Supporting Improvisation Work in Inter-Organizational Crisis Management

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ABSTRACT

Improvisation is necessary when planned decision-making as the main managerial activity does not fit the conditions the practice provides. In these cases, information technology should not just automate planned and structured decisions, but support improvisational practice. In this contribution we present an empirical study about the improvisation work in scenarios of medium to large power outages in Germany. Our focus is on inter-organizational cooperation practices, thus we examined the cooperation of fire departments, police, public administration, electricity infrastructure operators and citizens. Our empirical material allows to describe reasons and conditions for improvisation. Our resulting recommendations address the support of aggregation and visualization of information, a necessary individualization of information compositions, options for collaborative situation assessment, requirements for informal and formal communication, and accessibility of information resources.

Author Keywords

Improvisation; Crisis Management; Collaboration; Ethnography

ACM Classification Keywords

H.5.3 Group and Organization Interfaces

General Terms

Human Factors, Design

INTRODUCTION

Crisis management is a practice field that by its nature needs to prepare for the unforeseeable. 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.) makes it impossible to plan all crisis management activities ahead. Nevertheless, all organizations that help guaranteeing civil security (police, fire department, red cross, etc.) have developed systematic approaches to deal with these uncertainties and to allow for planned, coordinated activities in crisis situations. Still,

many situations require spontaneous, ad-hoc decisions and short-term (re-)planning. The ability to improvise remains a valuable asset for individuals and organizations, and is usually cultivated in crisis trainings and grows with experience.

While all these organizations have their established responsibilities and practices, many larger incidents require collaboration with these stakeholders. In Germany (and many other countries), there are established processes and practices of coordination between police, firefighters, infrastructure maintainers and administrative staff, usually prescribed by laws and regulations. All organizations rely on strong individual IT infrastructures. These inform the organization's emergency management by maintaining an overview on the current situation in an area of the organizations responsibility and on available resources for the crisis response measures the organizations feels responsible to engage in, and by providing means to coordinate emergency response activities. There is anecdotal evidence that showed that despite all efforts taken to be prepared, misunderstandings happened while actors were forced to operate and interact outside the system of established practices. Some of them may have been avoided if the IT systems had not only supported routine processes but also deviations.

Several examples of large crises (e.g. Hurricane Katrina [17]) showed that improvisation abilities face a completely different level of challenge when the crisis at hand is of a magnitude that requires emergency response organizations to collaborate. When dealing with larger power outages (the scenario we are looking at in our research project InfoStrom [24]), each of the organizations involved (police, fire department, infrastructure providers, etc.) sets up an own crisis management team. At county level a crisis management group tries to coordinate the efforts and also deals with the public. Nowadays, crisis managers as well as the crisis response teams, need to improvise at an inter-organizational level, and find their IT infrastructures not always prepared for that. As [9] reveals it:

> "Unfortunately, a focus on structure and doctrine obscures the need for technology that enhances improvisation and creativity. The specification and formalization of the planned-for structure has resulted in doctrine and technology to support it, ignoring the demonstrated, even inevitable, needs of the adhocracies that help manage the unanticipated contingencies presented by extreme events […] Improvisation and adhocracy have received considerable

examination from social scientists, but have been far less frequently addressed by ICT designers." (p. 49)

But what is the exact nature of improvisation work necessary in crisis response? Where do communication strategies fail? And how can we provide IT support for improvisation at an inter-organizational level? In this contribution we present an empirical study of the inter-organizational improvisation work of actors, which are involved in scenarios of medium to large power outages. We derive requirements for information systems that would be able to support these practices.

The paper is organized as follows: After defining relevant terms and discussing the literature we introduce the research filed and our research methods. Afterwards we focus on the improvisation practice we found in emergency management. Then we discuss our findings and focus on design issues with regard to IT support for improvisation, finally followed by a conclusion.

IMPROVISTATION AND INFORMATION TECHNOLOGY IN CRISIS MANAGEMENT

Improvisation can be defined as "*situated performance where thinking and action seem to occur simultaneously and on the spur of the moment*" [4]. It can be interpreted as the unforeseen [18]. While some authors define it from the management perspective as "*to be composed while performed*" [14] others describe it in the case of fire service management as "*thinking and doing unfold simultaneously*" and "*retrospective sensemaking*" [23].

