Sharing Incident and Threat Information for Common Situational Understanding (INSITU)

Project report: Requirements specification

SAMRISK project 295848

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Preface

The SAMRISK project “Sharing incident and threat information for common situational understanding“ (INSITU) started in May 2019. This report summarizes the initial data collection and analysis in the project, focusing on current practice and technology use for sharing information in inter-agency operations. In particular, the project focuses on common terminology and exchange of geospatial information for establishing a common operational picture and common situational understanding. Based on the needs expressed by emergency management stakeholders, review of related research, and areas of improvement defined from our analysis, we present a set of requirements for further work. A subset of these requirements will be focused in the next phase of the project, in collaboration with the project reference group.

We are grateful to the emergency management professionals who have contributed with their time and expertise, and look forward to further collaboration. The project is funded by the Research Council of Norway (project no. 295848).

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Abstract

The SAMRISK project "Sharing incident and threat information for common situational understanding" (INSITU) commenced in May 2019. The INSITU project develops solutions for establishing a common situational understanding in complex operations requiring collaboration between several agencies. This involves systematic analysis of existing information sources and defining the information elements that are critical to share in different phases of a crisis situation. In addition, the project will develop procedures and related tool support for efficient collection and integration of information. As part of this work, the project contributes to harmonisation of terminology across agencies to secure effective communication. A map-based interface for display of information from different digital map resources will be developed, as a basis for a common operational picture (COP). This solution will also support evaluation and learning from incidents and emergency exercises.

Based on an initial review of related research, the report briefly summarises the state of the art for the areas focused in the project. While challenges related to supporting situational awareness and COP have attracted much research focus, with several technology platforms developed for testing and piloting, the review shows that there is still a lack of unified practice and established solutions for supporting inter-agency collaboration. Especially related to evaluation and learning from incidents, we could not identify examples on the use of map-based COP as basis for joint After Action Reviews, of the nature targeted in the INSITU project.

Through interviews and discussions with emergency stakeholders, field observation during an exercise, and field visits at operations centres, current practice for information sharing and establishing a COP is analysed. This documents a fragmented information landscape, with different technological support systems and procedures being used for the same purpose by different emergency management stakeholders. An overall conclusion from the analysis so far is that technology does not represent a main limitation for achieving the goals focused in the project. For the most part the required functionality already exists in the available systems, but what is still lacking is a more coordinated effort towards standardisation and common practices across the sectors and stakeholders involved. However, part of the challenges expressed by the stakeholders still also involve interoperability for establishing seamless interaction between the systems in use. Security concerns also represent a barrier for sharing of graded information.

Based on the expressed needs from the emergency stakeholders and our analysis of current practice, the report specifies a set of requirements for information sharing, harmonisation of terminology, use of common map resources, and technology support for evaluation and learning from incidents. Several of these requirements would involve a national coordinated initiative for changing work practices and improving information sharing to be successfully addressed, involving mandated routines supported by required resource allocations. While this goes beyond the scope of the INSITU project, the report serves to document the potential and recommendations for improvements as a reference for further work.

The project will aim to establish information management procedures for collecting, sharing and synthesising information from different sources. As a basis for this we will collect and analyse the current procedures, and conduct a detailed mapping of the information needs of the collaborating partners related to different levels of operation in specific scenarios. The goal will be to develop templates for effective inter-agency information exchange.

Related to harmonisation of terminology, the high level requirement is to allow a user to search across relevant terminology sources, in a way that is supporting use across all common web browsers, and

devices including Mobile, iPad, and PC. To assure wide and frequent use, the solution should also be designed in such a way that it can be used on top of different digital applications, such as digital maps, or applications for task allocation among volunteers. A pilot application offering terminology search across 30 different sources is available from https://insitu.termer.no/. The goal is to contribute to a national authoritative online location for the terminology and search service, and a joint terminology repository for all Norwegian emergency map services.

For the map-based interfaces, the project will contribute to a repository of common operation cartographic symbols, and definition of interactive functions to be commonly implemented.

Being able to use a COP and integrated map interface also in the evaluation phase would represent a major improvement in practice. To support the learning from incidents, we will explore functionality for recording and playing back event handling in a common map. This will require technical solutions that enable digital information storing and dynamic retrieval of experiences and decisions made for re-construction of the decision-making process.

The further work will validate the solution concept and project deliverables in collaboration with emergency responders, related to selected scenarios.

1 Introduction

1.1 About the INSITU project

The project “Sharing threat and incident information for common situational understanding” (INSITU) is funded by the SAMRISK programme of the Research Council of Norway for the period May 2019 – September 2022.

The project is addressing expressed challenges from emergency managers at both the national and regional level related to information sharing for common situational understanding. Despite increasing access to digital information services relevant for emergency preparedness and response, an overview is lacking of how this information can be effectively collected and combined, and of the needs for information sharing between the agencies collaborating in a crisis situation. Different terminologies are also being used across disciplines, causing possible challenges for effective crisis communication and coordination of resources. Further, there is a lack of standardised map services for supporting cross-agency collaboration.

The INSITU project develops solutions for establishing a common situational understanding in complex operations requiring collaboration between several agencies. This involves systematic analysis of existing information sources and defining the information elements that are critical to share in different phases of a crisis situation. In addition, the project will develop procedures and related tool support for efficient collection and integration of information. As part of this work, the project contributes to harmonisation of terminology across agencies to secure effective communication. A map-based interface for display of information from different digital map resources will be developed, as a basis for a common operational picture (COP). This solution will also support evaluation and learning from incidents and emergency exercises.

The project is led by the Centre for Integrated Emergency Management (CIEM) at University of Agder, in collaboration with the following partners:

- Norwegian University of Science and Technology (NTNU), Department of Geography
- Linköping University, Center for Advanced Research in Emergency Response (CARER)
- University of Sydney, Communications and Technology for Society Research Group
- Tingtun AS – developing solutions for terminology harmonisation
- F24 Nordics AS (former One Voice) – provider of CIM, the main crisis management system used in Norway
- Emergency manager at the County Governor of Agder

The INSITU partners have interdisciplinary expertise in emergency management, information systems, geographic information science and systems (GIS), collaboration support, and terminology harmonisation. We work together with an extensive reference group of agencies responsible for different areas of emergency preparedness and management in Norway (see overview in Appendix A).

1.2 Aim and scope of the report

The report presents the results of the first phase of the project, focusing on analysing existing practice for information sharing among emergency stakeholders, and use of terminologies and map services. In addition, the report provides a brief overview of related research in the different focus areas of the project. The purpose here is not to provide an exhaustive review of extant research, but to summarize the current knowledge as reported in the literature. On this basis, the report specifies requirements that will guide the further work in the project to be able to meet the identified challenges and needs.

While the main focus is on Norwegian practice, the literature review and the experience provided by the Swedish and Australian project partners also provides a basis for comparison with current practice in other countries.

Regarding the scope of the incidents and threats focused in the INSITU project, the main focus will be on selected threat scenarios specified by the Norwegian Directorate for Civil Protection (DSB, 2019). These mainly include non-intentional crisis scenarios caused by extreme weather (e.g. flooding or forest fire) or industrial accidents. This means that intentional threats such as terrorist attacks, politically motivated violence and cyber attacks, requiring intelligence by the Norwegian Police Security Service (PST), the Norwegian Intelligence Service or The Norwegian National Security Authority (NSM), will not be focused specifically in this project. However, the mechanisms for inter-agency information sharing to be focused in this project is also considered relevant for these kinds of scenarios. As documented in this report, the project also has collected data on processes for information sharing and analysis from the military, as a basis for possible transfer of practice to the civilian sector.

1.3 Structure of the report

Chapter 2 of the report provides a brief review on related research in the four topic areas of the project: information sharing, harmonisation of terminology, map services, and evaluation and learning from incidents. Chapter 3 presents the methods used for data collection and analysis in the first phase of the project. Chapter 4 gives a summary of the current practice and identified needs related to the project areas, as a basis for presenting the requirements to be addressed in the next phases of the INSITU project. Chapter 5 outlines the high-level solution concept proposed from our initial requirements analysis, and Chapter 6 concludes the report and points to further work in the project.

2 Related research

2.1 Information sharing

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 operational picture of the evolving incident. Especially in inter-agency operations, challenges of effectively sharing information across organisational boundaries have been documented extensively in previous research (e.g., Laakso & Palomäki, 2013; Ley et al., 2014). The International Forum to Advance First Responder Innovation (IFAFRI, 2018) also lists one of four capability gaps as being 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.

A core concept in this research is situational awareness (SA), defined by Endsley (1995) as «the perception of elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future» (p. 65). Endsley further models SA as comprising three levels. Level 1 SA (lowest level) involves mere perception of information, level 2 SA is formed based on integrating various pieces of information in conjunction with operator goals to provide an understanding of the meaning of that information, while level 3 SA involves prediction of future events and system states based on the understanding formed at level 2.

It is commonly agreed that developing SA requires establishing a common operational (or operating) picture (COP). However, the term COP still lacks a unified definition (Bunker et al., 2015), and is both referred to as a visual object and a process (Steen-Tveit, 2020). Bunker et al. (2015), argue that a COP should be viewed as dynamic rather than static and that existing command and control based systems intended to support COP are not able to represent "the range of perspectives, options, facets and changes that often challenge responders" (p. 52). Similar, an ethnographic study of disaster exercises in the Netherlands (Wolbers & 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).

This indicates that even if COP is established with relevant information for the situation at hand, the different stakeholders involved are likely to interpret this differently. With the final goal being a shared situational understanding among the collaborating agencies, an important part of this process is to understand the information needs of the different parties.

While existing procedures for situational reports (e.g., DSB 2018) specify the communication structures and actors involved, 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 & Munkvold, 2017).

Within the European Union (EU), there is a wealth of research projects, initiatives and private-public collaborations to enhance the ability to collect and share information during crises and emergencies. To ensure scientific novelty and integration of results from relevant research, a review of EU-funded projects relating to situational awareness and common operating picture was conducted. Appendix B summarises key information on a selection of EU-funded projects which explore thematic areas that are of relevance to the INSITU project, including project focus and relevant outcomes. A common theme in these projects is the application of geospatial information to enhance situational awareness across institutions, and to enable a shared common operating picture between participants involved in emergency management operations. Together, these projects can be considered a non-exhaustive list of examples of the overarching effort to build resilient systems for managing crises and emergencies throughout Europe, with focal areas along the entire spectrum of human-technology interaction and enabling interorganisational data sharing. Some of the projects emphasise a holistic approach, aiming to augment management efforts regardless of incident type and stakeholder involvement, while others address specific gaps in capability for specialists within specific sectors. They all include significant sociotechnical elements, with integration of technological tools, novel approaches to share geospatial information between organisations and experience-building with user groups, to ensure efficient integration into crisis management structures.

The COPE project was an early initiative focusing on how to improve the information flow both from and to the first responders in order to increase situational awareness across agencies and at all levels of the command chain in emergency management situation. Through identification, evaluation, and selection of technologies suitable for first responder work, the project integrated different components into a demonstrator “System of Systems” that was tested in a large scenario based mixed live and tabletop type trial exercise.

BRIDGE and DRIVER+ are two long-running consortiums for capacity building in crisis and emergency management. BRIDGE focused on the establishment of digital platforms for crisis management, with software and information sharing protocols to enable responders’ access to a shared set of collaborative and platform-independent tools. DRIVER+ represents another major pan-European initiative. DRIVER+ emphasises the establishment of centres of expertise and learning networks for experience building and institutional learning.

BeAware and I-REACT are two recently finished projects, which together showcase a more technologically driven focus. These projects represent the sharp end of technological development, with the implementation of state-of-the-art sensemaking capabilities for responders, coordinators and the general public. The emphasis has been on combining streams of multidisciplinary sensory information with automated tools to combine and analyse incoming information. On a similar level of technical sophistication, HAZRUNOFF is a set of tools that enable rapid simulation and detailed modelling tools for flood-related events in coastal or riverine areas, based on remote sensing satellites and coastal sensory systems. It serves to illustrate the role that specialist tools can play in augmenting general crisis management platforms for in-depth analysis and sensemaking within subsets of incident types. The DECAT project focused on facilitating preparedness and response through developing a geospatial early warning decision support system for multi-hazard incidents.

ALPSAR and ALPDIRIS adopt a holistic approach to combine technology, methods and training to enable cross-border collaboration between Slovene and Venetian mountain rescue services in the Dinaric Alps. The projects are also significant in that they represent a ten year long continuous collaboration between consortium partners. Because of this, the resulting tools have been field-tested over a long period of time, and have been part of the tools deployed by the mountain rescue services in the Dinaric Alps. This has allowed for a gradual process of iteration on existing functionality, as well as the addition of new features as the needs of the primary users change over time. Similar projects include the following: FWEDROP - a multinational operational platform for conducting search and rescue (SAR) in aquatic settings. EASER - an Italian program focusing on SAR operations in natural disasters with elements of groundbased terrain deformities. EU-NU - a strategic collaboration between Nordic SAR institutions to enhance urban SAR capabilities in cold conditions.

While most of the projects in this last category are primarily focused on enhancing the capabilities of professional services, two of the projects have the activation of voluntary resources as a primary focus. The KUBAS and RE-ACTA projects represent another tendril of recent research within crisis management, namely the role of such software as a facilitator for activating the resources within a civil society during times of crises. Many of the European countries have a significant degree of voluntary networks involved in day-to-day emergency management, and these organisations act as a fundamental part of the preparedness for crises and emergencies.

Given the importance of map-based services for establishing a COP, this topic is also covered further in section 2.3.

2.2 Harmonisation of terminology

The importance of crisis communication is focused in emergency management research and practice, for responding to both small or large scale incidents (e.g., Coombs, 2015; Drake et.al, 2016; Edworthy et. al, 2015; Hagelsteen & Becker, 2014; Iluzia Iacob et. al., 2015; Johansen et. al., 2012; Ki & Nekmat, 2014; Liu & Fraustino, 2014). Therefore, the specific terms used in crisis communication must be precise, to be understood in the same way both by professionals responsible for handling a crisis and by the general citizens who need to stay informed about the crisis development. Precise terminology for crisis communication will reduce the risk of misunderstandings among those who are responsible for responding to the crisis (Thywissen, 2006). Communication to the general public also relies on their understanding of terms to ensure that they take appropriate actions in emergency situations. Unfortunately, even though crisis terminologies often are provided for free online, these resources remain unknown to the general public and are only being used to a limited extent among professionals for preparedness or in operations. On the other hand, the use of Information and Communications Technology (ICT) for preparedness, during the crisis or in the recovery period is increasingly adopted, especially in developed countries. The ICTs have been the main reason for the recent shift in the nature of crisis communication from a centralized command structure to multidirectional communication between a range of actors from various sectors and backgrounds (e.g., language, culture, and knowledge) (Tapia, Moore, & Johnson, 2013). In such urgent and complex interaction with multiple stakeholders, the risk of communication being misunderstood may increase, and the actual meaning of the message may not be properly conveyed. A shared conceptual meaning is as crucial as the crisis communication model or technology support to enhance the common understanding and improve the effectiveness of disaster response.

As argued by Mayner and Arbon (2015), harmonisation of definitions of disaster terms is required as a basis for building more unitary research, policy, and practice. They provide an example of analysis of the term “disaster” in a source with 110 glossaries containing disaster terminology, but with only 52 containing a definition of the term disaster itself. They point out that even for the term disaster there is very little consensus on the meaning of the term, identifying 128 different definitions. Likewise, Hagelsteen and Becker (2014) raise a concern regarding the potential discrepancies in how individuals or organisations perceive key disaster concepts. They used the essential concepts related to “disaster risk reduction (DRR)” and “capacity development” as a test case using groups of international experts as respondents and examining documents from nine capacity development projects for DRR. Their research found significant differences in how the respondents defined the DRR concepts. This finding strengthens the earlier study conducted by Lipson and Warren (2006) showing that the definition of “capacity building” was not homogeneous among their respondents that covered NGOs from 18 countries. As possible reasons for these inconsistencies, Hagelsteen and Becker (2014) point to a tendency of underestimating the importance of using terminology correctly and the assumption that different parties have the same understanding. Thywissen (2006) also argues that the definitions of the same terms have been developed simultaneously in multiple disciplines, causing the so-called “Babylonian Confusion” with varying definitions of the same term. Thywissen (2006) further suggests a common vocabulary of unique, well-formulated definitions and concepts, to avoid misunderstandings in the communication between different actors.

