Identifying Information Requirements for Improving the Common Operational Picture in Multi-Agency Operations

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ABSTRACT

While there exists a considerable body of literature on the importance of a common operational picture (COP) in multi-agency emergency operations, the COP concept itself still lacks a univocal definition. Despite the lack of consensus regarding the mechanisms underlying the COP, the literature implies a level of consistency in the focus on sharing critical information. Based on interviews with Norwegian emergency management stakeholders, this study investigates common information requirements for emergency management services and presents an example of a framework for structuring the sharing of critical information and building a COP. Termed 'the window report', this framework is used among emergency stakeholders in Norway and Sweden. The study identified eight common information requirement categories for managing extreme weather scenarios. With a focus on common information needs and a process for structured information sharing, future strategic emergency management planning might take a more holistic perspective on cross-sectoral operations than in current practice.

Keywords

Situational Awareness, Common Operational Picture, Information Sharing, Common Information Requirements, Multi-Agency Emergency Operations.

INTRODUCTION

There is a gap between theory and practice in multi-agency crisis management, which involves, among other things, the important domain of information sharing (Janssen, Lee, Bharosa and Cresswell, 2010). Furthermore, crisis operations are affected by ineffective information sharing processes due to the lack of knowledge regarding specific information needs in collaborative organizations (Munkvold et al., 2019).

Climate change results in an increase in extreme weather events (Stott, 2016). The emergency management related to these events is different from that of other events that are more limited in scope because extreme weather has consequences with cascading effects, threatening human survival and causing damage to property and critical infrastructure. These events often hit critical functions in society, such as buildings, electricity, telecommunications, and the Internet. They require extraordinary efforts from authorities and cannot be handled through ordinary routines and structures. Operational responses to natural disasters require coordination with organizations beyond regular emergency management services that handle crises on a daily basis. In addition, the first hours of a disaster are complex and chaotic, and emergency management in this critical timeline is crucial for outcome success. These operations require effective collaboration and information sharing in order to reach common goals, such as saving lives and mitigating destruction. Because of several heterogenous information needs among the organizations involved, there is an inability to determine what information needs to be shared (Bharosa, Lee and Janssen, 2010), which presents bottlenecks in collaborative efforts. The literature on multi-agency crisis management emphasizes the importance of the common operational picture (COP) for the purpose of collaborating and sharing information (e.g. Bunker, Levine and Woody, 2015). Scholarly articles present the COP differently, for instance, it is sometimes presented as an information system that enables information to be presented in visual form (Luokkala, Nikander, Korpi, Virrantaus and Torkki, 2017). Other times, it is presented as a checklist of the characteristics in a certain situation within a geographical area

(Wolbers and Boersma, 2013). Whether the COP is a process, a product, or an operating environment remains undefined.

There are different ways in which the organizations involved can share information in order to build a COP, one option is to communicate via technology, such as a geographic information system (GIS). The GIS uses custom symbols to display relevant operational information, such as location, topography, infrastructure, and different resources (Karagiannis and Synolakis, 2016). However, many emergency management services do not have access to a common GIS interface because they use support technologies with no interoperability across organizations. This means that they must share geographical information verbally. Several studies have addressed the difficulty of information sharing among the various actors, whereby the collection of relevant and verified information from different sources in the environment must be shared with the collaborating services (e.g. Luokkala et al., 2017; Seppänen, Mäkelä, Luokkala and Virrantaus, 2013; Steigenberger, 2016). More research is required in order to define the relevant information needs of different contexts so as to create a good situational awareness (SA) and build a COP (Seppänen and Virrantaus, 2015).

This paper aims to define common information requirement categories for multi-agency crisis management in an attempt to support the establishment of a COP during extreme weather events. Moreover, it discusses an example for how to share this information using a common practice among Norwegian first responders. The research question guiding this study is: *What common critical information is required by the multiple agencies involved to build a COP and respond to the impacts of extreme weather, such as flooding, storms, and forest fires?* The study is based on the Norwegian context and focuses on managing extreme weather scenarios in the acute phase. The target organizations are first responder agencies (fire and rescue, police, and medical services) and municipalities. The focus is on the common information requirements, not the agency-specific needs or the different information systems used in these organizations. The next section briefly presents a summary of the current practice as well as the relevant literature on SA and the COP. This is followed by a description of the research method, which consists of qualitative interviews and a web-based survey. Thereafter, the findings from the interviews are presented and discussed, followed by a conclusion.

