Collaborative Evaluation: Mapping Socio-Technical Patterns in an Emergency Exercise

Kjetil Rustenberg
Center for Integrated Emergency Management (CIEM), University of Agder, Norway
kjetil.rustenberg@uia.no

Kristine Steen-Tveit
Center for Integrated Emergency Management (CIEM), University of Agder, Norway
kristine.steen-tveit@uia.no

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

Jaziar Radianti
Center for Integrated Emergency Management (CIEM), University of Agder, Norway
jaziar.radianti@uia.no

ABSTRACT

Evaluating both exercises and real events can be challenging. This is especially evident in full-scale exercises, where a wide range of organizations must collaborate to solve a common problem. Information sharing, use of technology, and role understanding can be particularly challenging. In this article, we illustrate how academia can meaningfully engage in conducting and executing a comprehensive Emergency Exercise, ensuring that insights from prior research are evident from the outset. We employ a method where we co-create a Socio-Technical Network map together with practitioners. The method provides results that help visualize the complexity generated by large-scale collaboration, fostering involvement and engagement from both researchers and practitioners. Through this mapping, we gained valuable insights into barriers to Team Situation Awareness, technological possibilities and limitations, and a better understanding of various roles and their information needs.

Keywords

Full-scale exercises, collaborative evaluation, Team Situation Awareness, socio-technical network mapping

INTRODUCTION

Crises and unforeseen events are a part of reality. The frequency of these events can be related to contextual elements such as population density, climate change, and migration but also deliberate actions like terror and cyber-attacks (McCreight, 2023). A key feature is that these elements contain surprise (Deverell & Olsson, 2009). The wicked nature of a crisis challenges society to take relevant and adequate preparatory measures (Edzen, 2014; Owen et al., 2018), and handling crises demands various organizations to interact. Both defined emergency response organizations and organizations that do not usually handle crises must cooperate and form a new, temporary organization where cross-organizational collaboration is essential (Roud & Gausdal, 2019; Roud et al., 2021; Van Haperen, 2001). However, conducting exercises that prepare for collaboration in handling real events can be complex and challenging to achieve within the conditions that organizations typically operate under. There is an academic debate about the usefulness of full-scale exercises, which can be costly in terms of time and resources (Roud et al., 2021; Sørensen, 2017). Some have questioned the effectiveness of such exercises regarding individual learning outcomes (Berlin & Carlström, 2015; Borell & Eriksson, 2013). Previous studies also pinpoint the importance of differentiating between exercises focusing on individual skills and exercises focusing on collaboration and systems which prioritize the process to ensure effective collaboration (Roud et al., 2021). In the latter, elements such as information flow, communication channels, establishment of structures, and cross-organizational work beyond what one typically performs are central. A social-technical pattern within emergency management describes the integrated systems of human behavior and technology that impact the response. It acknowledges that effective emergency management encompasses not solely technical components like technology, infrastructure, and protocols, but also social aspects such as individual situation awareness (SA) and Team Situation Awareness (TSA) (Endsley, 1995; Endsley, 2020). TSA is SA distributed across organizations, involving shared awareness of protocols, goals, and situational information (Sorensen & Stanton, 2011). Understanding patterns is essential for designing and implementing effective emergency management strategies that address both the technical and social aspects of the response.

Collaboration between academia and practice is essential for addressing these issues, but Davenport (1998) argues that this can be challenging. Academic research findings can be diffuse, or their points are already known by practitioners (Davenport, 1998). Furthermore, academia can be seen as an actor that tends to problematize rather than come up with solutions related to real-life problems. This means the practice fields may be reluctant to involve academia in their projects. This perspective can also be valid in exercise planning and execution.

This research aims to address the issue of effective collaboration and effective evaluation of full-scale exercises, something that requires a shared understanding of the social-technical patterns including both organizational-specific and shared information needs. We draw from experiences participating in a full-scale exercise that simulated a collision between two vessels in the waters off the coast of Southern Norway. This incident required a coordinated response effort from various emergency response organizations, municipalities, and volunteers. To approach these challenges this paper attempts to answer the Research Question (RQ): *How can the co-creation of Socio-Technical Network maps aid collaboration and understanding between researchers and practitioners during emergency exercises?* We used a Socio-Technical Network (STN) approach to initiate the work to uncover communication patterns and barriers to TSA. We mapped communication pathways, information technology in use, and plans and procedures in detail from the moment of the collision until the various organizations had initiated their work phase, in collaboration with practitioners as a part of the data collection. We argue that this approach is fruitful and provides a common understanding of the situation, making the evaluation work effectively. The data collection was conducted through participatory observations and qualitative, in-depth interviews with relevant stakeholders.

Considering the importance of TSA elements and Shared Mental Models (SMM), we seek to identify factors that strengthen collaboration and those that weaken it. SMM is further explained in the Theories section.

Identified elements of improvement from evaluation of the exercise will be part of the next planned full-scale exercise in which the authors will participate (Figure 1). Thus, we have the opportunity to follow up results and further validate our methodical approach.

BACKGROUND

The field of exercise methodology encompasses a wide range of approaches, and extensive literature exists discussing the efficacy of exercises in relation to real crisis management (Berlin & Carlström, 2015; Roud & Gausdal, 2019; Roud et al., 2021; Roud & Schmied, 2020; Sørensen, 2017). A common denominator among methodological approaches is that exercises aim to prepare the various actors to face real crises (Borell & Eriksson, 2013; McCreight, 2023). In crisis management, there are typically four or five stages or phases including preparedness, response, recovery, and mitigation. Some models also include prevention as a distinct phase (Coppola, 2006; McCreight, 2023). Prevention means actively taking measures to prevent crises and undesired events from occurring. Exercises are part of organizations' preparations for crises and undesired events, where exercises and training are included along with their plans and guidelines on how organizations can best ensure the best possible outcome. In Norway, different organizations have a high level of autonomy, which influences the amount of time and resources they dedicate to preparing for hypothetical scenarios. This includes scenarios based on risk analysis of past events. For instance, municipalities have varying degrees of available resources and personnel with specific roles related to exercises and preparations for undesired events. In larger municipalities, there are dedicated personnel with full-time positions related to crisis management. In comparison, crisis management may comprise only a limited role in smaller municipalities associated with personnel with completely different daily tasks. Also, within the established emergency response organizations, such as fire departments, police, and ambulance services, there is a high degree of autonomy. In addition, it is challenging to conduct satisfactory evaluations of emergency management exercises, as it also requires personnel to step out of their daily tasks, which can be costly and must be prioritized by the individual organizations (Steen-Tveit, 2020). Overall, this can challenge the opportunities for large-scale training.

