On Emergency Management: Tools Used for Analyzing Findings of a Delphi Study

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Abstract--**Emergency managers need to make decisions, often with important consequences, under stress and time pressure. When dealing with disasters, identifying hazards, analyzing risks, developing mitigation and response plans, maintaining situational awareness, and supporting response and recovery are complex responsibilities. To implement adequate mitigation measures, emergency managers must make sense of the situation, although information may be lacking, uncertain or conflicting. In order to take effective actions in a disaster, actors are expected to work smoothly together, thus the flow of information is crucial. In this paper we describe a Delphi study on the topic and present two tools used for analyzing the findings of the study. We also discuss computer-assisted qualitative data analysis and the findings of the study, focusing on the better flow of information and interoperability of information systems and organizations.**

I. INTRODUCTION

It is typical of disasters that they cannot be managed by an organization on daily-based preparedness and resources alone. It is important to be aware of what has happened, what is likely to happen, and the consequences of the incident in terms of disaster management [16]. Usually it will bring together individuals belonging to many different organizations who represent different organization cultures that may differ in their communication. In this context, terminological differences also play a decisive role [11]. Depending on the individual structures and practices of the respective organizations, different terms are used, which can cause several communicational issues [18]. In addition, communication problems are a common occurrence where actors communicate across organizational boundaries [21,28]. The basis of reconciliation is that the different parties involved understand each other, particularly in a disaster scenario. In order to improve emergency management it is essential to anticipate and be ready for cross-sectoral collaboration with different organizations and different fields of operation [26].

When dealing with disasters, heterogeneity is ubiquitous in emergency management informatics. In fact, emergency situations are characterized by their complexity and the diversity of the available information [4,5]. There are various process rules, names for entities, sensor platforms, information systems platforms, data and communication formats, organizations, and even languages [23]. Such heterogeneity can hinder an effective disaster response, which was clearly seen in Haiti following the 2009 earthquake. As proposed by Galton and Worboys, an ontology that can provide unified definitions of entities, their properties and relationships, and thus facilitate improved communication in the presence of heterogeneity, would be one solution to this problem [5]. Emergency managers need to make decisions, often with important consequences, despite being under stress and time pressure. To implement adequate mitigation measures, emergency managers must make sense of the situation even though information may be lacking, uncertain or conflicting. Additionally, emergency managers are often confronted with redundant or irrelevant information causing information overload [4].

In many emergency situations related to disasters, especially in man-made disasters, the first responders in the situation are typically company personnel. Therefore their appropriate action in the situation is very significant. It is crucial that these personnel can communicate and act as effectively as possible in an acute situation. Murray Turoff gives an excellent analysis and summary in [30] of an instance when the communication within an organization goes seriously wrong in the management of a disaster and causes severe additional damage. Accordingly, one of the major communicational challenges related to disasters is that, since company personnel and other civilians are not professionals in the security or rescue field, their communication abilities in such situations may be limited.

Identifying hazards, analyzing risks, developing mitigation and response plans, maintaining situational awareness, and supporting response and recovery are complex responsibilities. Information connected with a place and time and in which the situation is described as reasonably as possible (using an image, voice, text, etc.) in order to know what has happened or is happening and which persons or objects the incidents may concern, is known as situation awareness [3]. Clear situation awareness is a key factor for the effectiveness of emergency operations. Situation awareness is based on the compilation of information collected from different teams of responders. The building up of such a picture relies on the exchange of information [22,28].

The forming of situation awareness for disaster management is a challenge for authorities, companies, and other actors such as volunteer organizations. The successful management of a disaster is based both on the existence of practical situation awareness and rescue operations being carried out in due time [29]. Kuusisto reports clearly the challenges caused by the parties taking care of different tasks, by their organization cultures, and division of responsibility areas [10].

For various reasons, different authorities or companies specialized in their own fields use different concepts and terms for the same issue, although the object domain is the same. Some of these differences may be explained by cultural

differences or differences in organization cultures [1,4,7,17,32]. Communication between the players involved has a key role in cases of serious accidents. It is noteworthy that:

1. There are several levels (from global to local) of regulations and agreements that have to be followed, all of which use terminology that is not necessarily the same as that used by others.
2. There are several authorities that have to be able to share information with each other and with companies.
3. There are companies that may cause a disaster or where a potential disaster may happen. In addition to regulations, companies may have international group or company policies to follow [12].