THEORETICAL FRAMEWORK

Current practice

Changes in the global climate are engendering change in many local communities in Norway (Norwegian Ministry of Climate and Environment, 2013). Evaluations of extreme weather scenarios show that scattered emergency management is a key challenge (NOU, 2000). In larger and more complex events, such as extreme weather, municipalities play a central role, as they are tasked with safety at the local level and are, therefore, an important part of the emergency management system (Civil Protection Act, 2010). The municipality collaborates with internal and external emergency organizations in large events (Regulation on municipal emergency duty, 2011). For first responders, such as police, fire and rescue, and medical services, the features of the information they receive can have major consequences for the outcome of the operation (Schroeder et al., 2018). They rely on information that reflects the situation they are handling (Liang and Gao, 2010). In joint events, where organizations besides first responders are participating, the need for information sharing includes other actors besides the operational units and their associated command and control centers (C3). In smaller everyday operations, first responders have a long tradition of collaborating on the emergency site, for instance, the first responder on site provides other stakeholders with a "window report" in the Norwegian Public Safety Network, which is a common platform for collaborative communication. There is no univocal standard for this kind of window reporting, but the essence is to provide knowledge on, for example, position, resources, and scope (Solberg et al., 2018). An example of such a reporting structure is the Gothenburg Window used in the Swedish Police (Borglund, 2017) (Figure 1), which provides information about *place* (location), *direction* (short description on the situation), *resources* (summary of operative units on site), and *trend* (status quo, and for instance if the situation is escalating or calming down). Recently, the Norwegian C3 for police, fire and rescue, and medical services implemented new procedures for common questioning of callers in nine different cross-sectional scenarios (Dreyer, 2019). However, this strategic way of information sharing is limited to internal use for first-responder services and do not include other external organizations involved in crisis management. A Norwegian project called OPSAM (Operation Center for Collaboration and Preparedness) (Fredheim, 2017) has demonstrated the need for an efficient and streamlined information sharing process between first responders and the municipality. Other international studies have shown that there is a lack of shared protocols for communication between agencies (Bunker et al., 2015). An applicable information sharing process can contribute toward building a COP between the operational units, with their associated C3, the municipalities, and other relevant organizations that must also act within their areas of responsibility. Cross-

Place	Direction
Trend	Resource

Figure 1: The Gothenburg Window (Borglund, 2017)

sectional processes simplify communication, and this corresponds with a structured procedure for equal information sharing as a "window report" with prioritized content. Studies show that the use of scripts for collaboration supports the SA of the agencies involved (Appelman & van Driel, 2005), which is important for COP building.

Situational Awareness

A substantial number of studies have pointed to SA as one of the key elements in emergency management (e.g. Dilo & Zlatanova, 2011; Endsley, 1995). It is also among the most researched topics in the domain of human factors related to emergency management (e.g. Cak, Say, and Misirlisoy, 2019). Dr. M. Endsley (1995, p. 287) made an extensive contribution to research on SA, defining it as "the perception of elements in the environment within a volume of time and space; comprehension of their meaning; and projection of their status in the near future." This definition refers to three hierarchical phases, described as levels 1, 2, and 3 SA. Level 1 SA is the first step in achieving SA and involves a perception of the relevant elements and the related attributes and dynamics connected to the specific information (Endsley, 1995). For example, a firefighter would perceive the size of the fire, topography, wind direction, and color of the smoke. Furthermore, the elements in level 1 SA provide the actor with an understanding of the situation in terms of what the different elements mean in relation to the agent's professional goals. This gives a holistic picture based on the element in level 1 SA and the professional's ability to form patterns with that information, which leads to level 2 SA (Endsley, 1995). In this case, the firefighter would understand that the wind direction, location, and topography indicate certain features about the situation. Some professional experience is required to achieve level 2 SA so as to relate the elements in level 1 SA to the relevant goals. Level 3 SA is the highest form of SA, and this involves the ability to project the future status of the situation (Endsley, 1995). For instance, the firefighter understands, based on the two previous SA levels, that the fire might spread to a populated area. The accuracy of the projection depends on the degree of the two lower levels of SA (Falkland and Wiggins, 2019). In general, the degree of SA is related to performance (e.g. Falkland and Wiggins, 2019; Jipp and Ackerman, 2016), and several studies have revealed the importance of SA in several emergency responder professions, such as firefighters (Li, Yang, Ghahramani, Becerik-Gerber, and Soibelman, 2014), military commanders (Riley, Endsley, Bolstad, and Cuevas, 2006), and pilots (Endsley and Robertson, 2000). This is further associated with fewer errors and a higher level of efficiency (Falkland and Wiggins, 2019).