In evaluation reports after major events in Norway, it is repeatedly pointed out that organizations struggle to learn from real events and exercises (Henriksen, 2022). Information sharing, TSA, and role understanding are recurring challenges. Despite identifying problem areas, the different organizations do not absorb the lessons, and it does not lead to real changes in behavior (Borell & Eriksson, 2013; DSB, 2020; Halvorsen, 2021; Henriksen, 2022;

Sønderland, 2012). In such cases, individuals or organizations continue to follow the same approach without critically examining or adjusting their methods, missing the opportunity for deeper learning and improvement that the events and exercises could provide (Deverell & Olsson, 2009; Roud et al., 2021). In the context of exercises, it is challenging to facilitate information sharing across organizational boundaries (Roud & Schmied, 2020). The established emergency response organizations have plans that ensure early sharing of important information so that each actor can have as accurate an understanding as possible of what they are responding to as early as possible. In Norway these are called Triple alert procedures (Steen-Tveit & Munkvold, 2021).

The procedure is anchored at the national level and has a historical basis in the unfortunate handling of a terrorist incident in 2013 (DSB, 2014). In this incident, the police knew that they were responding to an active knife stabbing while other emergency responders responded to what they believed was a bus accident. Procedures aimed at ensuring early similar situational understanding only apply to the collaboration between the fire department, ambulance service, and the police, as well as The Norwegian Joint Rescue Coordination Centres (NJRCC) and in some cases, the road traffic control center. In Norway, a collaborative model is used, where there are expectations that crises are handled by all relevant organizations in cooperation. Even if responsibility is not explicitly documented in procedures, the organization that normally has responsibility for a subject area or a geographical area should, as far as possible, assume this responsibility also in a crisis. This means that a cooperative response operation often becomes much larger than the established emergency response organizations, requiring planning and training for a sometimes very large, interdisciplinary, and cross-sectoral new organization.

THEORETICAL PERSPECTIVES

Team Situation Awareness (TSA) and Distributed Situation Awareness (DSA)

Theories on Situation Awareness (SA) are frequently used in emergency management, exercises, and evaluations following real-life events (DSB, 2020; Halvorsen, 2021). Shared situational understanding is essential when multiple actors interact and collaborate, but it can be challenging to achieve. Although reports have identified a lack of situational understanding as a challenge, barriers to obtaining shared situational awareness persist. Sharing relevant information and understanding the workflow processes within collaborating organizations are particularly challenging.

Endsley's 1995 SA model sheds light on SA as an individual, cognitive phenomenon and as a part of teamwork (Endsley, 1995). The theories for TSA refer to factors that promote shared situational understanding in collaborative teams. Central to successful collaboration is the sharing of information and familiarity among team members and building and maintaining SMM (Endsley, 2020; Endsley & Robertson, 2000). Mental models relate to internalized knowledge stored as schemas in long-term memory at an individual level. SMM relate to mental models being a product of collaboration and familiarity with the actors one collaborates with (Salas et al., 2015; Salas et al., 2005). With SMM, each team member can more easily understand the actions, needs, and future actions of other team members (Salas et al., 2005; Stout et al., 2017). A high degree of TSA is achieved when the team knows each other's needs and supports each other by sharing information and considering other members when performing an action (Endsley, 2020).

Stanton et al. recognize Endsley's theories regarding both individual and Team SA but emphasize the interaction between humans and technology. According to DSA (Distributed Situation Awareness) theory, SA is not primarily a cognitive phenomenon but an emerging phenomenon resulting from the interaction between both human and non-human actors in collaboration (Salmon, 2016; Stanton et al., 2006; Stanton et al., 2018). DSA can be characterized by the collective understanding of a situation among individuals or teams operating in a distributed environment. It involves sharing relevant information and knowledge to establish a common awareness of the situation. This shared awareness facilitates effective team coordination and allows synchronized actions and resource allocation across distributed entities. In DSA theory, it is argued that SA exists at a systems level and can be viewed as an emergent feature of collaborative systems (Salmon et al., 2017).

There is an ongoing debate about whether Stanton et al.'s perspectives contribute a new theoretical perspective or if this is part of Endsley's described Distribution of Situational Awareness. In this paper, we choose to utilize perspectives from both theories and believe that they complement each other at a higher level (Endsley, 2015; Salmon et al., 2008).

SCENARIO DESCRIPTION

Large-scale exercises aimed at testing collaboration at the local system level are a recurring event in Norway, occurring annually and in multiple locations. In the exercise used in this article, a maritime incident was simulated. The scenario involved a collision between two medium-sized vessels in the archipelago area between two municipalities in southern Norway. One vessel had 71 persons on board, while the other had 31 persons, totaling 102 actors who played the roles of shipwreck victims. The exercise commenced at 09:18 AM when one of the vessels sent out a MAYDAY distress call, which was intercepted by the Coastal Radio. The message reported a collision, water ingress in one vessel causing it to list and risk sinking, and smoke and fire onboard the other vessel. The message was immediately relayed to the NJRCC, who initiated the notification of police, fire brigade, and healthcare services in the relevant municipalities. Notification of emergency responders geographically linked to the incident follows national Search and Rescue (SAR) standard operating procedures (SOP). These procedures have similar wording and layouts to ensure an early common situational understanding among emergency responders.

Local tactical teams were then notified to respond to the scene, and a common radio frequency was established for coordination. Different emergency response organizations have independent responsibilities to alert other necessary resources, as specified in written SOPs available to operators. For instance, the Emergency Medical Communication Center (EMCC) is responsible for alerting ambulances and doctors in municipal duty rosters and keeping nearby hospitals informed. The police are responsible for leading local operations and also for notifying municipalities, volunteer organizations, and others who may have responsibilities related to handling the incident.

