similar cisterns in the area with collapse. Although the societal response involved various organisations, initially (during the first three days) the fire and rescue services were the dominant actors. Other actors included the city administrations, health care authorities, the police and the company that owned the cistern. The present account, which concerns the response process between the 4th and the 7th of February, serves as an example on how a response system could be analysed.

According to an investigation of the response operation that was reported (Danielsson & Winnberg, 2005), several deviations from the original plans were made. Interviews indicate that directing decisions and initiatives were taken by officers on the accident scene but were not negotiated or anchored with other officials. The report conveys the impression that the role of the various decision makers and organisations involved, as well as their responsibilities, were indistinct. It appears that the roles of the various staff functions were interpreted in differing ways, partly as exercising a decision function, partly as providing decision support and partly as something in between (this “blurriness” was also manifested in the response to the flood situation in southern Sweden in 2004). Danielsson and Winnberg (2005, p. 37) writes (our translation) “...occasionally the communication took any possible ways, ways that were accessible and useful”.

The report shows that several of the senior fire commanders were handpicked and summoned from other regions. One of the officers from another region said that “it was unexpected” when he was informed of this matter (Danielsson & Winnberg, 2005, p.33). This sort of thing also came to light in some of the interviews conducted in our investigation. During a seminar dealing with the response operation one of the participants, who also participated in the operation, criticised the fact that the response did not follow fixed plans or procedures. Despite this Danielsson’s and Winnberg’s report concludes that the operation functioned well. Various actors who cooperated with the rescue service(s) during the response stated that the “cooperation for the most part was

positive and well-functioning.” (Danielsson & Winnberg, 2005, p.52) In our investigation of the accident the respondents were asked to rate the success of the operation on a 1-5 scale. The mean value of these ratings was 3,6 (the median was 4).

Demonstration of a social network approach

For describing and analysing the emergency response system that responded to the release of the sulphuric acid in Helsingborg a method based on social network analysis, which has been described elsewhere (Uhr & Johansson, 2007), was employed. The aim of using the network method was to gather relevant structural data, i.e. data concerning relations between the various personnel who were involved in the emergency response. The assumption was that the combination of such relational data with interviews and document analysis would provide a better understanding of what happened during the response operation and why it happened.

Documentation from the accident was used to identify the different organisations and personnel participating in the operation. A questionnaire was then published on the internet in which the agents in question were asked to provide information regarding which other agents they had contact with during the response operation. They could also complete a questionnaire regarding the operation, for example what their formal role was, when they were active during the operation and what their opinion of the operation was. Initially the aim was to cover a complete network, e.g. gather information from all the personnel involved. To identify the agents in the network a snowballing approach (Scott, 2000 and Uhr & Johansson, 2007) was adopted. The process was started by asking representatives from various parts of the network to provide us with the names of the agents that they had had contact with, when no new agents were identified the network was considered complete. The resulting roster of people contained 80 agents from approximately 20 organisations. One should note that the focus was on personnel involved in the tactical and strategic decision making and we have thus not included, for example, the firemen that were involved in removal of the chemical sludge. All 80 people were contacted and asked to participate in the study. A total of 19 agents answered the questionnaire and provided us with information regarding their contacts during the operation. Although there are many people that did not participate in the study, we believe that the information provided by the 19 agents gave a rather good description of the response operation since these

participants were “in the centre” of the operation (see *figure 1*). Being in the centre means that many of the other people involved in the operation have answered that they had contact with the agent in question, as shown in *figure 1*. The larger the size of a node, the more people have reported that they had contact with the agent in question.

One could argue (1) that it is not possible to know if the “complete” network of agents has been identified and (2) that one cannot know who is in the centre of the network since not all agents who were identified participated in the study. However, we argue that the first issue (1) is managed by using various sources to identify people. The documents and official reports from the accident were used to identify names and organisations that participated, that source of information was complemented by information from the 19 agents who participated in the study. It is highly unlikely that anyone who had a central role in the management of the accident was neither identified in the written documents nor by the 19 participants. The second issue (2) is more difficult to deal with in an investigation of this type. Since it is highly unlikely that all the agents who participated in the management of matters pertaining to a serious crisis will answer the questions concerning who they had contact with, one always has to deal with this problem. In the present case, although most of the people involved in the emergency response were probably identified (see issue 1 above), one cannot claim that the network is complete since it lacks the edges (those who did not fill in the questionnaire), consisting of about $\frac{3}{4}$ of the people in the network. However, from the perspective of the Helsingborg Fire Brigade, it can be argued that the network is more or less complete. This means that it is unlikely that anyone from the Helsingborg Fire Brigade had contact with organisations or personnel not already identified in the network. Moreover, only a few of the 61 people who were included in the network but did not participate in the study were centrally placed there. For example, in *figure 1* one can see that only 12 of the 61 have received five or more links to them in the network.

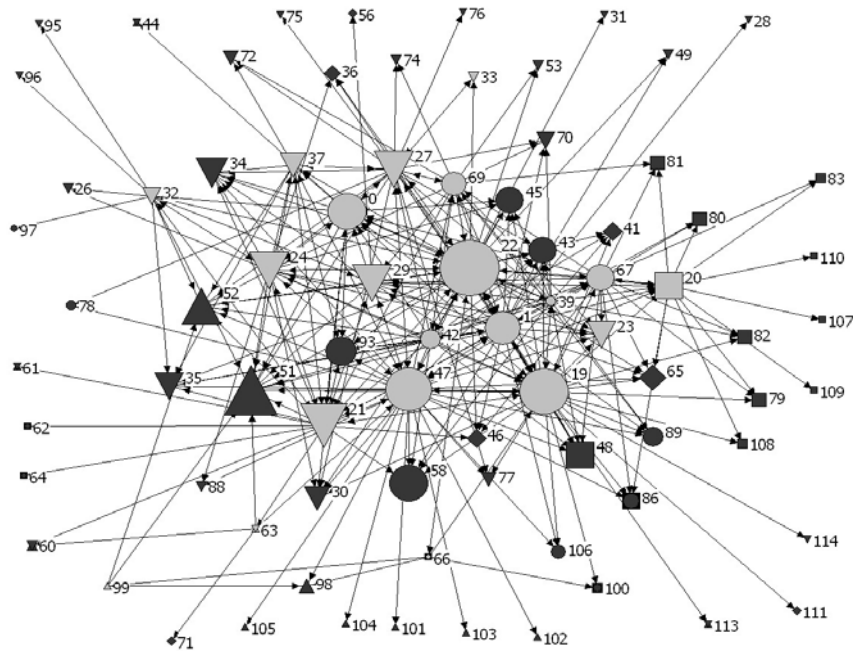
Initial interviews with decision makers were made when the response system still was engaged and preparations for the actual network study were initiated shortly after. Although our initial intention was to study the whole network (all organisations) of agents we soon shifted our attention to the Helsingborg Fire Brigade and tried to analyse the response operation from their point of view. The reason for this shift in attention was partly due to the fact that the

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Helsingborg Fire Brigade (together with various agents from other fire brigades) was the dominant actor during the emergency and partly due to the practical difficulties of getting valid responses from actors belonging to organisations that were not actively engaged in the management of the emergency (such as media).

In addition to asking the agents in the study whom they had contact with during the emergency they were also asked who were most important to them in order for them to complete their tasks and who they knew beforehand. Thus, in performing the network analysis three different types of relations between the agents were distinguished: *contact*, *importance* and *friendship*. As described above, the *contact*-relations provide an overall picture of how the agents interacted and serve as a starting point to a network analysis. Structural phenomenon like clusters could be identified and the network could be compared with structures based on other attributes, such as that of the formal organisation to which one belonged. *Importance* is a relation that unlike *contact*, could be weighted, which means that participants could rate the importance using a four category (0-3) scale. The most important agents were given 3 and the least important agents 0. Comparisons between networks constructed using the *importance*-relation and formal bureaucratic structures and roles could provide the analyst with valuable insights. Relations such as acquaintance would appear, according to reason and experience, to influence the structures of decision makers' contacts with each other, and thus how an emergency response system in general is built up. The interviews that were conducted support the notion that the process of "finding suitable personnel for certain tasks" in an emergency is of importance for emergency managers. The concept of trust (Uhr & Ekman, 2008) would readily be involved.

In *figure 1* we present a visualisation of the network containing contact relations between agents, together with the node attributes *organisational belonging* and the number of links directed at the individual nodes. The latter attribute is displayed by means of the size of the nodes.



- Helsingborg Fire Brigade
- ▽ Other Fire and Rescue Services
- △ The Company
- City of Helsingborg – other administrations
- ⊠ The Police
- ◻ The county administrative board
- ◇ Other org. (predominantly private)
- Participants active in the study
- Referred by others

Figure 1. Contact relations and organisational belonging

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It is important to emphasize the fact that the network shown here summarizes the course of events and that the agents were not all active at once. Every responder provided us with the time for their first and last action, which contributed to an understanding of the dynamics of the network. *Figure 1* illustrates an empirical structural example of Dynes' (1970) type II organisation – expanding organisations with regular tasks. In managing the emergency, Helsingborg Fire Brigade did include personnel from other fire and rescue services to be part of their organisation, for example agent 21, 24, 29, 27 and 37. According to Dynes (1970) the core of this type of organisation exists prior to the disaster event and they are often a result of community and organisational planning. Not all of the contacts in the present case could be related to formal planning though. An answer to why such agents (without a pre-planned formal role) are included in the network can possibly be found in *Figure 3* that illustrates personal relations. These agents, with no official connection to Helsingborg Fire Brigade, were likely included in the operation due to their personal relations with other agents, which can be seen as a manifestation of an emergent phenomenon. This hypothesis was further strengthened by the qualitative data from the survey. Furthermore, *Figure 1* reveals other interesting phenomena, such as agent number 51 and 21 who are boundary spanners between Helsingborg Fire Brigade and the Company. This interpretation is supported by the illustration in *Figure 2* in which agent 51 and 21 are regarded as important by many of the other agents. It is likely that their position as a link between the Company and Helsingborg Fire Brigade made them important for the other agents.

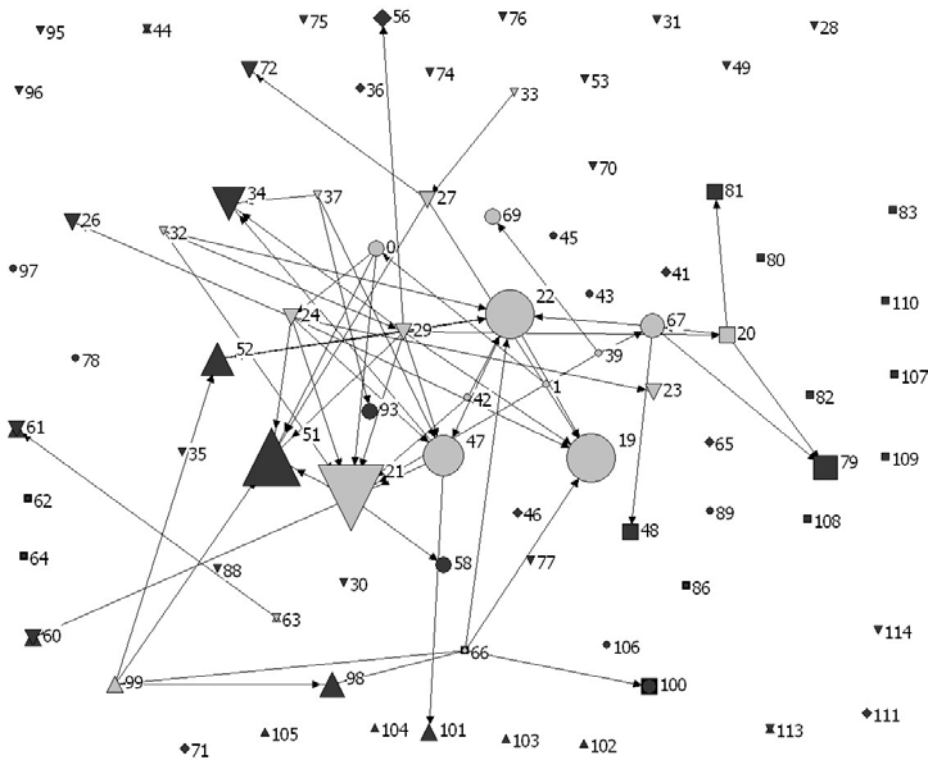


Figure 2. Most important relations and organisational belonging

Figure 2 shows the relation attribute “most important relations” and the size of the nodes represents the number of relations directed to the particular node. During the mapping process the participants had the possibility of using a three-point scale to indicate the strength in the relations in question. Figure 2 shows the strongest relation (most important relation) only. All the nodes are positioned at the same places as in Figure 1 in order to simplify comparisons of the two networks. The figure shows partial agreement with the network that consists of contacts only, but the centrality of several of the nodes in Figure 1 does not come into view in Figure 2. Node numbers 1, 24, 27, 29 and 58 are examples in which the proportional degree of centrality (given the smaller sum of links) becomes weaker when importance instead of simply contact is shown.

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Very few of the respondents who answered the question of whom they found to be of particular importance showed relations to each other, i.e. node A refers to B whereas B refers to someone else. Many links, all of them from the fire and rescue services, point to node 21, it in its turn showing to 51, 48 and 60, none of whom belonged to the fire and rescue services. As noted previously, agent 21 could be regarded as a boundary spanner who serves as a link between different organisations. Number 21 was the first on-scene commander engaged in the response process. The analysis of the qualitative data, collected through the web questionnaire confirms these conclusions.

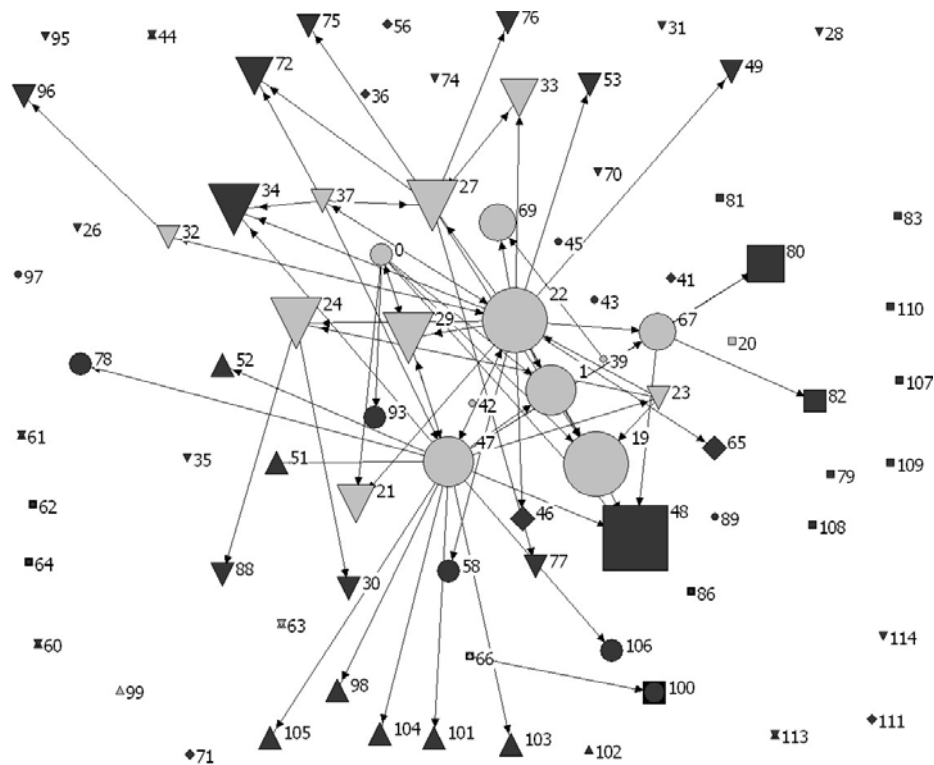


Figure 3. Personal relations and organisational belonging

Figure 3 demonstrates a network based on the strongest type of friendship relation on a scale inspired by a network study conducted by Krackhardt

(1988). The 5-grade scale consists of link attributes from “don’t know by name” to “trust as a friend”. The size of the nodes is proportional to the number of links a particular node has directed at it. We are aware of the concept of trust being context dependence (Uhr & Ekman, 2008) and that a very good friend still may not be trusted for special tasks. In “trust as a friend” (see Krackhardt, 1988) we accept “trust” as a measure of strength in the friendship relation. It is of interest to note that several nodes in the periphery are agents seen as good friends, at the same time as these agents have few contact links in *Figure 1*. It is worth noting that sometimes the only contact link is a strong friendship link. This leads us to believe that the reason why those agents were involved in the response operation is because they knew someone who was at the centre of the operation. One example of this is agent 47, who has contact ties to five agents who had not been in contact with any of the other agents belonging to the Helsingborg Fire Brigade (see figure 1). In addition, four of these five agents were categorised as very close friends by agent 47. *Figure 3* also illustrates the fact that many of the enlarged nodes (an agent who a considerable number of agents reported having strong friendship relations with) does not only belong to the Helsingborg Fire Brigade but also belong to other fire and rescue services as well as to the City of Helsingborg. This indicates that there are strong personal ties between Helsingborg Fire Brigade and these other organisations.