Information sharing and the common operational picture

An extensive and growing body of literature has highlighted collaboration as a critical success factor in complex emergency operations (e.g. Berlin and Carlström, 2014; Bharosa et al., 2010; Kapucu, 2008), such as multi-agency management of extreme weather scenarios. Nevertheless, there is a large volume of published studies describing the problems with information sharing among emergency response organizations (e.g. Bharosa et al., 2010; Comfort, 2007; Wolbers and Boersma, 2013).

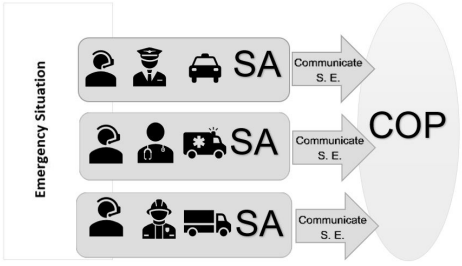

Figure 2: Agencies' SA and communication of shared elements (SE) to create a COP (Anonymous, 2020)

The COP is contemplated as a promising support in actors' development of SA and a solution to the collaboration and information sharing difficulties in the field (Comfort, 2007). However, the COP lacks a univocal definition (Wolbers and Boersma, 2013), although it consistently involves features of collaboration. A highly important element in the collaboration process is the information sharing aspect, and the accuracy of the information is essential in intensive operations (Abbas, Norris, and Parry, 2018). Actors' SA is an important basic component for the outcome of agency-specific tasks and goals, but it is also a central source in contributing to the COP. This can be briefly illustrated by first responders' communication with each other and their respective C3 (Figure 2). As Figure 2 shows, the three first-responder agencies (police, fire and rescue, and medical services) need to build SA and communicate the shared elements with each other in order to establish a COP. In multi-agency operations, including relevant organizations besides first responders, a majority of the goal-oriented operational actions are interdependent, and therefore, many of the information requirements are common and need to be shared. However, the COP is inadequate in supporting the stakeholders' SA because the COP concept generally supports management teams and does not factor in that the SA supports the different teams with their agency-specific tasks and goals (Luokkala and Virrantaus, 2014). This might result in a COP that includes all available information but does not prioritize the relevant elements that ought to be shared. In this case, the practice of an "all information to all people" approach (She et al., 2019) will result in information overload, i.e., the dissemination of redundant and irrelevant information (e.g. Ben Lazreg et al., 2018; Laakso and Palomäki, 2013). Humans have limited capacity to hold information available

for processing—what is called working memory (Lauria et al., 2019). Thus, information overload complicates decision-making and creates simplified mental models (Van den Homberg et al., 2018). SA is associated with cognitive capabilities such as attention, perception reasoning, and working memory (Cak et al., 2019). Since SA is subjective, one can say that the COP is created by the actors involved in the operation, as it consists of some SA elements, which the actor either understands must be shared based on experience or consulting with colleagues or has knowledge of through procedures, etc. Borglund (2017) acknowledged the COP as a selection of the important parts of the information available to actors—reported as descriptions and predications of the situation. Based on this, the COP is the result of both static and available dynamic information analyzed by the different actors involved, thus their SA. They must then decide what information needs to be shared and what is useless to the collaborating parts. By further drawing on the COP concept, Berggren and Johansson (2010) suggested that the COP is a GIS or map representation of the operational area and that it consists of units and fields of significance. In emergency management, this could mean visualizing the location of all the units involved, the areas of interest, evacuation spots, and the different types of resources. According to Looney (2001), several terrain features, such as road intersections, are important. This has been supported by Johansson, Hellgren, Oskarsson, and Svensson (2013), who have argued for the relevance of the ability to localize objects in the terrain of emergency management. Further, it has been suggested that the COP enables several agencies to share and view time-dependent information across a single picture (Bunker et al., 2015). Table 1 presents important features for building a COP (Steen-Tveit et al., 2020). However, several of the features require specific information that must be exchanged among the stakeholders building the COP. If these common information requirements are either missing or hidden in an overload of information, it becomes impossible to achieve the COP. Other features concern common preparation and training. Feature 6 is a direct call to use a framework or structure, such as the Gothenburg Window (Figure 1). Based on the COP features in Table 1, an identification of the common information needs in particular scenarios can specify the mechanisms for building a COP a more specific process. However, as long as the different organizations are characterized by different disciplines, tasks, goals, and working modes, the COP cannot guarantee that stakeholders will achieve a common situational understanding. These differences might result in a diverse operational understanding of the COP. For a successful outcome, the actors involved must have the same awareness of what is going on (Berggren and Johansson, 2010), and a comprehensive COP serves as a solid support for building a common situational understanding.