Some efforts have been initiated to harmonize the crisis management terms using various approaches such as taxonomies (Addams-Moring, Kekkonen & Zhao, 2005; Barthe, Truptil & Bénaben, 2015; Grant & Van der Wal, 2012; Pottebaum, Marterer & Schneider, 2014; Shamoug & Juric, 2011), terminology vocabularies (Reuter, Pipek, Wiedenhoefer & Ley, 2012; Temnikova, Castillo & Vieweg, 2015), domain ontology (Galton & Worboys, 2011; Javed, Norris & Johnston, 2011; Liu, Shaw & Brewster, 2013; Malizia, Astorga-Paliza, Onorati, Díaz Pérez & Aedo, 2008), semantic integration (Barros et al., 2015) or developing interoperability frameworks (Buscher, Bylund, Sanches, Ramirez & Wood, 2013; Gatial, 2016; John S. Park Jr., 2005).

In the Norwegian setting, the need for harmonisation of terminology among crisis responders has been most recently underlined in the Handbook for the Norwegian Rescue Services (JRCC, 2018). As an example of the challenge, there are at least four different Norwegian terms for the incident site ("åsted", "fareområde", "skadested", "tiltaksområde"). In addition, we have sectorial abbreviations for locations related to an incident site, like the following used by the Police: "S" for "Samlested for skadde" meaning location to gather the injured, or "STY" for "Venteplass for hjelpestyrker" meaning waiting location for the support squad.

This problem is not specific for Norway. Members of the project team (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. How to increase the adoption of such resources and make them easily accessible is not much studied in existing research, with the existence of such resources and how to use them in day-to-day practices being treated as separate issues. Reuter et al. (2012) address the same concern as our research, i.e., how to deal with terminology ambiguities in collaborative systems. Their study is mainly exploratory, and the technical approach discussed is more at the conceptual and requirement level than suggesting concrete ICT solutions.

Examples of useful resources on process and methodology for terminology harmonisation include: Terminology work - Harmonisation of concepts and terms (ISO 860:2007); Unified terminology for society protection and preparedness ("Enhetlig terminologi för fackområdet samhällsskydd och beredskap"), Socialstyrelsen, Sweden; Standard for terminology harmonisation and differentiation ("Forvaltningsstandard for begrepsharmonisering og begrepsdifferensiering"), Norwegian Digitalisation Agency; and Semicolon's project guideline on harmonisation of concept and regulation between agencies ("Harmonisering av begreper og regelverk mellom etater").

Section 4.2.1 presents more examples of different glossaries and collections of terminologies that we have identified in Norway and internationally.

2.3 Common map services

2.3.1 Situational awareness and COP

Situational awareness studies typically concern military cases (Hager, 1997; McNeese et al., 2006; Björkbom et al., 2013) where a common, real-time representation of the battlespace has always been of primary importance to commanders. Therefore, the early milestones in the 1980s concerned military command posts that benefited from, e.g., the development of large group displays for visually representing tactical, operational, and strategic information to enable situation awareness (Endsley, 1995). As McNeese et al. (2006) claimed, current studies on COP map-based interfaces constitute an extension of prior work on such displays.

Actors with different tasks, capabilities, and resources have different needs regarding displaying information on COP map-based interfaces and using their functionalities to perform specific operational tasks (Friedmannová, 2010). Sometimes, the same information needs to be displayed by means of large displays or laptop screens, but also, provided in small portable devices. All those issues make combining information from several subsystems and design settings of COP map-based interfaces challenging and effortful.

Another confounding issue when developing COP for improved situational awareness for disaster management purposes, is that the ultimate objective of responding agencies is to work with the general public for risk minimisation/mitigation rather than "defeat of the enemy". Both man-made and natural disasters tend to take their own course and there is generally very little that governments, agencies or the public can do to stop or "defeat" an unfolding catastrophe, other than anticipate and act to minimise the impact on lives, property and livelihoods and/or the co-develop mitigation strategies. This is where COP for disaster situational awareness differ from those developed for military purposes where there is little involvement from the general public and secrecy is paramount.

A wide range of disaster management stakeholder involvement (including the general public) is critical for the effective development of COP for situational awareness, as a lot of information is provided by the general public for the COP and they also expect to have access to a COP (of sorts) i.e. it may be necessary to provide different levels of access to mapping information. For example, in Australia, the rural fire service have developed an application called "Fires Near Me" which uses a map interface to communicate fire situational awareness to the general public. This application presents a level of granularity that is useful to the general public but would not be of sufficient use to fire service fire fighters.

2.3.2 COP to support emergency responders

Shortly after being introduced to military purposes, COP map-based interfaces have been successfully used to support emergency responders (Deschamps et al., 2002). However, studies that concern the needs of emergency management in general, and the needs during natural hazards in particular, are sparse and fragmented in the literature. Many large-scale military and civilian efforts incorporate elements of distance, time, rate, speed, identity, and locality, as well as other factors inherent to geographical entities. One recognized need, therefore, is geographical data since it is highly relevant when developing COPs (e.g., McNeese et al., 2006). If COPs are to support response to natural disasters, incorporating extensive information on environmental conditions is of importance to its users since such information can potentially save more lives (King, 2005). Information on environmental conditions is a need that is well exemplified in the Decision Support System established by the International Joint Commission to reduce the impact of future flooding in the Red River Basin in Canada and the US (Deschamps et al., 2002). With extensive geographical data, decision support systems resemble geographic information systems (GIS). Available thematic maps can serve as background layers to pin information to geographical coordinates and tie them to the environment. A similar role has been described by Chen et al. (2014) who argued that a mapping component displays real time operational information and combines it with GIS layers.

Not only content related issues, but also the way collaboration between group members can be reflected in COPs has also been addressed by scientists. Adibhatla et al. (2009) presented and evaluated a transactive memory system that draws upon Wegner's (1987) transactive memory theory. The theory emphasizes the role of knowledge specialization among group members in a group's ability of solving a composite problem. Collaboration between group members has also been investigated by Baber et al. (2013) who used social network analysis and agent-based modeling to explore different forms of information flow between actors. They defined two patterns – "command" and "control" that can be suited to complex emergency operations.

Implementation of command and control (C&C) within emergency management domains is shaped by societal factors and operational concerns. The Norwegian emergency management system is structured around four principles, namely responsibility, similarity, proximity, and cooperation. Together, these principles form the basis on which C&C is exercised (Norwegian Ministry of Justice and Public Security, 2016), and diverges from military C&C structures in some key matters. Emergencies are not managed through a centralized apparatus, instead emphasizing local decision-making and delegated authority, often including voluntary resources and semi-professional rescue workers. While the police are responsible for C&C at the operational and tactical levels, emergencies can see a wide variation in participants, particularly in rural areas where available resources may be sparse (Sikkerhetsutvalget, 2016). The systematic integration of voluntary resources, coupled with a decentralized C&C structure, creates a set of challenges when it comes to ensuring that stakeholders have access to the tools and data needed to build a COP. The use of different software systems and lack of interorganizational data access, particularly across the professional-voluntary divide, has been among the factors limiting efficient sharing of information during emergencies (Grottenberg & Njå, 2017). These difficulties give a compelling argument for establishing a common set of dedicated capabilities across organizations – "common operational functionality" (Chmielewski & Gałka, 2009), accomplished through the implementation of software solutions, robust application programming interfaces (APIs) and mechanisms for inter-organizational data sharing.

2.3.3 User-centric design of decision support map-based interfaces

COPs resemble other decision support tools that employ map displays. Therefore, in the design of COP map-based interfaces, developers follow similar approaches as those used for decision support geographic visualization tools (Kuvedžić Divjak & Lapaine, 2014). The latter are often designed to support specific tasks that are grouped into various task taxonomies (Zhou & Feiner, 1998; Gotz & Zhou, 2009). Such taxonomies facilitate optimizing tool functionalities since they can help assign adequate interactive functions to desired tasks to be supported, and thus, can help fulfill user needs.

Equipping map-based decision support tools in interactive functions is appreciated by target users, and therefore, following the user-centric design approach is a common strategy (Opach & Rød, 2014). In the context of COP, van Dijk (2015) and Balakrishnan et al. (2009) have provided some good examples. The latter investigated the performance of specific interactive functions: a layer management function and a spatially annotated chat. Their qualitative evaluation concerned user-centric problems related to human-computer interaction to support group work and the impact geo-tools have on group work.

Cartographic literacy is another aspect to be considered when designing COP map-based interfaces with a user-centric approach. Such interfaces, if well-designed, can facilitate communication of geographical information in crisis situations (Kuvedžić Divjak & Lapaine, 2014). The design of geographic background, thematic overlays, and thematic content needs to be addressed when elaborating map-based interfaces. The thematic content part, in particular, seems to be of key importance to emergency responders as it concerns event details such as affected areas, rescue squad positions and human resources in use. Therefore, establishing a common set of map symbols – "common operational symbology" (Chmielewski & Gałka, 2009), similarly as establishing "common operational functionality", can make communication between decentralized emergency officers more efficient. A good example of such efforts is an attempt to design a map key to monitor the transport of dangerous goods (Friedmannová, 2010). The resulting key is a compact system where colors and shapes are the leading attributes that knit groups of symbols together. The role of these two attributes has also been emphasized by Wang et al. (2010) who argued that they both have a strong visual impact on the map reader. Symbols for emergency maps were also analyzed by Dymon (2003) and Robinson et al. (2010). Their research revealed that standardization evolves and needs constant adaptation and improvements.

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 the individual user groups. Extended research should concentrate on map usability in both map content and visual controls to make map use more intuitive.

2.4 Evaluation and learning from incidents

In this section we review relevant research on evaluation and learning from incidents. We first define the term learning from incidents, as a basis for summarizing some suggested methods for this. Further, we present some examples of relevant research from the crisis management literature.

2.4.1 Defining "learning from incidents"

There are numerous studies on learning from incidents (LFI), and especially in the safety domain, e.g. in high-risk activities such as the aviation industry, medical care and the process industry (Jacobsson, Ek & Akselsson, 2011, 2012), health care and patient safety (de Kam, Grit & Bal, 2019), tunnel (Casse & Caroly, 2019) and refinery (Russell Vastveit, Boin & Njå, 2015; Russell Vastveit & Njå, 2014). Some studies refer to this as "Learning from Accidents" (e.g., Silva et al., 2017), or "learning from experience" (Casse & Caroly, 2019). This difference is because some authors make a clear distinction between accidents (any unplanned event that results in damages) and incidents (near misses or near hit events), but many scholars also use incidents and accidents interchangeably.

Jacobsson et al. (2011) define learning from incidents as "the capability of an organization to extract experiences from incidents that happen in the organization and convert them into measures and activities which will help in avoiding future incidents (and accidents) and in improving safety overall." (p. 333). Another definition includes multiple aspects, where learning from incidents can mean any of the following: (a) that the team of investigators has understood how and why an incident occurred; (b) that several people in an organization know how to prevent it from happening again; (c) that an organization has implemented a set of changes (e.g. in equipment and personnel behaviors) which will prevent this event from happening again; and (d) that an organization has implemented a set of changes which will prevent this event, and similar events, from happening again and learned about its processes for LFI as a result of an incident investigation (Margaryan, Littlejohn & Stanton, 2017).

The typical approach to evaluate or learn from incidents is by asking the following questions: 1) What are the measures actually implemented? 2) What measures could be taken if the organization would use the full potential for learning? 3) How does the actual learning compare with potential learning? and 4) Are plans for implementations of lessons identified? (Jacobsson et al., 2011). One critique of the learning from incidents is that the learning process often stops at the reporting stage. It usually focuses on the behavior of the hardware and the operators/workforce involved directly with the activities. Furthermore, a problem that research and practice often stays where lessons are identified but not learned and implemented (i.e improvements). Therefore, they tend to show up in the next evaluation report, for example such as in the Swedish incident report system on the forest fires.

2.4.2 Methods and models

In this section we briefly review research on methods for learning from incidents, including methods for organizational learning, and the learning from incidents questionnaire. In addition, we also looked into the literature on causation models and human reliability analysis. However, while the research in the latter category provides in-depth methods and instruments for investigating possible causes of an accident, it does not focus much on how to facilitate learning from the incidents. Thus, we refer to the article by Pasman, Rogers & Mannan (2018) for a review of accident investigation methods.

Organizational learning method

The focus of organizational learning is gathering information from individuals involved in the accident or incident and transferring this into organizational knowledge. In the safety domain, this learning occurs via many activities and instruments, such as safety audits, training, safety rounds, safety committees, risk analysis, inspections, and behavior-based safety activities. Organizational learning can refer to both products and processes. The products can be technical improvements, procedural improvements and personal improvements. The learning process can include the actual learning process, i.e., single-loop learning, meaning the incidents are reported in the normal incident learning systems, and double-loop, which means that the organization changes its guiding principles and/or values regarding how its activity should be performed. The learning system is implemented through a learning cycle, i.e., data collection and reporting, analysis and evaluation, decisions, implementation, and follow-up. Jacobsson et al. (2011) describe the following procedure for evaluating learning from incidents: 1) Evaluation of actual learning levels of reported incidents; 2) Evaluation of the potential learning levels of reported incidents; 3) Comparison of actual and potential learning levels of reported incidents; 4) Adjusting the results obtained in steps 1-3 for unreported incidents; 5) Consideration of possible learning from incidents on an aggregated basis (the second loop); 6) Consideration of other learning mechanisms for learning from incidents.

Jacobsson et al. (2011) also introduce a model of five levels of learning from incidents, based on experience from the process industry. The first level is limited local learning with almost no organizational learning, relying only on short-term memory such as discussing within a shift and possibly taking notes in a logbook. The second level is limited organizational learning, where the long-term memory is used such as changes in a specific procedure with documentation, possibly with some training. The third level is process unit level learning, where substantial organizational learning is adopted by changing some critical equipment significantly, changing procedures and training. The fourth level is site-level learning which includes major changes in engineering specifications, working procedures, and training program for the site. The fifth level is higher learning on the corporate level where fundamental changes on security policies occur in the overall organization. The model excludes the no-learning stage (level 0), i.e., when an organization shows minimal effort after experiencing an incident (e.g. just accepting human error, or fixing minor things).

Silva et al. (2017) suggest three key assumptions to learn from an event: 1) information about the event; 2) opportunity to share points of view about the event; and 3) acquisition of new knowledge. The strategies for intervention to support learning (technical and social) from incidents are diffusion, discussion, training, and change. Reason (2000b, 2016) encourages organizations to develop a reporting culture so that a learning culture becomes part of the organization's safety culture. A reporting culture stresses the importance of retaining knowledge obtained from small accidents and near misses. Reason also introduces a concept of just culture that allows errors and mistakes to be reported and everyone knows where the line must be drawn between acceptable and unacceptable actions, and avoid the blame culture that will prevent incident reporting. A learning culture means that the information is available, disseminated, discussed and changes are implemented. Moreover, Reason (1997) stresses that learning implies observing, reflecting, creating, and acting.

Learning from Incidents Questionnaire (LFIQ)

Littlejohn, Margaryan, Vojt and Lukic (2017) have introduced a toolkit called the Learning from incidents questionnaire (LFIQ). The LFIQ is designed to assess the quality of current LFI activities in an organization with a focus on how these activities might impact each individual's learning. There are different methods to assess the quality of LFI suggested in the literature such as ethnography, sensemaking, socio-cultural and cognitive-psychological approaches. LFIQ proposes a way to capture all facets of learning from incidents across an organization. The LFIQ framework is constructed from five key learning components : 1) Learning context: might be organized (e.g. courses or training) or informal (e.g. on-the-job learning); 2) Learning participants: to consider different ways of individual's learning given diverse roles that people may have in the organization; 3) Learning process that should be aligned with the specific learning goals that may require different processes; 4) Type of incidents: the learning solution can vary depending on the scale and complexity of an incident. In line with the organizational learning theory as presented by Agyris and Schön (1996), the LFIQ seeks to identify the discrepancy between actual policies and what happens in reality.

