ANALYTICAL INPUT TO EMERGENCY PREPAREDNESS PLANNING AT THE MUNICIPAL LEVEL – A CASE STUDY

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Abstract

In this paper an approach for employing risk and vulnerability analyses as the basis for emergency preparedness planning is discussed and exemplified using a case study. The study consisted of three connected parts: a broad scope hazard identification and analysis, an assessment of potential assistance needs should any of the hazards materialise and finally a mapping of actors and dependencies. The case study was conducted as a series of workshops, involving key actors from the studied municipality. Some thirty hazard scenarios, originating from five different categories; accidents, epidemics, infrastructure/utilities breakdown/interruption, criminal activity and socially induced scenarios were identified, described and initially evaluated in terms of possible consequences over a range of predefined attributes. In the next step, an analysis of potential assistance needs that may evolve during the identified scenarios was undertaken. Furthermore, an effort was made to identify municipal actors of central importance in the management of potential emergency scenarios, their respective tasks, resources and dependence on service from various technical infrastructures, other actors etc. Examples from the resulting overview of potential emergency scenarios, generated assistance needs and emergency management actors, tasks, resources and dependencies are presented and discussed, alongside with some implications for societal preparedness activities.

Introduction

The importance of planning and preparing for emergency and crisis has been increasingly evident over the last decades. In Sweden, this development is reflected in various ways, e.g. in the issuing of new legislation, requiring public authorities at all levels to perform risk and vulnerability analysis within their respective sector or area of responsibility, and furthermore to develop plans and make preparations for the management of potential forthcoming unwanted events (SFS, 2003, 2006a, b).

The challenges related to planning and preparedness activities have been extensively debated in the literature. For instance, the balance between preventive measures and preparedness activities have been discussed (McEntire, 2005; Pelfrey, 2005), and several suggestions on what could be called "sound principles" of emergency and crisis preparedness have been put forward (Perry and Lindell, 2003; Alexander, 2005). In these concepts, knowledge about the hazards and potential unwanted events facing a community is of importance when making

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preparations for the management of future potential emergencies and crises. However, several authors have argued that, particularly when discussing the concept of crisis in a complex system like a human society where the inherent level of uncertainty is vast, the possibility of anticipation is limited (Boin and Lagadec, 2000; Boin, 2004; French and Niculae, 2005; Gundel, 2005) thus generating a need for strategies of resilience, which is often referred to as developing a capacity to absorb, respond to and recover from harmful events[4]. Another interesting discussion on this topic, although more directed to risk evaluation and management is presented by Klinke and Renn (2002). Furthermore, McConnell and Drennan (2006) contribute with an excellent discussion on various "tensions" between the "ideals" of crisis preparedness and the realities of a crisis. Despite the fact that it is difficult to anticipate harmful scenarios in complex systems, we take the position that knowledge about the potential hazards a community is facing, in conjunction with a notion on what values one wants to protect from harm should to the extent possible be sought and used as input to emergency and crisis planning and preparedness.

The overall objective of the work which this paper is based on is to gain knowledge about how input from risk and vulnerability analysis work can come to better use in planning, preparing for and managing unwanted events in society. The final aim is to develop a framework for analytical input to the emergency preparedness process at the local, municipal level. It is a common notion in the crisis and emergency management literature that crisis management is predominately a local affair (Boin et al., 2003; Perry and Lindell, 2003; Alexander, 2005). For instance, according to Boin et al (2003) the trend in designing emergency management structures is to build them from the bottom up: local authorities begin to deal with disaster, regional and national authorities offer assistance. In this paper, the objective is to present some approaches we have used in practice in a Swedish municipality and some results and conclusions drawn from this work.

The case study

In 2006 a case study was carried out in a Swedish municipality with approximately 23 000 inhabitants (for full project report in Swedish, see Abrahamsson and Johansson (2007). A series of workshops and interviews with representatives from various actors in the municipality were conducted during the study, which consisted of three connected parts; a broad scope hazard identification and analysis, an assessment of potential assistance needs should any of the hazards materialise and finally a mapping of important actors and dependencies. The three parts of the study are presented in more detail in the following sections.