Table 1: Important features of a COP

1	Creation and maintenance of different levels of SA within the involved agencies.
2	Knowledge of each other`s operational modus, such as information needs, goals, capabilities, processes and resources.
3	Effective and time-specific communication of important static and dynamic environmental features, shared elements and common critical cues.
4	Harmonized terminology, both in vocabulary and software symbols.
5	Sharing useful comprehension of the current situation and actions/action planning important for the collaboration.
6	Follow a standardized framework for communication to avoid useless information and information overload.

METHODOLOGY

As there are limited references on the specific information requirements of multi-agency operations in relation to extreme weather, the people working in the investigated organizations are considered "knowledgeable agents" (Gioia et al., 2013). This term is used to address the unique insight of experts regarding their own working processes. Since this study seeks knowledge relating to these processes, a qualitative research approach was chosen. However, as the informants were individuals in a larger system, their answers may have been incomplete. Moreover, as the focus of this study is on specific information needs, it is important to note there seemed to be few procedures in the studied organizations that specified the information requirements in the selected scenarios. Therefore, qualitative interviews were conducted with twelve experts from first- responder agencies and municipalities. In addition, a survey was sent to three other organizations, all of which are characterized as support organizations because they are not responsible for handling the crisis (Table 2).

The answers from both the interviews and survey were categorized based on the selected scenarios and were further classified into information requirement categories using an inductive method. The classification was based on the informants' answers and not on universal definitions. For example, when an informant said, "*which area is affected by the forest fire*," this was classified into the information requirement category "location." Another example is that roads, power, and networks were classified under "critical infrastructure." Finally, the information requirements were compared, and the common requirements were determined and described (see Table 2). The informants were asked how they shared information in today's practice and what they characterized as the ideal sharing method. This was further discussed in light of the Gothenburg Window (Figure 1). The data from both interviews and survey were coded and analyzed in NVivo (QSRInternational).

Data collection

The data were collected through interviews with nine actors from the emergency management organizations and a supplementary survey with six additional experts (Table 2). The informants from the first-responder organizations were recruited by their leaders following a request from the author. The four emergency coordinators were contacted directly and agreed to participate. The interviews were conducted in the informants' workplace. Several of the informants from the first-responder agencies demonstrated their working process by means of a tour and gave an introduction of their information systems as well as how and when they were used. This gave a more holistic picture and resulted in the author's deeper understanding, in the interview situation, when an informant referenced a working process. In addition, I have had ten years' working experience as a medical emergency dispatcher, which also contributed to a mutual understanding.

Table 2: Respondents

Respondent Id	Organization	Role	Data Collection
1	Fire and Rescue Services	Emergency Dispatcher	Interview
2	Fire and Rescue Services	Shift Leader	Interview
3	Fire and Rescue Services	Professional Development	Survey
4	Police Services	Emergency Dispatcher	Interview
5	Police Services	Emergency Dispatcher	Interview
6	Medical Services	Head of Section, Acute Medical Communication Services	Interview
7	Medical Services	Professional Development in Acute Medical Communication Services	Survey
8	Municipality	Emergency Coordinator	Interview
9	Municipality	Emergency Coordinator	Interview
10	Municipality	Emergency Coordinator	Interview
11	Municipality	Emergency Coordinator	Interview
12	Municipality	Head of the Preparedness Section	Survey
13	The Ministry of Justice and Public Security	Director	Survey
14	The County Governor's Office	Assistant Director	Survey
15	The Civil Defence	Head of District	Survey