In order to take effective action in an emergency situation involving different actors who are expected to work smoothly together, more attention should be focused on the situations where their communication takes place. In Finland, a three round Delphi study is being carried out on this subject, with 48 experts representing authorities, company personnel, and volunteer organizations.

The aim is to create an overall picture of the challenges in the flow of information and communication, both in the preparedness phase and in the response phase of disasters. The first Delphi round was carried out by means of personal interviews with all the experts involved in the first half of 2012. The interviews were transcribed. Since the amount of transcribed material was large, it was decided to use computer-assisted analysis in order to manage data, create codes from the data, and handle the material so that everything would be stored systematically by computer [27]. The second Delphi round was accomplished using Internet-based questionnaires made with Delphi-specific software in autumn 2012. The third Delphi round will also be performed using Internet-based questionnaires during spring 2013.

In this paper the use of the two software programs, ATLAS.ti and eDelfoi, is presented together with some of the results from the first two Delphi rounds. Next, in the discussion section, an evaluation is made of whether computer-assisted data analysis techniques can provide opportunities for developing the qualitative analysis procedure to become integrated, explicit, and systematic. Finally, some conclusions are drawn and we also present the target for the final Delphi round on the importance of a common understanding in emergency management.

II. A DELPHI STUDY

A. The Delphi Method

Delphi is a survey or interview method where the knowledge and assumptions of experts on the issue or the development process being studied are collected in an interactive process. As a data collection method, Delphi falls into the category of both a quantitative and a qualitative study. It is especially useful when the phenomenon under study is complex or when the topic is somehow delicate – difficult to define, awkward to talk about, politically sensitive, etc. [6,14,20]. Delphi may be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem [24].

The Delphi method is particularly suitable for establishing a communication structure among members who have the same general core of knowledge and are well informed on the subject, and as such can be labeled an expert method. Experts for a Delphi panel are selected from among the experts in the field of study, with the aim of covering all the relevant aspects of the study subject [2,6,9,25]. These experts are then made to interact with each other the topic in a way that emphasizes the rationale of the arguments rather than the position or authority of the panelist in question. In addition to the variety of opinions this produces, the Delphi method boasts other advantages in finding solutions for communication problems: for example, its future orientation and its ability to take into account the tacit knowledge and experience of the panelists, etc. [8,19,20]. In addition to expertise, features that identify Delphi are anonymity and iteration [6].

The basic difference between ordinary surveys and the Delphi is its iterative and feedback nature. Unlike conventional opinion polls, opinions are not merely collected for analysis, but information about the answers is fed back to the panelists. Feedback information encourages the respondents to justify their choices. Therefore information builds up in each successive round so that the previous round forms the basis for the following one.

The study process begins with the first round interview or questionnaire. This also orientates the experts or panelists to position themselves with regard to both the Delphi process and to each other. In the comments and arguments made in the second and third rounds, the panelists clarify their stance and views and try to convince the others. Between the rounds, the manager (researcher) analyzes the results and forms the arguments into new claims for the panel to answer or to vote on in the next round. The panelists do not have to react to each claim, only to those on which they have something they wish to say. It has been shown that expert evaluations have improved when the panelists can also reflect on the credibility of their answer [6,31].

B. Research Setting

Using the Delphi method, circumstances are identified where different actors have recognized potential problems or risk situations related to the flow of information and communication in emergency management. This allows us to create an overall picture of the challenges in the flow of information and communication both in the preparedness and response phase of disasters.

The aims of our study were to:

1. Identify situations where there have been problems related to information flow in or between different organizations.

2. Identify problem situations in different action phases. What are the challenges in the pre-accident preparedness phase, and on the other hand, what are the challenges in actual disaster situations, i.e. in the response phase?

Thirty-five organizations were invited to join our Delphi study. 16 different authorities, 16 medium-sized or large companies, and 3 other organizations were represented on our panel [13,15].

From the public sector were invited:

- 2 Ministries; e.g. ministries responsible for policy making and development of legislation and other regulations concerning the topic of this research
- 10 State/Regional State Authorities
- 4 Local/Municipal Authorities.

From business life were invited:

- 4 Power/energy supply and telecommunications providers including a nuclear power plant
- 8 Companies including chemicals producers
- 4 Companies representing logistics/transportation including hazardous materials transportation.

In addition, three volunteer or similar organizations (e.g. volunteer fire brigade) were invited onto the Delphi panel. These 35 organizations nominated a total of 48 experts for the Delphi panel. All the experts had several years of experience in emergency management with backgrounds in different lines of business.