Improvisation in Emergency Management

Antecedent conditions, such as unexpected problems, changes in the structure of the problem areas or environmental and knowledge limitations, lead to the need for improvisation [18]. Even in highly structured organizations improvisation is a well-grounded process that can be leveraged to face those situations where rules and methods fail [3]. Improvisation can be performed on different levels and can be treated as an individual or as a team phenomenon [12]. Improvisation becomes necessary when beforehand planned decision-making does not work for any reason. This is especially the case in crises. Crises and emergencies often contain unexpected events. The root word '*krisis*' means 'judgment' and 'decision' which leads to the most important task: decision-making. 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*" [11]. Improvisation does not consist of more sophisticated methods or more structured systems [4]. Instead of trying to eradicate it through automation, the appreciation of flexibility and effectiveness seems more adequate. There "*improvisation and preparedness go hand in hand*" [9]: Without improvisation, emergency management loses flexibility, without preparedness, emergency management loses efficiency.

Characteristics of Emergency Management

To support improvisation in crisis management it is essential to know the characteristics of the field. Based on an analysis of the response to the 2001 World Trade Center attack, the following characteristics of emergency management can be considered as characterizing reasons for improvisation [9]. Firstly, (a) *rarity* of incidences limits opportunities for training and learning. Furthermore, (b) *time pressure* forces a convergence of planning and execution. (c) *Uncertainty* is present because the development of an extreme incidence is hardly predictable. Furthermore, extreme events have (d) *high and broad consequences*, therefore there is a need to manage interdependencies among a wide range of physical and social systems. The (e) *complexity* of the event arises, partly due to the high and broad consequences. Finally (f) *multiple decision makers* and responding organizations may negotiate while responding to the event. When more than one actor is involved, decision-making is often a process of "muddling-through" rather than a "scientific" process [8]. In emergency management this is not caused by a lack of planning, but is necessary because "*in fact the major problem in emergency management is that the team often does not exist formally until the emergency occurs*" [21], which is contrary to scientific communication processes. Crisis situations differ from routine situations and actors have to face new and unstructured tasks [15].

Supporting improvisation in crisis management

As stated above, decision-making is one of the main tasks where improvisation is needed. 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 involved in responding to unanticipated contingencies [9]. 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 [22]. Computer based comparisons of the current decision situation with past ones were identified as appropriate in this context [9]. Case-based reasoning systems, which catalogue the set for planned-for situations or decision alternatives, may be used for this purpose, too. Ad-hoc re-planning and the ability to share material were identified as design challenges for large-scale events [7]. Furthermore, the following IT-supported mechanisms for improvisation in emergency management are suggested: graphical representations of data during crisis response, intelligent systems that select and help to contact experts, centralization of data to enable actors finding information and virtual supported coordination to create shared information consistent in time [1]. In addition, verbal communication should be made persistent, visible and accessible in order to support accountability [6]. Finally

"*ICT in disaster contexts will give further rise to improvised activities and temporary organizations with which formal response organizations need to align.*" [13].

Much prior research focused on improvisation within an organization. Our aim is to examine improvisation on an inter-organizational level in order to derive requirements for potential IT-support for improvisation work. Aside from some theory-led considerations and case studies above, we aimed to understand the local and collaborative practices of the agents. Therefore we conducted an empirical study in Germany focussing on improvisation work for actors involved in scenarios of medium to large power outages.

RESEARCH FIELD

This paper reports from a study focusing on improvisation practices during coping and recovery work at emergency response agencies in Germany. We conducted this study in two regions of North Rhine Westphalia in Germany (counties Rhein-Erft (REK) and Siegen-Wittgenstein (KSW)). Siegen-Wittgenstein is a densely wooded, hilly county in the middle of Germany, whereas Rhein-Erft 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.*

Before we present findings from our empirical study, we will have a quick look on two interesting aspects in advance regarding police and firefighter forces at both counties. Firstly, related to the organization of fire and rescue forces, Rhein-Erft provides professional fire and rescue departments, whereas Siegen-Wittgenstein's firefighters are mostly members of voluntary fire departments. Here, just members of the control center have salaried positions. Secondly, another interesting aspect emerged, while we compared lead structures of both organizations. 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 control centers.

METHODOLOGY

The aim of the empirical study was to understand the application field and improvisational practices in crisis management. The view on the field was sensitized by our design intention. We conducted a grounded theory oriented approach [20], where we did not explore the field with predefined categories, but derived categories from empirical data. To reconstruct the practices we used different qualitative methods [16] such as document analysis, 4 observations, 5 group discussions, and 22 interviews 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, police, fire department, red cross and energy network operator (ENO). We used open coding [20] 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.

