Supporting Inter-Organizational Situation Assessment in Crisis Management

Benedikt Ley, Volkmar Pipek, Christian Reuter, Torben Wiedenhoefer
Institute for Information Systems, University of Siegen
Hoelderlinstr. 3, 57076 Siegen, Germany
e-mail address: {firstname.lastname}@uni-siegen.de

ABSTRACT

To assess current situation properly is crucial for effective decision-making in crisis management. However, gathering accurate information from incidence sites and providing appropriate support for assessment practices faces several challenges. The unique information demands of each crisis situation, the information availability or inter-organizational problems and obstacles to information exchange are important factors that need to be considered in designing ICT. In this contribution we present results from an empirical study about decision-making practices in scenarios of medium to large power outages in Germany. We focused on the needs and practices on information exchange at the level of inter-organizational cooperation. We examined the cooperation of fire departments, police, public administration, electricity infrastructure operators and citizens. Our empirical material reflects particularly conditions and challenges in current situation assessment practices, and we were able to derive design requirements for an inter-organizational situation assessment client as a complementary tool for existing crisis management infrastructures.

Keywords

Situation Assessment, Crisis Management, Collaboration, Improvisation, Information Technology, Ethnography

INTRODUCTION

Trying to draw conclusions from a large amount and variety of information is a very difficult task, but very typical in crisis management. Situation assessment, understood as gathering and analyzing information about the events to assess the current situation, is the basis of efficient decision-making. In crisis and emergency management actors need to prepare for the unforeseeable, and as the number of influencing factors (weather conditions, number of people affected, type of emergency, etc.) as well as structural dependencies (electricity, roads and railways, fuel resources, etc.) vary over time, so do the information needs in crisis management. Nevertheless, all organizations that help guaranteeing civil security (Police, Fire Department, Red Cross, Infrastructure providers etc.) have developed systematic approaches to deal with these uncertainties and to allow for planned, coordinated activities in crisis situations. Situation assessment is an important part in these approaches, but on an inter-organizational level may be further improved by information and communication technology (ICT).

In Germany, as well as in most other countries in Europe, the practices within the emergency response organizations already rely on strong IT infrastructures. These help to maintain an overview of the current situation in an area of responsibility, and of available resources for the crisis response measures in which the organizations are responsible to engage. Most of the information necessary to handle a critical situation (e.g. a burning house) can be retrieved and visualized (e.g. architecture plans of the house, location of the house and available fire engines), some of it needs to be collected from other organizations (e.g. the city administration delivers the number of registered inhabitants of the house) along standardized routines. But in larger crises the complexity of a situation requires emergency response organizations to collaborate, and the framing conditions for decision-making change as every organization becomes partially depended on other organization's decisions and situation assessment. When dealing with larger power outages (the scenario we are looking at in our research), each of the organizations involved sets up an own crisis management team and deals with similar challenges in situation assessment: The existing information systems face the challenge of unanticipated information needs, and as every organization does not only consume, but also produce highly relevant information (e.g. the Police "produces" road blocks, the electricity provider "produces" information on resupplying strategies), it may become necessary to intensify information sharing, and to help each other's situation assessment practices. Crisis managers as well as the crisis response teams on the ground then need to cooperate at an inter-organizational level, and find their IT infrastructures not always prepared for that.

But what are practices and their characteristics in situation assessment today? How do the actors deal with the challenges of inter-organizational collaboration, what kinds of information exchange are hindered or supported by the existing tools and routines? How do they cope with unanticipated information needs? What influences decisions on information sharing at the organizational level, from the organizational as well as from a technological perspective? And ultimately: In what ways do we need to improve information infrastructures to also support the ad-hoc practices of situation assessment?

We conducted an empirical study of situation assessment of actors, which are involved in scenarios of medium to large power outages. We derive requirements and present features for information systems that would be able to improve the practices we found. The paper is organized as follows: After defining relevant terms and discussing the literature we introduce the research field and our research methods. Afterwards we focus on situation assessment practices we found in crisis management. Then we summarize main challenges from our findings, which need be considered to develop appropriate ICT and finally we will present concrete design implementations, which address this issues, followed by a conclusion.

USING ICT FOR SITUATION ASSESSMENT IN CRISIS MANAGEMENT

Situation assessment is one of the most important tasks in crisis management because all crisis-related decisions are dependent on an accurate knowledge of the actual situation. The key dimensions for depicting crisis situations are time and space (Liu and Palen 2009). These dimensions are vital for the coordination of disaster relief efforts. Information and communication technology (ICT) such as Web 2.0 technologies (e.g. data mashups) enable appropriate temporal and spatial descriptions of crises for the purpose of situation assessment. Digital situation maps contain information about the environment and damages reported including sections and priorities. They also display provided, used and required resources and relief forces (Gahlen and Kranaster, 2008). The Permanent Conference on Disaster Reduction and Disaster Protection in Germany (SKK 2003) points out that the situation's representation on the individual levels of crisis management (e.g. teams, operational controls) with the aid of tactical symbols is an essential component of information processing inside the implementing agencies. In addition to that it is a crucial requirement for an effective situation assessment.