2.4.3 Learning from incidents in crisis management

Scholarly articles on learning from incidents in the context of crisis management are still limited, and especially the ones that focus on evaluating situational awareness, common operational pictures, and common situational understanding. Some scholars use other terms such as "learning after disaster" (O'Donovan, 2017), "lessons-learned approach" (Rostis, 2007) and "after-action review" (Savoia, Agboola & Biddinger, 2012; Tami et al., 2013) to refer to the evaluation and review process after a crisis or exercise. According to Rostis (2007), the "lessons-learned" approach refers to experiences gained during a disaster that are collected and filtered, and the mistakes or oversights are highlighted as lessons to ensure the organizations do not repeat the same mistakes. The term is used interchangeably with the after-action review. After action review (AAR) is the army method for providing performance feedback from a joint training exercise. The focus is primarily on information feedback, performance measurement, cognition and memory, group processes, communication theory, and instructional science (Morrison & Meliza, 1999). However, the original AAR focuses so much on human performance after performing military training. Application of after-action review in the disaster or emergency management domain seems to be more than just human performance, as AAR, according to Tami et al. 2013, seeks answers to questions such as "What was supposed to happen? What actually happened Why were there differences? What gaps materialized between planning and execution? What can we learn from this experience? Tami et al., 2013 proposed an AAR tool which is basically a set of tested/validated questionnaires applied for medical emergency responses that cover the team performance during the response, command-and-control, as well as emotions and reflections.

Savoia et al. (2012) suggest three central capabilities of organizations such as 1) Emergency Public Information and Warning, i.e., the ability to develop, coordinate, and disseminate information, alerts, warnings, and notification to the public and responders; 2) Information sharing, i.e., the ability to conduct multijurisdictional exchange of situational awareness data among different public and private agencies; and 3) Emergency Operations Coordination (EOC), i.e., the ability to direct and support an event or incident by establishing a standardized, scalable system of overview, organization, and supervision. Furthermore, concerning the information-sharing capability, there are several themes mentioned as barriers, such as difficulty in sharing with an external partner, lack of training in the use of technology, difficulty in tracking information, difficulty in sharing information across different groups within the same organization. While in the EOC, the most frequently appeared themes are: confusion between roles and responsibilities, poor familiarization of the incident command system, difficulty in aggregating and utilizing situation reports, communication and coordination issues, confusion in response activities vs. day-to-day activities, and poor action planning.

O'Donovan (2017) is using the term "learning after disaster" at a higher level, i.e., learning at the policy level after collecting knowledge on various policy failures. The author suggests the types of policy failures, especially policy programs and policy processes to allow policy learning. The types of policy failures are as follows: failure in policy program, failure of policy process agenda setting, policy formulation, decision making, policy implementation, and policy evaluation. Furthermore, O'Donovan (2017) suggests that the lessons-learned are successful if the following learning processes are promoted: 1) Instrumental policy learning i.e., the disaster brings new understanding about how a policy tool works, is designed and is implemented. 2) Social policy learning: i.e., the disaster brings a new understanding of policy by a change in the social construction of the problem and the causal reasoning underlying the definition of the problem. 3) Political learning, i.e. when the disaster brings the changes in the knowledge about the effectiveness of strategies that policy advocates to advance policy ideas or draw attention to problems.

Birkland (2009) observes that the importance of generating lessons-learned reports in the immediate aftermath of the event has been a part of social-political pressure, and therefore one would need to ensure that lessons really are learned so that the worst effects of the next disasters can be avoided. The paradox is that the timeline between the event and report creation is insufficient to allow any organizations or personnel to actually learn from incidents, and thus the report is referred to as “fantasy documents.” Disasters have provided an opportunity to learn from the events, but often, given the haste of the decisions made in responding to these events, the risk of superficial learning – that is, learning without some attempts to analyze the underlying problem – is likely to occur. Birkland suggests a process and a so-called “Event-related Policy Learning” model to maximize the learning process from the incident and avoid creating hasty learning from the incident report. In short, Birkland (2009) concludes that learning can exist if we learn from the processes of how to structure organizations and policy systems that bring serious learning from disasters.

We examined the ISCRAM digital library, one of the most comprehensive repositories where hundreds of publications on emergency management research are indexed. The following topics were found: learning from previous humanitarian operations (Charles, Lauras & Tomasini, 2009); learning from major forest fire (Marklund & Wiklund, 2016); learning from Y2K and 9/11 response (Toelken, Seeger & Batteau, 2005), and knowledge sharing from exercise (Nordström & Johansson, 2019). The learning suggested by Charles et al. (2009) is more about building a framework for improving previous weaknesses in the supply chains of humanitarian operations, especially in the management of system complexity, management of all types of processes, capitalization of enterprise knowledge and know-how, business process reengineering and enterprise integration. The framework, however, is at a conceptual level. Toelken et al. (2005) try to understand the ways the threats and crises become learning events, taking the well-known Y2K and 9/11 events as cases, but the authors mostly discuss the learning as a preparedness action and a way to mitigate crisis impact.

Marklund and Wiklund (2016) present the Swedish Armed Forces’s Joint Analysis and Lessons Learned Division (JALLD) approach to learning from complex operations. The lessons were manifested as a report as a result of a series of interviews from different responder organizations. The questions focus on describing some of the major challenges they had faced during the fire, especially how they managed these challenges so these lessons could be used in future situations and describing the best practices. JALLD conducted internal and external seminars and interviews with experts to comment on drafts of the lessons report. While the authors describe several lessons-learned such as insufficient knowledge about other actors’ capabilities, inability to make national priorities as well as the importance of continuity of the leadership and personal relationship, no detailed, systematic method or instruments has been presented in this paper.

Nordström and Johansson (2019) employ nine thematic clusters proposed by Granåsen, Olsén and Oskarsson (2018) to examine the inter-organizational learning derived from post-emergency management exercise reports to evaluate the different aspects of crisis management capability. These nine themes are interaction, relationships, coordination/C2, system performance, preparedness, situation awareness, resilience, decision-making, and information infrastructure and reviewing the suitability of the report for inter-organizational and organizational learning. There were similarities found in the report structure: (1) background to the exercise, (2) description of the exercise scenario, (3) description of the purpose and goals for the exercise, (4) description of the evaluation process, (5) evaluation, and (6) areas for improvement. The authors found that most of the thematic clusters were covered in the reports, except system performance, resilience, and decision-making. The authors also identified that the majority of the reports focused on describing what happened and what actions were carried out during the exercise, and did not so much focus on analyzing the problems that arose during the exercise, how the problems were solved, and what measures that would be needed to prevent the problems from occurring again. The suggestion for future improvements which are essential for organizational learning was not so well developed.

2.4.4 Remark on learning with specific focus on incidents

From our review of existing research on learning processes in general we can see that there exist a multitude of theories, practices and perspectives - but also that they have much in common, i.e. they share aims (double-loop learning, lessons identified, implementation at organizational level etc.) and challenges, the most common challenge being to actually turn evaluations and reports into knowledge that can be implemented (and to assess whether this has taken place).

This is true also when learning from incidents. Our own research, e.g., from the Swedish rescue services incident report system demonstrates how difficult it is to create double-loop learning from incidents (Pilemalm et al., 2014) In this case, the explicit aim of the project was to extend a incident report system (much based on statistics and response times) to a learning system. However, this did not take place, simply since nobody knew what to use the data for. We suggested added functionalities, repositories for exchange of experiences, user participation and organizational processes for knowledge transfer, as potential means to overcome this. The same holds to a large extent for after-action-reviews which is the most common approach in emergency and crisis management. As can be noted from the state-of-the art review, after-action-reviews in this context tend to blur the “review”, i.e. the process for capturing the experience and turn it into lessons really learned and implemented, with “reports”, which simply implies summing up the lessons identified in a report and leave it there until next incident takes place. Moreover, it can be noted that most of the evaluations of incidents, both in the safety and crisis management domain, focus on what happened and what actions were carried out, not on “the why”. If the why is lost, you cannot create lessons identified and prospects for double-loop learning in the first place. The challenge becomes even more substantial in large-scale crisis operations or exercises where numerous actors and organizational levels are involved. Pilemalm et al. (2008) suggested a multimedia tool for reconstruction of large-scale crises or exercises, using a timeline, that enabled to focus on the “why” rather than trying to reconstruct what actually happened.

Since 2008, the possibilities provided by ICT has expanded rapidly. Nevertheless, after having reviewed after action reports or various approaches for evaluating both real incidents and exercises, it is deemed difficult to identify findings on how to evaluate common operational picture (COP) and common situational understanding, as well as the process for reaching these two states. While situational awareness is focused as part of understanding an incident, it is not addressed in a similar extent in the context of evaluating the COP and common situational understanding. Further, we could not find reports on use of map services to support the evaluation and learning from incidents, indicating an untapped potential for increasing use of such services to analyse the process of establishing COP and common situational understanding. As will be elaborated in Chapter 4, we will address these perceived gaps in the current project e.g. by looking at how organizational processes can support evaluations/implementations of after-action-reviews, how the “why” can be addressed, and how integrated map solutions can support this by providing proper and useful data and information. The content of this information must be developed together with stakeholders.

3 Methods

Several different research methods were applied for data collection, as summarized in the following list:

- Stakeholder interviews
  - First responders
  - Map providers
  - Organisations responsible for terminology resources

- Document analysis

- Visits at operations centres
  - The Norwegian Joint Headquarters (NJHQ) in Bodø, coordinating the operational part of the Norwegian Armed Forces.
  - The Civilian Situation Centre at the Emergency Support Unit, Ministry of Justice and Public Security, Oslo

- Workshop with reference group
  - Focus group discussion and brainstorming

- Observation at field exercise
  - Observation at various sites during a field exercise in Agder county with a combined industry and forest fire scenario

- Surveys
  - SMS-based survey during and after emergency exercise
  - Survey among Norwegian municipalities administered by the Norwegian Directorate for Civil Protection

The use of the different methods are now described briefly.

3.1 Stakeholder interviews

A total of 23 interviews have been conducted with representatives for Norwegian emergency management stakeholders and system vendors, including the following roles:

- incident commanders from first responders (police and fire)
- emergency dispatchers from command and control centres
- municipal emergency coordinators
- providers and developers of map services

The interviews were semi-structured, based on an interview guide covering the different focus areas in the INSITU project: 1) current practice for collecting and sharing information, including the organisations' understanding and use of the terms common operational picture and common situational understanding; 2) terminology resources in use and experienced challenges related to lack of terminology harmonisation; 3) existing use of map systems and current practice for sharing geospatial information with collaborating partners, also including possible challenges with different map symbols being used; and 4) current practice for evaluation and learning from incidents, with focus on the use of map services and tool support for information sharing.

The interview guide was adapted to the role of the different informants. Most interviews were conducted face-to-face, while some took place online using Skype. When possible, the interviews were recorded. Some of the Skype interviews with map providers also involved product demonstrations which were recorded with video. All audio-recorded interviews were transcribed in full, and analysed to identify current practice and needs as a basis for developing requirements specifications for the different project areas.

3.2 Document analysis

Different types of documents have been collected and analysed, both in preparation for the interviews and as sources for complementary information. This includes national regulations and guidelines, government white papers, and reports from exercises and evaluations.

As part of the reference group workshop (see section 3.4), documents from related projects were also shared with us. Some of these included graded information, which limits explicit reference to these.

3.3 Visits at operations centres

Two one day visits were conducted to national military and civilian operations centres:

- The Norwegian Joint Headquarters (NJHQ) in Bodø, coordinating the operational part of the Norwegian Armed Forces.
- The Civilian Situation Centre at the Emergency Support Unit, Ministry of Justice and Public Security, Oslo

Both visits included presentations from staff members, discussion on current practices for collecting, analysing and sharing information to establish COP and situational understanding, and guided tours of the operations centres.

3.4 Focus group discussion and brainstorming

A two day workshop with the project reference group was held in Oslo in October 2019. Altogether 24 participants from 20 organizations took part, including national directorates and authorities, first responders (police, fire and health), county and municipal emergency management, the Norwegian Industrial Safety Organization and the Norwegian Defense Research Establishment. The participants were mainly recruited from the INSITU project reference group, with additional participation from the Emergency Support Unit at the Norwegian Ministry of Justice and Public Security.

The workshop was organised in three main sessions:

1. Group roundtable discussions and experience exchange on current practice for establishing COP and common situational understanding.
2. Brainstorming in groups on needs for improvement
3. ‘World cafe’ with groups rotating to discuss the following four topics:
    - Collecting and sharing information for common situational understanding
    - Harmonisation of terminology

- Integration of map-based information from different systems and standardisation of map symbols
- Support for evaluation of exercises and incidents

The notes from the group discussion and brainstorming were subject to thematic analysis related to the four focus areas, as a basis for the results reported in Chapter 4.

3.5 Surveys

Two surveys were conducted. The first of these was a small scale SMS-based survey administered as part of the data collection during the field exercise, see details on this in section 3.6.

The second survey was part of the annual survey from the Directorate for Civil Protection (DSB) to Norwegian municipalities in 2020, where the INSITU project was invited to include a set of questions related to the use of system and tool support for information sharing and establishing common situational understanding and specifically on the use of map services.

3.6 Observation during field exercise

The INSITU research team participated in a field exercise in Birkenes municipality in Agder county on September 18, 2019. The scenario was an industrial fire that spread to the nearby forest, creating needs for evacuation of inhabitants in the affected area. The scenario also included search for a missing person. The purpose of the exercise was to train the first responder agencies and the municipal crisis management team on how to handle a serious incident and thereby strengthen crisis management skills (cooperation, coordination) and planning for such a complex scenario.

The project team members conducted observations at four different sites: the CIEMlab at the University of Ager, the crisis team of Birkenes municipality, the emergency dispatcher CCC and the Directorate for Civil Protection (DSB). Data were collected through an SMS-based survey, and interviews with selected participants both during and after the exercise.

For the SMS survey we sent two SMS messages at different times during the exercise to collect the perceived status of the participants regarding access to information and resources, for being able to analyse their ability to establish situational awareness and a common operational picture. A detailed description of the procedure and results of the survey is reported in Steen-Tveit et al. (2020).

4 Requirements

Based on the information collected in the project so far, this chapter outlines requirements related to the four focus areas of the project: information sharing, harmonisation of terminology, common map services, and evaluation and learning from incidents. For each area, a summary of current practice is first presented, followed by identified needs and resulting requirements. The requirements point out suggestions for further work, which also goes beyond the scope of the INSITU project.

4.1 Requirements for information sharing

4.1.1 Analysis of current practice

Our analysis of current information sharing practices among Norwegian emergency responders to a large extent mirrors the findings from the review of former research. After the terrorist attack on 22nd July 2011, cooperation (‘samvirke’) has been introduced as a core principle. National and regional exercises focus on improving the agencies’ ability to effectively share information and work together in responding to different scenarios. However, evaluations from real incidents such as the 2014 fires in Lærdal, Flatanger and Frøya in Norway (DSB, 2014) and large-scale exercises such as HarbourEx15 (DSB, 2016), document challenges of ineffective information sharing between involved responders and lack of a common operational picture (COP).

The stakeholders express a general challenge with defining the correct level of detail in the information to be shared, as the information needs vary between the different operational levels. Often, too much information is included in the situation reports, making these too comprehensive to be useful during time-critical operations.

Another basic problem pointed to is on the one hand a lack of knowledge about the information needs of the different agencies, and on the other hand a lack of overview of what information is available from different sources. As a result, potentially useful information is neither shared nor requested during the operations.

Further, there is a challenge with exchanging graded information. This is especially the case for hybrid operations involving information exchange between the military and the civilian sector. Several informants point to that there is a tendency to overuse grading requirements, and that often only specific parts of the material should be graded (see recommendations for ‘punktgradering’ in §28 in Virksomhetssikkerhetsforskriften). There is also a challenge with aggregating information elements that separately are not considered sensitive, but that together represent sensitive information on critical infrastructure such as telecommunications infrastructure.