In the early stages of the operation, it was decided that the vessels would prioritize going to two different ports in each municipality. The land-based aspect of the incident had to be coordinated as both the same and as two separate incidents. Two centers for evacuees and relatives were established, and there was a need for information from local actors, such as the press, at both locations. However, only one of the vessels made it to port. For the other vessel, it was simulated that it sank, and passengers came ashore on various islets and rocks.

Overall, the scenario ensured that a relevant selection of actors that one would normally expect in a real scenario was notified and had the opportunity to practice cooperation and communication. There was also relevant stress on the technical structures, including intensive use of the Norwegian Critical Communication Network (NCCN), which was pushed close to its maximum capacity.

The exercise concluded at 1:00 PM. Individual organizations sporadically evaluated it through Hot Wash sessions, but none took the initiative for a larger, cross-organizational evaluation. We, as researchers, distributed a Survey and gathered input from observers.

METHODOLOGY AND DATA COLLECTION

Prior to the exercise, as researchers, we were engaged by the exercise committee to work with them to develop clear exercise objectives that could be followed throughout the exercise and evaluated afterwards. Figure 1 shows how we were engaged throughout the exercise.

The exercise objectives were the result of a workshop held beforehand, as well as a tabletop exercise focusing on identifying whether each organization's plans and procedures aligned with those of the other collaborating organizations. The exercise objectives are shown in Table 1.

Table 1. Exercise objectives

Goal #	Description
Overall goal 1:	Conduct the exercise with unified contingency plans, wherein participating organizations collaborate towards common objectives and optimal resource utilization across agencies.
Overall goal 2:	Ensure that the rescue service always has the necessary information to create a team situational awareness.
Overall goal 3:	Ensure coordinated media and information services at all levels to provide correct information at the right time.
Overall goal 4:	Optimize resource utilization by leading, coordinating, and supporting rescue resources at strategic, operational, and tactical levels.