Broad scope hazard identification and analysis

As mentioned above, knowledge about the hazards and potential unwanted events facing a community is of importance when trying to prepare for future emergencies and crises (Perry and Lindell, 2003; Alexander, 2005). In this part of the study, our aim was to be able to make a structured, comprehensive identification of potential risk scenarios facing the municipality, and in this endeavour we found the framework provided by Kaplan and colleagues in the form of an operational definition of risk based on systems theory very useful (Kaplan and Garrick, 1981; Kaplan, 1997; Kaplan et al., 2001). In this framework, when the system under analysis behaves as intended, it follows the "success scenario" S_0. To determine the risk in the system one needs to find all the scenarios (or at least the important ones) that deviate from S_0 and leads to unwanted consequences (of significance), i.e. the risk scenarios, S_i, and further to estimate their respective probabilities (L_i) and consequences (X_i). Another way to put this is that one needs to find the answers to the questions: "What can go wrong?", "How likely is it?" and "What are the consequences?" (Kaplan, 1997). In order to make use of the

[4] Wider conceptions of the term resilience, including anticipation and prevention of harmful events, have been presented; see for instance Leveson et al. (2006).

framework one needs to generate an understanding of what constitutes S_0 in the system of interest. This in turn requires a notion of what is included in the system and of its boundaries, something that is well known to have major influence on the results of an analysis.

In this study, the system of interest was the whole municipality with its inhabitants, technical infrastructure, industry, administrative functions, etc. To make an explicit, detailed description of what constitutes S_0 in such a complex system is a task of monumental proportions. In this particular study, our approach was to define S_0 as any scenario that does not generate negative consequences (above a specified level) in any of a number of predefined consequence categories[5]:

- Life and health
- Environment
- Economy
- Living- and functioning conditions
- Democratic and legal values

The category "Life and health" has to do with whether a risk scenario may result in fatalities, people being severely injured or ill, people in need of health care etc. The category "Environment" encompasses the environmental impacts a risk scenario could bring about in geographical and temporal sense, the possibilities of recovery etc. The economic impact refer to short term as well as long term effects on the whole "system" i.e. effects for the municipality's inhabitants, industry and trade and societal functions are considered. Further, the category "Living- and functioning conditions" has to do with the proportion of inhabitants and/or trade and industry that have their living conditions and/or prerequisites to function in a normal fashion considerably complicated or ruined. Finally, the category "Democratic and legal values" refers to the extent to which an unwanted event could result in defiance against democratic principles, society's laws and regulations etc. A starting point for the identification and analysis was that the focus should be on unwanted events with consequences of severe magnitude, i.e. only scenarios resulting in significant consequences in any or several of the above categories were assessed explicitly, while identified scenarios scoring low in all consequence categories were omitted. This will be further discussed in relation to issues of completeness below.

For every consequence category a five level scale was constructed in order to enable rough estimates of potential consequence levels in the different categories that a risk scenario might generate. For each level a short description of the corresponding consequences was made. An example regarding the consequence category "Life and health" is presented in table 1 below.

Table 1. Example of consequence scale for the attribute "Life and health"

	Life and health – consequence scale
1	Single fatalities and/or several severely injured and/or some ten in need of medical care
2	Several fatalities and/or some ten of severely injured and/or hundreds in need of medical care
3	Some ten fatalities and/or hundreds of severely injured and/or thousands in need of medical care
4	Hundreds of fatalities and/or thousands of severely injured and/or tenths of thousands in need of medical care
5	More than a thousand fatalities and/or tenths of thousands severely injured and even more in need of medical care

In a similar manner a five level scale regarding the expected frequency with which the different potential emergency scenarios may occur, ranging from "less than once in ten

[5] In this part of the study, a number of "basic values" important to protect from harm were defined, leading to the consequence categories given above. A sixth category, not originating from "basic values" was used in the analysis: "demand on societal resources" having to do with to what extent societal resources will be needed to deal with the effects of a specific risk scenario and whether resources from outside the municipality will be needed.

thousand years" for level 1 to "more than once in ten years" for level 5, was constructed to help evaluation of the identified scenarios.

