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Emergency Management Capability under Task Complexity: The Role of Knowledge Transfer Mechanisms

Johannes Schmied

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Johannes Schmied

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Abstract

This thesis focuses on how knowledge transfer may increase organisational emergency management capability under task complexity via certain knowledge transfer mechanisms.

The ability to successfully execute highly interdependent tasks may be of vital importance when organisations experience emergencies and other types of crises. Although organisations often adapt well and react quickly to internal and external changes, organisational capabilities in the form of emergency management capabilities have become an important asset, particularly for high-performance organisations. This is because high-performance organisations may operate in a context where task complexity predominates. According to existing research, the more options that are available for reaching goals, and the more unexplainable the interrelations among components in the network of actors are, the greater the task complexity. With increased complexity there may be an increasing gap between the required and the existing emergency management capability. Research suggests that factors that may - among others - narrow this potential emergency management capability gap include resource allocation, legislation, and knowledge transfer mechanisms. As previously stated, the thesis focuses on knowledge transfer mechanisms and hereby mostly on knowledge codification and knowledge articulation. The overall research question is: How do task complexity, knowledge transfer mechanisms, and emergency management capability relate to one another in the emergency preparedness phase of crisis management?

A research model is developed (Figure 2). The thesis consists of a set of four articles, with each article using a case study approach and methodological triangulation. Both single- and multiple-case study approaches are chosen, and each paper contains a separate body of empirics. The research data are mainly from 2016 to 2019. Overall the thesis predominantly focuses on how organisations create and

enhance their preparedness capability. The knowledge transfer mechanisms that appear to be central among the studied cases are then presented.

Specifically, connecting the individual papers leads to identifying and understanding the roles of the knowledge transfer mechanisms in relation to the complexity variable and emergency management capability. Paper 1 in particular contributes to the understanding on how context may be relevant to describe complexity as well as highlighting the role of decision making in the light of managing crises and emergencies. Paper 2 particularly looks at field configuring events represented by exercises and learning on individual, group, organizational, and trans-organizational level. Paper 2 also provides background on the role of environment to describe complexity. Paper 3 is central to provide a deeper understanding of organizational complexity in relation to knowledge transfer, and to describe the important role of knowledge transfer mechanisms to develop emergency management capability. Paper 4 gives insights on information management and situational awareness and introduces the task complexity to the complexity concept in the thesis.

Altogether the thesis finds that task complexity affects both knowledge transfer mechanisms and emergency management capability. Emergency management capability within this thesis is described by the organisation's preparedness level, where the availability of procedures and situational awareness provide the basis for acting on available decision-making strategies. Emergency management capability does depend on the knowledge transfer mechanisms that organisations foster. Individuals, groups, and sub-organisations thereby serve as producers, curators, transmitters, and receivers of knowledge to carry, increase, and develop the preparedness of emergency management capabilities on behalf of larger organisations via articulation and codification. Establishing preparedness capability, such as by creating standards, regulations, and routines, is part of these knowledge transfer mechanisms (knowledge codification) from a preparedness perspective.

However, knowledge transfer mechanisms aim to assist not only in adequate routines but also in increasing flexibility as well as in making knowledge more explicit and more widely usable (knowledge articulation). Due to growing recognition of this benefit, the role of knowledge articulation is becoming increasingly important. Moreover, complexity may lead to non-linear cause–effect correlations while implying a lack of knowledge, uncertainty, and knowledge asymmetry. This may challenge the knowledge transfer process and increase the emergency management capability gap. Therefore, three context-related concepts are investigated to attain an increased understanding of task complexity: (1) the environmental level, (2) organisational level, and (3) individual level. Knowledge transfer mechanisms can also be affected by emergency management capability. A lack of situational awareness may affect the quality of information which is relevant for knowledge. Consequently, knowledge transfer may then bring about a change of the information stored within actors and affect the relevance of information, the timeliness of information, and the role of information hubs. As a result, knowledge transfer may have some effect on the organisational and individual level of context, which is described in the variable of task complexity.

To conclude, in this thesis, knowledge transfer mechanisms are regarded as vital when building necessary emergency management capabilities adequate for a prevailing context predominated by task complexity.

Keywords: context, emergency management capabilities, knowledge transfer mechanisms, preparedness, task complexity

Sammendrag

Denne avhandlingen har til hensikt å utvide den teoretiske forståelsen av hvordan mekanismer for kunnskapsoverføring kan lette generering av evnen for beredskapshåndtering under oppgavekompleksitet.

Evnen til å gjennomføre oppgaver preget av høy gjensidig avhengighet kan være avgjørende når organisasjoner opplever nødsituasjoner og kriser. Selv om organisasjoner ofte tilpasser seg godt og reagerer raskt på interne og eksterne endringer, har beredskapsledelse blitt en viktig kompetanseressurs, spesielt for organisasjoner med høy ytelse. Dette er fordi organisasjoner med høy ytelse ofte opererer i en kontekst med høy grad av oppgavekompleksitet. Forskningen viser at jo flere alternativer som er tilgjengelige for å nå et mål, og jo mer uoversiktlig relasjonene mellom komponentene i nettverket av aktører er, desto større blir oppgavekompleksiteten. Med økt kompleksitet kan det bli et økende gap mellom nødvendig og eksisterende evne for beredskapshåndtering. Forskningen forslår at faktorer som kan begrense dette potensielle gapet innen eksisterende og ønsket beredskapshåndtering inkluderer blant annet ressursallokering, lovgivning og mekanismer for kunnskapsoverføring. Som nevnt fokuserer denne studien på mekanismer for kunnskapsoverføring og da mer konkret på kunnskapskodifisering og kunnskapsartikulering. Det overordnede forskningsspørsmålet er: Hvordan forholder oppgavekompleksitet, mekanismer for kunnskapsoverføring og beredskapsevne seg til hverandre i krisehåndteringens beredskapsfase?

Denne problemsstillingen er undersøkt her gjennom fire artikler og kappa. Hver artikkel bruker en casestudietilnærming og metodisk triangulering. Både enkelt- og fler-casestudie tilnærming er valgt. Hver artikkel inneholder en egen empirisk tilnærming hvor dataene i hovedsak ble samlet inn i perioden fra 2016 til 2019. Hovedfokus i avhandlingen er hvordan organisasjoner skaper og forbedrer sin evne for beredskapshåndtering. Artiklene identifiserer og bidrar til å forstå rollene til mekanismene for kunnskapsoverføring relatert til kompleksitet og evnen for

beredskapshåndtering. I kappa presenteres kunnskapsoverføringsmekanismene som er funnet å være sentrale blant de studerte casene.

Paper 1 bidrar til forståelsen av hvordan kontekst kan være relevant for å beskrive kompleksitet, samt fremhever rollen til beslutningstaking i lys av håndtering av kriser og situasjoner som krever beredskapsledelse. Paper 2 ser spesielt på feltkonfigurasjonshendelser representert av øvelser og læring på individ-, gruppe-, organisasjons- og trans-organisatorisk nivå. Paper 2 gir også bakgrunn om miljøets rolle for å beskrive kompleksitet. Paper 3 er sentralt for å gi en dypere forståelse av organisatorisk kompleksitet i forhold til kunnskapsoverføring og for å beskrive den viktige rollen av mekanismer for kunnskapsoverføring for å utvikle evnen for beredskapshåndtering. Paper 4 gir innsikt i informasjonshåndtering og situasjonsforståelse og introduserer perspektivet på oppgavekompleksitetsbegrepet i avhandlingen.

Resultatene i avhandlingen er at oppgavekompleksitet påvirker både mekanismer for kunnskapsoverføring og evnen for beredskapshåndtering. Evnen for beredskapshåndtering er i denne avhandlingen basert på organisasjonens beredskapsnivå, der tilgjengeligheten av prosedyrer og situasjonsforståelse gir grunnlag for å handle på tilgjengelige beslutningsstrategier. Evnen for beredskapshåndtering er funnet å avhenge av kunnskapsoverføringsmekanismene som kompetansefremmende for organisasjoner. Enkeltpersoner, grupper og underorganisasjoner fungerer dermed både som produsenter og kuratorer, samt sendere og mottakere av kunnskap. Formålet er å øke og utvikle evnen for beredskapshåndtering gjennom artikulering og kodifisering for organisasjoner. Det å forbedre beredskapsevnen, for eksempel ved å lage standarder, forskrifter og rutiner, er en del av disse kunnskapsoverføringsmekanismene (kunnskapskodifisering) sett ut fra et beredskapsperspektiv. Mekanismer for kunnskapsoverføring tar imidlertid sikte på å hjelpe, ikke bare med tilstrekkelige rutiner, men også å øke fleksibiliteten, samt å gjøre kunnskap mer eksplisitt og allmenn. På grunn av en økende anerkjennelse av

disse kompetanser, blir også kunnskapsartikulering stadig viktigere. Dette er blant annet fordi kompleksitet fører til ikke-lineær korrelasjon mellom årsak og virkning samtidig som denne kompleksiteten kan skape mangel på kunnskap, usikkerhet og kunnskapsasymmetri. Dette kan utfordre kunnskapsoverføringsprosessen og øke gapet til evnen for beredskapshåndtering. Av den grunn ser jeg her nærmere på tre kontekstrelaterte begreper for å oppnå økt forståelse av oppgavekompleksitet: (1) miljønivå, (2) organisasjonsnivå og (3) individnivå. Mekanismene for Kunnskapsoverføring kan også påvirkes av beredskapshåndteringsevnen. Mangel på situasjonsforståelse kan påvirke kvaliteten på informasjonen som er relevant. Følgelig kan kunnskapsoverføring medføre en endring av informasjonen som er lagret i aktører og påvirke relevansen av informasjon, aktualitet av informasjon og rollen til informasjonsknutepunkt. Følgelig kan kunnskapsoverføring ha en viss effekt på individnivå og organisasjonsnivå av kontekst, som beskrives i variabelen oppgavekompleksitet.

Som en konklusjon på avhandlingen blir mekanismer for kunnskapsoverføring sett på som sentrale i å bygge nødvendig beredskapshåndteringsevne som er adekvat for en kontekst med høy grad av oppgavekompleksitet.

Nøkkelord: beredskap, beredskapshåndtering, kontekst, mekanismer for kunnskapsoverføring, oppgavekompleksitet

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1 Introduction

Successfully executing highly interdependent tasks may be of vital importance for organisations experiencing emergencies and other types of crises. Therefore, emergency management capability has become an important asset for many companies and may be of interest to high-performance organisations (Kapucu et al., 2010). This thesis focuses on how knowledge is transferred between actors connected to high-performance organisations because high-performance organisations may operate in a context in which complexity predominates (De Waal, 2007). Thus, these organisations need to adapt well and react quickly to internal and external changes (De Waal, 2007). Consequently, this thesis includes some resilience or reliability aspects in its definition of high-performance organisations, namely a culture that is (1) focused on errors, (2) aware of weaknesses (Reason & Reason, 1997), and (3) preoccupied with failures (Weick & Sutcliffe, 2001). The studied organisations must act when faced with unexpected events, emergencies, and other crises. Therefore, organisational capability may be a crucial asset when managing unexpected or unwanted events (Yang & Hsieh, 2013). This thesis defines organisational capabilities as 'the dynamic, non-finite, firm-specific *[or organisation-specific in this case]*, and path-dependent processes that are not obtainable in the market place, are difficult to copy, and are accumulated through long-term, continuous learning' (Spanos & Prastacos, 2004, p. 31). Organisations must adapt to change and create more knowledge while needing to enhance their performance when action is required (Fraser & Greenhalgh, 2001). All actors (both individuals and organisations) possess different backgrounds, procedures, routines, and leadership cultures. They also follow different schedules and budgets. Studies such as that of Subramaniam and Youndt (2005) indicate that knowledge may be stored, prioritised, and applied differently; however, it may be generated, assessed, and needed jointly. Actors are often aware of the limitations of their capabilities, including the procedures, work plans, action cards, and decision-support tools that they employ (Bigley & Roberts, 2001), and they may see the need for improving those capabilities.

Therefore, it is important to have space in which to prepare for emergencies and crises. Learning from other actors (Argote, 2012, p. 9) (in this case, about how to manage emergencies), including through 'collaboration between and across entities' (Liyanage et al. (2009, p. 127), may counteract the challenges an organisation must address (Brennan & Krohmer, 2006; McElroy, 2000). Collaboration – such as group and team processes as well as communication with affiliated actors and other organisations – may, therefore, be essential during a crisis. Furthermore, cross-border knowledge exchange and the building of relevant capability during more 'business-as-usual' times may be essential to facilitating a common understanding about preparedness and emergency management (Hällgren et al., 2018).

This thesis concentrates on how organisational capability is established in the area of crisis and emergency management. It does so by examining the role of knowledge transfer-related processes. Notably, knowledge transfer-related processes may occur in a somewhat unstructured way (see Blome et al., 2014; Gulick (1937); McElroy, 2000) and may include multiple actors. These actors engage in social processes (Weick et al. (2005, p. 413) to address complexity by decreasing the effects of structural challenges and unpredictability. Additionally, this thesis is focused on the area of emergency preparedness, which originates from the areas of safety, security, and disaster and which is a continuous process of improving interventions and ensuring recovery (Hémond & Robert, 2012). Emergency preparedness, which can be relevant to individuals, structures (organisations) and systems, refers to the ability to react to threats in order to minimise any negative effects on health, safety, integrity, and function (Perry & Lindell, 2003). Moreover, 'emergency' is defined in Brennan and Krohmer (2006, p. 202) study as a situation or event in which capacity is overwhelmed and may be in need of external assistance (a definition that this thesis uses). Crises are defined in this thesis as follows: Crises occur irregularly (Christensen et al., 2018, p. 6), may be perceived as 'highly salient, unexpected, and potentially disruptive' (Bundy et al., 2017, p. 1662), and could be threatening to the objectives or existence of individuals, organisations, or systems.

This thesis has selected the above definitions even though the definitions of both 'emergency' and 'crisis' (and other terms in the field such as 'disaster', 'contingency', etc.) may vary greatly depending on the context in which such terms are used. This thesis argues that the variable of task complexity may be an important variable to describe the context that may challenge emergency management. Complexity can be defined through a system of non-linear, cause–effect correlations between actions and outcomes (Erdi, 2008), while 'context' concerns 'implicit situational information' (Morse et al., 2000), which, for the purposes of this thesis, means that the information is relevant for some actors within emergency management and knowledge management. The information is located throughout the system without necessarily being explicit knowledge but also without necessarily excluding it. Context may help to define what plays 'an important role in turning an event into a crisis' (Strømmen-Bakhtiar & Mathisen, 2012). Notably, complexity in science originated from system dynamics and, as early as 1948, has been discussed and put into perspective (Weaver, 1948). Complexity involves converting sizeable amounts 'of factors which are interrelated into an organic whole' (Weaver, 1948) and describes 'a system, which is the mixture of order and randomness' (Erdi, 2008, p. 202). Complexity is also referred to in organisational and management theories. For example, Damanpour (1996) defines organisational complexity as the product of organisational size and the number of hierarchical ranks performing different tasks (Damanpour, 1996, referring to Blau and McKinley (1979), and Hall (1977). Dooley (2002, p. 2) defines organisational complexity as 'the amount of differentiation that exists within different elements constituting the organization' (p. 2). There are cases in management studies where 'complexity' is very nearly synonymous with highly challenging situations or problems. Many studies, however, manage to understand and describe complex problems in organisational and management theory, where non-linear cause–effect correlations between actions and outcomes, as Erdi (2008) describes, may exist and may pose challenges to successfully executing tasks (Bigley & Roberts, 2001; Blome et al., 2014; Boisot & McKelvey, 2010; Campbell, 1988;

Damanpour, 1996; Glouberman & Zimmerman, 2002; Hærem et al., 2015; McElroy, 2000; Robson et al., 2008; Schloss, 2014; Wood, 1986). The concept of task complexity is where the present thesis locates its research, without ignoring the origins of complexity in system dynamics.

For different individuals, any type of complexity that may influence them is affected by a certain degree of subjectivity. A context in which task complexity predominates, for example, is accompanied by challenges to situational awareness as the 'complexity and dynamics of the environment increase' (Endsley (2017, p. 33). Endsley (2017) highlights organisations where practitioners are challenged in different aspects. They may confront physical or perceptual as well as complex cognitive tasks . The current PhD assesses three dimensions which may challenge situational awareness. Within this thesis, , three complexity concepts are identified which, when aggregated, provide the context variable of task complexity, namely: (1) the environment, (2) the organisation, and (3) the individual. According to Christensen et al. (2018, p. 7), management activity in a crisis 'involves interest conflicts and issues concerning power, trust and legitimacy, leading to complex political administrative decision-making processes' (p. 7). The ability to successfully complete highly interdependent tasks – that is, tasks that 'require the input of several people to complete' (Wageman, 1995, p. 146) and that lead to a multitude of outcomes – may be of vital importance when organisations experience crises.

The preparation of management capabilities and related activities – such as developing management skills, establishing structuring mechanisms, sharing information, mitigating risks, making decisions, and building operational competence related to crisis and emergency responses – has, therefore, become a common activity within many different organisations operating in contexts potentially characterised by task complexity (Borch and Andreassen (2015); (Chen et al., 2008; Ghosh & Rubly, 2015; Rake & Njå, 2009; Schmied et al., 2017). This thesis recognises the importance of the ex-ante establishment and preparation of relevant capabilities.

Prior studies have found that actors are aware of the need to learn from one another to jointly prepare their capabilities. The thesis identifies knowledge transfer and its mechanisms as the main concept to discuss joint efforts for preparation of capabilities.

This thesis also adopts the definition of 'knowledge transfer' given by Easterby-Smith et al. (2008), that is, an event where an organisation experiences a learning effect via interaction with another organisation, and where the recipient's ability to diffuse the knowledge within the organisation is of additional importance. Knowledge transfer (among other factors) may contribute to the building of shared group and team processes (Smith-Jentsch et al., 2005) and 'frame the perception of problems or opportunities that the organization[s] need[s] to work on' (Choo, 2002, p. 79). Thus, to be aware of – and to counteract – all potential conflicts and issues related to a crisis as Christensen et al. (2018, p. 7) describe, knowledge transfer mechanisms appear to be highly relevant, especially in building emergency management capability. Knowledge transfer mechanisms also appear to require ongoing intra- and inter-organisational collaborative effort.

Emergencies are predominantly characterised by events or circumstances that overwhelm available resources, whereas a crisis is specific to existential threats on the network, organisational, and individual levels (Bundy et al., 2017); (Liu et al., 2014; Sturges, 1994). Because the deployment of resources is often cited as a major capability in emergency management (Amit & Schoemaker, 1993); (Luo, 2000), it appears that capability research may provide valuable insight into emergency management problems. An organisation's 'capability' is defined in this thesis as the capacity to channel, integrate, and utilise a combination of resources through a range of organisation-specific processes, acting toward an objective (Amit & Schoemaker, 1993). Preparing, adapting, and developing capability is regarded as crucial to operate succesfully within emergency management. Emergency management capability not only needs to be adapted to the tasks of different stages of a response

and organisational activity but is also an organisational activity in itself. For example, the policy-level study by Wu et al. (2016) indicates that emergency management capability must include (1) early warning capability, (2) readiness capability, (3) response capacity, and (4) recovery capability. This means that the preparation and adaptation of capability are involved in all four of these stages before, during, and after actual crisis situations. This thesis analyses the preparation stage, with a focus on readiness, because most data come from pre-crisis exercises or from the post-crisis, post-emergency, or exercise evaluation stage. However, preparation may need to interact with all other levels of crisis-related management capability.

A number of studies have examined organisational capabilities in the area of emergencies and crises (Borch & Andreassen, 2015; Chen et al., 2008; Ghosh & Rubly, 2015; Rake & Njå, 2009; Schmied et al., 2017); however, there is less focus on the role of the range of knowledge-related mechanisms in enhancing organisational capability. By studying the range of knowledge-related mechanisms, it becomes possible to analyse how organisations can build emergency management capability. Additionally, a relation of the thesis to task complexity may be beneficial, because task fulfilment appears to be central for managers (Wright et al., 2004). Mechanisms may explain how events occur or how 'significant processes work' – they are 'entities and activities organized' to cause ongoing changes to the events from beginning to end (Machamer et al., 2000). Therefore, this thesis focuses on the knowledge transfer mechanisms that are related to 'collaboration between and across' (Liyanage et al. (2009, p. 127) organisations via individuals, groups, organisations, and networks of organisations.

1.1 Research question

The research question of this thesis is:

How do task complexity, knowledge transfer mechanisms, and emergency management capability relate to one another in the emergency preparedness phase of crisis management?

To answer this question, three relations between the variables are explored throughout this thesis, namely: the relations between (1) task complexity and knowledge transfer mechanisms, (2) complexity and emergency management capability, and (3) knowledge transfer mechanisms and emergency management capability.

Definitions of the main variables are as follows:

Task complexity is defined as the aggregation of parameters on the context connected to environmental complexity, organisational complexity, and individual complexity.

Knowledge transfer mechanisms are defined as the interplay between knowledge articulation and knowledge codification. They appear on the intersection between different actors on the network, organisational, and individual levels.

Emergency management capability within preparedness has a focus on readiness capacity and is defined as the availability of procedures and the situational awareness that provide the basis for decision-making strategies.

The main variables and dimensions are summarised in the table below, which provides an overview of which dimensions are linked within the analysis.

Table 1 Main variables and dimensions

Variable	**Dimensions**
Task complexity	The context connected to environmental complexity The context connected to organisational complexity The context connected to individual complexity
Knowledge transfer mechanisms	Knowledge articulation Knowledge codification
Emergency management capability	The availability of procedures Situational awareness

1.1.1 Relation between task complexity and knowledge transfer mechanisms

This thesis analyses the relation between knowledge transfer mechanisms and their dimensions and task complexity on the individual, organisational, and environmental levels. Knowledge transfer may be impeded by complexity via a lack of structure for the transfer (Blome et al., 2014). Studies such as McElroy's (2000) posit that knowledge transfer can sometimes be strategically planned (i.e. *order*); however, knowledge transfer is also frequently governed by *randomness*. This combination of order and randomness is often linked to complexity (Erdi, 2008). Therefore, there must be some interaction between the knowledge transfer variable and the presented task complexity. Complexity may also pose further challenges to decision-makers and organisations that may affect knowledge transfer mechanisms – such as uncertainty (Xia & Lee, 2005), asymmetry (Erdi, 2008), or lack of information – in the distribution of knowledge (in contrast to the knowledge being evenly distributed among actors).

By analysing the above challenges, this thesis stipulates how complexity influences knowledge transfer mechanisms. However, the knowledge transfer mechanism dimension may influence complexity by ensuring information quality. Here, Hærem et al.'s (2015) discussion of task complexity aids in understanding how the concept of 'task complexity' can be seen as a context variable.

The theory section shows that task complexity, as Hærem et al. (2015) summarise, may also be affected (in the case of the thesis by knowledge transfer mechanisms and is therefore not wholly independent), in contrast to other studies that characterise task complexity as an independent variable. This thesis also posits, in agreement with Hærem et al. (2015), that task complexity may change over time. This is one connection point explaining why this thesis perceives a relation between task complexity and knowledge transfer mechanisms. This thesis takes the position that tasks within emergency management may evolve according to the knowledge transferred to the decision-maker exposed to the task complexity that the context

describes. However, the complexity variable in this thesis is always assessed at a certain point in time and not as a process. Once there is new input from the context available or the decision-maker has new knowledge, complexity and the task can be reassessed.

1.1.2 Relation between task complexity and emergency management capability

This thesis recognises the vast body of literature that points to a relation between complexity and emergency management capability (Erdi, 2008; (Weick & Sutcliffe, 2011); (Kylen, 1985); (Boisot & McKelvey, 2010). As such, this thesis examines preparedness and focuses on readiness capability (which the literature describes in terms of emergency supplies, emergency personnel, the improvement of emergency management systems, and special emergency funds) and, to lesser degree, response capacity (which the literature describes in terms of organisational ability, commanding ability, controlling ability, and coordinating ability) as dimensions of the emergency management capability variable (Wu et al., 2016) that may be affected by prevailing complexity. Throughout this thesis, the dimensions related to emergency management capability are developed. However, the extant literature already provides substantial evidence indicating that emergency management capability is affected by the context-related aspects of complexity, such as individuals' and organisations' degree of familiarity with crises, the structure within the organisational set-up, and the physical distances and other 'elements in the environment' (Endsley (2001); Wright et al. (2004).

Among other considerations, this thesis discusses the role of knowledge asymmetry, herein defined as knowledge unevenly distributed among actors, including information about different backgrounds, procedures, routines, and leadership cultures among organisations. Such asymmetry may affect these aspects of capability (e.g. the ability to command, coordinate, and control; the availability of resources, etc.), which may be relevant to emergency management capability (Erdi, 2008); (McPherson et al., 2001). Concomitantly, there is a need for these capability

gaps to be closed in order to potentially increase preparedness and be less dependent on sole actors carrying essential knowledge. This may be achieved by two approaches. Either it is possible to standardise knowledge components (the availability of procedures) in different locations (decreased asymmetry), or to have external specialists holding distinct tacit as well as explicit knowledge. Both approaches are expected to increase emergency management capability, signalling that there may be non-linear cause–effect correlations within and across organisations (Erdi, 2008) in connection with complexity and emergency management capability.

Another aspect that is discussed in coherence with the previous literature (Chung, 2005; Endsley, 2017; Gerdtz & Bucknall, 2001) concerns situational awareness in combination with a challenged system of communication. Situational awareness may suffer from 'information gaps, a lack of fluent communication, and the fact that there is no common operational picture' (Seppänen et al., 2013, p. 1). Awareness may also be challenged by complexity; for example, standardisation may be less efficient (Alexander, 2003) and the mechanisms capable of introducing new ideas to the system or organisation may catalyse innovation, regardless of the conditions (Aiken & Hage, 1971). Endsley (2017) also claims that task complexity is a challenge to gaining situational awareness.

1.1.3 Relation between knowledge transfer mechanisms and emergency management capability

This thesis also examines the relation between the variables of knowledge transfer mechanisms and emergency management capability. Knowledge transfer mechanisms, including knowledge articulation and knowledge codification, aim to contribute to an overall sense-making and awareness of a situation (compare Choo, 2002; Weick et al., 2005) and especially within emergency management. Sense-making may include aspects related to the quality of information (Weick et al., 2005, p. 412), as well as group and team processes (e.g. (Gioia et al., 1994 In Weick,

Sutcliffe, and Obstfeld (2005: 409)), which contribute to the collective understanding of decision-making strategies. Situational awareness may also contribute to activities related to furthering knowledge transfer mechanisms, such as ensuring information quality. Additionally, the availability of procedures (and the dimensions that support these factors, such as time, experience, position, etc.) provides a base from which knowledge transfer may evolve. However, this requires the ability to devise alternatives to procedures as part of emergency management capability (Mendonca and Al Wallace (2007). Thus, knowledge transfer mechanisms increase both the availability of procedures as well as understanding of their limitations (Bigley and Roberts (2001), while also developing them.