Several information resources exist that specify operational procedures for communication and information sharing, such as:

- Håndbok for redningstjenesten (Handbook for the Norwegian Rescue Services) (JRCC, 2018)
- Politiets beredskapssystem (The police emergency system)
- Enhetlig ledelsessystem (Guidelines on unitary command system for incident response related to fire, search and rescue, and acute pollution).
- Retningslinjer for varsling og rapportering på samordningskanal (Guidelines for alert and reporting on common communication channel) (DSB, 2018).

As an example, a principle specified in the latest Handbook for the Norwegian Rescue Services (JRCC, 2018) pointed to by several as important is that during the first 45 minutes of a life threatening event, no one should expect or request information who are not directly involved in the response so as not to disturb the operation.

In terms of technology support, the current status is that the different sectors develop their own support systems, without necessarily considering support for intersectoral information sharing. This again is explained by the stakeholders as a result of each sector having separate budgets. The analysis shows varying levels of sophistication in use of technology support within the different sectors. As pointed to by several, the main challenge is often not to collect information but to have the sufficient capacity and skills for analysing the information to support further actions. As could be expected, the military can be considered most advanced both in terms of technological support and analytical capacity. Their operations centre involves 30 soldiers and 18 officers working in shifts 24/7 with building a COP as a basis for further analysis to support the operations. This process is based on extensive methods for data collection and analysis defined by NATO standards, covering metrics for both Measures of Effectiveness (MoE) and Measures of Performance (MoP) (NATO, 2015). Here the added value and effect of the information collected is the main focus. The joint headquarters also support civilian operations when requested. The contact interviewed here points to the need for the civilian actors to be more specific when requesting information, as the military has access to enormous amounts of information (also including historical data). In terms of technology support, the defense headquarters use a range of different systems for real-time collection of data. While thus being in the forefront in terms of technology use, they also point to challenges with interoperability between their many systems in use. Table 1 lists examples of information systems currently in use on a national scale in Norway.

Several of the emergency organisations are also in the process of updating or replacing their technological support systems. Examples of this include the 110 Command and Control Centre (CCC) in Agder, which has developed a requirements specification for map support as a basis for implementing a new system by the end of 2020. The 110 CCC has also recently implemented a system enabling callers to stream video and audio live from the incident scene through their mobile phone. The live streaming can also be shared with the CCCs for police and health.

The importance of co-location is also emphasized for effective inter-agency information sharing. Based on the positive experience from the co-located operations centre (Samvirkesenteret) established during the UCI Road World Championships in Bergen in 2017, the city has decided to develop this as a permanent function. During the world championship, 127 persons from 31 organisations worked together on monitoring and collecting information on critical societal functions for quick response to any occurring situations. Bergen municipality also received the 2019 societal security award from DSB (Samfunnssikkerhetsprisen) for their work with establishing the centre. In addition, resulting from a joint analysis of a concept for holistic crises management, Oslo police, Oslo fire and rescue services, Oslo University Hospital and the municipalities of Oslo, Asker and Bærum, have established the common OPSAM operations centre co-located with the Oslo police operations centre. Similar initiatives for co-location of CCCs and other emergency responders are currently being considered in other regions in Norway.

The liaison function represents another form of co-location, whose importance is mentioned in several evaluation reports. As an example, during the Trident Juncture NATO exercise in 2018, liaisons from 18 different emergency response organisations were present at the Norwegian Joint Headquarters in Bodø during the exercise. However, these liaisons shared information with their 'home organisations' using their own information systems. The Norwegian Directorate for Civil Protection (DSB) has developed a national guide for the liaison function (DSB, 2017).

Table 1. Examples of information systems supporting emergency management in Norway.

Information system	Description
Shared resources register (SRR) (Felles ressursregister)	A collection of information about resources from government agencies, voluntary organisations, and private businesses. The Shared Resources Register (SRR) streamlines operational efforts by sharing updated information about relevant resources across agencies and organisations. The tool is an initiative that helps strengthen public security.
Kriseinfo.no	The official Norwegian website providing valid and secure information to the general public before, during and after a crisis. The website presents updated and coordinated information from relevant Norwegian authorities and emergency actors. Hosted by the Directorate for Civil Protection.
CIM - Incident and crisis management software	Module-based crisis management software in use by most public organisations in Norway. Basic version offered for free by the Norwegian Directorate for Civil Protection
Nødnett	Digital nationwide multi-agency public safety network, offering secure inter-agency audio-based communication
H-VTC	Graded video teleconferencing
SARA (Search and Rescue Application)	Developed for the Joint Rescue Coordination Centres (JRCC) and the Ministry of Justice and Public Security. The Norwegian Coastal Radio and the Medico service are also using the application. Includes an event log and a map service.
Kystinfo Beredskap*	Service provided by the Norwegian Coastal Administration that provides real-time map services for COP and decision support related to marine incidents.
Barentswatch*	An open information system for sharing information from different partners related to the Norwegian coastal and marine areas. In addition, a shielded monitoring system is under development which will contribute to the efficiency of operational efforts.
Finnsenderen.no	The service provides an overview of the location of all base stations for public mobile and broadcasting services that have been put into commercial operation. Hosted by the Norwegian Communications Authority (Nkom) in cooperation with Norwegian mobile and broadcasting operators.
Traffic information (175.no)	Interactive map with traffic information and route planner, provided by the Norwegian Public Roads Administration.

*For more examples on map-based support systems, see section 4.3.1.

The visits to the military and civilian command and control centres also identified a need for more systematic pre-configuration of information sources to be activated in the CCC during different events. While this to some extent was defined for the military operations centre, the civilian situation centre had yet to establish such pre-configuration.

Access to sensor-based data also represents new potential sources of information. An example mentioned here is the European eCall automatic emergency alert system installed in all new cars after March 2018. When an accident occurs, the eCall system is automatically activated and transfers data from the vehicle to the 110 CCC (time, position, type of vehicle etc.) while an audio connection is also established among the passenger in the vehicle and the alarm central.

Another use of sensor-based information is provided by the mobile network operators who develop services for real-time monitoring of public mobility patterns in defined geographical areas. An example of this is the Telia City Vitality Insight solution that identifies crowd movement patterns from anonymized network data. And the project "Trygg in Oslo (TRIO)" (Safe in Oslo) run by the City of Oslo has explored the use of this kind of information since 2014. Their solution concept involves development of a web-based system from real-time integration of data from different sources to analyze possible risk situations in various parts of the city. The concept also includes an app that can be downloaded for free that lets the public report on incidents and suggested actions to improve public safety.

4.1.2 Identified needs

Analysis of current practice shows a general lack of common routines and tool support for sharing information among the emergency stakeholders in inter-agency operations. A range of different systems are in use, but with little integration in place.

Based on the analysis, the following list summarizes the expressed needs for improvements related to information sharing in inter-agency operations:

- Better understanding of the information needs of the collaborating partners
- Understanding the different information needs at tactical, operational and strategic level
- Identifying core information elements and related aggregation levels needed for establishing and sharing a situational picture for each core national function
- Establishing an actor map of involved organisations
- Developing standards and templates for electronic sharing of incident information
- More automatic collection and aggregation of data input
- Automated action cards
- Pull-based sharing, based on intersectoral platform for need-based information collection and sharing
- Sharing of reports between different CIM installations
- Support for cut and paste of textual information between the event logs of different agencies
- Better overview of resources, including 'rest capacity' that could be used by other agencies
- Mandated routines for information sharing
- Training in tools for information sharing and related templates·

These needs relate to different levels of the emergency management operations, some of which clearly exceed the scope and 'mandate' of the INSITU project. For example, several of the emergency stakeholders point to how a national coordinated initiative for changing work practices and improving information sharing is required for successful change, involving mandated routines supported by required resource allocations. The INSITU project can only contribute to document the potential and recommendations for improvements.

The stakeholders suggest that the ideal basis for information sharing would be a common data repository that could enable role-based access to relevant data for the operations of the different agencies. This would enable pull-based sharing of data on a need basis, and thus solve the inefficiencies reported in current practice. Such a solution would then require that each sector contributes relevant data to the repository, and that adequate access control is provided. Further, this service should be based on open data formats and non-proprietory solutions for data storage.

In general, from our analysis we have identified several systems that cover some of the needs in the above list, but limited to one or a few sectors or a specified subset of the national emergency actors. Thus, one possible way forward could be to suggest and specify extended use of these systems. However, this will require resources to be allocated from national authorities.

An example is the Shared Resources Register (Felles ressursregister) that already includes information about resources from government agencies, voluntary organisations, and private businesses. This service could possibly be extended further to include other resources related to critical functions in society, e.g. for the health sector.

Also, improved interoperability of the different versions of the CIM system being used in different sectors is pointed to as required for supporting more efficient information exchange. This again would be a task to be addressed by the CIM vendor, possibly based on a request from the Norwegian Directorate for Civil Protection as part of their framework agreement.

4.1.3 Requirements specifications

From the discussion of identified needs, we have specified the following requirements to be addressed in the INSITU project for developing collaboration support for information collection, synthesis and sharing.

Table 2. Requirements for information sharing

#	Requirement	Description
1	Procedural support for information sharing	Information management procedures for collecting, sharing and synthesising information from different sources
1a	Templates for information exchange	Refining existing action cards in terms of inter-organisational information exchange
1b	Automated support for collection and aggregation of data	Collaboration scripts supporting (partly) automated collection and aggregation of relevant data from different sources.
2	Scenario-based configuration of information sources to be displayed in (civilian) control and command centres	Predefined configuration of information sources to be displayed in combination in operations centres in different phases of a scenario.

The focus in this part of the project will be on contributing to better developed and unified procedures for information management. As a basis for this we will collect and analyse the current procedures, as specified in existing action cards (tiltakskort) and similar documentation. Implied in this will also be a detailed mapping of the information needs of the collaborating partners, related to different levels of operation in specific scenarios. The goal will be to develop templates for effective inter-agency information exchange.

Further, we will explore the possibility for defining collaboration scripts that include support for automated collection and synthesis of data from relevant sources. Related to this, we will focus on developing ‘best practice‘ for combining information sources in command and control centres, in the form of predefined configuration of information to be displayed in different phases of selected scenarios.

As specified in the INSITU project plan, these activities are intended to complement the integrated map support to be developed in the project. The requirements for these map services are presented in section 4.3.

4.2 Requirements for harmonisation of terminology

4.2.1 Analysis of current practice

We have searched the web and asked the project partners and members of the reference group to provide an overview of the existing glossaries in use in the fields of preparedness and rescue. Most of these are glossaries with Norwegian terms and definitions. We have also found a few examples with translations for cross border collaboration. The sources are presented in different forms including web pages, PDF documents, search service and some with an Application Programming Interface (API).

To allow glossaries to be harmonised we have collected some thirty different sources as proposed by the project partners. They have been prepared in the INSITU project to allow users to search across them, as a first step towards harmonization (see section 4.2.3). The covered sources are listed below in Table 3.

Table 3. Collected terminology sources

Source	Name or comment
Decision (EU) 2019/1930	EU document with preparedness relevance
Decision 1313/2013/EU	EU document with preparedness relevance
Decision 2014/762/EU	EU document with preparedness relevance
EUMC Terms	EU Military Committee
Flom	Vocabulary related to Flooding published by varsom.no
GEMET	General Multilingual Environment Thesaurus
Kartverket ordbok	Terms used to describe land, property and related services.
Kartverket symboler	Preparedness symbols for use on maps
KBT, Kollegiet for Brannfaglig Terminologi	Association for fire professionals terminology
Klima fra Språkrådet	Climate terms
MOM, Medisinsk Operativ Manual	Medical Operative Manual
Nødnett	Terms to describe the infrastructure and services
NS 5830 no - en, Samfunnssikkerhet - Beskyttelse mot tilsiktede uønskede handlinger	Norwegian Standard, Societal security - Prevention of intentional undesirable actions - Terminology
NS 5830 no - no, Samfunnssikkerhet - Beskyttelse mot tilsiktede uønskede handlinger	Norwegian Standard, Societal security - Prevention of intentional undesirable actions - Terminology
NSO no - en, Næringslivets sikkerhetsorganisasjon	The Norwegian Industrial Safety Organisation
NSO no - en, Næringslivets sikkerhetsorganisasjon	The Norwegian Industrial Safety Organisation
PTIL (Petroleumstilsynet)	Petroleum safety authority Norway

Redningshåndboken - forkortelser intl.	International abbreviations from the rescue handbook
Redningshåndboken - forkortelser	Norwegian abbreviations from the rescue handbook
Redningshåndboken – Navn	Norwegian names from the rescue handbook
Redningshåndboken - termer intl.	International terms from the rescue handbook
Redningshåndboken - termer	Norwegian terms from the rescue handbook
SML (Store Medisinske Leksikon)	Norwegian medical dictionary
SNL (Store Norske Leksikon)	Norwegian general dictionary
SUS	Stavanger University hospital acute medicine
UTKAST Barents Watch en - no	Sea rescue terms en - no
UTKAST Barents Watch no - en	Sea rescue terms no - en
UTKAST INSITU begrep	Terms collected in the INSITU project
UTKAST INSITU symbol	Comments about symbols collected in the INSITU project
Vegtrafikk (Statens vegvesen)	Road authority terms

Some additional glossaries we may want to include are listed below.

- The Norwegian Directorate for Civil Protection (DSB) https://www.dsb.no/lover/brannvern-brannvesen-nodnett/veiledning-til-forskrift/brannsikring-av-kirkebygg--en-temaveiledning-for-kirkebyggforvaltninger/#ordliste

Related European glossaries

- European glossary (2012) for wildfires an forest fires https://www.valabre.com/wp-content/uploads/en_european-glossary-for-wildfires-and-forest-fires.pdf
- Forest Fires Multilingual Glossary Mediterranean Forest Fire Fighting Training Standardization https://www.mefistoforestfires.eu/sites/default/files/annexes/mefisto_d_c_1.pdf and https://www.mefistoforestfires.eu/sites/default/files/annexes/forest_fire_multilingual_glossary_it.pdf
- Wildfires report https://ec.europa.eu/commission/news/annual-report-forest-fires-europe-2018-sep-20_en
- Risk Assessment and Mapping Guidelines for Disaster Management https://ec.europa.eu/echo/files/about/COMM_PDF_SEC_2010_1626_F_staff_working_document_en.pdf

International glossaries

- The National Wildfire Coordinating Group (USA) https://www.nwcg.gov/glossary/a-z
- The Canadian Forest Service https://cfs.nrcan.gc.ca/terms
- Alaska Department of Natural Resources http://forestry.alaska.gov/fire/glossary

4.2.2 Identified needs

The need for common terms are underlined by Jon Halvorsen, the newly appointed Director of the national rescue centre. In the Norwegian Security Journal called “Sikkerhet”, issue 3/2019, p40, Halvorsen stated - “Det er viktig at den norske redningstjenesten er lojale til et felles sett med ord og faguttrykk” (“it is essential that all stakeholders in the Norwegian rescue service are loyal to a common set of concepts and terms”).

Currently, terminologies for crisis management are fragmented and not maintained in a single repository. The Handbook for the Norwegian Rescue Services published in 2018 contains definitions of terms and acronyms to be used across sectors. However, this resource is only available as a PDF-document[1] or as a printed version, and does not include any targeted search functionality.

For smaller events the terms used to coordinate task, role, time, and location may not involve more than one sector, such as fire. For for such cases there is no need for harmonisation. However, for larger events where for example the fire resources in more than one municipality need to collaborate, then the need for harmonisation is pressing. This need lead to the forming of an association of firemen in Norway already in 1995, Kollegiet for brannfaglig terminologi, KBT (Professional association for fire-related terminology). Since then, several larger events increase the need to communicate among sectors and languages.

After the experience with the big forest-fire in Sweden (2018) where responders from several European countries came to help, there is also a clear need to facilitate cross-border collaboration, and to involve volunteers.