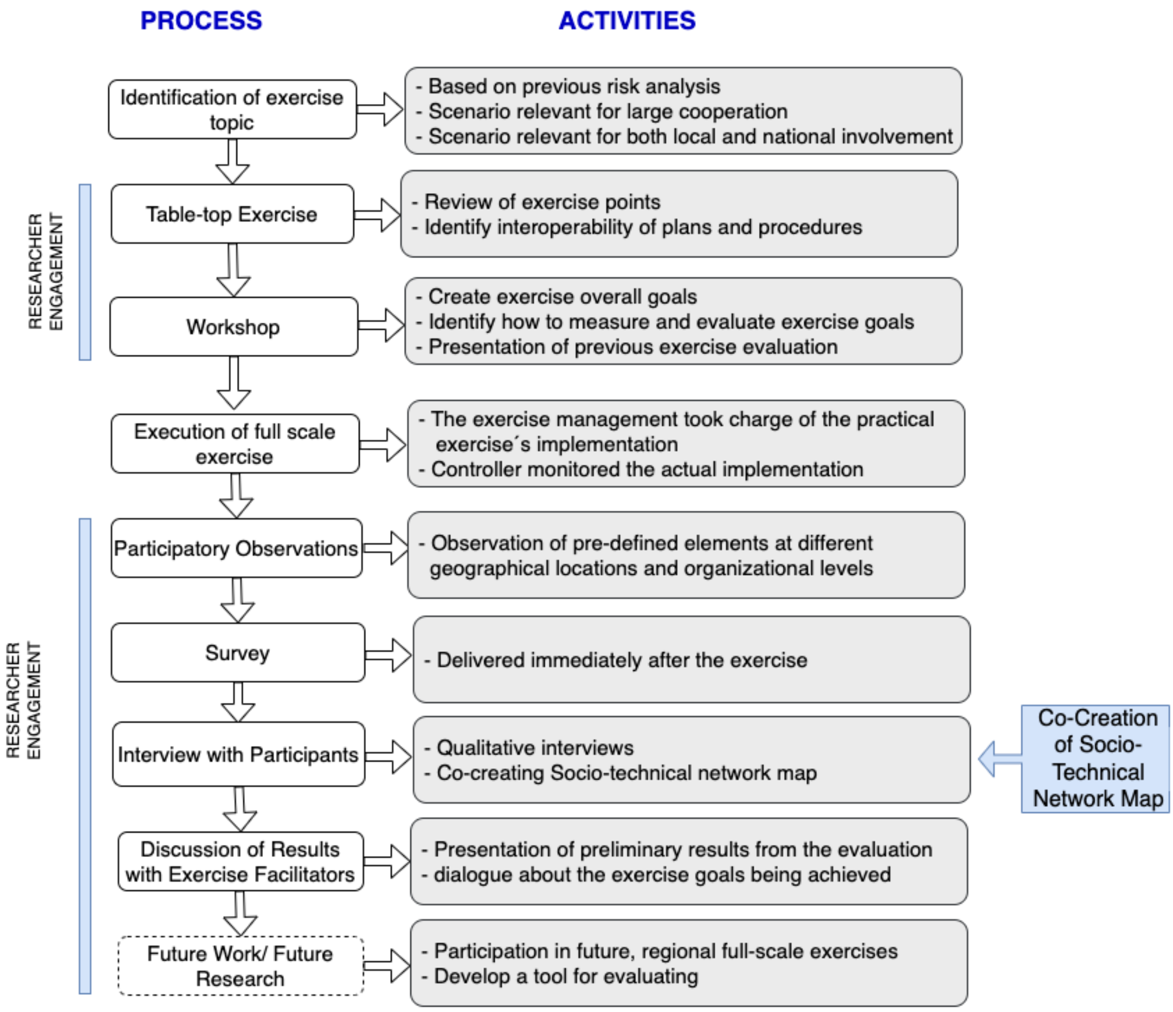

Figure 1. Researcher engagement in exercise

Data from the exercise was collected in four different ways: 1) A total of seven individuals, including three of the authors of this study observed the exercise at various geographical locations. At predefined times, observations related to the exercise objectives were recorded, using an observation guide to direct attention towards predefined elements and minimize observer bias; 2) Following the exercise, a survey was distributed to approximately 200 respondents, of whom 154 responded. The survey contained both closed and open-ended questions; 3) Selected findings from both observations and the survey are now being followed up with qualitative interviews. At the time of writing this article, a total of 13 interviews have been conducted. The interviews follow an interview guide aimed at clarifying respondents' role understanding, use of information systems, information sharing and communication, and experiences with evaluation and learning from exercises and real events. The length of each interview varies from 50 minutes to 150 minutes; 4) Before the interviews, we mapped the notification sequences, information systems in use, communication channels, and SOPs using MindManager[1]. This commercial mind-mapping software allows users to visualize information in mind maps and flowcharts. Together with the respondents, we enriched the initial mapping and co-created a network map that visualizes how information flows and how it is supported or not supported by adequate technical solutions and SOPs, thus supporting or creating barriers to TSA. Figure 2 shows the initial mapping of notification sequence, and Figure 3 shows initial notification with communications relations to VHF Maritime channels and the NCCN. Note that the original mapping is done in Norwegian. In this article, the figures demonstrate our methodical approach, but details have been removed for security and confidentiality reasons.

[1] https://www.mindmanager.com/en/

Socio-Technical Network (STN) Mapping

To approach an evaluation of whether the overall goals were achieved (Table 1), we, together with the respondents, have conducted an STN mapping as a part of our qualitative interviews (Figure 1). The mapping is delimited in time from the exercise's inception until the notification phase was over and the various organizations began the work phase. To gain an overview and to map information patterns and identify how information technology supported the human actors' SA, our mapping aims to identify both the human and the technical, or non-human, actors. Our approach is inspired by Salmon et al.'s (2017) approach to representing DSA, and also the Delphi method (Linstone & Turoff, 1975) where the "informed judgements" and expert opinions from practitioners are highly valued (Linstone & Turoff, 1975; Plotnick et al., 2011). The use of Social-technical network analysis in connection with emergency management is not uncommon. As an example, Houghton et al. (2006) seeks to elucidate and categorize archetypal networks in Command&Control networks. It suggests that social network analyses can be a valuable part of general studies of command and control. Mapping social networks along with other elements of an information system seems timely. In this article, we consciously call our approach a STN-mapping to clearly emphasize a connection between human and non-human actors, procedures, and communication pathways, and to clarify a distinction between Mapping and Analysis. Our mapping is a part of our analysis, but not an analysis on its own. In social networks, the relationship and/or flow of communication between human actors as individuals and groups and non-human actors such as computers and other data processing devices are plotted as connections between entities (Houghton et al., 2006).

Our STN mapping serves as a valuable tool in an interview situation. Collaboration between practitioners and researchers is essential, and input from practitioners can immediately be translated into a product recognizable to the practitioner and usable by the researcher to clarify what actually transpired. Thus, both parties have ownership of the end product. As a premise, only respondents in the interview were allowed to comment on the parts of the mapping they were involved in. Any objections or comments of others were noted and discussed with the relevant parties. The idea of the researcher being fully objective is an obsolete idea, at least from an interpretivist understanding of epistemology (Klein & Myers, 1999; Wynn Jr & Williams, 2012). An interview situation involving a researcher and a respondent represents an asymmetric power relationship, where the researcher holds a position where (s)he both leads the dialogue and interprets the information that emerges. Our method alleviates this asymmetry and the product we co-create functions as a boundary object (Star, 1989).

PRELIMINARY RESULTS AND DISCUSSION

In our analysis, we observe that the initial resource notification worked well in the very first sequence (Figure 2). In this part of the notification process, a SOP regularly drilled by established emergency response organizations was used. The SOP is well-known among all personnel and is rooted in national guidelines. However, as the complexity of the incident increased, the established emergency response organizations encountered increasing challenges in continuing resource notification. In cases where automated responses managed the notification, the process itself was unproblematic. However, when operators had to manually notify using, for example, call lists, there were failures in the notification process. For instance, the EMCC conducted macro alerts via the emergency network, where predefined NCCN macros alerted all healthcare resources considered relevant within the municipal boundaries in a cascading operation. This included hospitals closest to the incident site. Operators could verify that the alert had been sent and the call received without verbal confirmation over the communication system. However, organizations responsible for notifying volunteer organizations depended on operators physically calling each organization, providing relevant information, confirming receipt of the mission, and their deployment. In the exercise, we observed that this process did not function as intended. Some operators reported that they were overwhelmed with incoming calls, and that their organization's internal information needed in some cases forced personnel to prioritize this over following protocol. The STN network mapping clearly highlighted the causes of certain functions becoming bottlenecks in the flow of information. Here, we identified issues that challenged the overall exercise goals 1 and 2 (Table 1), such as organizations that were not present on the NCCN and, therefore, omitted from the information loop (Figure 3).

