

Sharing Incident and Threat Information for Common Situational Understanding

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ABSTRACT

This paper presents the INSITU research project initiated to provide a systematic approach for effective sharing, integration and use of information from different sources, to establish a common operational picture (COP) and shared situational understanding among multiple actors in emergency response. The solution developed will provide an interactive map display, integrating harmonisation of terminology and collaboration support for information sharing and synthesis. The enhanced COP will also support evaluation and learning from exercises and incidents. The project involves close collaboration with emergency management stakeholders in Norway, for requirements analysis, participatory design, and validation of project deliverables. The research will improve information sharing and decision support in emergency operations centres, which will contribute to improve societal resilience through more effective response capability.

Keywords

Common operational picture, situational awareness, collaboration support, geographic information systems, terminology harmonisation.

INTRODUCTION

A recurring challenge in emergency response is to quickly be able to collect and integrate relevant information to form an initial shared understanding of a crisis situation, and to dynamically update a common situational picture of the evolving incident (Laakso and Palomäki, 2013). The core of this challenge is to be aware of the information needs of the collaborating partners, effectively share relevant and timely information to the right receivers, and similarly - to know what information is available to be requested (Petrenj et al., 2012). Evaluations from several incidents and large-scale exercises document challenges of ineffective information sharing between involved responders and lack of a common operational picture (COP) (e.g., Bunker et al., 2015; Steigenberger, 2016; Wolbers and Boersma, 2013).

While an increasing amount of digital information sources are available, the information landscape remains fragmented with lack of interfaces among the different sources and a varying data quality. Digital map services provide a key resource for developing a COP. However, the lack of standardisation of tools and symbols in use for crisis maps limits the possibility for integrated use for sharing incident and threat information across collaborating entities (JRCC, 2018). Further, as highlighted by the Norwegian Ministry of Justice and Public Defense (Stm. 10, 2016-2017), different terminology in use by the different responders for depicting the same concepts and events also represents a challenge for information sharing and shared situational understanding. Finally, there is currently limited support for visualising and sharing a COP as a basis for systematic learning from incidents and exercises.

On this basis, we have initiated a research project titled “Sharing Incident and Threat Information for Common Situational Understanding” (INSITU), funded by the Research Council of Norway. The goal of this project is to contribute to effective sharing, integration and use of available information from different sources, to establish a COP as a basis for shared situational understanding. Reaching this goal requires systematic analysis of current practices and needs for information sharing, developing suggested standards for map symbols and a common map-based interface, supporting harmonisation of crisis terminology, and developing methods and tool support for collaborative information synthesis. These research challenges are currently being addressed by an interdisciplinary team of experts in emergency management, information systems, geographic information science and systems (GIS), terminology harmonisation, and computer science. The project is led by the Centre for Integrated Emergency Management (CIEM) at University of Agder, Norway. Other academic partners are the Norwegian University of Science and Technology (NTNU), Department of Geography, the Center for Advanced Research in Emergency Response (CARER) at Linköping University, Sweden, and the Interoperability in Extreme Events Research Group, The University of Sydney Business School. The project consortium also includes two companies: Tingtun AS is a developer of methodology and software for terminology harmonisation, and One Voice AS is supplier of the leading crisis management system (CIM) in Norway. End user involvement is secured through the participation of the emergency preparedness office of the County Governor in Agder as a partner in the project, and there is a broad representation of core emergency management stakeholders in the project reference group.

To address the above-mentioned challenges, a core focus of this project is to strengthen the collaborative process in establishing a COP and shared situational understanding. This will include contributing to harmonisation and standardisation of crisis-related terminology and map support, and procedures for effective collection and sharing of relevant information. The INSITU project seeks to answer the following research questions:

- Which information elements are critical to share in scenarios involving collaboration between several emergency responders, and how and in what formats can this information be accessed?
- What are the perceived needs for harmonisation of terminology in use between the different responders, and how can such harmonisation be supported?
- How can geographic resources and interactive map-based interfaces be used more effectively to support collaboration and shared situational understanding, e.g. through standardisation of map symbols and functionality?
- Which method and tool support is required for effective synthesis and presentation of information from different sources, as a basis for common situational understanding and for evaluation and learning from incidents?