In the following we give some examples where different use of terms may be a source of misunderstanding among emergency responders in Norway. If a person is dead or alive may not be clear for all involved if one of the following terms are used: *drukning* (drowning), *MORS* (from Latin *Mortis*, dead), *puster ikke* (not breathing), *ikke vekkbar* (cannot be woken), *blek og kald* (pale and cold), *død og varm* (dead and warm). There are also issues concerning technical terms, especially *nett (network) which is used in different ways.* For example there are EKOM nett, (networks for telecommunication) and *transportnett (network for transport)*. In the health sector, a positive *test can* indicate a detected disease which is not positive for the patient. And *akuttfase* (acute phase) in a nuclear/radiation event can be longer than *akuttfase* in health and medicine. Yet an example is isolering (isolation), where health staff can isolate a person from spreading a disease, while the police use the term for a captured person.

A collection of all relevant sources for concepts and terms in the areas of rescue and preparedness, is a practical need underlined by members of the project reference group in the Oslo workshop.

Once we have a collection we will also need to search across all the sources. Indeed, a search service to support the lookup of terms was planned as part of the publication of the Handbook for the Norwegian Rescue Services.

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1 https://www.hovedredningssentralen.no/redningshandboken-er-endelig-her/

Methodology
The harmonisation methods indicated in section 2.2 do not address the practical needs to identify and adjust terms for better coordination across sectors.

A challenge is to find what cases and terms that are of common interest among different stakeholders. Initially we assume that concepts needed to communicate, status for event, location, timing, role of responders, and actions across sectors are those we need to focus on. However, depending on who arrives first to a site there may also be cases where for example a fireman are asked to do health tasks with instructions from health staff on their way.In practice people may forget a misunderstanding from communications in a stressed situation. One approach to find critical concepts can be to collect terms that have caused misunderstandings in exercises or in real events. Transcriptions from exercises is an interesting source. Interviews with first responders may also reveal issues.

A second approach to find critical concepts is to explore the collected sources. We plan to analyse the sources to find words with similar spelling but different meaning, similar sounding (homonyms), or similar definitions with associated with different terms.

A third approach to find potential conflicts among terms or definitions is to analyze learning materials across the sectors: how are they taught? Are they using the terminology from the Handbook for the Norwegian Rescue Services?

Currently the owner of the terminologies are aware of some differences among different stakeholders or organizations, thus, harmonization can lead to changes that may be expensive to carry out. While the benefit of harmonization is clear, the cost of implementing it may be to high to justify the changes. For each case this needs to be decided among the stakeholders owning the terminology sources, to decide if a change is needed or if it can be sufficient just to be aware of a difference.

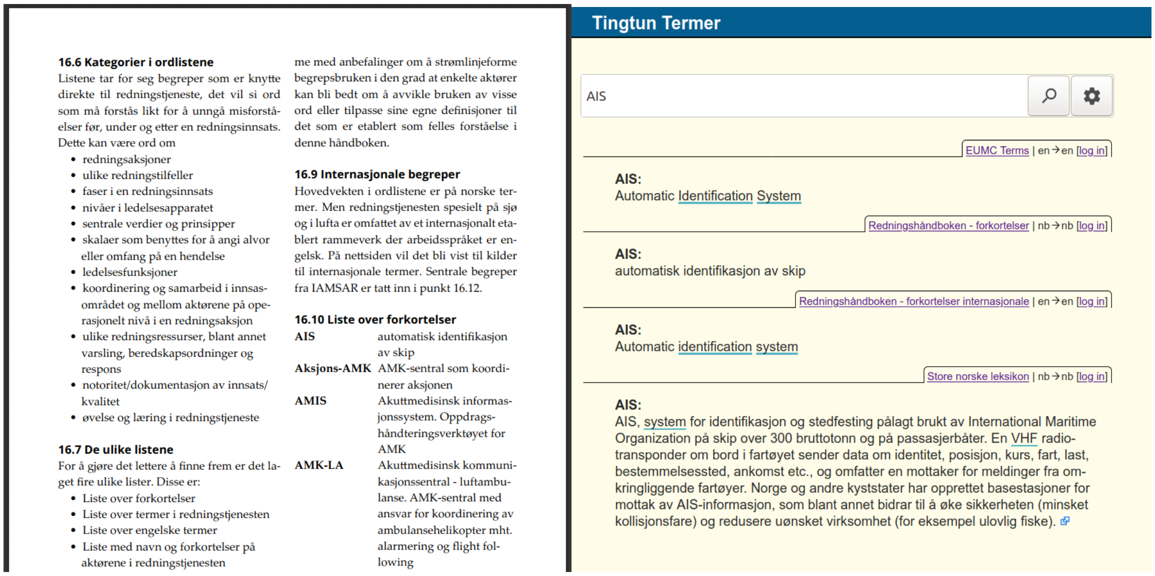
In addition to the expected general reluctance to change of terminology practices, we note that it is not clear who would be the owner and maintainer of a common terminology resource.

4.2.3 Requirements specifications

The high level requirement for the solution is to allow a user to search across relevant terminology sources, in a way that is supporting use across all common web browsers, and devices including Mobile, iPad, and PC. The service needs to be universally designed to make sure people with disabilities can use it. To assure wide and frequent use, the solution should also be designed in such a way that it can be used on top of different digital applications, such as digital maps, or applications for task allocation among volunteers.

As a pilot we have adapted the Tingtun Termer solution, available from https://insitu.termer.no/. This enables search across the terminology sources listed in Table 3. Figure 1 illustrates the use of the system. The collection of terminologies that are available in the *Handbook for the Norwegian Rescue Services* can be seen in the left hand side of the figure. While the suggested technology solution to search the terminologies across the sources, is shown in the right hand side.

Figure 1. Illustration of the Tingtun termer pilot



16.6 Kategorier i ordlistene

Listene tar for seg begreper som er knytte direkte til redningstjeneste, det vil si ord som må forstås likt for å unngå misforståelser før, under og etter en redningsinnsats. Dette kan være ord om

- redningsaksjoner
- ulike redningstilfeller
- faser i en redningsinnsats
- nivåer i ledelsesapparatet
- sentrale verdier og prinsipper
- skalaer som benyttes for å angi alvor eller omfang på en hendelse
- ledelsesfunksjoner
- koordinering og samarbeid i innsasområdet og mellom aktørene på operasjonelt nivå i en redningsaksjon
- ulike redningsressurser, blant annet varsling, beredskapsordninger og respons
- notoritet/dokumentasjon av innsats/kvalitet
- øvelse og læring i redningstjeneste

16.7 De ulike listene

For å gjøre det lettere å finne frem er det laget fire ulike lister. Disse er:

- Liste over forkortelser
- Liste over termer i redningstjenesten
- Liste over engelske termer
- Liste med navn og forkortelser på aktørene i redningstjenesten

me med anbefalinger om å strømlinjeforme begrepsbruken i den grad at enkelte aktører kan bli bedt om å avvikle bruken av visse ord eller tilpasse sine egne definisjoner til det som er etablert som felles forståelse i denne håndboken.

16.9 Internasjonale begreper

Hovedvekten i ordlistene er på norske termer. Men redningstjenesten spesielt på sjø og i lufta er omfattet av et internasjonalt etablert rammeverk der arbeidsspråket er engelsk. På nettsiden vil det bli vist til kilder til internasjonale termer. Sentrale begreper fra IAMSAR er tatt inn i punkt 16.12.

16.10 Liste over forkortelser

AIS	automatisk identifikasjon av skip
Aksjons-AMK	AMK-sentral som koordinerer aksjonen
AMIS	Akuttmedisinsk informasjonssystem. Oppdragshåndteringsverktøyet for AMK
AMK-LA	Akuttmedisinsk kommunikasjonssentral - luftambulanse. AMK-sentral med ansvar for koordinering av ambulansehelikopter mht. alarmering og flight following

Redningshåndboka p96. *«AIS» acronym search in several sources.*

From the discussion of identified needs, we have specified the following requirements to be addressed in the INSITU project for terminology harmonisation.

Table 4. Requirements for terminology harmonisation

#	Requirement	Description
1	Seamless and simple ways to access terms and symbols	Wide and frequent use of terminologies and symbols are necessary to make sure they are properly understood in training and practice.
2	A national authoritative online location for the terminology and search service	To assure wide use of a harmonised terminology it has to be presented on a website known and used by the collaborating stakeholders.
3	Joint terminology repository for all Norwegian emergency map services	A common repository of terminologies, glossaries and dictionaries for use across map services used by the stakeholders.
4	A simple feedback channel for comments	User feedback is crucial to maintain the quality of the sources. Nasjonalt Redningsfaglig Råd, NRR (National professional rescue council), will be invited to deal with comments as input to an update of the Handbook for the Norwegian Rescue Services.
5	A verified overview of properties of terms to take into account for harmonisation	In our preliminary harmonisation methodology we have proposed several properties of terms to use for comparisons in harmonisation, such as orthography or sound for audio communications. This list needs to be verified with real cases and users.

6	A consolidated list of sources of terminologies and symbols	The basis for harmonisation is the overall list of terms and symbols currently in use.
7	Automated support for collection and verficiation of sources	Tools to enable automated retrieval of online sources to assure that the source owners can continue to maintain their sources. Changes could be verified by NRR before they are made available for search.

4.3 Requirements for common map services

4.3.1 Analysis of current practice

Survey on COP map-based interfaces in use by selected emergency responders in Norway As documented in the 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 Online, Avinet's map services, Basecamp, GIS-link, Locus TransMed, Locus TransFire, Terra and Vision). However, none of these are considered to fully cover the needs for the emergency responders (Røed-Bottenvann, 2018). Furthermore, the use of symbols and colour are 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 integrating data from different sources (JRCC, 2018).

Our study on the data content (map background, thematic overlays, dynamic content on-the-fly, forecasts), functionality provided (supported use case scenarios) and cartographic symbolization of COP map-based interfaces in use by selected emergency responders in Norway revealed that apart from TransMed, the other surveyed interfaces (Table 5) have been primarily designed for planning and execution of day-to-day operations. A common feature of the surveyed tools is their rich content. The tools either directly enable displaying of various map backgrounds, overlays and thematic content (in particular in The Marine Spatial Management Tool), or redirect to other sister-tools that enable displaying various map layers (the Wave forecast tool).

Table 5. COP map-based interfaces included in the survey

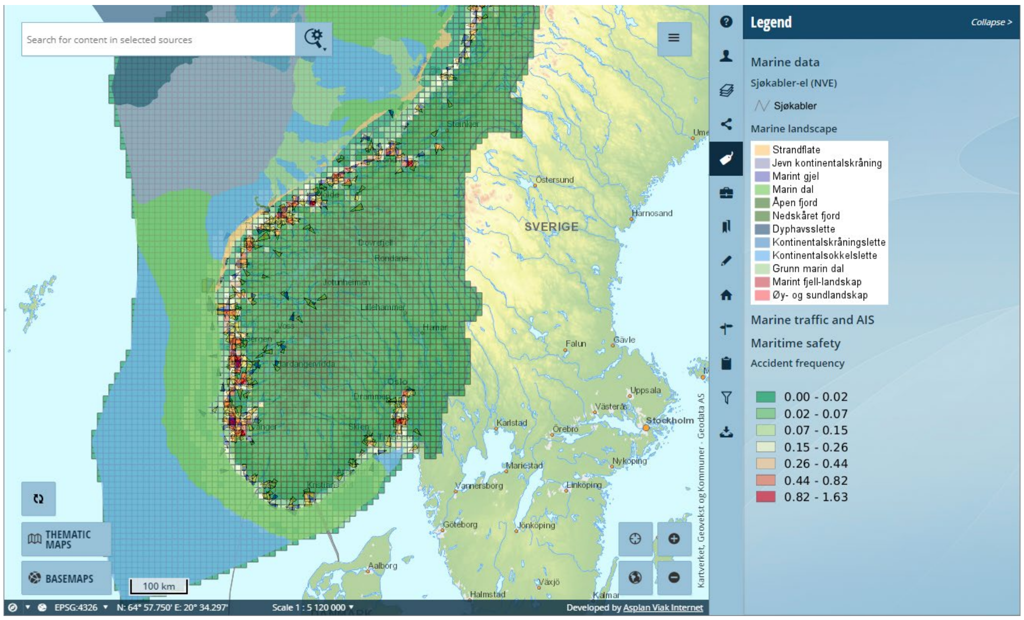
Service name (URL)	Service provider	Service producer
TransMed (unavailable)	Ambulance services	Locus Public Safety
KystInfo (https://kart.kystverket.no/)	The Norwegian Coastal Administration (Kystverket)	Avinet
DSB Map (https://kart.dsb.no/)	The Norwegian Directorate for Civil Protection (DSB)	Avinet
Wave forecast (https://www.barentswatch.no/en/waveforecast)	BarentsWatch	Avinet
The Marine Spatial Management Tool (https://kart.barentswatch.no/)	BarentsWatch	Avinet

Surveyed tools offer functionalities typical for regular web mapping services such as layer manager (e.g., DSB Map, Wave forecast), measuring distances and areas (e.g., Wave forecast), and data filtering (The

Marine Spatial Management Tool). Moreover, the considered tools enable drawing objects on a map (e.g., KystInfo) that can be saved and shared (with the background map) with other system users.[2]

The surveyed map-based tools from Avinet feature similar functionality. To some extent, they also share similar layout and design (e.g., KystInfo, DSB Map, and The Marine Spatial Management Tool) (Figure 2).

Figure 2. Kystinfo – one of Avinet's map-based tools that share similar layout and design with other Avinet products



The layout of Avinet's fourth considered tool, i.e., Wave forecast, has undergone modifications and redesign in comparison with the design of the company's earlier products. For example, its layer manager has been moved to the left-hand side and the legend is shown at the bottom of the interface (Figure 3).

The surveyed tools use map symbols that have been inherited from their map backgrounds and thematic overlays. This causes diversity in the cartographic symbolization. Reading difficulties, i.e., problems with visual information decoding, appear if several thematic overlays are shown simultaneously. Figure 2 shows KystInfo with four thematic content layers being displayed: sea cables (sjøkabler), marine landscape, marine traffic and AIS (Automatic Identification System), and maritime safety (accident frequency). Since two of the layers, i.e., marine landscape and maritime safety, use similar colors for two of their legend categories, the map interpretation needs to be careful.

TransMed is of a different nature as it is to be used by a first-response emergency actor whose responsibilities and tasks are strictly determined by regulations and procedures. TransMed combines a map display with tables. The map shows status and positions of ambulances, various points of interests, and events, whereas the tables contain information about selected objects and communication logs. The symbology in use has been determined by the target users. However, background maps and thematic

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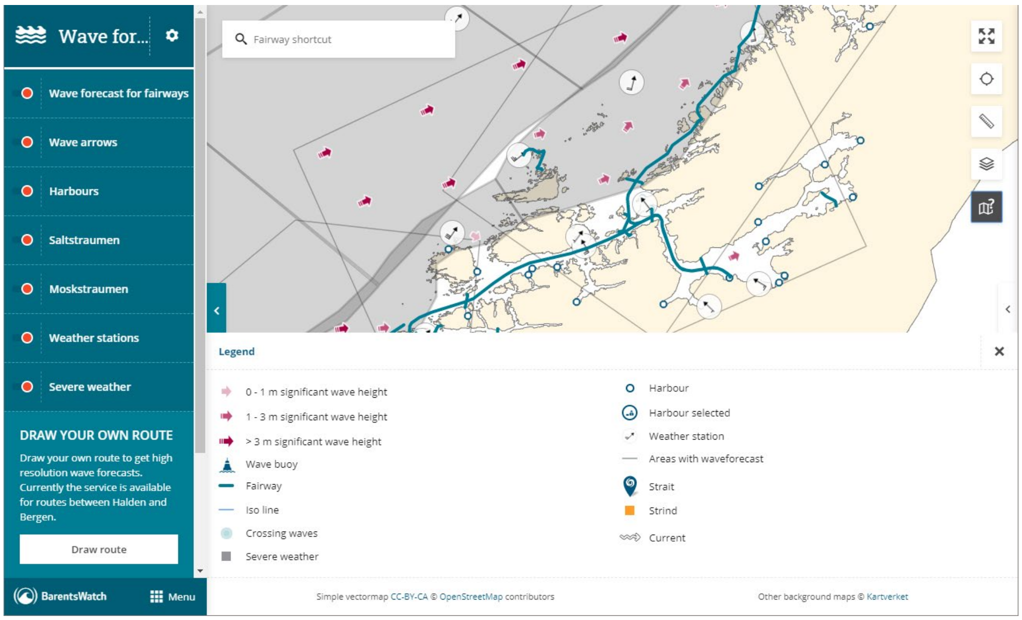
[2] See here for a demonstration in Norwegian: https://youtu.be/r0JJefwqEzQ

map overlays, typically retrieved as Web Map Service raster tiles, use the same symbolizations as those used by the authorities the maps come from.