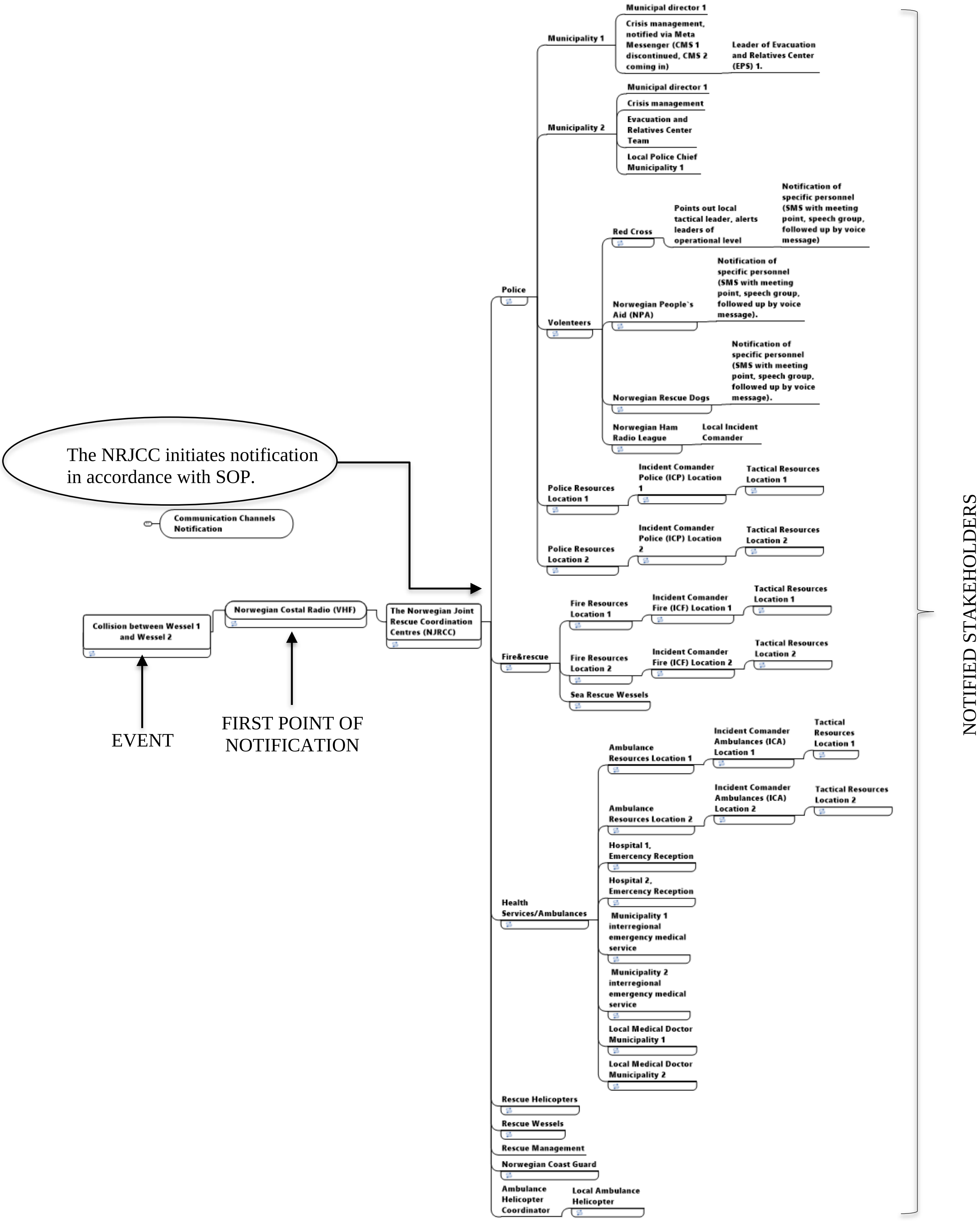

Figure 2. Socio-Technical Network (STN) Mapping of alerting phase without communications relations