RELATED RESEARCH AND PRACTICE

While former research has provided important contributions in the form of concepts, architectures and tools for supporting situational awareness and COP (e.g., Cordeiro et al., 2015; Luukkala et al., 2017; Stiso et al., 2013; van Dijk, 2015), experience from practice shows that developing a shared situational understanding remains challenging. For example, the Norwegian National Forum for Exercises and Evaluation in 2018 hosted a seminar with Norwegian emergency responders for discussing current challenges in establishing a COP and shared situational understanding. Among the barriers discussed here were inefficient information sharing due to lack of knowledge on the information needs of the different response organisations, and problems with interoperability of existing support technologies being used by the different responders. The responders agreed that rather than aiming for developing a joint, national COP supporting different scenarios, what is needed is an information infrastructure supporting COPs for specific scenarios that can be adapted to the context of the local emergency responders.

Bunker et al. (2015) discuss how existing solutions for supporting a COP are not able to represent “the range of perspectives, options, facets and changes that often challenge responders” (p. 52). Further, there is currently no

universally agreed upon definition of a COP. The International Forum to Advance First Responder Innovation (IFAFRI, 2018) also lists as one of four capability gaps the first responders' ability to collect data from traditional (e.g., weather maps, sensor readings) and nontraditional (e.g., social media) information sources and integrate this data into a user-configurable COP.

As an illustration of the problem, according to the rescue services personnel working at command and control level during the extensive forest fires in Sweden in summer 2018 a major challenge inhibiting fast decision-making and response was the lack of digital maps and other digital tools, e.g. for information sharing and weather forecasts. Thus, the Swedish rescue services had to rely on whiteboards with information and forecasts that quickly became outdated.

The INSITU project focuses on three core elements in supporting a common situational understanding: 1) integrated map services; 2) harmonisation of terminology; and 3) collaboration support for information sharing. A brief status on knowledge in these three areas is presented here.

Integrated Map Services

As documented in the recently published Handbook for the Norwegian Rescue Services (JRCC, 2018), no common norm exists for map support among the different first responders and public emergency stakeholders. A range of different "platforms" for map services is currently in use (e.g., ArcGIS, Avinet, Basecamp, GIS-link, Locus TransMed, Locus TransFire, Terra and Vision). However, interviews with emergency responders show that none of these services are considered to fully cover their needs. Furthermore, the use of symbols and colours is not fully standardised, and good drawing functionality is not fully incorporated. There are also local variations in the services utilised within each sector. This limits the possibilities for effective information sharing based on a common map interface, and points to a need for more standardisation of map support that also allows for integrating data from different sources (JRCC, 2018).

While formalised map symbol standards for emergency contexts do exist, these have not been widely adopted by map providers (Robinson et al., 2013). A main goal for map displays is to design effective representations of spatial information using cartographic symbols. Ideally, all users should understand the symbols correctly, quickly, and identically, but this is not always the case. Further problems arise when map users are unable to spend time referring to a legend during the map reading process because the map is used in an emergency situation where response time is critical (Akella, 2009).

A change is needed to encourage the standardisation of symbols for emergency response, and future maps for emergency management must be better adapted to individual user groups. As agencies are obligated to collaborate in their operational practice and emergency scenarios during crisis incidents such as industrial hazards or flooding, an extensive understanding of common scenarios is required to equip a COP map display with adequate and efficient interactive functions. The functions, on the one hand, must efficiently support expert users in their operational tasks, and, on the other hand, cannot make users confused with their multiplicity and complexity. Thus, our research will focus on map usability in both map content and visual controls to make map use more intuitive.

Harmonisation of Crisis Management Terminology

The need for harmonisation of terminology among crisis responders has been recently highlighted (JRCC, 2018). As an example of this challenge, there are at least four different Norwegian terms for an incident site ("åsted", "fareområde", "skadested", "tiltaksområde"). In addition, we have sectorial abbreviations for locations related to an incident site.

This problem is not specific for Norway. Snaprud et al. (2016) have explored the availability of crisis vocabularies in several countries and found that if such resources exist they are generally scattered on different websites, represented in different formats and forms, and not harmonised across sectors.

Examples of resources on process and methodology for terminology harmonisation that we might build on in the INSITU project include: Terminology work - Harmonisation of concepts and terms (ISO 860:2007) and ISO 22300:2018 Security and Resilience – Vocabulary.