Figure 3. Wave forecast – one of Avinet's map-based tools that has undergone layout redesign



Interviews with software producers/distributors

The interviews with COP software producers/distributors (Table 6) enabled us to get an understanding of current practice with regard to common map services, how the producers try to fulfill requirements and expectations of emergency responders. Such understanding is needed to get insight into features that make COP map-based interfaces usable and useful.

Table 6. Interviews with COP software producers

Service producer	Date	Details
Locus Public Safety	October 14, 2019	A representative of Locus Public Safety was interviewed by two representatives of the INSITU project. The meeting lasted 1.5 hour.
Avinet	November 13, 2019	A representative of the Avinet company was interviewed by two representatives of the INSITU project. The meeting lasted one hour.
Geodata	March 5, 2020	The meeting with two representatives of the Geodata company was organized online and lasted one hour.

Locus Public Safety

The first responder agencies, i.e., police, fire departments, and ambulance services, are the target users of the solutions offered by the Locus Public Safety company. The solutions consist of tools for command posts, such as TransFire for fire departments, TransMed for ambulance services, and Tellus for the police, as well as tools for emergency mobile units such as TransMobile. Both tool types communicate with each other, e.g., TransFire can continuously update task descriptions that are automatically provided to specific mobile units that use TransMobile. Furthermore, TransMed and TransFire offer customized map data, with functionality of map-based interfaces tailored to organizational responsibilities and the workflows of the respective agencies. The geographic and map-based components are "integrated from external mapping companies", according to customer specifications. The current generation of systems has not been integrated with other map-based solutions, but cross-organizational collaboration was said to be increasingly required to fulfil the responsibilities of each agency.

Tools that enable multi-agency data access and dynamic integration of real-time geographic content (e.g., resources, events, missions) across various agencies are not yet supported in the company's products. This was not due to technical restraints, but rather related to concerns about legal frameworks and systems requirements from customers. Some information has already been shared for specific users, e.g., emergency medical communication centers have an overview of police cars and fire trucks and, as one interviewee put it "I don't think the trend is to share less, I think the trend is to share more." It was emphasized that tool development is a multistage process with mutual interaction between user groups and system designers and, as one interviewee put it "it is very rare that something that is really good comes without a proper effort." Agencies often do not recognise the benefits of seeing extra information on their map displays, until they have such information provided. Then, they can determine new operational tasks.

As one interviewee suggested, a solution could be to assign "a unique number to each emergency mission." As a result emergency responders "can start to link things together so (...) they, on the mission, can gain position on others on the same mission." Thanks to this one can share the operational picture across the three first responder agencies based on such a unique number. Having all information on a screen instead of reading various textual reports is an essential advantage. Moreover, various local actors expressed willingness to share information on maps, but one needs to remember that the actors also have sensitive data they are not allowed to share.

Symbolizing data in map-based interfaces was stated to be a challenge, as "too much data shown on the map means no information, but only data and noise." The company tries to follow design solutions already known from maps published by Norwegian authorities. Moreover, the company has also elaborated its own standardized symbol scheme, which is for instance implemented in TransMed. When it comes to background maps, the company has a map variant in which the amount of information is reduced if zoomed out. This helps to emphasize real time data content. The latter is typically visually encoded by means of symbols from the emergency symbols set from the Norwegian Spatial Data Infrastructure register.[3] Additionally, the symbols are color-coded depending on determined principles, e.g., in TransMed, the symbols are presented in red, yellow, green, and white, depending on the event priority. Several agencies use the same symbology; however, there is still a need for a common symbology, e.g., if a specific area is contaminated and first responder agencies need to know that they need protective clothing. Furthermore, the way the same information is presented in command posts and in the field differs. For example, display devices used outdoors may need to use saturated and strong colors, and as a consequence, presented information may have to be shown with less details.

[3] Available from: https://register.geonorge.no/symbol/symbolpackages/details/765ad2b6-5994-44ff-9ae0-2d759edc309f

Avinet
The company has so far delivered several map-based decision support tools for directorates, county governors, and county councils in Norway. Although Avinet develops map-based interfaces based on specific requests, the tool development process is typically stepwise and requires continued collaboration with the customer. As an interviewee put it "together we find a solution." Their map-based tools are used, for example, in exercises and, along with exercise customization, modification needs arise. Continuous modifications were needed, for example, during the development of map-based solutions for the Norwegian Coastal Administration (NCA).

Although Avinet has developed tools for various agencies, NCA is the main user of its map-based solutions for information sharing. In NCA, the need for map-based interfaces for emergency management and situation awareness has been recognized quite early. A major reason was some major ship accidents that resulted in oil spills with severe environmental consequences (e.g. the Full City accident from summer 2009). After severe oil spills, there is a need to register *where* the affected areas are, *what* are the required actions and available resources we may deploy to clean up the oil. Avinet develops the map-based solutions for the many actors that are involved, and who need common situation awareness, such as various inter-municipal panels for acute pollution (Interkommunale Utvalg mot Akutt forurensing, IUA). An effective emergency preparedness or response requires access to information from various sources, e.g., information about ship traffic resources available from the Coastal Administration, from the Norwegian Clean Seas Association for Operating Companies (NOFO), and others, and information from third-parties are also needed, such as data on vulnerable or protected areas from the Norwegian Environment Agency. Finally, the development process of map-based interfaces for emergency responders is challenging since it is not only about providing data and functionality to responsible agencies during an emergency preparedness situation. Such interfaces are also in use by third-party actors such as the media to gather necessary information. As the interviewee put it, "Third-party actors who needs to know the status and development of an oil spill situation, whether it has relocated and so on. So that is an important requirement, to have functionality to gather information there and then, but also to disseminate information. Put simply: data sharing."

There are no specific repositories with standardized symbols in use by Avinet and often the customer has some ideas for how specific information should be represented on a map. However, Avinet needs to adapt customer ideas to map conditions. For example, the needs expressed by a customer may lead to problems with map interpretation since one "often needs to see a lot of information at the same time, and a lot of the data one may get from third-party sources." Then, "the third-party objects are represented with a certain color that the third-party has determined as required." However, the color cannot be used in an emergency or planning context if this color is already used to encode a specific message. As one interviewee put it "if you combine together many actors you will have a conflict." Therefore, a common symbol library will help to avoid misunderstandings.

Geodata
Geodata is a distributor of ESRI's ArcGIS platform. The platform is used in Norway by the police, defense, AMK centers, health authorities, and fire / rescue in connection with crisis management. The platform is used both for planning in advance and for fleet management during incidents. It is a collaboration platform that makes it possible to communicate across organizations and have a live updated situation map available to everyone on different devices (mobile, PC or web). The platform provides functionality typical for GIS tools, therefore, it enables users to get access to geographical data integration and spatial analysis methods such as spatial selection and buffer analysis. Moreover, through further integration with

reporting tools such as CIM, TransMed, or TransFire, emergency responders get access to a fully equipped environment.

For the police, Geodata is delivering the GIS platform, while Locus Public Safety delivers the map client. Geodata also collaborates with county governors who have access to parts of the software platform. The company also works with the road administration, NVE, and Norwegian Mapping Authority. In turn, Agder Energi uses ArcGIS to inform the public about where there is a power outage.

Meetings with emergency responders

Two meetings with emergency responders were conducted (Table 7) to gain a better understanding of the way COP map-based interfaces are used by the emergency responders and to gain feedback on the interfaces' advantages and shortcomings.

The first meeting was arranged as a two-day workshop with multiple emergency response organizations. The workshop consisted of three group sessions that employed different empirical techniques such as brainstorming and world café, see section 3.4 for more information. In this section we refer to the workshop's brainstorming session. The second meeting was arranged as a Skype meeting with a representative from the Norwegian Coastal Administration. A live demonstration of the map-based tool in use by the NCA constituted the basis for the discussion.

Table 7. Meetings with emergency responders

Date	Meeting format	Details
October 15-16, 2019	Two-day workshop in Oslo	The workshop was divided into three group sessions and aimed to discuss information sharing for common situational understanding. Twenty individuals attended the workshop. They represented various agencies and emergency responders such as police, fire department, health services and the Norwegian Directorate for Civil Protection (DSB).
November 29, 2019	Skype meeting	The meeting was built around a live demonstration of the COP map services in use by the Norwegian Coastal Administration (NCA). The meeting lasted 1.5 hour.

Workshop with multiple emergency responders

After the extraction of the brainstorming session data from the Oslo workshop, seven categories were identified as requirements for COP map-based interfaces: (1) symbolization, (2) visualization, (3) extra information, (4) functionality, (5) standardization, (6) knowledge, and (7) management.

Among the participants, the symbolization issue (1) generally appeared as a requirement of a common cartographic symbolization and a standardized symbol usage with a common cartographic design of basic map backgrounds. The backgrounds should be established for all emergency responders, and desired information should be overlaid on those basic map backgrounds. Visualization (2) was identified as a map or a graphic representing both map-based information and extra information with thematic overlays (3). The latter should result in developing mapping solutions tailored to needs, i.e., it is necessary to have a map display with thematic layers and levels of info-types such as electricity, water, waste, weather, crimes, operations, activities, and statistics. These maps should serve as a foundation, and emergency responders need more situation-specific overlays, e.g., weather forecasts, power, resources. A complete resource overview across agencies and organizations should be included in the map. In turn, functionality (4) should contain a set of predefined interactive analytical functions, for instance, sharing the same COP map-based interface across different agencies at a national level to avoid misunderstandings caused by inconsistencies in terms of geographical names. A common interface should support transferring data or images, real-time sharing of resources and events. As some attendees argued, it is important to have a map-based interface for "drill-down" and to have "various perspectives" such as satellite-night-sea, sea level view, and aerial imagery. The stakeholders need more openness to connectivity as third-party actors, and the compatibility between different map systems. The map solution should be intuitive and made available as a unified system both internally and externally.

The participants reported on the need for establishing a "sharing regime" standard (5), i.e., a national-level standard for providing and sharing information. The standardization should include the datasets to be integrated in different systems. It is important to have a joint map repository for all Norwegian emergency map services. The leading agency should report to the collaborating agencies by following a standardized template with map overlays. The participants also expressed knowledge needs (6) regarding existing solutions and various sources that can be used on the map. As an example, one of the representatives from the police referred to the CompStat system developed in the 1990s at the New York Police Department to help reduce crime (Weisburd et al., 2003). CompStat stands for 'computer statistics' and supports law enforcement dealing specifically with crime. Lastly, the management aspect of the overall map-based interfaces (7) was mentioned to be equally important as good technologies. The map-based information of any kind should be a "freshware" that needs to be updated frequently, e.g., every week. However, this implies further challenges since adequate human resources are necessary to administer and maintain such systems.

Meeting with the Norwegian Coastal Administration

In this meeting, a representative from NCA presented and gave a demonstration of the agency's COP map-based interface. During the meeting, five members of the research team were asking follow-up questions.

While NCA's main focus is marine traffic, its primary concern is oil spills resulting from vessel accidents. NCA's map-based solutions facilitate documentation, effective decision-making and action. The tool which is freely available at NCA's website does not offer typical COP functionality. However, such functionality is provided through the tool's version "Kystinfo Beredskap" [eng: Coastal Information - Emergency].

Kystinfo Beredskap has an open part that provides typical web mapping functionality, and another part that is password protected and assigns users specific roles. This part integrates background maps with thematic overlays such as environmental characteristics and infrastructure, with situation data such as real-time observations and engaged resources, as well as weather forecasts and driveway calculations. Moreover, Kystinfo Beredskap enables selective and targeted information sharing. The tool's recent developments have been comprehensively tested with emergency responders dealing with oil spills. The functionalities include accessing remote measurement data from boats, aircrafts, and drones. A lot of remote sensing data undergo real time geo-processing.

4.3.2 Identified needs

The analysis of current practices in terms of COP map services reveals the following needs:

1. **National-level standard for providing and sharing information**
   Stakeholders reported on the need for establishing a "sharing regime" standard. It results from

the shortages in terms of national regulations to determine rules for multi-agency data access and dynamic integration of real-time geographic content (e.g., resources, events, missions) across various agencies. Such regulations are for instance needed for sensitive or graded data, which, typically, are not allowed to share.

2. **Cross-institutional collaboration and mutual interaction between user groups and system designers**
   Agencies often do not see the benefits of seeing extra information on their map displays, until they have such information provided. Then, they can determine new operational tasks.
3. **Joint map repository for all Norwegian emergency map services**
   Common cartographic design of basic map backgrounds is needed. The backgrounds should be established for all emergency responders, and emergency relevant information should be overlaid on those basic map backgrounds. Relevant emergency information needs to be available as thematic maps that can be accessed as web map services (WMS) by all institutions. Map services should also contain background maps where the content is reduced when the map display is being zoomed out. This helps to emphasize real time data content. Use of common map backgrounds are also important to avoid misunderstandings caused by inconsistencies in terms of geographical names that appear if different map backgrounds are used.
4. **A unique number to each emergency mission**
   Such ID key numbers enable linking actions and resources together.
5. **Limited information to be shown at once in a single map-based interface**
   Symbolizing data in map-based interfaces was stated to be a challenge, as "too much data shown on the map means no information, but only data and noise."
6. **Common operation symbology**
   Common map symbol repository along with a standardized symbol usage - the rules that determine how the symbols are to be presented (colour, size, background) in specific situations.
7. **Common operation functionality**
   A set of predefined interactive analytical functions to support transferring data or images, real-time sharing of resources and events.

4.3.3 Requirements specifications

From the discussion of identified needs, we have specified the following set of requirements for COP map-based interfaces (Table 8).

Table 8. Requirements for COP map-based interfaces

#	Need	Requirement description
1	National-level standard for providing and sharing information	Regulations to determine rules for multi-agency data access and dynamic integration of real-time geographic content across various emergency responders
2	Cross-institutional collaboration and mutual interaction between user groups and system designers	Cross-institutional collaboration procedures for designing and developing COP map-based interfaces

3	Joint map repository for all Norwegian emergency map services	A common repository of thematic maps available as web map services (WMS) including those with reduced content to be used in simplified operational map interfaces
4	A unique number to each emergency mission	Regulations to assign a unique ID key to each emergency mission to facilitate the share of information in COP map-based interfaces
5	Limited information to be shown at once in a single map-based interface	Rules for reducing information to be shown in a single map-based interface to prevent visual clutter and information overload
6	Common operation symbology	Repository of common operation cartographic symbols along with the standards of their usage (to be addressed in the INSITU project)
7	Common operation functionality	Definition of interactive functions to be commonly implemented in COP map-based interfaces of any kind (to be addressed in the INSITU project)

As indicated in the table, requirements 6 and 7 will be addressed in the INSITU project.