III. THE FIRST DELPHI ROUND

The first Delphi round was carried out by interviewing the 48 experts individually. The interviews were themed interviews; the themes were preparedness including regulations, and rescue situations related to disasters. The aim of the interviews was to ascertain when and what kinds of problems related to information flow within or between different organizations had been experienced by the interviewees. The interviewees were asked about their views on the challenges and problems in communication and the flow of information related to disaster management.

The interviews were recorded and transcribed. The transcribed data consisted of over 400 pages of written material in MS Word. Since the amount of material was so large, it was decided to use ATLAS.ti software to analyze it (see www.atlasti.com). ATLAS.ti is qualitative data analysis (QDA) software that offers tools to manage, extract, compare, and explore meaningful pieces from large amounts of data in systematic ways.

First, the transcribed data was imported to the ATLAS.ti software. Next, the data was coded and classified. Codes were used as classification devices at different levels of abstraction in order to create sets of related information units for the purpose of the comparison tool perspective. The codes were typically short pieces of text referencing other pieces of text. The purpose of the codes was to classify a large number of textual units. The codes were also classified into themes (regulation, preparedness, rescue operation). Within one theme, all the codes related to a certain domain were put together. The coded domains within the themes were calculated and exported as an Excel-compatible table.

In total, we identified 683 issues mentioned by the Delphi panel as possible reasons for weak communication and a poor level of information flow in disaster management. 351 of these were related to the preparedness phase, including regulation, and 332 were related to the response phase.

A. Problem Domains in Preparedness Phase of Disasters

One part of our Delphi study dealt with preparedness related to disasters, including regulations. As a result of the analysis of the transcribed material, we identified a total of 351 issues mentioned in the interviews related to problems of communication in disaster preparedness. These 351 issues were grouped into 16 domains, all of which included issues mentioned five or more times, as follows:

- Attitude to preparedness
- Co-operation between companies and authorities
- Co-operation between the companies involved
- Difficulties in applying regulations
- Issues related to outsourcing
- Issues related to operations of authorities
- Issues related to communication systems
- Issues related to emergency supplies
- Issues related to insurance companies
- Issues related to preparedness planning
- Issues related to training
- Lack of resources
- Necessity to improve regulations
- Prioritizing of preparedness resources
- Safety management
- Tight group policies of international companies

As an example, there follows a brief presentation of the most common domains in preparedness. The most frequent domain was issues related to the operations of authorities, mentioned 72 times. Experts in the panel highlighted the lack of cooperation between the authorities and the need for better coordination between different authorities.

The second most frequent domain was business contingency planning with 37 mentions. For example, different backup systems, contingency planning itself, as well as the development of operations for a variety of unexpected situations were at the top of the list, and also the fact that regulations and group policies are sometimes contradictory.

The third most frequent domain, with 32 mentions, was issues related to training and education. The panelists highlighted the need for instance for increasing safety training extensively throughout a company. Authorities were expected to have more skills and knowledge, for example, of chemicals. The fourth most frequent domain was the attitude to preparedness. By this the experts wished to say for

instance that actions taken for preparedness are too often made only to follow regulations or company policy literally without thinking of the usefulness of the actions taken.

B. Problem Domains in the Response Phase of Disasters

The other part of our study addresses the disaster response phase. The companies involved in this Delphi study are all the kind that are obliged, due to the nature of their business, to organize accident/rescue drills at least once a year where the local rescue authorities are invited, and if required, also the official regulatory authority at national level (e.g. Finnish Safety and Chemicals Agency for the chemical industry, the Radiation and Nuclear Safety Authority for the nuclear industry). Therefore, rescue drills were included in the research. The aim was to ascertain when and what kinds of problems related to information flow in or between different organizations had been experienced in the response phase.

As a result of the analysis of the transcribed material, we identified a total of 332 issues mentioned in the interviews related to problems in communication in the response phase. These issues were then grouped into 15 domains, all of which included issues mentioned five or more times, as follows:

- Analysis of accidents
- Communication at the accident site, including the media
- Communication at the time of the incident and immediately after
- Co-operation between organizations at the site
- Functionality of the command center
- Issues related to communication systems
- Issues related to the company fire brigade
- Issues related to joint company-authorities rescue drills
- Issues related to knowledge of the accident area
- Language skills
- Managerial skills
- Situation awareness and the flow of information
- Skills of authorities
- Usage of live cameras
- Usage of secured communications networks

As an example, the most frequent domains in the response phase are presented next. Situation awareness and the flow of information was the most common domain, with 72 mentions. The experts on the panel had often experienced problems with special vocabulary and terminology as well as jargon. Additionally, the lack of a proper system for collecting and sharing situation-related information was very often mentioned in this domain. According to the experts, there is plenty of potential for improvement in the information systems required to obtain the right kind of situation awareness. One of the most significant single factors that arose was the lack of interoperability between data systems used by the authorities. This causes problems, particularly in the management of major disasters where units from various authorities perform rescue operations simultaneously.