1.2 Summary of the area of contribution

This thesis provides a set of contributions connected to a model of emergency management capability with a focus on preparedness, and it establishes a context variable of task complexity to better understand the challenges to emergency management capability as well as why such capability is important. Furthermore, it argues that complexity-related variables present as a combination of 'order and randomness' (Erdi, 2008) and, therefore, cannot be adequately described in purely quantitative terms. Therefore, this thesis uses a qualitative approach to describe the complexity-related variable. Task complexity affects both knowledge transfer mechanisms and emergency management capability in addition to being affected by knowledge transfer mechanisms. The approach of the thesis is to develop the context variable of task complexity to extend context-related theory in the crisis and emergency management literature (Borch and Andreassen (2015); (Chen et al., 2008; Ghosh & Rubly, 2015; Rake & Njå, 2009; Schmied et al., 2017). Task complexity comprises the three dimensions of the context variable: individual, organisational, and environmental. If new relevant knowledge is transferred, this may again impact and change task complexity. Previous literature has often connected tasks to individual positions (Campbell, 1988); Oeser and O'Brien (1967); (Wood, 1986, p. 62) or has focused only on certain levels of crisis and emergency management (i.e.

tactical, operational, strategic, political). One major message of modern task complexity theory is that it is no longer exclusively bound to a single level, such as that of the individual (Hærem et al., 2015). With the context variable of task complexity, it is possible to move between individual, group, organisational, and inter-organisational levels, as well as to adjust the level of complexity to the level of crisis and emergency management. The current model does not argue against approaches such as those of Campbell (1988) or Hærem et al. (2015), nor does it argue against task dependency in relation to problems within crisis and emergency management. However, it does extend understanding of how task complexity affects emergency management capability. Therefore, in its approach, this thesis contributes to engagement with the ever-changing interaction between the individual and organisational levels (which is also important for knowledge transfer as well as crisis and emergency management capability). The thesis includes inter-level interaction as well as the interaction between these levels and the environment, which is often not included within studies in crisis and emergency management and related decision-making challenges.

In addition, this thesis broadens the understanding of how mechanisms of knowledge transfer are applied to increase the preparedness of emergency management capability. Studies on knowledge, such as that of Choo (2002), establish an interesting conception of how shared meanings contribute to sense-making, the creation of knowledge, and decision-making; however, they are – by design – incapable of providing context-related challenges from complexity or integrating decision-making into the concept of crisis and emergency management. Although studies such as that of Sayegh et al. (2004) provide deep insight into individual decision-making connected to crises, they take into account only the minor-level context and the organisational perspective, which appear to prevail wherever emergency management capability needs to be established, adapted, and developed.

Understanding the range of mechanisms that contribute to emergency management capability provides further insight into how actors can develop their capability. Thishis thesis uses a a preparedness perspective. Moreover, this thesis examines the role of task complexity; that is, this thesis creates a framework to present how emergency management capability is developed in the context of task complexity. It also operationalises the concept of knowledge transfer mechanisms by distinguishing the dimensions of knowledge articulation and knowledge codification. Therefore, it is important to ensure information quality, strive for group and team processes of knowledge as well as shared understanding across all levels, and to apply modes of knowledge creation.

1.3 Outline of the dissertation

The second chapter of this thesis provides an outline of its theoretical foundation, presents the concept of emergency management, and describes important processes related to emergency management capability with a focus on preparedness. It then explains task complexity, which is followed by a discussion on knowledge transfer mechanisms. The methodology is presented in the third chapter, which is divided into several subchapters dedicated to philosophies, strategy, methods, data, context, quality, and ethics. The fourth chapter contains summaries of the four empirical research papers, as well as their contributions to the overall research question of this thesis. Chapter five discusses the findings connected to the relations of the variables, after which the model is presented. The sixth and final chapter is devoted to concluding the main findings. It contains a discussion of the implications connected to practices and policy; information on additional limitations and directions for future research is also provided.

2 Theoretical Background

This chapter lays the theoretical foundation for this thesis. In the first step, it presents the concepts related to emergency management capability to elaborate on the challenges related to capability in that specific field. It then presents the context per task complexity. It argues how the context complexity dimensions of the individual, organisation, and environment can describe task complexity. In the last step, there is information (and, thereby, forward understanding) about knowledge transfer in general and knowledge transfer mechanisms in particular. Hereby, the focus is placed on outlining knowledge transfer and its mechanisms as a system whose design follows the complexity presented by the context.

2.1 Emergency management capability

Wu et al. (2016) define emergency management capability as the sum of capabilities related to early warnings, readiness, responses, and recovery to get back to 'business as usual'. Other studies, such as that of Li and Jiang (2012), recognise similar dimensions. Management capability is crucial to the adequate preparedness of emergency and crisis responders (Borch & Andreassen, 2015; Chen et al., 2008; Ghosh & Rubly, 2015; Rake & Njå, 2009; Schmied et al., 2017), and evidence suggests that such capability may be attributed to the ability to adapt to change, create further knowledge, and enhance performance (Fraser & Greenhalgh, 2001). Dosi et al. (2000, p. 2) offer the following explanation of capabilities:

> To be capable of some thing is to have a generally reliable capacity to bring that thing about as a result of intended action. Capabilities fill the gap between intention and outcome, and they fill it in such a way that the outcome bears a definite resemblance to what was intended. (p. 2)

Amit and Schoemaker (1993, p. 35) study of firms yielded another suitable explanation:

> Capabilities […] refer to a firm's capacity to deploy resources, usually in combination, using organisational processes, to effect a desired end. They are information-based, tangible or intangible processes that are firm-specific and are developed over time through complex interactions among the firm's resources. They can abstractly be thought of as 'intermediate goods' generated by the firm to provide enhanced productivity of its resources, as well as strategic flexibility and protection for its final product or service. (p. 35)

Eisenhardt and Martin (2000) combine a set of capabilities into what they call 'resource allocation', which includes copying, transferring, and recombining resources. Other studies, such as that of Luo (2000), also refer to this model of capability as resource allocation. Unlike resources, capabilities are based on developing, carrying, and exchanging information through the firm's human capital. Brennan and Krohmer (2006) refer to emergency management-related capability as well, highlighting in their definition the combined effort of internal and external resources and the assistance of organisations to overcome a present crisis.

Per the above, this thesis defines emergency management capability as the sum of capabilities related to early warnings, readiness, responses, and recovery (Wu et al. (2016). These capabilities are interlinked and information-based processes that work together; they may be internal or external (Brennan and Krohmer (2006) and may be tangible or intangible (Amit & Schoemaker, 1993). They are crucial to the adequate preparedness of emergency and crisis responders (Borch & Andreassen, 2015; Chen et al., 2008; Ghosh & Rubly, 2015; Rake & Njå, 2009; Schmied et al., 2017).

This thesis recognises how the literature suggests that within emergency management on all levels scarcity of time as well as the increased use of time may

potentially challenge actors (Gerdtz & Bucknall, 2001); (Khodarahmi, 2009). Furthermore, Janis and Mann (1977) as well as Edland and Svenson (1993) argue that time pressure imposes limits on exploring the depths of alternatives in order to gain situational awareness, thereby affecting decision-making at a later stage. Chung (2005) identifies time constraints and communication difficulties as the most common reasons for activities being performed with incomplete situational awareness. Moreover, some of my individual research papers from this thesis include discussions about time and timing.

However, a choice must be made concerning the role of time and change in this thesis, which examines the preparedness stage of crisis management – a stage at which the scope, theme, and details of a potential crisis are not yet known. This thesis, therefore, does not detail timing or change throughout all response phases. Instead, it elaborates on tasks from the perspective of the preparedness phase. In terms of individuals and cross-organisational groups from different levels acting on behalf of organisations, crisis and emergency management requires the development of attributes that emergency management capability entails. Emergency preparedness is defined by the United Nations (UNISDR, 2009), as 'the knowledge and capacities developed by governments, professional response and recovery organizations, communities, and individuals to effectively anticipate, respond to, and recover from the impacts of likely, imminent, or current hazard events or conditions' (UNISDR, 2009, p. 21).

In terms of relevant capability, however, all stages – before, during, and after an emergency or crisis – may be important. In accordance with existing crisis and emergency management research, this theory-centric chapter examines emergency management capability from two perspectives: first, it examines how emergency management must be linked with decision-making capability; second, it discusses the two dimensions of the availability of procedures and situational awareness as the main dimensions of the emergency management capability variable.

In this thesis, decision-making capability is closely linked with emergency management capability because this thesis views decision-making as the main managerial task through which actors utilise emergency management capability. Kapucu and Garayev (2011) also link decision-making with capability, describing collaborative decision-making as the 'combination and utilization of resources and management tools […] to achieve a common goal' (Kapucu & Garayev, 2011, p. 366). The importance of the effective utilisation of resources and goals is similarly expressed in capability theory (Amit & Schoemaker, 1993). The routines of individuals may already support straightforward choices, but other types of decisions (such as strategic decisions) may require other characteristics. In their strategy-related paper, Eisenhardt and Zbaracki (1992, p. 17) discuss the 'infrequent decisions made by the top leaders of an organization that critically affect organisational health and survival' (p. 17). However, in emergency management, managers who are not in top leader positions may also be forced to make such decisions. Intriguingly, just as emergency management capabilities in general require flexibility and dynamism, flexibility and dynamism are major concerns for decision-making (Shimizu & Hitt, 2004).

In this thesis, two dimensions relevant to decision-making are deemed relevant to emergency management capability, namely: (1) the availability of procedures and (2) situational awareness. The next two sections describe how they are related to emergency management capability and offer insight into why they are chosen as relevant dimensions. These two dimensions are also represented in Paper 1 and support the creation of the model used in this thesis.

2.1.1 The availability of procedures

This thesis starts from the assumption that emergency management capability may be both static (structured) and dynamic or, as Winter (2003) discusses, zero level (routines or capabilities) and non-zero level (dynamic capabilities). A good example of this is the use of decision support in the form of procedures as one set of capabilities in emergencies and crises.

Standard operating procedures are a way for decision-makers to implement a 'single course of action' as long as the problem is recognised and particular (Flin et al., 1996, p. 267). They also assist in making a choice and garnering a quick response (Bigley & Roberts, 2001; Schmied et al., 2017). However, Bigley and Roberts (2001) discuss some of the limitations of standard operating procedures: Not only might they hinder an operation's full potential in dealing with a crisis, but they may also discourage the pursuit of divergent, fruitful alternatives to finding a solution as necessary. Procedures and routines are, therefore, closely connected.

The capability or routine that helps actors to perform simpler tasks, where a limited amount of change and dynamism exists (zero-level capabilities; (Winter, 2003), is also part of the recommended capabilities. Routines are often seen as a capability or as one of the enablers of emergency management capability (Amit & Schoemaker, 1993; Peng et al., 2008). The effect of routines has to be observed with care, because in some sense-making literature such as that of Weick (1993) and Maitlis and Sonenshein (2010), routines appear to make the organisation and its people resistant to possible change when it is necessary.

Nevertheless, it appears that regulations, standards, and routines are crucial for emergency responders. Overall, routines lead to individuals and organisations communicating better and exchanging learning effects (Denzau & North, 2000). Smith-Jentsch et al. (2005) study a safety and emergency setting (citing (Cannon-Bowers et al., 1990); (Kraiger & Wenzel, 1997); (Klimoski & Mohammed, 1994); (Mohammed et al., 2000) and discuss the importance of effectiveness in team processes. According to Schaafstal et al. (2001), emergency management capability relates to 'teams of teams' who need a shared understanding of the tasks to be performed. As an example, understanding which information to provide may aid decision-making in emergencies (Paton & Jackson, 2002). Rosenthal and Kouzmin (1997) discuss exceptions to the strict adherence to standard operating procedures. In their study context (the public government), they point out that crises may

automatically lead to the abandonment of common practices (Rosenthal & Kouzmin, 1997) or the overwhelming of institutional mechanisms (Boin & Renaud, 2013). Therefore, an alternative path is needed for procedures and routines that are often linked to information exchange (Polites & Karahanna, 2013).

2.1.2 Situational awareness

Amit and Schoemaker (1993) suggest that exchanging information or communication is a crucial capability dimension in general. Whereas some studies, such as that of Mendonça et al. (2007), focus on the technology aspect when referring to information- and communication-related capability, this thesis focuses on communication content and information quality as they relate to the emergency management capability variable. Information gaps (Seppänen et al., 2013, p. 1) or the non-timeliness of information (Gerdtz & Bucknall, 2001) challenge situational awareness. Boin and Renaud (2013) consider this and list challenges ranging from rapid changes and little available time to uncertainty, group interaction (as opposed to single-person interaction), and organisational barriers. That is, 'institutional mechanisms such as deliberation, specification, and verification (characteristic of the bureaucratic process)' do not persevere in a crisis, while potential gaps in knowledge and sense-making increase (Boin & Renaud, 2013, p. 42). Boin and Renaud (2013) are, therefore, concerned about situational awareness and orchestration prior to the occurrence of a crisis, labelling this 'meta-leadership'.

Situational awareness may be a catalyst for successfully finding alternatives when existing procedures have reached their limits (Weick, 1996). Moreover, individuals with lower situational awareness are more prone to errors in decision-making linked to procedures (Wright et al., 2004). This is because situational awareness requires actors to be up to date with the capabilities of other actors, groups, and organisations ((Coffey, 2012); (Rimstad et al., 2014)). Moreover, contexts such as the 'task' may present challenges when gaining situational awareness

(Endsley, 2017). The task fulfilment of a major goal, therefore, depends on a collection of sub-goals that does not necessarily follow the procedures.

Mendonca and Al Wallace (2007) refer to situational awareness in a crisis during which increased effectiveness can be achieved only by departing from a structure such as a standard operating procedure. Flexibility and sufficient dynamism (Shimizu & Hitt, 2004) may be major attributes of this set of capabilities, which entails combining competences and resources (Teece et al., 1997). Crisis and emergency management capability in the form of situational awareness, therefore, is closely related to flexibility and dynamism. Here, dynamism contributes to emergency management-relevant capability when adaptation to the changing environment is needed. When a change is highlighted, scholars (often studying firms) discuss dynamic capabilities as a very specific capability (Winter, 2003). Dynamism, as Fraser and Greenhalgh (2001) present it, is the extent to which individuals are able to adapt to change, create further knowledge, and enhance their performance. Further, Borch and Madsen (2007), although in an SME field, discuss dynamic capabilities as the ability to create, integrate, and re-establish internal and external resources and routines. Dynamic capabilities, therefore, contribute to the mechanisms connected to learning and strategy (i.e. developing some capabilities in the mid to long term), which may also be an important activity of organisations (Borch & Madsen, 2007). Learning as a general organisational activity also appears to be crucial, as ad hoc learning during emergency situations involving increased uncertainty may often come too late (Moynihan, 2008). Knowledge as a resource within and beyond the organisation is also important. That is, integrative capability enables organisations to incorporate and use knowledge within and across organisational boundaries (Henderson, 1994). Consequently, analysis shows that this integrative capability may have positive effects due to an organisation's ability to acquire and utilise available knowledge (Mitchell, 2006). This emergency management capability relates to what Nonaka and Von Krogh (2009) discuss, namely having different forms of knowledge to interact with and apply in place.

To conclude, emergency management capability relies on situational awareness, which is closely linked to dynamism and learning, as it requires adapting to sudden changes in underlying complexity. Contingency theory sees no single set of independent variables for organisational success but rather includes those that fit with the current situation, structure, and performance goals (Donaldson, 2001). Providing organisational performance tailored to the situational awareness of the present complexity is, therefore, a core element of emergency management capability. Furthermore, in terms of management capability related to a crisis, Brennan and Krohmer (2006) highlight in their definition the combined effort of internal and external resources, as well as the assistance of organisations, to overcome a present crisis. The above discussion (structures, dynamism, and the contingency aspect) stipulates that there is no static, general set of capabilities.

2.1.3 A short summary of emergency management capability

Based on the arguments presented in this chapter, it can be concluded that emergency management capability includes adaptability to change and the induction of relevant performance, and that it is in constant interaction with knowledge development (Fraser & Greenhalgh, 2001). Both resources and processes, whether internal or external (Brennan & Krohmer, 2006) to individuals, teams, and organisations, may be relevant to warnings, readiness, responses, and recovery (Wu et al. (2016). Notably, this thesis focuses on preparedness, which is mostly connected to readiness but is also of relevance to responses. It can also be stated that time represents an important dimension in terms of capabilities within emergency management. However, rather than focusing on time, this thesis focuses on context to provide the characteristics that emergency management capabilities need to address. Furthermore, it can be posited that decision-making (the main task of managers within emergency management) is closely related to emergency management capability. The availability of procedures (structures and resources), as well as ensuring that managers and their organisations gain situational awareness,

are deeply embedded in the variable of emergency management capability. By having increased situational awareness, theory suggests that decision-making may consequently be more beneficial and may result in more reliable decision-making, as described in the previous chapter and in greater detail in Paper 1 (to include strategies for decision-making sets of procedures [SOPs], improvisation, and the strategic decision process). This, in turn, provides the basis for a preparedness perspective of emergency management capability.

2.2 Task complexity

Context and complexity are crucial in this thesis. As already outlined in the above subchapter on procedures and situational awareness, context in crisis management represents the background and action setting that may be connected to a potential crisis. Among other factors, context can be determined by objects, individuals, and potential changes (Schilit & Theimer, 1994). Moreover, the physical environment can become a major variable in determining the complexity of context (Schilit & Theimer, 1994; Xia & Lee, 2005), particularly in crisis management (Strømmen-Bakhtiar & Mathisen, 2012). In terms of the question of how to describe and characterize context, in the past, there have been studies from different fields that have linked to complexity theory (Abelson, 1981; Feltovich et al., 1997). However, it is essential to figure out in what way a complexity concept relates to context. Within crisis and emergency literature, in which the task of decision-making is prevalent (Chung, 2005; Considine et al., 2007; Gerdtz & Bucknall, 2001; Ody, 1995; Parnell, 2017; Sayegh et al., 2004); (Gerdtz & Bucknall, 2001; Małyszko & Wielgosz, 2016), and task complexity is given great importance (Campbell, 1988; Hærem et al., 2015; Haerem & Rau, 2007), the focus of this section is to acquire a further understanding of the context variable of task complexity.

Morse et al. (2000) provide a simple definition of context when stating that in human interactions, context is 'implicit situational information'. Steinberg and Rogova (2008) state that, among others, the characteristics of both the environment

and the situation may be context variables or context parameters. Other studies, such as that of Covin and Slevin (1989), examine aspects of strategic management in organisations (firms) and consider organisational culture and industry structure as important contexts, and they use environmental context as a main variable. Schilit et al. (1994a) take an approach more related to the individual, stating that context is constructed by the question of where you are, whom you are with, and what resources you have. Three possibilities to classify context are, thus, per location and the environment, agreement and sharing (among groups of peers), and the activity of a user, which are among the classifications identified by Bolchini et al. (2009). Therefore, this thesis considers the following three dimensions as relevant for the given context: the environment, the organisation, and the individual.

Furthermore, a distinction can be made between non-changing or static context variables and changing or dynamic variables (Steinberg & Rogova, 2008). George and Jones (2000) highlight the benefits of incorporating temporality theory development within organisational theory. Likewise, some research on context, such as that of Schilit et al. (1994b), postulates that context also includes change over time. In this thesis, the change itself is seen as a change in the conditions related to the environment, organisation, or individual. In emergency management, the aspects of context are subject to change that can be characterised by, among other factors, complexity (Hermes & Mainela, 2014). Erdi (2008) describes complexity generally, stating that 'a system, which is the mixture of order and randomness, is structurally more complex' (p. 202). Furthermore, dynamism is a combination of changes in order and randomness; specifically, potential dynamism is expressed in this thesis by the underlying complexity connected to the areas of the environment, organisation, and individual.

Schloss (2014) highlights a study by (Kleinke et al., 2009), in which disruptive innovations create a sudden change in the context. In this case, the authors discuss firms and new innovations or technologies (Kleinke et al., 2009; Schloss, 2014);

however, this sudden move away from the status quo into partially unknown territory is one that can also be characterised by complexity. Changes may imply that individuals are faced with new roles and tasks, organisations suddenly have to cooperate in unfamiliar networks and settings, and parts of the uncontrollable environment may become more challenging and unpredictable in terms of cause–effect. Some studies, such as that of Glouberman and Zimmerman (2002), highlight a shift from simple to complicated and complex problems as they relate to each other: Here, complex problems refer to formulae or recipes (procedures) with limited applications and that give no assurance of an exact outcome or success through problem solving. Expertise may also aid in problem solving but also may not guarantee success. Kurtz and Snowden (2003) distinguish a fourth domain, 'chaos', in which no formulae or cause–effect understanding is ever available. This thesis considers problem solving to be a task performed by managers . Therefore, this thesis empirically studies the development of emergency management capability and managers' preparedness to handle complexity. Since the complexity that managers may face is expressed within the tasks that they must perform, it is necessary to examine previous research on task complexity. Focusing on complexity in this thesis is appropriate for another reason – namely, task complexity demands the intensive use of knowledge (Pew, 1994), which is at the core of this thesis' developed model.

Hærem et al. (2015) research on task complexity draws upon Oeser and O'Brien (1967) study. They establish task complexity as being similar to a decision tree, where nodes and ties may change over time and, thus, provide a dynamic element to task complexity (Wood, 1986). In contrast to simple tasks, the more choices that are available to reach goals (Wood, 1986) and the more unexplainable the interrelations between components in the network of actors (Flood, 1987), the more complex the task. Notably, there have been attempts at quantifying the complexity of tasks (Campbell, 1988; Feldman & Pentland, 2003; Hærem et al., 2015). As stated, Hærem et al. (2015) draw upon Oeser and O'Brien (1967) study and formulate task complexity as follows: 'Task complexity = $\sum_g \sum_p ties_{g,p}$, where paths (p)

are routes to particular goals (g) representing the attainment of an outcome'. Task complexity is also related in the literature to the perceiving (Haerem & Rau, 2007), solving (Campbell (1988), and performing (Feldman & Pentland, 2003) of tasks.

The complexity of tasks, according to the framework of Campbell (1988), is characterised by changes (which Campbell refers to as an increase) in the information load, the diversity of information, or the rate of information change. Information and knowledge intersect, whereas knowledge management is much more capable of taking into account a human (manager's) perspective than us information management (Terra & Angeloni, 2003) and may be intended to make the information in the system usable. Thus, developing knowledge may connect even more closely with coping with task complexity.

Campbell's (1988) concept enables the distinguishing of four task characteristics that contribute to complexity: (a) the presence of multiple potential ways (i.e., paths) to arrive at a desired end-state, (b) the presence of multiple desired outcomes (i.e., end-states) to be attained, (c) the presence of conflicting interdependence among paths to multiple outcomes, and (d) the presence of uncertain or probabilistic links among paths and outcomes' (Campbell, 1988, p. 43). The higher the value of each of these characteristics, the more complex the task is in working on a major goal. As stated previously, the present thesis argues that the environment, organisation, and individual can describe all the parameters and link back to the four characteristics that Campbell (1988) delineates, including goals and objectives.

Wright et al. (2004) analyse tasks and conclude that 'major' goals are reached by fulfilling a set of sub-goals. Wright et al. (2004) also claim that situational awareness is required for each of the sub-goals. Therefore, task fulfilment of the major goal is dependent on a collection of task complexities and requires several sets of knowledge and situational awareness.

Weick and Sutcliffe (2015, p. 66) argue that the organisation of complex tasks should not be overly simplified, as this may discourage the potential for 'process variety, […] argumentation, and more capability and willingness to act to understand' (p. 66). This suggests looking at extended task complexity concepts such as that of Hærem et al. (2015). This thesis agrees with Hærem et al. (2015, p. 458) in many ways, especially with the concept of extending 'task complexity to include multiple actors at any level of analysis' and to be observer-dependent. In addition, this thesis intends to elaborate on the notion that many different mechanisms may contribute to task complexity (Hærem et al., 2015). In terms of complexity, Hærem et al. (2015), based on Wood (1986) and Campbell (1988), also argue that information must be processed; otherwise, it increases task complexity. Here, a new approach presents itself, namely that of exploring the aforementioned role of developing knowledge, which persists as a way for individuals and their organisations to make information available (Terra & Angeloni, 2003).

In addition, Hærem et al. (2015) argue that the complexity of each task changes over time. Although this thesis agrees with their assertion, it also finds that the task itself may, with new input, become obsolete almost immediately due to only a few factors changing. As such, the task may still be complex, but it may no longer be relevant. Therefore, the connection of a variable to overall capability rather than solely to the task performer appears important because it describes the potential for task performance, if necessary. The task still exists and remains complex, but only when its relevance is reinstated through transferred knowledge does it become relevant again. This agrees with Hærem et al. (2015), who stipulate that it may be relevant to establish task complexity as a dependent variable. This is where the model presented in the current thesis becomes applicable, as there is some feedback from knowledge transfer mechanisms to complexity. Thus, the current thesis also explores how knowledge transfer can influence complexity, which is shown in the model. In their discussion, Hærem et al. (2015) suggest that complexity may be presented as a logarithmic scale that makes it measurable.

The notion espoused in this thesis is that it may be possible to characterise only parts of complexity in numerical terms, while the remainder may need to be described by qualitative dimensions. This thesis argues that complexity – and task complexity is not expected to be an exception to this – presents as a combination of 'order and randomness' (Erdi, 2008) in terms of its effects. However, when effects are uncertain, this thesis argues that the variable that leads to these effects can also never be characterised completely. Therefore, Hærem et al. (2015) suggest that a concept for task complexity be provided that can be applied to all levels of analysis. As stated above, this thesis agrees with their suggestion but seeks to move away from a generic type of formula that can be used for all levels of analysis, instead suggesting a qualitative description of context. Specifically, in this thesis, a context variable of task complexity may be relevant beyond levels of analysis and areas with multiple actors. However, in contrast to the suggestion of Hærem et al. (2015), the variable in this thesis cannot be computed for different fields at present.