In order to facilitate identification of potential unwanted events (i.e. the risk scenarios) the municipality might face, extensive check-lists were constructed containing support for generating risk scenarios in five different categories;

- accidents (both in socio-technological systems and materialised natural hazards),
- spread of disease,
- infrastructure/utilities breakdown/interruption,
- criminal activity (including terrorism), and
- socially induced scenarios.

During the workshops, some thirty risk scenarios (or rather "sets" of risk scenarios, see below) were identified, described and initially evaluated in terms of likelihoods and possible consequences in the categories described above. In addition to the checklists mentioned above, existing risk assessments, for instance regarding the petrochemical industry, were used as input to the identification and evaluation process. To illustrate the range of scenarios considered, some examples are given: "a large release of chlorine gas from industrial facility", "a large release of hydrocarbons from industrial facility – vapour cloud explosion", "a severe storm", "a severe epidemic", "many people are falling sick, the reason unknown", "a long-lasting (more than one week) disruption of freshwater distribution", "a long-lasting (more than one week) loss of electric power", "a long-lasting (more than one week) disruption of district heating system", "virus attacks on municipal IT-systems", and "a credible threat regarding attack on petrochemical industrial facility". For each of the identified scenarios, an appraisal of the likelihood and consequence in the predefined consequence categories (using predefined, 5-level consequence- and likelihood scales like the one in table 4 above) was made. This part of the study resulted in a comprehensive overview of the kind of events that may affect the municipality alongside with an indication of what consequences these may implicate.

Here, some comments related to the framework provided by Kaplan and colleagues mentioned above should be made. In the general definition of risk given by Kaplan et al. (2001), the set of potential scenarios in a system is by nature infinite and non-denumerable. However, for practical purposes, if one is interested in determining the (approximate) risk in a system the set of scenarios should be finite, complete, and disjoint. The first requirement can be met by "partitioning" the infinite set of scenarios, S_A, into a finite set of scenarios, S_i, where each scenario, S_i, represents an infinite subset of more detailed scenarios, S_α (Kaplan et al. 2001). For instance, in this study, the scenario "Long lasting (more than one week) loss of electric power[6]", comprises all scenarios matching that description, e.g. blackouts lasting two weeks, or three weeks, blackouts occurring during the warm summer, or during cold winter months etc., which could all lead to different consequences (and have different likelihoods). The "scoring" in the evaluation of the scenarios in the study was based on *one* representation of that scenario (or set of scenarios). The level of detail in the partitioning of the scenario space, S_A, will affect how well the approximate measure of the risk, gained though the analysis, corresponds to the "real" risk in the system.

In this study, the set of scenarios evaluated were finite (by letting an infinite set of scenarios, S_α, be represented by one scenario, S_i, as described above). The completeness requirement means that the set of risk scenarios, S_i, should in aggregate cover the scenario space, S_A. In this study, completeness was achieved, in a rather technical sense, by adding the scenario (or set of scenarios) "all scenarios not explicitly treated" to the set of risk scenarios. The reason for this was twofold. Firstly, it is an acknowledgement that all potentially important risk

[6] This scenario could in turn be seen as a subset of the scenario "Loss of power" (disruptions lasting less than a week not being explicitly included in the assessment).

scenarios in S_A (S_A being defined by the five categories of risk scenarios given above[7]) may not have been identified and evaluated yet and that future assessments should strive to identify more scenarios in the different categories. Secondly, a deliberate choice was made not to include risk scenarios with "minor" effects on the municipality in terms of consequences in the different consequence categories. For instance, power disruptions lasting less than a week were not explicitly considered in the evaluation. The third requirement; that all scenarios be disjointed, i.e. that there is no "overlap" between the scenarios cannot be said to be fulfilled in the study. For instance, there may be an overlap between the scenarios "Severe storm" and "Long-lasting (more than one week) loss of power" in the sense that the first may well lead to the other. However, since the objective is not to generate a "measure" of the overall risk in the system (municipality), but rather an extensive overview of potential risk scenarios and a rough understanding of their related consequences, this is of little importance. In the next section, this overview is used to identify and describe potential assistance needs that may evolve in the different scenarios.