Examples of analysis of qualitative data

The questionnaire used in collecting the network information also provided us with added information about how respondents interpreted the response. We hoped that by asking the straightforward questions “What do you think functioned well during the response?” and “What do you think functioned poorly?” we could gather supplementary qualitative data in an exploratory way that could be used in an analysis of its own and be compared with the network data (as regards both structural findings and individual attributes) as well as with reports about the accident. In addition to these two questions, we added a “free text” field in which the respondents could develop their thoughts about the response in general or provide comments on our method.

Since our study focused on only part of the response system our empirical findings cannot be generalized to the response as a whole. In this connection, as in many others, one needs to put considerable effort into the description of the system involved but be conscious of the limitations of the conclusions based on it. The respondents in the study could be characterized to a

considerable extent as decision makers in senior positions. The majority belongs to different fire and rescue services, but agents from other administrations and from the private company have also participated in the study.

The answers provided by the participants were categorized in terms of themes. In this section we discuss the dominant themes based on the answers in the given questionnaire. Factors that appeared to contribute to a well functioning response were: *legibility, communication, cooperation, and knowledge of people*. Legibility refers to known formal organisational structures and clear directives. On the basis of the data we interpret what was understood as being good communication to involve good qualities of information and adequate distribution of it. The cooperation category simply catches basically synonymous phrases implying cooperation used by the responders. Knowledge of people could be related to both communication and cooperation but was only mentioned by participants as something that had a positive effect on their work, without it being analysed or discussed by them. Factors that were regarded as problems and as contributing negatively to the response could be generalized into *problems in getting an overall picture, problem in receiving relevant information and communication problems*. The problem of getting an overall picture relates to difficulties in grasping the response organisation, or parts of it, in understanding who was responsible for what, and obscurity in decision mandates. Information and communication problems could be seen as in part being the reasons for the difficulties in getting an overall picture. Some of the respondents concretized this issue and wrote that it made the decision making processes more complicated. Since the communication during the emergency also was perceived positively (see above), these findings are indeed somewhat paradoxical. This incongruence could be found both in the individual answers of participants and in the compilation of the material. Very likely the responders referred to different parts of the complex response system, doing so from many different standpoints. This finding indicates the intricate problems involved in analysing and, above all, evaluating such a system. In a comparison with the results of the analysis of the networks presented earlier we can attest to the complexity of the response system. Even if we focus on a subset of the system, numerous interactions between agents from various organisations with quite different formal roles can be identified. *Figure 3*, which shows the strongest types of friendship relations, indicates that agents located in the periphery of a given network (due to them having few connections) could at the

same time have strong friendship relations with individual agents located in the centre of the network. In a comparison with the structure at the periphery in *figure 2* and *figure 3*, we see that not many of the agents with strong friendship relations are considered by the respondents generally as being their most important contacts. The correspondence between strong friendship and importance here is vague, although the qualitative data support the conclusion that knowledge of people is an important latent condition for the development of a response system.

In comparing our findings with the results of the interviews conducted by Danielson and Winnberg (2005), we observe that the problems in understanding the response organisation as a whole, and the sometimes vague decision structures, are described as negative aspects of the emergency operation in both studies.

Discussion

One aspect of the emergency response operation not visible in the network illustrations (*Figure 1-3*) is how the networks evolved over time. All of the people involved in the present study were not active at the same time, something that cannot be seen in the networks. We did, however, collect information regarding when the agents were active and it would therefore, to some extent, be possible to illustrate the dynamic development of the networks. The operation continued for a longer time period than a “normal” operation, something that contributed to the fact that individuals from other professional bodies, not involved at the start, had to be brought in and be integrated with the pre-designed structures. Having personal contacts with individuals from other organisations was of clear value for senior managers when finding such people. This illustrates that personal relations, that are not normally incorporated into plans or bureaucratic structures, can be of importance for a functional response system.

Danielsson and Winnberg (2005) concluded that the distribution of authority in the emergency response was often unclear and sometimes confusing. This observation was also made when analysing the data collected from the web questionnaires. Those results also indicated the complexity of the response operation. The method presented here is a tool for collecting and analysing data with the aim of exploring and gaining an understanding of such complex operations. Furthermore, the method also provides the possibility of conducting

in-depth studies with specific agents such as boundary spanners or agents that several other agents regarded as being truly important. The networks and the interviews also support the notion that emergent constellations occur in response operations and that such constellations can have a clear impact on the response process.

Studying emergency response systems using the network approach presented here has certain limitations. Obviously, in major crises with many organisations involved it is clearly unrealistic to include all people involved in the operation. In such cases, it can therefore be practically impossible to cover a “complete” network. Instead, one can then focus on a part of the network, which was the case in the present study, or one could use organisations as the unit of analysis so as to decrease the number of people that needs to be interviewed. The drawback of handling the greater size (number of nodes) of the network needs to be weighted against the positive aspects of collecting network data on the individual level. Another aspect that one needs to consider is how to define which agents to include in the network analysis. In the present study, for example, we started with the intention of collecting information on all agents that were part of the emergency response system. However, one could have limited the number of people included in the study by only identifying people that worked on the scene of the accident, in a specific organisation, etc. In the end, our data did not become complete enough so that we can claim that we have covered the complete network of people involved in the emergency. Instead, our data gives us good information regarding one actor, Helsingborg Fire Department, and its connections to other actors.

In our analysis of the network data and the interviews conducted we find evidence that the emergency response operation to some extent deviated from the plans that were established before the emergency. We believe that in the present context this can actually be functional. In planning processes and in bureaucratic structures too little attention appears to the fact that a complex and dynamic environment can call for certain flexibility in organisation, plans and procedures. With this, we do not mean to say that rigid structures and clear decision mandates are entirely dysfunctional characteristics of a response system. Rather, we believe that decision makers at a high system level should be aware of the versatility within the system and aim for a balance between top-down and bottom-up influences. We consider the approach presented here to be useful for obtaining understanding of empirical phenomena and thus to

increase the possibilities of the society for dealing adequately with emergency situations.

In further advancing our understanding of the phenomena there is a need for future research in this area intended to improve the data collection process and analysis of a response system. The need is not one of creating new and more sophisticated calculation or simulation methods or performing academic juggling of network data, but of developing better routines and greater precision in the process of mapping and analysis so as to be able to better understand the reality of emergency response and enable normative strategies based on valid empirical findings to be adequately developed.

Conclusions

A method for analysing emergency response operations using a systems approach as a starting point is presented herein. The method is based on three sources of evidence: (1) analysis of documents pertaining to the emergency, (2) interviews with agents involved in the response operation and (3) social network analysis. The social network analysis is the key part in this method since it provides a way of finding important people (such as boundary spanners) that can be interviewed, and it illustrates the connections (of various types) among the people involved in the response operation. These connections can then be used to draw conclusions regarding many phenomena that are of interest in the study of emergency response systems.

Examples of such phenomenon that have been identified and analysed in the present paper includes the presence of *emergent phenomena* in emergency response operations, *expanding organisations*, *boundary spanners* and the effect of *trust* in emergency response systems. In summary, the social network approach contributed to the study of these phenomena in the following ways:

- It improved our ability to identify *emergent phenomena* (Drabek & McEntire, 2003), e.g. involvement of personnel from other fire departments than Helsingborg's that were not included in any formal plans. Examples of such personnel can be seen in *figure 1* (agent 33, 74 and 75).
- The identification of *expanding organisations* (Dynes, 1970 and Scanlon, 1999) was accomplished using the social networks. Although it might have been possible to identify these groups without the social

network it nevertheless provided insight into how well integrated the expanding group was in the original organisation. An example of such a group is agents 21, 24, 29, 27 and 37. All of these agents belong to fire departments in other cities than Helsingborg.

- The social network approach allowed us to identify *boundary spanners* (Mulford, 1984 and Kapucu, 2006). For example, agent 47 and 51 serves as important links between the Helsingborg fire brigade and the Company.
- The approach also improved our ability to gather information concerning *trust* among people involved in the response operation. An important result from the mapping of the social relations is that many of the organisations involved in the emergency response are connected by a very strong network of friendship relations (see *Figure 3*).
- In addition to these concrete advantages the approach also improved our ability to select people for interviews since we could use the network to find people of particular interest such as those that were centrally positioned in the network.

In conclusion, we believe that this method provides a good way of getting important information concerning the behaviour of an emergency response system that can improve our ability to study many of the relevant phenomena identified in the literature.

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Appendix – Paper IV

Paper IV

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Groups and Key Agents in Emergency Response Systems

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Abstract

Groups of agents forming during emergency response operations have been discussed previously in the literature. Here, we present a new way of identifying such groups in emergency response operations that involves the use of social network theory. This method provides the opportunity to identify groups based on the interactions between the agents that participate in the response operation. These groups can then be compared with the formal organisations and conclusions can be drawn regarding the tendency of agents from the various organisations' to mix with others to form new groups during an emergency response. A measure of this tendency is suggested. Besides facilitating the identification of groups, the use of social networks also allows measurements of how many other agents a specific agent has had contact with during the operation. This allows for the identification of the agents that were central to the operation, i.e. had many interactions with other agents. Such agents are called key agents here. We propose a hypothesis that the distribution of the number of interactions a specific agent has had during a response operation follows a heavy-tailed distribution, possibly a power law. The reason for this is the fact that the network of agents grows, i.e. all agents do not become involved in the operation at the same time, and that the new agents included in the response operation are more likely to establish contact with agents that have more contacts with other agents than with those with fewer contacts. We exemplify the approach by performing an analysis of the response operation following a fire in a factory in Forserum, Sweden.

Introduction

Regardless of the many attempts to define concepts such as emergencies, crises, disasters and catastrophes, there still seems to be no consensus among researchers and practitioners on how these definitions should be employed. In Sweden, local perturbations involving slight community impact are commonly described as emergencies, even if they can be regarded as disastrous on the micro-level, while situations including many casualties and extensive damage and destruction generally seem to be described as various kinds of disasters. We acknowledge that in many contexts it is meaningful to classify societal perturbations depending on their nature. The work presented in Quarantelli (1998) is an example of this. However, in the analysis presented here, such classifications are not essential. Instead, we focus on the phenomena we believe come into play and must be dealt with in any type of societal response operation, regardless of whether it is a response to a small local accident or to a national disaster. We agree with

Alexander that *emergency* represents a broad concept that includes “... disasters, catastrophes and smaller disruptive events” (Alexander, 2005, p. 159). In light of the above, we have chosen to use the term *emergency response* to denote societal responses to situations that involve several organisations and coordination between them.

An emergency response operation can be visualised in terms of a network consisting of nodes with links between the nodes, where each node represents an agent (a person) and the links between them represent various relations. The network of agents and their relations provide information concerning a response operation in addition to that which can be gained using more traditional methods such as document analysis, surveys, interviews, etc. In the words of Scott “Relations are not properties of agents, but of systems of agents; these relations connect pairs of agents into larger relational systems.” (Scott, 2000). In the present context this means that in order to understand an emergency response operation as a whole, one needs to consider all (or most of) the important agents who contributed to the operation and their interactions. However, increased understanding of the phenomenon of emergency response will not automatically be gained simply by considering networks; care must be taken in selecting both the agents and the types of relations that are identified between them.

The complex management structures in a mega-system

Denis discusses how different organisations involved in dealing with disasters can be coordinated in a disaster mega-organisation (Denis, 1995). Our ambition, to describe the organisational aspects of emergency response management analytically, is influenced by her holistic lines of reasoning. In the present context, the interactions between agents from various organisations create structures that are illustrations of such a responding disaster mega-organisation. The patterns of these interactions are influenced by predetermined plans and procedures, as well as emergent phenomena. In the present paper the term emergent phenomena is used in the context of something that is *novel*, *ad hoc* or *non-planned*. Other authors who have discussed similar topics include Wenger, as cited by Drabek & McEntire (2003), where the organisations active during a specific disaster are denoted a Type V, or supra-organisation.

To avoid an association with structures of *formal organisations* we chose to describe our system as a *mega-system* instead of a *mega-organisation* (see Uhr et al., 2008). The use of the word *mega* indicates not only that the system is large as such (mega – from the Greek word *megalo*, which means large), but also that it comprises

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elements, for example agents, from several *different* organisations (Denis, 1995), and various kinds of artefacts, although the latter are not discussed in this paper. The mega-system can be illustrated here in terms of a network where the various organisations and agents are linked to each other depending on their interactions. Other researchers, such as Drabek (1983), Wachtendorf (2004) and Wise (2006), among others, have used the network approach in their discussions on emergency response. Denis (1995) writes, “The disaster mega-organization is a kind of network oriented toward managing the response to a disaster”. Thus, the network perspective is nothing new to the field, but our study aims to refine the discussion of networks and emergency response systems by mapping the network of agents interacting within the system and using it to analyse the response operation.

Our approach to emergency response management can be related to Drabek’s important contribution from 1983 – “Alternative Patterns of Decision-making in Emergent Disaster Response Networks” (Drabek, 1983). Drabek uses a holistic approach and identifies managerial difficulties, still highly relevant, related to what we here call a mega-system. The Disaster Research Center at the University of Delaware’s typology of organisations participating in an emergency response (Dynes, 1970) can be related to this research. Dynes distinguishes between *established organisations* performing routine tasks with the same operational structure as before the event, *expanding organisations* performing routine tasks but with a new operational organisational structure, *extended organisations* performing non-routine tasks with a pre-disaster operational structure and *emergent organisations* performing non-routine tasks with a new operational organisational structure. The last type, in particular, inspired us to develop methods to better understand the formation of groups relevant in an emergency response situation. We believe that these emergent groups play a significant, perhaps even a decisive, role in emergency response management (not only in major events such as earthquakes or hurricanes). Our earlier research (Uhr and Johansson, 2007; Uhr et al., 2008) indicates that many solutions to operational problems can be related to contacts taken with agents outside the formal organisations with little or no support from formal plans or procedures. Improved knowledge about these formations/groups (or sub-systems), ways in which we can make use of their potential, and methods of checking potential maladaptive behaviour is likely to be important in emergency response management. The method of data collection presented by Uhr and Johansson (2007) and Uhr et al. (2008), which is also used here, provides researchers with a tool for mapping and analysing such emergent groups.

A responding mega-system is thus made up of numerous organisations, agents and artefacts that interact in numerous ways. This paper focuses on the interaction between agents within the context of such a mega-system, henceforth called the response system. We believe that using a network perspective to understand various patterns of interaction will improve our knowledge of the way in which emergency response operations function.

Using networks to identify groups and key agents

There are many ways of analysing the networks formed by the interactions between agents. Of particular interest here is the formation of groups and the characteristics of the relations between the agents. More precisely, it is interesting to compare groups of agents forming during a response operation with the formal organisations and pre-emergency plans. Such comparisons could provide valuable information on the formation of the various types of groups defined by the DRC typology. Furthermore, networks can reveal interesting information concerning the agents. One can, for example, compare the agent's position in the network with his/her position in the formal organisation. Such comparisons can lead to the identification of agents that assume a more central role than planned during the response operation, and vice versa. We illustrate the use of network analysis in the present context by showing how such methods have been employed in analysing the emergency response to a fire in the small town of Forserum in Sweden.

The emergency response

At 6:30 p.m. on October 3, 2007, in the small community of Forserum in Sweden, the workers in a factory producing latex noticed a smell of burnt rubber. Half an hour later they discovered a fire in a drying machine, evacuated the building and called the fire and rescue services. The local fire and rescue service arrived but failed to completely extinguish the fire. Poisonous smoke began to drift into Forserum, and contaminated water threatened to leak into a nearby stream. At this point, several other organisations became involved. Together, individuals who were affiliated to formal organisations such as the Municipality of Nässjö (in which Forserum is located), the police, various local and regional civil administrations, volunteers and politicians, formed a core in what we call an emergency response system. Although the response system included formal organisations with clear hierarchies, the system emerged with no formally agreed structure or coordinating body at the top. Although responsible for the rescue operation, the on-scene rescue commander thus had no formal authority over all

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the actors in the response system. Coordination was partly fragmented, distributed, and ad hoc but, notably, seems to have been considered successful by the majority of the actors.

A couple of weeks after this emergency response operation, we started to collect empirical network data concerning the operation, in collaboration with the regional rescue service. Since we were interested in agent relations on an individual level, which are not to be found in any official documents, we had to collect these data by contacting each of the agents involved. This was done using a previously developed method to identify agents and their various relations (Uhr and Johansson, 2007).