2.2.1 The environment

An organisation's environment refers to the external effects to which an organisation is subject (Sharfman & Dean Jr, 1991); thus, organisations are, to a certain degree, shaped by their environment and interact with it (Miles et al., 1974).

A study by Brown and Lampen (2012) states how context can have many facets, particularly including location or the environment. Environmental complexity appears in a 'field in which organizations and their personnel interact and transact with counterparts in other organizations' (Child, 1997) and their surroundings. This thesis, therefore, considers the field of interaction as the environment, while the actual network and active interaction are connected to organisational complexity. This is because the environment may provide organisations with opportunities as well as constraints (Damanpour & Schneider, 2006). Moreover, according to Jarillo (1988), environmental complexity is constructed through the relationship between an organisation and its external environment. Coskun and Ozceylan (2011) identify the

environment as one major aspect (besides an individual's tools and tasks) connected to human errors when exposed to complexity.

Based on Dooley (2002) and Erdi (2008) studies, this thesis can define a complex environment as an organisation's physical surroundings (i.e. resources) that affect the organisation due to 'circular causality, feedback loops, logical paradoxes, and strange loops' (p. 7). Because optimising any type of strategy in a complex environment is quite challenging (Hogarth & Makridakis, 1981), organisations need to prepare emergency collaborations through inter-organisational learning processes. Examples of such an environment are given in the studies of (Roud & Schmied, 2020), (Hogarth & Makridakis, 1981), (Bigley & Roberts, 2001), and (Andreassen & Borch, 2020), in which there is an unpredictable and harsh environment with scarce resources and limitations in the communication infrastructure.

2.2.2 The organisation

Organisational complexity appears due to 'structural components or units' and a diversity of specialists working within organisational constructs (Damanpour, 1996, p. 695). It may challenge overall organisational performance (Erdi, 2008) and the individuals therein.

In emergencies, organisational management personnel often encounter a lack of information, which creates ambiguity (Becerra-Fernandez et al., 2007). For example, increased organisational complexity leads to an organisation being unable 'to distinguish ex ante what is usable information from what is noise' (Boisot & McKelvey, 2010, p. 416). A main challenge of organisational complexity (as with other complexities) for managers is, therefore, that there is 'circular causality, feedback loops, logical paradoxes, and strange loops […] Small changes in the cause imply dramatic effects [that are subject to] emergence and unpredictability' (Erdi, 2008, p. 7). Another relevant aspect that Erdi (2008) discusses is the role of asymmetry (e.g. unevenly distributed power and resources, as well as knowledge) across the system and its contribution to the level of complexity. Additionally, management within

organisations under complexity must confront additional unpredictability (Borch & Andreassen, 2015). Notably, different approaches and thoughts exist within an organisation and may especially emerge during emergencies (Halverson et al., 2004; Weber & Maximilian, 1947). Therefore, organisational complexity has been clarified, and it is clear that emergencies may enhance the effects of complexity. Additionally, organisational complexity causes uncertainty in terms of cause–effect, leading to both judgemental and inspirational strategies (Thompson, 1967).

Notably, this thesis considers the field of interaction to be the environment, while the actual network building, interaction, and co-evolution of affiliated organisations (or sub-organisations) is connected to organisational complexity. In terms of international strategic alliances, organisational complexity may arise due to problems with coordination, inconsistencies, and different approaches to work (Erdi, 2008). Moreover, McPherson et al. (2001) argue that interactions among organisations can depend, in many cases, on how alike or symmetrical the organisations are.

McElroy (2000) and Aiken and Hage (1971) emphasise the evolution of networks of organisations and how this contributes to forming 'complex adaptive systems'. Complexity in organisation studies is often described by management challenges arising due to the structure (Dooley, 2004) and size (Damanpour, 1996) of an organisation. Thus, complexity evolves through the arrangement of an organisation and how it expands. Furthermore, uncertainties in the organisation connected to unexpected events may also contribute to an increase in this type of organisational complexity (Kylen, 1985; Weick & Sutcliffe, 2011).

Per the previous chapters and the discussions about organisational complexity, relevant dimensions need to be related to structure and asymmetry, uncertainty, interaction challenges, and the existence of multiple knowledge donors and recipients.

2.2.3 The individual

Individual aspects related to complexity may be stipulated in the manifold identities within humans (Kurtz & Snowden, 2003). That is, individuals occupy different roles both outside and inside their organisation and may behave differently depending on context parameters (Kurtz & Snowden, 2003). Individuals, therefore, also experience uncertainty (Baoding, 2007, p. 459). This interconnects with the different paths of task complexity.

First, both the individual attributes of an actor and their expertise may influence how much information is needed to perform a task, as well as how many sub-tasks need to be performed (Hærem et al., 2015; Haerem & Rau, 2007; Hunter et al., 1990; Levin et al., 2001).

Second, how organisational routines are interpreted, put into action ('the performative aspect'), and developed may play a role in the overall complexity experienced (Feldman & Pentland, 2003; Hærem et al., 2015). This also depends on how capable the individual is of perceiving task complexity (Haerem & Rau, 2007) and how willing they are to prioritise and act on it. Becker and Knudsen (2005, p. 747) discuss the unclear 'subjective probabilities' that individuals experience in an organisation, while Haerem and Rau (2007) state that it is more through thought and perception that a task becomes complex. For Feldman and Pentland (2003), on the other hand, it seems more likely that the act of doing creates different approaches. What most studies agree upon, therefore, is their understanding of how requirements or objectives for how to perform a task and actual task performance may diverge (Hærem et al., 2015).

Kurtz and Snowden (2003) provide several reasons for why individuals contribute to complexity:

- Individuals may not always be in a position to act according to standards and rules.

- Individuals may see and act upon large-scale patterns rather than being limited to local patterns and thoughts.
- Individuals may provide order with different means (i.e., order and un-order), and they might understand and define order differently.

Additionally, Kurtz and Snowden (2003) reason that individuals may have to balance between tasks that appear simple to them and tasks that appear complicated or complex to them. Therefore, remaining aware of different tasks may be among the tasks of individuals.

2.2.4 A short summary of task complexity

Based on the arguments presented above, this thesis assumes that task complexity may determine the extent of problem characteristics within crisis and emergency management. This thesis takes as a starting point the discussion of task complexity and its relation to individuals' perceiving (Haerem & Rau, 2007), solving (Campbell (1988), and performing (Feldman & Pentland, 2003) of tasks based on accessible information and knowledge. Hereby, the context is highlighted as the concept that may lead to the relevant input required to describe the level of task complexity with qualitative dimensions. Time and change can also be relevant attributes; however, the current thesis focuses more on the preparedness stage, which is somewhat disconnected from the time constraints of other emergency management stages. Thus, the choice is made to focus on the three main attributes of the environment, the organisation, and the individual, which apply best to the overall model. Within this model, however, time and change can be described at a certain stage in comparison to another complex task at another specific time.

2.3 Knowledge transfer mechanisms

Knowledge transfer may be crucial to the necessary preparedness of emergency management capability so that task complexity can be addressed. However, little is known about the mechanisms behind knowledge transfer in this

setting. Research on knowledge transfer 'examines whether organisations learn from the experience of other organisations [or units in an organisation] [and] whether organisations benefit from knowledge acquired at others' (Argote, 2012, p. 9). Anand and Jones (2008, p. 1056) analyse DiMaggio and Powell (1983) and (Bourdieu, 1993) studies, finding four mechanisms relevant for knowledge transfer:

1. The constant interaction of actors within trans-organisational structures (DiMaggio & Powell, 1983)
2. The creation of a common purpose among actors (DiMaggio & Powell, 1983)
3. Coalition between actors (DiMaggio & Powell, 1983)
4. The use of capital (e.g. knowledge) for different purposes (Bourdieu, 1993).

Hatten and Rosenthal (2001, as cited in Sun & Scott, 2005) state that relying on knowledge transfer is inevitable when organisations form strategic alliances and prioritise core competencies. Therefore, this thesis aims to acquire a greater understanding of the specific mechanisms of knowledge transfer. Specifically, this chapter highlights how knowledge transfer mechanisms may contribute to the capabilities that organisations need to deal with crises and emergencies.

According to Machamer et al. (2000):

> Mechanisms are sought to explain how a phenomenon comes about or how some significant process works. Specifically, mechanisms are entities and activities organized such that they are productive of regular changes from start or set-up to finish or termination conditions. (p. 2)

While a set of studies covers knowledge transfer mechanisms, the study contexts and fields vary by empirical and theoretical backgrounds.

For example, Pedersen et al. (2003) examine multinational firms (the inter-organisational level). When subject to extensive changes (as described in the task complexity chapter), studies such as those of Hatten and Rosenthal (2001 in Sun &

Scott (2005)) and Sun and Scott (2005) argue that relying on some knowledge transfer is inevitable because organisations must start prioritising their core competencies and relying on strategic alliances. Thus, the mechanisms to transfer knowledge become increasingly important.

According to Pedersen et al. (2003), knowledge transfer mechanisms (in their study within media) must depend on the characteristics of knowledge. Explicit knowledge, which is easily reproduced, must be transferred differently from tacit knowledge (Pedersen et al., 2003). Further, Jasimuddin (2007) focuses on communication through media as a knowledge transfer mechanism, stating that status and personal connections, as well as the proximity of knowledge donors and recipients, help in identifying which mechanisms are relevant. Therefore, the means of interaction and the consideration of how information is presented and processed may be important.

Nokes (2009, p. 2) studies mechanisms of knowledge transfer by uniquely focusing on cognitive processes within individuals who apply a set of these mechanisms depending on the conditions of transfer – 'i.e., what relevant knowledge they possess, how it is encoded, and the relation between the training and transfer problems' (p. 2). In the study, three mechanisms are summarised from the literature and are observed to be triggered solely through training efforts (Nokes, 2009, pp. 3-4). First, there is analogical transfer, which is described as 'retrieving a prior exemplar, creating a mapping between it and the current problem or situation, and then using that mapping to draw an inference relevant to the application context, knowledge compilation, and constraint violation'. Second, there is knowledge compilation, which translates and interprets advice, instructions, and tactics into procedures to be used for problem solving. Third, there is constraint violation, which is a three-step process involving the generation, evaluation, and revision of knowledge to correct task performance.

For this thesis, the aspect of experience and how knowledge is received (e.g. exercises and training) are vital. One way of analysing knowledge transfer mechanisms connected to exercises is to study not only individuals but also the interaction of individuals, organisations, and networks of organisations. As an example, the 7i framework of learning (extended from Crossan et al., 1999, and Jones & Macpherson, 2006) described in Paper 2 stipulates learning effects (hence, the successful transfer of knowledge) across the levels of the individual, group, organisation, and inter-organisation.

This thesis is, therefore, differently positioned and only partly comparable to the studies of Nokes (2009); Pedersen et al. (2003), in which the only level of analysis is the individual level. Notably, previous task complexity-related literature is more focused on the individual level, but in recent years, Hærem et al. (2015) suggest that more attention should be paid to the organisational level and external influence. Therefore, this thesis is dependent on individual, organisational (including inter-organisational), and environmental perspectives and is more closely connected to an approach such as that of Liyanage et al. (2009, p. 127), who stipulate that knowledge transfer mechanisms are related to 'collaboration between and across entities, i.e. between individuals, individuals to teams, between teams, across teams, teams to organisation, between organisations, etc.' (p. 127). Liyanage et al. (2009) also pose several relevant questions, including 'Who needs the knowledge?', 'What units are involved in the knowledge transfer?', 'What is/are the type(s) of knowledge to be transferred?', and, importantly, 'What are the factors that will influence the process of knowledge transfer?'.

When mechanisms in crisis and emergency management are sometimes endowed with limited resources, such as time (Chung, 2005; Janis & Mann, 1977), an 'organised understanding of mental representations of knowledge that is shared by team members' is important (Denzau & North, 2000, p. 349). This includes implementing a common, or at least a similar, understanding of ideologies, as well as

institutionalisation (Denzau & North, 2000). Some of the characteristics behind the implementation of a common understanding can be attained by ensuring information quality. Compact bundles of information are said to 'support diverse, complex, and often simultaneous tasks' more effectively (Gorman et al., 2000, p. 287). Therefore, technology that makes information mobile (Hajiheydari & Hanafizadeh, 2013), as well as relying on other organisations to provide information management and technology, have been connected to increased task performance (Talpeanu & Rusu, 2017).

Although many categories have been created for framing information quality (Lee et al., 2002), it appears that ensuring contextual information flow, quality, and relevance are central. This may be because information is relevant for situational awareness and the literature thus far varies, with some studies noting decreasing and others noting increasing effects of information on task complexity (Campbell (1988); Wood, 1986; Hærem et al. (2015); Gorman et al. (2000), etc.). This is why storing specific knowledge elements within the actors may be important. Actors, then, should have the power to provide information to other actors based on the relevance of that information rather than overwhelming them with irrelevant information, as Wood (1986) and Campbell (1988) describe. Time also appears to be connected to the relevance of information (Gerdtz & Bucknall, 2001). For instance, the same information that was irrelevant at a certain time during an operation may later become highly relevant or at least receivable in different ways (compare Wright et al., 2014). Therefore, to remain aware of relevant information and inform actors in a timely manner, this thesis examines the importance of the role of establishing information hubs (since it recognises that it is not only individuals or organisations that hold the information).

There remains the question of what may serve as mechanisms to guide, develop, and ensure common knowledge elements and information quality. According to Weick et al. (2005), knowledge is constantly interpreted within given

frameworks; however, those frameworks are also constantly tested and newly interpreted. This perspective connects more to knowledge as a subjective, contextual construction during interaction than to knowledge as an isolated object (Paulin & Suneson, 2015). As part of this discussion, Weick et al. (2005, p. 413) refer to the term 'articulation,' defined as 'the social process by which tacit knowledge is made more explicit or usable'. Also, for Nonaka (1994, p. 20), articulation is central. When discussing organisational creation in relation to articulation, the processes of socialisation and internationalisation are highlighted as being important:

> During organisational creation, a team or field is created through socialization to facilitate experience and perspective sharing. Dialogue rounds exist where individuals articulate perspectives in order to unveil 'hidden' tacit knowledge. Then, concepts, data, and knowledge are combined and further developed through coordination. Existing knowledge is documented and used. Concepts become more concrete through further articulation. It may include trial and error and experimentation triggering 'internalisation'. Explicit knowledge through interaction may be translated into tacit knowledge. Tacit knowledge is at the core of organisational knowledge creation; however, all four modes of knowledge creation interact in a spiralling form ('spiral model'). The more actors, the more interaction and spiralling effects of knowledge that will transfer knowledge from individual to group to organisational to inter-organisational level. (Nonaka, 1994, p. 20)

In addition to articulation or similar concepts, Jennex and Raman (2009) advocate for further research on the 'issues inherent in the context of transferring knowledge between crisis responders in all three phases of pre-, during, and post-crisis periods […], particularly issues involved with codification' (Jennex & Raman, 2009, p. 80). Some studies consider codification as producing shareable information from knowledge (Hall, 2006). Here, Cohendet and Edward Steinmueller (2000, p. 204) cite David and Foray (1995), arguing that it is the 'reduction and conversion of knowledge

into messages that can then be processed as information' (p. 204) and that 'tacit knowledge is contrasted with explicit knowledge, which is expressed knowledge that is communicated to others. When explicit knowledge is documented, it becomes "codified." Codified knowledge is usually quite structured and appears in written reports, databases, and other media' (Stover, 2004, p. 164).

2.3.1 A short summary of knowledge transfer mechanisms

This chapter on knowledge transfer mechanisms highlights how these mechanisms may contribute to emergency management capability. The review suggests that knowledge transfer mechanisms appear at the intersection of various actors, including individuals, teams, groups, organisations, and networks ((Liyanage et al., 2009, p. 127); Crossan et al., 1999; Jones & Macpherson, 2006). Specific knowledge elements can thereby be stored and exchanged among the actors. The main mechanisms of knowledge transfer highlighted in this chapter are related to articulating (social processes to make tacit knowledge more usable and explicit) (Nonaka, 1994; Weick et al., 2005, p. 413) and codifying (producing shareable, reproducible, and well-documented forms of knowledge) (Hall, 2006); Nonaka, 1994).

2.4 Summary of the theoretical background

This chapter shows that it is relevant to integrate knowledge transfer mechanisms into a model that explains the interconnections between complexity and emergency management capability. This thesis attempts to enhance the understanding of how the development of overall emergency management capability preparedness cannot follow a certain process, because it evolves as a consequence of complexity. That is, if task complexity increases, emergency management capability will develop (e.g. via using knowledge transfer mechanisms) to potentially become prepared. This thesis also examines preparedness. Activities for creating preparedness can be described as a combination of the interactions among individuals, groups, and sub-organisations affiliated to organisations and networks. The next chapter of this thesis provides insights into the methodology used, including

the choice of research design, the collection and analysis of data per the previously discussed theoretical background, and research questions.

3 Methodology

3.1 Research philosophies

This research project uses a qualitative approach for several reasons. Qualitative data offers access to attitudes, values, and feelings (Seale, 2012, p. 211). Furthermore, sensitive issues can be addressed and an exploration of suppressed views achieved (Seale, 2012, p. 211).

Epistemological and ontological perspectives constitute a researcher's choice to use qualitative data – that is, the utilisation of data is central to choosing a qualitative approach (Becker, as cited in Weinberg, 2001, pp. 84–85). Yet, critical considerations connected to epistemology must be made. Particularly, per Immanuel Kant (1724–1804), who, in line with constructivist epistemology, reasoned that everything that may be taken as reality is still based on social construction, this research relies on the constructions and interpretations of the sources approached.

Many studies within crisis and emergency management employ an applied science approach and a more pragmatic perspective guiding the research design and reasoning. However, there is a growing field moving more toward a critical realist approach, which sometimes appears somewhat positivistic in terms of the ultimate goal of saving all lives, organisations, and societies. The current research considers this. As examples, this thesis accepts the given organisations and networks as they are, accepts some of the ultimate goals and objectives of crisis and emergency management, and assumes that saving people, the environment, assets, or reputation is the 'right thing to do'. Thus, even though this thesis' research philosophy is not wholly positivistic (perhaps even post-positivistic), it may be essential to be critical and thorough in following the recommendations of Miles and Huberman (1994, pp. 278-280) when working with qualitative data, namely by aiming for construct validity, credibility (internal validity), transferability (generalisation, external validity), dependability (reliability), and confirmability (objectivity). The

relevant recommendations are further described in the subchapter on research quality.

However, the normative view that this thesis holds concerning the importance of emergency management capability, effectiveness, the goals of management in a crisis, etc. (Denzin & Lincoln, 2008) is not only an axiological question with values (Hart, 1971) but is also a warning to ensure that constructivist perspectives are not ignored. That is, the information received from the sources of this thesis may be, alongside with what (Hatch, 1997) indicates, created only through interpretation, and is therefore to be understood with caution. Silverman (2016, p. 52) social constructionist view states that 'no knowledge about a reality that is out there in the social world can be obtained from the interview because the interview is exclusively an interaction between the interviewer and the interviewee' (p. 52). Therefore, the case study approach, including interviews and observations, must be understood as an interactive process of creating subjective results that are potentially affected by both the interviewee and the interviewer; that is, the process is dynamic (Goffman, as cited in (Weinberg, 2002)). Central to this process is that it is meaning-making work with a focus on interaction: How the meaning-making process unfolds in the interview is as critical as apprehending what is substantively asked and conveyed (Gubrium & Holstein, 1997). The intention of this qualitative thesis is, therefore, to understand the context and phenomena under study (Denzin & Lincoln, 2011) by creating models and following a rigorous research process. Providing 'thick descriptions' (Geertz, 1973) – that is, quotations from the sources to obtain a clear overview of the data – is also important.

From an ontological perspective, this thesis follows a more relativistic approach, meaning that the understanding and truth of the topic being researched are created by the groups of people and members of the organisations who helped in generating the data (Easterby-Smith et al., 2012). Although the studied groups' perspectives are more akin to those of an agent, the context variable of task

complexity allows for both structure (environmental complexity) and agency (organisational, individual complexity) (Archer & Archer, 1995).

3.2 Research strategy

This thesis is designed to answer several main research questions, which requires:

a) identifying and understanding the variables and the underlying dimensions thereof, and
b) identifying and understanding the interrelations among the variables.

When choosing the case study design, several observations concerning the nature of the studies are of importance. First, the studies manage a problem in the way that Smith et al. (1995) describe: as a balancing act in studying the cooperation among the inter-organisational, organisational, group, and individual levels. Second, the research design must allow for a combination of purposeful sampling, specifically including typical case sampling, which allows for broadening the sample if necessary (Coyne, 1997), as well as snowball sampling, to actively search for recommendations for further data sources (Patton, 1990).

By combining the research streams of complexity, capability, and knowledge sharing-related mechanisms, the aim of this thesis is to develop and extend theory within the area of emergency management. Qualitative research in general, and the case study approach in particular, are considered fruitful methods when extending or generating theory (King et al., 1994). Two main design features of the case study approach are filling gaps and establishing theory in a new area (Ridder, 2017), which this thesis intends to achieve by establishing a model of the preparedness of adequate emergency management capability under task complexity.

The design of this thesis denominates the methods and procedures used to perform scientific inquiries (Creswell & Creswell, 2017). Per the above, a qualitative case study design with embedded cases is chosen. Each of the four embedded case

studies provides a sub-model that contains dimensions relevant to the overall model of the thesis, as well as information about the interactions among the variables to which these dimensions are related.

3.3 Research methods

Each paper uses methodological triangulation. That is, the data generation consists of a set of qualitative methods, including archival data such as logs, reports, publicly available reports, and presentations from organisations. The main pillar, however, comprises observation reports, observations, background conversations, and unstructured in-depth interviews following important exercises. The interviews allow for further and more detailed questioning, particularly to elaborate on specific elements of the story (Bryman & Bell, 2015).

The research data are mainly from 2016 to 2019. Both single- and multiple-case study approaches are chosen, with each paper having a separate body of empirics, as follows (see the Appendix for information on the papers):

- Single case study – Paper 1
- Multiple case study – Paper 2
- Single case study with additional secondary data – Paper 3
- Single case study – Paper 4

Cases are chosen in accordance with Yin (1994) outlines, namely that the case is a critical, potentially unique, accessible, and least-restricted case due to the network of peers.

3.4 Research data

Table 2 provides an overview of the data presented in this thesis. The respective research designs of each of the four papers and key considerations related to the units of analysis are also presented. Moreover, the table indicates the papers' contributions to the overall discussion of the thesis in terms of relevant key concepts.

It can be observed that there is little overlap among the four studies in the databases used. (Papers 2 and 3 may have an overlap of data that has been screened, whereas Papers 1 and 4 have entirely different data.) This may increase the suitability of each paper to serve as individual sub-units of the embedded case study design. Yet, the cases are all located within emergency and crisis management, with significant references to the relevant dimensions of task complexity.

As stipulated earlier, all of the subchapters about the theoretical background of this study aim to link the relevant concepts of this thesis with one another. However, the relations, be they one-way or two-way, cannot provide any information about the precise temporality connected to these effects. That is, the effects of one variable on another that can be measured in this thesis are an accumulation of single events (not full processes). However, they are very likely to interact with and reinforce one another. Furthermore, the indicators and attributes are related to the interactions observed in similar forms within the different empirical cases, adding the necessary depth to the assumptions made. However, due to the lack of extensive longitudinal data, no specific reciprocity of effects and counter-effects between the variables is measured. Therefore, the model developed also has two arrows pointing in opposite directions – rather than a single two-sided arrow – in case there are effects measured in both directions.

Table 2 Research design of the papers

Paper	Type of study	Case	Research questions	Data material	Unit of analysis	Key concepts
Paper 1. The development of decision-making capability: How an organisation prepares for a crisis in a complex context	One embedded case study	A Norwegian subsidiary of a multinational oil and gas company and the responses of various personnel about decision-making strategies in a crisis	RQ1: What is the relation between context complexity, the development of organisational decision-making capability, and decision-making strategies? RQ2: How is decision-making capability developed in the organisation?	Primary data: 19 semi-structured interviews with 12 sources, four visits to three departments, information about action cards, crisis response plans, emergency management plans, and incident management plans. Secondary data: Introduction on Crisis Management, pocket guide crisis team, information flow SEMT, crisis management process information	The strategic crisis management level in the organisation	Context complexity, decision-making capability, decision-making strategy

Paper 2. Emergency collaboration exercises and learning: Experiences from the Arctic	Four embedded case studies	Four emergency collaboration exercises: Exercise Nord, the SARex exercise, the AECO SAR exercise, and the Arctic SAR	How can the inter-organisational learning process occur from emergency collaboration exercises within a complex environment?	Primary data: observation reports, observations, background conversations, and unstructured in-depth interviews. Secondary data: archival data from emergency organisations, including logs, reports, publicly available reports, and presentations	Management personnel and their organisations	Environmental complexity, inter-organisational learning

Paper 3. Knowledge transfer and emergency management capability under organisational complexity	One embedded case study with support documents	In-depth insights from participation, as well as observations of a rescue and survival exercise around Svalbard/ Spitzbergen (Exercise SAREX Spitzbergen, 2016), form the core data of this study	RQ1: What characterises knowledge transfer strategies? RQ2: What are the relations between knowledge transfer, organisational complexity, and emergency management capability?	19 documents from SAREX Spitsbergen and 18 support documents, 15 of which contain primary data and 22 secondary data	Knowledge transfer in Arctic emergency management	Organisational complexity, knowledge transfer mechanisms
Paper 4. Situational awareness under task complexity: The role of information	One embedded case study	Nordland hospital emergency management	RQ1: What is the role of information in reducing task complexity? RQ2: What is the role of situation awareness in mediating information and task complexity?	Primary data: 16 semi-structured interviews	An ambulant professional organisation of Nordland hospital and partnering organisations	Task complexity, information quality, situational awareness

3.5 Research context

Empirically, this thesis is located in the area of preparedness, which stems from the safety, security, and disaster areas and is a continuous process to improve interventions and ensure recovery (Hémond & Robert, 2012).

The area of preparedness is chosen due to a methodological choice concerning the roles of time and change in this thesis. Some causal relations (in this thesis, both time and change are regarded as such) may require cyclical patterns of study (George & Jones, 2000). The focus is on uniting the embedded case studies so that each provides a sub-model containing the dimensions relevant to the overall model of this thesis, as well as information about the interactions among the variables to which these dimensions relate. Although these cases provide sources for the subjective assessment of time (available time, timing), they do not provide a full range of objective measures for the time or change variables, nor is a periodic recurrence of exercises and interview questions available for a broad and sufficiently robust data set.