Decision-making in crisis management often requires rapid information gathering from diverse data sources. The integration of citizen generated content via social software (e.g. Reuter et al. 2011) may also be helpful. Gupta and Knoblock (2010) reveal that geospatial mashups are an effective solution for this. However, these do not cover the issue of data visualization. Therefore Gupta and Knoblock present an approach to visualize data in geospatial mashups which allow its users to customize the visualization. Liu and Palen (2009) surveyed 13 crisis-related mashups to derive some high-level design directions to guide the design and testing of next generation crisis support tools. Their derived design directions include (a) the use of temporal data to communicate different levels of knowledge granularity, (b) learning from the past through the preservation of spatiotemporal information flows and (c) the recognition of geographical vulnerabilities with spatiotemporal data. Kraut et al. (2002) found out that visual information in shared spaces improves communication efficiency and increases the knowledge of the task structure and the situation awareness, especially in complex problem solving tasks.

Zlatanova and Fabbri (2009) show that "maps are largely used as background information for location awareness and decision making, but the functionality of offer is varied". They argue that time restriction and human perception are some of the major bottlenecks for working with complex models, therefore greater awareness of and trust in Geo-ICT are needed. Schafer et al. (2007) present a software architecture that facilitates the development of geo collaboration solutions. They emphasize the community-oriented nature of emergency management. The architecture extends prior geo collaboration research and reuses existing geospatial information models. Wu et al. (2009) present the design of CIVIL, a system prototype developed to support map-based decision-making. Based on an evaluation, they develop guidelines which include (a) integrating map services that people are familiar with, (b) allowing users to add personal comments and drawings that overlay on maps, (c) providing both shared and private maps as well as supporting information transfer between them, (d) providing visualization tools to present information and help information analysis, (e) allowing platform-independent, distributed collaboration and (f) developing architectures that allow delegation of non-critical information management tasks to online public services.

On the opposite to situation assessment in non-critical environments, the characteristics of emergency management, such as the rarity of incidences, time pressure, uncertainty, high and broad consequences, complexity and the existence of multiple decision makers (Mendonça 2007), lead to processes of "muddling-through" rather than "rational" procedures (Lindblom 1959). Therefore it is additionally necessary to support improvisation: Improvisation is required when decision-making planned beforehand does not work for any reason. The necessities to judge highly novel problems and to act quickly reduce the chances of extensive

planning: "Decision makers in emergencies must be prepared to improvise" (Mendonça and Wallace 2007, 547). Improvisation does not consist of sophisticated methods or structured systems (Ciborra 1996). Instead of trying to eradicate it through automation, the appreciation of flexibility and effectiveness seems more adequate. In doing so, improvisation and preparedness go hand in hand: Without improvisation, emergency management loses flexibility, without preparedness, emergency management loses efficiency (Mendonça 2007).

As stated above, crisis-related decision-making is one of the main tasks in which improvisation is obligatory. Organizations need to maintain flexibility in order to respond to unanticipated events. Computer-based systems can support these processes, if the system design is informed by an understanding of the cognitive processes which are involved in the response to unanticipated contingencies (Mendonça 2007). These systems must support the actors to rework their knowledge in order to fit the requirements of the current situation. Information technology supporting improvisation needs to handle ad-hoc coordination, unique problem solving strategies and new or changed information needs (Waugh and Streib 2006). Computer-based comparisons of the current decision situation with past ones were identified as appropriate in this context (Mendonça 2007). Ad-hoc re-planning and the ability to share material were identified as design challenges for large-scale events (Lindström and Pettersson 2010). Furthermore, the following IT-supported mechanisms for improvisation in emergency management are suggested: (a) graphical representations of data during crisis response, (b) intelligent systems that select and help to contact experts, (c) the centralization of data to enable actors finding information and (d) virtual supported coordination to create shared information consistent in time (Adrot and Robey 2008). In addition, verbal communication should be made persistent, visible and accessible in order to support accountability (Landgren 2006).

RESEARCH FOCUS

Unlike much prior research that has focused on situation assessment within organizations, our objective is to examine situation assessment - which is based on situation maps - on inter-organizational level. In this paper we then intend to derive requirements for potential IT-support of collaborative situation assessment using digital situation maps. In order to extend the theory-led considerations and the case studies mentioned above, we had to understand the local and collaborative practices of the agents. Therefore we conducted an empirical study in Germany exploring current practices of situation assessment and the use of situation maps of professional actors involved in situation assessment in scenarios of medium to large power outages.