The interviews lasted between 45 minutes and one hour each and were based on a semi-structured interview guide. The guide consisted of open-ended questions, divided into the following four areas: (1) the informant's background, (2) human systems, (3) technological systems, and (4) building a COP and common situational understanding. A series of questions were asked during the interviews, with a special focus on the informants' working modes, such as the structures or procedures used to collect information on the emergency, whom to contact, with whom and how they share information, and their specific information requirements. In addition, the informants were asked about their experiences and opinions regarding the construction of a COP and the achievement of a common situational understanding. Therefore, the qualitative interviews were connected to complex events, using a forest fire scenario as an example. However, they also targeted the general aspects of operations in extreme weather and other operations. The main purpose was to learn about the organizations' processes for information sharing and discovery of specific information requirements as well as the informants' framework of meanings. This was in keeping with the issue of avoiding my assumptions to the greatest extent possible (Britten, 1995). During this study, I did gain experience at a C3 but did not possess the specific knowledge investigated in this study. Nevertheless, I have an insight into the domain. However, it is important to be aware of one's pre-knowledge and how this can affect interviews. Finally, the qualitative interviews were recorded and transcribed in detail. The texts were coded in NVivo and analyzed by the author.

In order to collect information requirements intended for extreme weather scenarios, experts in several emergency management organizations were contacted. These informants received a link to a survey with the scenario descriptions and were asked to write their information requirements in the specified fields. They were again contacted prior to receiving the link. As the respondents had direct contact with the author, the interactions can be regarded as mutual communication. The informants represented first responders as well as municipality and support organizations. The information requirements from the support organizations were collected in order to investigate the differences between their requirements and those of the key organizations. The information

requirements were listed and categorized based on data from the qualitative interviews.

RESULTS AND DISCUSSION

The specific information requirements identified were classified into eight categories. The reason for the categorization is that the different organizations need somewhat different details regarding the information requirements. For instance, the fire services require more elements on the terrain than others, and the medical services must know more details about the victims. Thus, the information needs of organizations require different levels of details. The information requirement categories are listed in Table 3, including an explanation of what each category entails, based on the data. Further, the "window report" structure was used to demonstrate how and with whom the information can be shared, as presented in Figure 3.

Information requirements

During the data collection, eight relevant information requirement (IR) categories for sharing were identified and classified into static and dynamic information (Table 3). The categories were not organized in prioritized order at this stage. Each information requirement category is presented below, including the basis for it. However, not all requirements were common for all support organizations. IR 3, 4, and 7 were not included in any of the responses from the support organizations. The reason might be that IR 4 (evacuation possibilities) and IR 7 (critical buildings) are closely related to the tactical level, while the support organizations are more interested in the information connected to the operational level. IR 3 (victims) was mainly the responsibility of "situation-owners." Nevertheless, further research on these "missing" information requirements might yield different results.

IR 1 concerns the possible scope and exact position of the important locations. This can be the coordination point for the operations leaders from first-responder agencies, a meeting place for operations units, and support organizations or representatives from the municipality. In particular, the organizations interviewed did not have access to the same GIS interface, and on occasion, they spent a considerable amount of time explaining locations to collaborative organizations. As an informant said, "*If we could see the positions in the map instead of describing (…) then you would know exactly where to go.* According to another, "*Now, everyone is searching for position (…) where it has happened, separately*." This non-sharing of information relating to position was specifically stated in the interviews and came out very clearly when it turned out that two of the first-responder agencies had the possibility of sending the GIS position to each other. Both organizations pointed to the major advantage of this feature and underlined its time-saving functionality. As one stated, "*It [shared position in GIS] saves us a lot of time when you don't have an exact address*." Such statements indicate that a common GIS interface would be beneficial for creating a COP concerning emergency locations. In fact, all the informants emphasized a common GIS interface for location sharing. Location information also concerns the type of terrain and topography of the area. To address the different needs related to this information, a scaling of the details on the map could solve the issue of information overload. This information is also important when operating with the impacts, or the mapping of the possible impacts, of the scenarios. Setting visible positions and lines in a GIS can improve strategic coordination between the actors involved.