To explore the influence of task complexity on emergency management capability and the mediator variables, a relevant context must be chosen. What constitutes a relevant context is extracted from the literature review, where implicit situational information (Morse et al. (2000)) concerning the environment (Steinberg and Rogova (2008), the organisation (Covin and Slevin (1989), and the individual (Schilit et al. (1994a) are found to characterise task complexity.

Seale (2012, p. 251) argues that people do different things in different contexts; thus, care must be taken in choosing a context relevant to producing suitable critical data for the field of mechanisms affecting capability. In terms of organisations and individuals managing the unexpected, complexity is of great relevance (Weick, 2005) and, as such, is a means to characterise the context. In crisis and emergency management, the subject of complexity is used as one of several characteristics (e.g. volatility, uncertainty, complexity, ambiguity, dynamism) that are

usually combined (Andreassen et al., 2020); Borch and Andreassen (2015); (Schmied et al., 2017). Therefore, a context characterised by one of these, namely complexity, is deemed an interesting and novel means to construct the context, as it allows for a more in-depth exploration of the variable.

The environment can be seen as a major variable in determining the complexity of a context (Schilit & Theimer, 1994; Xia & Lee, 2005), particularly in crisis and emergency management (Strømmen-Bakhtiar & Mathisen, 2012). Furthermore, the individuals involved, as well as the complexity of tasks with which decision-makers are faced, constitute a central part of context complexity (Campbell, 1988; Hærem et al., 2015). Accordingly, the decision-making path, the set objectives, and how individuals make choices are particularly important (Campbell, 1988; Hærem et al., 2015). Existing organisational structures, such as 'different parental control systems' and 'dissimilar work procedures', may also be relevant to understanding the complexity of a context (Robson et al., 2008, p. 648).

Per the above, three studies focus individually on one of the three dimensions of a context variable of task complexity – the environment, the organisation, and the individual task performer – while the fourth case study takes a more holistic position on context complexity.

3.6 Research quality

Qualitative studies intend to advance theory (Hale et al., 2005), and, considering that this thesis' research question is designed to develop theory (Edmondson & McManus, 2007), the case study approach is appropriate. The intention of this thesis is to rigorously assess the data yielded by the sources (Gioia et al., 2013). As Bourdieu (1993) expresses, in reality, the rigour of the construction of the object is most important. Qualitative coding presents an acceptable way of analysing the data (Van Maanen, 1979), for which NVivo software is used.

In line with suggestions for qualitative inductive research, such as that of Van Maanen (1979), a first- and second-order approach to data analysis is mostly adapted and extracted from the individual papers and applied to the overall thesis. The intention is to follow Gioia et al.'s (2013) methods and fulfil their call for rigour as an interplay between the sources or informants and the researcher. Additionally, per both Van Maanen (1979) and Gioia et al. (2013), this thesis promotes mostly inductive logic. Yet, the present study does contain some deductive elements, or what could be termed an 'abduction-like back and forth' between data and theory (Blaikie & Priest, 2019). As an example, the research streams are known and taken as starting points, and the research questions and hypotheses are established and tested where possible; nonetheless, the emerging findings aimed at developing theory are given the greatest acceptance and priority.

As already stated within the subchapter on research philosophies, the recommendations of Miles and Huberman (1994, pp. 278-280) for research quality are considered. First, they mention validity. In the data analysis of the papers, the intention is to follow the primary criterion of validity as (Whittemore et al., 2001) present. Additionally, Van Wijk et al. (2008) suggest using multiple measures for the same construct – as well as multiple respondents – to increase reliability. Combining four studies with different databases may decrease the chance of misinterpreting 'outlier' opinions and thereby increase credibility.

Transferability is another quality criterion that this thesis aims to meet. Therefore, this thesis considers the criteria presented by Slevin and Sines (1999), who refer to Cresswell (1994), Lincoln and Guba (1985), Schofield (1993), Schofield (1993), and (Strauss & Corbin, 1990). This thesis conducts in-depth analysis (rich data); provides potentially typical cases related to crisis and emergency management levels with a focus on preparedness; considers several individuals, sub-organisations, and locations of the studied units (multi-site); conducts several interview rounds or

multiple observations with important data sources (change); and intends to systematically develop the concept (approach).

Dependability is also sought. According to Lincoln and Guba (1985), a study should be dependable; hence, there is a responsibility to ensure that the research is logically conducted, traceable, and properly documented. A major challenge in doing so is that the terms used in the field are not always congruent to the terms related to the concepts used. For example, if an individual uses terms such as 'improvisation', 'standard operating procedure' ,or 'complexity' during their interview, it would be necessary to clarify what the interviewee means by these terms, both during the interview and during the analysis. Similarly, different actors, organisations, and networks may differ in their use of terms. Hence, the terms related to concepts, explanations, and thought processes must all be assessed in consideration of the full interview and previous interview rounds, the observation, and the reports analysed.

When considering confirmability, I examine the research problem externally, with the intention of being as objective as possible, yet considering the generally known restriction that everything is subjective to some extent (Lincoln & Guba, 1985; Simmel, n.d., as cited in Weinberg (2001).

An in-depth literature review supports this thesis. Likewise, it is important to balance between the emic perspective of sources (authenticity) (Whittemore et al., 2001), which are related to the individual's and their organisation's culture (e.g. meanings, native viewpoints, own interpretations) (Pelto & Pelto, 1978), and the intended etic perspective of observation. The ultimate aim of this thesis is to be applicable to, or at least relevant beyond, the culture of the research subjects (Harris, 1976). It helped that the researchers generating the data are from the same project group, thus potentially decreasing the possibility for measurement errors due to extremely diverse perceptions.

Multiple screenings of the coded data and the elimination of non-relevant cases should ensure criticality. For example, some of the cases deemed interesting at the start of some of the papers are omitted during the research process. This is because using fewer cases ensures the possibility of proceeding in a more in-depth manner with the remaining cases used in the case studies.

Connecting the findings of this thesis to previous research frameworks is performed as rigorously as possible as a part of the validity control process (integrity) (Whittemore et al., 2001). Notably, the researchers must be alert during observations and then remain critical and rigorous to understand and analyse the coded data.

3.7 Research ethics

Research and science should be credible, methodologically consistent, applicable, and accountable, and should try to capture the truth and manage subjectivity well (Cannella & Lincoln, 2011). Since these are performed mostly as individual tasks, a scientist is the foremost safeguard to ensure that both ethics and professionalism are considered (Diener & Crandall, 1978). Research ethics related to the research theme, methodology (including data collection), and the assessment and dissemination of findings are, therefore, considered in this thesis.

The Guidelines for Research Ethics in the Social Sciences, Humanities, Law, and Theology that the Norwegian National Committee for Research Ethics in the Social Sciences and the Humanities (NESH, 2019) published are followed as closely as possible. These guidelines establish a set of norms for research, society, and ethics; respect for individuals; respect for groups and institutions; and respect for the research community.

To follow these guidelines, the project for this thesis (including detailed considerations of data collection, data use, data storage, etc.) is registered at the NESH.

The field of research and empirical methods used require close ethical consideration. Depending on the paper, sources may be individuals, groups, or organisations, including private and public entities, that may have experienced or may be exposed to critical events and tragedies in the form of physical, financial, and psychological challenges; injury; a traumatic series of incidents; or death, as (Christians, 2005; Ellis et al., 1997) list. According to Bartlett and Canvin (2003), it is important to pay attention to these experiences from an ethical perspective.

Bell and Bryman (2007) 11 categories of ethical principles are helpful when considering what constitutes good conduct. The aim here is to also comply with Diener and Crandall (1978) assertion that the researcher's conscientiousness – which guides the project – is the most important factor, and I feel that my actions during this thesis have been correct. It is particularly important to obtain the consent of interviewees, participants at the observed exercises, and other subjects relevant for data generation. Consent is obtained by informing interviewees about the purpose of data generation, the research aim, and in what way the data would be processed. Additionally, I anonymised all sources in my papers.

Therefore, I declare that, to the best of my knowledge and belief, there are no conflicts of interest relating to this thesis and its findings. Moreover, because the Ministry of Education and Research funds most of this research via a PhD scholarship position at Nord University, with this thesis I aim to create value for society in general and for the research community and crisis and emergency management-related practitioners in particular. The complexity of systems, the challenges of knowledge transfer, and the overcoming of crises are research areas worth exploring, and I regard the contributions made by this thesis as valuable.

3.8 Summary of the methodology chapter

To summarise, this study is based on a case study approach and methodological triangulation including interviews, observations, archival data, and a literature review. Each of the four embedded case studies provides a sub-model that

contains dimensions relevant to the overall model of the thesis and information on the interactions among the variables to which these dimensions are related. By combining several research streams (i.e. complexity, capability, knowledge sharing-related mechanisms), this thesis develops and extends theory within the area of crisis and emergency management, with an empirical focus on preparedness. Each of the first three case studies focuses on one of the three dimensions of context describing task complexity: the environment, the organisation, and the individual task performer. The fourth case study takes a more holistic position to context complexity. The intention of this qualitative research is to gain a better understanding of the context and phenomena of interest (Denzin & Lincoln, 2011) by creating models throughout a rigorous research process in a vacillating manner between literature and data. Notably, NVivo software is used to analyse the data. The recommendations of Miles and Huberman (1994, pp. 278-280) for research quality are also considered (i.e. validity, transferability, dependability, confirmability, authenticity, criticality, and integrity). Additionally, norms for research, society, and ethics; respect for individuals; respect for groups and institutions; and respect for the research community (NESH, 2019) are followed, to the best of my knowledge and belief.

4 Research Papers: A Summary

This section provides summaries of how each paper contributes to the overall thesis and conceptual model. Each summary provides a short introduction to the topic and research question, a theoretical orientation, a short description of the methodological approach, and the findings. Additionally, the main contribution of each paper to the overall thesis is described. Table 3 presents an overview of the four included papers, and the full versions of the articles are presented in the Appendix.

Table 3 Information about the articles

Title	Authors	Variables	Data	Publication status
Paper 1. Development of decision-making capability: How an organization prepares for a crisis in a complex context	Schmied, Johannes	Crisis and context complexity; the development of organisational decision-making capability; decision-making strategies	Single case study	Prepared for a journal within management studies. Previously submitted to the journal *Safety Science*. Accepted with minor revisions, then rejected. Accepted for presentation at EGOS Colloquium 2018 in Tallinn.
Paper 2. Emergency collaboration exercises and learning: Experiences from the Arctic	Roud, Ensieh and Schmied, Johannes [1]	The complex environment; emergency collaboration exercises; inter-organisational learning processes	Multiple case studies	Published in Andreassen, N., & Borch, O. J. (Eds.). (2020). *Crisis and emergency management in the Arctic: Navigating complex environments*. Routledge.

[1] Both researchers have been using this paper, as well as extracts from the paper, for their dissertation at Nord University.

Paper 3. Knowledge transfer and emergency management capability under organisational complexity	Schmied, Johannes	Emergency management capability; knowledge transfer mechanisms; organisational complexity	Single case study	Prepared for submission to a journal within strategy and management studies. Previously rejected by *Journal of Contingencies and Crisis Management* (2021) Accepted for proceedings (abstract) and presentation at the Academy of Management's Annual Meeting (2019) in Boston, MA, USA.
Paper 4. Situation awareness under task complexity—the role of information	Schmied, Johannes and Strømmen-Bakhtiar, Abbas	Task complexity; information quality; situational awareness	Single case study	Published in *IJIDE*: Schmied, J., & Strømmen-Bakhtiar, A. (2020). Situation awareness under task complexity: The role of information. *International Journal of Innovation in the Digital Economy* (IJIDE), 11(4), 1–26.

4.1 Paper 1

4.1.1 Introduction and research question

Studies such as that of Paton and Jackson (2002) highlight decision-making as a core management capability; however, they often do not examine how this capability is developed. Yet, organisations wish to prepare individuals by training them to make appropriate choices when they are exposed to a crisis. Context is an important parameter in crisis management (Coombs, 2014); in this paper, context complexity is used to describe the exposure of decision-makers to challenges in crisis management.

As the complexity and unpredictability of a situation increase, certain standards and procedures may no longer apply (Cohen et al., 1972, p. 2), while several alternatives to decision-making strategies may become relevant. Therefore, preparation for a crisis is a challenge. The aim of this study is to illuminate the dynamic involved in the development of organisational decision-making capability to

meet complexity when individuals are using a decision-making strategy. I identify two major factors of relevance to the decision-making strategy – the availability of procedures and the ability for situational awareness – and provide a theoretical discussion based on these two factors.

The research question of this paper is: What is the relation between context complexity, the development of organisational decision-making capability, and decision-making strategies?

4.1.2 Theoretical orientation

Paper 1 establishes the development of organisational decision-making capability as an organisation's effort to prepare for the competent deployment of resources (Amit & Schoemaker, 1993) so that decision-making can be performed as efficiently and in as goal-oriented a way as possible. Thus, it is regarded as part of crisis management capability, which is a set of actions that an organisation takes to respond immediately to a crisis, recognising that some aspects of the crisis are beyond the organisation's control (Reilly, 1987).

Context complexity is used in this paper to describe the background and action setting of the crisis at hand. Objects, individuals, and potential change (Schilit & Theimer, 1994), as well as the physical environment (Schilit & Theimer, 1994; Xia & Lee, 2005), are particularly important for context complexity, and they make the tasks of decision-makers complex as well (Campbell, 1988; Hærem et al., 2015).

The development of organisational decision-making capability should enable the effective handling of a crisis in a complex context. That is, organisational decision-making capability is an organisation's preparation for management adaptability during crisis situations. The objective is, therefore, to potentially increase organisational efficacy and to be goal-oriented by acting on a crisis-specific decision-making strategy. With the prevailing complexity in mind, this paper considers two main factors that can be developed to contribute to decision-making. First, there is

the availability of procedures, which assist in making a choice and in responding quickly (Bigley & Roberts, 2001; Schmied et al., 2017). Second, situational awareness can be connected to decision-making to provide relevant skills (Crichton et al., 2005) in crisis-related management; Endsley (2017) views situational awareness as an important prerequisite for decision-making. Additionally, three attributes can be linked to situational awareness: finding hidden hints, understanding the evolving context, and knowledge (Gaba et al., 1995).

4.1.3 Methodological approach

Paper 1 is based on a single case and uses methodological triangulation. Choices pertaining to case selection as well as data collection and generation are based on how well the case can provide insights into the development of organisational decision-making capability while considering decision-making strategies.

This paper chooses to examine an organisation from the oil and gas industry due to its historically high level of risk and crises. The case is a Norwegian operating subsidiary, as well as its international owner. The head office in Norway has more than 100 employees, while the entire company has more than 20,000 employees.

Data collection employs several qualitative methods. The first step includes unstructured talks and archival data from protocols and reports, as well as secondary documents. The core of our data, however, consists of semi-structured interviews.

Semi-structured interviews allow for further questions that require informants to elaborate, in detail, on specific elements (Bryman & Bell, 2015). The informants are interviewed between one and three times, and the interviews last around 1 to 1½ hours each. Twelve interviewees are interviewed one to four times, and three different sites are visited.

The coding process for the interviews relies on the coding approach that Rake and Njå (2009) describe, which utilises open and axial coding (Corbin & Strauss, 2014); (Saldaña, 2009), with coding occurring 'around the axis of a category, linking categories at the level of properties and dimensions' (Strauss & Corbin, 1998, p. 126).

4.1.4 Findings

This study looks at the regulations *Aktivitetsforskriften* (Activity Regulations: (Petroleum Safety Authority Norway, 2019) and *Rammeforskrift* (Framework Regulations: (Petroleum Safety Authority Norway, 2018), which require oil companies operating in Norway to fulfil certain structures and procedures connected to crisis and emergency management. In response, the studied organisation has established a three-tier system (i.e. incident level, emergency management level, and strategic crisis management level), where some aspects are outsourced; there is also a fourth corporate level (i.e. the strategic crisis management level at international headquarters).

This study shows how context complexity may influence the tenor of applied decision-making strategies. It illuminates the conditions under which decision-makers would consider the situation to be too complex to follow their procedures, work plans, action cards, and decision support tools (i.e. SOPs). I also reflect on which alternative decision-making strategies they are aware of. The strategies are described by two factors: situational awareness and availability of procedures. The study shows that decision-makers are affected by the availability of procedures, how much time they have, as well as how much relevant and extractable information exists for each decision. In terms of the development of organisational decision-making capability, the study reveals several conditions that support this finding. The first implication is that both the international and the Norwegian strategic crisis management levels seek to define task distribution as clearly and leanly as possible. Some of the informants also consider having a previously developed organisational structure in a crisis as a means to free the resources of top management and the strategic crisis

management level in general to act on issues for which there would be no existing work plans, action cards, decision support tools, or even roles.

Decision-makers agree that the majority of their decision-making is based on an SOP. However, decision-makers appear to have some situational awareness, indicating that context complexity, which may be accompanied by a level of uncertainty, can increase the potential limitations of their procedures, work plans, action cards, and decision support tools. Time and timing are also highlighted as potential limitations of an existing SOP where other decision-making strategies are expected.

Overall, there is a tendency toward improvisation in situations that demand rapid decisions based on limited information, such as helping to save lives or the environment; decision-makers must be aware of this tendency. These positions are connected to the incident, the emergency management level, and those more experienced in their crisis-related roles. At the strategic crisis management level, on the other hand, if the decision could have major or long-lasting effects on the organisation – or even threaten its existence – and the role responsible does not have an SOP available, the preferred approach is similar to a 'business-as-usual' approach. I call this the 'strategic decision process'. This type of approach is based on the appearance of ad hoc problems for which the decision-makers have more time to act, allowing them to search for background information and input from other stakeholders and to discover solutions through an active and engaged thought process.

4.1.5 Contribution to the thesis

Paper 1 contributes to the understanding of context complexity, highlighting that crisis and emergency management (observed through decision-making in the paper) takes place at several levels and in several forms (Farazmand, 2014). The findings illuminate the representation of interconnectedness within the organisation

and with other organisations. However, individual factors such as experience, preparation, lack of time, and misunderstandings add to context complexity. Paper 1 also contributes by creating an understanding of the connection between context complexity and certain attributes of crisis and emergency management capability (i.e. the availability of procedures and situational awareness); this understanding includes recognising that it is the parameters characterising context complexity that change (from 'business as usual' to a crisis, where 'you are back to [where] you cannot plan for everything' [OGC Crisis]).

The paper also contributes by explaining how the assertion that it is key to have clear overview of standards and concepts (Pina e Cunha et al., 1999) is central to the organisation's development of organisational decision-making capability. This explanation relates to the knowledge codification dimension (producing shareable information from knowledge; (Hall, 2006)) and the articulation dimension of knowledge (e.g. 'the social process by which tacit knowledge is made more explicit or usable'; Weick et al. (2005, p. 413)). In addition, the paper describes a positive effect of development activity related to articulation and codification, with overall capability related to crisis and emergency management.

4.2 Paper 2

4.2.1 Introduction and research question

In a complex environment, inter-organisational collaboration during an emergency response may become challenging. There is a need for a clear hierarchical division of tasks, structure, and rapid decision processes (Faraj & Xiao, 2006). Studying inter-organisational learning, therefore, becomes important (Crossan et al. (2011); (Engeström & Kerosuo, 2007; Greve, 2005; Hardy et al., 2003; Inkpen & Tsang, 2007; Jones & Macpherson, 2006; Nooteboom, 2008).

Paper 2 considers extending the literature on inter-organisational learning by introducing new processes connected to the inter-organisational unit of analysis. By

doing so, this exploratory study empirically challenges and validates the 5I inter-organisational learning framework (Jones & Macpherson, 2006) and develops theoretical nuances that can enrich our overall understanding of inter-organisational learning processes. Therefore, the paper conceptually extends the 5I framework.

The research question of this paper is connected to discovering more about learning processes in the context of collaborative exercises and in a complex environment.

4.2.2 Theoretical orientation

This paper treats learning as a multi-dimensional phenomenon wherein processes occur at different levels and where learners may be individuals, groups, whole organisations, or inter-organisational networks (Tynjälä, 2008). Collaboration is considered important in inter-organisational learning and helps in resolving intractable problems (Jones & Macpherson, 2006).

In terms of inter-organisational learning, multiple levels of analysis in the form of individuals, groups, and organisations may be relevant (Zietsma et al. (2002); Crossan et al., 1999). Crossan et al. (1999) developed a framework that illustrates the processes of learning, as well as how these processes evolve and are incorporated within organisations. Crossan et al. (1999) term this multilevel framework the '4I Framework'. Notably, these four processes connect the individual, group, and organisational levels of learning (Crossan et al., 1999). The individual level is based on the learning processes of intuiting and interpreting. At the group level, interpreting and integrating are present. Finally, at the organisational level, integrating and institutionalising occur. Jones and Macpherson (2006) expand the 4I framework by including the inter-organisational level and adding 'intertwining' as the fifth process.

As a third step, this paper examines emergency collaboration exercises in a complex environment as a setting for inter-organisational learning. Although the environment may provide the potential for learning from externals, it may also mean

that there is the potential to 'outsource' knowledge and resources and rely on someone else who specialises in specific tasks (Moynihan, 2008).

4.2.3 Methodological approach

In accordance with Yin (2013), four cases from between 2016 and 2019 – likely producing similar results – are chosen, because a fully embedded case study design is not obtainable for lack of complete analysis units per case. Choices about which data to generate and collect are based on how closely the emergency collaboration exercises resemble emergency management scenarios in a relevant complex environment.

Data collection consists of a set of qualitative methods, including archival data from emergency organisations such as logs, reports, publicly available reports, and presentations. The main pillar, however, comprises observation reports, observations, background conversations, and unstructured in-depth interviews during important exercises.

The findings are categorised into the processes of intuiting, interpreting, integrating, institutionalising, and intertwining (Jones & Macpherson, 2006). As a final step, findings giving possible extensions to the 5I framework are stipulated in a separate section, 'Learning beyond the 5I learning framework'.

4.2.4 Findings

The paper finds that emergency collaboration exercises in scenarios that may not be as common as the scenarios of smaller exercises (in which the individual-level benefits) may bring benefits to the group, organisational, and inter-organisational levels. On the other hand, the data show that the large, full-scale exercise type held in a complex environment might involve some limitations connected to intuiting for more experienced individuals.

Learning on the group level is represented mostly via activities connected to communication and the creation of mutual understanding during exercises. The data indicate that group-level learning is often connected to challenges that provide a framework enabling the active integration of all individuals to experience intuition simultaneously as interpretation for the group.

On the organisational level, I observe substantial effort on the tactical and operational levels; only a few materials are provided for high-level organisational discussions on the strategic and political or diplomatic levels. Overall, long-term exercise evaluation, learning implementation, and improvement can be improved. However, there are challenges connected to the participating group sometimes being isolated from the actual organisations to which they belong, and as such, exercises cannot guarantee learning on the organisational level.

Learning on the inter-organisational level is connected to intertwining – that is, active engagement between the organisation and its external knowledge network (Jones & Macpherson, 2006). The paper indicates that inter-organisational learning may depend on the increased professional collaboration of competent exercise participants who can then contribute to the inter-organisational level of learning. A factor that can be connected to 'intertwining' is the range of how far learning on the inter-organisational level can be spread beyond the organisations participating in the exercise. Settings in which many organisations meet for table-top exercises give participants the opportunity to discuss and be exposed to different views and approaches. The periodic recurrence of exercises also appears to provide an additional inter-organisational learning effect and comparability of learning effects.

4.2.5 Contribution to the thesis

Paper 2 contributes to this thesis by introducing the environment as a dimension of complexity. Complexity in this paper also affects the emergency management exercises. Additionally, Paper 2 connects with some comments (which

are also made in Paper 3) that highlight exercises as events where intra- and inter-organisational efforts are made in the form of a combination of articulation and codification.

Thus, exercises in the form of field-configuring events may serve as knowledge transfer mechanisms. Elliott (2009) claims that organisational learning is limited by a lack of knowledge acquisition integration, knowledge transfer and knowledge implementation, and that the links to field-configuring events serve as mechanisms for learning (in Paper 2, with a focus on environmental complexity). Emergency management collaboration exercises may be an event that fosters this type of intra- and inter-organisational learning and, as such, impact emergency management capability. Additionally, decision-making strategies may be facilitated (Crossan et al., 1999); (Jones & Macpherson, 2006); (Dewi et al., 2019).

4.3 Paper 3

4.3.1 Introduction and research question

This study examines the challenges of organisational complexity confronting emergency responders during crisis situations and investigates how knowledge transfer mechanisms help in creating capabilities to address such challenges. The study finds that group and team processes, as well as communication with affiliated actors and other organisations, are essential to manage knowledge across levels. The study illuminates the roles of knowledge articulation and knowledge codification in transferring knowledge under complexity. Also in Paper 3 it is concluded that combination of knowledge in a joint intra- and inter-organisational effort is vital for knowledge transfer mechanisms.

Paper 3 discusses the view of Easterby-Smith et al. (2008), which states that knowledge transfer is an event whereby an organisation experiences a learning effect through interaction with another organisation and a recipient's ability to diffuse knowledge within the organisation. An organisation's capability is defined as its

capacity to channel, integrate, and utilise a combination of resources through a range of organisation-specific processes, acting toward an objective (Amit & Schoemaker, 1993). Notably, organisational characteristics linkable to complexity are important for the success of knowledge transfer (Bacon et al., 2020). Complexity affects not only emergency readiness and response capability, but may also affect the knowledge transfer needed for coordinated action to occur. Thus, there needs to be compensation with further knowledge transfer that is also decoupled in a timely manner from the emergencies (i.e. transfer mechanisms during all stages of emergency management, including pre- and post-stages).

Little is known about the mechanisms behind knowledge transfer in emergency management. Research on knowledge transfer 'examines whether organisations learn from the experience of other organisations [or units in an organization] [and] whether organisations benefit from knowledge acquired at others' (Argote, 2012, p. 9). Anand and Jones (2008, p. 1056) analyse DiMaggio and Powell (1983) and Bourdieu (1993) studies, noting several mechanisms as being key to successful field-configuring events during which knowledge is transferred; however, an understanding of the specific mechanisms related to knowledge transfer is needed.

The research question is designed to develop theory (Edmondson & McManus, 2007) and highlights how knowledge transfer mechanisms may contribute to the development of capability for organisations that need to respond to an emergency. Although knowledge transfer mechanisms may increase capability and counteract knowledge asymmetry, organisational complexity may present a challenge to both organisations and emergency responders. This study indicates that adequate knowledge transfer mechanisms may limit capability development barriers. It also identifies the two core mechanisms of knowledge transfer: knowledge articulation and knowledge codification.