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

The *observations* were used to acquire 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 cultural event with about 400.000 visitors (6 hours).

The *group discussions* (see table 1) allowed us to understand the communicative practice of inter-organizational crisis management. We conducted 4 inter-organizational group discussions, each lasting of about 4 hours, including the participation of leading actors.

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 1. Group Discussions

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. It helped to increase their validity and comparability and to develop ideas concerning improvements of tools to support improvisational practice.

The *interviews* (see table 2) 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 the developed scenario framework. The third part covered information and communication systems as well as perceived problems with these tools.

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	Köln	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 2. Interviews

RESULTS: IMPROVISATION IN PRACTICE

Facing novel problems and the need to act quickly, plays a significant role in handling crisis situations. Our study revealed that at both counties improvisation is a common procedure of decision makers responding 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) or "*We improvise as usual. We see to it that we make the best out of each situation.*" (I11).

In this section we are going to point out existing improvisation practices of actors involved in crisis management (see Table 2), which have been identified after analyzing existing coping and recovery practices. We have divided this section into aspects of improvisation in current management structures of emergency services, possible causes of improvisation and conditions of improvisation.

Improvisation in current management structures

When we take a closer look at emergency response work, we can see that improvisation is a common practice in todays' emergency management processes, besides executing on one or more response plans. As we could see at police work practices, to be capable of facing uncertain events, flexibility is already part of their common working procedures: "*No, all workflows are flexible. This is necessary, because each situation is different.*" (I2). One police officer explains, that "*once there is a problem, our command center gives us basically plenty of rope, to solve the problem*" (I4). When we focus on the degree of improvisation or situated actions, our study identified two factors: the audience and the scale of an incident. We have to distinguish between two cases: "*There are incidents, which are managed by incidents commanders and there are events, where a crisis management group is in charge*" (I1). Incident commanders are usually full responsible for coordination and decision-making at the incident scene, when response plans can be executed properly. This work is not so much shaped by improvisation actions as by executing predefined tasks: "*We get the tasks and we perform them*" (I7). However, when emergency services are faced with complex, unpredictable events and a bigger picture is needed to perform further actions, a crisis management group takes over decision-making on a higher level. Because these kinds of events are "*not static, they can develop in any direction*" (I5). At that point, response plans can rarely be executed, the procedures in this group and on decision-maker level "*are more flexible*" (I1) in order to be capable of generating and executing new orders or plans nearly simultaneously. An example of a typical order is: "*Look for schools or gymnasiums to accommodate 500 people. How you do it is your business.*" (I1).

Reasons for Improvisation

Due to the uniqueness of each operation, the actors' procedures during coping and recovery work essentially depend on improvisation rather than on predefined workflows. "*This is necessary, because no situation is equal to any other. [...] Our work is fundamentally different from other local authorities. There are no predefined processes we are working off – we would be helpless and lost. That's why we tactically work with frame orders.*" (I2). Although these frame orders describe concrete tasks, the way how they are performed strongly depends on the current situation in the field: "*No one gets told by us: 'You have to enter the house via the left sidewalk.'*" (I2).

Improvisation 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 (I2). For that reason, many actors individually collect supplementary information from various sources, for example, the 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).

Outside influences from an incident itself are not the only reason that requires an improvised acting. Also *organizational factors* and structures can bear unpredictable challenges. That is why each actor will have to be able to divert from given routines to be capable of acting even if the given structures and circumstances change: *"If a system is strongly rigid and structured, and then one component is missing, mostly the whole system will collapse. For this, informal acting can be helpful."* (I1). Reasons mentioned for such a collapse is that technology, especially communication tools, can fail (I3) or internal information resources (e.g. phone lists) required during an operation are unavailable (I2). Also *human factors* play an important role. Especially during major catastrophes staff members can also be affected personally: *"When an employee gets the call that his home is flooded, you are trying to relieve that staff member from his duties. It makes no sense to keep him here. You would arrange a replacement and say: 'Here, care about your home or about your family.'"* (I2) In addition to organizational reasons, the collaboration with other agencies requires a more flexible and improvised acting in general due to different organizational structures and work practices (I1).

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).

I5 and I4 mentioned that *personal biases* have a significant impact on the interpretation of given information. Mostly, members of the public with no professional expertise about the current situation tend to exaggerate or to understate their report about the current situation. For instance, one citizen reported about "*a major car accident*" which led to take actions by the local emergency medical services for seriously injured or even dead passengers, while it was just a minor car accident only with material damages (I5). I4, I5 reported about contrary cases, as well.