IR 2 concerns critical infrastructure such as transportation systems, water supply, and telecommunications. One informant described how they coordinated the bus transportation in a storm scenario by using a real-time GIS solution: "*We knew a lot of trees would break (…) but the public transport must go on. We then called in the bus company, and they have a real-time view of all their busses. This was incredibly useful because when a tree fell over the road, the coordination of the bus could adapt to the situation*." In this case, the overview of the transport systems and access to information on obstacles enabled the organization to maintain its responsibility in a crisis situation. Critical infrastructure is also important for sharing information regarding different challenges in an area, and several of the informants highlighted the importance of mapping and taking early actions concerning weak groups, such as old, sick, and disabled people. Many people need electricity for medical reasons, home care, and special measures. While this is the responsibility of municipalities, in many scenarios, it might result in tasks that need to be solved by first responders. One informant illustrated the despair of not having the overview: "*In X scenario, 40,000–50,000 people had no electricity (…) and we don't know how many patients have received a COPD apparatus that needs to be refilled (…). How should we know this? They (the patients) are sitting and calling someone and worrying about the electricity being gone. So, this is just chaotic, so to speak*." This quote illustrates how the responsibility of municipalities fuses with that of first responders if the patients' condition worsens because of sustained power outages and if measures are not implemented in time.

IR 3 is important for several reasons. First, first responders must prepare medical treatments and search and rescue operations for victims, both in scope and under specific conditions. These are resource-demanding operations that require great effort from several stakeholders. Second, this is important information concerning

the evacuation process. Third, during disasters, an important step is to keep people informed. The extent of damage, perhaps especially when it comes to injuries, is of great interest to the public.

IR 4 is connected to IR 3, but it also concerns the number of people, including victims and next of kin. In addition, the need for evacuation is not exclusively for injured people but also involves situations where people need to evacuate from their homes. IR 4 also considers the need for staff in the evacuation situation. IR 1 relates to this information requirement in the sense that the location of the evacuation spot or center must be determined.

IR 5 concerns resources. The informants talked about resources in different terms. For instance, resources can be the operations units of the first responders involved. Another side of resources has to do with different supplies, aid, and support that can be used when needed. This illustrates the importance of the fourth COP feature concerning a harmonized terminology, whereby actors need to be knowledgeable about the terms used by each other and what the concepts entail. An overview of available resources can help organizations mobilize measures while also considering resource adequacy vis-à-vis the situation at hand. One informant explained resources like this: "*Available resources, who, what, where? Are there other resources besides ours we can take advantage of? That's the first thing*."

IR 6 is crucial for planning the next steps of the operation. For instance, wind direction, rain fall, and wind speed are important pieces of information in preventing and handling the consequences of extreme weather.

IR 7 involves important buildings, both in terms of handling the operation and preventing damage. Examples include nursing homes, hospitals, and evacuation centers, all of which are connected to IR 4.

IR 8 is an interconnected information requirement, which concerns weather trend (IR 6), possible victims (IR 3), and resources (IR 5). In addition, the requirement covers other projections on how the situation might develop. According to an informant, "*How we comprehend the situation, if it's a threatening situation and it poses a danger for others involved*." In the "window report" structure, IR 8 can be seen as an information requirement in itself because it illustrates some information that needs to be shared. However, this information requirement can also be seen as an indication of the need for analyses of IR 1–7 to achieve level 2 and 2 SA, which is more suggestive of a process for achieving common situational understanding.

Table 3: Common Information Requirement Categories

Information requirement category		Description	Static/dynamic information
IR 1	Location	Exact area for coordination point or meeting place. In addition, topography, terrain and exact scope.	Static
IR 2	Critical infrastructure	Essential assets such as transportation systems, water supply, electricity, and telecommunications	Static and dynamic
IR 3	Information on possible victims	Whether there are people involved who are, or are at risk of being, injured, threatened, or dead because of the situation; vulnerable groups that might be in the affected area	Dynamic
IR 4	Evacuation possibilities	Whether evacuation is required now or in the future, where the possibilities are and the approximate number of people	Dynamic
IR 5	Resources	All operations units from the first responders involved, the collaborative organizations' resources, such as power generators and water supply. Other available resources, such as tractors and buses	Dynamic
IR 6	Weather forecast	Current weather at affected locations and weather forecasts	Dynamic

IR 7	Critical buildings	Hospitals, evacuation center, and schools	Static
IR 8	Situational development	Expert assessment on how the situation can develop	Dynamic

One obvious finding to emerge from the analysis of the different information requirements is that it is not possible to operate with a single COP, as it must consider all the organizations involved and their need for an operational picture. The information overload issue would be a component, in addition to the fact that the consideration of all information needs would require a COP that is difficult to build and maintain. The informants' responses clearly demonstrate that their need for specific information is related to agency-specific tasks and goals. However, there are many common features in the identified information requirements (demonstrated in the categorization), which should be the foundation for sharing common information and for building the COP.