Assessment of assistance needs

One starting point in this work is that the assistance needs that may arise in the affected population over time and space in an emergency situation should be a cornerstone in societal emergency preparedness, a point of view inspired by for instance the work of Buckle and Fredholm (Buckle, 1998; Buckle et al., 2000; Fredholm, forthcoming).

Based on the identification and description of emergency scenarios that was made in the previous stage, an attempt was to identify and characterise the potential assistance needs that may arise in such events. To facilitate this identification and characterisation a model was constructed based on the following categorisation of need domains: "protection of life and health", "psychosocial needs", "life and function support", "protection of property and the environment", "protection of democratic values", and "recovery", which were derived from the categorisation given by Fredholm (forthcoming).

Two workshops with representatives from various functions in the municipality were held where the emergency scenarios identified in the previous part of the study were considered in order to identify and categorise potential assistance needs in the affected population. It should be noted that discussions on for instance whose responsibility it might be to prepare for and act in order to meet a specific need were deliberately not held during the workshops. The intention was rather to generate a comprehensive overview of needs on all levels to be used as input to discussions on such matters. Some examples of results are given below:

- Protection of life and health:
    - Need for information (what happens, how to act etc?), Need to distance oneself from exposure (e.g. evacuation, vaccination, isolation of infected), Need for caretaking of injured and ill, Need for caretaking of diseased etc.
- Psychosocial needs:
    - Need for acute support for anxiety and grief, Need for information (e.g. what happens, is the dangerous situation over, how long will it continue?) etc.
- Life and function support:
    - Basic needs like food, water, lodging etc. Need for alternative societal services in case of disruptions (fresh water distribution, electric power, communications etc).
- Protection of property and the environment:
    - Need for restoration of damaged property, trade and industry facilities etc. Need for protection/restoration of environmental values etc.

[7] Potential scenarios that can not be related to any of the five categories described above falls, should they exist, "outside" of this definition completeness.

- Protection of democratic values:
    - Need for protection of equal rights of citizens in times of chaos etc.
- Recovery:
    - Need for restoration of functions of societal importance, both administrative and physical (e.g. technical infrastructures). Need for long term psychosocial support etc.

Risk scenarios and the potential needs and consequences they may result in, put demands on the capability of various municipal actors to respond to and manage such events. In the following section, a mapping of important municipal actors and their dependence on various resources etc in order to perform certain tasks related to the management or prevention of such events is presented.

Mapping of central actors and dependencies

In order to facilitate an analysis of the municipality's emergency management capabilities, an effort was made to identify *actors* (i.e. an organisation or part of an organisation) of central importance in potential emergency scenarios. Furthermore, the respective *tasks* of critical importance that each actor might perform were identified and described alongside with the necessary *resources*, in terms of for instance personnel and artefacts required to perform a certain task. Finally the actors' dependence on service from various *technical infrastructures*, other *actors* etc in order to be able to perform a certain task was mapped out. Thus the following kinds of elements were considered in the survey:

- *Actors*, e.g. Health care and Rescue services.
- *Tasks,* e.g. to fight fires or to operate the district heating system.
- *Resources* (in addition to technical infrastructures), e.g. vehicles and population directories.
- *Technical infrastructures*, e.g. roads, power distribution system, sewer system.

The objective of this part of the study was to assess the dependencies between an actors' capability to perform a certain task and the access to resources, technical infrastructures and other actors performing certain tasks that might influence this capability. This was done using two measures of dependence relationships: the *occurrence* of dependence, i.e. how often does the dependence occur, and the *strength* of dependence, i.e. how severely is the actors capability to perform a certain task affected when for instance a certain resource, "normally" used to perform this task, is unavailable. The approach is presented in more detail below.