RESEARCH FIELD

This paper reports from a study focusing on situation assessment practices during coping and recovery work at emergency response agencies in Germany. The study was conducted in two regions in North Rhine Westphalia in Germany (counties Rhein-Erft (REK) and Siegen-Wittgenstein (KSW)). KSW is a densely wooded, hilly county in the middle of Germany, whereas REK consists of 10 growing communes in the west of Cologne. In both regions we focus on several persons and organizations affected: *Infrastructure suppliers* (e.g. power supplier), *public strategic administration* (e.g. crisis management, county administration), *public operative administration* (e.g. police, fire department) and *citizens.*

There are two interesting aspects regarding police and firefighter forces at both counties. Firstly, related to the organization of fire and rescue forces: REK provides professional fire and rescue brigades, whereas KSW's firefighters are mostly members of voluntary fire departments. Here, just members of the control center have salaried positions. Secondly, despite the fact that firefighter forces process coordination from the field via incident commands, police forces in the field receive commands from members of the official control centers.

METHODOLOGY

The aim of the empirical study was to understand the application field and to include new findings that may occur during the data collection process. We conducted a grounded theory oriented approach, where we did not explore the field with predefined categories, but derived categories from empirical data. To reconstruct the practices we used qualitative methods (Randall 2010) such as document analysis, 4 observations, 5 group discussions (see Table 2) and 22 interviews (see Table 1) including the development of a crisis scenario. All empirical work took place at the observants'/interviewees' workplaces. All in all we talked to more than 50 different actors from district administration (e.g. regulatory authority or office civil protection), police (e.g. head of control center or patrol duty), firefighters (e.g. Operation controllers or Control center dispatcher), red cross (Local head) and energy network operator (e.g. operation engineer) (ENO). We used open coding to analyze the material and to uncover interesting phenomena. We are neither focusing on similarities nor differences but on breakdowns of practices that depend on inter-organizational collaboration.

No	County	Organization	Role
I1	KSW	Administration	Regulatory Authority
I2	KSW	Police	Head of Control Centre
I3	KSW	Police	Head of Section
I4	KSW	Police	Patrol Duty
I5	KSW	Fire Department	District Fire Chief
I6	KSW	Fire Department	Deputy Head of Control Center
I7	KSW	Fire Department	Workmanship
I24	KSW	Fire Department	Head of Control Center
I8	REK	Administration	Office Civil Protection
I9	REK	Fire Department	Chief Officer / Chief of Fire Dept.
I10	REK	Fire Department	Operation Controllers
I11	REK	Fire Department	Clerical Grade Watch Department
I12	REK	Fire Department	Control Center Dispatcher
I13	REK	Fire Department	Head of Control Center
I14	REK	Police	Member of the Permanent Staff
I15	REK	Police	Head of Control Center
I16	REK	Police	Head of Group
I18	-	ENO	Higher Area, High Voltage
I19	-	ENO	Operation Engineer, High Voltage
I20	-	ENO	Operation Technician, Low Voltage
I21	-	ENO	Dispatcher, Low Voltage
I22	-	ENO	Workmanship Technical Incidents

Table 1. Interviews

No	County	Topic	Participants
W1	-	Challenges in practice, Visit of Control Center	Energy Network Operator (ENO)
W2	REK	Challenges in practice, Visit of Control Center	County Administration Police Fire Department
W3	KSW	Challenges in practice, Visit of Control Center	Department Head: Public Safety Head of Civil Protection Head of Police Control Center Deputy Head of Control Center District Fire Chief
W4	KSW	Analysis of User Interactions and Communication Flows	Head of Police Control Center, Head of Staff Coordination, Deputy Head of Control Center, Local Head of Federal Agency of Technical Relief (THW), Local Head German Red Cross
W5	REK	Analysis of User Interactions and Communication Flows	Head Regulatory Authority, District Fire Chief, Red Cross: Disaster Management, Red Cross: Communications, Members of other aid agencies.

Table 2. Group Discussions

The goal of *document analysis* was to obtain an overview of the organizations in crisis situations. We analyzed documents that represent the work in crisis management (laws, regulations, directives, and course materials).

The *observations* were used to obtain knowledge about practical work in inter-organizational crisis management. These were conducted in a control center during a normal working day (observation time: 9 hours), in the crisis management group and the operations management during a crisis communication training (4 hours), as well as on a major event (6 hours).

The *group discussions* allowed us to understand the communicative practice of inter-organizational crisis communication. We conducted 5 inter-organizational group discussions, each lasting of about 4 hours and the participation of leading actors.