The second most frequent domain was joint company-authorities rescue drills. The experts on the panel were quite dissatisfied with the rescue drills they had attended and above all with the execution of the development ideas arising from the drills. They also argued that the planning of rescue drills is very often poor and also that the commitment of attendees could have been better. According to the experts, even though drills were organized, they tended to concentrate on only the most typical or small-scale accidents. It was considered that there was a lack of drills concerning major disasters and serious cases in particular. This results in the fact that insufficient attention is paid in the drills to situations where, for example, there would be several units from different authorities carrying out rescue operations at the same time.

Communication at the time of the accident and immediately after was the third most common domain. The poor level of information, improper or inadequate information given to the authorities (e.g. fire service) at the site was one of the most frequently mentioned issues. The lack of sufficient instructions and to-do lists for company personnel was also often mentioned. Communication at the accident site was the fourth most common domain. The panelists also emphasized the importance of good communication outside the accident site (e.g. via radio, press and Internet). They also knew of cases where poor communication and flow of information had changed things for the worse.

IV. THE SECOND DELPHI ROUND

In the second Delphi round, the aim was to explore the critical problem domains, i.e. the findings of the first Delphi round, using the expertise of the same Delphi panel. Instead of using traditional pen-and-paper questionnaires, the Internet-based Delphi software eDelfoi was used in the second Delphi round. Questions and claims for the Internet-based questionnaire were formulated on the basis of a desk study and the analysis of the first round interviews.

eDelfoi software has been developed by the Finnish Delphi Community (see https://edelfoi.fi). The main features of the software are user administration, questionnaire creation, and organization of answers and comments. In addition, the software has various reporting possibilities. eDelfoi contains several question types and forms, which help the Delphi facilitator to create the questionnaire. Below we present one question from the preparedness phase and one from the response phase where different eDelfoi question types were used.

A. Improving operations of the authorities in preparedness phase

Some development proposals arose from the first round interviews, which the respondents thought would enable the authorities to improve their operations in relation to the disaster preparedness phase. In the second round, we

attempted to test the importance of these proposals from the aspect of improving safety.

The experts were asked to evaluate the importance of 12 different factors to improve the operations of the authorities in development related to disaster preparedness in the short and long term. The experts chose the three factors out of the 12 that were most important in their opinion for the short term (1-2 years) and for the longer term (five years). In this question the "Grouping" question type with the drag-and-drop feature of eDelfoi was used. The suggestions for improving safety that were evaluated in the second round questionnaire were:

- Attention to the local significance of companies in prioritizing of contingency measures
- Capacity of authorities to benefit from existing municipal IT systems with regard to industrial risks of their area
- Developing authorities' expertise through training (e.g. knowledge of chemicals)
- Development of backup systems
- Development of interoperability of different authorities' IT systems
- Ensuring co-operation between authorities so that successful collaboration is not dependent on specific persons
- Ensuring the quality of co-operation between authorities and industry so that successful collaboration is not dependent on specific persons
- Improving authorities' knowledge of companies' plant sites
- Improving capability of authorities to utilize corporate IT systems
- Increasing authority resources
- More active participation of authorities in company rescue drills
- Moving focal point of operations of the authorities towards advisory and preventive actions

Figures 1 and 2 present the ranking of the suggestions.

In short-term development proposals for authorities, experts stressed that authorities and the business sector should increase co-operation and that authorities should participate more actively in joint company-authorities rescue drills. The panel of experts also considered that nowadays co-operation between authorities and industry relies too much on certain individuals, and that successful collaboration should not depend on specific persons. An overall concern for the development of the interoperability of IT systems was also seen as an important development area for the short term.

Development and increasing co-operation and collaboration between authorities and industry were also considered very important in the long-term proposals. Cooperation should be open and bound to a common goal. Panelists also found moving the focal point of the operations of the authorities towards advisory and preventive actions to be important for the long term. The panelists pointed out that there is a huge amount of information in digital and electronic form that should be better utilized by the authorities.