The data collection method

Our interest in the Forserum emergency response was directed towards (1) the active agents participating in the response, and (2) the relations they had to each other during the response. To collect these data we created a tentative list of agents by analysing documents and interviewing commanders, health care personnel and factory representatives. This list was presented in a web-based questionnaire. We then asked these agents, via individual e-mails, to log onto the website and mark the agents in the list that they had been in contact with during the response. They were also asked to describe how important these contacts had been to *them* in fulfilling *their* tasks. Finally, and critically, we asked them to add any agents that they had had contact with, but were not included in the list. Added agents were then contacted and invited to participate in the process in the same way as the initial agents. In this way, the list gradually expanded. We continued the process until no new important¹ agents were identified. Apart from providing information about their relations to other agents, participants also provided us with other information about themselves, such as age, organisational affiliation, their general opinions about the operation, etc. This is valuable information and, together with interviews, it can be used to validate the quantitative data in the networks and provide us with valuable insight into how the response system behaved. A thorough description of the method and further examples of applications can be found in Uhr and Johansson (2007) and Uhr et al. (2008). The network mapping in the Forserum case ran for two months before the expansion of the network was stopped and information gathering ceased.

A central issue affecting the results of the analysis is how we deal with agents stated as being active in the response, thus appearing in our network, but who did not participate in the study and provide us with relational data. In the present

study, we identified 67 agents. Although it is difficult to make every agent participate actively in the study, the lack of relational data should not be too extensive, as this would seriously affect the validity of the results of the analysis. Therefore, the proportion of agents that participate in the study is an important factor when determining how long one should continue to encourage agents to participate in the study. To discuss this in a tangible way, and to allow the comparison of empirical analyses in the future, we here introduce the measure *completeness*. The network presented in this paper consists of 67 agents, 35 of whom were active in the study. Just over 50% (52%) may appear to be a poor result, but given the structure of the network we believe that it is not. Several of the agents who participated in our study constituted the “core” of the network, each having multiple relations with others. Moreover, many of the agents that did not participate in the study had only one or very few relations². Although an agent who has few relations might be very important to a specific agent, it is unlikely that such an agent was crucial to the response operation as a whole. Therefore, comparing the number of agents active in the study with the total number of agents in the network can be misleading when assessing the validity of the results. Instead, we use *relations* to measure the completeness of our network. A useful measure of completeness can be obtained by dividing the number of relations between agents *active* in the study by the total number of relations. The concept of completeness can be exemplified by the illustration in Figure 1. There, the nodes with hashed shading represent agents who did not provide any information regarding their relations to other agents, while the shaded nodes represent agents that provided this information. Both networks have the same number of agents and the same number of relations, but the structure of the relations differs, as well as the completeness. Network 1 has a high degree of completeness (75%) which implies that the validity of the conclusions reached regarding the response operation is likely to be higher than in the case of Network 2, where the completeness is only 25%. If this had been a real situation, greater effort should have been made to contact more of the agents in Network 2 who did not take part in the study, since many of the relations in the network are directed towards them, indicating that they were important in the response operation.

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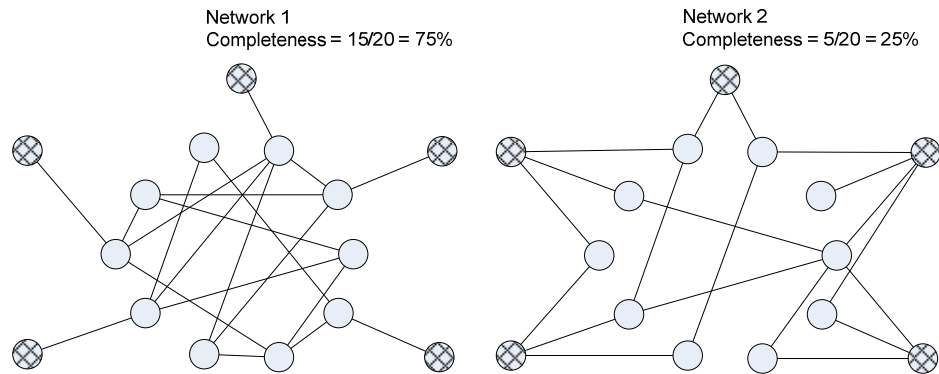


Figure 1 Illustration of two hypothetical networks with 10 active agents (in the centre) and 5 agents who did not provide any information regarding their relations.

The total number of relations in the network constructed in the present study is 379. The number of relations between agents participating in the study is 272. This gives a completeness of 72%, which means that 72% of the relations stated by agents are directed towards agents who also participated in the study. Due to the limited number of studies performed using networks in the present context, it is difficult to know whether this is good or not. However, the majority of the agents with many relations directed at them participated in the study. Therefore, we concluded that the information concerning the response operation that we obtained from the participating agents should provide us with a good idea of what happened during the operation.

The analysis

The data provided by the agents enables us to create a social network model of the agents' relations. Our model is multidimensional as the data describe two dimensions of each relation – *contact* and *importance*. These dimensions are directional, which means that they point *from* the agent (X) who told us about the relation *to* the agent (Y) to whom X referred. Both dimensions are also weighted. We used a scale ranging from 0 to 3 for the *contact* dimension³, and a scale ranging from 0 to 5 for the *importance* dimension⁴. This weighting enables us to screen out weaker relations from the analysis. We may, for example, want to consider only *importance* relations with a weight of 4 or more. We denote such a network

Importance-4. This principle is illustrated in Figure 2, where a fictitious network with three nodes, agents A, B and C, and their mutual relations, is illustrated. It can be seen that the agents have reported different weights of their *contact* relations, e.g. agent A reported that he/she had contact with agent B once (level 1) while agent B reported that he/she had contact with agent A between 2 and 5 times (level 2). Such discrepancies are not uncommon, and it is therefore important not to attach too much importance to the exact weights of the relations, but instead to use the screening method discussed above to ascertain whether the general conclusions regarding the network are valid for different screening levels. This approach should reduce the problem significantly. In the network termed *Contact-2* the *importance* dimension has been removed, and only *contact* relations with a weight of 2 or higher are shown. Similarly, the network *Importance-3* is created by removing the entire *contact* dimension as well as the *importance* relations having a weight of less than 3 from the original network.

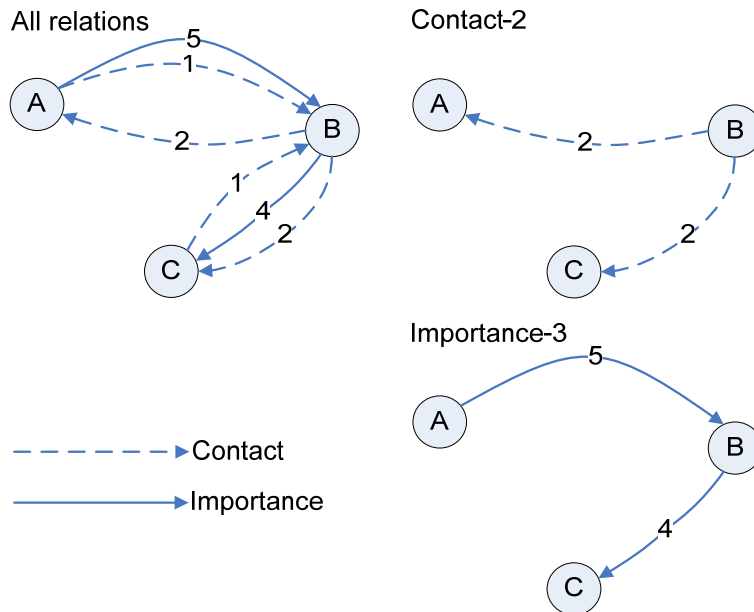


Figure 2 Illustration of three nodes representing agents A, B and C and their relations.

Groups in networks

There are several ways of identifying groups in social networks. We used a technique called *divisive hierarchical clustering* (Wasserman and Faust, 1999; Newman and Girvan, 2004). With the complete network as a starting point, we successively identified the *least* connected parts of the network and then remove the links (relations) connecting those parts. As this procedure is repeated, the network will start to break up into groups of nodes. To do this, we used the algorithm introduced by Newman and Girvan (2004), which has proven to be both efficient in terms of computer time, and reliable in terms of identifying relevant groups in networks. The result can be displayed in terms of a dendrogram which shows the groups created as more and more links are removed from the network. Since all the links in the network will be removed sooner or later, it is obvious that *some* groups will be identified by the algorithm. However, the question is whether the identified groups are real or merely a result of the method used. To check this, we calculated the modularity, which is a measure suggested by Newman and Girvan (2004) representing the extent to which the observed connections between the various groups deviate from what would be expected due to chance.

The modularity (Q) of a network divided into groups using a specific method is calculated by first creating a matrix containing the fraction of the total number of links in the original network that goes from a node that belongs to a specific group, to a node that belongs to another, or the same, group. More precisely, Newman and Girvan define a $k \times k$ symmetric matrix, \mathbf{e} , which contains this information. A cell in that matrix, e_{ij} , is the fraction of the total number of links that connect group i to group j . Furthermore, a_i is the share of the total number of links that extends from group i to *any* group, i.e. the sum of row i in the matrix \mathbf{e} . The modularity is then given by Equation 1, where k is the number of identified groups.

$$Q = \sum_{i=1}^k (e_{i,i} - a_i^2) \quad (1)$$

A value of 0 means that the links in the network fall between the nodes, without any regard to the group structure, i.e. randomly. This implies that the groups identified by the division of the network in that particular fashion are not very strong. A high modularity is desirable (1 is the maximum value) since this indicates that the identified groups are not likely to have occurred by chance. However, a

value close to 1 cannot be expected in many real-world networks. Instead, as Newman and Girvan state, values between 0.3 and 0.7 are more likely to be observed, even when the groups are strong.

We have performed several analyses of groups (a group is defined as containing 3 or more agents) regarding both the *contact* and *importance* relations. Although the two types of relation reflect different aspects of the agents' behaviour, the groups identified in the two types of networks overlap to a considerable extent. This is to be expected, since if an agent has assigned a high value to an *importance* relation directed towards another agent, then he/she is also likely to have assigned a high (or at least non-0) value to the *contact* relation. Therefore, the results are similar when performing an analysis of groups using the two types of relations. Moreover, the results are also similar when performing the analysis for the various levels of relations, e.g. *Contact-1*, *Contact-2*, etc. The difference between the analyses when using the lower levels, e.g. *Importance-1* and *Contact-1*, and the higher levels is that the number of agents in the identified groups is lower when higher level networks are used. This is due to the fact that there are fewer relations in the higher level networks, and therefore more agents are likely to be excluded from the groups when higher level analyses are performed. The exception in this case was in the analysis of the *Contact-1* and *Contact-2* networks, where there were more agents in the groups resulting from the analysis of the *Contact-2* network than the *Contact-1* network. The results of the analyses of the two types of networks at the various levels are presented in Table 1, where the column labelled Group A gives the number of agents contained in the largest group, Group B the number of agents contained in the second largest group, etc.

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Table 1 The modularity (Q) for various analyses of groups within the emergency response network. The columns labelled Group A to Group F give the number of agents in each group and the column labelled "Total" gives the total number of agents in all the groups.

Relation	Modularity Q	Group A	Group B	Group C	Group D	Group E	Group F	Total
Contact-1	0.226	25	10	6	5	3		49
Contact-2	0.335	20	19	10	4	3		56
Contact-3	0.391	11	8	5	5	5	3	37
Importance -1	0.334	19	9	6	6	3		43
Importance -3	0.426	11	9	4	3			27
Importance -5	0.523	4	3	3				10

The results of the analysis of the *Contact-1* network are illustrated in Figure 3, in which the nodes representing the agents belonging to the various groups are shown. The circular nodes belong to one of the five groups identified, triangular nodes indicate those that do not belong to any of the groups. Although the modularity of this particular division of the network is only 0.226, the groups identified by the algorithm appear to be reasonably strong and therefore relevant. Group A is the largest, and consists of actors from various organisations, mainly the rescue services, and the municipality. The analysis of the *Contact-2* and *Contact-3* networks⁵ seems to reveal two subgroups within Group A, one that is more connected to agents belonging to Group D and one that is more connected to agents belonging to Group B. Group B consists mostly of agents from the county council (nine of the ten agents in that group), 6 of them belong to the ambulance service which is part of the county council organisation. Group C also consists of members from the county council, but are identified as a separate group due to

the structure of the relations, i.e. the dominating role of agent 15, who is the only one in that group, except for agent 82, that has had contact with agents in other groups. Group D is made up of agents from the municipality, and group E is made up of agents from the county administrative board. Note that group F is not included in Figure 3 since it illustrates the *Contact-1* network and in that network only 5 groups were found.

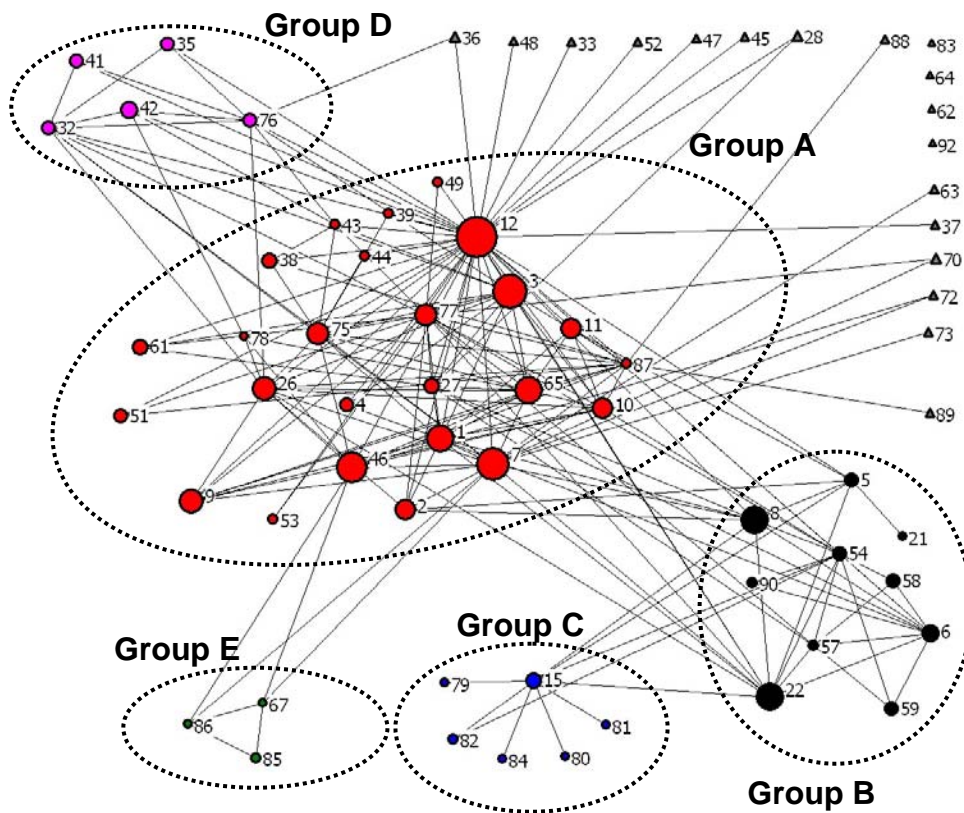


Figure 3

The Contact-1 network for the response operation following the Forserum fire. The circular nodes represent agents that belong to one of the identified groups and the triangles represent agents that do not. The diameter of a specific node is proportional to the number of relations a specific agent has directed towards him/her. The directions of the links have not been included to maintain the clarity of the illustration.

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The dendrogram in Figure 4 shows the results of the analysis of the groups in the *Contact-1* network. The horizontal dotted line illustrates the best level of division, i.e. where the modularity is greatest, i.e. 0.226. The vertical dotted lines delineate the various groups identified in the analysis, which correspond to those shown in Figure 3 above. When analysing groups using higher levels of relations, e.g. the *Contact-2* and *Contact-3* networks, the group structure is stronger than for the lower levels (as can be seen in the Modularity column of Table 1). This could be interpreted as “cores” of agents within the groups. In the present context, a core would mean a subgroup within one of the groups A-E. This phenomenon is most clearly visible in Group A, in which agents 1, 3, 11, 12, 26 and 65 appear to constitute such a subgroup (using the *Contact-3* network).