Occurrence of dependence

Sometimes, in order to be able to establish whether dependence as described above exists, a relatively detailed description of the tasks is necessary. Assume, for instance, that one task for the rescue services is "*to fight fires"*. To be able to perform this task, one can imagine that the resource "*ladder truck*" is needed for some, but not all types of fire. This could be handled in (at least) two ways. One way is to divide the task "*to fight fires"* into a number of sub-tasks of higher level of detail, e.g. *"to fight fires in high-rise buildings"* (where this dependence is likely to occur), *"to fight forest fires"* (where this dependence is not likely to occur) and so on. However, it is not always necessary to describe the tasks in more detail. Instead, one could indicate how often one estimates that the dependence occurs, which allows tasks of more general character to be assessed. This was done by using a three-level categorisation as described in table 2.

Table 2. Occurrence of dependence

	When an actor is to perform a certain task, how often is there a dependence of a certain : technical infrastructure/resource/ other actor performing a certain task
1	The dependence is always present
2	The dependence is often present (2/3 of the times)
3	The dependence is sometimes present (1/3 of the times)

Strength of dependence

All dependencies are not of equal importance for an actors' capability to perform a certain task. For example, the loss of one resource may reduce the efficiency with which a specific actor will be able to perform a certain task while the loss of another resource prevents the actor to perform the task at all. In order to achieve a rough understanding of the level of importance of the different dependencies that were identified for an actors' capability to perform a certain task a measure of strength of dependence was introduced, see table 3.

Table 3. Strength of dependence

	Effect on an actors capability to perform a certain task in case of: technical infrastructure disruption/resource unavailability/other actor not performing a certain task
A	The task is not possible to perform
B	The task is possible to perform but with severely reduced efficiency (1/3 of normal efficiency)
C	The task is possible to perform but with somewhat reduced efficiency (2/3 of normal efficiency)

To exemplify the approach let us look at the actor *fire and rescue services*. Among the tasks that were identified for the fire and rescue services were:

- Managing fires in buildings, which involves everything the emergency services does when handling fires in buildings, e.g. search and rescue and limit the spread of fire.

To be able to perform this task the actor *fire and rescue services* has resources in terms of personnel, vehicles and other equipment etcetera. The dependence on such resources alongside with dependence on technical infrastructures and tasks performed by other actors, were mapped out for each of the tasks identified for the rescue services using the measures of occurrence and strength of the dependence described above. One example of the resulting information is presented in table 4.

Table 4. Example of a task with corresponding dependencies[8].

Tasks	Resources	Technical infrastructure	Tasks performed by other actors
Managing fires in buildings – industrial buildings	Personnel, max 17 2 regular fire engines (1,A) 1 industrial fire engine (1,A) 1 Ladder truck (3,A) Foam system (1,A) 2 Hook loaders (1,A) 2 Management vehicles (1,A)	Roads (1,A) Fire hydrants (1,A) Radio communication (2, A) Mobile telecommunication (3,A) Public warning system (3,B)	Reinforcement from neighbouring municipality (1,A)

This kind of mapping was performed for municipal actors identified to have tasks important to emergency management, providing an overview of the structure of actors and resources (and dependencies) available within the municipality to meet the needs and demands arising in potential emergency scenarios. Some examples of actors included in the study were: the

[8] Numbers and letters within parenthesis represent an assessment of the occurrence and strength of the dependence; see tables 2 and 3 above.

rescue services, health- and geriatric care, the office of energy and the environment, the municipal district heating company and municipal schools.