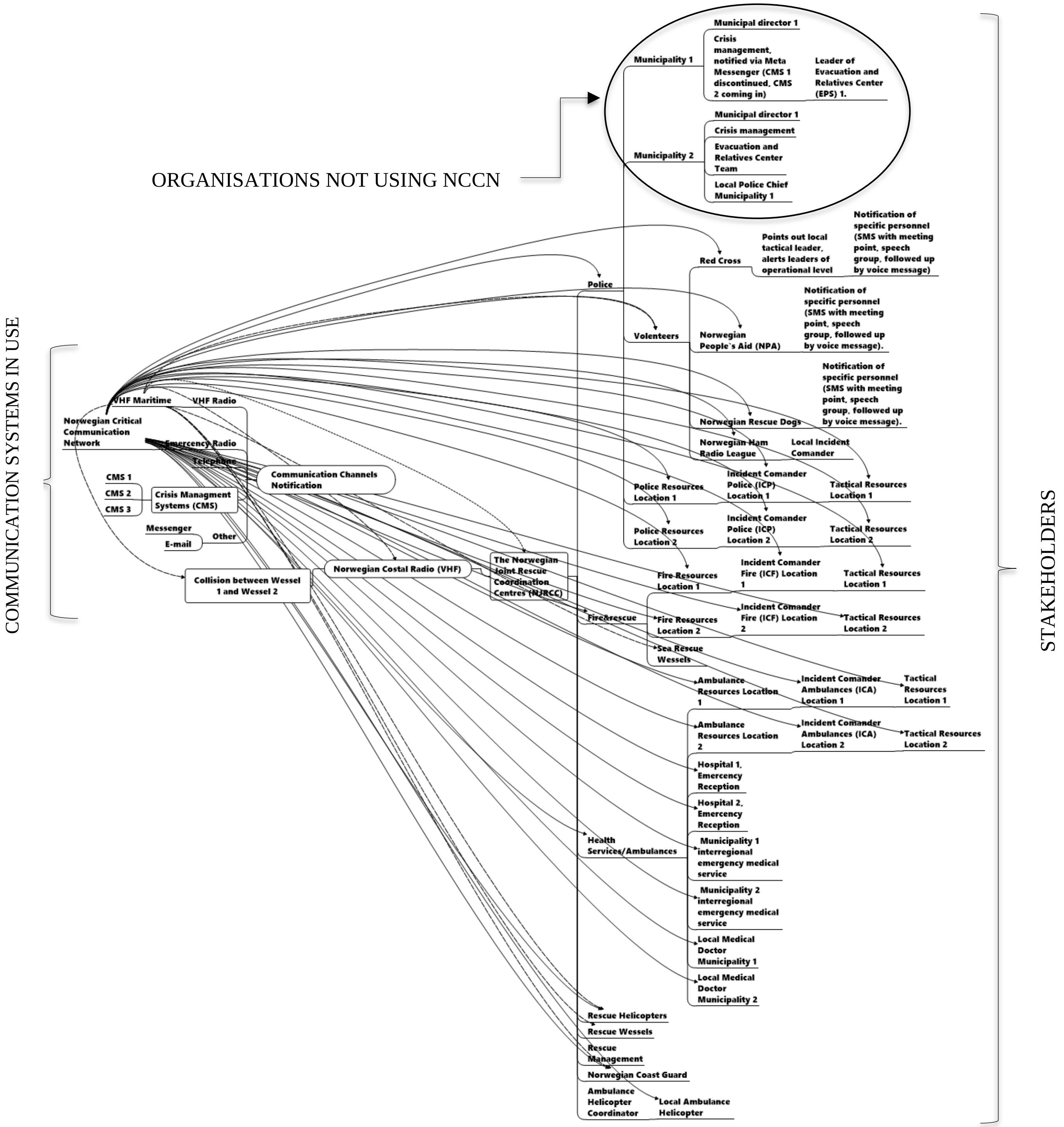

Figure 3. Socio-Technical Network (STN) Mapping with communications relations

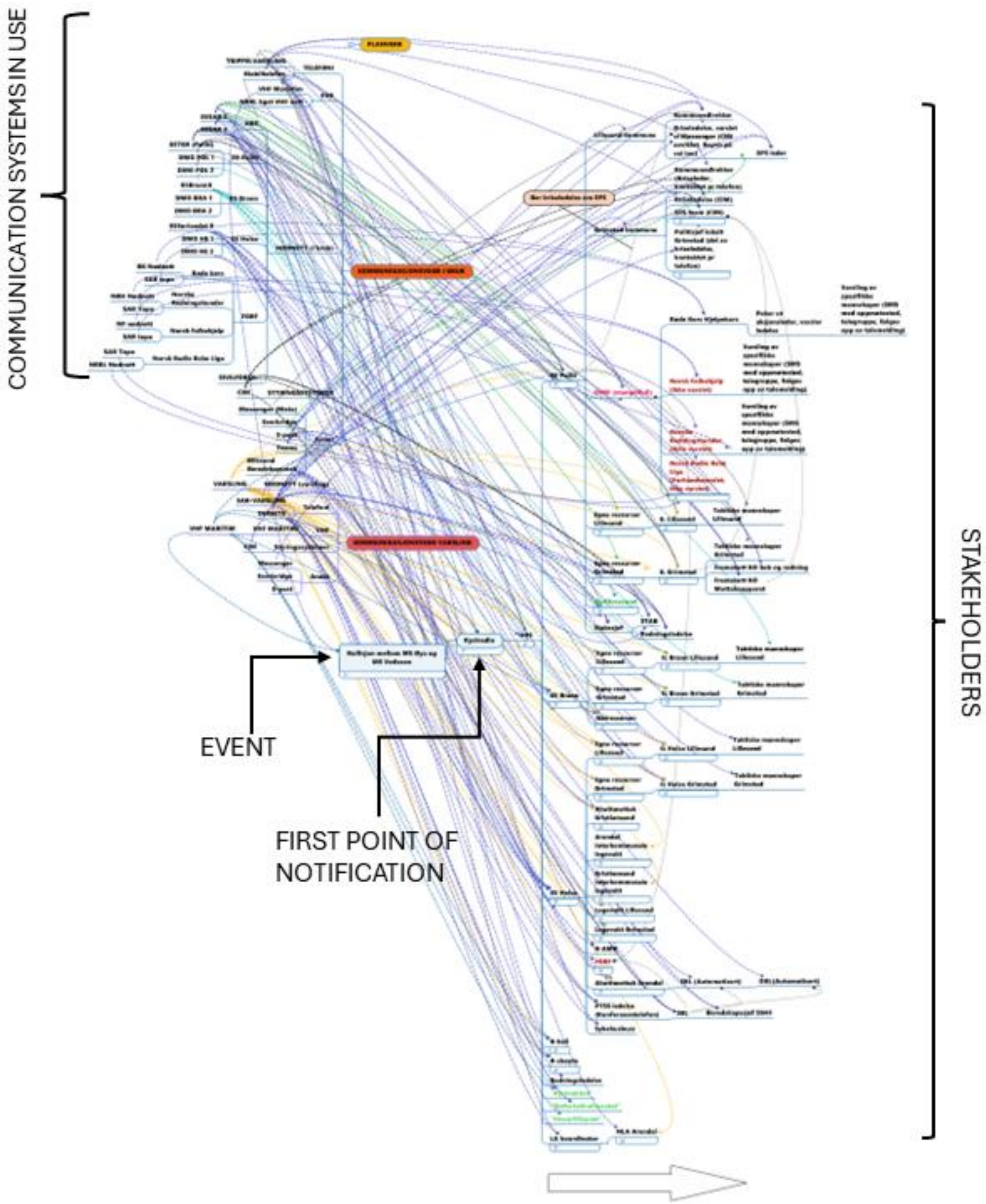

Figure 4. Socio-Technical Network (STN) Mapping full-blown from actual exercise

The mapping effectively illustrates the diversity of information systems operational during the exercise and to what extent they supported or hindered the achievement of a high level of TSA within the collaboration (Figure 4). In the initial alerting phase, eight different communication systems were in use, none of them overlapped. Consequently, interoperability posed a challenge, particularly affecting organizations unfamiliar with emergency network radios. This also challenged overall exercise goal 2 since it hampered the rescue service in getting necessary information to create TSA (Table 1).

An important function of the NCCN is the ability to set up different call groups or “digital rooms.” It is possible to set up several call groups, both agency-specific and cross-organizational, during one emergency operation (Tveit et al., 2022). We observed that the NCCN structure was challenged as the number of call groups increased as the exercise progressed. Initially, agencies were notified by phone, and tactical teams were alerted in their own agency-specific call groups. They were then moved to a common call group in the very first part of the response phase. When the first resources arrived at the scenes, there were six active call groups across multiple base stations. As the operational phase progressed, this number grew to twelve call groups, with only one base station.

Additionally, several tactical teams communicated directly using direct mode communication, (i.e., communication from terminal to terminal, bypassing a common base station which releases network capacity). This fragmentation of communication pathways and information channels meant no single common location where all involved actors could expect to receive important information relevant to the collaboration.