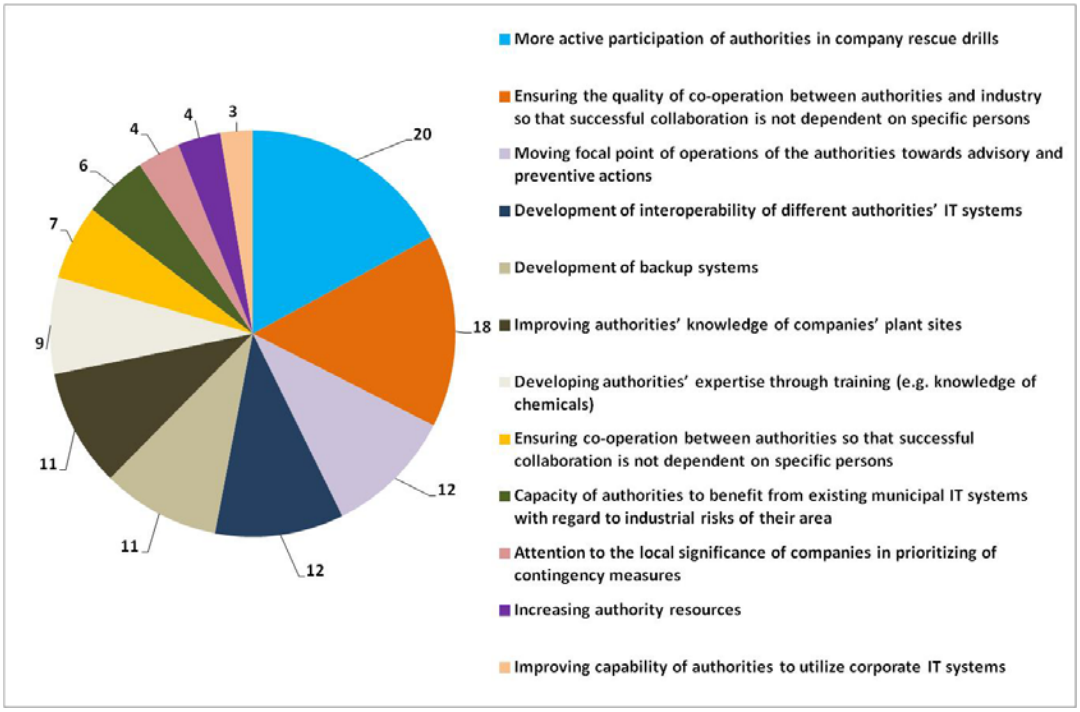

Figure 1. Most important development areas for authorities in the short term

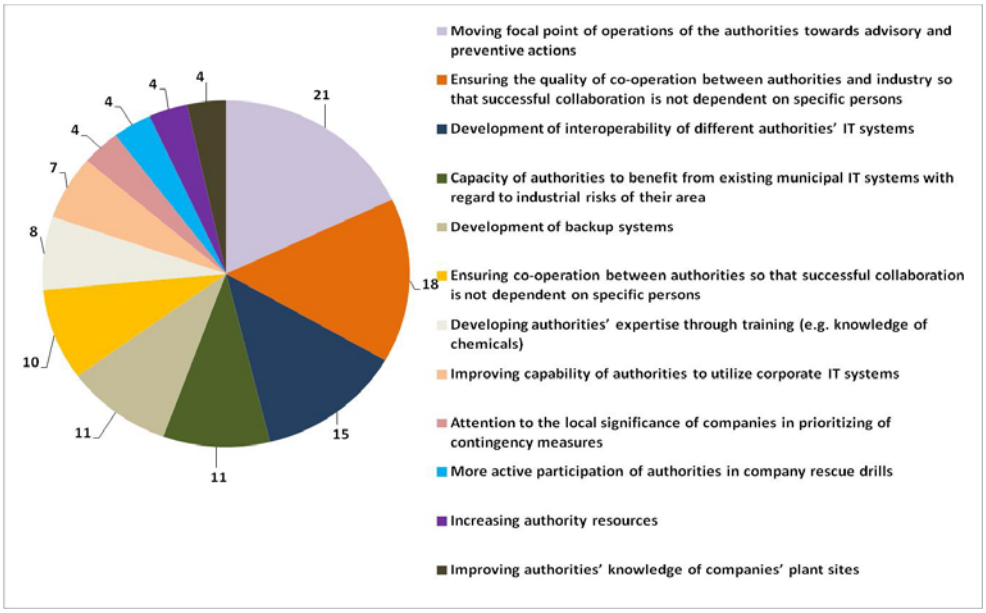

Figure 2. Most important development areas for authorities in the long term

B. Response phase: improvements to situation awareness and flow of information

During the first round of Delphi interviews, some development proposals arose which the respondents thought would enable better situation awareness and flow of information with regard to major accidents in future. In the second round, we attempted to test the importance of these proposals from the aspect of improving safety. Using the "Sorting" question type of eDelfoi, the panelists were asked to rank 8 different factors to improve rescue operations related to major accidents (in the next five years):