4.4 Requirements for evaluation and learning from incidents

4.4.1 Analysis of current practice

The analysis mainly focuses on practices in Norway and Sweden. The Norwegian Directorate for Civil Protection has published a set of guidelines on how to conduct and implement exercises and the evaluation during the exercise (DSB, 2016). This guideline is published together with other sets of methods for conducting exercises, which is so far only available in Norwegian (both bokmål and nynorsk). The guidelines and method resources include:

1. *Veileder i planlegging, gjennomføring og evaluering av øvelser – grunnbok (2016) (Basic guide for planning, conduct and evaluation of exercises)*
2. *Metodehefte: Fullskalaøvelse (2016) (Method handbook: full scale exercises)*
3. *Metodehefte: Spilløvelse (2016) (Method handbook: game exercise)*
4. *Metodehefte: Diskusjonsøvelse (2016) (Method handbook: table-top exercise)*
5. *Metodehefte: Evaluering av øvelser (2018) (Method handbook: evaluation of exercises)*
6. *Metodehefte: Lokal øvingsleder (2018) (Method handbook: local exercise leader)*

For our purpose, resources 1) and 5) are most relevant. The first document consists of three main parts: about the general perspective of exercises, about the framework on deciding the exercise options, and about planning, implementation, and evaluation of the exercises. The latter is the relevant part for our purposes.

Currently, there are seven core documents required for implementing an exercise: 1) Exercise guideline (*Øvingsdirektiv*); 2) Guideline for implementation (*Gjennomføringsdirektiv*); 3) Phonebook consisting of list of addresses/phone numbers that will be used in the exercise (*Sambandskatalog*); 4) Exercise script which needs to be made available two weeks before the actual exercise (*Dreiebok*); 5) Evaluation guideline that describes how the exercise will be evaluated, the valid choice of method, how to organize the evaluation, and the time table (*Evalueringsdirektiv*). Sometimes in smaller exercises, this document is only a chapter under the practice guideline document instead of a separate document. The guideline should also operationalize the goals of the exercise into measurable indicators as a guide for the evaluators; 6) Evaluation report, which must consider both the size of the exercise and what seems appropriate (*Evalueringsrapport*). Usually, a preliminary version of the document is sent to participating actors and evaluators, allowing them to correct factual errors before distributing to those who have participated in the exercise; 7) Action plan to follow up on the evaluation report and to monitor learning points from the exercises (*Oppfølgingsplan*).

Concerning the definition of evaluation, the guideline document emphasizes that the evaluation is a systematic assessment according to the defined goals of an exercise and the goal achievement criteria. The primary purpose of an evaluation is to enable reflection that can contribute to learning and identify needs for changes (DSB 2016, 2018). The reasons for conducting evaluation are to document what has happened, analyze why this happened, to assess what practices can be continued and what can be done to make changes to improve, and to find learning points and suggestions for action. The evaluation work must be part of the planning process, as the person responsible for the evaluation has an important role right from the start of the work on the exercise. There are several roles assigned for this evaluator team, i.e., the evaluation leader and the local evaluators. The leader of the evaluation team will be responsible for the overall evaluation processes. The local evaluators can come from other organizations, and should be experienced and have enough knowledge of the activities and points that need to be evaluated.

Overall, the suggested evaluation method after the exercise follows the model of After Action Review (AAR) that has been discussed in Chapter 2. It should occur immediately, and this is referred to as a *Førsteinntrykkssamling (First impression gathering)*. This activity should be completed as quickly as possible, preferably right after the exercise, and should involve all participating stakeholders. The central questions of the AAR are the following: 1) What did we expect to happen? 2) What happened? 3) What went well, and why? 4) What can be improved and how? The idea is to observe the exercise and then combined with AAR in the form of interviews with participants, connect the answers to e.g. command and control capacity and from here propose ICT supported solutions to improve this capacity. In the long run, the solutions may support not only learning processes but also more objective evaluations, e.g. of capacities.

Document 5) (*Method handbook: evaluation of exercises)* in the above list provides technical evaluation details of many points mentioned in the first document, from the beginning of the evaluation planning. Relevant questions to be asked during the planning process include: What do you want answers to? How to implement this? What are the boundaries? What questions should be asked? Which method(s) are suitable for which type of question? How will the data be processed? Will a written report be required? How will the evaluation result be conveyed to the relevant stakeholders? The document also emphasizes the need for using indicators to assess whether or not the evaluation goal is fulfilled. An indicator is a description of activities, measures, decisions or time factors that need to be fulfilled, which can be qualitative, quantitative or both. It primarily recommends specific methods for data collection as a basis for evaluation, such as observation, questionnaire, interview, and log from other documents. Some methods such as interviews can also be done before, during and after the exercise.

Further, document 5) includes ten attachments as a set of forms and templates that can be used and adapted directly, so that the users can have a more concrete understanding of what to do in different phases of the planning and implementation of the evaluation. For the INSITU project, the most interesting is to see whether or not these practical guidelines include a focus on a common operational picture and shared situational understanding. Attachment 4 provides a form to capture the experience after an incident or exercise. In this form the respondent is asked to describe the situation through answering the question of what happened, which should include the consequences of the event; what measures were implemented; and which actors were involved in the event or exercise. These are all questions that can be considered as a way to describe the operational picture and shared situational understanding. However, as this only gives a verbal description, it provides a limited basis for evaluating whether or not a common operational picture and shared understanding were established properly during the event.

In addition, the responders are supposed to fill out immediate learning points as specified in the attachment 5, which focuses more on different responsibilities (cooperation, communication, media response, caring for the affected, health, environment and security), and evaluate which ones function well and which do not. These aspects are necessary to identify learning points from the events, but cannot be used to evaluate when and how common understanding was shaped, and if there were misunderstandings, how these misunderstandings were solved, among which actors these misunderstandings occurred, what were barriers causing the delay of establishing a common operational picture and common understanding, what were the consequences of this delay, and so on.

Two guidelines have been published in Sweden by the Swedish Civil Contingencies Agency (Myndigheten för Samhällsskydd och Beredskap, MSB) on the fundamentals of exercise planning (MSB, 2017a), and on exercise evaluation (MSB, 2017b). Before these two publications, another guide called Handbook Evaluation Exercise was produced but initially was used for the Barents Watch exercise 2011 in Sweden (MSB, 2011). Apparently, the evaluation term is used instead of "learning from incident," "learning from disaster," or "after-action report," but the evaluation is considered as a part of lessons learned activities. The exercise evaluation guideline (MSB, 2017b) incorporates evaluation in all exercise cycles: before, during, and after the exercise. The evaluation process has its own structure such as the evaluation leader, the local evaluators, system evaluators, the observers, and the exercise participants, which will be evaluation objects, but also recipients and end-users.

An exercise evaluation should answer the questions, 'how did it go?' and 'why did it become so?' The exercise evaluator needs to consider both the pre-existing conditions, the process, and the result, to acquire a picture of how it went and why. Furthermore, MSB (2017b) recommends the use of indicators for exercise evaluations. An indicator indicates whether a certain ability has been demonstrated during the exercise. Indicators are often defined in terms of observable data, such as questions that can be answered by true/false, or measurable data such as time, numbers or percentages. Indicators are often tied to objectives, and they then provide support in assessing the achievement of objectives.

Although the guideline itself is very general, a concrete case provides a useful example that can indicate the attempt to build a common operational picture or common understanding through information sharing. For example, the actors' joint objective can be to increase the capability to share information that is of actors' joint interest. The actors' joint indicators can be the percentage of actors' attempts at information sharing that succeeded in establishing contact with the desired function of another actor. Thus the evaluation can be formatted as: " How were other actors contacted?", "How did other actors share information with the actor you are evaluating."

It is also suggested to collect data, but it is essential to consider that it is "good to have ", or just to be "on the safeside", and not just for the sake of collecting data. The recommended methods are to choose a combination of methods, including, e.g., both an evaluation protocol during the exercise, and evaluation questionnaires and interviews after the exercise, also via documentation. During the debriefing, evaluation questionnaires can be distributed. Quality assurance is also highlighted throughout the entire process, with an emphasis on participation and regular dialogue with the exercise actors, and on having a reference group attached to the planning and conduct process.

In short, MSB has produced advanced exercise evaluation documents to assess emergency management drills, which in theory, is applicable for the real incidents as well.

4.4.2 Identified needs of improved evaluation

There is currently a lack of shared resources for supporting systematic learning from exercises and for supporting "double loop" learning. Being able to use a COP and integrated map interface also in the evaluation phase, would represent a major improvement in practice. To support the learning from incidents, we consider integrating terminology and map support and adding functionality for recording and playing back event handling in the common map. Based on the workshop discussion and brainstorming with the national stakeholders (ref. section 3.4), the following needs have been identified. It should be noted that, at this point of time, many of them are described at a high-level and needs to be explored in more detail as regards content, i.e., what kind of facts on which to base the evaluation.

1. **Objective and Fact-Based Evaluation:** There is a need for a better fact-based evaluation process, and ability to reconstruct an event or exercise in evaluations. The evaluation should be objective and knowledge-based, based on a correct understanding of reality.
2. **Evaluation on Collaboration:** There is a need to evaluate collaboration both horizontally and vertically.

3. **Coordinated, Interdisciplinary or Agency-specific Evaluation:** There is a need to coordinate evaluations from each sector to an overall picture, which should be based on facts and provide the ability for retrospective analysis. It would provide added-value in evaluations by looking deeper into mutual and cross-sectoral dependence and challenges. In some contexts, agency-specific evaluation for some can yield the best results.
4. **Resources for evaluations:** There is a need for more resources for evaluations.
5. **Tools that support evaluation:** There is a need for tools that can support the evaluation such as digital information and dynamic information that enables understanding of consequences, during and after a crisis. Moreover, there is a need for tools that provide systematic, and aggregated evaluations.This digital information can be used for systematic evaluation and follow-up. In addition, tools for simulations of events could support better evaluations.
6. **Map-based evaluation of situational awareness and common operational pictures:** Today, screenshots are used to register and share situational awareness and common operational pictures. There is a need for a map-based solution with time stamps, maps, logs, and symbols, to improve COPs and better evaluations of command and control of crisis operations. These map-based solutions should also provide decision material (decisions taken during operations/exercises) to be used in evaluations. Map-based tools will particularly be beneficial for evaluations of large-scale events. It is important as well to be able to collect map-based data for evaluation purposes. This can be supplemented by ICT resources that provide updated COPs. Moreover, situational awareness during an exercise is often difficult to evaluate. One way to focus this is to conduct exercises with specific focus on evaluating the actors' situation awareness during different phases of the incident.
7. **Quality Improvement of Evaluation and Common Practices**: In general, quality improvement of evaluation and common practices is deemed important. To fulfill the needs, attention should be paid to the following aspects: focusing on best practices and what can be improved; establishing a culture or common practice for evaluation and feedback mechanisms (so that it becomes an integrated part of any operation); establishing how information for evaluation should be stored, owned and distributed, to enable transfer of the identified challenges from one exercise or operation to the next and improve exercises based on previous evaluations; and developing a general structure for evaluation based on direction and recommendations from the Norwegian Directorate for Civil Protection.

4.4.3 Requirements specifications

From the discussion of identified needs, the following set of requirements for evaluation and learning from incidents have been specified (Table 9).

In summary, it is possible to say that needs 1-4 are somewhat covered, or at least regulated by the existing procedures, as outlined in the formal routines suggested by DSB and MSB. However, as indicated by the stakeholder needs expressed in the workshops, and due to our previous experience from similar research projects, the routines are not sufficiently put into practice. One likely explanation is cost; especially large-scale inter-sector exercises are costsome and therefore they are carried out infrequently and with limited resources set aside for evaluation.

Table 9. Requirements for evaluation and learning from incidents

No	Need	Requirement description
1	Objective and Fact-Based Evaluation	A process that supports fact-based evaluation and clearly defines what facts a system solution should provide. ICT support for re-construction of events.
2	Evaluation on Collaboration	A repository that collects actors and agencies relevant to crisis management and systemizes them horizontally and vertically, i.e, an emergency response system, to be accessible for evaluations.
3	Coordinated, Interdisciplinary or Agency-specific Evaluation	Same as above.
4	Resources for evaluations	To set aside resources for evaluations in advance, not after a crisis has occurred, to establish common practices around evaluations
5	Tools that support evaluation	Tools that collect and present digital, dynamic and aggregated information. Scenario-based simulations of crises. What kind of information must be further explored.
6	Map based evaluation for situational awareness and common operational pictures:	Map-based solutions providing e.g. time stamps, maps, logs, and symbols. COPs with up-dating functions. Repository storing decisions taken during exercise or operation for re-construction of decision-making process.
7	Quality Improvement of Evaluation and Common Practices	Repository storing e.g. best practices, lessons identified and outcomes of previous evaluations.

As for large-scale real crises they often occur infrequently leading to that the evaluations following them often remain in reports until the next crisis takes place; i.e. they are not implemented in agencies as "lessons learned". Typical examples here are the forest fires in Sweden 2014 och 2016. The project can address this by allowing for technical solutions (needs 5-7) that enable digital information storing, dynamic retrieval of experiences and decision-making stored for the future. This needs to be accompanied by processes for how to optimally retrieve the information and plans for implementations of evaluation results. Of particular importance for this project is to explore in detail exactly what facts and digital information are needed for evaluation (e.g. response times, positions, symbols) so that they can be retrieved e.g. from an integrated map solution.

5 Initial design of integrated solution

Figure 4 presents a high-level design of the solution concept to be developed in the INSITU project, connecting the different areas of the project.

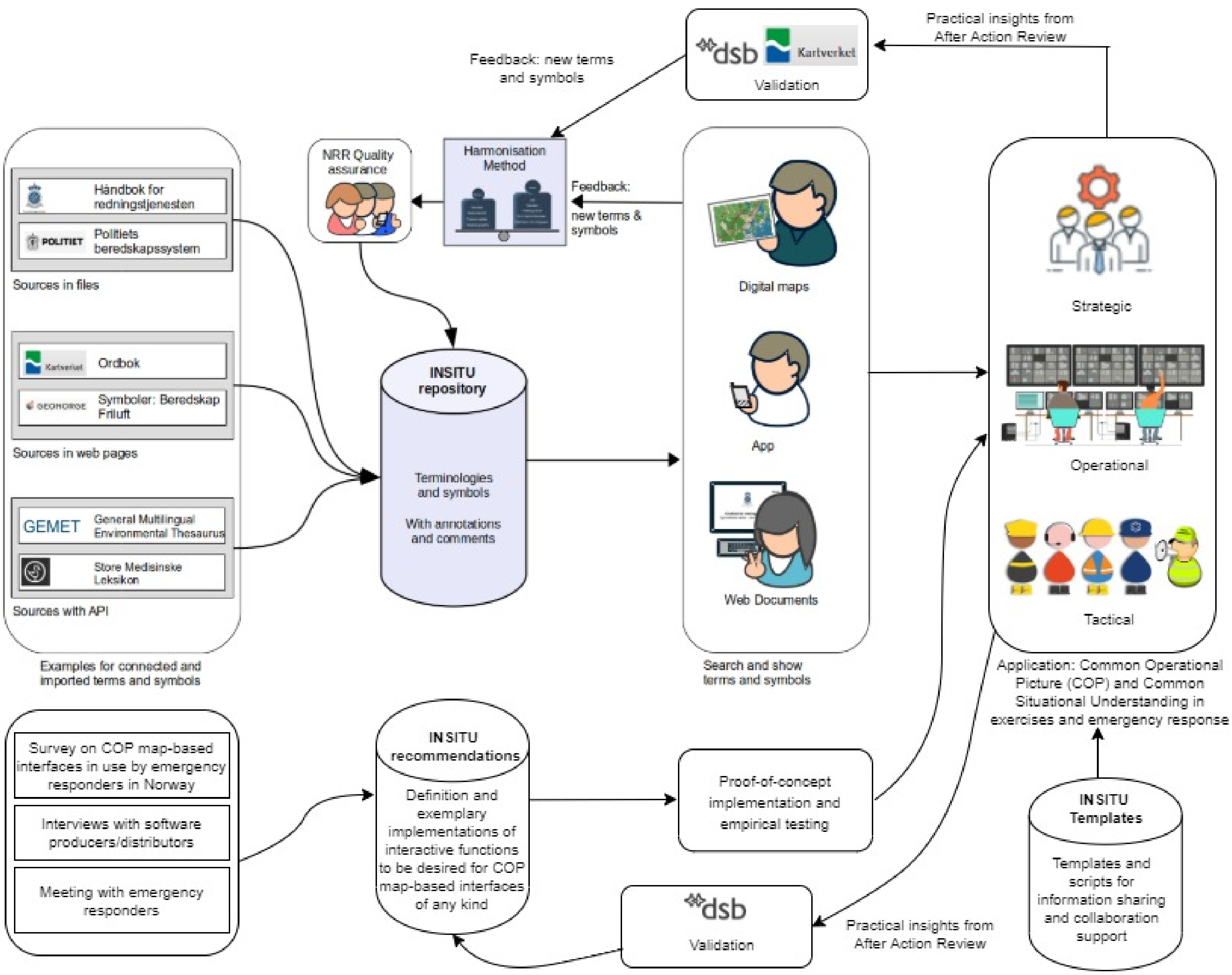


Figure 4. Illustration of INSITU solution concept

Sources for terminology and for symbols can be included in the INSITU repository in three different ways as indicated in the figure. For sources available from web pages we can harvest the contents with web scraping. This way we fetch the content from the source for each time it is requested. Examples of this are contents from Kartverket and Geonorge.