The mapping also revealed deficiencies in the procedures used by the actors, demonstrating how, in some cases, procedures had to be abandoned because they were not practically applicable in the real world. As such, the mapping serves to operationalize procedures further by identifying why they did not function satisfactorily. For example, the procedure supporting municipal employees in establishing centers for evacuees and relatives required registration of evacuees in two ways, both in an Excel spreadsheet and in a separate system. However, the separate system had usability issues, such as the end-user receiving no information or confirmation that entered personal data was sent and received by the appropriate party. Additionally, evacuees could enter their information into this system by scanning an available QR code. This led to people being double-registered or not registered at all, without those on the front lines having oversight. The solution was to abandon the entire system and enter patient data into an Excel spreadsheet, which was then emailed to the central police. Another example was that, at one point, there were challenges associated with disseminating information from the centers for evacuees and relatives to other relevant stakeholders. Initially, there were no apparent reasons for this beyond the high workload of the centre's personnel. As completing the STN-map progressed, the issue became visually and explicitly apparent, leading to further exploration and contact with the center's leader. In dialogue with them, it emerged that they were receiving conflicting instructions about where they should be located, and at one point, the leader was ordered by the on-site police to relocate to the reception site where the involved vessel was arriving. With that, the contact point other organizations utilized to reach the center also disappeared, compromising the flow of information.

The collaboration process with practitioners to develop a STN map provides a thorough and objective illumination of potential barriers to Team Situational Awareness. In the co-creation process, we highlighted the complexity that extensive collaboration entails, including diverse roles, inter-organizational work across sectors, and various communication technologies with varying degrees of interoperability. The mapping also identified organizations that fell outside the majority, thus risking missing crucial information and consequently having a lower level of TSA.

We have presented our findings, illuminated through the mapping, to exercise leaders and leaders from the involved organizations. The feedback has been positive, and there is a plan for greater involvement in the next exercise to be implemented.

Both data collection and analysis processes in this type of study are demanding. As two researchers have a practitioner background, we quickly gained access to organizations where insight is typically hard to obtain. An example is that two of the researchers have a national personal security clearance that includes exposure to classified and sensitive information. This placed us in a dual role where, on the one hand, we gained rapid access to unrestricted information, while on the other hand, we individually and personally had to take responsibility for not exposing data that should not be disclosed. The solution to this is to collaborate closely with leaders from the various organizations, ensuring redundancy in the control of the information exposed for scientific purposes.

CONCLUSION AND FUTURE WORK

If academia is to be involved in such exercises as we describe, we find it highly beneficial to have early involvement. By being able to shape the wording of the exercise objectives and anchor them in the real problems experienced by the collaboration, we found that the entire process of ensuring that the various actors were involved in the exercise with the same focus, as well as the evaluation work, became much easier. We see the value of having a presence in the field of practice and approaching experts from various disciplines with a certain humility. The interaction between academia and practice can be highly fruitful and valuable. Still, it can easily be compromised if there are questions about ulterior motives or if trust between researchers and practitioners is undermined. Using a simple STN mapping, as demonstrated in this article, provides an element of objectivity. The map serves as a boundary object between practitioners with experience from exercises and real events, and us as researchers. The collaboration in recreating what actually happened, how it happened, and what support each actor received from other actors, technology, or predefined procedures allows for a good and candid dialogue between practice and academia, which we argue is valuable. The network mapping effectively visualized the complexity of some of the roles that needed to be fulfilled (Figure 4). In some cases, this visualization led to a demystification of acknowledging mistakes. Some actors were surprised to see how they were part of such a large interaction with other actors and technology. The findings can be used to refine the use of technology, with the understanding that TSA is necessary for the cooperation to achieve its goals when working together in a collaborative, large, fragmented, and temporary organization. We expect that a visualization similar to the one we have conducted will strengthen and develop the SMM of the involved actors. Preliminary feedback suggests that the co-creation of the STN map and early researcher involvement have already contributed to a greater understanding of participants’ roles, the information needs of collaborating organizations, and technological possibilities and limitations.

In our future research we will further develop and test a tool for evaluating post-exercise measures. We will also seek to identify Information Trading Zones (ITZ) within the various communication structures, and thus further validate a preliminary framework introduced in (Rustenberg et al., 2024). ITZ in the context of Emergency Management can be defined as a space where various actors “trade” their ideas about the relevance of available crisis information (Boersma et al., 2014; Boersma et al., 2012). Central to this is identifying barriers to the involved stakeholders' and organizations' ability to develop and maintain TSA. The STN mapping described in this paper will be further developed to visualize how the information trading during the exercise actually occurred and the limitations and potential of the Information Systems in use.

REFERENCES

Berlin, J. M., & Carlström, E. D. (2015). Learning and Usefulness of Collaboration Exercises: A Study of The Three Level Collaboration (3LC) Exercises Between The Police, Ambulance, and Rescue Services. *International Journal of Mass Emergencies & Disasters*, *33*(3).

Boersma, F., Comfort, L., Groenendaal, J., & Wolbers, J. (2014). Incident command systems: A dynamic tension among goals, rules and practice. *Journal of Contingencies and Crisis Management*, *22*(1), 1-4.

Boersma, K., Wagenaar, P., & Wolbers, J. (2012). Negotiating the'Trading Zone'. Creating a Shared Information Infrastructure in the Dutch Public Safety Sector. *Journal of Homeland Security and Emergency Management*, *9*(2).

Borell, J., & Eriksson, K. (2013). Learning effectiveness of discussion-based crisis management exercises. *International Journal of Disaster Risk Reduction*, *5*, 28-37.

Coppola, D. (2006). *Introduction to international disaster management*. Elsevier.

Davenport, T. H. (1998). Putting the enterprise into the enterprise system. *Harvard business review*, *76*(4).

Deverell, E., & Olsson, E.-K. (2009). Learning from crisis: A framework of management, learning and implementation in response to crises. *Journal of Homeland Security and Emergency Management*, *6*(1).

DSB. (2014). The Valdress Express: Evaluation of the authorities' handling of the November 2013 incident. The Norwegian Directorate for Civil Protection.

DSB. (2020). *Evaluation of The Viking Sky incident*. The Norwegian Directorate for Civil Protection. https://www.dsb.no/globalassets/dokumenter/rapporter/evaluering_av_viking_sky_hendelsen.pdf

Edzen, S. (2014). Table-top exercises for emergency management: tame solutions for wicked problems. 2014 47th Hawaii International Conference on System Sciences,

Endsley, M. R. (1995). Toward a theory of situational awareness in dynamic systems. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *37*(1), 32-64. https://doi.org/10.1518/001872095779049543

Endsley, M. R. (2015). Situational Awareness misconceptions and misunderstandings. *Journal of Cognitive Engineering and Decision Making*, *9*(1), 4-32.