- Developing company alarm guidelines
- Development of interoperability of authorities' IT systems
- Improving capability of authorities to utilize corporate IT systems
- Improving communication (and instructions) at the accident site and outside the site
- Increasing the possibility for company personnel to use the same radio network as the authorities
- Mandatory site fire and rescue plan for companies having high risk potential
- Standardization of the varied terminology used by different actors
- Technical improvements for situation picture systems

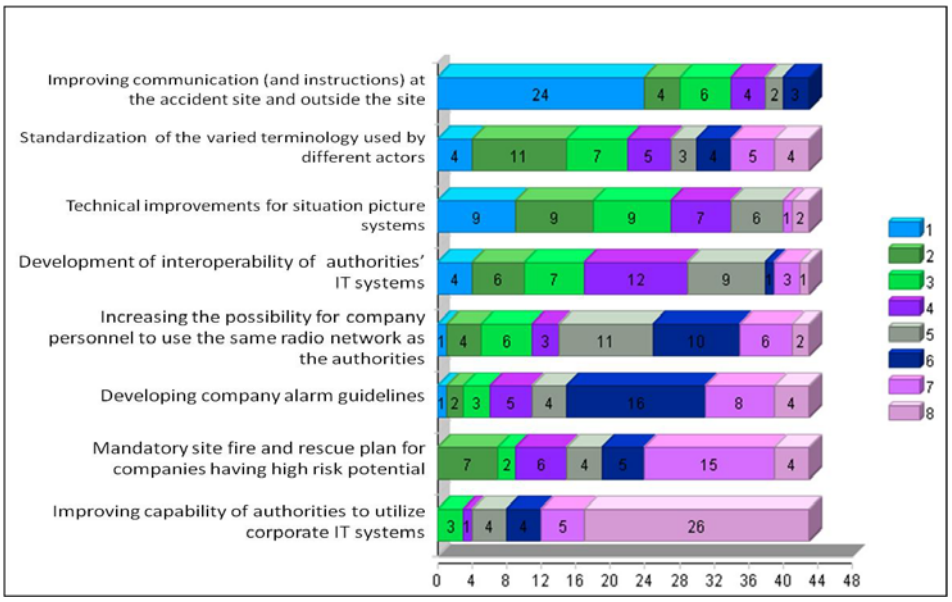

Figure 3. Most important development proposals related to situation awareness and flow of information

Figure 3 presents the ranking of the suggestions. The figure can be interpreted as follows: Improving communication (and instructions) at the site and outside the site was the most important according to 24 panelists. In addition, four panelists ranked it the second most important, six ranked it third most important, four fourth most important etc.

The panelists found the following four development proposals to be the most important:

1. Improving communication (and instructions) at the accident site and outside the site was among the four most important suggestions for 38 of the panelists.
2. Making technical improvements for situation picture systems was among the four most important suggestions according to 36 panelists.
3. Development of the interoperability of authorities' IT systems was among the four most important suggestions for 29 panelists.
4. Standardization of the varied terminology used by different actors was among the four most important suggestions according to 27 panelists.

V. DISCUSSION

A. Evaluation of the use of ATLAS.ti in the first Delphi Round

This computer assisted qualitative data analysis software is useful in the data coding process. Although ATLAS.ti facilitates many activities involved in qualitative data analysis and interpretation (particularly selecting, coding, and annotating), its purpose is not to automate these processes. ATLAS.ti software does not produce analyses itself; instead, it is a tool for classifying data and looking at relationships in the data.

It provides a good way to discover relationships and interconnections in the data. It offers a variety of tools for accomplishing the tasks associated with any systematic approach to unstructured data, i.e. data that cannot be meaningfully analyzed by formal, statistical approaches.

ATLAS.ti assisted the analyzing process of the first Delphi round interviews. Firstly, one of the benefits observed in the process for analyzing findings was that it supports the management of large volumes of data very well. ATLAS.ti was a powerful workbench for the qualitative analysis of large bodies of textual data (48 themed interviews - over 400 transcribed pages).