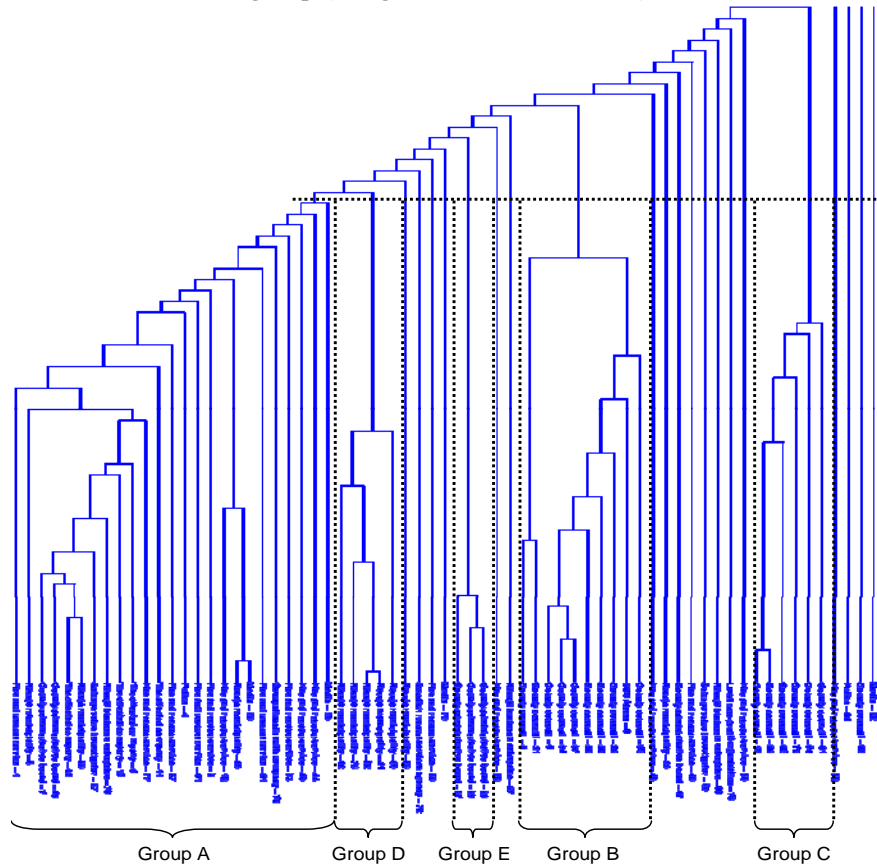


Figure 4 Dendrogram illustrating the various groups in the *Contact-1* network.

Another way of visualising the information obtained from the various networks is by considering the groups and the connections between them. This is illustrated in Figure 5, in which the diameter of the nodes representing the various groups is proportional to the number of agents in the groups. Likewise, the thickness of the links is proportional to the number of relations between the agents in the various groups (the number of relations is given next to the links). The numbers in brackets following the group names are the number of relations *within* the group. These groups were derived using the *Contact-1* network. In the figure, only *contact* links with a weight equal to or greater than 2 were included when determining the thickness of the links in the *Contact-2* group, etc. The same type of information using the *importance* relation is shown in the lower row in the same figure.

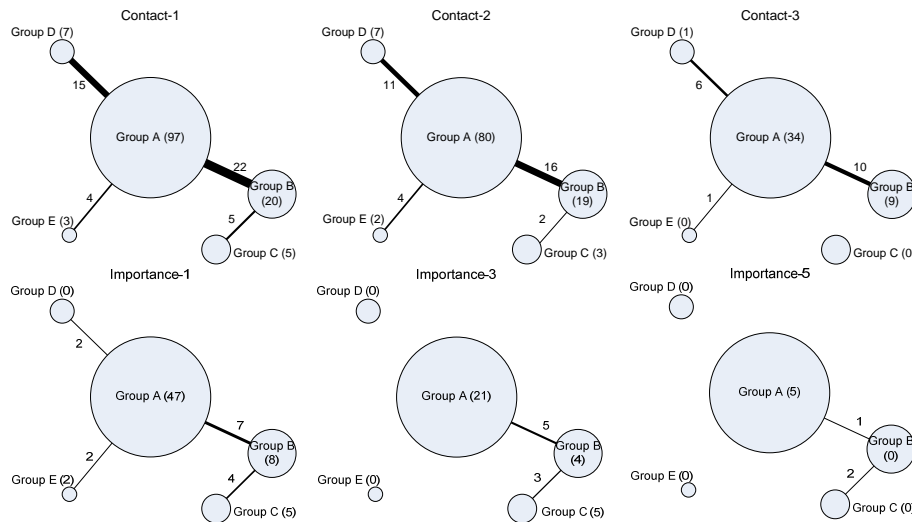


Figure 5 Illustration of the groups and the relations between them in the *Contact-1*, *Contact-2*, *Contact-3*, *Importance-1*, *Importance-3* and *Importance-5* networks. The diameter of the nodes is proportional to the number of agents in each group, and the thickness of the links is proportional to the number of links between pairs of agents in the various groups (the number is also given next to the links). The numbers in brackets after the group names are the number of links between pairs of agents within the group.

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The groups identified using the *contact* relation can be compared with the grouping of agents according to their organisational affiliation. We identified 13 organisations that were involved in the response operation following the fire. Representing these organisations as nodes in Figure 6, we illustrate the information contained in the *Contact-1* network. The diameter of the nodes is proportional to the number of agents belonging to a specific organisation, and the thickness of the links is proportional to the number of pairs of agents within two organisations that are connected by a relation. By studying Figure 3, the *Contact-1* network in Figure 5 and Figure 6 it is obvious that the structure of the *contact* relations between agents deviates from that of the organisational boundaries. Although we did not expect all relations to be contained within organisational boundaries (some coordination and communication between organisations are necessary), Figure 6 shows that during the operation, a considerable number of contacts were made between agents across organisational boundaries. In fact, there are considerably more links extending out from the organisations than those contained inside. Krackhardt and Stern (1988) suggested an index (the E-I index) which measures the ratio of links contained within an organisation to those extending outside it. Although Krackhardt and Stern were concerned with friendship relations between and within organisations, the same index is used here to measure *contact* and *importance* relations. The E-I index is defined by Equation 2, in which EL is the number of external links (linking an agent within an organisation to one outside) and IL the number of internal links. The possible values of the E-I index range from -1 to +1. A value close to +1 means that the majority of the links to agents in the organisation are external, while a value close to -1 means that the majority of them are internal, and a value of 0 means that the numbers of internal and external links are equal.

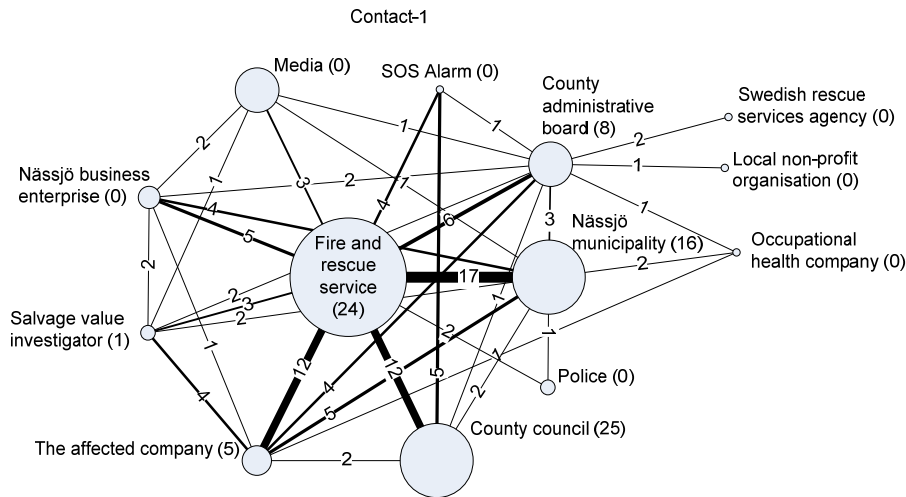


Figure 6 Illustration of the Contact-1 network with the organisations involved in the operation shown as nodes. The diameter of a node is proportional to the number of agents from each organisation participating in the response operation. The numbers on the links between the organisations are the number of pairs of agents in the two organisations that are connected by a link in either direction. The numbers given after the name of the organisation (in brackets) are the number of pairs of agents within the organisation in question that are connected by a link in either direction.

$$E - I \text{ Index} = \frac{EL - IL}{EL + IL} \quad (2)$$

The E-I indices for each of the organisations are presented in Table 2, where it can be seen that the majority of the organisations have positive indices for most of the different types of networks. Unsurprisingly, organisations with only a limited number of agents participating in the operation have high indices. Indeed, the index for an organisation with only one agent engaged in the operation (there are four such organisations in the present case) will automatically be 1 if that agent had any relations to other agents. Nevertheless, the index reveals interesting information when comparing some of the organisations that had the most active agents. For example, of the four largest organisations (in terms of agents active in the present context), the fire and rescue service (16 agents), county council (16 agents), Nässjö municipality (10 agents), and the county administrative board (6

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agents), only the county council had negative indices for all networks except the *Importance-5* network, where the index was equal to 0. In other words, agents from the county council had more contact with agents within their organisation than with agents outside it, compared with other agents. They also attribute greater importance to agents within their own organisation than to agents from other organisations. This is in contrast to the agents from Nässjö municipality, who considered external agents to have been more important for them than agents from within their own organisation. In this particular response operation, it appears that the fire and rescue service, Nässjö municipality and, to a certain extent the county administrative board, tended to “mix” with other organisations, whereas the county council did not.

Table 2 The E-I index for the organisations and six types of networks.

	Contact-1	Contact-2	Contact-3	Importance-1	Importance-3	Importance-5
Fire and rescue service	0.28	0.23	0.22	0.46	0.08	-0.33
Nässjö municipality	0.14	-0.15	0.00	0.64	0.78	1.00
The police	N/A	N/A	N/A	N/A	N/A	N/A
County council	-0.32	-0.43	-0.25	-0.52	-0.33	0.00
County adm. board	0.14	0.18	0.33	N/A	N/A	N/A
SOS Alarm	N/A	N/A	N/A	N/A	N/A	N/A
The affected company	0.25	0.14	-0.33	0.25	1.00	N/A
The media	N/A	N/A	N/A	N/A	N/A	N/A
Swedish rescue services agency	1.00	N/A	N/A	1.00	1.00	N/A
Local non-profit organisation	N/A	N/A	N/A	N/A	N/A	N/A
Nässjö business enterprise	1.00	1.00	1.00	N/A	N/A	N/A
Occupational health company	1.00	1.00	1.00	N/A	N/A	N/A
Salvage value investigator	0.87	0.85	1.00	0.83	0.33	N/A

N/A=Not applicable.

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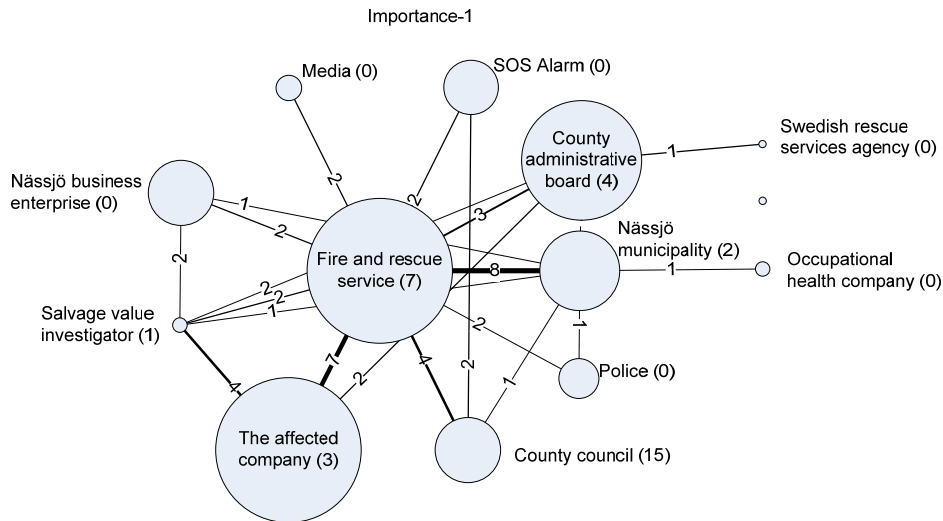


Figure 7 Illustration of the Importance-1 network using the organisations that were involved in the operation as nodes. The diameter of a node is proportional to the number of Importance-1 links that are directed at the organisation in question from other organisations. The numbers on the links between the organisations are the number of pairs of agents in the two organisations that are connected by a link in either direction.

Key agents

In an emergency response system, we would not be surprised to find that some agents have significantly more relations with other agents than others. In this paper we call these agents *key agents*. The meaning of being a key agent depends on what the relations in the network mean, in our case the relation types are *contact* and *importance*. From the *contact* network we can determine whether or not the contacts made within the response system are dominated by a small group of agents. From the *importance* network we can determine whether a small group of agents is considered important by a majority of the agents in the response system, or if the agents that are considered important are more evenly distributed. In networks terms, the number of links that are connected to a specific node (agent) is called the node *degree*. In a directed network it is also common to distinguish between links going into a node, in-degree, and links extending out from a node, out-degree.

It is important to note that the term “key agent” primarily relates to the *network of relations*, not to the *actual emergency situation*. Although it is likely that a key agent also has a decisive role in the management of the emergency, it is not certain. Imagine, for example, an agent that has only had one or very few contacts during the emergency, but whose actions were the key to the success of the operation. Such an agent would not be identified as a key agent using our method. However, since the complexity of many emergency operations makes it difficult for any single agent to judge who was the most important agent for the operation as a whole, it is difficult to identify such agents unless the operation is very limited. It is much more likely that agents will be able to identify the most important agent for *them* in doing *their* tasks, and we therefore used this information to create the network of relations, which is then used to identify the key agents.

Previous research concerned with social networks has indicated that the distribution of the number of links connected to a specific node often follows a heavy-tailed distribution, or more precisely a power law (Barabási and Albert, 1999). Barabási and Albert suggested that the heavy-tailed distribution observed is due to two processes: *growth of the network* and *preferential attachment*, which means that when a new node is attached to the network it is more likely to be linked to a node that already has many links. In the present context, this means that in a network consisting of *contact* relations, the growth and preferential attachment process would imply that the network of agents that is engaged in dealing with an emergency grows during the early stages of the response, and when a new agent is engaged it is more likely that he/she will contact, or be contacted by, an agent that already has a high degree of contact, i.e. already has many contacts with other agents. It seems reasonable to assume that the emergency response system grows in response to an emergency, i.e. agents are not engaged at the same time in response to an emergency. The preferential attachment process also seems reasonable since if a new actor has a central formal role, for example, a police commander, he/she is more likely to initially make contact with other agents that have central roles, such as the fire chief, who in turn is more likely to have a high degree. If, on the other hand, the new actor has a less central formal role, such as a local fire unit commander or a volunteer engaged in the operation, he/she is also more likely to initially have contact with an agent already engaged in the operation that has a high degree than one that has not, since such agents are likely to have information relevant to the new agent or a formal position, making the contact more likely. Therefore, it is interesting to investigate whether networks of agents participating in emergency response operations exhibit the same characteristics as

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mentioned above and, in that case, whether it is due to these two suggested processes.

We propose a two-part hypothesis related to the structure of relations between agents in emergency response operations. The first part of the hypothesis is that *contact* relations and *importance* relations in a network of agents responding to an emergency follow a power law distribution or at least a heavy-tailed distribution. The second part is that the structure of *contact* and *importance* relations between agents in emergency response systems is the result of two processes: *growth* and *preferential attachment*. Both parts of the hypothesis can be tested empirically. The first part can be tested by collecting information on who communicated with whom during a response operation, or who the various agents believe were important for their ability to conduct their tasks, for example, in the same way as we have done using the web questionnaire. Moreover, by logging the times at which agents become active in an emergency response operation, it can easily be determined whether an emergency response system grew. However, it would be very unlikely for an emergency response system not to grow, and therefore it may not be of great interest to investigate this process. On the other hand, the preferential attachment process is more difficult to detect empirically. One could, for example, conduct in-depth interviews with agents to see what happened when they were engaged in the operation, and how they reasoned when choosing which agents to contact during the operation. However, such an investigation would have to be very carefully designed since the independent variable, i.e. the degree of a specific agent, can probably not be detected by other agents, and it is therefore necessary to use proxy variables such as formal position and access to specific knowledge, etc. and then try to determine the connection between the proxy variables and the degree. Instead of focusing on this type of investigation we have chosen to analyse the distribution of links connected to the agents, i.e. the degree distribution. This provides us with evidence relevant to the first part of our hypothesis and indirect evidence regarding the second part. If we find a degree distribution that does not follow a heavy-tailed distribution, then we can conclude that no part of our hypothesis is valid, or at least when it comes to the second part, that other process affect the structure of the networks to a greater extent than the two suggested. On the other hand, if the degree distribution follows a power law, we cannot dismiss either part of the hypothesis. In that case, we would need additional information from more emergencies, as well as other types of information, for example, qualitative data obtained from interviews with agents, to rule out other possible reasons for the occurrence of the power law.

We determined the degree distribution using the *contact* relations. Since the contacts are directed, i.e. if agent A stated that he/she had contact with agent B a link is drawn *from A to B*, we calculated how many such links a specific actor had directed towards him/her (in-degree). We did this for all 67 agents in the network. There is likely to be a variation between the individual agent’s perceptions of what constitutes a contact. One agent might consider a contact to be “talking to another agent”, while another may consider that “important information has to be exchanged” in a contact. To reduce any possible bias we used the number of links going *in* to a node rather than the number going *out* when calculating the degree. We used the algorithms provided by Clauset et al. (2007) and fitted a power law distribution to our empirical data. The result is shown in Figure 8.