Endsley, M. R. (2020). Situation Awareness in Teams: Models and Measures. In *Contemporary Research* (pp. 1-27). CRC Press.

Endsley, M. R., & Robertson, M. M. (2000). Situation awareness in aircraft maintenance teams. *International Journal of Industrial Ergonomics*, *26*(2), 301-325.

Halvorsen, J. (2021). *EVALUATION: The rescue operation and the acute handeling of the crisis during the quick clay landslide at Gjerdrum*.

Henriksen, S. V. B., Torgeir; Hoel, Linda; Kruke, Bjørn Ivar; Myhrer, Tor-Geir; . (2022). *Evaluation of PST's and the police's handling in connection with the Kongsberg incident on 13th October 2021*.

Houghton, R. J., Baber, C., McMaster, R., Stanton, N. A., Salmon, P., Stewart, R., & Walker, G. (2006). Command and control in emergency services operations: a social network analysis. *Ergonomics*, *49*(12-13), 1204-1225.

Klein, H. K., & Myers, M. D. (1999). A set of principles for conducting and evaluating interpretive field studies in information systems. *MIS quarterly*, 67-93.

Linstone, H. A., & Turoff, M. (1975). *The delphi method*. Addison-Wesley Reading, MA.

McCreight, R. (2023). *An introduction to emergency exercise design and evaluation*. Rowman & Littlefield.

Owen, C., Brooks, B., Curnin, S., & Bearman, C. (2018). Enhancing learning in emergency services organisational work. *Australian Journal of Public Administration*, *77*(4), 715-728.

Plotnick, L., Turoff, M., & White, C. (2011). Partially distributed emergency teams: considerations of decision support for virtual communities of practice. *Supporting Real Time Decision-Making: The Role of Context in Decision Support on the Move*, 203-220.

Roud, E., & Gausdal, A. H. (2019). Trust and emergency management: Experiences from the Arctic Sea region. *Journal of Trust Research*, *9*(2), 203-225.

Roud, E., Gausdal, A. H., Asgary, A., & Carlström, E. (2021). Outcome of collaborative emergency exercises: Differences between full-scale and tabletop exercises. *Journal of Contingencies and Crisis*

Management, *29*(2), 170-184.

Roud, E., & Schmied, J. (2020). Emergency Collaboration Exercises and Learning: Experiences from the Arctic. In *Crisis and Emergency Management in the Arctic* (pp. 180-211). Routledge.

Rustenberg, K., Radianti, J., & Gjøsæter, T. (2024). Adopting a Trading Zone Framework to Emergency Management. In Proceedings of the 57th Hawaii International Conference on System Sciences. HICSS.

Salas, E., Shuffler, M. L., Thayer, A. L., Bedwell, W. L., & Lazzara, E. H. (2015). Understanding and improving teamwork in organizations: A scientifically based practical guide. *Human resource management*, *54*(4), 599-622.

Salas, E., Sims, D. E., & Burke, C. S. (2005). Is there a "big five" in teamwork? *Small group research*, *36*(5), 555-599.

Salmon, P. M. (2016). *Distributed situational awareness : theory, measurement and application to teamwork*. Routledge.

Salmon, P. M., Stanton, N. A., & Jenkins, D. P. (2017). Distributed situation awareness: Theory, measurement and application to teamwork. CRC Press

Salmon, P. M., Stanton, N. A., Walker, G. H., Baber, C., Jenkins, D. P., McMaster, R., & Young, M. S. (2008). What really is going on? Review of situation awareness models for individuals and teams. *Theoretical Issues in Ergonomics Science*, *9*(4), 297-323.

Sønderland, O. D., Bjørn Kåre; Eriksen, Egil; Frøyland, Espen; Krogstad, Terje; Paulsen, Øystein Stavdal;. (2012). *22 July 2011: Evaluation of the police's efforts*.

Sørensen, J. L. (2017). *Norwegian maritime crisis collaboration exercises: are they useful?* Northcentral University.

Sorensen, L. J., & Stanton, N. A. (2011). Is SA shared or distributed in team work? An exploratory study in an intelligence analysis task [Article]. *International Journal of Industrial Ergonomics*, *41*(6), 677-687. https://doi.org/10.1016/j.ergon.2011.08.001

Stanton, N. A., Stewart, R., Harris, D., Houghton, R. J., Baber, C., McMaster, R., Salmon, P., Hoyle, G., Walker, G., & Young, M. S. (2006). Distributed situational awareness in dynamic systems: theoretical development and application of an ergonomics methodology. *Ergonomics*, *49*(12-13), 1288-1311.

Stanton, N. A. D., Salmon, P. D., & Walker, G. H. D. (2018). *Systems thinking in practice: applications of the event analysis of systemic teamwork method*. CRC Press.

Star, S. L. (1989). The structure of ill-structured solutions: Boundary objects and heterogeneous distributed problem solving. In *Distributed artificial intelligence* (pp. 37-54). Elsevier.

Steen-Tveit, K. (2020). Identifying information requirements for improving the common operational picture in multi-agency operations. Proceedings of the 17th ISCRAM Conference,

Steen-Tveit, K., & Munkvold, B. E. (2021). From common operational picture to common situational understanding: An analysis based on practitioner perspectives. *Safety science*, *142*, 105381.

Stout, R. J., Cannon-Bowers, J. A., & Salas, E. (2017). The role of shared mental models in developing team situational awareness: Implications for training. In *Situational awareness* (pp. 287-318). Routledge.

Tveit, K. S., Munkvold, B. E., & Radianti, J. (2022). Using live video for communication between lay bystanders and emergency dispatchers in command and control centres. *International Journal of Emergency Management*, *17*(2), 154-176. https://doi.org/10.1504/IJEM.2021.122930

Van Haperen, K. (2001). The value of simulation exercises for emergency management in the United Kingdom. *Risk Management*, *3*, 35-50.

Wynn Jr, D., & Williams, C. K. (2012). Principles for conducting critical realist case study research in information systems. *MIS quarterly*, 787-810.