Supporting Inter-Agency Collaboration in Emergency Management: Recurring Challenges Relevant for CSCW

Bjørn Erik Munkvold
Centre for Integrated Emergency Management (CIEM), University of Agder
bjorn.e.munkvold@uia.no

Abstract. Emergency management requires effective collaboration between different agencies. This work implies several challenges due to a heterogeneous mix of actors with different procedures, practices, and support tools. Despite being focused in various research streams, emergency responders still report challenges with sharing information and establishing shared situational awareness in responding to complex events. The paper presents results from a large-scale digital tabletop exercise that illustrate recurring challenges related to support for collaborative procedures, a communication network structure combining several media, use of geocollaborative tools, and configuration of collaborative environments in co-located operations centers. CSCW researchers are well positioned to further address these challenges and thus make an impact in a domain of high societal importance.

Introduction

Emergency response in large-scale incidents requires effective collaboration among a number of actors from different agencies, including first responders (police, fire, health services), public authorities at different levels (municipalities, county governor, national directorates and ministries), infrastructure providers, as well as volunteers. This kind of work setting is complex and challenging, involving information sharing and coordination between different disciplines with varying practices, procedures, terminology and tool support, operating under demanding conditions and time pressure. The term inter-agency collaboration is here used to denote this complex form of inter-organizational collaboration, as established in the domain of emergency management (see e.g., WHO, 2020). While being focused in CSCW and other research fields for several decades (Pipek et al., 2014), evaluations from both real events and emergency exercises document recurring challenges in sharing information effectively for establishing shared situational awareness.

Based on insights from a large-scale tabletop exercise involving 20 different organizations, this paper discusses core challenges related to inter-agency collaboration that CSCW research could contribute to resolve. The paper is thus a call to arms for the CSCW research community to strengthen the focus on supporting collaborative practices in emergency management, a domain that is of increasing importance at community, national and global level in society.

The next section briefly points to relevant work in CSCW as well as other areas. Then our emergency exercise is presented as an illustration of possibilities and challenges in creating shared situational awareness in a complex scenario. Based on the exercise evaluation results, core challenges relevant for CSCW research are discussed.

Brief overview of related work

Research on technology support for emergency management is quite fragmented, being pursued in different disciplines and communities such as information systems, computer science, crisis informatics, geoinformatics, as well as CSCW. Typically, the research in these areas is disseminated in different conferences and journals, with little cross-fertilization and aggregation of knowledge between these fields. As an example, the international conference on information systems for crisis response and management (ISCRAM) that has been running annually since 2004 (see iscram.org) is still little cross-referenced in 'mainstream' information systems literature and CSCW research (though with some exceptions).

A special issue of the CSCW journal from 2014 focused on Crisis Informatics and Collaboration (Pipek et al., 2014). In their introduction to the special issue the editors present a comprehensive view on the crisis informatics term, to include "an interdisciplinary perspective on the socio-technical, informational and collaborative aspects of developing and using technologies and information systems in the context of the full disaster lifecycle" (op.cit., p. 339). They here also refer to "collaborative resilience" that involves "collaborative services and technologies to improve the resilience of cities, infrastructures, logistic chains, etc. through public-private partnerships" (p. 340). Of the six papers accepted for this special issue, four focused on practices involving crowdsourcing and/or social media. A later comprehensive review by Reuter et al. (2018) also documents how the crisis informatics research has had a core focus on the role of social media in crisis management.

The special issue paper most relevant for the focus in this article is the study by Ley et al. (2014), reporting from the initial stage of developing inter-organizational collaboration functionalities in the form of an inter-organizational situation assessment client and an inter-organizational information repository. Their work highlights the complex nature of these inter-organizational practices and the resulting need for improvisational support, as well as the challenges involved in validating the solution concepts because of the limited possibilities for real-life testing in emergencies.