Discussion

The objective of this study was to apply an approach to generate analytical input to emergency preparedness planning in a case study at the local, municipal level. The approach is based on a systematic and comprehensive identification of the broad range of potential hazards and risks facing the municipality. This feature of the approach, i.e. the objective to identify and analyse risk scenarios originating from a very broad spectrum of risk and hazards sources, a process facilitated in the approach by predefined categories and checklists, is one of the major points. We find that in many existing practical approaches to analytical input to preparedness activities, the focus is mainly on one or a few types of hazard, sometimes to a large extent based on previous experience. We claim that in adopting a broad scope in terms of hazard and risk scenarios considered in an analysis, the municipality has a better platform for comprehensive preparedness planning activities. One could argue that there are two sides to that coin, in that it is a time and resource (in terms of personnel) consuming activity. The response from the municipality under study indicates however, that the advantages were considered to be worth the extra effort, in that the participants gained a better knowledge of the total spectrum of risks facing the municipality, and that they were able to identify and discuss potential unwanted events that they had no experience of beforehand. The second major point of the approach used is the explicit, structured identification and description of potential assistance needs that may arise given a specific risk scenario, a process facilitated in the approach by a model based on a number of predefined domains of assistance needs. On a general level, the information obtained from these two parts of the study could be used by municipality officials, planners and politicians as one input to reasoning about for instance the distribution of responsibility to meet identified needs, identification of areas in needs of improvement, identification of education and training needs, resource allocation issues etc.

The third part of the study was more focused on the structure available for meeting potential consequences and needs, in terms of important actors and their dependencies on various resources, technical infrastructures and coordination with other actors. The information obtained from this kind of work could also be used by the municipality as input to the assessment of the capabilities of the different actors to meet the needs generated by various risk scenarios. The issue of being able to describe and evaluate such capabilities in a structured manner is discussed by Jönsson et al. (2007), where an operational definition of the term emergency response capability is given.

All parts of the study are tightly connected in the sense that information generated in one stage can be (and were) used as input to the others. To exemplify, information from the mapping of actors and dependencies can be used as input to the assessment of potential consequences that may arise in identified emergency scenarios (which will be dependent on the capabilities of the actors to meet the needs and demands generated by the event). The other way around, the identification of potential emergency scenarios and the related assistance needs may generate input regarding “new” tasks that need being managed by one or several actors. In this sense, the approach with the three interconnected parts can be seen as a circle of feedback and feed forward loops of information.

It may also be a point that the kind of inter-organisational workshops that were conducted during the study, with representatives from many different administrative units within the municipality, could assist in building professional networks. Such networks have proved to be of importance in the management of emergencies and crises, see for instance Uhr and Johansson (2007).

Conclusions

We have demonstrated an approach that can be used to focus the emergency preparedness efforts undertaken in a municipality on the various needs that may arise should any of the hazards facing the municipality materialise. The approach consists of three parts; starting with an identification effort where the potential hazard scenarios that the municipality is facing are mapped out. The next part of the approach focuses on the identification and description of different needs that may arise if any of the hazard scenarios identified should materialise. In the third part the actors responsible for meeting those needs are identified, and furthermore an analysis of what the different actors are dependent on, in terms of resources, technical infrastructures etc.., in order to be able to meet the needs is conducted. We argue that in using the suggested approach one creates a suitable foundation for emergency preparedness planning which is based on the spectrum of hazards relevant to the specific municipality in question and on the range of specific needs that may arise in that municipality as a consequence of any of the hazards materialising.

References

Abrahamsson, M. and Johansson, H. (2007). En studie av risker och sårbarheter i Stenungsunds kommun. Lund University Centre for Risk Analysis and Management (LUCRAM), Lund.

Alexander, D. (2005). Towards the development of a standard in emergency planning. *Disaster Prevention and Management*, Vol. 14, No. 2, pp. 158-175. Emerald, United Kingdom.

Boin, A. (2004). Lessons from Crisis Research. *International Studies Review*, Vol. 6, pp. 165-174. Blackwell Publishing, USA.

Boin, A. and Lagadec, P. (2000). Preparing for the Future: Critical Challenges in Crisis Management. *Journal of Contingencies and Crisis Management*, Vol. 8, No. 4, pp. 185-191. Blackwell Publishing, United Kingdom.

Boin, A., Lagadec, P., Michel-Kerjan, E. et al. (2003). Critical Infrastructures under Threat: Learning from the Anthrax Scare. *Journal of Contingencies and Crisis Management*, Vol. 11, No. 3, pp. 99-104. Blackwell Publishing, United Kingdom.

Buckle, P. (1998). Re-defining community and vulnerability in the context of emergency management. *Australian Journal of Emergency Management*, Vol. 13, No. 4, pp. 21-26. Emergency Management Australia, Australia.