Collaboration Support for Shared Situational Understanding

Challenges of effectively sharing information across organisational boundaries for managing emergency situations have been documented in several studies (e.g., Laakso and Palomäki, 2013; Ley et al., 2014). An ethnographic study of disaster exercises in the Netherlands (Wolbers and Boersma, 2013) documents how the coordination process was distorted by the emergent management professionals attributing different meanings to

information. They thus conclude that “information management during emergency response operations is about interpreting information and negotiating its relevance for different professions” (p. 195). Barriers to effective cross-agency communication and information sharing have also been reported in disaster healthcare (Abbas et al., 2018). The related efforts of specifying minimum data sets of essential data elements to be exchanged among the agencies are clearly relevant for our project.

Existing procedures for situational reports provided by the Norwegian Directorate for Civil Protection specify the communication structures and actors involved. However, they do not provide detailed guidelines concerning what specific information elements to share, where to find them, and how to best synthesise and present this information. Research in the area of collaboration engineering focuses on how to develop detailed, easy to use ‘scripts’ for effectively conducting collaborative processes without a trained facilitator (de Vreede et al., 2009). These collaboration scripts also specify the use of relevant digital tools, and provide support for inter-disciplinary teams in effectively processing and making sense of available information (Lazareva and Munkvold, 2017). In the domain of emergency response, the use of collaboration scripts has been demonstrated to support situational awareness (Appelman and van Driel, 2005).

Finally, there is currently also a lack of shared resources for supporting systematic learning from exercises. Being able to use a COP and an integrated map-based interface also in the evaluation phase, would represent a major improvement in practice.

RESEARCH APPROACH

As depicted in Figure 1, the INSITU project will apply a combination of research methods for addressing the three focal areas in the project as presented in the previous section.

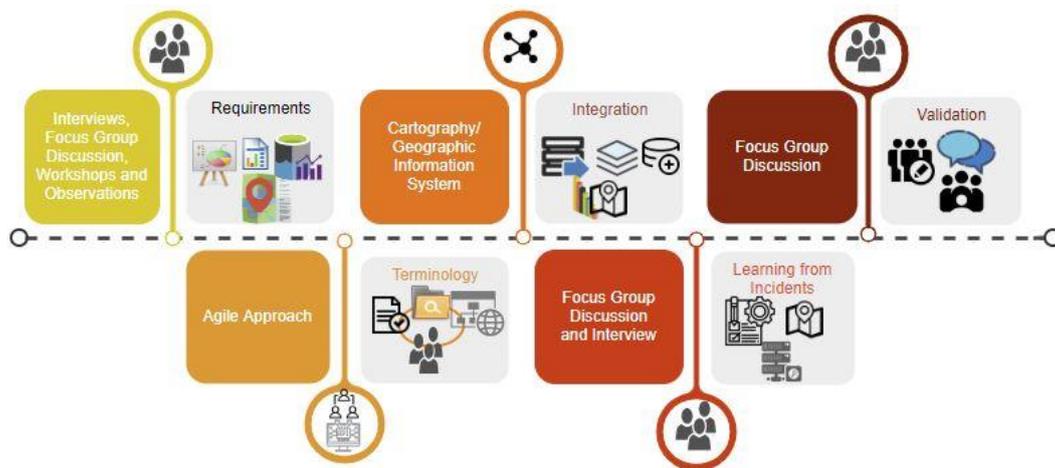


Figure 1. Combined Research Approach

The initial *requirements gathering* will be conducted through focus group discussion (FGD), literature review, document analysis, workshops for requirements elicitation and prioritisation, and observation of emergency exercises. This task will focus on identifying the critical information elements needed to be shared between the involved stakeholders, what information sources are currently being used, and the format of the relevant information. This analysis will explore different types of threats and incidents, as caused by both natural and man-made hazards. The analysis will also consider additional information sources that are not already used, such as sensor data and social media data. Processing such data will then require use of methods for real-time detection, filtering and classification, based on natural language processing, machine learning and visual analytics (Reuter et al., 2018). This task will also scrutinize possible security concerns involved in sharing information between different responders. This will form the basis for design recommendations for a harmonised terminology and standard map symbols and the integration of these in a common map interface. An agile approach will be used, working together with end users in a participatory design process (Sanders et al., 2010), and collecting their feedback throughout the development process.