It is difficult to observe the practice of crisis management within an actual crisis situation, because crises mostly happen unforeseen. Furthermore, on an inter-organizational level, it is hard to observe spatial distributed actors at the same time during an actual crisis. To overcome these circumstances, we and members of ENO, police and fire department, cooperatively developed a *scenario framework* existing of a windstorm with many incidents and energy breakdowns. The purpose of our scenario was to be able to quickly create a common understanding of a crisis situation and context in our interviews.

The *interviews* allowed us to analyze the work context and the use of information and communication systems of relevant actors. The interviews lasted between 1 and 2 hours and followed an interview guide. The first part of the interview focused the participants' role, qualification, activities and work steps in normal conditions. The second part covered the tasks in crisis situations and was based on a scenario framework. The third part covered information and communication systems as well as perceived problems with these tools.

RESULTS: SITUATION ASSESSMENT IN PRACTICE

Facing novel problems and the need to act quickly, plays a significant role in handling crisis situations. Our study revealed that decision makers at both counties and at each organization have to act situational in order to respond successfully to uncertain circumstances under risk and time constraint: "*Improvisation is essential, next to extensive planning. You can have the best predefined response plans, but there is always a situation, where you have to improvise.*" (I1). So, besides executing on one or more response plans, we could see that in todays' emergency management processes straying off plans and predefined actions, is common practice "*No, all workflows are flexible. This is necessary, because each situation is different."* (I2). Hence, the uniqueness of each crisis situation and the resulting improvisation practices form the basis of situation assessment work at each organization.

In this section we are going to point out existing characteristics, conditions and challenges situation assessment practices have to deal with in current coping and recovery work. We have divided this section into characteristics and conditions of situation assessment practices.

Characteristics of situation assessment practices

Like mentioned before, coping and recovery work requires making in-situ decisions based on the current condition. Hence, it is necessary to keep track of the occurrences. Information resources, which are considered for this purpose, often contain uncertainties and have to be evaluated cautiously. For instance in case of severe weather alerts, preparations are made, e.g. putting staff on standby. However, those warnings are published too frequently and in many cases no critical weather conditions occur. For that reason, many actors individually collect supplementary information from various sources, e.g. current weather condition outside the building, other weather information systems or webcams that are focused against the wind direction, to obtain a better overview of the situation: *"You need as much information as possible"* (I24).

Besides the work in the control centers, on-scene actors also depend on an optimal overview of the situation. For this purpose, some of them use their private smartphones as an information medium, because the authorities do not provide such technology for their staff: *"Some of the colleagues have an Internet connection on their smartphone that is often useful, for example to get an aerial image from the locality via Google Maps to check other information. This can be helpful for mediation, when you need a phone number […]. Generally, we don't have navigation systems on board and there is often the problem: 'Go to house number 17' and when you have found number 5, the next three numbers are hard to read and then you suddenly find a house number 28 and then there is the question: 'Where are the others?'"*(I4).

In this context, *terminological differences* play a decisive role. Depending on the individual structures and practices of the respective organizations, different terms are used which can cause several communicational issues: *"There is a person with a cut finger and an employee from THW [agency for technical relief] reports this injury – This nearly sounded like a fatality!"* Due to the different focuses of the organizations, it is difficult to expedite a terminological assimilation. *"Even if the police are talking to the fire department, there is a big deviation in the terminology and consequently terms are perceived differently."* (W2) Terminological differences with other organizations, especially in the private sector, can be even greater. An example describes a misunderstanding about the number of people injured after a fire in a factory where 19 casualties were reported: *"People injured in the perception of the factory management, consist of 19 people who were only triaged by doctors but weren't necessarily injured."* Actually, in the understanding of the rescuers there were only *"two people whose health was affected."* (W2).

Besides loosing available information there is sometimes a lack of information provided by infrastructure operators, such as energy network operators or transport services. These organizations do not necessarily inform proactively about further development, but they have to be asked directly: "*The other actors have a different perception because – they concentrate on their problems and not on providing information*" (I15). In case infrastructure operations sometimes provide information with missing details such as the amount of affected households (I10): "*What broke down, how much of the energy network is out of work and how many people are affected?*" Many organizations provide their information by email or phone, which is another source of information that needs to be handled.

Further *media disruptions* in the field of retrieving information occur in operations management where liaison officers of the police usually cannot access information provided by the police intranet. They also have to ask by phone. For actors working in the field additional information is usually obtained from the control center (I3). For instance, in case of a fire they ask the control center how many people are registered at a certain building (I4): *"If we now had a fire or something, we would like to look up something in the Civil Registration Office: How many people are registered at that address? For example, we now have to match five people standing here in front of the house who say that they left the house. Okay, now we must assume that others are still in the house. In such incidents the registration office is probably the most important source"*.

Conditions for situation assessment

We found several conditions and ways for situation assessment. Beginning with findings about formal and informal practices, the use of official systems and non-digital maps, we also detected issues concerning privacy, trustworthiness, time pressure and cooperation which influence the situation assessment practice.