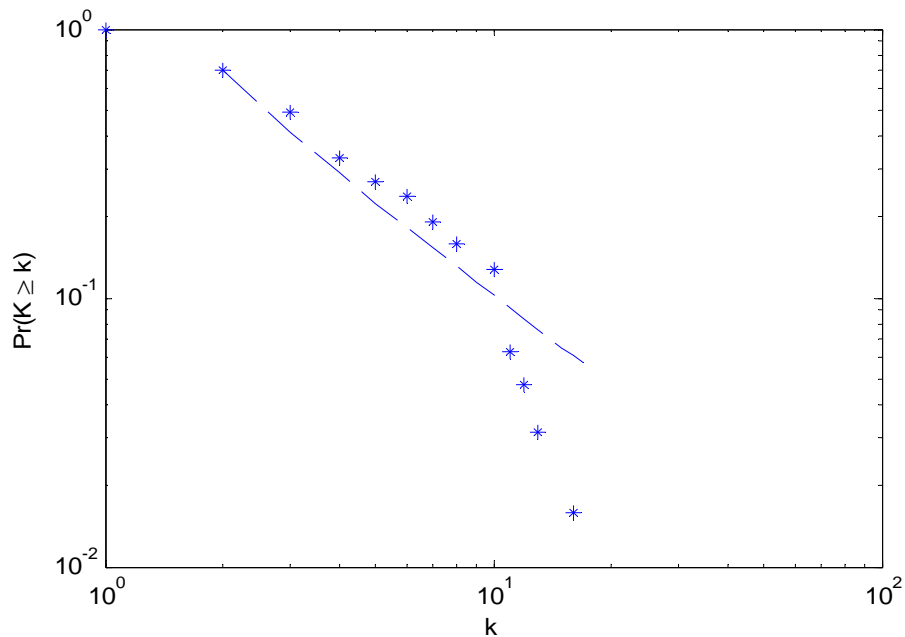


Figure 8

Cumulative in-degree (k) distribution in the emergency response network formed in response to the Forserum fire. The links in the network represent contact relations, i.e. an agent has said that he/she had contact with the agent that the link is connected to. A high k -value means that many agents have reported having contact with that agent.

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Given the modest size of our network, and the fact that the data were provided by only 52% of the actors listed, we cannot expect to be able to draw any definitive conclusions regarding the degree distribution of the network. Indeed, the power law fit is only valid for $k > 1$, where k is the in-degree of an agent, and the fit is not very good. The D -value, i.e. the maximum distance between the cumulative hypothesized distribution and the data is 0.11 and the p -value, i.e. the probability that the observed data were drawn from the hypothesized distribution, is only 0.026. Therefore, we cannot say whether the distribution follows a power law or not. However, on closer inspection of the data there seem to be two different regions in the distribution. One between $k = 2$ and $k = 10$, which appears to follow the fitted power law distribution reasonably well, and another between $k = 11$ and $k = 16$, which deviates from the fitted distribution. Nevertheless, two straight lines in the diagram, with logarithmic scales on both axes, seems to fit the data points reasonably well in the two regions, and therefore we believe that although the degree distribution might not follow a power law, it is still likely that it follows some kind of heavy-tailed distribution. The reason for the poor fit to the power law distribution could be related to our small sample size (only 67 agents in the network) and the fact that only 35 of these provided us with data, as was noted above. Apart from the poor fit of the power law, the figure shows that there is a relatively small number of agents with high degree, and a large number of agents with low degree. The agent with the highest degree is the on-scene commander (16 contacts), the agent with the second highest (13 contacts) is a person employed by the municipality who was made responsible for providing the general public with information on the fire, and the agent with the third highest degree (12 contacts) is an expert at the county administration.

The information collected in the present study supports a weaker formulation of the first part of the hypothesis, namely that the degree distribution in a *contact* or *importance* network of agents in an emergency response operation follows a heavy-tailed distribution. This means that there are agents, so-called key agents, that have considerably more relations than most other agents in the emergency response system. Although we have too little empirical data to determine whether this is a general property of emergency response systems, both processes responsible for creating such properties in other networks (growth and preferential attachment) seem reasonable in the present context, and we therefore believe that the second part of the hypothesis is also reasonable in the present context. However, this must be investigated further to rule out the possibility of other processes being responsible for the observed heavy-tailed distributions.

Discussion

Interpersonal networks are often mentioned as a key for success in emergency response operations. The reason why both theoreticians and practitioners emphasize the necessity of such networks probably derives from experience of real emergency situations, in which several formal organisations on various societal levels have to coordinate their efforts, and where the formal organisational structures do not have provision for doing this. From a scientific point of view, the concepts of networking and pre-existing inter-organisational networks can be obscure. Atkinson and Moffat, for example, write, “We talk loosely about networking, meaning interacting with other people ... How do we begin to make some kind of sense out of all of these networks?”. (Atkinson and Moffat, 2005, p. 42). Our impression is that the everyday use of the word “network” often refers to existing channels of information that can be used when necessary. We hope that our approach to groups and key agents will contribute to the concrete discussion on the use of networks as a tool for analysing emergency response operations, and give substance to the holistic understanding of emerging management structures that influence these operations. Moreover, the concepts of *key agents* and power-law distributions, exemplified in Figure 8, can be found in other management discussions (see, for example, Atkinson and Moffat, 2005) and are relevant in many contexts, for example, when examining the distribution of power in a mega-system. Distribution of power does not necessary have to do with formal hierarchy but could, for example, be related to legitimacy and trust. Power can also be related to the position of an agent within the network of contacts, for example, an agent bridging two parts of the network may become powerful because he/she controls the information flow between the different parts of the network. Power can also be related to the number of *importance* or *contact* relations directed towards a specific agent, and thus to the structure of the *importance* and *contact* networks.

In the present paper we have argued that preferential attachment is one of the processes determining the structure of these networks. It should be noted that the process only describes the growth of a network, not the behaviour of the agents in the real world. Therefore, although preferential attachment may be appropriate when describing the emergency response operation in terms of a network, it provides no information on why agents tend to connect with agents that already have many contacts with other agents (in the case of a contact network) or why agents tend to assign high importance to agents that have been assigned high importance by other agents (in case of an importance network). A number of attributes related to agents are likely to influence the occurrence of such

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phenomenon, for example agents' formal positions within the organisational hierarchies, their context-specific knowledge, and their personal contact network, etc. Therefore, although we have seen indications of the preferential attachment process when studying these networks, they may be due to any one of these attributes, or indeed something else. We have not investigated this in the present study. However, qualitative information gained through interviews and from the web questionnaire indicates that the three attributes discussed above, i.e. formal position, emergency-specific knowledge and personal contact network, influence who becomes a key agent and how groups of agents are formed in emergency response operations. Additional research could help determine the extent to which different factors affect the formation of networks, and the dependence of their importance on the type of emergency with which the agents are dealing.

The degree to which these networks are useful when analysing various phenomena of interest in response operations is dependent to a great extent on whether one has been able to identify all, or at least most of the agents participating in the operation. Determining whether someone participated in the operation or not is not always easy, since we do not want to automatically exclude agents that do not belong to an organisation with a formal mandate to act in the emergency situation under study (such as the rescue services). For example, in the present case, an agent belonging to a local fly fishing club was identified by one of the other agents. The agent from the fishing club was given the task of monitoring the stream that passed the factory in which the fire started, to see if he could detect a leakage of contaminated water from the factory into the stream. In this particular case we included the fishing agent in the network, but we did not ask him for relational data, since we did not consider that he was important for the emergency response operation. This decision was partly based on the fact that only one agent reported having had contact with him, and partly because the monitoring of the stream was not vital to the operation since no leakage of contaminated water occurred. If there had been a leakage, his role might have been different and consequently he might then have been asked to participate in the study. In emergencies of greater magnitude than the one studied here, such judgments are likely to be common. In such cases it would be very important to state who was not contacted and asked to participate in the study, despite the fact that he/she was identified by other agents, and why the decision was made to exclude the agent in question.

Another aspect that might influence the usefulness of the networks discussed here is whether the participating agents interpret the meaning of their relations

differently. Since we are using a self-administered questionnaire (web-based) there is room for different interpretations of the meaning of words defining the relation attributes, such as “importance”, “contact” etc. For example, one agent might report a contact relation to another agent if he/she has talked to the other agent, whereas another agent might require substantial information to be exchanged in order for him/her to report it as a contact relation. To eliminate possible negative effects of differing interpretations, we used an instruction manual to concretize the words used in the questionnaire. However, an interesting phenomenon that came to light in this study is that of two individuals who claimed to have had a communication relation; one of them indicating that they had a low communication frequency while the other indicating that the communication frequency was high. There are examples where two agents participated in the study, but only one refers to the other. These significant differences in individual evaluation were, however, not common. Moreover, the overall conclusions concerning the groups and the key agents are relatively stable, regardless of differences in the interpretation of relations between agents (see the discussion on the use of in-degree and the use of different networks levels above).

Network formations consisting of individuals and their interconnections, as presented here, do not show the dynamics of the emergency response system. Instead, they illustrate the collected evaluation of the interactions between the participants during the whole emergency response operation. In many cases, we have data that indicate when the various agents became active in the response operation, which might allow us to visualise the growth of the network. However, illustrating the dynamic development of an emergency response network was not the aim of this study, and the quality of the information regarding the activation times of the agents and that on when they had contact with each other is thus not very high. Additional empirical studies are therefore required to study the dynamic development of emergency response systems. Such studies would be very important in our attempt to describe and understand the behaviour of emergency response systems, and they constitute an important area for future research.

Conclusions

We have shown how network analysis can be used to analyse multi-organisational emergency response operations to gain a better understanding of the functioning of various organisations often engaged in such endeavours. Our approach involves the use of network data gathered from the agents participating in the response operation to identify groups of agents. Thus, the data describe what actually took place during the operation, e.g. the contacts that were actually made

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during the operation. It is then interesting to compare this information with the structures of the formal organisations. This comparison can lead to conclusions regarding the tendency of agents from the various organisations to engage in inter-organisational contacts. A measure of this tendency is suggested in the paper.

To illustrate the approach, the response to a fire in the town of Forserum in Sweden was analysed. The analysis of the operation revealed that although there were groups that consisted solely of agents from one organisation, the major group (25 agents) included agents from almost all the participating organisations. Furthermore, when analysing the extent to which the agents interacted with agents outside their own organisation it was concluded that inter-organisational contact was very common during the response operation, except for agents from the county council who tended to interact more with agents from their own organisation.

An analysis of the number of *contact* relations of a specific agent (the in-degree) showed that the distribution of the number of contacts followed a heavy-tailed distribution, i.e. a limited number of agents can be regarded as key agents, whom many other agents contact. These “hubs” are of a particular interest from a managerial perspective since they have the opportunity to influence a large part of the network via their contacts. The same type of analysis was conducted using the *importance* relations. The resulting distribution of the number of importance relations directed towards a specific agent was found to have the same shape, i.e. it followed a heavy-tailed distribution. Thus, when the agents were asked who were the most important agents for their ability to perform their tasks during the operation, the majority named a relatively small group of agents.

The heavy-tailed distribution of the number of contacts a specific agent has had with other agents suggests that two processes may be responsible for the development of the emergency response system: growth and preferential attachment. That an emergency response system grows, i.e. that all agents are not engaged at the same time, seems self-evident. However, the preferential attachment process, i.e. agents that are engaged in the response operation being more likely to have contact with agents that already have many contacts, seems reasonable, but additional research is needed to establish whether this process is a general constituent of emergency response operations.

Notes

¹We determined importance based on our judgement of the importance of the agent for the development of the emergency response operation. However, determining whether an agent is important or not is a delicate matter, which may affect the validity of the results. We elaborate on this in the discussion

²Since an agent that did not participate in the study has not reported his/her relations to other agents it might seem misleading to use the number of relations to determine whether an agent was central to the operation. However, we only use the relations directed *at* a specific agent, so called in-relations, when calculating the number of relations not the number of relations directed *from* the agent. Therefore, an agent that did not participate in our study might still have many relations directed at him/her.

³A contact value of 0 means that the agents did not have contact; a value of 1 signifies that the focus agent (the agent providing the information) was in contact with the other agent once; 2 - that the focus agent was in contact with the agent two to five times and; 3 – that the focus agent was in contact more than five times.

⁴An importance value of 0 means that focus agent did not consider the other agent to be important for his/her work during the response. At the other end of the scale, a value of 5 means that the focus agent considered the other agent vital for his/her work.

⁵These networks were used in the analysis but are not illustrated here.

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Appendix – Paper IV

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Appendix – Paper V

Paper V

Multi-organizational Emergency Response Management

Emergency Response Coordination from a Social Network Perspective

Christian Uhr

Abstract

Based on literature findings and empirical analyses the paper discusses the concept of coordination in emergency response operations. It is suggested that coordination can be considered as a broad concept that can include various strategies for dealing with interdependencies in complex systems. The paper argues that coordination can include both elements of traditional command and control and bottom-up activities such as self-organization. Three studies on emergency response operations conducted in Sweden are used to illustrate how coordination can be analyzed and understood from a social network perspective. In these studies certain network relations, such as communication intensity and perceived importance, are employed as proxy attributes indicating coordination. The interpretations of network data imply that coordination activities were distributed among the individuals active in the operations. Put in other words, coordination was not performed by individuals with “formal coordination functions” only. Moreover, coordination was partly characterized by an emergent behaviour. Finally, the empirical analysis implies that emergent behaviour can be positively related to high complexity and vice versa. The network approach and the empirical findings are critically discussed. It is concluded that social network analysis can be a useful tool for analysing and understanding the complex nature of emergency response coordination, but that further studies need to be conducted in order to facilitate improved normative suggestions on emergency response management.

Introduction

Emergency response management is a multi-dimensional subject area that continuously provides practitioners and researchers with challenges and scope for improvement. A key issue in contemporary discussions seems to be how to deal with multi-organizational responses, i.e. situations in which several organizations have to operate harmoniously to satisfy various needs without a single authority governing all the active and available resources for doing this. It is likely that the characteristics of multi-organizational responses are changing in a changing society. New technology stimulates new ways of interacting and the interdependency among different segments of the society seems to grow stronger. Several researchers suggest that an important part of emergency response management is to coordinate available resources (Quarantelli, 1988; Boin, t' Hart, Stern & Sundelius, 2005; Wise, 2006 and Wybom & Latiers, 2006). Modern emergency response often involves a conglomerate of resources and shows an intricate complexity to almost anyone who tries to understand its nature. This paper proposes that coordination comes about behind static bureaucratic arrangements and can from a structural approach be described in terms of networks of interacting individuals.

Earlier research on emergency response management highlights how empirical analyses on emergency response can be performed from a network perspective. Examples of such research are Drabek's contributions (i.e. Drabek, 1983), Comfort's (i.e. Comfort, 1999) work where analyses and reasoning are based on a complex adaptive systems approach in which different actors are connected to each other in network like patterns, and Denis' (1995) article on mega-organisations where she uses the network approach to describe multi-organizational configurations. Another example of research using a social network approach for studying coordination is Kapucu (2005, 2006). In the Command and Control Research Programme (CCRP) multi-organizational contexts and various forms of management networks have been given considerable attention (Alberts & Hayes, 2003 and Atkinson & Moffat, 2005 among others). Recent research by Uhr and Johansson (2007), Uhr, Johansson and Fredholm (2008) and Tehler, Uhr, Ekman and Fredholm (2009) was designed to further develop methods for data collection and empirical analysis of emergency response systems from a social network perspective. The work on improving such methods together with interviews with emergency response decision makers and literature studies motivate the use of the concept of coordination when discussing management in complex response systems. The concept of coordination appears to have room for various management characteristics discovered in empirical analyses, i.e. the

importance of informal networks such as trust relations (Uhr & Ekman, 2008) and emergent groups (Parr, 1970; Dynes 1970 and Uhr, Johansson & Fredholm, 2008) not normally associated with hierarchical structures of formal authorities. However, the broad concept of coordination, including many aspects of management, can be seen as vague and needs to be further elucidated, both theoretically and practically.

The aim of this article is to:

- Elucidate the concept of coordination in an emergency response management context
- Demonstrate how a social network approach can be utilized to better understand coordination behaviour
- Present interpretations of coordination behaviour among individuals in emergency response networks
- Discuss the implications of the network approach

The paper begins with a general account of the concept of coordination in an emergency response context and how it is discussed in the literature. This section aims to provide a theoretical foundation for further reasoning. The next part enters more deeply into coordination from a social network perspective and demonstrates how this approach can be utilized to understand empirical behavior. Interpretations of data from three studies on emergency response operations are presented. Finally, the concept of coordination, the network approach and the empirical findings are critically reflected and future implications discussed.

Coordination in an emergency response system

Coordination in the context of emergency response is an important but understudied research issue (Chen, Raj, Raghav & Shambhu, 2008, p. 73). The modern emergency management discourse often seems to use the concept when discussing activities that involve several formal organizations that operate “harmoniously” in one way or another. Even if the coordination concept in many connections is used without theoretical precision both practitioners and theorists probably have a broad understanding of what it implies. However, when one starts analyzing the assumptions that lie behind the everyday use of the word, several questions emerge. Is coordinating an element of command and control or are they separate concepts or downright polar opposites? How does coordination relate to concepts such as self-organization? (Comfort, 1994; Uhr, 2007 and

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Atkinson & Moffat, 2005). What is actually coordinated? etcetera. The common sense definition (see Malone & Crowston, 1990), “the act of working together harmoniously” provides us with no distinct answers to questions such as the ones above and the concept needs to be elucidated?.