4.3.2 Theoretical orientation

Paper 3 examines the challenges of organisational complexity that emergency responders face during crisis situations and investigates how knowledge transfer mechanisms may help in creating capabilities to handle them.

In a first step, the paper establishes emergency management capability and analyses readiness and response capabilities. Wu et al. (2016, p. 866) characterise *emergency readiness capability* as 'emergency supplies, emergency personnel, improvement of emergency management system, emergency special funds' (p. 866), which can also be described as organisational resources. On the other hand, they characterise *emergency response capacity* as 'organization ability in emergency, commanding ability in emergency, controlling ability in emergency, coordinating ability in emergency' (p. 866). Recent studies in emergency management-related fields indicate factors connected to the decision-making literature, namely factors related to experience (Considine et al., 2007; Gerdtz & Bucknall, 2001; Ody, 1995; Parnell, 2017; Sayegh et al., 2004), regulations, standards, and routines (Chung, 2005; Gerdtz & Bucknall, 2001; Małyszko & Wielgosz, 2016).

The next step considers how several studies identify a relation between knowledge transfer and capabilities (Cavusgil et al., 2003; Nonaka & Von Krogh, 2009); however, a greater understanding of the mechanisms necessary to facilitate emergency management capability is needed. Knowledge transfer is a means of managing organisational memory (Harvey (2012) or shared meaning (Choo, 2002, p. 79), giving importance to organisational, group, and team processes and to the communication among them. Knowledge transfer mechanisms are, therefore, related to 'collaboration between and across entities' (Liyanage et al. (2009, p. 127).

In the last step, organisational complexity is added. This study defines organisational complexity as a system of organisations, groups, and individuals with different sizes, capacities, and structures, where both order and randomness – and

non-linear cause–effect correlations – may exist. The impact of organisational complexity on knowledge transfer for managerial responses is an important consideration (Erdi, 2008), in addition to how it leads to uncertainty about what is relevant to emergency management capability.

4.3.3 Methodological approach

An exploratory research design utilising a qualitative case study approach is chosen because it offers great potential for exploring new insights in this research area (Yin, 1981) of knowledge transfer and capabilities within emergency management. The research idea was inspired by a one-week event connected to a rescue and survival exercise called Exercise SAREX2016 in Svalbard/Spitzbergen on one of the Norwegian Coast Guard's icebreakers. The event forms the basis of the research idea, as it connects meetings with actors from different organisations with in-depth insights from a participation observation study, as well as observations from a rescue and survival exercise around Svalbard/Spitzbergen. The case inspired me because it provides a good understanding of the capabilities needed to respond in an emergency while dealing with organisational complexity, especially in relation to 'causal mechanisms and [the] delineation [of the] relevant aspects of the surroundings' (Falleti & Lynch, 2009, p. 1152).

The study consists of participant experiences from SAREX2016. In addition, 18 documents – including interviews, communication protocols, and the official final report – are included in the analysis. Furthermore, where in-depth data are necessary, documents closely related to SAREX2016 are analysed to obtain more insights. An open and axial coding approach, initially using loose categories (Strauss & Corbin, 1998) formed from theory, is chosen. The categories are expanded during the first coding round and combined into properties or dimensions during further coding, following which they are clustered within categories. The dimensions are then reshuffled and united to extract relevant variables remaining in this study for a final comparison with the literature.

4.3.4 Findings

Paper 3 finds that a substantial effort is exerted in concluding and reasoning about what lessons can be learned from knowledge transfer-related activities. Articulating what knowledge is relevant to creating readiness and building response capacity appears to be essential.

Knowledge transfer can strengthen overall readiness by assuring resource availability as needed and creating experiences among the team as well as increased response activity through participants' signals. The data indicate that, during exercises, a sense of preparing emergency management capability is created throughout the pre-stage and incident (or simulation). The documents produced from the exercise also indicate substantial activity in the post-stage, where capability may be implemented or, at least, form the basis for future initiatives.

Knowledge transfer mechanisms are observed through the initiative of individuals or from their affiliated organisation; on the organisational level, they are often represented by someone external providing knowledge. Regarding individual-level transfer, for both explicit and tacit knowledge transfer, a 'buddy system' with actors from different organisations is observed. For group- and organisational-level transfer, two ways of dealing with this situation are noted: The first is connected to articulation, the second to codification. As many of the sources show, understanding the location of knowledge and the differences in experience and routines can aid in structuring and focusing on each one's core knowledge. However, certain degrees of asymmetry concerning specific knowledge due to the location, accuracy, depth, or type of knowledge persist.

Notably, much of what is organised into the category of complexity is connected to unpredictability related to the multitude of actors.

4.3.5 Contribution to the thesis

The findings from Paper 3 contribute to this thesis by providing a greater understanding of how the context variable of task complexity (represented through the dimension of organisational complexity) may limit the knowledge transfer needed to facilitate coordinated action.

Paper 3 argues that knowledge articulation processes related to knowledge transfer occur in a somewhat unstructured way (see Blome et al., 2014; Gulick, 1937; McElroy, 2000) due to multiple actors. These actors engage in social processes (Weick et al. (2005, p. 413), try things, and engage in joint activity such as the buddy system. By doing so, however, they also counteract a potentially chaotic path by applying knowledge codification. Group processes and communication among actors and beyond organisations are also seen as ways to decrease the effects of structural challenges and unpredictability, which are two dimensions of organisational complexity.

Challenges from organisational complexity may appear in all of the areas relevant to emergency management capability, as Wu et al. (2016) present. This paper 3 contributes to explaining the direct effects of organisational complexity on readiness and response capacity. Emergency management capability is affected through the asymmetry of resources (including knowledge and people), the location of knowledge, the background of actors, and an incapability to deploy resources.

Paper 3 also contributes to this thesis by creating an image in which the development of emergency readiness and response capability through knowledge transfer mechanisms is as organic as the complexity concept. This may give some insight into how the variables in the overall model are linked and interact. Field-configuring events, such as the activities around and during SAREX2016, are a means to create a greater understanding of these mechanisms. Additionally, Paper 3 contributes to this thesis by illuminating the role of individual articulation and

codification processes in transferring knowledge. By doing so, the study reveals how knowledge transfer contributes to creating an understanding of what relevant knowledge is, how to use this knowledge, and which knowledge should be developed. Applying modes of knowledge creation (organisational knowledge creation) partially explains why emergency management capability is affected. By successfully applying knowledge transfer, capability may consequently increase (Henderson, 1994).

4.4 Paper 4

4.4.1 Introduction and research question

Tasks are behavioural responses of an individual with the aim of reaching a 'specific level of performance' (Wood, 1986, p. 62). According to Hærem et al. (2015), tasks are paths and potential routes to reach particular goals in a network. In contrast to simple tasks, the more choices that are available to reach goals (Wood, 1986), and the more unexplainable the interrelations among components in the network of actors are (Flood, 1987), the more complex the task will be.

Per Hærem et al. (2015) and Campbell (1984), complex tasks and situational awareness are closely interconnected. Endsley (2001, p. 4) defines situational awareness as a three-level model consisting of 'perception of the elements in the environment,' 'comprehension of the current situation,' and 'projection of future status' (p. 4). High stress and high workload may additionally hinder situational awareness (Wright et al., 2004). Specifically, information and the quality of information appear to be important for both assessing tasks and gauging their complexity in terms of situational awareness (Endsley, 2001; Wright et al., 2004). The quality of information depends on the level of completeness, accuracy, format, and currency of the information (Nelson et al. (2005). However, more insights into the relation between situational awareness and task complexity and how information quality contributes to this relation are needed.

The research question is, What is the role of information in reducing task complexity, and what is the role of situational awareness in mediating information and task complexity?

4.4.2 Theoretical orientation

Paper 4 begins by aiming to discover more about situational awareness in terms of task complexity. Wright et al. (2004) argue that individuals with lower situational awareness are more prone to decision errors. Furthermore, situational awareness requires that actors be up to date with the capabilities of other actors, groups, and organisations (Coffey, 2012; Rimstad et al., 2014). Information gaps (Seppänen et al., 2013, p. 1) or the non-timeliness of information (Gerdtz & Bucknall, 2001) can, therefore, be seen as challenges to situational awareness. Endsley (2017) additionally mentions task complexity as a challenge to gaining situational awareness.

The complexity of tasks, according to the framework of Campbell (1988), is characterised by changes (Campbell refers to an increase) in the information load, the diversity of information, or the rate of an information change. However, the literature suggests that it is not always clear whether information increases or decreases task complexity in terms of situational awareness. Hærem et al. (2015) are aware of the importance of information (see 'information cues') to complexity. Moreover, Wood (1986) and Campbell (1988) argue that information must be processed; otherwise, it increases task complexity. Making units of information or bundles of information as well as the help of technology may both affect complexity (Gorman et al. (2000).

The greater the number of paths, goals, and connections among actors, the higher the task complexity, according to (Campbell, 1988; Hærem et al., 2015), and Oeser and O'Brien (1967). Wright et al. (2004) claim that situational awareness (levels 1–3) is required for sub-goals. That is, the task fulfilment of a major goal is dependent

on a collection of complex tasks, unless precise sub-goals are designated as the main goals.

4.4.3 Methodological approach

This research occurs in a medical setting. It focuses on ambulant staff (actors) connected to a northern Norwegian hospital. Two types of situational awareness are considered, namely patient awareness and logistics awareness; however, the latter is deemed more important for the study.

The present study is framed around data generation based on 16 semi-structured interviews with the actors connected to the study object, both prior to and after a full-scale mass rescue exercise. Furthermore, the observation of incident leader health (ILH) at the NORD 2019 exercise, a full-scale mass rescue exercise, provides in-depth data.

As in Paper 3, an open and axial coding approach, initially using loose categories (Strauss & Corbin, 1998) formed from theory, is chosen. The loose categories are expanded during the first coding round and organized into properties or dimensions during further coding, after which they are clustered again within categories. They are then reshuffled and united to extract relevant variables remaining in this study for a final comparison with the literature.

4.4.4 Findings

Paper 4 finds that the criticality of an action related to crisis and emergency management – or at least how critical it is assessed to be – plays a large role in how complex the following tasks will be and how urgent the actors will judge the situation to be.

As a first step, much importance is given to communication systems and pre-installed procedures and hierarchies in receiving situational awareness of risk, safety, criticality, and urgency. The second premise is more connected to the wellbeing of

the patients and the availability of necessary resources. This process, together with collecting subtle cues from the environment, is necessary create a shared mental model of the worst-case scenario for the situation.

Information is constantly gathered and updated in the system. Whereas a path of recurrent information collection increases the task complexity in the present, it potentially decreases each individual's future task complexity. This is achieved by providing necessary additional information and other resources to enable the shortening of future pathways or the distribution of sub-goals to available additional resources. The less common the set of sub-goals is, the less likely it is that the procedures will be available. Further, more people may be assigned similar tasks, leading to a decrease in the clarity of the sub-goals, a decrease in necessary connections, and a decrease in the paths needed to reach the sub-goals. Deeper insights into learning can, therefore, provide more knowledge about situational awareness and task complexity and how organisations may prepare for them.

4.4.5 Contribution to the thesis

Paper 4 contributes to this thesis by extrapolating on the assumption in the overall conceptual model that task complexity may be influenced by knowledge transfer mechanisms. Although Paper 4 does not explicitly discuss knowledge transfer mechanisms, the discussion of information and information quality can be directly linked to those of Pedersen et al. (2003) or Jasimuddin (2007), who discuss communication aspects and how information may be processed and, thereby, how it becomes relevant to the knowledge transfer mechanism variable. The in-depth discussion of information quality also improves the understanding of how task complexity may be affected (information stored within the actors, the relevance of information, the timeliness of information, information technology, and the use of information hubs) (Lee et al. (2002); Wood, 1986; Campbell, 1988; Wright et al., 2014; (Schoonhoven et al., 1980) (Hajiheydari & Hanafizadeh, 2013).

In contrast to the other papers, in which knowledge transfer mechanisms mostly affect emergency management capability, Paper 4 posits the opposite, namely that emergency management capability can affect knowledge transfer mechanisms. Situational awareness is one of the dimensions of emergency management capability, and Paper 4 argues how a lack of this ability may affect the quality of information (which can be seen as part of the knowledge transfer mechanism dimension). In Paper 4, this is described by a string of information that can be connected to an awareness of the overall mental model of the situation for all of the involved actors (see Coffey, 2012; Rimstad et al., 2014). In addition, Paper 4 raises the safety and risk awareness of the actors. This aspect of situational awareness provides additional important strings of information that can make the actors' tasks more complex. Procedures and communication standards, such as those for potential chemical, biological, radiological, and nuclear material, as well as personal security-related aspects (e.g. ongoing life-threatening violence), provide additional support. The co-dependency of actors (e.g. 'both one's own security and group security is important' [S11]) also increases. Although the presented theory related to situational awareness does not explicitly refer to safety, studies such as those of Endsley (2001) and Wright et al. (2004) highlight the importance of 'elements in the environment'.

5 Discussion

Developing management capabilities has become an important activity for high-performance organisations (Borch and Andreassen (2015); (Chen et al., 2008; Ghosh & Rubly, 2015; Rake & Njå, 2009; Schmied et al., 2017). These types of organisations often must operate in contexts where complexity predominates (De Waal, 2007). This chapter of the thesis discusses the findings of the four individual papers in connection with the overall research question:

> **How do task complexity, knowledge transfer mechanisms, and emergency management capability relate to one another in the emergency preparedness phase of crisis management?**

Each of the four papers is an independent study, yet each also contributes to developing insights into the variables and how they interact with each other. Figure 1 provides an overview of the relevant relations cited within the research question and puts them into perspective as they pertain to the individual papers. The figure shows that Papers 2 and 3 directly contribute to the discussion of concepts and their relation to all aspects of the research question, while Papers 1 and 4 contribute to the discussion of concepts and their relation to two of the three aspects of the research question.

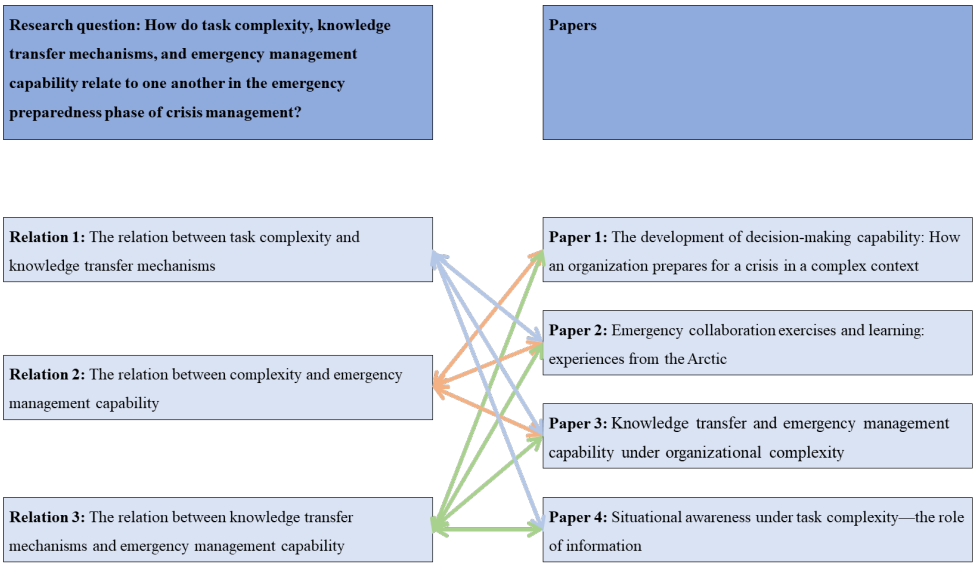

Figure 1 The connection between the research question and the papers

5.1 The relation between task complexity and knowledge transfer mechanisms

The first part of the research question is concerned with how the relation between knowledge transfer mechanisms and the context variable of task complexity can be explained. Complexity-related challenges can affect knowledge transfer mechanisms. The challenges are connected to uncertainty, a lack of information (Xia & Lee, 2005), as well as asymmetry (Erdi, 2008). Asymmetry is in the current thesis also represented by asymmetrically distributed knowledge.

The findings contribute to this thesis with a greater understanding of how the context variable of task complexity may limit the knowledge transfer needed to facilitate coordinated action. Task complexity is in Paper 3 represented through the dimension of organisational complexity. Affected by complexity, knowledge articulation processes ('the social processes by which tacit knowledge is made more explicit or usable;' Weick et al., 2005, p. 413) occur in an unstructured way (see Blome et al., 2014; Gulick, 1937; McElroy, 2000). Multiple actors from different institutions and backgrounds are forced to engage in social processes (Weick et al.

(2005, p. 413). The social processes include trying new things, and learn from one another (e.g. the buddy system). Joint activity to learn from each other serves as an action against chaotic knowledge distribution by applying knowledge codification. Group processes and communication among actors and beyond organisations are therefore important. These processes are regarded in this thesis as means of decreasing the effects of structural challenges and unpredictability. Structural challenges and unpredictability are two dimensions of organisational complexity. Notably, knowledge transfer articulation in the studied field does not always follow a strict hierarchy. Additionally, the interaction between the donors and recipients of knowledge appears voluntary to a certain degree. Furthermore, it can be understood that regardless of the extent of building preparedness, the context of organisational activity continues to be, to some extent, one of complexity.

Paper 4 does not explicitly discuss knowledge transfer mechanisms. However, it helps to extrapolate on the assumption in the overall conceptual model that the variable of task complexity may be influenced by knowledge transfer mechanisms. The discussion of information and information quality links to the studies by Pedersen et al. (2003) or Jasimuddin (2007). They discuss how information may be processed as well as how communication plays out through information. Information thereby becomes relevant to the knowledge transfer mechanism variable. Discussing information quality also improves the overall understanding of how task complexity may be affected (Lee et al. (2002); Wood, 1986; Campbell, 1988; Wright et al., 2014; (Schoonhoven et al., 1980); (Hajiheydari & Hanafizadeh, 2013). Examples with an effect on task complexity could be related to the information stored within the actors, the relevance of information, the timeliness of information, which type of information technology was used and the use of information hubs . Similarly, Paper 1 shows that, for different individuals, complexity is affected by a certain degree of subjectivity. That is, the memory of a previous activity connected to knowledge transfer, such as an exercise and developed strategies, is cited as a major influencing factor on this degree of subjectivity.

Paper 2 extrapolates from some of the comments about exercises (which are also made in Paper 3). Crisis and emergency management collaboration exercises in a complex environment or under organisational complexity require both intra- and inter-organisational collective activity; thus, a combination of articulation and codification is likewise required. Hence, these exercises, in the form of field-configuring events, serve as knowledge transfer mechanisms, wherein complexity plays a role in how the exercise proceeds. In terms of exercises, organisational learning may be limited by a lack of integration of knowledge acquisition, knowledge transfer, and knowledge implementation (Elliott, 2009). Nevertheless, exercises in the form of field-configuring events serve as mechanisms to counteract limited learning.

Overall, knowledge transfer mechanisms can be seen as an expansion of what Boin and Renaud (2013, p. 45) labelled 'meta-leadership' within sense-making, namely 'preparing […] for the challenges […] before the next crisis occurs' (p. 45). Knowledge transfer mechanisms appear to be less of a structured management style and – as previously stated – more of an ongoing, joint, intra- and inter-organisational effort. This effort is put into practice at various types of events, as shown by the fact that the data for this thesis are obtained from exercises, reports, joint events, real incidents, etc.

Per the above, I posit that task complexity impacts knowledge transfer mechanisms by giving rise to challenges from asymmetrically distributed knowledge and unstructured knowledge articulation processes (see Blome et al., 2014; Gulick, 1937; McElroy, 2000). At the same time, however, there are effects to suggest that the task complexity may also be influenced by knowledge transfer mechanisms. Counteracting potential complexity from chaotic paths by applying knowledge codification via group processes, communication, and information quality are major examples of this. In particular, field-configuring events (exercises) are observed to provide an area in which to counteract but also expose greater complexity.

5.2 The relation between task complexity and emergency management capability

The second aspect of the research question for this thesis examines how to explain the relation between complexity and emergency management capability, with a focus on emergency preparedness. The base assumption is that the effort to coordinate among a multitude of organisations and individuals, as well as their interactions in different environments, contributes to complexity, which, in turn, challenges emergency management capability (Boisot & McKelvey, 2010); (Comfort & Kapucu, 2006).

Paper 1 provides the foundation for this assumption. Stakeholders are aware of the relation between complexity and the necessity for increased emergency management capability. Procedures are available, yet it is believed that the greater the complexity, the greater the need for other capabilities. Therefore the thesis discusses limitations to procedures when faced with complexity. Preparedness is the main focus of this thesis. Thus, the papers included in this thesis also examine the aspects of response capability ('organization ability in emergency, commanding ability in emergency, controlling ability in emergency, coordinating ability in emergency'; Wu et al. (2016, p. 866) and readiness capability ('emergency supplies, emergency personnel, improvement of emergency management system, emergency special funds,' which can also be described as organisational resources; Wu et al. (2016, p. 866).

The thesis has created further understanding of preparedness by analysing both response capacity and readiness capability by elucidating on the connection between complexity and the attributes of emergency management capability (i.e. the availability of procedures and situational awareness). The contribution includes that it is context (and hence, task complexity) that changes (from 'business as usual' to crisis, where 'you are back to [where] you cannot plan for everything;' OGC Crisis).

The change of context in turn, determines whether procedures are in place and to what extent actors retain the ability to assess information.

Per the above, the thesis contributes to the understanding of complexity. It can be highlighted again that management of crisis and emergency management (represented by decision-making in some of the papers) occurs at several levels and in several forms (Farazmand, 2014). The findings of Paper 1 illuminate the representation of interconnectedness within the organisation and with other organisations. Individual factors such as the level of experience, preparation, lack of time, and misunderstandings increase complexity. These individual factors may be connected to knowledge transfer mechanisms, suggesting that emergency management capability may have an indirect influence on task complexity via knowledge transfer mechanisms. Further, environment has been introduced as a dimension of complexity. Large, full-scale exercise types show how complex environment may entail some limitations connected to increasing learning effects for more experienced individuals. This is mostly because the overall complexity of the environment is so high that the tasks must be kept at a safe and performable level – that often means, at low individual complexity.

It is likely that challenges from complexity may appear in all of the areas relevant to emergency management capability (Wu et al., 2016). However the thesis helps explain the direct effects of complexity on preparedness (mostly emergency readiness capability and some aspects of emergency response capacity). Asymmetry of resources (including but not limited to knowledge and people), where the knowledge is located, which background the actors have and if there is inability to deploy resources all affect emergency response capacity. Organisations, therefore have to act, but they can take two totally opposite initiatives. First, sometimes they establish similar tacit and explicit knowledge in different locations (decreased asymmetry). Second, sometimes they bring in specialists who have distinct tacit and explicit knowledge. Both initiatives appear to increase emergency management

capability, while at the same time causing opposite changes to complexity. Non-linear, cause–effect correlations both within and across organisations (Erdi, 2008) in connection with complexity and emergency management capability therefore seem to prevail. Sometimes, a certain level of complexity can only be controlled or accepted within emergency management. Standardisation may not be relevant, may cost too much time and effort, or may not be possible at all. In such cases, a certain level of complexity may persist (Aiken & Hage, 1971; McElroy, 2000) and can affect emergency management capability.

To summarise, this chapter describes the direct effects of task complexity on crisis and emergency capability. Increased needs for coordination among a multitude of organisations and individuals, as well as for interaction in different environments, contributes to complexity, which challenges emergency management capability (Boisot & McKelvey, 2010); (Comfort & Kapucu, 2006). These challenges are especially salient in terms of decision-making tasks. Furthermore, the indirect effects of emergency management capability on task complexity via knowledge transfer mechanisms are expected because resource asymmetry contributes to complexity.

5.3 The relation between knowledge transfer mechanisms and emergency management capability

The third aspect of the research question concerns how the relation between knowledge transfer mechanisms and emergency management capability can be explained. Several previous studies have observed a relation between knowledge transfer and capabilities. Much of the research has focused on firms (Cavusgil et al., 2003; Nonaka & Von Krogh, 2009). Nevertheless, knowledge transfer may also be relevant throughout all stages connected to emergency management capability (Wu et al., 2016). That is, knowledge transfer in the field appears to be connected to an overall sense-making and awareness of the situation at all management stages (compare Choo, 2002; Weick et al., 2005). However, notably, I focus on preparedness with emergency readiness capability and emergency response capacity (Wu et al.

(2016, p. 866) in this thesis. Additionally, the thesis views knowledge as an aspect of readiness capability that directly affects response capacity.

The thesis explains particularly in Paper 1 how a sound overview of standards and concepts is key to an organisation's development of organisational decision-making capability (Pina e Cunha et al., 1999). Both the knowledge codification dimension (producing shareable information from knowledge; ((Hall, 2006)) and the articulation dimension of knowledge (e.g. 'the social process by which tacit knowledge is made more explicit or usable' (Weick et al., 2005, p. 413)) come into play here. Likewise, this may support the definition of crisis and emergency response capacity (as part of emergency management capability (Wu et al., 2016, p. 866)).

Furthermore, the papers describe positive effects of development activity related to articulation and codification on overall capability related to crisis and emergency management. Sources were aware that complexity increases during a crisis or an emergency and that 'everything is upside down'. Likewise, organizations seem to be aware of their limitations. Procedures, work plans, action cards, and decision support tools may all reach their limits and alternatives may be needed in a crisis (Bigley & Roberts, 2001). However, most actors within the studied organizations agree that the development of these same standard operating procedures, work plans, action cards, and decision support tools still forms the basis of the preparedness of an organisation's emergency management capability through the successive availability of procedures and situational awareness. These findings are in line with those of Paton and Jackson (2002), showing that the transference of basic knowledge is still regarded as the most efficient factor in the development of some capabilities, such as those related to decision-making.

The thesis recognises codifying knowledge, as well as articulating existing and new knowledge, as key. For example, Paper 3 illuminates the role of individual articulation and codification processes in transferring knowledge. By doing so, the study reveals how knowledge transfer helps actors to understand several aspects

related to knowledge. First, knowledge transfer elucidates as to what relevant knowledge is. Second, knowledge transfer can help to clarify how knowledge is used. Third, knowledge transfer also supports actors and organizations to understand which knowledge should be developed. Combining knowledge articulation and codification may be as important as alternating between tacit and explicit knowledge within the model of Nonaka (1994). In addition, processes related to what is described in the modes of knowledge creation (e.g. sharing of experience and perspective; documenting and using existing knowledge; experimentation; dialogue of multiple actors) (Nonaka, 1994) are deeply integrated into this thesis' knowledge transfer mechanism model and explain, in part, why emergency management capability is affected. As a result, application of this study's model may increase capability (Henderson, 1994).