Buckle, P., Mars, G. and Smale, S. (2000). New approaches to assessing vulnerability and resilience. *Australian Journal of Emergency Management*, Vol. 15, No. 2, pp. 8-14. Emergency Management Australia, Australia.

Fredholm, L. (forthcoming). Dealing with all types of emergencies from everyday accidents up to disasters In L. Fredholm and A.-L. Göransson. *Emergency Response Management in Today's Complex Society*. Swedish Rescue Services Agency, Karlstad

French, S. and Niculae, C. (2005). Believe in the Model: Mishandle the Emergency. *Journal of Homeland Security and Emergency Management*, Vol. 2, No. 1, Article 2. The Berkeley Electronic Press, USA.

Gundel, S. (2005). Towards a New Typology of Crises. *Journal of Contingencies and Crisis Management*, Vol. 13, No. 3, pp. 106-115. Blackwell Publishing, United Kingdom.

Jönsson, H., Abrahamsson, M. and Johansson, H. (Submitted to TIEMS 2007). An Operational Definition of Emergency Response Capabilities. Submitted to *TIEMS 2007 - Disaster Recovery and Relief: Current & Future Approaches*, Trogir, Croatia.

Kaplan, S. (1997). The Words of Risk Analysis. *Risk Analysis*, Vol. 17, No. 4, pp. 407-417. Plenum Press, USA.

Kaplan, S. and Garrick, B. J. (1981). On The Quantitative Definition of Risk. *Risk Analysis*, Vol. 1, No. 1, pp. 11-27. Plenum Press, USA.

Kaplan, S., Haimes, Y. Y. and Garrick, B. J. (2001). Fitting hierarchical holographic modeling into the theory of scenario structuring and a resulting refinement to the

quantitative definition of risk. *Risk Analysis*, Vol. 21, No. 5, pp. 807-819. Blackwell Publishing, USA.

Klinke, A. and Renn, O. (2002). A New Approach to Risk Evaluation and Management: Risk-Based, Precaution-Based, and Discourse-Based Strategies. *Risk Analysis*, Vol. 22, No. 6, pp. 1071-1094. Blackwell Publishing, USA.

Leveson, N., Dulac, N., Zipkin, D. et al. (2006). Engineering Resilience into Safety-Critical Systems. In E. Hollnagel, D. Woods and N. Leveson. *Resilience Engineering - Concepts and Precepts*. Ashgate Publishing Limited, Aldershot

McConnell, A. and Drennan, L. (2006). Mission Impossible? Planning and Preparing for Crisis. *Journal of Contingencies and Crisis Management*, Vol. 14, No. 2, pp. 59-70. Blackwell Publishing, United Kingdom.

McEntire, D. A. (2005). Why vulnerability matters - Exploring the merit of an inclusive disaster reduction concept. *Disaster Prevention and Management*, Vol. 14, No. 2, pp. 206-222. Emerald, United Kingdom.

Pelfrey, W. V. (2005). The Cycle of Preparedness: Establishing a Framework to Prepare for Terrorist Threats. *Journal of Homeland Security and Emergency Management*, Vol. 2, No. 1, Article 5. The Berkeley Electronic Press, USA.

Perry, R. W. and Lindell, M. K. (2003). Preparedness for Emergency Response: Guidelines for the Emergency Planning Process. *Disasters*, Vol. 27, No. 4, pp. 336-350. Blackwell Publishing, United Kingdom.

SFS (2003). *Swedish statutes* Lag (2003:778) om skydd mot olyckor

SFS (2006a). *Swedish statutes* Förordning (2006:942) om krisberedskap och höjd beredskap

SFS (2006b). *Swedish statutes* Lag (2006:544) om kommuners och landstings åtgärder inför och vid extraordinära händelser i fredstid och höjd beredskap

Uhr, C. and Johansson, H. (2007). Mapping an emergency management network, *Int. J. Emergency Management*, Vol. 4, No. 1, pp. 104-118. Inderscience Enterprises Ltd,

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