The methodology for *harmonisation of terminology* will combine a participatory process with a quantifiable justification process as a basis for selecting terms to be included in a common vocabulary. The idea is to compute a justification score for each term as input to the harmonisation discussions. The justifications will include references to external definitions of a concept in a law, regulation, standard, guideline or other prominent

references. The sources of references and possible weights for them will be tested and agreed with the users in the participatory design process. The harmonisation will address both the form and the content of the terminologies. The form will cover how to represent the terminology from the metadata describing it, the terms and their properties including attributes and classifications.

Concerning *integration*, the aim is to integrate various interactive displays into one, consistent map-based interface facilitating shared situational understanding in the different phases of an incident. The resulting interactive tool support will provide users with a map display featuring switchable thematic layers showing standardised cartographic symbols representing critical information elements. The symbols will be retrieved from a shared data repository that is to be designed as a project deliverable. Of critical importance in this task is to avoid sharing irrelevant information that may lead to information overload. Literally, a map-based interface cannot be visually cluttered by a multiplicity of point, line, and area symbols, and at the same time it cannot be overloaded by too many interactive functions. Therefore, the interactive tool support will be developed through a sequence of proof of concept implementations accompanied by rapid prototype assessments with target users, in order to test combinations of various map symbols with particular interactive functions.

Complementing the integrated map support for COPs, the project will develop collaborative scripts detailing information management procedures for collecting, sharing and synthesising information from different sources. These collaborative scripts will specify required information elements, the sources for these elements and how to access them, the procedure for sharing information with other stakeholders (including formats and tools), and how to effectively combine the information elements to support situational understanding. The collaborative scripts will be presented through an interactive, easy-to-use, web interface.

For developing enhanced support for systematic *learning from incidents*, a combination of focus group discussions, review of incident report studies, and After Action Reviews will be conducted. This task will address the need for common information sources supporting systematic learning from exercises and incidents. The integrated terminology, map and collaboration support will be adapted for this purpose. In addition, the possibility of adding functionality for recording and playing back event handling in the common map-based interface will be analysed.

The process for *validation* of project deliverables will be conducted iteratively throughout the project, using process walk-throughs for all project outcomes in workshops, questionnaires, field trials in relevant exercises, and validation in a simulated, realistic environment provided by one of the project partners in the form of an experimental control room facility for crisis management training and tool testing.

PRACTITIONER INVOLVEMENT

As outlined in the previous section, the participatory design process applied in the INSITU project requires close interaction with emergency management practitioners from the initial requirements elicitation to the validation of project deliverables. This involves authorities and associations both at the national and regional level.

Examples of organizations that so far have confirmed their participation in the project reference group include:

- Norwegian Directorate for Civil Protection
- Norwegian Police Directorate
- Norwegian Communications Authority
- Norwegian Radiation and Nuclear Safety Authority
- Norwegian Water Resources and Energy Directorate
- Norwegian Mapping Authority
- Norwegian Public Roads Administration
- Norwegian Defence University College
- Norwegian Fire Protection Association
- Norwegian Fire Academy
- Norwegian Council for Search and Rescue
- The Joint Rescue Coordination Centre, Southern Norway
- Barentswatch (Centre for the Sharing of Sea and Coastal Information)
- The Society of Voluntary Search and Rescue Organisations
- The Language Council of Norway

This broad representation is required for being able to develop useful support for information sharing and collaboration that caters for the needs of the organisations involved. Also, the list demonstrates the shared view on the importance of the research questions addressed in the INSITU project, and provides a good basis for the uptake of the project deliverables among the practitioners.

CONCLUSION

The research presented in this paper will contribute to strengthen the overall resilience of society by providing methods and tool support for developing common situational understanding among different emergency management sectors and units. The INSITU project will develop knowledge that addresses critical shortcomings in today's practice, regarding harmonisation of terminologies in use and interoperability and standardisation of map resources. By this, the project will contribute to improved preparedness, response and learning from experience. Through broad involvement of key crisis management stakeholders in Norway, the project will facilitate knowledge development on practices in the different sectors and increased understanding of the information needs for the tasks and roles involved. The software tools developed and adapted in the project will provide easy access to a harmonised terminology and common map support, for being included in COPs, training material and procedures for inter-sectoral communication and collaboration.

The INSITU project is based on an interdisciplinary perspective, building on knowledge from multiple, related research areas including situational awareness and COP, collaboration engineering, terminology management, GIS and crisis mapping, and human-information interaction. The project will also contribute new knowledge in these domains, through combining harmonised terminology, standardised map support and collaboration scripts for information sharing and synthesis, in an integrated solution for enhanced situational understanding.

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