Secondly, ATLAS.ti is a good storage of qualitative data. Our research project is a two-year project and it was noticeable that ATLAS.ti helps the researchers keep in mind the qualitative data and findings for the longer period too. The tool also supports coordination of the research project if there is a group of researchers studying the same data, since using ATLAS.ti allows access to the same data source for all the members of a research project.

ATLAS.ti also supports data classification. ATLAS.ti facilitates many of the activities involved in qualitative data analysis and interpretation, particularly selecting, coding, and annotating data. It enables different cross-sections to be taken from the data. Coding allows the making of different comparisons from the data; for instance all the responses related to a certain theme can be observed simultaneously. The tool also increases the reliability of the research. The reliability increases as the amount of potential mistakes decreases by the use of managing data systematically.

Finally, ATLAS.ti also supports the reporting phase of a research project. ATLAS.ti is Excel- and SPSS-compatible. Therefore all the aggregated counts based on codes and themes may be exported for instance as an Excel-compatible table. This compatibility enabled us to make different graphs from the results of coded data. In addition, the tool also makes it easy to capture interesting or otherwise important quotations from the data. This supports the reporting phase as the quotations from the interviews can be easily added to the project's report text.

B. Evaluation of the use of eDelfoi in the Second Delphi Round

The Internet-based Delphi software eDelfoi was used in the second Delphi round. The first version of eDelfoi was created (1998) in co-operation with the Futures Research Centre of Finland and other futures research orientated institutes, and was funded by the Finnish Ministry of Education and Culture. The main features of the software are user administration, questionnaire creation, and organization of answers and comments. At the time of writing, the latest version of the eDelfoi (2012) has been partially translated into English.

The software can help a Delphi manager to design, implement, analyze, and report on a research study. In the first stage of the survey, the manager creates a questionnaire or questionnaires, which may include textual and graphic sections (for instance introduction and explanations), quantitative sections (different types of questions), textual answer (qualitative material), and links.

Compared to other questionnaire software programs, the advantage of eDelfoi is particularly the fact that the software is designed with the needs of the Delphi method in mind. In this software it is possible to select several query types appropriate for Delphi use, such as various scale queries to evaluate the likelihood, desirability, and/or importance of a certain variable, as well as timeline and time series queries (Figure 4). One of its strengths is that respondents also have the opportunity to make an argument to justify their own answer in each query type.

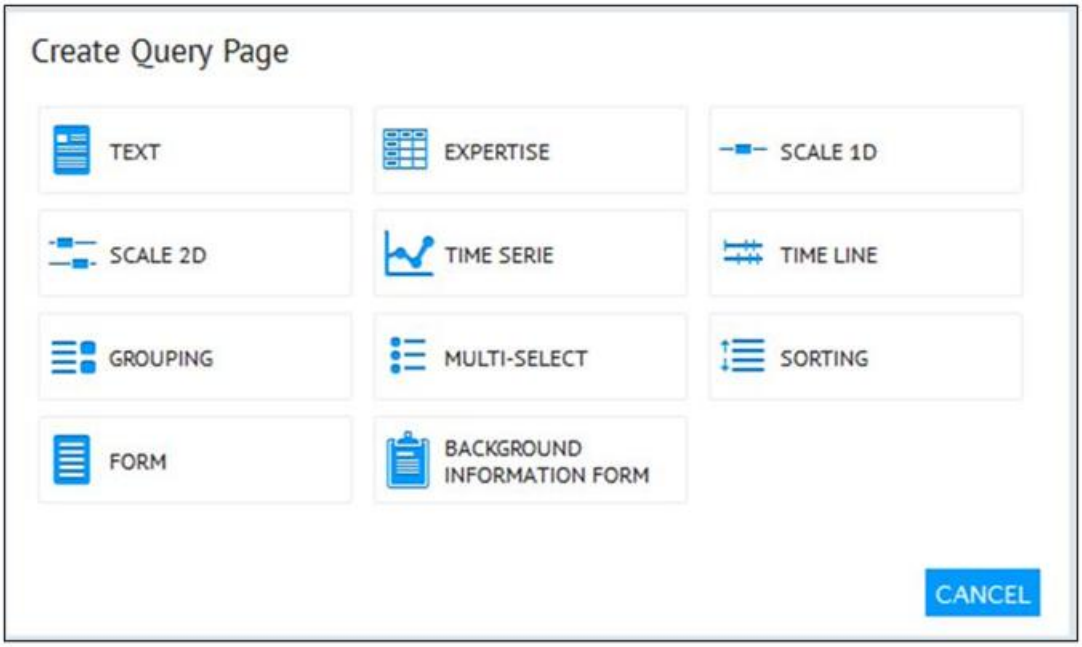

Figure 4. Window for selection of a query type in eDelfoi

The eDelfoi software also enables the use of grouping, multi-select, and sorting query types. The benefit of these query types is that they allow the collection of for instance the rankings of a certain variable. These query types also function particularly well as a stimulus for argumentation by the panelists, since putting the alternative variables of some subject into order of importance motivates respondents to justify their choice.