To clarify the dimensions of codification and articulation, Paper 2 discusses emergency management collaboration exercises as events of knowledge transfer mechanisms that foster organisational and inter-organisational learning. That is, this type of event is designed to impact emergency management capability positively. After all, the events lead to creating, applying, and understanding standardisation, regulation, and routines. Additionally, decision-making strategies will be facilitated (Crossan et al., 1999; Dewi et al., 2019; Jones & Macpherson, 2006).

Papers 1, 2, and 3 mostly describe how knowledge transfer mechanisms affect emergency management capability, while Paper 4 discusses how emergency management capability may affect knowledge transfer mechanisms. Situational awareness is one of the dimensions of emergency management capability. A lack of emergency management capability may affect the quality of information. Information can be seen as part of the knowledge transfer mechanism dimensions articulating as well as codifying knowledge. In other words, a string of information is connected to an awareness of the overall mental model of the situation for all of the involved actors (see Coffey, 2012; Rimstad et al., 2014). Situational awareness such as safety

and risk awareness may also provide additional strings of information that can increase the complexity of actors' tasks. Procedures and communication standards on the other hand provide support. Co-dependencies of actors may also increase, if increased situational awareness is the objective. These co-dependencies will also lead to increased demands for applying knowledge transfer mechanisms. The thesis shows, that situational awareness does become dependent on knowledge or information exchange.

To summarise, the thesis has discussed how there are relations that move both ways between knowledge transfer mechanisms and emergency management capability. Knowledge codification and articulation are also identified as being necessary for emergency management capability by improving existing procedures while also distributing information and knowledge to the right spots and thereby aiming to increase situational awareness. On the other hand, the dimensions related to emergency management capability (particularly situational awareness) – or a lack thereof – influence information that may become relevant for knowledge transfer.

5.4 The model: Task complexity and emergency management capability – The role of knowledge transfer mechanisms

Per the above discussion on the relations among the variables, as well as the understanding of the dimensions of each variable, a model of 'task complexity and emergency management capability (i.e. 'the role of knowledge transfer mechanisms') is created. This model is presented in Figure 2. As presented in the above chapters, each research paper contributes to a set of dimensions related to a number of variables and relations.

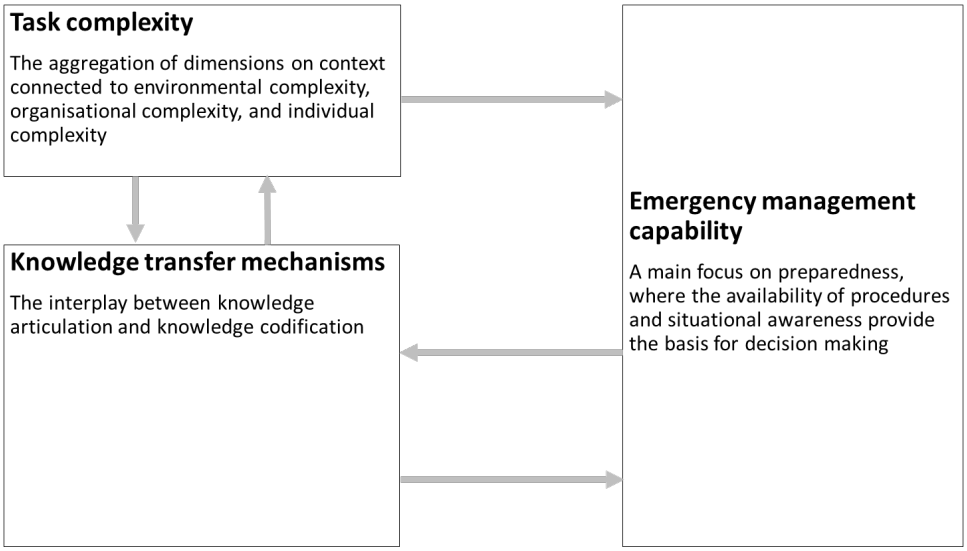

Figure 2 Task complexity and emergency management capability – The role of knowledge transfer mechanisms

Figure 2 presents an overview of the attributes of each of the variables. Moreover, it illustrates the relationships between the three variables of task complexity, knowledge transfer mechanisms, and emergency management capability.

An investigation into the relations between task complexity and emergency management capability shows that task complexity may influence emergency management capability because the dimensions characterising context complexity change (e.g. from 'business as usual' to crisis). Additionally, this thesis finds that emergency management capability is affected through the asymmetry of resources (including knowledge and people), the location of knowledge, the background of actors, and inability to deploy resources.

A direct influence of emergency management capability on complexity is not explored. However, task complexity both affects as well as is affected by task complexity and emergency management capability. That is, task complexity may influence knowledge transfer mechanisms, and, simultaneously, knowledge transfer may influence the variable of task complexity. Among other processes, knowledge

articulation related to knowledge transfer occurs in a somewhat unstructured way (see Blome et al., 2014; Gulick, 1937; McElroy, 2000) due to there being multiple actors. These actors engage in social processes (Weick et al. (2005, p. 413) such as group processes and communication, which in some circumstances may counteract a potentially chaotic path. The counteraction may be induced by the application of knowledge codification.

Knowledge transfer mechanisms constitute an ongoing, joint, intra- and inter-organisational effort during different types of events (such as the studied exercises) and can be seen as a combination of the articulation and codification of knowledge. By putting forward this definition, this thesis creates an overview of the development of emergency preparedness capability through knowledge transfer mechanisms. The development of emergency preparedness capability and connected processes evolve as organically as complexity in systems (McElroy, 2000; Aiken and Hage, 1971). For organisations, this means that their capability is constantly changing (i.e. they cannot rely on rigidity). Rather, their actors must be flexible and adaptive to the expected complexity (highlighting the importance of situational awareness) while also maintaining their ability to solve other, more predictable tasks (thus highlighting the importance of procedures). Furthermore, an in-depth discussion of information quality as part of knowledge transfer expands upon how task complexity may be affected (e.g. information stored within the actors, relevance of information, timeliness of information, information technology, and use of information hubs) (Lee et al. (2002); Wood, 1986; Campbell, 1988; Wright et al., 2014; (Schoonhoven et al., 1980); (Hajiheydari & Hanafizadeh, 2013)).

Further, knowledge transfer mechanisms may influence emergency management capability, which itself has the power to directly influence knowledge transfer mechanisms.

This thesis analyses how emergency management capability is linked to the concepts connected to decision-making strategy. It finds that having procedures

available, including a clear overview of standards and concepts (Pina e Cunha et al., 1999), is key. This finding relates to the knowledge codification dimension (e.g. producing shareable information from knowledge; (Hall, 2006) and the articulation dimension of knowledge (e.g. 'the social process by which tacit knowledge is made more explicit or usable'; Weick et al. (2005, p. 413)). Moreover, emergency management collaboration exercises (as field-configuring events) may foster organisational and inter-organisational learning and thereby impact emergency management capability. Likewise, the application of modes of knowledge creation (i.e. organisational knowledge creation) can be deeply integrated into the knowledge transfer mechanism model and may explain why emergency management capability is affected by knowledge transfer. Ultimately, applying this thesis' model may increase capability (Henderson, 1994).

Situational awareness is one dimension of emergency management capability. The results from this thesis argue that a lack of situational awareness may negatively affect the quality of information (which can be seen as part of the knowledge transfer mechanism dimensions), as described by a string of information that can be connected to an awareness of the overall mental model of the situation for all actors involved (see Coffey (2012); Rimstad et al. (2014)).

6 Conclusion, Implications, Limitations, and Directions for Further Research

The main question of this thesis seeks to identify the relations among the variables of task complexity, knowledge transfer mechanisms, and emergency management capability. In this chapter, I draw main conclusions per the main findings. I then discuss the theoretical, practical, and policy-related implications of this thesis. Finally, I recognise the limitations of this research and suggest directions for further research.

6.1 Conclusion

Building crisis and emergency capability has become a common activity for many organisations operating in contexts that may be characterised by task complexity. This thesis examines a certain group of organisations – specifically, high-performance organisations – to extend the theory of context (individual, organisation, environment, and task), capability (preparedness perspective – including situational awareness, decision-making, and task performance), and knowledge (information and knowledge management, learning, and field-configuring events). The relations between the three variables are then discussed.

It is shown that task complexity may have a direct effect on both emergency management capability and knowledge transfer mechanisms. Additionally, emergency management capability may depend on the knowledge transfer mechanisms fostered by actors such as individuals, groups, organisations, and sub-organisations. Notably, these actors carry, increase, and develop the preparedness of emergency management capability within organisations through either articulation or codification. Knowledge transfer mechanisms, in turn, are affected by emergency management capability and affect task complexity.

Specifically, it can be concluded that organisations are aware of their exposure to complexity while conducting 'business as usual'. They are also aware that the

context will become more complex during emergencies and crises, which is why organisations develop relevant capabilities before these capabilities are needed. This thesis also focuses on organisations developing these capabilities with the help of knowledge transfer mechanisms. Knowledge transfer mechanisms rely on 'collaboration between and across entities' (Liyanage et al. (2009, p. 127) and lead to entities (actors, organisations) having a learning effect on one another (Easterby-Smith et al. (2008). In this thesis, knowledge transfer mechanisms are regarded as central in building necessary emergency management capability adequate for a prevailing context predominated by task complexity. This thesis also empirically analyses the preparedness perspective and focuses specifically on readiness capacity, where the availability of procedures and situational awareness provides the basis for acting on available decision-making strategies.

The requirements of the mechanisms are as multifaceted as the range of attributes related to task complexity. Therefore, this thesis demonstrates that the more complexity the context presents, the more complexity will be presented within the set of relevant and suitable knowledge transfer mechanisms, partially because the complexity may challenge knowledge transfer with the asymmetry of resources among actors, the multitude of actors and elements, and the existence of unpredictability in causes–effects, among others**.** Creating standardisation, regulations, and routines are part of knowledge transfer mechanisms (knowledge codification) from a preparedness perspective. However, knowledge transfer mechanisms aid not only in creating adequate routines but also in increasing flexibility. Therefore, because the role of knowledge articulation is increasingly important, this thesis concludes that knowledge management connected to the preparedness of emergency management capability is related to these two mechanisms (i.e. articulation, codification). Furthermore, this thesis concludes that in the studied context of task complexity, knowledge articulation and knowledge codification are both present. Specifically, the context of task complexity is described by three parameters or dimensions:

- Individual: identities, roles, expertise, activity, thought, perception, etc. (Kurtz & Snowden, 2003); (Hærem et al., 2015; Haerem & Rau, 2007; Hunter et al., 1990; Levin et al., 2001); (Feldman & Pentland, 2003; Hærem et al., 2015))
- Organisational: structural components, units, size, diversity, information management, the location of information or knowledge, networks across organisations, uncertainty in the organisational system, etc. (Damanpour, 1996, p. 695; (Becerra-Fernandez et al., 2007); Erdi (2008); McPherson et al. (2001); McElroy (2000); Aiken and Hage (1971); (Dooley, 2004); (Damanpour, 1996); (Kylen, 1985; Weick & Sutcliffe, 2011))
- Environmental: relations with the environment, physical surroundings, and resources, etc. (Damanpour & Schneider, 2006); Jarillo (1988); Dooley (2002); (Erdi, 2008); (Roud & Schmied, 2020); (Hogarth & Makridakis, 1981); (Bigley & Roberts, 2001) (Andreassen & Borch, 2020)) parameters

Articulation may occur both in hierarchical and organically operating groups. Articulation may also be dependent on the self-responsibility of both the donors as well as the recipients of knowledge. The donors and recipients of knowledge also often understand that even if knowledge is transferred, the context within which organisations operate continues to be, to some extent, a complex one.

Stover (2004) allocates codification, which has a function to overcome asymmetry and unpredictability in cause–effect, mostly to documenting and structuring knowledge into explicit knowledge. Knowledge transfer mechanisms constitute an ongoing, joint, intra- and inter-organisational effort during different types of events and can be seen as a combination of the articulation and codification of knowledge. By arguing this, this study creates an overview of the development of emergency preparedness through knowledge transfer mechanisms being as organic as the complexity concept, which leads its second point.

Second, per task complexity, this thesis presents a concept through which the level of complexity can be described by qualitative dimensions and through which

change (e.g. from 'business as usual' to crisis) is represented by a description of the context dimensions of the individual, organisation, and environment. Whereas some studies establish complexity as a computable variable, this thesis argues that a generalised complexity measurement based on quantitative criteria may not always be relevant, thus supporting the importance of qualitative criteria within complexity-related research in organisational studies.

A third conclusion that can be drawn is connected to the range of concepts related to knowledge transfer under complexity. This thesis discusses how situational awareness is embedded in emergency management capability per the concepts of shared understanding and group and team processes, sense-making, and learning under uncertainty in general. Specifically, the discussion of the establishment of shared understanding as well as group and team processes in Paper 3 is central to knowledge transfer mechanisms. In accordance with Denzau and North (2000), the implementation of a common – or at least an overlapping – understanding of what knowledge is relevant and what knowledge is shared, as well as the establishment of institutionalisation, constitute shared understanding and group and team processes. Situational awareness fuels preparedness, which is represented by readiness capability (e.g. knowledge as a resource). There may also be some influence on response capacity (e.g. controlling abilities and coordination beyond actors); however, the focus here is more on readiness capability.

Further conclusions can be drawn about the role of situational awareness in the emergency management capability variable. Similar to sequenced sense-making–situational awareness, evidence would suggest the viability of a sequence learning–mental model. Yet, similar to these two pairs, learning and sense-making, mental models and situational awareness, and sense-making and mental models can also form sequences. This thesis, while finding all four concepts during the independent research articles, is most closely connected to the ability of situational awareness and learning under uncertainty. This is paired with the need for the availability of

procedures and may lead to the choice in a decision-making strategy. Consequently, the effect of learning from knowledge transfer mechanisms is part of the process to reach emergency management capability, and vice versa. Simultaneously, sense-making occurs when complexity is understood, knowledge transfer mechanisms are applied, and emergency management capability is developed as the basis for decision-making strategies.

A fourth conclusion related to the methodology is that field-configuring events, such as the studied exercises in Paper 4, provide a good area for data collection in terms of the variables reflected in this thesis. That is, not only are exercises highlighted as events during which intra- and inter-organisational efforts are made as a combination of articulation and codification, as Schüßler et al. (2015) state, but DiMaggio and Powell (1983) also confirm that knowledge transfer at these events can reach a 'recognised area of institutional life' and thereby have a large effect on emergency management capability. However, as Paper 3 states, it remains uncertain 'how created and transferred knowledge [are automatically and strategically developed by groups and organizations][…], and further studies could examine organisational learning processes connected to knowledge transfer mechanisms'. Yet, the recurrence of exercises can have extensive effects on the improvement of emergency management capability by increasing preparedness under complexity, although further studies are needed on this. Furthermore, among others, inter-group collaboration enables participants to learn an efficient way of working together by establishing mutual understanding for the emerging temporary organisation (including different groups within a single organisation or from other organisations) in a short time. Moreover, there is the potential for inter-organisational-level learning to be fostered through emergency collaboration exercises.

6.2 Practical implications

Some of the papers in this thesis illuminate how field-configuring events (e.g. seminars, exercises, and training) can affect inter-organisational learning processes to some degree. Notably, this thesis offers several practical implications.

For example, the results can be useful for managers in charge of organising field-configuring events, those who invest in exercises, and the emergency personnel who participate in exercises. This can be particularly important for high-performance organisations, which must be able to adapt particularly well to changes. The papers also indicate that, in order for organisations to maximise learning outcomes, they must develop sophisticated approaches to collaboration exercises such as intensive planning, periodic updates, and follow-up exercises.

Therefore, as stated in the conclusion, the periodic recurrence of exercises can have extensive effects on both intertwining and other learning processes, providing high-performance organisations with even better means to prevent possible failure and help them to understand their weaknesses. The exercises may also present regular opportunities for improving preparedness for complex organisational structures, although this possibility requires further study. Additionally, future studies can examine which processes should be followed on the individual, group, and organisational levels during the period following emergency response exercises to promote improved collaboration.

Another implication for practitioners is the increased understanding of context-related challenges. This thesis highlights complexity-characterising parameters related to the environment, the organisation, and the individual. Each of these parameters has its own challenges, but this thesis provides insights into the relevance of resource allocation, training in procedures, the role of experience, and the value of information quality (and, to a lesser degree, the value of time). This thesis also analyses suggestions for how actors can prepare to face some of these challenges. As an example, the findings from Paper 2 underline the need to follow up

on how what was learned will change an organisation's strategies and routines. Moreover, Paper 1 examines learning and strategy, examining decision-making in particular to discover how the studied organisation prepares their emergency management capability to exceed simple reliance on plans and procedures. Although several studies in the past have identified improvisation training as being important for increasing event preparedness, this study (particularly Paper 1) demands a careful consideration of the conditions under which improvisation training should be emphasised. This thesis also highlights the role of increasing knowledge related to more 'common' scenarios by practicing standard operating procedures while creating an awareness and expectation of the procedures' limitations. Resources such as personnel, time, and infrastructure are limited in most organisations, so organisations and personnel must make choices about the scope of what they can prepare for. Thus, organisations often select carefully whether to prepare managers for activities that go beyond 'business-as-usual' operations, such as crisis-specific roles.

Additionally, this thesis shows that an emergency management capability such as preparedness is dependent on both articulation and codification. Because there are usually a multitude of actors (e.g. with different tasks for individuals, specialised groups, networks of organisations, collaboration across borders, and cultural differences), this thesis provides insight into what organisations may focus on when preparing their emergency management capabilities. This also includes which individuals and organisations to utilise and which environmental parameters to focus on.

6.3 Policy implications

This thesis sheds light on policy-relevant issues related to the effectiveness of implemented knowledge development initiatives in the areas of safety, security, and emergency management. Policy measures may include rules and regulations, an emergency collaboration exercise for national entities, standard operating

procedures, standardised information systems, and the like. This thesis suggests that policy measures for knowledge development with the objective of improving the emergency management capability of a sector may not always have the same impact on different individuals, groups, organisations, and networks who must implement or abide by the rules of the initiative. The findings also show that a combination of measures – rather than one generalised method – may be necessary to implement any initiative.

Additionally, policy makers should be aware that their policy initiatives may never fully cover all potential eventualities that can arise from an emergency or crisis. Analysis of the individual papers in this thesis shows that there will always be limitations in terms of the extent to which individuals, groups, organisations, and institutions can feasibly and possibly prepare themselves.

Understanding the above-described policy implications may help to design policy on a national level that builds and institutionalises emergency management capability within different sectors, which may include improving tailored quality management or quality control following the implementation of a policy initiative.

6.4 Limitations and directions for further research

The main variables chosen for the research model are the result of combining the literature review presented in the theoretical background of this thesis with the findings and models from the individual research papers. The research question asks about the relations among these main variables. Consequently, this thesis consciously makes a choice about which variables not to choose. For example, using a context variable on task complexity leads to a wider context than if the focus were solely on definitions of 'emergency' or 'crisis'. While furthering theory building, the choice of the attributes of the context variable of task complexity (individual, organisational, environmental) also imposes limitations.

As stated previously, several possible attributes of the complexity – in particular, time and change – may need further consideration in future studies. This is

because the capability section of this thesis is designed to examine the preparedness stage of crisis management – a stage at which the scope, theme, and details of a potential crisis are unknown. In terms of complexity, tasks characterised by context at a given time point for a given decision-maker appear to be appropriate choices to describe potential complexity. Again, this accompanies the fact that details about timing and change are excluded. This thesis is aware that the literature suggests that there is an effect of time, timing, and change, but it is also aware of the benefits of incorporating temporality into organisational theory development, as well as of the fact that some context concepts include change over time. However, as described in the methodology section, the focus is on uniting four embedded case studies, each of which provides a sub-model containing the dimensions relevant to the overall model of this thesis, as well as information about the interactions among the variables to which these dimensions are related. Although the cases do provide sources for the subjective assessment of time (available time, timing), they do not provide a full range of objective measures of a time or change variable, nor is the periodic recurrence of exercises and interview questions available for a broad, deep, and sufficiently robust data set. Therefore, I chose to exclude time and instead direct my focus toward the preparedness phase. By extending the set of attributes presented (individual, organisational, environmental), a thorough and robust alternative to the existing complexity concepts within social sciences could be created.

Another limitation arising from the choice of variables (but also from the choice of methodology) is connected to not measuring the specific impact of knowledge transfer mechanisms on actual individual, group, organisational, and cross-organisational learning. Rather, the current thesis measures this impact on the preparedness phase of emergency management capability and is, therefore, capable only of postulating an increase in readiness – and, to a minor degree, response capacity – without clarifying how knowledge (both created and transferred) becomes part of more thorough learning processes. Thus, further studies can focus more on organisational learning processes. As an example, additional research can explore

how stakeholders determine structures from a more operational perspective. Despite the insights obtained from regulations and standards, specific tools and means of knowledge transfer can still be determined. That is, some of the sources criticise how individual knowledge may, at times, fail to reach all of their colleagues or all corners of their organisation. Future studies can go into further detail on this topic.

Another area where which further research is suggested is that of how organisations and individuals (i.e. who contribute to knowledge transfer mechanisms to affect emergency management capability) determine structures from a more operational perspective. The discussion about decision-making strategies, regulations, and standards provides some initial insights into how these structures are created. However, there is room for research to identify the tools and means of knowledge transfer. As an example for more room, this thesis suggests further longitudinal studies to assess whether inter-organisational learning leads to increased collaboration or the potential for collaboration after an exercise, as well as what processes are enabled by periodic exercises.

Another limitation is connected to the methodology: This thesis relies on cross-sectional data connected to several case studies, with a focus on preparedness in non-crisis and non-emergency situations. Due to the lack of thorough longitudinal data, no specific reciprocity or influence of effects and counter-effects between the variables is measured. The model, therefore, also has two arrows pointing in opposite directions instead of one two-sided arrow to indicate the possibility of effects in both directions. A longitudinal study method may provide more insights into reciprocity and learning effects over time, as well as long-term effects on the variables. Further studies can, therefore, compare crisis and emergency experiences with the development of capability to a greater extent to better analyse the cycle between learning, crises, and lessons learned. For example, this thesis designs a model of how emergency management capability is affected (preparedness perspective), but the model should be further tested in a longitudinal study and also on an organisation that experiences several pre-, during-, and after-crisis stages. In this thesis, I also do

not focus on how lessons learned ultimately change the applied strategies and routines of the organisations involved. Thus, further research is needed to examine this crucial next step to determine the effect of learning on the actual organisational effectiveness in managing emergencies. Additionally, this thesis focuses on conceptual and qualitative methodology, but a quantitative approach may aid in testing any presumptions or indications within the qualitative findings.

Per the above, it is recommended that further research analyse whether other concepts related to the variables and attributes (e.g. 'business as usual' and a crisis as a context, decision-making, mental models, sense-making, and learning under uncertainty) may be variables themselves, which can help to extend the model of this thesis.

7 References

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Paper 4

Situation awareness under task complexity—the role of information

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Situation Awareness Under Task Complexity:
The Role of Information

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ABSTRACT

Performing tasks under task complexity (TC), for example, during the management of a crisis, can be challenging. One relevant research stream has so far dealt with modelling task complexity while another research stream has established the importance of situation awareness (SA) during crisis management. This study takes into consideration these two research streams and builds a model on how SA is achieved under task complexity. The research shows that information of high information quality (IQ) reduces the level of task complexity, and influences—as well as is influenced by—situation awareness. The practice of collecting and disseminating relevant and timely information as a critical resource in improving SA should be carried out continuously. This continuous process can be improved by using information technologies as automating tools. Moreover, the study shows how shared mental models can improve SA under task complexity. A case study approach, based on qualitative data focusing on theory building, is applied. Unit of analysis is a Norwegian hospital.

KEYWORDS

Complexity, Crisis Management, Emergency Management, Information, Information Quality (IQ), Situation Awareness (SA), Task Complexity (TC)

INTRODUCTION

We adopt the definition of "task as behaviour requirements" by Wood (1986, p. 62), stating that tasks are a behavorial responses of an individual. The aim of these responses is to reach a "specific level of performance" (Wood, 1986, p. 62). In our interpretation, the definition can include more than one person, as several individuals within and across organizations can be joining to perform the responses.

We use the definition of task complexity (TC) by Hærem, Pentland, and Miller (2015), who in turn draw upon Oeser and O'Brien (1967). Both sets of scholars establish TC similar to a decision tree. According to Hærem et al. (2015), tasks are paths and potential routes to reach particular goals in the network. This creates nodes and ties which may in addition change over time, which gives a

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dynamic element to complexity (Wood, 1986). In contrast to simple tasks, the more choices that are possible in order to reach goals (Wood 1986), and the more unexplainable interrelations of components in the network of actors (Flood 1987), the more complex is a task. As our systems and organizations evolve into more complex systems, dealing with TC has become more urgent (Campbell, 1988; Hærem et al., 2015).

Although in literature on complex systems there is a focus on situation awareness (SA) as part of the decision process, TC is less of an issue (Endsley, 2001; Wright, Taekman, & Endsley, 2004). However, coming back to Hærem et al. (2015) and Campbell (1984), complex systems and complex tasks are so interwoven that we believe SA is central within TC as well. We use the SA definition by Endsley (2001), which is also supported by Wright et al. (2004, p. 4). Endsley (2001, p. 4) defines SA as a 3-level model consisting of "Perception of the elements in the environment", "Comprehension of the current situation" and "Projection of future status". High stress and high workload may additionally hinder SA (Wright et al., 2004).

When comparing the studies by Hærem et al. (2015) and Campbell (1984) with the studies by Endsley (2001) and Wright et al. (2004), there is one more aspect which becomes clear: Information and the quality of information appear to be important for both assessing tasks and gauging their complexity when it comes to *SA* (Endsley, 2001; Wright et al., 2004). In our view, both Hærem et al. (2015) and Campbell (1984) give this aspect too marginal consideration. We define information as "know who, what, where, when and how many" (Ackoff, 1989). In contrast to Ackoff, we also include how-to (Ackoff, 1989). We start with the *information quality* (IQ) definition by Nelson, Todd, and Wixom (2005), stating that quality of information is created by the level of completeness, accuracy, format and currency of the information. However, throughout the analysis, we find out that the given model requires a different look at the information-related parameters.