Situational acting usually does not occur in the pure form: "*There is always a mishmash of formal structures and informal ways"* (I1). As said by the actors, structures are important to handle basic tasks and flexibility is necessary to react to very dynamic situations: "*We have standard measures and things, which we decide at the*

spur of the moment." (I13). Besides the fact that they have "*a very clear communication structure*" (I2) they do not consider themselves as an civil servant, such as an administrative officer or a taxman: "*We [police] and the fire department work in a way which is different from all other authority: We do not have a litany that we follow strictly, because then we would be lost.*"(I2). This shows that they calculate with a certain degree of flexibility contrary to detailed planned processes that just need to be executed. The decisions on the field level do not just base on regulations, but on assessments of the situation and are done "*within the given clearances*" (I9).

To decide what to do and how to deal with a certain situation, much important information is necessary. Some of the information to fulfil the work tasks in operations management is provided by "official" information systems. In major catastrophic events or in case of weather alerts these internal information resources are enriched by many external, *informal information resources*, which are necessary in various situations. Therefore, actors sometimes use about "*40 windows which have to be observed*" for different applications and websites to have an overview of the current state and to handle the situation appropriately (I5). This external information includes webcams, water levels, weather forecast, wind directions, storm warnings and traffic service. Much of that information is provided on different websites – but not in a compulsory "official" application with the result that actors have to improvise and search by themselves.

Besides information from third party providers, internal information such as *digital and non-digital maps* is of central importance for all actors to plan and to deal with major catastrophic events. Emergencies always have a geographic reference, therefore the operations management and the crisis management group gather related information on maps. Besides the utilization of technical supported maps, actors also use different non-digital maps: "*We always have to work redundantly to prevent chaos during technical breakdowns. We have to be able to proceed anytime*" (I9). In addition, the representation of the resources and their availability are only maintained on non-digital maps (I15). But this always depends on the given incident and how likely a breakdown is.

Apart from the fact that actors are interested in information of other organizations, *privacy* for their current state is required: "*Maps got nothing to do with anyone else but us, because we do not reproduce the current state but rather try to imagine what will happen next"* (I9). Due to the strategic and tactical operations, maps are kept locked up and cannot be passed to other agencies or organizations. Based on available information, the operations management does not just reproduce the current state but tries to foresee how the situation will develop. It considers what could happen next in order to derive actions and minimize the resulting damage: *"In the beginning we have to follow up the damage. […] Our aim is to be in advance of the incidents"* (I9).

Trustworthiness plays a significant role in sharing or retrieving information, especially for kinds information which have high impact on complex and lifesaving decisions: "*The safest information is the one I have seen by myself*". I2, I3 and I10 count on "*good human relations*" (I3) to members of other organizations in order to ensure reliability and to accelerate information verification processes. "*For security reasons we need up-to-date development schemes and building plans*" (I21). This shows that *timeliness* is another important dimension of information. All participants point out that, especially for handling crisis situations, up-to-date information, e.g. on situation maps or contact lists (I1), become more essential.

A wide range of emergency response actions show, that situation assessment is *often a collaborative task*. To deal with an uncertain and changing environment during crisis situations, usually a great number of people are involved in gathering and analyzing data, decision-making and monitoring of implementations and consequences. Two quotations explain these practices. The first one from a policeman on operational level: "*We all have to get the big picture of the scene at first. Than we have to coordinate ourselves: finding appropriate ways of solving the problem together and then running these actions*" (I4). In addition a member of a command center of an ENO said: *"[…] but if it's critical anywhere you willingly ask a colleague: 'What do you think about it? Give it the once-over.' The big advantage we have, is that there are at least two of us sitting here, even twenty-four-seven.*" (I20). Focusing on crisis management group work, our study revealed that there are lots of informal actions. They especially occur during coordination processes between members of different agencies. To assess the potential impacts of present or future events, members of the group (usually police, fire department and county administration) share their knowledge within the group or – depending on the case – they have to consult external experts (e.g. members of the residents registration office to access numbers of occupants in case of a burning house). What we have seen is that gathering and analyzing situation information and decision-making is often performed cooperatively.

CHALLENGES IN CURRENT COLLABORATIVE SITUATION ASSESSMENT PRACTICES

As we have seen in our empirical study, situation assessment practices got faced by several challenges, especially in inter-organizational manner. We have seen that no situation is equal to the other. Besides, highly novel problems require ad hoc decision-making based on available information on the situation. However, this

information is not necessarily available in the own organization. Especially during unique emergency events, many external resources need to be consulted. Now, we are going to summarize all factors shortly, which challenge to find and retrieve relevant information.