Example of an information sharing structure

Although the actors involved in multi-agency operations have some agency-specific goals, collaboration is a critical success factor in the achievement of common goals. In order for this collaboration to be as successful as possible, it is crucial that the common information requirements are shared with the relevant stakeholders and not remain within the agencies or individual actors (Sorensen and Stanton, 2016). A study on SA for building a fire emergency response demonstrated the importance of information collection in SA building, especially information items from the emergency site (Li et al., 2014). Thus, the "window report" structure should not be limited to a fraction of the organizations involved; it should include all relevant levels of cross-sectional collaboration. Today, the structure is mainly designed for information sharing between first responders and is perceived as a well-known structure for information sharing where elements are distributed within the inter-agency network—appearing as an effective and prioritized structure. During the data collection for this paper, several of the actors refers to the window structure when asked about how they build a COP, e.g.: *"I really like what we call "window report" in the common call group, the first actors on the scene – what do they observe? This is important for us in the CCC because we do not have any visual picture of the situation".* Such structure of information sharing among the relevant agencies can therefore be seen as the foundation of the COP. The use of an information sharing structure to build a COP can enable the expansion of the scope of information receivers in order to enhance the SA of the organizations involved.

One can argue that level 1 SA represents the information collection and might be the essence of the "window report." The exception could be *Trend* on occasions where the status quo is escalating or calming down, and the distributor of the "window report" must understand the information and form cognitive patterns based on professional experience. This would indicate level 2 SA, and some cases could be associated as level 3 SA if they are deemed relevant in reporting a projection, i.e., a future status report. *Place*, *Direction*, and *Resources* require objective information that reflects actors' first impressions. SA levels do not represent the actual manner of reporting but, rather, the specific situational information being reported. One must consider that SA is not the performance or action itself (Wickens, 2008), thus, the "window report" relies on external structures or procedures, in addition to the actors' perception of the environment. This is important because even if the stakeholders hold relevant information on the situation, it is not necessarily shared with the collaborating organizations.

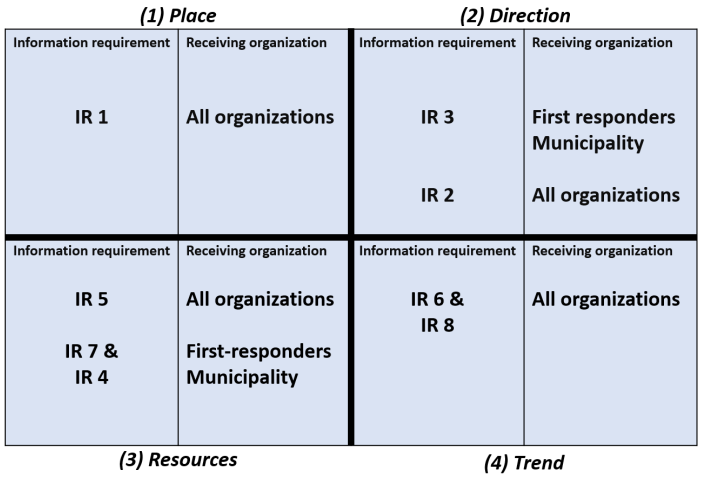

Figure 3: The Gothenburg Window as structure for sharing common information

Although this study was limited to identifying information requirements and did not address the prioritized order of the elements in the reporting structure, the *Trend* and *Resources* sections in the Gothenburg Window (Figure 1) have switched places in this paper's suggestion of the "window report" structure (Figure 3). This is based on the informants' answers regarding the information needs, where the information requirements for *Resources* were generally prioritized over those for *Trend.* However, further research on such a "window report"

structure and the prioritized order for the information requirements is needed.