Within one workshop (W2) a firefighter reported about the problem of *losing and changing information* during the transmission between organizations. "*We got the information about several seriously injured kids, during the world youth day in Cologne, 2005. After conducting appropriate actions, we figured out that these kids were hardly injured at all*" The information changed, while it was transferred from the first responder via skilled and non-skilled organization members to the responsible medical service.

Besides loosing available information, there is sometimes a lack of information provided by infrastructure operators (e.g. 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 of infrastructure operations they 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 always 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): *"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 Improvisation

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

Improvisation 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 authorities: 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 improvisation 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 forecasts, 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 is directly connected to reliability and plays a significant role in sharing or retrieving information, especially for those kinds of 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 example, I9 mentioned that "*good connections to police members*" help to trust on information accuracy and to better understand each other. However, "*people who put themselves in the limelight*" (I4), even from the same organization, can affect this relationships negatively. Because of the need for good relationships, a lot of informal contacts and relationships have been established alongside predefined communication lines, especially in Siegen-Wittgenstein. "*Police officers directly talk to members of the leading group via mobile phone and don't take the way via section officers as it should be*" (I2). This can lead to a significant problem: The loss of information. Furthermore, when receiving information from non-trusted information providers such as citizens (W3), each organization starts its individual verification process. "*If we receive a non-reliable emergency call, we will just wait for a second call*" (I3), "*we react on on-scene information from citizens but we will immediately verify this information by experts*" (I1) or I12 and I22 stated that they use 'Qualified Interviews' to get appropriate information from non-experts.

"*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. However the following statement shows a conflict to guarantee accurate, complete and timeliness information: "*The more stressful a situation becomes, the less information can be provided to*

others" (I3). Furthermore, particularly in stressful situations, informal communication lines do not work anymore because everyone has to do what they are supposed to do (I15).

A wide range of emergency response actions shows that improvisation 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 will 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 improvisational 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.

DISCUSSION

As shown in the results, no situation is equal to the other. Highly novel problems require ad hoc decision-making based on available information on the situation. This information is not necessarily available in the own organization. Especially during unique emergency events, many external resources need to be consulted. Finding and retrieving relevant information are still huge challenges for several reasons:

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.

3. *Accessibility of Information/Policy Issues*: Because of technical shortcomings (e.g. missing appropriate interfaces) and policy issues at the information providers, retrieving relevant information is either time-consuming or even not a possible task in many cases.

4. *Handling of information uncertainties*: In reality data is 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 on situation maps 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.

Even if these challenges partially agree with earlier research findings on coordination practices in emergency response management [2] and previously identified challenges in designing interactive systems for emergency response [5], our study underlines their relevance on an inter-organizational level. In the following sections we will respond to these issues with regards to existing practices that we identified in our study.

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.

Gathering and analyzing data, assessing the potential impacts of events and executing related actions are main activities of most of the actors we have described in the antecedent sections. 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. It can be explained with the aid of two examples: In early phases of emergency events members of emergency response organizations are not necessarily at the same location to consult about the latest events. For instance, members of crisis management groups call each other from different locations so that they are not able to use a joint situation map. Even situation maps at the control center differ from maps of on-scene commanders of the same organization, therefore synchronizing missing information shapes communication. 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.

Definitions about responsibilities and formal communication channels in organizations usually work well and are important for a smooth interaction within the agency. However, the results show that structures can collapse, e.g. due to the failure of technology, outdated phone lists or human reasons. In this circumstance as well as in urgent emergency situations it might be necessary to diverge from rigid standards and to use unofficial channels instead. The same applies to inter-organizational communication, for instance, when a responsible liaison officer is not available for any reason. Induced by the different structures of the two investigated counties, the significance of informal communication differs strongly. The rural structure of Siegen-Wittgenstein and the mainly voluntarily organized agencies entail that many of the members know each other. As a consequence, communication channels are much more informal than in the more urban county Rhein-Erft. These differences emphasize that both formal and informal communication channels are equally important for cooperative work. To support both there is a need for a better awareness about the structures of involved organizations as well as the availability of suitable contact persons including capabilities for contacting.