For sources that are only provided as pdf files and thus not suitable for automated harvesting, we can manually import the contents into the repository. This includes Redningshåndboken (Handbook for the Norwegian Rescue Services) and Politiets beredskapssystem (the Police emergency system).

Finally, for sources with an Application Programming Interface (API) we can use more targeted queries, and a change to the webpages will not break the connection. Examples of such sources include The General Multilingual Environmental Thesaurus (GEMET), and Store Norske Leksikon (the Great Norwegian Encyclopedia).

Depending on the nature of the sources they can be stored in the repository or they can be connected directly to the users who use them in various applications to allocate tasks, on maps, for search or for lookup from documents. The INSITU repository will support an API demonstrator to connect the collected content to digital maps, to an app for mobile users, and to a service for web documents hosted on websites. This can allow content owners to maintain their sources like before and offer application developers and users a unified way to access them. The planned app will be implemented as a Progressive Web Application (PWA) with similar functionality as the search page at https://insitu.termer.no/search.

Nasjonalt Redningsfaglig Råd (NRR, National Rescue Council) maintains the terminology of Redningshåndboken. Moving forward, we will invite them to use the INSITU approach to add new terms and symbols sources, and to harmonise among them. A discussion has been initiated with Hovedredningssentralen (Joint Rescue Coordination Centre) to explore how we can offer the service to a wider audience.

The INSITU recommendations of the interactive functions for COP map-based interfaces are based on the analysis of the current practice. Such an analysis includes three steps as indicated in the figure. Survey on COP map-based interfaces in use by emergency responders in Norway enables us to gain insights into functionalities provided in existing solutions. In turn, interviews with software producers and distributors facilitate recognizing customer demands regarding specific interactive functions. Lastly, meetings with emergency responders result in the identification of scenarios on how interactive functions are being used in practice and what functionalities are still missing. The defined recommendations are to be experimentally implemented in a map-based web tool and empirically tested with stakeholders.

The right hand side of the figure illustrates the use of the INSITU repository and map functions for supporting COP and situational understanding at tactical, operational and strategic level. This will also be supported by templates and scripts for information sharing and collaboration, to be developed in the project.

Evaluation from exercises and incidents in the form of After Action Reviews (AAR) forms the basis for validation and further development of the different elements of the INSITU solution concept, in collaboraiton with DSB and other stakeholders.

6 Conclusion and further work

This report has summarized the results from the initial data collection conducted in the INSITU project, and outlined a set of requirements for addressing identified needs. Our review of related research documents the timeliness of the focus areas of the project, with several completed and ongoing projects identified that provide relevant basis for our work. Yet, on an international scale we have not been able to find solutions that are yet established in practical use.

As expected, our analysis of the current practice among Norwegian emergency stakeholders documents a fragmented information landscape, with different technological support systems and procedures being used for the same purpose by different emergency management stakeholders. One example is the register of rescue and preparedness resources maintained by Barentswatch, which currently does not include resources from the health sector. However, the landscape is also changing quickly, with several projects currently underway for improving the coordination across sectors and/or updating the technological support. In this sense, the focus of our project represents a moving target. New technological opportunities are also a driving force for change with increasing access to sensor data and artificial intelligence opening new possibilities for real-time identification and monitoring of evolving incidents and for analysing the effect of the response.

An overall conclusion from our analysis so far is that technology does not represent a main limitation for achieving the goals we focus in this project. For the most part the required functionality already exists in the available systems, but what is still lacking is a more coordinated effort towards standardisation and common practices across the sectors and stakeholders involved. However, part of the challenges expressed by the stakeholders still also involve interoperability for establishing seamless interaction between the systems in use. Security concerns also represent a barrier for sharing of graded information.

Through interaction with the project reference group and other emergency stakeholders, the project has identified several needs related to information sharing, harmonisation of terminology, use of common map resources, and technology support for evaluation and learning from incidents. In the report we have chosen to also include some needs and requirements that go beyond the scope of our project, as a reference for further work. Further, the report has outlined an initial high-level design of an integrated solution concept, connecting the different parts of the project. This concept will be further defined through analysis of selected scenarios. Currently we are exploring the following candidate scenarios: forest fire, extreme weather, transport accident, industrial accident, pandemics. These categories of incidents are all included in the Norwegian crisis scenarios presented by the Directorate for Civil Protection (DSB, 2019).

It should be noted that this report mainly serves as a basis for defining the focus and scope of the further work in our project, and is not intended to provide an exhaustive review of former research and current practice. We know there exists other relevant information sources not yet covered in our analysis, and we will continue to collect relevant experience and insight from practice. For this, we will also appreciate further input from emergency management stakeholders on possible relevant information.

As a first outcome to be applied from the INSITU project we are planning to implement a search functionality across sources of terms and symbols on the website of the Joint Rescue Coordination Centres (JRCC, https://www.hovedredningssentralen.no/). This can both become a practical reference and raise a way to raise the awareness about different terminologies in the different rescue sectors.

Close interaction with emergency management stakeholders will continue to be emphasized in the project for validation of the project deliverables and ensuring the relevance of the project results.

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Appendix A – Project reference group

Norwegian name	English name
Agder Energi Nett AS	Agder Energi Nett
BarentsWatch, Kystverket	BarentsWatch, The Norwegian Coastal Administration
Direktoratet for samfunnssikkerhet og beredskap (DSB)	Norwegian Directorate for Civil Protection
Direktoratet for strålevern og atomsikkerhet (DSA)	Norwegian Radiation and Nuclear Safety Authority
Forsvarets Forskningsinstitutt (FFI)	Norwegian Defense Research Establishment
Forsvarets høgskole	The Norwegian Defence University College
Frivillige Organisasjoners Redningsfaglige Forum (FORF)	Society of Voluntary Search and Rescue Organizations
Fylkesberedskapssjefen i Agder	Emergency Manager, County Governor of Agder
Fylkesberedskapssjefen i Trøndelag	Emergency Manager, County Governor of Trøndelag
Helsedirektoratet	Norwegian Directorate of Health
Hovedredningssentralen Sør-Norge	Joint Rescue Coordination Centre, Southern Norway
Kartverket	The Norwegian Mapping Authority
Kristiansand kommune	Kristiansand municipality
Norges brannskole	Norwegian Fire Academy
Norsk brannvernforening	Norwegian Fire Protection Association
Nasjonal kommunikasjonsmyndighet (Nkom)	Norwegian Communications Authority
Nasjonalt redningsfaglig råd (NRR)	The Norwegian Council for Search and Rescue
Norges vassdrags- og energidirektorat (NVE)	Norwegian Water Resources and Energy Directorate
Næringslivets sikkerhetsorganisasjon (NSO)	The Norwegian Industrial Safety Organisation
Oslo kommune	City of Oslo
Oslo politidistrikt	Oslo Police District
Politidirektoratet (POD)	The Norwegian Police Directorate
Språkrådet	The Language Council of Norway
Statens vegvesen	The Norwegian Public Roads Administration (NPRA)
Sørlandet sykehus HF	The Hospital of Southern Norway
Østre Agder Brannvesen (ØAB)	Eastern Agder Fire Department

Appendix B – Summary of relevant projects

Project name + website	Project period	Coordinator	Focus	Relevant results
ALPDIRIS http://www.alpdiris.eu/	01.01.2017 – 31.12.2018	HITEC Luxembourg S.A.	Holistic approach to trans-national response to disasters in remote, mountainous areas.	AlpDIRIS Reporter (Android App for handheld devices): - Follow team members on the map. - Report information via pictures, POIs, surveys. - Sends your GPS information. - Full offline compatibility
ALPSAR http://www.alpsar.eu/	01.10.2010 – 31.03.2013	HITEC Luxembourg S.A.	Implementation of the collaboration between both Slovene and PCRAFVG Mountain rescue. and international coordination of search missions caused by avalanches or missing or injured people in the Alpine mountains	Implementation of tools that enable collaboration and shared situational awareness for members of the Slovene and Venetian mountain rescue services, to enable transnational operations in the Dinaric Alps.
BeAware https://beaware-project.eu/	01.01.2017 – 31.12.2019	Centre for Research and Technology Hellas (CERTH)	beAWARE proposes an integrated solution to support forecasting, early warnings, transmission and routing of the emergency data, aggregated analysis of multimodal data and management the coordination between the first responders and the authorities.	• New enhanced decision support and early warning based on aggregated analysis of multimodal data • Shorter reaction time and • Higher efficiency of reactions • Improved coordination of emergency reactions in the field • Contribution to the European Policy regarding disaster risks and crises management
BRIDGE http://www.bridgeproject.eu/	01.04.2011 – 30.04.2015	SINTEF	BRIDGE's contribution to better crisis management includes a software platform that allows emergency responders using incompatible communication systems to share information over ad-hoc networks. The platform brings together and orchestrates the management of data during a disaster.	This "system of systems" would allow responders using different devices and software to: • establish short-range communication networks; • monitor the environment through drones and sensors; • tag victims using electronic triage bracelets; • tag and monitor significant locations at a disaster site; • receive alerts using smartphone enabled app.
COPE http://cope.vtt.fi/	01.02.2008 – 31.01.2011	Teknologian Tutkimuskeskus VTT	Common Operation Picture Exploitation (COPE) aimed to achieve a significant improvement in emergency response management command and control performance, reliability, and cost. The project sought to improve information flow both from and to the first responder in order to increase situational awareness across agencies and at all levels of the command chain in emergency management situations. A user-driven approach was taken to develop new technologies for	• The identification, evaluation, screening and selection of technologies suitable for first responder work • Analysis and development activities in modifying and adapting the technologies for the purpose of COPE. • Human Factors effort in regarding the end-users' input in technology development and verification, trial exercise design and validation.

			supporting user information requirements at the scene of the event.	• The integration of all components into a demonstrator "System of Systems" with mixed live and tabletop type trial exercises.
DECAT https://decatastrophize.eu/	01.01.2016 - 31.12.2018	Cyprus University of Technology	The goal is to use geo-spatial early warning decision support system (GE-DSS) for rapid deployment, interoperability, transferability and sustainability to assess, prepare for and respond to multiple and/or simultaneous natural and man-made hazards, disasters, and environmental incidents.	The project resulted in a decision support system coined DECAT, developed by GeoSolutions. The implementation emphasised open standards and interoperability, with a modular structure to enable functionality as needed.
DRIVER+ https://www.driver-project.eu/	01.05.2014 - ongoing	Atos SE TNO	Developing a pan-European Testbed for Crisis Management capability development enabling practitioners to create a space in which stakeholders can collaborate in testing and evaluating new products, tools, processes or organisational solutions.	• Trial Guidance Methodologies and accompanying Testbed Technical Infrastructure • Implementation of trials using the TGM and TTI frameworks. • Establishment of the Crisis Management Innovation Network Europe (CMINE) • Portfolio of Solutions – Online database of technologies Establishment of a network of DRIVER+ Centres of Expertise
EASER https://www.easerproject.eu/	2018 -> 2020	Fire Department of Pisa, Italy	EASeR focuses on search and rescue (SAR) assessment during emergency interventions in response to natural disasters. EASeR shall provide a practical strategy to carry out the assessment in SAR more efficiently, with a positive cascade effect on the general performance of all subsequent operations.	1. Italian Standard Operating Procedures for USAR assessment an 2. International Standard Operating Procedures for USAR assessment • Recommendations for different levels of rescue mission and actors for USAR assessments
EU-NU https://www.cmcfinland.fi/en/projects/cooperation-project-on-strengthening-the-eus-nordic-usar-modules-eu-nu/	01.01.2015 - 30.06.2016	Crisis Management Centre - Finland	The EU-NU project supports and complements efforts made by Finland and Sweden in the field of Urban Search and Rescue (USAR) in Cold Conditions and thus facilitates reinforced cooperation between the two countries in the field of preparedness in civil protection.	Enhancement of Nordic USAR cooperation and exchange of good practices. Strengthened the capacities of a joint Nordic USAR team and builds foundations for future action. Improved links between actors in Nordic countries and European wide throughout the disaster management cycle
FWEDROP Joint Force Water Environment Disaster Relief Operations Platform http://www.protezionecivile.it/	01.03.2014 - 28.02.2016	Italian Civil Protection Department	To develop a multiagency-multinational operational platform to develop best practices for water emergencies aiming at searching, rescuing and recovering of missing persons in water environment	JFWEDROP module for underwater search and rescue and surface technical capacities. JFWEDROP website, an online web platform allowing for exchange of information between participants. Guidelines for JFWEDROPERATIONS – description of objectives, deployment and operational procedures.
HAZRUNOFF http://www.hazrunoff.eu	01.01.2018 - 31.12.2019	IST - Técnico Lisboa	Improve preparedness and the response capacity in case of flood conditions and pollution in rivers and	Rapid simulation and more detailed modelling tool for assessing the impact of flood-

			estuaries, in particular through the use of new detection tools (drone, remote sensing) combined with the development of behaviour models in order to identify the risks and reduce alert and response times.	related events on coastal or riverine areas. Models flood-related indicators from meteorological, hydrological and oceanic disciplines.
IREACT http://project.i-react.eu/	01.06.2016 – 31.05.2019	Links Foundation	I-REACT aims to integrate emergency management data coming from multiple sources, including that provided by citizens through social media and crowdsourcing, to produce information faster and allow citizens, civil protection services and policymakers to effectively prevent and/or react against disasters. • Integration of EM data from multiple sources • Climate crisis managements solutions Coordination of the emergency response operations	Suite of tools for communicating complex, multidisciplinary information, consisting of four modules: 1. I-React Social 2. I-React Reporting 3. I-React EMS 4. I-React Added Value Services Gathers thematically diverse data. Integrates data from satellite services, UAV imagery and social media, to understand ongoing situations.
KUBAS https://kubas.uni-halle.de/en	Unknown - up to late-2019	Martin-Luther-Universität Halle-Wittenberg	The KUBAS Project aims to enable and improve the coordination of on-site volunteers during emergencies by providing • dissemination of help searches • coordination of relief efforts/supporting measures • updates on site status • volunteered Geographic Information for creating crisis maps.	• Attributes and a system model for the simulation of spontaneous volunteers • A System Entity Structure for describing disaster scenarios in the context of spontaneous volunteers • Requirements and architecture that comprises a chatbot for communication between volunteer coordination systems and spontaneous unaffiliated volunteers • The XML-based Spontaneous Volunteer Coordination Scenario Definition
RE-ACTA http://blog.roteskreuz.at/reacta/	01.11.2013 - 30.06.2015	AIT – Austrian Institute of Technology	RE-ACTA provides a systematic approach based on crowdtasking to define the processes and tasks as well as tools to manage crisis and disaster processes. Need to find new ways of loosely binding volunteers to their organization in order to continue of being a significant and powerful part of Austria's crisis and disaster management strategy.	Toolsets and methods to assist in mobilization of volunteer organizations during disasters, based on the following modules: • Community building, registration of volunteers, and data maintenance. • Launching of crowdtasking. • Crowdtask execution. Analysis, visualization, and generation of reports.