In general, the CSCW research focusing on awareness is also relevant in the context of this paper. In an extensive review of 25 years of awareness research in CSCW, Gross (2013) summarizes several research streams, concepts and technological developments relevant for coordination and collaboration in emergency management. This includes media spaces, collaborative virtual environments, and shared workspaces, based on technology support for capturing, storing, and presenting awareness information to the users. Interestingly, this review article neither includes any explicit mention of the term 'situational awareness', nor refers to the model by Endsley (1995) defining three levels of situational awareness: the perception of elements in the current situation, comprehension of the current situation, and projection of the future status. This model by Endsley is a core reference in much research on emergency preparedness and response (Steen-Tveit and Munkvold, 2022), with over 11000 citations. While this could then be viewed as an example of the mentioned disconnect between CSCW research and the research related to technology support for emergency management, it should also be noted that the mentioned article by Ley et al. (2014) does indeed discuss Endsley's model. And another article in the same special issue also presents a collaboration tool supporting shared situational awareness through visualization of real time information in a common map (Heard et al., 2014).

Based on this brief mapping of research in CSCW and other areas relevant for supporting collaboration among agencies involved in emergency preparedness and response, the next section presents a case to illustrate challenges involved in this domain.

Case illustration: Supporting shared situational awareness in a large-scale forest fire exercise

The INSITU research project (insitu.uia.no) funded by the Research Council of Norway and led by the Centre for Integrated Emergency Management (CIEM) at the University of Agder, focused on developing solutions supporting information sharing and situational awareness in complex emergency events involving collaboration between many stakeholders (Munkvold et al., 2019). As part of this project, a large-scale digital tabletop[1] exercise was conducted to explore the potential of supporting shared situational awareness in a forest fire scenario. The scenario involved three simultaneous forest fires in three neighbor municipalities, with each fire threatening critical infrastructure due to flames and/or smoke (hospital, railway, road traffic, cell towers and electrical substations). This kind of scenario is also included in the national risk analysis developed by the Norwegian Directorate for Civil Protection (DSB), described as three large simultaneous forest fires getting out of control and thus challenging the response capacity and resulting in serious consequences for life and property (DSB, 2019). In our exercise, each of the three fire scenarios were developed by local fire chiefs to ensure sufficient realism.

Facilitated by the County Governor of Agder as partner in the INSITU project, altogether 70 participants from 20 different organizations were involved in the exercise. These organizations included first responder agencies (police, fire and health services), civil defense, municipal and county government crisis teams, the Norwegian Directorate for Civil Protection (DSB), the Crisis Support Unit at the Norwegian Ministry of Justice and Public Security, as well as critical infrastructure providers (energy and telecommunications companies, public road administration, railroad).

Figure 1 provides an overview of the different stakeholders involved in a complex emergency event such as the forest fire scenario in this exercise. While a detailed description of the figure is beyond the scope of this article, it serves to depict the different levels (local, regional and national) involved in this kind of large-scale and complex event. The main purpose of the exercise was to gain experience with sharing situational pictures from the incident command at the local level through the regional level coordinated by the County Governor, and

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[1] A tabletop exercise is a discussion-based session where team members discuss their roles during an emergency and their responses to a particular emergency situation (Ready.gov/exercises)