This study investigates the role of *SA* under task complexity. In addition, it poses a fundamental question connected to *SA* under *TC* – whether information may play a more significant role than previous research suggests.

The study provides a literature survey and establishes the analytical model of *SA* under *TC* and the role of information. An empirical case study investigates the ambulant professional organisation of Nordland hospital. Interviews, discussion of existing procedures as well as observation of the largest University-organized emergency management exercise ("exercise Nord 2019") are the main means of data collection.

LITERATURE SURVEY

Situation Awareness in the Light of Task Complexity

According to Crichton, Lauche, and Flin (2005), *SA* is one of the five incident command skills besides decision-making, teamwork, leadership and communication. *SA* may suffer from *"information gaps, the lack of fluent communication, and the fact that there is no common operational picture"* (Seppänen, Mäkelä, Luokkala, & Virrantaus, 2013, p. 1). Information is constantly mentioned as an attribute to support a common operational picture (ibid.).

Improvement in situation awareness, including tasks such as the assessment of urgency, is connected to increasing decision-making capability (Chung, 2005; Endsley, 2017; Gerdtz & Bucknall, 2001). *SA* literature particularly states the importance of being up to date with overall capabilities in a dynamic environment (Endsley, 2017).

Some studies have looked at the individual challenges of a decision process connected to *SA* if something is urgent (Gerdtz & Bucknall, 2001). Klein (2000) places *SA* in a model linked to the performance of the actor (e.g. in such a task as an assessment). Other studies have focused on the fact that *SA* also requires actors to be up to date with the capabilities of other actors, groups and organisations (Coffey, 2012; Rimstad et al., 2014). Shared sense-making and joint mental models

may become important here (Grimes, 2010; Pearson & Clair, 1998). Particularly shared mental models have been connected to increased team *SA* (Bolstad, Cuevas, Gonzalez, & Schneider, 2005). Also, according to Bolstad et al. (2005), shared mental models play a direct role in forming (shared) situation awareness. Shared mental models have in addition been connected with "a set of concepts and language" to simplify the transmission of information (Denzau & North, 1994, p. 10).

In this light, increased *SA* is linked to the available information in the shared mental model. However, if the information is not available, information search may take time, which in turn may potentially deteriorate the situation that needs to be solved (Gerdtz & Bucknall, 2001). Janis and Mann (1977) argue that time pressure leads to a less thorough information search, which limits going into the depths of alternatives to gain *SA* (Edland & Svenson, 1993). Also, Chung (2005) sees time constraints as well as communication difficulties as the main criteria why decisions have to be made based on incomplete information, and - as a consequence - potentially incomplete situation awareness.

According to Gerdtz and Bucknall (2001), primary reasons that influence assessment time to increase *SA* are:

1. There was preparation time (decrease of assessment time);
2. The process is interrupted (increase);
3. If information donor and recipient use different languages (increase);
4. The background of the actor (depending).

To understand the role and the sequence of situation awareness, it helps to look again at the "model of SA in dynamic decision making" by Endsley (2017, p. 35) in the introduction. The *SA* model consists of three levels and precedes the act of decision making (see also Wright et al. (2004)).

These levels do constitute some overlap to what Gaba, Howard, and Small (1995) present as constituents of *SA* – namely being aware of subtle cues, noticing evolving situations as well as being aware of particular knowledge elements. All these constituents by Gaba et al. (1995) are dynamic. They imply that once a task is being performed, a change of the *SA* may appear that may require an adjustment to the action (Gaba et al., 1995).

Wright et al. (2004) argue that individuals with lower *SA* are more prone to decision errors. Interestingly, Endsley (2017) mentions *TC* as a challenge to gaining situation awareness. Even though we see that the *SA* literature does draw upon *TC* of situation awareness, it does not seem to be central. Besides, there is little reference to the objectives of those tasks.

Understanding Leading Task Complexity Theory

There have been attempts at quantifying the complexity of tasks (Campbell, 1988; Hærem et al., 2015). Hærem et al. (2015) draw upon Oeser and O'Brien (1967) and design TC as a formula: "Task complexity = $\sum_g \sum_p ties_{g,p}$ where paths (p) are routes to particular goals (g) representing the attainment of an outcome". In addition, Campbell (1984) mentions that contradiction and interrelation when facing a task may be described by task complexity.

The complexity of tasks, according to the framework by Campbell (1988), is characterised by changes (Campbell refers to an increase) in the information load, the diversity of information or the rate of an information change. It will be interesting to discuss information further at a later stage, as first impressions suggest that it is not always clear whether information increases or decreases task complexity.

Additionally, Campbell's concept enables to distinguish four task characteristics which contribute to complexity. These are "(a) the presence of multiple potential ways (i.e., paths) to arrive at a desired end-state, (b) the presence of multiple desired outcomes (i.e., end-states) to be attained, (c) the presence of conflicting interdependence among paths to multiple outcomes, and (d) the presence of uncertain or probabilistic links among paths and outcomes" (Campbell, 1988, p. 43). The higher the value of each of the above characteristics, the more complex the task to work on a major goal.

Interestingly enough, Wright et al. (2004) analyse tasks and conclude that "major" goals will be reached by fulfilling a set of sub-goals. Wright et al. (2004). They also claim that *SA* (levels 1-3) is required for each of the sub-goals. This means, consequently, that task fulfilment of the major goal would be dependent on a collection of task complexities, unless exact sub-goals are designated as main goals. But what if the goal is not clear, or partly unknown, or changes over time?

Information and Task Complexity

In line with Wright, Schoonhoven, Scott, Flood, and Forrest Jr (1980, p. 894) suggest that "An interest in "technology" - as this focus (somewhat misleadingly) has been labelled - is justified by the sensible assumption that one cannot intelligently design appropriate organisational arrangements unless one first knows what type of work is to be performed". Yet, when information is lacking, objectives become fuzzy (Bellman & Zadeh, 1970) and strategies to cope with the situation become less clear.

Weick and Sutcliffe (2015, p. 66) argue that the organisation for complex tasks should not be overly simplified, as this may discourage the potential for "process variety,[…] argumentation, and more capability and willingness to act to understand". This suggests therefore that a simplification of, or a decrease in value of the variables within the presented formula by Hærem et al. (2015) may not be the single solution to cope with task complexity. Another solution may present itself by exploring further the aforementioned information.

Hærem et al. (2015) are aware of the importance of information (see *"information cues"*) to complexity. Based on Wood (1986) and Campbell (1988), they argue that information needs to be processed, otherwise it increases task complexity. On the other hand, there are studies which consider complexity to increase through lack of information (Xia & Lee, 2005), which may often lead to problems of coordination (Robson, Katsikeas, & Bello, 2008). Obviously, there needs to be some difference between the two concepts of information presented; the discussion on *IQ* may be able to provide some help to clarify the discrepancy. *IQ* ascribes specific attributes to information, so it can be used to its fullest potential (Nelson et al., 2005). Related to situation awareness, the literature on shared mental models does also mention that added information of quality may improve awareness (Denzau & North, 1994). Although in their meta-study Lee, Strong, Kahn, and Wang (2002) construct a method for assessing and benchmarking information quality, they do not mention whether it may be of relevance for *TC* and situation awareness.

Information quality-related discussion in literature is wide-reaching. For example, Gorman et al. (2000) ask if information may be used in small units, or whether it is more problem-oriented to use bundles of information. Bundles are said to be better to "support diverse, complex, and often simultaneous tasks" (Gorman et al., 2000, p. 287), while previous sources talk about increased complexity through information overflow. Gorman et al. (2000) also discuss the role of other physical support for technology related to information management (Kardex notes, ICU flow sheets, Resident's worksheets…), with a generally positive emphasis on the performance. Technology to make information mobile (Hajiheydari & Hanafizadeh, 2013), as well as relying on other organizations to provide information management and technology has also been subject of performance related research (Talpeanu & Rusu, 2017). Also studies within business research, assign platforms and tools to manage information an important role (Lavassani & Movahedi, 2017). Can technology add to information quality when presented with task complexity?

ANALYTICAL MODEL AND RESEARCH QUESTIONS BASED ON THE THEORY PERSPECTIVE

Similarly to Hærem et al. (2015), and drawing upon Oeser and O'Brien (1967), Schoonhoven et al. (1980) explain *TC* and uncertainty via 1) *"the set of activities performed"* when performing a task (eg triage) and 2) the set of choices which the actor has to choose from. At the same time, we take into account literature such as Wright et al. (2004) and Endsley (2017), where *SA* always precedes the

decision task. Hence, it is *SA* rather than decision making or task fulfilment, which is most closely connected to the *TC* variable. A preliminary model, therefore, should contain the variables: situation awareness, *TC* and information.

Based on the review of the extant literature, we pose two research questions:

RQ1: What is the role of information in reducing task complexity?
RQ2: What is the role of *SA* for mediating information and task complexity?

STUDY FIELD AND RESEARCH OBJECT

Choosing the right study context may be relevant. Gorman et al. (2000) state that context characteristics may be important for a model including task complexity. Characteristics include the user (or research subject), the task they have to perform and the information space they are operating in (ibid.). Previous studies are located among others in the area of *SA* in clinical settings (Gorman et al., 2000) and children's hospital intensive care units (Brady et al., 2013).

Our research rests in a medical setting. It focuses on so called ambulant staff (actors) connected to a Northern Norwegian hospital. We have determined that a study of these actors, who require *SA* to deal with task complexity, helps to elaborate on our research questions. The relevant sub-organizations for data-generation stem from the "Norsk Indeks for Medisink Nødhjelp"/[Norwegian Index for Medical Emergency Aid] (NAKOS, 2018). The ambulant staff is connected to the following sub-organizations:

- **"*Akuttmedisinsk kommunikasjonssentralen*" [Ambulance communication center] (AMK):** Actors at AMK coordinate the ambulance resources to and from an incident-site. They need to be in constant contact with the incident commander health (who is part of ambulance on an incident site) as well as the ambulance-centers. AMK is connected to the joint planning headquarters by ambulance, police, fire brigade, the (so called SAMLOK) located in Bodø/Northern Norway;
- **Ambulance:** These actors can be sent via air or ambulance-car and are often the first professionals on site. They receive information from AMK and take the relevant decisions on site. This unit also includes the position of ***incident leader health* (ILH)**, which is a main role during coordination of larger incidents and is located at the ***incident leader commando area*** (ILKO) on site;
- **330 Squadron:** In Bodø, the area of this study, this military-affiliated helicopter unit supports airborne activity. They carry on board a doctor from the hospital and rescue personnel with ambulance education. They are often faster than ambulance cars and have an important role in difficult terrain (sea, mountains,…);
- **"Akuttmottak"/*Emergency room* (ER):** Actors in the ER will be the ones to receive the patients at the hospital. They need to assess what to do with the patients and what resources to mobilize and use.

The *Norwegian Index for Medical Emergency Aid* (NAKOS) stated a main challenge connected to *SA* in ambulant work: *"Systemene for lokal, regional og nasjonal registrering og rapportering holder ikke det kvalitetsnivået som er ønskelig"* [The systems for local, regional and national registering and reporting do not meet the desired quality level] (Nilsen et al., 2014, p. 18). Hence, it is important to understand which challenge within the Norwegian system these actors will face to create *SA* and to manage to handle *TC* beyond their own position. Two types of *SA* are important in the ambulant field:

- **Situation awareness concerning patient:** When it comes to *SA* within the health sector, studies such as Braddock, Fihn, Levinson, Jonsen, and Pearlman (1997, p. 340) provide a good insight on the implications of performing a task: Namely, *"committing to a particular course of action"*.

Nonetheless, these studies focus mostly on the tasks directly related to the patients and they observe both cues for *SA* and decision made (Ofstad et al., 2014);

- **Situation Awareness Concerning Logistic:** When faced with task complexity, (e.g. a mass-rescue incident; special incidents such as *chemical, biological, radiological and nuclear defense* (CBRNE) or incidents with *ongoing life-threatening violence* (pågående livstruende vold (PLIVO)), the operational aspect related to the logistics of a rescue operation becomes more and more important, as well as a main concern of situation awareness.

These two types of situation awareness, "patient" and "logistics", are interwoven and find consideration in every role. Nonetheless, this study mostly concentrates on the second one - logistics.

When it comes to information management within the Norwegian ambulance system, a set of standards provide clear framework for decision tasks. One of the most important standards is the previously mentioned Norwegian Index for Medical Emergency Aid (NAKOS, 2018). Within the standard, a group of mass-rescue incidents *("masseskadehendelse")* are mentioned as particularly critical due to time-resources-challenges. Time-critical information related to availability and mobilization of resources to the incident site is therefore regarded as crucial for studying situation awareness:

Kjørevei, Møteplass, Innsatsområde, Skadeomfang, Melder, vitner, mv; farlig område, Situasjonsrapport fra første enhet på stedet, Viktig informasjon for den videre planlegging av ressurser, I form av materiell, personell, beredskap osv. [Infrastructure, meeting places, areas of operation, extent of injury, person reporting from the incident site, dangerous areas, situation report by the first professional at the site, important information for further planning of material-, personnel- and emergency resources] (NAKOS, 2018, p. 21) are all part of the important information.

As an example, when it comes to mass-rescue incidents, the "Nasjonal veileder for masseskadetriage"/[national guidelines for mass-rescue triage] come into play, particularly as long as there is an imbalance between the quantity of injured people and the available resources (Helsedirektoratet, 2013). This shall support *SA* towards the right issues. According to the document, "common" principles of documentation will come back into play as soon as enough resources are restored.

METHOD

To acquire knowledge on the variable (situation awareness),– a look at the explanation of previous studies helps to gain an understanding of how to measure it. Brady et al. (2013) define key indicator events which demonstrate a lack of *SA* in case they appear. Gaba et al. (1995) refer to Tenney et al. (1992) and Sarter and Woods (1991), who introduce hypothetical scenarios and simulations to gain an insight into the *SA* (in this case, most likely a perceived situation awareness).

Wright et al. (2004), on the other hand, highlight several means of measuring including measurement of direct performance (time on task, rate of error, deviations from the objective), mental measures of side tasks - which indicate that the actor is not too invested with the core-task - and physical analysis of the task-performers' body (e.g. Eye tracking, time used…). When it comes to tasks with potentially unclear objectives, these studies are aware that objective measures (such as *Goal Directed Task Analysis* (GDTA) [compare Gaba et al. (1995)]) may be challenging, hence a subjective assessment is needed. The present study is therefore framed on a data generation based on hypothetical case discussion with actors connected to the study object. Observation of the incident leader health (ILH) at exercise NORD 2019, a full case mass rescue exercise, provides in-depth data.

The first methodological step was to cooperate with the potential sub-organizations throughout informal interviews. This created an understanding of the relevant types of tasks to be assessed. These tasks were related to the decision makers' *SA* under task complexity.

In a second step, semi-structured interviews were conducted to gain further insights into the relations between situation awareness, *TC* and information. In contrast to Schoonhoven et al., who followed a quantitative approach (Schoonhoven et al., 1980), this study has built up theory by a qualitative case study approach.

Questions were related to background of participant, information and professionalization-related topics and situation awareness, as well as further considerations, context and on-task complexity. The following table describes the interview participants.

RESULTS

This research is aimed at finding out what the role of information is in the light of *SA* capability under task complexity. The results show that information has a substantial effect on task complexity, as well as that it interacts with the dependent variable situation awareness.

Situation Awareness Under Task Complexity

The criticality of a mission, or at least how critical it is assessed to be, plays a large role on how complex the following tasks will be and how urgent the actors judge the situation. On both the operational and the tactical level, the actors in the study acted on the basis of two main premises concerning *SA* and relevant information.

Situation Awareness on Risk, Safety, Criticality and Urgency

The first premise for on-site actors is personal safety and assessment of risks connected to any activity at the incident site. Aspects such as perception of elements in the environment like weather conditions (e.g. mass rescue at sea or avalanches), threats from potential chemical, biological, radiological and nuclear (CBRNE) material, personal security-related aspects (e.g. ongoing life-threatening violence (PLIVO)), all these issues were brought up, which made the ambulance work more complex and the actors more dependent on their network.

Hereby, the interviews showed, how much importance is given to communication systems and pre-installed procedures and hierarchies. As an example, while more common ambulance tasks rely on the self-responsibility of an actor, some of the above aspects require specialized knowledge connected to roles with the legitimacy and responsibility to decide over others.

S09, for instance explained the legitimacy of a leading role for cooperation on operational level if both ambulance, police and fire brigade needed to mobilize:

Det er gjerne politiet som oppretter den talegruppa, for det er de som har styringen med det. Så da setter de en radio i den. Så da kan vi kommunisere bare med ambulansen i en talegruppe, og så kan de også kommunisere med sentralene her og med hverandre i den andre talegruppa. [It is often the police who create that speech group, because they are the ones with the control. So they put the radio on. So then we can only communicate with the ambulance in one speech group, and then they can also communicate with the centers here and with each other in the other speech group].

An example concerning safety and relying on another tactical actor was given by S11:

jeg sa til første redningsmann… så gikk han og snakket med en person som var i skredet og undersøkte litt og så ble vi enige om at jeg også skulle ned, så ble jeg heist ned. Og da hadde vi på oss snøskredsekk og sender/mottaker og søkestang og alt vi trengte for å lete og grave. Men da ble redningsmannen

Table 1. List of interview partners

Source Acronym	Organization	Position	Organizational Level (Tactical, Operational, Strategic)
S1	Nord University	Study program leader / faculty for ambulance and health-sciences	-
S2	Nordland Hospital	Assistant leader of Emergency Room	tactical
S3	Nordland Hospital	Specialized nurse / in charge of training- and exercise	tactical
S4	Ambulance of Nordland Hospital	Leader of ambulance	tactical
S5	Ambulance communication center (AMK) of Nordland Hospital	Leader of AMK	operational
S6	Nordland Hospital and AMK	Specialized nurse (coordinator at ER, 113-operations AMK)	Tactical
S7	Ambulance of Nordland Hospital	Leader of Ambulance, Bodø region	-
S8	Nordland Hospital and AMK	Professional 113-operations AMK	operational
S9	Nordland Hospital and AMK	Specialized nurse, professional 113-operations AMK	operational
S10	330 Squadron	Rescue operator	Tactical
S11	Nordland Hospital / 330 Squadron	Medical doctor both at 330 Skvadronen and Nordland Hospital	Tactical
S12	330 Squadron	Pilot, helicopter operations lead	Tactical
S13	Nordland Hospital and AMK	Specialized nurse (coordinator at ER, 113-operations AMK)	Tactical
S14	Nord University	Specialized ambulance, Observer/Conducteur at Exercise NORD for paramedics and ILH position	Tactical
S15	Nordland Hospital / Vesterålen	Specialized ambulanc, Observer/Conducteur at Exercise NORD for ILH position	Tactical
S16	Ambulance of Nordland Hospital	Spec. ambulance, ILH role at Exercise NORD	tactical

sendt ned først for at han har større forutsetninger for å gjøre sånne vurderinger og for å bevege seg i snøskredet enn det jeg hadde, før han fant ut at det var trygt, og så kom jeg ned. Så både egen og gruppesikkerhet er viktig. [I said to the first rescuer ... then he went and talked to a person who was in the landslide and investigated a bit and then we agreed that I should also go down, then I was taken down. And then we had avalanche backpacks and transmitter / receiver and search bar and everything we needed to search and dig. But then the rescuer was sent down first. He had greater preconditions for making such assessments and for moving in the avalanche than I had before finding out it was safe, and then I came down. So both self and group security are important]

Updates on Current and Future Complexity

The second premise is more connected to the wellbeing of the patients. After the obligatory assessment of the first responders on the criticality of patients (mostly procedure-driven), and after bringing the patient to a safe spot and calling the necessary resources, recurrent information gathering and situation update is performed. This process, together with gathering subtle cues from the environment, is necessary in order to paint a shared mental model of potential worst case scenario for the situation.

If the shared mental model is not painted, examples show, that actors from different sub-organizations would have different situation awareness. S11 stated:

Sånn tilbake til det snøskredet som jeg var ute på for noen uker siden. […] midt i hendelsen, en time etter at vi hadde vært der for eksempel, så ville nok vi på skadestedet, de på politiets operasjonssentral, de på AMK, de på HRS ville sitte med forskjellig situasjonsforståelse. Fordi at det blir veldig mye prat på nett og det blir vanskelig at alle får med seg alt. [Back to the avalanche I was out a few weeks ago. […] In the middle of the incident, an hour after we had been there for example, then we probably would have been at the scene of the injury, those at the police operations center, those at the AMK, those at HRS all would have different situation awareness. Because there is a lot of talk on the web and it becomes difficult for everyone to get everything done.

S04 gave a good insight on how important SA updates were for patients with critical situation:

Det er jo å gjøre de samme vurderingene på nytt flere ganger gjennom et oppdrag. Måle blodtrykk gjentatte ganger, måle pulsen, følge med på EKG, overvåkning rett og slett [It is, after all, to make the same assessments again several times through a mission. Measure blood pressure repeatedly, measure heart rate, monitor ECG, simply monitor…]

The above example may be used to reflect on the dynamic elements in the management process of each actor's tasks. Even though they often follow clear procedures and have a general mental model on what to do, additional information both from patients, from colleagues (horizontally, vertically, diagonally) and the environment may require some of the actors to restructure their tasks.

While a path of recurrent gathering of information increases the *TC* at present, it potentially decreases each individual's future task complexity. This is done by providing necessary additional information and other resources to enable the shortening of future pathways or distribute sub-goals to available additional resources. An example by AMK S05 provides a good understanding:

så er det jo det potensielle i dette her du må prøve å forestille deg i tillegg, alle eventualiteter. For eksempel sender vi et helikopter ut til en plass det går an å kjøre så sender vi alltid en ambulanse, for du vet aldri om at det helikopteret verken får landet eller få tekniske problemer. Så vi er alltid at vi kjører dobbelt. Det er en sånn både/og. Du må jo alltid ha prosedyreverk i bunnen som sier noe om hvordan det skal gjøres. Men så lenge du har det så har du muligheten til å være kreativ og finne løsninger som ikke passer inn i det verket, så lenge du har det i bunnen. Vanskelig å forklare. [Then

there is a possibility that you must additionally try to imagine all eventualities. For example, we send a helicopter to a place that can be reached by car and we always send an ambulance, because you never know. The helicopter might not be able to land or get technical problems. So we always have a backup. It's either or. After all, you always have to have procedures at the bottom that say something about how to do it. But as long as you have the procedures you have the opportunity to be creative and find solutions that do not fit exactly to the procedure. As long as you have the procedure as a basis. Difficult to explain.]

The data showed that all actors were aware of the limitations of every-day resources and that receiving additional resources was often the most critical issue. It means that with lack of resources, there were tasks that were too complex for the existing actors and what they had available. Information management could help to mobilize a share of relevant alternative resources. For instance, there was a so-called "catastrophe alarm" across the sub-organizations. This would transmit an automatic information and warning to all sub-organizations to mobilize extra resources, which would in turn increase both physical resources and capabilities to increase the information flow and the situation awareness.

Complexity and Sub-Paths, -Ties, and -Goals

When it came to the overall complexity of the organization of ambulance work at exercise Nord, there was a multitude of actors from different sub-organizations. This network was described by S11 to include:

112, altså politiets operasjonssentral, AMK-sentralen, 1-2-3 ambulanser, hvor hver enkelt har et håndsett radio, 1-2-3 leger, redningsmann, Røde Kors kan melde seg inn i tilsvarende gruppe, redningshundene…det blir ganske mange. og da kan det være vanskelig å få oversikt over alle som er der. [the police operation center, the AMK-central, 1-3 ambulances, where each one has a handset radio, 1-3 doctors, rescuers, the Red Cross can join a similar group, the rescue dogs ... there are quite a few. And then it can be difficult to get an overview of everyone who is there]

This is a quote about the different stakeholders' sub-organizations, but one should keep in mind that, in addition, inside each sub-organization there could also be a multitude of specialists. The trauma-team at the emergency room, which is the latest stage this study looks at, is a good example. When we observed them gathering to take care of a young patient, a plethora of actors was summoned – among others anesthesiologist, an anesthesia nurse, surgical nurses, reception nurses, a general surgeon, an orthopedic surgeon, a neurosurgeon, a radiographer, a porter, a radiologist, a bioengineer and support personnel such as doctors in education and observers. Altogether our observer counted close to 20 persons who had mobilized to receive the patient.

In order to handle these logistic challenges, it seems that all the actors in the ambulant field are operating with a shared mental model of an overall goal related to their task – namely saving the lives or health of most possible people. On a daily basis, in most of the cases complexity is in a range that is manageable by all with the spectrum of procedures. With these procedures in mind, S05 from AMK stated that "Vi tenker ikke så komplekst når telefonen ringer inn, vi tenker veldig sånn systematisk abcde… enkelt" [We don't think so complex when the phone rings, we think very systematically abcde ... easy]. A statement that strengthens this point was given by S13: "det kan gå fortere rett og slett på grunn av at de har jo det samme triagesystemet i ambulansene" [it can go faster simply because they have the same triage system in the ambulances].