First of all one needs to create a framework for the context in which coordination is studied. Uhr, Fredholm and Johansson (2009?) propose that an emergency response system can be seen as the assembled resources in a society that are engaged to take action against an emergency agent (e.g. a fire or a flood) and reduce the negative consequences following such an agent. Depending on our interest an analysis should focus on various subsystems of such a mega-system. Ashby (1956, p. 40) writes that “any suggestion that we should study all the facts is unrealistic”. He continues, “What is true is that we should pick out and study the facts that are relevant to some main interest that is already given”. This paper assumes that coordination involves many system components (artefacts in forms of communication systems and other physical resources as well as rules and regulations) but that coordination processes primarily should be associated with individuals and their interactions. Such approach does not mean that individuals and their interactions are completely differentiated from an overall context. The sub systems studied are influenced by various conditions, such as formal organizational structures.

An emergency response system can be regarded as a complex adaptive system (CAS) (see Comfort, 1994, 1999; Uhr, Johansson & Fredholm, 2008 and Atkinson & Moffat, 2005). The characteristics of a CAS are discussed in various literatures (i.e. Holland, 1995) and will not be examined deeply here. However, from a coordination aspect some characteristics of a CAS need to be considered. In a CAS, order derives from bottom-up behaviour (self-organization) that is based on local adaptation processes made by agents. Such local behaviour generates *system emergence*, e.g. system properties that are more than the sum of the local parts. In physics, temperature is an example of such an emergent property. It is not possible to talk about temperature on a molecule level. What can be described as system emergence is also discussed within sociology (Sawyer, 2001 and Parker, 2004). Sociologically oriented disaster research literature sometimes approaches the concept of emergence from a slightly different perspective. This literature often pays attention to *emergent phenomena* (Drabek & McEntire, 2002, 2003) or *emergent groups* (Dynes, 1970) and other constructions involving emergence and uses the concept to indicate an ad-hoc, non-planned behaviour (Quarantelli, 1993, Scanlon, 1999, Neal & Phillips, 1995). Introducing the concept

of emergence in sociology “was a reaction against the prevailing views of social structure, which were too static to capture the behaviour which was observed in the field.” (Dynes & Aguirre, 1979, p.5) A closely related characteristic of a CAS is its non-linear behaviour (Holland, 1995), which makes precise reasoning on cause and effects unfeasible. The difficulties to control the system from the outside (Atkinson & Moffat, 2005) become unmanageable. Also Quarantelli (1998) expresses a related reasoning. One may ask oneself if it is possible to discuss management in CAS due to its complex self-organizing nature. Axelrod and Cohen provide us with a useful concept – harnessing complexity – in their book with the same title. (Axelrod & Cohen 2000) “Harnessing” is also a concept used by disaster researchers such as McEntire (2007). Influenced by Axelrod’s and Cohen’s reasoning this paper suggests that management in an ERS has to do with understanding complexity and influencing system behaviour by using various means. On a local system level, describing for example a fire and rescue unit, influences can be synonymous with operational orders, but on a high system level where many different formal organizations are integrated this approach is not realistic. Seldom does one single authority (not even in totalitarian regimes), have the formal power, to “control” the complexity that arises from numerous dynamical interactions among individuals belonging to various different organizations. Nor is it likely that one individual could possess enough cognitive capacity to perform such a task. Both the legal and the practical prerequisites for “controlling” complexity in an ERS can be regarded as weak or even impossible. However, sometimes efforts must be made to adjust system behaviour in order to achieve a common goal. (Examples of common goals can be values expressed in the constitution, see the reasoning below). Local behaviour may be appropriate on a micro level but inappropriate and maladaptive, from a macro level. Harmonizing the ERS’s local behaviours can be described as acts of coordination.

Malone and Crowston (1990) suggest that the following questions are common problems that have to do with coordination:

- How can overall goals be subdivided into actions?
- How can actions be assumed to groups or to individual actors?
- How can resources be allocated among different actors?
- How can information be shared among different actors to help achieve the overall goals?

The authors relate the components of coordination; goals, activities and interdependencies, to the associated coordination processes; identifying goals, mapping goals to activities (e.g. goal decomposition) and managing

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interdependencies. This leads Malone and Crowston to a more narrow definition of coordination: “*the act of managing interdependencies between activities performed to achieve a goal.*” (Malone & Crowston, 1990). “...if there is no interdependence, there is nothing to coordinate.. ...Interdependence between activities can be analysed in terms of common objects that are involved in some way in both actions.” (Malone & Crowston, 1990, p.6). A similar approach to coordination is suggested by Malone and Smith: “The additional information processing performed when multiple, connected actors pursue goals that a single actor pursuing the same goals would not perform”(Malone & Smith 1988). Comfort (2007, p. 194) writes that “coordination means aligning one’s actions with those of other relevant actors and organizations to achieve a shared goal”. Klein (2001, p. 70) describes coordination as “the attempt by multiple entities to act in concert in order to achieve a common goal by carrying out a script they all understand”. Hage, Aiken and Marrett (1971, p2) talk about coordination as “...the degree to which there are adequate linkages among organizational parts, i.e., among specific task performances as well as among subunits of the organization, so that organizational objectives can be accomplished”. Thus, coordination can be seen as something that does not necessarily have to involve many different formal organizations. In this article the concept of coordination is associated with all types of organizations including formal bureaucracies and informal networks.

To better understand coordination we need to reflect on goal as an important component in the discussion on coordination. Coordination reasonably has to have a purpose and this purpose can be to achieve some overall goal or decompositions thereof. It is relevant to discuss the precision associated with formulated goals. Malone and Crowston (1990) contend that situations where actors, at least partly, have conflicting goals are almost universal and that conflicts are common. When analysing coordination the collective behaviour of the actors must be evaluated in terms of how well it achieves some overall goal (Malone & Crowston, 1990). “Even when a group of actors has strong conflicts of interests or belief, they may still produce results that observers would judge to be ‘good’ or ‘harmonious’” (Malone & Crowston, 1990, p. 2). In a situation where many formal agencies, volunteers and private companies act together there might exist various goals on an operational level, i.e. the police in a given situation want to evacuate a block, healthcare organizations want to provide medications, the fire brigade wants to control a fire and so on. Such different operational goals can be seen as decompositions of an overall goal. An example of an overall goal can be; return to a functional society or to protect life, property and environment. Harmonizing operational goals on various system levels in order to efficiently achieve the

overall goal is here seen as an essential component in coordination. Coordination is not necessarily a top-down driven process where one authority solely determines the overall goal and its compositions. Operational goals reasonably develop from local perceptions of a dynamic environment.

Thus, it is possible to discuss coordination on various system levels. Coordination on an accident scene where several fire fighting units have to operate jointly in order to extinguish a fire can be seen as coordination on a low system level and the goal to efficiently extinguish a local fire is a subset of an overall goal as exemplified above. A low system level can involve a high resolution of system elements but covers a more finite segment of the resources involved in the response. If a major emergency affecting many parts of a society (such as a flood, pandemic or earthquake) occurs, various formal organizations need to coordinate their objectives on a high system level. Most probably priorities need to be assigned, resources need to be shared and activities must be synchronized. In this context, a high system level implies a broad coverage of emergency response resources but principally a low resolution of the constituent system elements, i.e. the system components from such perception tend to be bigger entities and not hoses and stretchers. However, as implied in the beginning of this section, actual coordination processes are, irrespective of adopted system perception, arguably strongly related to individuals and their interactions. To be able to make different abstractions and change system perceptions are arguably important abilities associated with certain response managers. Coordination on a high system level is associated with a holistic approach and a deep understanding of the complexity characterizing the entire context (Uhr, Fredholm & Johansson, 2008), an understanding of the meta-level (Wybom & Latiers, 2006). However, overall coordination in a community disaster of any magnitude is problematic. (Quarantelli, 1998)

Dynes and Aguirre (1979) suggest that organizations can be coordinated by plan and by feedback. Coordination by plan is based on “pre-established schedules and programs directing and standardizing the functioning of organizations” (p.2) and coordination by feedback “is centred in the transmission of new information so as to facilitate the mutual adjustment of parts.” (p.3). They summarize: “coordination by plans relies on external control over organizational members while coordination by feedback is more dependent on internal control....Clearly these two types of coordination are ideal constructs.” (p.3). Furthermore, they write that “...coordination by plan is considered to be normative.” (p. 10) and that “this mode of coordination is seen as most appropriate, since a military model of

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organizational functioning in crisis is assumed to be most effective for such circumstances.” (p.11). “Coordination by plan characterizes many of the traditional emergency organizations, such as police and fire departments.” (Dynes & Aguirre P.9.) It is interesting to note here that emergency response management involves improvisation (Wachtendorf, 2004), self-organization (Comfort, 1994, 1999) and emergent behaviour (Quarantelli, 1998, Drabek & McEntire, 2002, 2003). Faraj and Xiao (2006) found that coordination practices amongst fast response organizations were highly emergent and that they cannot necessarily be specified. Earlier studies conducted in Sweden supports these international findings (Fredholm, & Uhr, 2007). The problems with a plan-based approach are also highlighted by Chen, Raj, Raghav and Shambu, (2008) who state such an approach sometimes leads to response inflexibility in the face of unexpected events.

Kuldeep and van Dissel (2006) use Thompson’s (1967) classification of how organizational units may be dependent on one another: Pooled dependency (units share and use common resources but are otherwise independent), Sequential dependency (units work in series where the output from one unit becomes the input to another) and Reciprocal dependency (units feed their work back and forth among themselves; in effect, each receives input from and provides output to others, often interactively). In the paper “sustainable Collaboration: Managing Conflict and Cooperation in Interorganizational Systems (Kuldeep & van Dissel, 1996) March and Simon’s typology of coordination is used to highlight parallels between the three types of interdependence and three types of coordination. “With pooled interdependence, coordination by standardization is appropriate; with sequential interdependence coordination by plan is appropriate; and with reciprocal interdependence, coordination by mutual adjustment is called upon, p. 286). Reciprocal interdependence has the highest level of contingency and implies the lowest level of initial structure. (Kuldeep & van Dissel, 1996). Mutual adjustment is discussed as a coordination mechanism and Kuldeep and van Dissel claim that mutual adjustment relies “upon a high level of ad hoc activity that will further reduce the structure” (p. 287).

A hypothesis influencing the following reasoning is that both coordination by plan and coordination by feedback are occurring in most emergency response situations and that the context in which coordination occurs is complex by nature. NSF-IRIS, A report by the NSF-IRIS Review Panel for Research on Coordination Theory and Technology, suggests that coordination means “*the operation of complex systems made up of components*”. This article supports this approach and advocates

that coordination in emergency response operations represents dealing with complexity and that there are many managerial approaches of doing this. Here, coordination can involve both emergent behaviour (here indicating new, novel ad-hoc characteristics) and strict mechanistic command and control processes. Coordination is sometimes used as a polar opposite to command and control (See for example education programmes in European community mechanism for civil protection, OCHA) but from the perspective used in this paper command and control is a possible component in coordination processes. It is important to note that command and control and its amalgams can be seen as imprecise concepts with multiple meanings (Arbuthnot, 2008). Skyttner (2005) makes the observation that command and control has been used lately more and more in a civilian framework, in a manner synonymous with management and decision-making. One reason why coordination sometimes is described as an “opposite” to command and control (and often as a more realistic management alternative) may be that C2 by many scholars is associated with strong centralization. “With command and control is usually referred to centralized steering management with the objective to optimize the collaboration of involved professionals or parties” (Helsloot, 2008. p.173). Alberts and Hayes “Power to the edge” (2003) and Atkinson and Moffat’s “The Agile Organization” (2005) can be seen as examples of command and control literature that do not represent a traditional mechanistic approach.

At this point we can conclude that coordination is a broad concept that involves dealing with complexity. Managing interdependencies between activities performed to achieve an overall goal can be seen as a central part of coordination. An overall goal does not have to be associated with an overall authority or management function. Individuals operating in a dynamic environment have operational goals that are generated by their local perceptions. Sources of influences affecting their perceptions can be other individuals, culture, rules and regulations etcetera. Coordination has to do with harmonizing these operational goals and the activities performed to achieve them so that the overall goal can be satisfied. It is relevant to relate coordination to various system levels. Coordination on high system levels involves dealing with multi-organizational comprehensive problems while coordination on low (local) system levels concerns a more delimited context. The theoretical reasoning presented in this paper opposes the view that coordination and strict command and control are polar opposites. If an authority structure exists a formal order can be seen as a subset of coordination. However, since coordination on high system levels is likely to concern multi-organizational environments where no unified chain of command

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exists, other tools for coordination are normally required. Research literature (Dynes & Aguirre) suggests that coordination can be divided into two general categories; coordination by plan and coordination by feed-back, and that coordination in emergency response is partly characterized by the latter. It is here suggested that both types are to be found in an emergency response operation.

Coordination from a social network perspective

This paper proposes that coordination can be seen as a central aspect of emergency response management and that discussions on coordination do not necessarily have to take their starting point in formal organizations and bureaucratic structures. The meaning of formal organizations and bureaucratic structures can here be related to what Robey and Sales write about an organization's structure: "An organization's structure defines the expectations for each role and the connections between each role" (Robey & Sales, 1994, p.9 as cited by Kuldeep, 1996, p. 6). Ideal abstractions as diagrams of formal organisations can be seen as components that influence the coordination process within an ERS, but they do not reasonably represent the entire coordination context. There is a lack of understanding of the interaction between formal and informal institutions Zenger, Lazzarini, and Poppo,(2002). "Too often it is assumed that the organization of a company corresponds to a blue print plan or organization chart. Actually it never does" (Roethlisberger & Dickson, 1939). This paper suggests that that the most important components in a coordination process are humans and their interactions. Adopting a social network perspective is therefore a realistic starting point for discussing coordination.

Disaster management researchers have earlier paid attention to the network perspective (see i.e. Drabek, 1983; Comfort, Ko & Zagorecki, 2004 and Wise 2006) but empirical analyses based on interactions among individuals can be further developed. In order to analyse and discuss coordination from a social network perspective we need to start with relating to the connectivity of the agents involved in the system and employ a structural approach. Agent interactions can be seen as the foundation that carries various information relevant for coordination. Comfort, Ko, Zagorecki, 2004 write "If complex networks transmit massive amounts of information, how is it possible to identify the core information? Core information is both structure and context dependent. The structural approach is to check the connectivity." (Comfort, Ko & Zagorecki, p. 309).

A tool developed by Uhr and Johansson (Uhr & Johansson, 2007, Uhr, Johansson & Fredholm 2008, Uhr, Johansson, Ekman & Fredholm, 2009) has been used for mapping and analysing emergency response networks. Briefly, the connectivity among various agents, thus the foundation of the different networks, is based on the agents' own assessments of who they were in contact with during the actual response process given that this contact was of significance for their work. The data collection process includes a snowballing procedure (Uhr & Johansson, 2007 and Scott 2000) in order to identify as many agents as possible. When a participant has rendered his or her personal network in a web questionnaire they are asked to add information about the importance of the relations as well as an estimation of contact frequency. Furthermore, they are asked to add attributes such as time when they got involved, organizational belonging and overall impressions about the operation. Based on methods developed within social network theory a number of analyses can be performed.

One of the main motives behind the development of the tool was to better understand management in response situations involving various societal resources. During this work the method has been tested in three different empirical studies so far. None of the three accidents involved human casualties and they cannot be considered to be devastating from a societal point of view. However, they were more complicated and involved more resources than an everyday accident. In this paper data from these studies are reanalysed in order to present how coordination can be studied from a social network perspective. The aims of the studies have never been to evaluate the response operations. At this stage, understanding of empirical behaviour is prioritized.

Case 1 – A chemical spill

For a couple of days in February 2005 the residents of the city of Helsingborg in Sweden were facing the potential danger of a chemical accident occurring in an industrial area. A cistern containing 16 000 tons of sulphuric acid had collapsed and another cistern was threatened due to the spill. The area near the cisterns became contaminated and poisonous gas developed when the acid reacted with water. Resources from southern Sweden became involved in the demanding response process. Examples of problems facing the managers were: evacuation, dealing with acid and potential clouds of gas, personnel turnover and public announcements. Many of these problems had to be dealt with by dealing with interdependencies and synchronizing activities, i.e. coordination. Reports stated that the response diverged from existing plans and showed emergent behaviour

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(Uhr & Johansson, 2007). Behaviour that can be related to the concept of coordination by feed-back (Dynes and Aguirre, 1979).

Case 2 – A factory fire

On the 3rd of October 2007 the small village of Forserum in the southern part of Sweden suffered from a fire in a local factory producing latex products. Several formal organizations became involved in the response operation. There were no human victims but the potential consequences for environmental damage were high due to contaminated water from the sprinkler system and the fire and rescue services attempts to extinguish the fire. It became clear that there was an intensive communication flow among the individuals engaged in the operation and that the communication between the formal organisations (i.e. fire and rescue service, country administrative board, health care services, the affected company and municipality administration) seemed to be motivated by need and not “controlled” by bureaucracy.