further to the national level represented by DSB and the Crisis Support Unit (CSU) at the Ministry of Justice and Public Security.
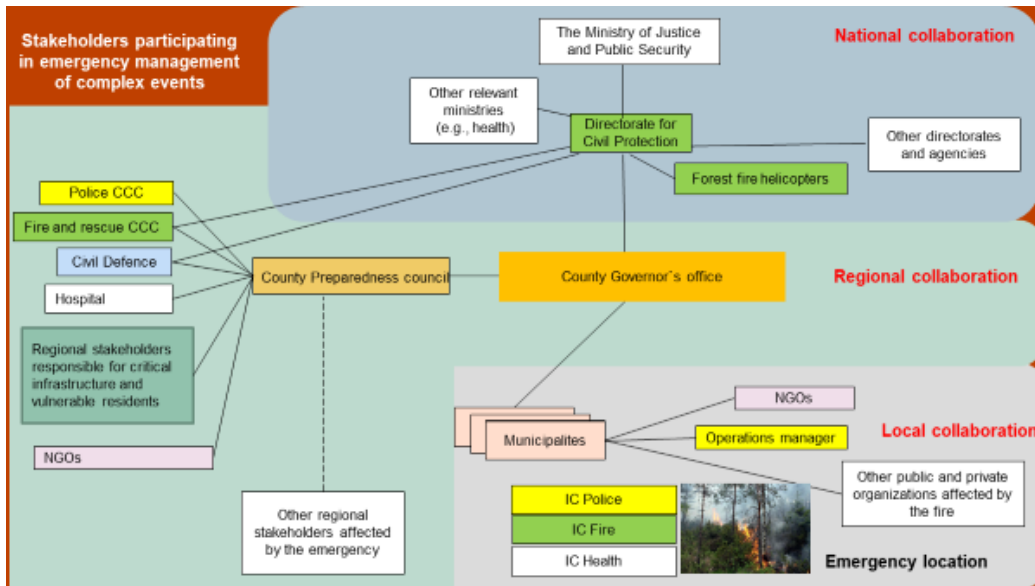

Figure 1. An overview of stakeholders involved in a complex emergency event
(courtesy of Dag Auby Hagen, County Governor of Agder)
CCC = Command and Control Center, IC = Incident Command

Collaboration tools used in the exercise

The collaboration platform used for the exercise was the forest fire module of the DSB map system (kart.dsb.no) in combination with the Norwegian critical communication network (Nødnett). The map system gives access to thematic layers of information relevant for a forest fire scenario, such as forest-related information, vulnerable objects and critical infrastructure. Except for in some regional exercises and a very small number of real fire events, the use of this map system is limited. Instead, the different agencies typically use their own map systems with little or no interoperability (Opach et al., 2020). A goal of the exercise was thus also to show the potential of using a common map system for being able to share geolocated information related to the incident. For the tabletop exercise, four user logins were created for the different categories of users. One user login for each of the three fires, intended for the local fire departments and the municipalities, and a fourth login for users with a coordinating function at the regional (County Governor, critical infrastructure providers) and national (DSB, CSU) level. The latter user category could then monitor the three fires simultaneously, and also add their own information in the map to supplement or edit the information from the local incident command. For the radio

communication network, a common call group was established where all participants having access to a terminal could report and/or listen in. In addition to regular users of this network (first responders and some of the critical infrastructure providers) we also provided terminals to other organizations that currently are not users of this network such as the municipalities and the County Governor's office, to explore whether this additional channel of information would be considered useful for situational understanding. For both the map system and the communication network, video tutorials were made available to the participants three weeks before the exercise. This also included voluntary exercise tasks in use of the map system that could be submitted to the research team.

Since the exercise took place during a phase of partial Covid-19 lockdown, Microsoft Teams was used as the communication platform. This also meant that several of the participants from the involved organizations participated from their home office instead of being co-located in their respective crisis teams. However, the participants did not report this to have any significant impact on their work during the exercise.

Evaluation from the exercise

The evaluation of the exercise was based on several sources of data. During the exercise, the research team followed the conversation in the radio communication network and had access to all four user logins of the map system. Further, we were copied on textual situational reports that were sent from the incident command to the County Governor's office, including screendumps from the map system. Immediately after the exercise, a first impression session ('hot washup') was conducted where representatives from each of the participating agencies briefly shared their experiences from the exercise. This session was recorded. After the exercise an online survey was distributed to the participants asking about their perceived situational awareness, access to information, and use of the support tools (map and communication network). Also, some of the participating organizations (DSB, County Governor) provided written evaluations. Finally, during the week after the exercise we conducted six online group interviews with a total of 25 participants from 17 different organizations. Each interview lasted 1,5 hours, giving a total of 9 hours of recorded interviews that were transcribed in full. The interview data, observation notes, and other material collected during the exercise, were analyzed together related to the themes focused in the exercise, i.e. experiences with the common map support in combination with the audio communication, and how this was used for situational reports and information sharing between the agencies involved. The results were summarized in an evaluation report from the exercise (Munkvold et al., 2021).