1. *Information is mostly distributed*: Even routine situations require managers to retrieve various information, which is often not necessarily available at the own organization. Managers have to access several kinds of external information resources at different organizations (e.g. Weather Services, Electricity Providers, Logistic Companies, etc.) via different media channels (e.g. Phone, Internet, Face-to-Face, etc.). During non-routine events this typically takes place in an ad-hoc manner.
2. *Missing awareness about information available*: Our study revealed that current inter-organizational emergency management lacks instruments, which distribute meta-information about suitable and available data or about resources at external organizations. On the one hand users do not know what information is available and where to find it and on the other hand policy issues prevent the access to certain information, what we address next.
3. *Accessibility of Information/Policy Issues*: Besides technical shortcomings (e.g. missing appropriate interfaces), accessibility restrictions due to policy issues are a big challenge actors have to deal with. Especially non-public information, such as the degree of power supply for a certain area might be helpful for agencies during specific emergency situations. Obtaining such information through official channels can be extremely time-consuming. That is why there is a demand for negotiation processes for exchanging information needs associated with necessary access agreements.
4. *Handling of information uncertainties*: In reality data are seldom absolutely reliable. Looking at current decision-making processes, it shows that shortcomings exist in providing accurate visual depictions of critical data sets from different domains.
5. *Terminology issues*: Different symbols or different technical terms, for instance, make it difficult to share information and knowledge between organizations, especially when they originate from other domains.
6. *Perceiving interdependencies between information:* Certain Information resources are possibly only relevant in conjunction with others (e.g. formation of smoke and wind direction and strength). Those interdependencies have to be identified to obtain any necessary information.

To overcome the shortcoming, that not every piece of information needed is officially available or accessible at current emergency management systems, actors have developed several strategies. For example, by using the WWW, actors have bookmarked websites with additional information resources such as webcams, to check weather conditions or the water level statuses of nearby rivers. Our study shows that technophile people, rather than people with less computer skills, have performed these strategies. Taking a closer look on these information compositions shows that they are arranged highly individual. Actors have retrieved only those information resources, which are suitable for their individual tasks.

Collecting and analyzing data related to current events actions are main activities for situation assessment of most of the actors we he have talked to. What we have seen, when unanticipated events or unclear situation information emerge, actors often consult colleagues or other experts to collaboratively assess the information. Our study reveals that situation maps are essential artifacts to fulfill these tasks. Analyzing data with colleagues with the same knowledge background, in a same room (e.g. a control center) and therefore with a common situation map, usually works well. However, challenges arise when it comes to sharing situation information with geographical distributed participants or even with actors of different agencies. This problem gets more significant when actors of different agencies with different situation maps are involved. Typically, these maps only visualize agency-related information and use different terminologies and symbols. This circumstance makes collaborative assessment actions even more complicated.

Accessibility to required information resources is a big challenge actors have to deal with. On the one hand users do not know what information is available and where to find it and on the other hand policy issues prevent the access to certain information. A reason that information cannot be found by the user is that they are mostly distributed and not listed in a central directory. The results of our study show that actors often consult the same or similar information services during a certain situation, no matter to which organization they belong to. Hence, the question arises whether it is helpful to have a central repository for information resources with access to actors from any organization. Accessibility restrictions due to policy issues are more complex to handle (e.g. non-public information, such as the degree of power supply for a certain area might be helpful for agencies during specific emergency situations). Obtaining such information through official channels can be extremely time-consuming. That is why there is a demand for negotiation processes to allow for a fast access to necessary information in crisis situations, but also sufficient protection to prevent malpractice.

SUPPORTING INTER-ORGANIZATIONAL SITUATION ASSESSMENT

Facing these challenges, we conceptualized our inter-organizational situation assessment client (ISAC). It provides an interactive map-based interface that displays georeferencing information to the user in order to support collaborative situation assessment, inter-organizational map sharing and dynamic adding of information resources through users. When designing ISAC we focused on several functionalities and features, which are described below.

Feature 1: Aggregation and visualization of external and various information

Besides internal information, information from other organizations is needed to get a proper picture of current and future events. Furthermore, most information is location-based (e.g. emergency plans for buildings or electricity breakdowns) as well as those actors in emergency response organization work with map-based information systems to visualize current situation information. For the design of ISAC we chose an enhanced map-based information repository that allows including different types of internal and external information (e.g. place marks, weather information, specific geo-referenced infrastructure maps, etc.). To avoid information overload, the user should be able to save and load specific map compositions depending on the situation.

Feature 2: Individualization of information compositions

We have observed that actors of emergency response organizations adapt information compositions due to their personal needs. Therefore, another feature-set in ISAC is to provide instruments that enable users (technophile and non- technophile) to customize information compositions in real-time. We follow a two-level approach. On the first level, users have the opportunity to easily show and hide information resources from the repository on the map. On the second level, the users are able to add additional and new information resources to the map. That can be place marks with annotations on specific locations or even external web services (e.g. Web Map Services (WMS)) as map layers.