Based on the data from the interviews, first responders are familiar with the "window report" structure, which arguably depicts a relevant procedure for information sharing. Therefore, it could be valuable to discuss what features of *Place*, *Direction*, *Trend*, and *Resources* can be linked to the COP concept as well as important COP features (Table 2). Further, the common information requirement categories can be placed in the window and serve as a structure indicating what information must be shared and to whom (Figure 3), as a conceptual structure for the information presentation. Since the second and fourth COP features concern knowledge of the other collaborative organizations and a univocal terminology, respectively, they involve training, preparation, and relationship building and do not include information that is directly a part of the "window report" structure. However, features 1, 3, 5, and 6 have a clear relationship with the structure's content. *Place* is connected to sharing critical location information, for instance, the exact position of the emergency event, the meeting point, and other elements connected to IR 1 (Table 2). This is the first square in the window and must be accurately communicated, with no room for errors. Incorrectly communicated information regarding location can have critical consequences, such as resources being delayed. An exact position in a common GIS would obviously be effective. *Direction* involves SA because it is a short description of the situation. Because a "window report" is a first-impression description, the *Direction* should mainly consist of level 1 SA elements, whereby the actor describes the situation in an objective way and distributes the elements in the environment to the collaborative organizations. This could relate to victims (IR 3), information about whom should be presented in an objective manner, such as whether or not there are injuries, since there are several pitfalls in projecting the status of patients, and injured people must be evaluated by medical personnel. Critical infrastructure (IR 2) represents issues concerning closed roads or other dynamics of the environment that could impact the operation and should be presented in the *Direction* square. In the *Resources* square, the information requirements 5, 7, and 4 should be presented: first, all available resources; second, whether critical buildings are destroyed or threatened; and third, the possibilities for evacuating the area. The last square in the window is *Trend*, where information requirements 6 and 8 should be presented. These requirements are interconnected in the sense that the weather forecast needs to be shared, and the consequences need to be predicted. IR 8 can also be interpreted as an analysis of the previous information requirements.

There are implications regarding how to handle the kind of information that might be provided by the COP in this case. New available information and insights are likely to emerge into more alternatives in the working processes, both internal and collaborative. It is beyond the scope of this study to discuss all working processes, but how information sharing is performed is likely to be affected. In today's practice, information sharing processes in Norway are mainly verbally performed in the Public Safety Network and by telephone. Some of the responders mentioned e-mail as a possible way of sharing information, for instance, on one occasion where a fire and rescue C3 was overloaded by incoming inquiries, a collaborative organization communicated with them by e-mail. However, the COP concept indicates "a picture" of the situation, which makes it seem more like an object. In this sense, the organizations would benefit from a common GIS interface, where the information requirements are visualized and scaled by different techniques. The static information must be displayed in some sense, and the dynamic must be inserted. However, some of the content of the information requirements, such as IR 8, might be communicated verbally because it concerns the common situational understanding. The COP is an important foundation for this understanding, but the common situational understanding requires bidirectional communication to clear up misunderstanding as well as the possibility for additional questions.

CONCLUSION

This study has identified eight information requirement categories, which are necessary for building a COP when the first-responder agencies and municipalities tackle extreme weather scenarios. However, it is important to emphasize that a single COP is not sufficient to provide a holistic operational picture for all the agencies involved; rather, it is a selection of the relevant dynamic and static information that will contribute toward building a COP. Based on the combination of the information requirement categories identified, the COP concept as an object is described in Table 1, along with the important features. One can argue that the COP is the result of preparation and a structured working methodology. This preparation consists of knowledge regarding each other's operational modes and harmonized terminology and the pre-knowledge on common information requirements that needs to be shared during an operation. The working methodology, in this case, consists of how to share the relevant information. This paper discusses the "window report" structure as an example of how to effectively share both static and dynamic operational information and make the information sharing process more integrated in the working processes. However, one must acknowledge that the working processes need to forge a way in which information provided by the COP is handled and used efficiently.

Predefining the information requirement categories for the organizations in the different contexts might facilitate the inclusion of a COP perspective at the strategic level of emergency management. Today, the information

must be shared verbally in the Public Safety Network, but a common GIS interface seems to be the way forward. The "window report" structure would in this case serve as a template for what areas of information need to be shared, which information categories and to whom, in different types of crisis.

Given the small sample size of this study, the findings presented must be validated by users, and further research should focus on developing a conceptual model on how to build a COP in multi-agency operations handling extreme weather events. Finally, as the study is limited to Norwegian and Swedish practice, further research could compare these results with structures used in other countries.

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