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. However, 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 IMPROVISATION WORK IN INTER-ORGANIZATIONAL CRISIS MANAGEMENT

One of the fundamental design requirements for supporting improvisation work for the inter-organizational level is to create a complementing information infrastructure, not a tool to replace existing IT. Technologically, this can be implemented relying on a service-oriented architecture that allows to connect to the existing IT infrastructures in the participating organizations. But with regard to the functionality we need to support improvisation work at the inter-organizational level we can outline five specific implications for the design that focus on geographically visualized data on information and collaboration resources:

Aggregation and Visualization of External and Various Information

We have seen that, besides internal information, information from other organizations is needed to get a appropriate picture of ongoing and future events and activities. Most information is spatial (e.g. emergency plans for buildings or areas with electricity breakdowns). We suggest 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 specific map compositions. As confidence in information is crucial, it is also important to distinguish between information sources (particularly internal vs. external) and degrees of information reliability.

Individualization of information Compositions

We have observed that actors of emergency response organizations adapt information compositions due to their personal needs. Users need instruments that enable them (technophile and technophobe) to customize information compositions in real-time. Users should have the opportunity to easily show and hide information resources on the map, to add additional and new information resources to the map (that may also be provided by external web services), and to add place marks with annotations at specific locations in the map.

Supporting Collaborative Situation Assessment

The common practice to perform situation assessments collaboratively needs an explicit inter-organizational support. Actors need be able to share map-based

compositions of information resources with other actors in a very controlled way. Visualization and interaction should be possible in various environments and locations, e.g. from a notebook at home, via mobile phones at the incident location or on a large screen in the crisis management center. Additional communication channels need to support the collaborative analysis of the information on the map, e.g. instant messaging services or audio channels. Because current situations can change rapidly, all participants require the option to modify information compositions on the map approximately in real time. Issues of information rights may occur while sharing information and annotations; we address that below.

Supporting Informal and Formal Communication

Both, informal and formal (along official roles, usually recorded/documented) communication channels need to be supported. Actors should be able to spontaneously decide which ones to use. For a better support of formal communication the actor has to be aware of organizational structures of his own as well as of other involved organizations. In an ongoing incident, it is often not clear which organization is reacting how, who is on duty and how she can be contacted. Redundant and outdated information can be avoided by providing a central repository. For informal communication it is more important to know who is in reach and working on a subject I need information about. Organizational structures are less relevant, but personal relations are: It may be good to know who works 'nearby' (meaning spatial, but also social distance) the contact I am interested in. Offering a large variety of communication channels may be as important as offering options for an informed choice among them.

Accessibility of information resources

Each of the organizations involved are using or hosting information resources, or being an information resource by producing information (e.g. the police 'produces' road closures). All that may be relevant for other organizations as well. For improvisational work, it is necessary to provide mutual awareness of the information available: It requires a shared information repository where proper services can be registered, described and rated by the user. The information resources could be selected as required by the situation and could be integrated into the intermediate infrastructure. Some of this information is subject to (e.g. for copyright or security reasons) restricted organizational access policies. For supporting improvisational work, it is not only enough to map these policies to access rights at design time, but to provide interactive access rights to allow for unforeseen, but necessary information flows. Computer Supported Access Control may support spontaneous information needs while enabling the user to attempt access and to legitimate it during use [19]. 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 will be implemented:

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 more flexible approach also predefines access rights. 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 is documented. That means that the user must be aware of possible consequences when "breaking the glass" unauthorized.

CONCLUSION

In medium to large crisis situations, the pressure on emergency response organizations (police, firefighters, administration, etc.) to collaborate with each other effectively increases. While some aspects of coping and recovery work are covered by negotiated procedures (sometimes prescribed by law) and trained routines, the variety of influencing factors and framing conditions always leads to a need for improvisation also at an inter-organizational level. Improvisation has been previously addressed as a topic [1,9,10,11,12], but our study was able to show additional difficulties we encounter at the inter-organizational level. In our study of the improvisation practices during larger power outages between police, firefighters, public administration and an electricity provider in two counties, we showed that improvisation work suffers on the one hand from a lack of options for sharing information among the organizations, but also from a lack of awareness of information about the activities of others, and from a lack of collaboration in consolidating and interpreting the information available. If external organizations required explanations about established and successful inner-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 significantly 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 improvisation work in crisis management 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 (e.g. for situation assessment)

that can as well be individualized/localized. The exchange of information regarding 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.

As a next step, we are going to develop such a complementary infrastructure based on geographically visualized data on information and collaboration resources necessary for improvisation, and with additional support for ad-hoc sharing of information. We also plan to integrate citizens as potential crisis managers on their own behalf to the scenario (as also requested in [13]). The most important experience resulting from our studies here was: No matter how much control and preparedness we wish for in the event of a crisis, we need to acknowledge, support and take pride in our abilities to improvise.

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