Overall, the participants found the exercise scenarios to be realistic, and reported that the use of a common map in combination with the communication network provided a better situational awareness than they normally would have in a complex scenario like this. Especially the users in a more supporting role (municipalities, critical infrastructure providers) perceived to be better able to follow the scenario, as in their normal mode of operation their crisis management team would depend on telephone calls with the incident command and/or a liaison from the police:

"The municipality received limited information on the phone, and with a map that was updated regularly we had access to a lot of information that could be used to make good decisions for the municipality as early as possible." (Municipal emergency coordinator)

The exercise also identified several issues in need for further improvement (so-called learning points) related to the inter-agency collaboration. The local incident command at the fire services were responsible for preparing and sharing the map information, including detailed geospatial information on the fire fronts and the response operation. These maps from the fire scenarios were then intended to be processed further at the coordinating level. However, a combination of lack of training in the rather complex map system with limited intuitive functionality, lack of analytic capability related to geospatial data, as well as time pressure, resulted in that the detailed maps from the incident scene were not processed further before being passed on to the next level in the information chain. This again resulted in that the CSU at the national level received maps with a level of detail not useful to them. As summarized by DSB in their written internal evaluation of the exercise:

"The CSU expected situational reports on whether life or health was threatened, and whether those handling the situation had sufficient resources to save lives (if needed), and then whether any critical societal functions were threatened or could be affected. […] We managed to convey a situational picture of the positions of the field personnel, the location of the fire and where the fire hoses were placed, but we could not communicate the essential regarding vulnerabilities, such as Nødnett [the critical communication network] or other infrastructure."

It was also pointed to a general lack of clearly defined procedures and templates for situational reports, and the County Governor receiving these reports "in different formats, and at different times".

Apart from this, the study also resulted in a detailed list of requirements for improved map support, which is being considered by DSB for further modernization of their map support.

Discussion and suggestions for further research

While this exercise was designed and conducted as part of a research project, the focus on inter-agency collaboration is highly relevant for regional and national large-scale emergency management exercises in Norway. After the 2011 terrorist

attack in Norway (Rimstad et al., 2014), collaboration among emergency responders was defined as one of four core principles of emergency preparedness and response in Norway. Yet, despite the ensuing emphasis on this collaboration principle, a recurring challenge reported in evaluations from both real events (e.g., the near grounding of the Viking Sky cruise ship (DSB, 2020) and the Gjerdrum landslide (HRS, 2021)) and large-scale exercises (e.g., Trident Juncture 2018 NATO exercise (Grunnan et al., 2020)), is to obtain situational awareness and a common situational understanding.

Thus, based on the findings from our tabletop exercise as well as a broad mapping of current practice for inter-agency collaboration and information sharing conducted in the INSITU research project, we here discuss some core research challenges where the CSCW community could bring relevant expertise.

Support for collaborative procedures

Our study identified a general lack of procedures defining inter-agency information sharing. While the different organizations have internal procedures and 'action cards' for different scenarios, these typically do not specify what information should be shared with other organizations and how. Also, when observing emergency exercises involving personnel that are not trained as first responders, we see that the existing procedures often fail to be activated or are deviated from. Part of the reason for this is that personnel in supporting organizations may only have emergency preparedness and management as a limited percentage of their position (such as in smaller municipalities), and the emergency drills conducted once or twice per year are not sufficient for internalizing the procedures and related support tools in use (if any).