Feature 3: Supporting collaborative situation assessment

As we have discussed previously, it is a common practice to perform situation assessments collaboratively, especially during uncertain emergency events. Based on the features mentioned before, users are able to share map-based compositions of information resources with other actors. Actors are able to access maps from various places, e.g. from a notebook at home, via mobile phones at the incident location or from desktop PC at the office. To be able to analyze the information on the map together with other actors, a communication channel is needed. Therefore, instant messaging services and audio channels will be provided to support these communication processes. Because current situations can change rapidly, participants require the opportunity to modify information compositions or add annotations on the map in real time and share them synchronous with other actors.

Feature 4: Accessibility of information resources

To improve accessibility of required information during an emergency situation the actors need to be aware of available and suitable resources. To match this requirement, ISAC shall provide an information repository where proper services can be registered, described and rated by the user. Thus, the resources can be selected situationally and can be integrated into the application. Another important issue is how to deal with information that is not accessible due to organizational access policies. Here we are facing a clash between information needs and secrecy. Trust and privacy were identified as important issues. An access to secretive information might be possible under certain conditions, but has to be negotiated again and again. Computer Supported Access Control may support spontaneous information needs while enabling the user to attempt access and to legitimate it during use (Stevens and Wulf 2009). In our current work we are experimenting with various access control mechanisms to simplify the access in crisis situations but without undermining necessary policies. In a first step three different types of access controls shall be implemented and evaluated with the users:

1. Role based access control: The access rights for each information resource are predefined and based on the user's role. A user can either have access by definition or not.
2. Gatekeeper access control: This is a more flexible approach where access rights are also predefined. However, users without assigned access rights can request those from a so-called gatekeeper who has the right to allocate access to unauthorized users or a certain time period.

3. Break-glass access control: This concept enables a flexible and fast access to the required information. Even if a user has no access by definition, he is able to get access by breaking a symbolic glass. Thus, there is no need to request access privileges from an authority but every access becomes documented. That means that the user must be aware of possible consequences when "breaking the glass" unauthorized.

Feature 5: location- and platform-independence

Most of crisis management and response work happens distributed. Even within the same organization, actors are located at various places and do not have necessarily access to the private network of the control center. However, situation assessment is not only important for the crisis management group, but also for on-scene commanders and other involved persons. To enable a common view on a situation, necessary information has to be spread to all relevant actors, both intra- and inter-organizational. To make this possible, ISAC has been designed as a web based solution which is location-independent as well as platform-independent and allows a usage detached from the users location and device and is accessible via any latest web browser.

CONCLUSION

This contribution revealed that situation assessment needs in complex crisis scenarios can't be completely covered by routine processes and anticipable information demands. We could see that there is a variety of influencing factors and frequently changing conditions, what lead to the need for supporting ad-hoc practices of gathering and making sense of information, particularly at an inter-organizational level. Ad-Hoc practices are an aspect inherent to every situation identified as a 'crisis', and they have been previously addressed as a topic (e.g. Ciborra 1996, Moorman and Miner 1998, Mendonça 2007, Adrot and Robey 2008). Our study was able to show the additional difficulties we encounter during situation assessment work at the inter-organizational level. In observing and interviewing actors from police, fire departments, public administration and an electricity provider in two counties, we showed that situation assessment practices suffer from several challenges: First, the difficulty of retrieving all relevant situation information from internal and external information resources. Second, missing awareness about information available. Third, accessibility restrictions due to policy issues. Forth, handling of information quality and uncertainties. Fifth, terminology issues between organizations and sixth, the difficulty of perceiving interdependencies between information. Findings about collaborative map-based decision support systems for situation assessment (e.g. Wu et al. 2009, Gupta and Knoblock 2010, Schafer et al. 2007) offer already solutions, but do not focus on inter-organizational levels.

Furthermore, if external organizations required explanations about established and successful inter-organizational practices for a successful crisis management (and thus opened up for external critique), there would not only be a severe possibility for misunderstanding (even the organizational structures and strategies of frequent collaborators like Police and Firefighters are sufficiently diverse) but there would also be concerns about becoming vulnerable against legal or political claims.

Considering this aspect, it does not make sense to support inter-organizational work in situation assessment with IT concepts that require centralized, aligned procedures dominating the practices of the individual organizations. It is more appropriate to offer a complementary infrastructure that allows maintaining informal information sources and manages informal collaboration opportunities (particularly for the sensemaking and interpretation work for situation assessment) that can as well be individualized/localized. The disclosure of information regarding an organization's own status, resources and measures is also very valuable, but needs to be thoughtfully protected with interactive (gatekeeper model, break-glass model) access rights that allow easy information sharing when necessary.