Case 3 – A fire in a apartment building

During the night between the 26th and 27th of November 2007 a major apartment building in the city of Malmö caught fire. Around 80 apartments were affected and many people had to be evacuated. The response operation was complicated and considerable fire and rescue services resources were involved. Half way into the operation formal decision makers were replaced and the on-scene organization was changed. Even if the response personnel mainly consisted of individuals from various fire and rescue services the situation involved coordination aspects and coordination challenges. Since the response to a great deal was carried out by professionals from one type of organization, e.g. the fire and rescue service, the prerequisites for traditional command and control were higher. In this case the task of coordinating the resources in the ERS can be associated with a few decision makers having formal mandate to command involved personnel.

Analysing coordination structures from a social network perspective

Based on the reasoning above it is assumed that coordination in an emergency response context is a broad concept that has to do with dealing with a complex system. In order to achieve an overall goal interdependencies between various activities need to be managed. Coordination can be discussed at various systems levels, but irrespective of one talking about “high level coordination” (See UN office for coordination of humanitarian affairs for example) or local coordination between two fire fighters trying to break through a door to extinguish a fire,

coordination activities are reasonably always dependent on interpersonal communication. Network configurations based on emergency response managers' perception of their various interactions during the response process can be seen as a framework in which coordination activities have taken place. Thus none of the studies are based on communication patterns that are logged by computers. The method used, based on voluntary participation, could result in an incomplete representation of the studied system. On the other hand the method provides the researcher with qualities that are hard to catch when analysing patterns of communication based on records of traffic patterns.

Since coordination by itself is treated as a concept with various qualitative dimensions indirect attributes, or proxy attributes (Keeney & Raiffa, 1976), become useful in empirical analyses. Proxy attributes are mainly discussed within decision theory. Kleeney and Raiffa (1976, p. 55) write: "A proxy attribute is one that reflects the degree to which an associated objective is met but not directly measure the objective. Thus, proxy attributes indirectly measure the achievement of a stated objective". In the context of emergency response systems "communication intensity" (i.e. how often two agents communicate) and "estimated importance" (i.e. how important the particular contact was for the activities performed by the asked agent) can be seen as proxy attributes for coordination. According to Kleeney and Raiffa (1976) it is important to reflect how the proxy attributes are related to the stated objective, in this case coordination. Can we say that coordination has taken place if we can observe these two relations? By asking different response managers to name the contacts they had during the response operation, under the prerequisite that the contacts were of any significance for their work, one type of dependence relation associated with performed activities is mapped. When the intensity of communication and the grade of importance of various contacts are also mapped, indicators for various dependencies among the agents, and thus the activities performed by them, becomes further strengthened. These dependencies are here associated with coordination.

The interpretations of the empirical material can be summarized in three points:

- The coordination processes were distributed among the agents in the networks
- Coordination was partly characterized by emergent behaviour
- Low complexity can be associated with less emergent behaviour

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Distributed coordination processes means that the interactions indicating coordination can be observed between agents with various formal functions and hierarchical positions. Formal organizational borders were frequently crossed. Coordination processes were not associated with few management functions building single bridges between formal organizations. In other words, the networks were characterized by reasonably high connectedness.

Emergent behaviour is used in correspondence with its meaning in disaster management literature, i.e. it indicates something new, novel or ad-hoc. Results from previous studies point towards the fact that response management to a certain degree is characterized by various ad-hoc solutions in order to meet various demands. The empirical material presented here supports these findings. For example; formal organizational boundaries were frequently crossed in ways that did not always correspond to plans and procedures, emergent group constellations can be identified and some individuals assumed new roles during the response.

The data on the individuals engaged in the response operations and their interactions can be analysed in several ways. Below, some variations are presented. The interpretations of the empirical material are here supported by a number of examples, however since the aim of this article is not only to present results from empirical studies, the number of comparative analyses is restricted.

The coordination processes were distributed among the agents in the networks

Figure 1 – Networks demonstrating distributed coordination in case 1

The network study carried out focussed on individuals working for Helsingborg fire brigade, the biggest formal actor in this response. However, since the agents were asked to state other agents who were of significance for their work during the response agents belonging to other formal organizations were included and asked the same questions. The results from this study are presented in Uhr and Johansson (2008). In figure 1a data is reused to illustrate how links of communication are distributed among the agents in the network. Figure 1b shows only contacts who were perceived as being of particular importance. (The instructions were to rate the three most important contacts. However, some responders misunderstood this intention and indicated none or more than three.) What can be seen here is that both links of communication and the perceived importance of contacts are distributed among the agents. The relations cross

formal hierarchies and there is no single representative from each and every formal organization that manages the contacts with other formal organizations even if some “hubs” (e.g. agent 19, the vice fire chief) can be observed.

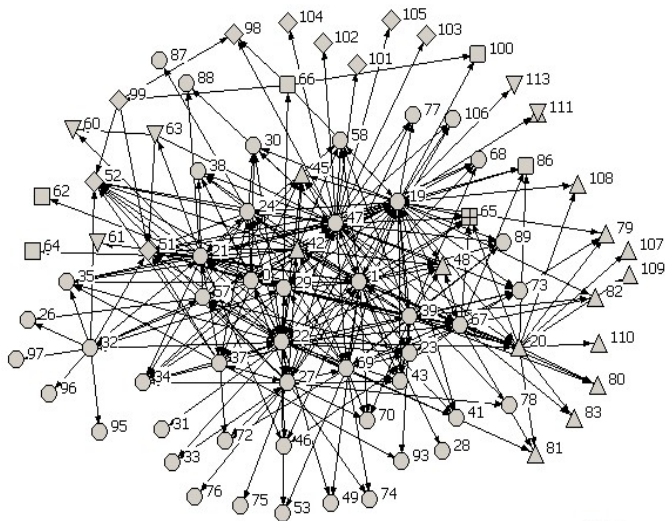


Figure 1a

- Fire and rescue service
- ▲ City of Helsingborg
- Scania county administration board
- ▣ Health care
- ▤ Private company 1
- ▥ Private company 2
- ◆ Affected company

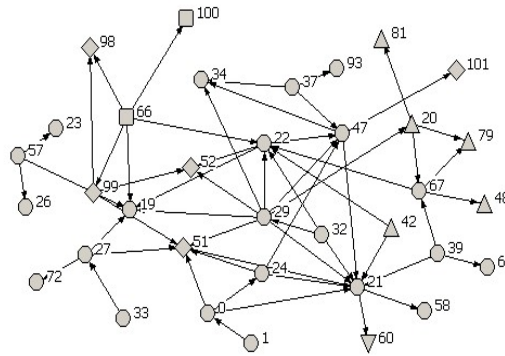


Figure 1b

Figure 2 – Networks demonstrating distributed coordination in case 2

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The network data presented in figure 2 are characterized by a better *completeness* (see Tehler, Uhr, Ekman & Fredholm, 2009) than the data in case 1. In other words: the results can be interpreted with higher precision since most of the agents perceived as important by others participated in the study themselves. The illustrations below are results of improved methods for data collection and analysis. Figure 2a illustrates a network consisting of all identified agents who had managerial tasks during the response to the factory fire in Forserum and their contact relations. All agents are grouped according to their formal organizational belonging. Similar to Figure 1b, figure 2b represents contacts that for different reasons were considered to be of special significance for the agents' work during the response. In this particular study the respondents had to choose between 5 levels of perceived importance and the number of chosen relations was not restricted. The network in figure 2b represents relations of grade 3,4 and 5 where 5 indicates "contact of decisive importance". Each respondent active in the study also stated estimated communication intensity. In figure 2c communication relations showing "more than 5 occasions" are illustrated. Figure 2a, 2b and 2c all indicate distribution of relations between the agents.

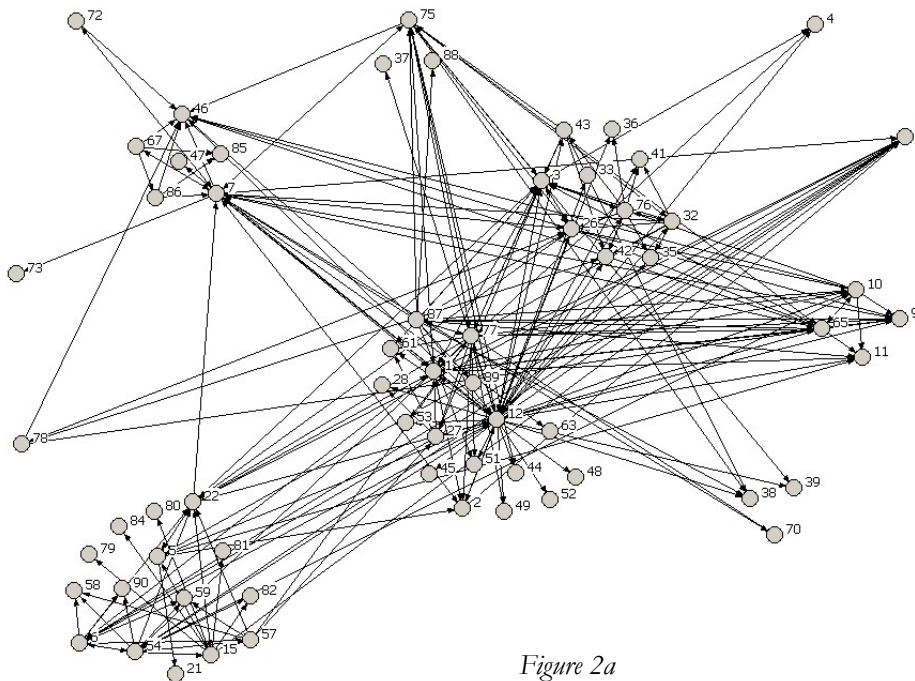


Figure 2a

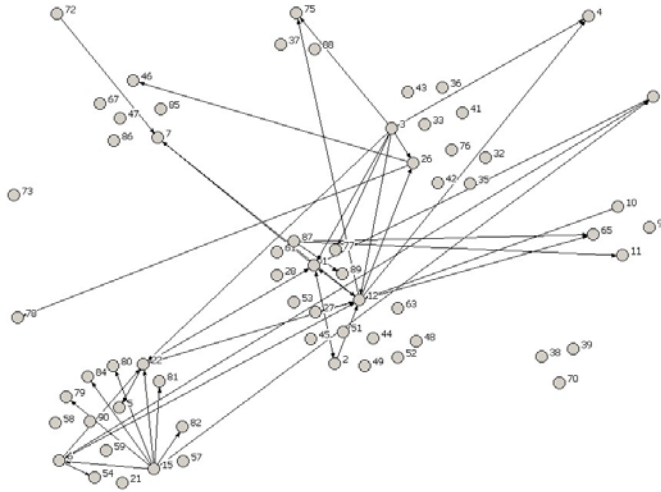


Figure 2b

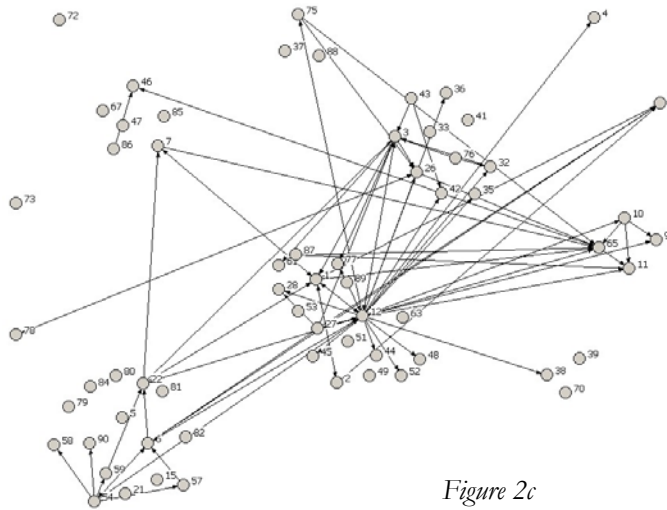


Figure 2c

Figure 2 – Networks demonstrating distributed coordination in case 2

Coordination was partly characterized by emergent behaviour

Studying emergent behaviour (such as the establishment of emergent groups) from a social network perspective can be seen as a complement to traditional interviews. By using both interviews and social network analyses the validity of final results pointing towards emergent behaviour in response operations can be strengthened through triangulation.

Figure 3 – Network formation demonstrating emergent behaviour in case 1

Figure 3 demonstrates a network of agents active in the response to the discharge of sulphuric acid in Helsingborg and the contact relations that were mapped. The size of the nodes corresponds to the amount of relations that are directed to them (in-degree). One can observe that the agents with highest in-degree are the vice chief of Helsingborg fire brigade (22) some of the on-scene commanders who were active during different phases of the operation (51,21) and the chief of Helsingborg fire brigade (19). However, agent 47 was assigned with an in-degree that was equivalent to, and in some cases even higher than, the on-scene commanders who generally are considered as very central for response operations. Agent 47 (employed by the fire brigade) occupied no formal role in the formal organisations. Instead, due to his knowledge of different people, he had a free role (supported by the chief of the fire brigade) with the aim of supporting coordination. Agents 34 and 37 were commanders in a “chemical staff function” that to a high degree was initiated and designed by the two well recognized experts themselves. (One of the agents, 37 drove to the accident scene on his own initiative.) According to interviews the decisions made in this function were important influences for the operational alignment of the response. However, the commanders’ “official mandates” were not equivalent with e.g. the on-scene commanders’. 34 and 37 show a high in-degree in the network presented in figure 3.

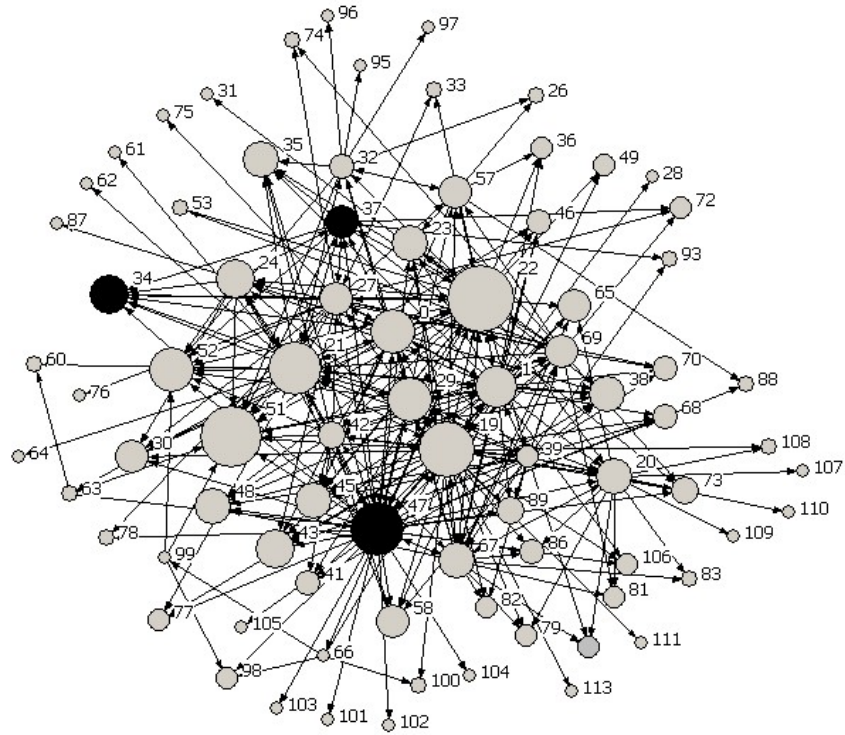


Figure 3

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Figure 4 – Network demonstrating emergent behaviour in case 2

In figure 4 a Newman-Girvan algorithm (applicable when detecting communities in complex systems, see Tehler, Uhr, Ekman & Fredholm, 2009) is used to group agents active in the response to the factory fire in Forserum. The relations used for performing this analysis are relations showing perceived importance of grade 2, 3, 4, and 5. Thus, the figure shows clusters of agents based on interactions and not on formal organizational belonging. What can be observed is that the biggest group is heterogeneous, e.g. is consists of agents with various belonging to formal organizations. Such groups can be seen as an example of an emergent phenomenon in a response operation.