Given the unique characteristics and unforeseen elements of any crisis event the need for some improvisation in response operations is well accepted (e.g., Ley et al., 2014). Still, the practitioners we interacted with in our research project pointed to a need for better procedural support than what they currently have access to. The ICT systems in use by Norwegian emergency responders today provide very little support for collecting and integrating information from different sources. With the support systems mainly serving as repositories of the plans and procedures, and being mostly used for logging of the emergency response activities, the decision-makers themselves need to identify sources of relevant information and collect this rather than the system automatically pushing this to the responders.

The research on collaboration engineering (CE) focuses on "the design and deployment of repeatable collaborative work practices that can be executed by domain experts without the ongoing support of external collaboration professionals" (de Vreede and Briggs, 2019). Supporting the argument by Koch et al. (2015) on the possible benefit from combining CSCW and CE research, we

argue for developing a set of partially automated collaborative scripts that can be implemented in the incident management systems to aid the decision-maker in the required information management procedures.

Combined use of audio and textual support

At the operational level[2], the critical communication network is the main means of communication, both within each agency and for inter-agency communication. The exercise illustrated the benefit of combining audio communication with a common map, for obtaining a more precise situational awareness. The first responders have pre-defined call groups and procedures for their internal and inter-agency communication. But in practice these procedures are not always followed "by the book", and as showed in our exercise there are also several organizations involved in large-scale events that do not have access to the critical communication network and thus must rely on other channels.

In the forest fire exercise, the common call group created was considered to give added insight for some users, although it was also considered time-consuming to follow all the communication exchange in this call group. And for the first responders being used to their specific call groups to support their work, the extended scope of a "common for all" group was perceived to generate noise. What is still needed is to develop a systematic communication network structure, adapted to the different roles involved and the available communication channels.

Use of geocollaborative tools

The analysis from the exercise showed a generally low proficiency in the use of the digital forest fire map among the involved participants. Thus, the training provided prior to the exercise was instrumental for being able to make use of the map solution. However, as described in the case example, advancing from being able to read and interpret a map to also being able to further analyze and modify the information represents a further challenge. Developing map services that automatically guides the user in building a common operational picture (COP) adapted to the level of operation (operational, tactical and strategic) would here be a significant improvement of today's practice.

Co-located collaboration in joint command and control centres

While not covered explicitly in our digital tabletop exercise, a relevant area for CSCW is also the current trend of establishing common regional Command and Control Centers (CCC) for the first responders. Being co-located is expected to

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2   This paper here refers to the three-tier command and control structure, i.e. operational, tactical, and strategic (Bharosa et al., 2010). In Norwegian emergency management, the three levels are often referred to as tactical, operational and strategic.

make inter-agency information sharing and coordination easier and faster, and positive experiences of this have been reported (e.g., Antonsen and Ellingsen, 2019). There are also examples of a more extended co-location concept such as Samfunnssikkerhetens hus ('House of Societal Security') in Bergen, where also supporting organizations such as road administration, energy services and others are included.

The configuration of these CCCs and the related new work practices are still under development and there are regional pilots and practices being tried out. The rich body of CSCW research on operations centers and control rooms (see Silvast et al. 2022 for a recent review), could here provide an important basis for developing well-functioning configurations of such collaborative environments.

Conclusion

This study has highlighted several core challenges of inter-agency collaboration in emergency management that align well with the focus and expertise of CSCW researchers. While presented under separate sub-headings, these challenges are also connected within a broader framing of developing effective collaborative work practices for inter-agency emergency management.

The case illustration from the emergency exercise contributes to show the complexity in developing a shared situational awareness in a large-scale incident involving many stakeholders at different levels. The challenges identified from this exercise are not specific for a forest fire scenario, and also apply to other complex scenarios resulting from natural or man-made hazards.

As implied in the title of this paper, many of these challenges have also been reported in previous research. However, as the challenges remain largely unsolved, there is a need for a strengthened research focus. The CSCW community can here have a strong impact on practice in a domain of critical societal importance.

Acknowledgments

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