We were able to identify some requirements for such a complementary infrastructure, and began with the design of an Inter-Organizational Situation Assessment Client (ISAC). A map-based information repository, which aims to support aggregation and visualization of information, individualization of information compositions, collaborative situation assessment, and accessibility of information resources. After the ongoing implementation we plan to conduce an iterative evaluation study at the organizations, which are involved at our research project, in order to proof our concept and implementation.

ACKNOWLEDGMENTS

The project 'InfoStrom' is funded by the German Federal Ministry for Education and Research (No. 13N10712).

REFERENCES

1. Adrot, A. and Robey, D. (2008): Information Technology, Improvisation and Crisis Response: Review of Literature and Proposal for Theory, *14th Americas Conference on Information Systems*.
2. Ciborra, C. (1996): Improvisation and Information Technology. *International Conference on Information Systems*, Philadelphia, PA, 369-80.
3. Gahlen, M., and Kranaster, M. (2008): *Krisenmanagement: Planung und Organisation von Krisenstäben*. Stuttgart: Deutscher Gemeindeverlag, W. Kohlhammer.
4. Gupta, S. Knoblock, C. (2010): Buliding Geospatial Mashups to Visualize Information for Crisis Management. *Proc. of the 7th International ISCRAM Conference – Seattle, USA, May 2010*
5. Kraut R.E., Gergle, D. and Fussell, S.R. (2002): The use of visual information in shared visual spaces: informing the development of virtual co-presence, *Proc. of the ACM conference on CSCW*.
6. Landgren, J. (2006): Making action visible in time-critical work. *Proceedings of the SIGCHI conference on Human Factors in computing systems (CHI '06)*, ACM-Press, 201-210.
7. Lindström, S. and Pettersson, M. (2010): Supporting ad-hoc re-planning and shareability at large-scale events. *Proceedings of GROUP*, 245-252.
8. Lindblom, C.E. (1959): The science of "muddling through". *Public administration review*, 19(2), 79–88.
9. Liu, S. and Palen, L. (2009): Spatiotemporal Mashups: A Survey of Current Tools to Inform Next Generation Crisis Support. *Proc. of the 6th International ISCRAM*.
10. Mendonça, D. (2007): Decision support for improvisation in response to extreme events: Learning from the response to the 2001 World Trade Center attack. In: *Decision Support Systems*, Vol. 43, Issue 3, 952-967.
11. Mendonça, D., Wallace, W.A. (2007): A Cognitive Model of Improvisation in Emergency Management. *IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans*, 37(4), 547-561.
12. Moorman, C. and Miner, A.S. (1998): Organizational improvisation and organizational memory. *The Academy of Management Review*, Vol. 23, No. 4, 698-723.
13. Palen, L. and Liu, S. B. (2007): Citizen communication in crisis: Anticipating a future of ICT-supported public participation. In *Proc. CHI '07* ACM-Press, 727-736.
14. Randall, D. W., Harper, R. H. R. and Rouncefield, M. (2007): *Fieldwork for Design: Theory and Practice*. Springer, London.
15. Reuter, C., Marx, A., and Pipek, V. (2011): Social Software as an Infrastructure for Crisis Management – a Case Study about Current Practice and Potential Usage. *Proc. of the 8th International ISCRAM Conference*.
16. Schafer W.A., Ganoe C. and Carroll J.M. (2007): Supporting Community Emergency Management Planning through a Geocollaboration Software Architecture. *CSCW*, 16 (4-5).
17. SKK (2003): Tactical Signs [Taktische Zeichen]. Köln: Ständige Konferenz für Katastrophenvorsorge und Katastrophenschutz / Geschäftsstelle.
18. Stevens, G. and Wulf, V. (2009): Computer-supported access control. *ACM TOCHI*. 16, 3.
19. Turoff, M., Van de Walle, B. and Hiltz, S. (2010): Emergency Response Information Systems: Past, Present, and Future. In Van De Walle, B., Turoff, M., Hiltz, S.R. (Eds.) *Information Systems for Emergency Management*. Armonk, NY: M.E. Sharpe, 369-387.
20. Waugh, W. L. and Streib, G. (2006): Collaboration and Leadership for Effective Emergency Management." *Public Administration Review*, 66, 131-140.
21. Wiedenhoefer, T., Reuter, C., Ley, B. and Pipek, V. (2011): Inter-organizational crisis management infrastructures for electrical power breakdowns. *Proc. of the 8th International ISCRAM Conference*.
22. Wu, A., Zhang, X., Convertino, G. and Carroll, J.M. (2009): CIVIL: Support Geocollaboration with Information Visualization. In *Proc. of ACM Group*. ACM Press, NY.
23. Zlatanova, S. and Fabbri A.G. (2009): Geo-ICT for Risk and Disaster Management. *Geospatial Technology and the Role of Location in Science* (Eds H. J. Scholten, R. Van De Velde, N. Van Manen).