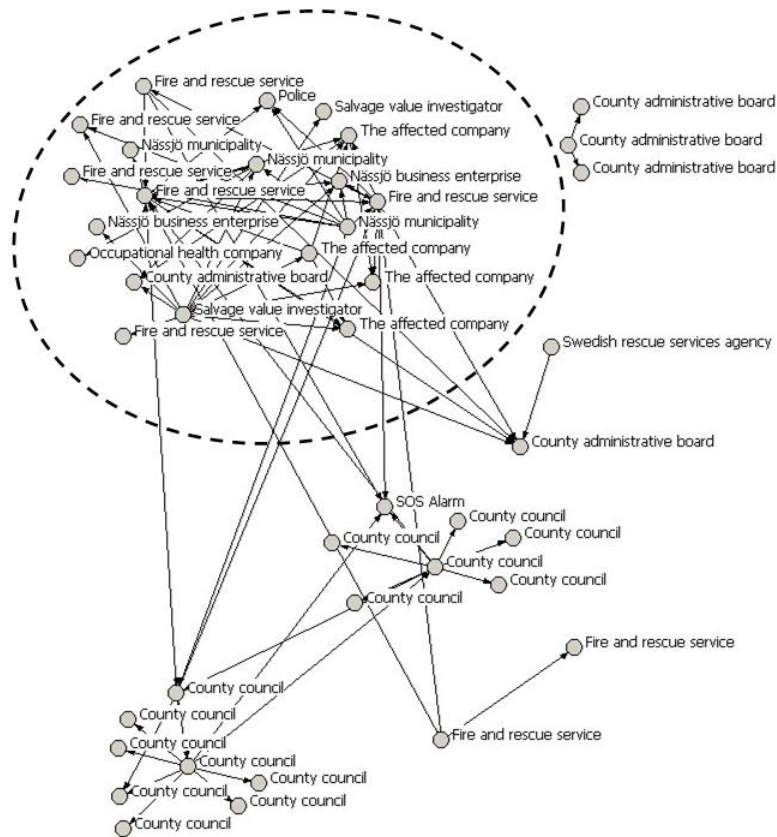


Figure 4

Low complexity can be associated with less emergent behaviour

Even if case 3 can be regarded as a complex response process that included more resources than an everyday operation, it has characteristics that differ from case 1 and 2. The response process involved personnel from several formal organizations, but few of them had central roles during the response operation. In other words, the total number of involved agents with managerial tasks only was less than in the other two cases and most of them belonged to one formal organization. The response system active in case 3 can be described as a system characterized by less complexity than the systems active in the other studied responses. In the first two cases no one had the formal mandate to “be in charge” over the entire operation, there were no unified chain of command, but in case 3 the authorized possibilities to influence the whole process were greater. In the previous section it is suggested that coordination does not necessarily have to be associated with processes including resources belonging to many different formal organizations. Coordination can be discussed within the frames of a single formal bureaucracy, in this case a fire and rescue service.

In order to deal with the fire one type of on-scene organization was initially “established” by the current on-scene commander. However, the response operation turned out to be more and more complicated. In the turn-over process, where the first on-scene commander was going to be replaced, an officer with high rank hand-picked the new on-scene commander who restructured the on-scene organization. The network study that was carried out later divided the response operation into two phases, one phase representing the first on-scene organization and one representing the second. One of the reasons why this network study was conducted was to see how the network structures altered when the formal on-scene organization was changed. How much did the formal structure influence the manifestation of networks based on “information” and “importance”? Even if the study did not include network data from all managers included in both phases, valuable insights can be obtained.

Figure 5 – networks demonstrating how lower complexity can be associated with less emergent behaviour

The group configurations in figure 5 show that the Newman-Girvan algorithms, here based on communication relations indicating communication at more than five occasions, result in clusters corresponding to formal organizational structures. It can also be observed that the change of formal organization had an impact on the configurations of the clusters. In figure 5a, representing the first of the two studied phases, A1 includes individuals from the strategic and operational staff

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functions together with the first on-scene commander and B1 and C1 include commanders from two of the sectors (organizational arrangement normally used on bigger accident scenes) used. In Figure 5b, representing the second phase studied, A2 includes individuals belonging to the strategic and operational staff functions and B2 and C2 include individuals belonging to the new sectors decided by the new on-scene commander. The size of the nodes is due to the number of incoming relations indicating “importance” of grade 5, i.e. highest importance. Commanders with a high rank, such as agent 1 and 2, show a high in-degree of this type of relation.

Even if it is possible to observe parallels between group formations and formal organizational structures in case 2, the main impression when interpreting the data presented in figure 5 is that the group formations to a great deal correspond to the formal organizational structures. Moreover, the change of the formal on-scene organizational arrangement had an obvious effect on the network formations. Interviews with agents with managerial tasks in case 1 and 2 indicate emergent behaviour. In case 1 these findings are supported by an official report (Danielsson & Winnberg, 2005). Such behaviour was not confirmed by the respondents in case 3. One could claim, however, that the change of on-scene organization and the selection of the second on-scene commander are examples of emergent behaviour. The general impression though, is that this response operation was characterized by less emergent behaviour than the other two cases.

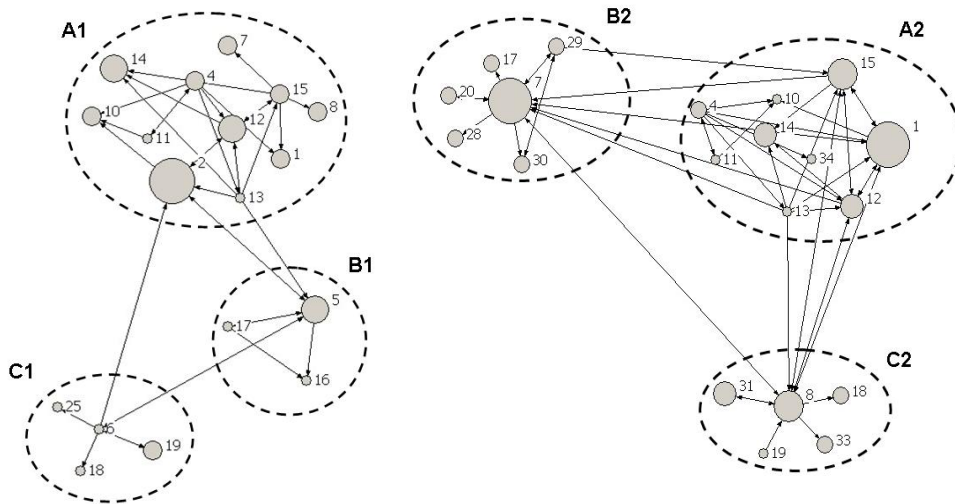


Figure 5a

Figure 5b

Discussion

The purpose of this paper is fourfold: (1) to elucidate the concept of coordination in an emergency response management context, (2) to demonstrate how a social network approach can be utilized to better understand coordination behaviour (3) to present interpretations of coordination behaviour among individuals in emergency response networks and (4) to discuss the implications of the network approach. In this discussion the literature findings are reflected and related to the empirical results. Moreover, the validity of the network approach, the results from the three studies and future implications are discussed.

Literature findings and the empirical analysis

A quantifiable definition of what coordination is and what it is not will not be provided here, however through references to literature and showing how coordination structures can be studied it is anticipated that the paper provides the reader with material for deeper understanding of the frequently used concept. Malone's and Crowston's (1990) definition – *the act of managing interdependencies between activities performed to achieve a goal* – covers many important dimensions of coordination. It is here argued that a common operational goal can hardly be declared by a single authority in a response involving many formal organizations. Instead overall goals are probably represented by common values in a modern society. The process of decomposing these values into various operational goals and then subdividing them into interdependent actions among agents in an emergency response system is intricate. Coordination can be placed on a level with harnessing the complexity in emergency response systems. Although various chains of command are present in an emergency response context all the available resources in a society cannot be related to one single all-embracing chain of command. Wise (2006) shows a very critical attitude towards what he calls “the idea of top-down (i.e., hierarchical) coordination” providing stability in a multi-organisational environment, in analysing events connected with Hurricane Katrina. He cites Adler (2001, p. 216) who writes “By their non-routine nature, such tasks cannot be programmed, and the creative collaboration they require cannot be simply commanded.” However, it is argued here that coordination can include elements of traditional command and control. Without entering too deeply into what the terms command and control really mean, it can be said that coordination can exist and include elements of both “tight control” and self-organization. The discussion on coordination is facilitated by relating it to certain system levels. Coordination on a high system level, including a broad spectrum of system resources, can for various reasons discussed above not easily be performed through “tight control” from a single authority. On the other hand, on a lower

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system level, where all included agents fit into a pre-planned formal authority structure “tight control” may be possible. Hélène Denis (1995) suggests that coordination can be either spontaneous or imposed. She also writes (p. 34) that coordination “is not a neutral mechanism” and that in disaster situations there is “a need for a loosely-coupled type of coordination (Weick, 1976) on the one hand, but for a centralized type of coordination on the other hand.” In an emergency response system it is reasonable that coordination processes are characterized by influences flowing both bottom-up, top-down and side-to-side in different formal hierarchical structures. The prerequisites for top-down imposed coordination, such as orders relying on formal authority, logically decreases with a higher system level and vice versa.

Drabek and Aguirre (1979) make an important distinction between coordination by plan and coordination by feedback that can be related to commonly used concepts such as emergent phenomena and emergent groups. Moreover, their categorization relates to what Zenger, Lazzarini and Poppo (2001) among others write about the interaction between formal and informal institutions. Not surprisingly there are numerous empirical examples of response operations that show a behaviour that does not correspond to what is described in pre-existing plans and procedures. Indeed responders are influenced by official documents, but these are not real blueprints for behaviour. It is sensible that responders improvise and cross organizational borders to achieve goals that from their perception seem to be realistic. One needs to reflect how this knowledge affects the way preparedness solutions are designed. A common practical approach to coordination seems to be that it has to do with management of formal organizations working together. Using such a framework as a starting point may have advantages, however, it is here argued here that the social network perspective to coordination is more representative of how coordination actually takes place. With that, the meaning of formal structures (or institutions) is not neglected. Formal structures, laws and regulations accompanied by trust relations are examples of conditions that affect how coordination is carried out and manifested in forms of network structures among agents in an emergency response system.

When analysing coordination from the network perspective suggested here, one accepts the reasoning on proxy attributes as indicators for coordination. It is not a matter of course that the attributes *communication intensity* and *perceived importance* are the only, or even the best, attributes that can be used for analysing coordination, but it is presupposed that they are strong indicators. The network structures can

be seen as an empirical example showing the interplay between what Denis (1995) calls “loosely –coupled coordination” and “centralized coordination”. It can be observed that both links of “importance” and “communication” are distributed among the agents. At the same time we see that there are agents with high in-degree centrality who also are associated with certain high hierarchical positions, such as on-scene commanders. Faraj and Xiao’s (2006) findings that coordination practices among fast response organizations were highly emergent and that they cannot necessarily be specified are also supported by the empirical findings, both in the network structures, where some nodes emerged as important ones without being represented in existing plans, and in interviews and official reports. The three cases represent relatively small events with far less “magnitude” than a devastating earthquake or terrorist attack. Nevertheless, they reveal characteristics similar to what has been found in studies of responses to larger emergencies.

There is enough empirical data to perform more comparative analyses. However, the purpose in this paper has been to exemplify how coordination can be studied and not to provide extensive descriptive analyses. It is important to emphasize that the empirical characteristics discussed are results of interpretations of existing data. In other words, even if the characteristics presented in the previous section harmonize with what is found in the literature and the interpretations can be seen as interesting indicators, one has to be careful when making general conclusions.

Addressing validity concerns

Reflecting on coordination from a social network perspective appears to be a fruitful approach when understanding coordination, but validity issues should be discussed. The following matters need to be critically considered:

- Relevant representation of agents
- Various biases rooted in the researcher’s presumptions about empirical behaviour
- The dynamic character of coordination
- Imprecise definitions of commonly used concepts such as complexity

We need to critically reflect on how we abstract the studied objects into an emergency response system or its parts. Which agents are to be included in a study and which are not? This issue is earlier discussed by Uhr and Johansson (2007). The intention of the data collection process is to identify agents that have been important decision makers during a response operation. A useful tool for judging the representativeness of the collected data is to use the *completeness measure*

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introduced by Tehler, Uhr, Ekman and Fredholm (2009). When a system is studied we to make mental demarcations of the reality and these demarcations will always be to some degree subjective. In other words, we need to be aware of how we bias the data collection process as well as the data analysis. Researchers are likely to be biased by their own paradigms generated by their culture, their theoretical perspective², practical experience etcetera. Being aware of the effects of bias and including other researchers in the discussions can help minimize this problem.

When it comes to emergency response one has to bear in mind that the dynamics of such processes are hard to condense in a system, such as a network of interacting agents. The analyses of the cases illustrate structural approaches to coordination but do not include data on when the various interactions took place. All networks can be seen as compressed representations of a complex and dynamic reality. Case 3, capturing two different time sequences, is an example how study on dynamics can be improved. Additionally, all the agents active in the three studies provided points of time when they became involved and when they left the process. Future analyses need to take this parameter into consideration in order to find out more about e.g. the power law hypothesis (Clauset, Cosma, & Newman 2007 and Atkinson & Moffat, 2005).

The last matter reflected here possibly concerns the whole emergency response discourse, namely the lack of precise definitions of commonly used concepts. This paper shows that e.g. coordination, command and control and emergence are burdened with multiple meanings. As long as there is no consistency in the meaning of the various concepts used by both practitioner and academics the task of communicating and understanding research results and practical experience will be complicated. A solution to the problem would be to ask various users of the concepts to define what they mean more precisely.

Studying emergency response coordination from a social network perspective involves a comprehensive approach for understanding complexity and can be used as a complement to interview studies. Being aware of the problems associated with the word complexity – complexity might fit well in the exhortation jargon that sometimes burdens the current discourse – this characteristic cannot be underemphasized. The complexity of an emergency response system lies in the eye of the beholder and it is hard to quantify the concept in the current context. However, it is proposed that we in a theoretical discussion jointly can grasp different quality aspects of “low complexity” and “high complexity”. A response

system, defined by few active resources, can still be complex depending on the resolution used when abstracting the reality. In comparative analyses, such as the ones presented here, one must bear in mind that the level of detail of the systems described and their principal outer boundaries should correlate. When they do not, this needs to be discussed. One way to approach complexity and estimate if it is “high” or “low” is to relate to the number of formal “resource holders”. In case 3, for example, most of the resources active during the response phase belonged to the fire and rescue service. If the situation had involved many people needing medical assistance resources from health care organizations these would be included in the particular response system and the level of complexity would increase as a consequence. In case 1 and 2, due to the snow-balling principle (Scott, Uhr & Johansson, 2007), agents from various formal organizations were included in the networks. Thus these two responses could be said to be characterized by a higher complexity than case 3.

Future implications

The literature describes many characteristics of emergency response that can be verified through social network analysis. Emergency management literature often talks about observed behaviour that differs from, or is not included in, plans and procedures. Parr, for example, writes in his analyses: “some emergent groups become the nexus for decision-making” (Parr, 1970, p.429). Social network analysis cannot only help verifying such findings, it can also help us to better understand important characteristics. It can among other things provide answers to where coordination hubs emerge and raise questions regarding system vulnerability and system redundancy. Social network analysis can also identify valuable interview respondents that in other cases are hard to discover. Understanding empirical behaviour is almost certainly important when designing response systems and when harnessing the complexity that arises in an actual response. The conditions for effective emergency response are changing with a changing society and we cannot rely on normative ideas based on tradition and conventional management ideas only. When analysing emergency response systems and coordination from a social network perspective one realizes that we have merely scratched the surface of a dynamic and very complex research field.

The analysis of the empirical material presented here is not contradictory to other empirical observations, if anything the other way around. Based on both literature and the studies one can conclude that is very likely that coordination in major responses is partly characterized by emergent behaviour. Logically, there might also be a generally positive relationship between complexity and occurrences of

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emergent solutions. Of course, there may be examples of operations characterized by low complexity and significant emergent behaviour. The data on which the analyses in this paper are based can be further explored.

One can argue that the empirical implications and the characteristics discussed in the literature are not sufficiently taken into consideration when discussing design of response systems and operational procedures. Normative ideas that govern preparedness efforts might be incompatible with empirical behaviour. In order to confirm and draw more detailed conclusions on how coordination can be distributed among agents in networks and better understand the conditions for emergent behaviour more studies need to be conducted. One needs to bear in mind though, that even if some empirical behaviour may be universal, context related conditions such as culture, legal systems and different hazards certainly play important roles for how different responses are carried out.

Conclusion

Coordination in an emergency response context has to do with dealing with various interdependencies in a complex system in order to achieve an overall goal. An example of an overall goal can be common values manifested in a country's constitution. In a response operation managers most likely have to harmonize various operational goals generated by local interpretations made by different individuals. Coordination can be discussed on different system levels and include various managerial strategies. The concept does not have to be a polar opposite to traditional command and control.

Research literature implies that coordination in emergency response operations do not always correspond with existing plans. An important impetus for descriptive analyses of coordination behaviour is that improved normative ideas most likely are facilitated by better empirical understanding. A formal organizational perspective is seen as an insufficient starting point for analysing coordination during emergency response. As a supplement a social network approach is suggested. Structures describing various relations among emergency response managers reveal context specific dimensions of coordination that are not shown in bureaucratic representations of emergency response systems.

Data from three studies indicate that coordination processes can be distributed among the agents in an emergency response network and that coordination partly is characterized by emergent behaviour which can be linked to the level of complexity that constitutes the system. Further studies need to be conducted in

order to better understand empirical conditions. Such descriptive analyses need to be taken into consideration in the normative reasoning, especially when discussing coordination at high system levels.

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