The tailoring of the software for the needs of the Delphi method is also visible in the fact that the compiler of the questionnaire can build an expert matrix from the specialists on the eDelfoi panel. An expert matrix supports for the researcher well in selecting a panel of experts, as the selection of an expert and comprehensive panel is a decisive phase in a Delphi study.

In addition, another clear benefit of eDelfoi is the opportunity it presents to transmit response data to the experts immediately. The feedback data means the respondents are guided to justify their selections through argumentation. This immediate feedback also enables the implementation of Real-Time Delphi.

C. Evaluation of the Computer Aided Delphi Process

The objective of our research is to produce new knowledge on emergency preparedness and disaster management for authorities and the business sector. The aim is to study emergency situations by using the Delphi method and to identify circumstances where different actors have recognized potential problems or risk situations related to the flow of information and communication and also obtain proposals for solving these problems.

There are many benefits of using Delphi to solve challenges in the communication process between the actors in disasters. In particular, Delphi is a proven research method for exploring the underlying assumptions or information leading to different judgments; allowing exchange of tacit knowledge among professionals; seeking out information which may generate a consensus on the part of the respondent group; correlating informed judgments on a topic spanning a wide range of disciplines; and educating the respondent group on diverse and interrelated aspects of the topic.

It is often suggested that computer-based data analysis is best conducted by following certain structured methodological principles, in our case the Delphi method. Software does not force users to work according to particular guidelines, but it does urge them to conduct a systematic and properly documented data analysis. We used ATLAS.ti and eDelfoi for analyzing data obtained in the first two Delphi rounds. ATLAS.ti proved to be a good tool for analyzing large amounts of qualitative data, which consisted of over 400 pages of transcribed interviews from the first Delphi round. Internet-based eDelfoi was used in the second Delphi round questionnaires and was found to be very suitable for our purposes. As a whole, we are very satisfied with both software programs. eDelfoi will also be used in the third Delphi round.

VI. CONCLUSIONS

Globalization, the network economy, and technological development have changed our outlook and modes of operation. The new kind of awareness of disaster situations requires better integration of public and private sectors. The

common goals of authorities and companies are to guarantee the security of personnel and the public and in addition to prevent or minimize material damage and to help restore the functioning of society. In order to improve disaster management, it is essential to anticipate and be ready for cross-sectoral collaboration between different organizations and different fields of operation.

The findings of the first two rounds of a Delphi study with 48 experts from different lines of business support the central thesis of our paper, i.e. the importance of a common understanding in emergency situations. Problems were found both in the communication of company personnel and in that of the authorities. In addition, communication problems are a common occurrence where actors communicate across organizational boundaries. This may result in a situation where, for example, the emergency services that arrive on site cannot be guided to the right place in the plant. The consequence of this may also be that both the expertise and the managerial skills within the company cannot be utilized immediately in support of the rescue operations and the work of the rescue services and the disaster management to minimize damage. One of the findings was the weak interoperability of IT systems. This could lead to situations where key information cannot be brought in a timely manner to the right persons even though it already exists.

In our future research and the third Delphi round, the aim is to explore the critical problem domains, i.e. the findings of the first two Delphi rounds, using the expertise of the same Delphi panel. Questions and claims for the Internet-based questionnaire will be formulated based on the desk study and the analysis of the first two rounds. The focus in the last Delphi round will be on obtaining more detailed development proposals for emergency preparedness and the response phase regarding the problem domains identified by the experts.

The knowledge obtained in our research can be used when improving the interoperability of organizations' management and communication systems in emergency situations. New knowledge could also be utilized in the development of emergency preparedness as well as in personnel education and training. This new knowledge could also be used in actions related to actual disaster situations where the role of collaboration is significant, so that damage could be prevented or minimized more effectively for all those concerned: companies, personnel, authorities, as well as society and the environment.

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