When a case becomes more complex, however, it should be noted that - according to our observations - reaching major goals under *TC* mostly worked out by dividing the major goals into sub-goals. The less common the set of sub-goals, the less likely that procedures are available. Also,

more persons may be assigned similar tasks. This leads to a decrease of the clarity of sub-goals, a decrease of the necessary ties as well as a decrease of the paths to reach the sub-goals. S05 described this process well by stating that:

målet er jo veldig enkelt: vi skal redde flest mulig liv. Så for oss er det ikke så vanskelig. Og det gjelder jo for brann og politi også. Så er det en stor hendelse så er det det vi skal gjøre. Men vi har jo alltid delmål for at vi skal lykkes best mulig i en sånn prosess. Veldig ofte store hendelser så… et av delmålene vil alltid være å ikke skape flaskehalser som gjør at du må sluse mennesker igjennom en masse sjekkpunkter før du kommer fram til de som faktisk kan gi dem behandling. Og det vil jeg jo kalle delmål. Så vi har mange sånne punkt underveis i en hendelse. [the goal is very simple: we want to save as many lives as possible. So for us, it's not that difficult. And that applies to fire and police as well. If it is a big event then that's what we're going to do. But we always have sub goals to succeed in such a process as best we can. Very often in big events... one of the sub-goals will always be to not create bottlenecks that require you to lead people through a lot of checkpoints before you reach those who can actually treat them. And I would call that a sub-target. So we have many such points along the way in an event]

While S05 painted a rather clear picture of how several actors and sub-goals could result in decrease of task complexity, other sources mentioned the opposite: They stated how different actors could have different type of sub-goals, which in turn would raise complexity. This may make it more difficult to achieve overall *SA* and have a complete shared mental model. Conversely, predefined procedures may have the potential to provide better shared mental model, as expressed by S14:

Jeg tror at en av de største utfordringene i helsevesenet i dag, altså i ambulansetjenesten i dag, det er det at vi ikke har forhåndsdefinerte ledere. Sånn at ved en reell hendelse så er det en risiko for at første enhet til stedet har en relativt fersk ambulansearbeider som tar rollen. Og det står jo i tiltaksboka vår at mer erfaren personell kan komme inn og ta over rollen, men det ligger ikke noen automatikk i det. Og vi har ikke noen retningslinjer på det. Sånn at mange ganger på mindre skadested så har jeg nok sett det at vi har litt uerfarne og uatuoritære ledere som forsvinner litt og ikke tør å stikke seg fram og ta ansvar. [I think that one of the biggest challenges in the health care system today, I mean the ambulance service, is that we do not have predefined leaders. So in case of a real event, there is a risk that the first unit of the site has a relatively fresh ambulance worker taking the role. And it says in our action book that more experienced personnel can come in and take over the role, but there is no automaticity in it. And we don't have any guidelines on that. So many times at a minor injury site, I have probably seen that we have a bit of inexperienced leaders with less authority who disappear a bit and do not dare to step forward and take responsibility.]

The above quote represents an exception within the ambulance section, other response organizations such as military, police and fire-brigade rely more on procedures for predefined on-scene leaders. Also in the presented study, on many positions there had been established institutionalized roles and hierarchies. Also, there were ad hoc- platforms and methods for learning. These would be directed both towards individual *SA* capabilities as well as shared *SA* via shared procedures and mental models. Yet, in many of the positions there were not sufficient back up resources to free people to do substantial training and learning of specifically complex tasks.

Likewise, also when it came to debriefing and defusing to create shared awareness and mental model of the operations after a difficult case involving (too) complex tasks, many informants stated that more such options would be welcome. This showed that some sub-organizations did have structures for debriefing and defusing in place, while others were struggling due to lack of time and resources.

One testimony showing that there could be greater focus on more debrief was given by S13:

Jeg føler at det er blitt mindre og mindre å lære av det man gjør, fordi at man får ikke… man ser pasienten, man hører pasienten i et bitte lite tidsvindu, man vet ikke hva som skjedde før, man får et lite resyme, så sender man ut ressurser og får hjelp av pasienten, og så vet man ingen ting, vi får ingen feedback på hvordan det går med pasienten. Og det er jo veldig utilfredsstillende, for vi mister jo den læringsbiten, at man vet om man faktisk gjør rett eller… [I feel that it has become less and less to learn from what you do, because you do not get… you see the patient, you hear the patient in a tiny window of time, you do not know what happened before, you get a short summary. So you send out resources and get help for the patient, and then you know nothing, we get no feedback on how the patient is doing. And it is very unsatisfying, because we lose that learning bit, that you know if you are actually doing right or…]

In conclusion, the present study showed that deeper insights on learning could provide further knowledge related to *SA* and *TC*, and how organizations may prepare for it.

INFORMATION QUALITY AND TASK COMPLEXITY

Relevance of Information

Specific knowledge elements which are stored somewhere in the system – either via mental models in guidelines, rituals, procedures or habits, but also elements specifically stored by each actor – were relevant for this study. These types of information could be retrieved and applied when necessary. In this study, particularly as regards the assessment of risk and safety, but also when it came to finding out what to do with patients or where to get further resources, all actors had specific roles and responsibility. This helped them to assess and provide relevant information for the ongoing processes.

As an example, the helicopter rescuer (Redningsman) reflected on his/her responsibilities connected to how to salvage persons from a ship. S10:

For hvis jeg hadde brekt en arm på båten så hadde på en måte de vært overlatt til seg selv, for da hadde vi ikke hatt noen backup. Mens i havet så er det… selv om bølgene var store så var det ikke… havet er ikke så hardt, det er litt mykere enn stål, så… [Because if I had broken one arm on the boat then in a way they would have been left to themselves, because then we would have had no backup. While in the sea it is ... even if the waves were big... the sea is not so hard, it is a bit softer than steel, you understand.]

While this piece of information concerning logistics was to be assessed by the rescue operator, other positions in the crew were in charge of other aspects. For instance, questions concerning the approach on medical issues were taken care of by the medical doctor on board. S11 gave a good insight into responsibilities by different roles at the 330 squadron:

Hvis det er medisinske oppdrag hvor de vil diskutere om man skal bruke helikopter eller legebil så ringer vi til legen på vakt. Og så bestemmer jeg. Og så… er det helt åpenbare medisinske hendelser hvor AMK melder til HRS [Joint Rescue Coordination Center] at de vil ha et helikopter, og da sender HRS da alarm til oss. Og så er det da helt åpenbare redningsoppdrag hvor HRS får en melding som da… hvor de da sender oss ut direkte. Men hvis det skal diskuteres, altså hvis det er en diskusjon rundt skal/skal ikke osv. så er det legen… [If there are medical assignments where they want to discuss whether to use a helicopter or medical car then we call the doctor on duty. And then I decide. And then ... there are obvious medical events where AMK reports to the JRCC [Joint Rescue Coordination Center] that they want a helicopter, and then JRCC sends an alert to us. And then there are completely obvious rescue missions where JRCC gets a message... where they then send us out

directly. But if it is to be discussed, that is if there is a discussion about should / should not etc. then it is the doctor who decides.]

It should be stated that our data demonstrate how these aspects are additionally connected to issues of background and professionalization. Both observation and interviews showed how further experience and background created further capability. Also teamwork and integration into the team via workshops and exercises seemed to do something to increase legitimacy and trust. This, in turn, seemed to affect task complexity, albeit more on a perceptive - or subjective - level rather than objectively measurable. Tasks were characterized as complex by S05 when:

Det er skadepotensialet eller risikoen vi utsetter våre ansatte for. Og en del prosedyrer de da må følge på det området som går på beskyttelsesutstyr og du har lov å gjøre sånn og sånn og ikke sånn. Jo større skadepotensial, jo mer komplekse blir prosedyrene. [It is the potential injury or risk that exposes our employees. And some procedures the employees have to follow are about protective gear. The greater the potential for injury, the more complex the procedures become.]
Also it was mentioned that "Du har prosedyrene, men de er jo bare en liten byråkratisk del i alt dette her. Det er jo erfaringer, utdanningen, personlighet, kombinasjon av mennesker, hvor mange mennesker, altså kompleksiteten, det er jo så vanskelig at det er bare noe du må forholde deg til og vite at det er der. Men det er jo det… alt påvirker jo, sånn at det samme vaktlaget i dag kan jo ha helt annerledes i morgen." [You have the procedures, but they are just a small bureaucratic part of all this. After all, it is the experience, the education, the personality, the combination of people, how many people, that is the complexity, it is so difficult that it is just something you have to relate to and know that it is there. But that's it ... everything creates effects, after all, so that the same team today may have completely different tasks tomorrow.]

While experience is touched upon in some of the findings, a choice had to be made not to plough too deeply there, as it would go beyond the limits of the study.

Timeliness

Timeliness of information refers to the actor having available relevant information at hand when it is needed. This also means that some information should not be generated too early, as it would not be relevant by then, or it would take up too many of the capabilities connected to situation awareness. However, the studied sub-organizations showed that it was crucial that information be timely and more or less standardized in order to create a solid model of potential scenarios – particularly information by the first responders. This timely initiative was regarded as the main factor for success in the operations, as we can see from the following statement byS15:

Og når man da kommer fram så har man en inngangsverdi for å skaffe seg ytterligere presis situasjonsforståelse og mens de i større deler denne hvis man har den tidlig. Og da vil igjen det være en eksponentiell effekt av det, hvis situasjonsforståelsen kommer kjempetidlig så vil en [uklart] 38:20 tidlig, og bli oppfattet av flere tidlig. Og det er avgjørende for å lykkes egentlig. [And when you arrive then you have a start knowledge to gain even more precise situational understanding and it is profitable if you have it early. And then again it will be an exponential effect of that, if the situational understanding comes at a timely pace then understanding will be early, and will be perceived by several early. And it is crucial to succeed really.]

This first information prepared actors who will have to perform tasks connected to the patient on a later stage. Whether the informants were from ambulance drivers, the 330 helicopter squadron

or the hospital's emergency room, all stated that it helped to have a better comprehension of what they could expect.

However, as much as the timely accumulation of information was valued, it was highlighted several times that - in many case -, tasks have to be performed without access to complete information and situation awareness. As a result, the actors, even if they were aware of increased *TC* with potential information deficit, had to take action because of time scarcity. The following statement by S15 also provides a good insight:

En må organisere seg. Ikke overorganisere seg og ikke oversikkerthetstenke, men begynne å organisere seg sånn at kaosfasen blir kortest mulig. For kaosfasen er alltid der og det er bare å akseptere at den er der. Og da er vi over i driftsfasen. Og da er det så fort som mulig å få flest mulig folk ut i feltet for å redde liv. Gi fri luftvei, legge i sideleie, stoppe blødninger, forebygge hypotermi. [One has to be organized. Do not over-organize and do not think about uncertainty, but start to organize in such a way that the chaos phase (uncertainty) becomes as short as possible. Because the chaos (uncertainty) phase is always there and you just have to accept that it is there. And then we go over in the operational phase. And then it is to get as many people as possible, as fast as possible, into the field to save lives. Provide free airway, lay them on their sides, stop the bleeding, prevent hypothermia.]

While timeliness was so closely connected to the information variable used in this study, several aspects of time may prove to be a variable connected to complex tasks themselves (similar to professionalization); yet it would go beyond the limits of this study to expand further on this topic.

Information Coordination and Information Hubs

Previous findings of this study indicate that goals may be sectioned into sub-goals, which may impact task complexity. However, information flow is also sectioned. The data shows how important a structure and the sectioning of information coordination can be, particularly when it comes to incidents involving a lot of resources. The observed system even went as far as to provide two operational hubs which both coordinated information and the movement of medical resources.

During exercise NORD 2019, operational level land-based tasks were coordinated by the Ambulance communication center (AMK) (as part of the joint planning headquarters by ambulance, police, fire brigade - called SAMLOK- led by the Police), while the sea-based action was coordinated by the *Joint Rescue Coordination Center* (JRCC). This led to two almost individually driven networks, connected to each other only to a minor degree. Information on available resources and overall prioritization of either land- or sea-based patients by air-borne resources were coordinated by those two centers, with little or no exchange of information between tactical resources. S15 could shed som light on the challenges:

Sånn som det var lagt opp eller sånn som det ble i denne øvelsen så har du faktiske en landoperasjon og så har du en sjøoperasjon. Og innsatsleder politi er leder på land, og on scene coordinator er leder på sjøen. Så her hadde du på taktisk nivå to forskjellige operasjoner som foregikk parallelt som var veldig lite avhengig av hverandre. Ledelse for on scene coordinator det er hovedredningssentralen. Ledelse for det som skjer på landoperasjonen det er det vekselsentralene, altså politi, brann og helse. Så til og med på operasjonelt nivå så hadde du to operasjoner pågående som var ganske lite avhengig av hverandre. [As planned for in this exercise, you actually have a land operation and then you have a sea operation. And the chief of police forces is the leader on land, and the on-scene coordinator is the leader at sea. So here you had on a tactical level two different operations that were going on in parallel that were very little dependent on each other. The management for the sea-based on-scene coordinator is the Joint Rescue Coordination Center. Management for what happens at the land

operation are the coordination centers for police, fire and health. So even at the operational level you had two operations going on that were quite little dependent on each other.]

Nonetheless, S14 stated how important these platforms and potential information hubs were:

Og ved en stor hendelse, sånn som Øvelse Nord, hvor vi kanskje må jobbe på tvers av foretak på et nasjonalt nivå, da er det kjempeviktig at vi alle har en felles plattform som er lik for alle sammen. [And at a big event, such as Exercise Nord, where we may have to work across organizations at a national level, it is crucial that we all have a common platform that is the same for everyone.]

An absence of exchange between coordination resources on the tactical level, whether good or bad, was clearly displayed at the incident leader command site (ILKO) position for the land-based incident. The helicopter resources were all used in the sea-based action to lift people off the boat. Yet, both incident leader health (ILH) and the ILKO-incident leader stated that their *SA* was such that they critically needed helicopter resources to transport critically injured people to the hospital. However, it seemed they did not have the ability and legitimacy to contact the tactical resources of the sea-based action. In the words by ILH (S16):

på en måte at det ble to skadeplasser. Men for min del så tror jeg jeg hadde evig nok med den informasjonen som vi hadde på det skadestedet. Og ved ressursbehov osv. så føler jo jeg kanskje at så lenge jeg forholder meg til innsatsleder [Police] så er det hans jobb på skaffe til vei det som trengtes. Så jeg føler vel ikke at jeg hadde behov for å høre på det ute på ferga også [in a way there were two incident areas. But for my part, I think I had enough with the information we had at my incident site. And when it comes to resource needs, etc., I feel that as long as I relate to the incident leader [Police], it is his job to get what is needed. So I don't feel that I needed to listen to the information from the ferry as well]

Neither did the ILH feel that they were fully heard when they were in touch with AMK (land-based coordination), in order for them to negotiate more with JRCC (sea-based coordination) to free helicopter resources. Whether this was only ILH's perception, whether JRCC and AMK made the decision not to relocate the resources together based on available information, or whether one of the coordination hubs had more authority to decide over the resources not based on available information, can at this stage not be said. What can be assessed, however, is that information coordination and hubs were not providing satisfactory *SA* at tactical level, thus creating inefficient extra sub-paths when actors seeked to find out more or tried to be heard.

The above paragraph indicates another important point when it comes to the information coordination function. It is connected to the authority and sound of information communication. While on an operational level it can only be speculated that this may be an issue, on a tactical level several sources stated that the degree of authoritativeness and loudness as well as the type of body language actors used to convey the information would influence the effect of delivering the information and the receivers' awareness of its relevance. S13, for instance, stated that *"noen er tunghørte og så snakker de litt høyere og så… Noen er mer ivrige og av og til så er det litt unødvendig prat, det er det"* [some do not listen so well and then they talk a little louder and then ... Some are more eager and sometimes there is some unnecessary talk, that's it.]

Also S14 offered an insightful observation:

Og det er klart at de som er litt sånn sammensunkne, litt forsiktige og stille, de når ikke like godt fram. Hvis du er rett i ryggen, brystet litt fram og bruker litt tydelig stemme så blir du lagt merke til. Det er veldig, veldig tydelig. Det har mye å si. [And it is obvious that those who are a little more

reserved, a little cautious and quiet, they do not reach as well. If you are straight in the back, chest slightly forward and use a clear voice then you will be noticed. It is very, very clear. It has a lot to say.]

Overflow of Unprocessed-Lack of Processed Information

The aspect which the information hubs try to overcome is not only the bare distribution of resources. The second objective of information hubs appears to be connected to the distribution of information, as is reflected by several different aspects.

On the one hand, there are actors who are presented with an overflow of information. In this case, actors may either have to deal with too much unprocessed or less-relevant information. If the time aspect in those situations is not critical, and the actors have enough resources to handle the information, they have the capability to create additional *SA* with the information. Yet, in case of lack of time or extreme focus on a task, this type of information may constitute a hinder and the information hubs may counteract this.

Similarly, when it comes to task complexity, the interviewees mentioned that they (as an actor) only had a certain amount of overall capability to give or receive information. This meant that wrong timing could lead to information being held or not getting through to the intended recipient. It could also mean that processes were interrupted if the communication was not going seamless, or if the recipient was currently occupied with a demanding activity. For instance, a helicopter pilot (S11) stated:

Du prøver å filtrere ut mye når du… hvis man hører mye på radio. Men samtidig så hender at vi bare sier at nå må vi… nå må dere slutte å prate til oss for vi… La oss si man står i en type sånn heiseoperasjon hvor man står og heiser på en båt som beveger seg. Da kan ikke piloten sitte og prate på radioen, da må… vi er opptatt med å fly, maskinisten og systemoperatøren er opptatt med å heise, og lege og redningsmann er opptatt med å heise inn eller heise ut. [You try to filter out a lot when you ... if you listen a lot to the radio. But at the same time we just say that now we have to ... now you have to stop talking to us before we ... Let's say you are in a kind of lift operation where you stand and lift on a moving boat. Then the pilot can't sit and talk on the radio, then ... we have to fly, the machinist and the system operator are busy hoisting, and the doctor and rescuer are busy hoisting or hoisting out.]

On the other hand, there may be actors who are presented with a lack of relevant information, when the system or network around them is not capable or aware of providing the relevant information. Another observed cause in the data was when the actors themselves were not capable of extracting the relevant processed information out of the patient or the logistics. In our material we found an array of examples, which also include an overflow of irrelevant information:

Jeg følte jo på en måte det hele tiden at jeg klarte stort sett ikke å få hodet over vannet holdt jeg på å si, i og med at jeg ble såpass nedjammet av informasjon. […]. Ja som du sier, tiden gikk jækla fort når du ble nedlesset av informasjon. [I felt, in a way, all the time that I was unable to get my head above the water, as I was loaded up by them with information. [...]. Yes as you say, time went by fast when you were overloaded with information.] (S16)

It can also mean a lot of irrelevant information and noise:

Men av og til så kommer det inn ting der som er uviktig, som ikke burde ha vært der men som jeg tror går på kapasiteten på hvor mange talegrupper kan det være på. Hvis du har bare en terminal så må du velge en der alt foregår. [But sometimes things are mentioned there that are unimportant - things which should not have been there. I think this affects the capacity of how many speech groups there can be. If you only have one terminal then you have to choose one where everything is going on] (S12)

In this light, a capability for the communication of information is particularly crucial. However, depending on the situation and the actor at hand, there are some factors that may impact on the transmission of the information. The study showed that, particularly when it came to oral communication, both sound and timing were a factor that affected the transmission of the information. This is demonstrated by an example from exercise Nord: on the tactical level, there was a lot of noise production due to helicopters flying in and out. This made the task of communicating for creating joint *SA* more complex.

Information Technology: Efficiency of Information Flow

In order to lower the potential for lack of timely and relevant information and overflow of irrelevant information, all organizations in the study had adopted technologies such as procedures, tools and IT-based decision support systems.

The multitude of these technologies shows how specialized some of the complex tasks are. Yet some tools observed in the study were jointly used in different organizations, as was the case for some more general practices. In general, it can be said that for most of the participants the principal aim of the technology, was to provide quicker relevant processed information if needed. Additionally, some technology was relevant to pass information from one actor to another, for log keeping and to provide brainstorm- or decision-making capability. Particularly when it comes to the passing on of information, several factors were raised concerning the technology.

First, there seems to be a current transition phase from physical to digital information systems. Information systems are also becoming more automatized. S13 highlighted the benefits of automatized IT through the following example:

4-6 år siden da var det et cruiseskip som gikk på grunn i Lofoten. Og det er klart at da er det lite med 3 personer. Men det gikk jo heldigvis bra. Men han som var ambulansekoordinator… jeg er sikker på han hadde flere hundre telefoner… nei det blir kanskje litt mye da, men kanskje 100 telefoner, og må ringe til alle mulige slags legekontor, han må ringe til kommunelege, han må ringe å få inn sykehusleger. Så det er et stort apparat som skal hentes inn. Men nå har vi denne UMS som vi… Uniformed Message System der vi sender ut digitalt, så der kan vi nå de fleste rett og slett med en melding på telefon. Og det blir letter det, det er det. [4-6 years ago there was a cruise ship that crashed in Lofoten. And obviously three people at the coordination center is little. But luckily it went well. But the ambulance coordinator ... I'm sure he had hundreds of phones ... no it may be a bit much then, but maybe 100 phones, and he needed to call all kinds of doctor's offices, he had to call the municipal doctor, he needed to call to get hospital doctors. But now we have this UMS... Uniformed Message System where we send out digitally, so there we can reach most people simply with a message on the phone. And it gets easier.]

Also S09 emphasized that:

Det er jo det med kartet som jeg sa, at vi får inn alle nye adresser i kartet. Ellers så har vi bra system synes jeg. Jeg har jo vært her så lenge at vi satt og skrev med penn og papir, så jeg synes jo det er helt fantastisk at vi har her og at alle ser hva de andre skriver. [When it comes to the map, we should get all new addresses in the map. Otherwise, we have a good system I think. I have been here for so long. We sat and wrote with pen and paper, so I think it is absolutely wonderful what we have now and that everyone sees what the others write.]

Like the interviewees stated above, in the past there were many situations were information had non-perfect connection points from one actor to the next. However, non-perfect connection points were still observed in this study.: This included potential loss of information and additional paths of

task performance which needed to be done. As an example, information had to follow a patient on a physical sheet (ambulance; hospital) at the same time as digital information on that same person existed in the online journal. This could produce doubletted versions. Also, copying physical documents into a digital database caused extra time and the information sometimes was not following the patient in real time. Although a smoother transfer of information depends on confidentiality, several actors stated that:

i hvert fall en stor gevinst er å ha et felles journalsystem, at man har samme journalsystemet pre-hospitalt, på legevakt og på sykehuset. For jeg tror veldig mye informasjon rett og slett forsvinner i og med at man ikke bruker det samme. For eksempel hvis man hadde hatt elektronisk journal, at det jeg skriver kommer direkte på sykehus for eksempel. For vi ser jo det at selv om jeg har fylt ut en fin og flott papirjournal så er det ingen som gidder å lese den, den blir bare lagt bort liksom. Og så er det kanskje viktig informasjon som… selv om du har sagt det så er det så mye som skjer samtidig at det forsvinner. [in any case, a great benefit is to have a common medical record system, that you have the same medical record system pre-hospital, at the emergency room and in the hospital. Because I think a lot of information simply disappears as one does not use the same. For example, if you had an electronic journal – what I write comes directly to the hospitals, for example. Because we see that even though I have filled out a nice and beautiful paper journal, no one bothered to read it, it just gets put away somehow. And then maybe there is important information that ... even if you said it, there is so much going on at the same time that it disappears] (S6)

Second, almost all actors were working with visualization tools such as maps, screens with overview tables, color codes, etc. On an operational level, the sub-organizations had fixed devices and were relying heavily on the visualization tools for their own situation awareness. On a tactical level, this was a different picture. In ambulance cars, the IT system with visualization was in place, however as soon as it came to the coordination function (e.g. Incident leader health (ILH)), mostly paper-pen and radio communication were used to manage information. One actor said:

jeg har stor tro på teknologi, men akkurat når det gjelder taktisk ledelse så skal taktisk ledelse være tett på, du skal bruke hjelpemidler som er lett å håndtere og som ikke tar kapasitet fra den taktiske lederen. Og så kan man se for seg droner, skjermer og hjelmkamera, you name it, men det vil ikke avhjelpe i den situasjonen her. Tvert imot, det vil bare medføre mer white noise og mer informasjonsinntrykk på de lederne som er der. Så bruk av audiovisuelle hjelpemidler i et taktisk innsatsleder-KO [kommando], det ser jeg ikke så veldig stor verdi i [I have a lot of faith in technology, but just when it comes to tactical leadership, tactical leadership should be focused, you should use tools that are easy to handle and that do not take the capacity of the tactical leader. And then you can imagine drones, screens and helmet cameras, you name it, but that will not help in that situation here. On the contrary, it will only cause more white noise and more informational impressions on the leaders who are there. So the use of audio-visual aids in a tactical incident leader, I don't see that much value here.] (S15).

Other areas on a tactical level, such as the 330 squadron, were also mostly focusing on radio communication when it came to information and situation awareness. In addition, however, they were using mms and mobile telephones to transmit pictures for a better understanding of the task. In the words of one of the informants:

For eksempel, skredkart. Få det skriftlig. Der har vi liten tilgang. Og så bilder. Hvis det er bilder av et skadested, for eksempel hvis du kan få det inn fra politi til HRS som kan sende det, om så bare per telefon, en MMS, det vil gi oss et godt mentalt bilde på hva som møter oss når vi kommer fram. Og det er veldig sjelden vi gjør. Og det er noe vi kan gjøre per i dag. Vi kan be… send oss et bilde, og

så får du… så kommer du fram enda bedre forberedt [For example, avalanche maps. Write it down. There we have little access. And then pictures. If there are pictures of an injury site, for example if you can get it from the police to the HRS who can send it, if only by phone, an MMS, it will give us a good mental picture of what is facing us when we arrive on site. And here comes something we very rarely do – and that's something we could do today. We can ask… send us a picture, and you will… then you will come even better prepared] (S12).

They were clearly open for more. As an example, the 330 staff was at times using body-cams to record their activity and achieve better debrief and learning possibilities – which in turn was intended to raise *SA* in the aftermath of incidents.

Third, the safety telephone network "Nødnett", which is a set of emergency radio communication lines, was a major resource to decrease the level of complexity and increase situation awareness, particularly when being used accordingly. Some of the informants compared "Nødnett" to the system before and stated how it made the process of information transmission easier:

Sånn at den digitaliseringen der vi kan snakke igjennom verktøyene til våre ressurser gjør jo at operatøren har kapasitet på å gjøre mer, kan bruke tiden sin mer dedikert. Bare utviklingen av nødnettet har jo gjort det at kapasiteten til operatøren kan brukes på andre ting enn å sitte og ringe i telefon. [The digitization where we can talk through tools to our resources makes the operator have the capacity to do more and use his time more dedicated. Just the development of the emergency network has already meant that the capacity of the operator can be used for things other than sitting and calling on the phone.] (S05)

Yet, they also maintained that it was very important to keep focusing on the relevancy, the timeliness and the quality of the information, otherwise the perceived level of *TC* seemed to increase again. This is somewhat connected to the need by all actors of a joint mental model of what was worth informing about. In case irrelevant information or unprocessed information was delivered, this could have the same disturbing effect as factors from the external environment such as helicopter noise, wind etc., as they all put challenges on the *SA* around the actor.

Fourth, this study revealed how important the coordination function was for the whole network of actors in order to limit task complexity, an issue which is further expanded in the chapter on Information "coodination and Information" hubs. Additionally, further capabilities to manage situations requiring a cooperation of health, police and fire brigade- resources ("trippelvarsling") were important. In our material, the point was raised several times that it had increased these capabilities to integrate the operational centers of the three organizations in one building (the so called SAMLOK). Interviewees from the Ambulance communication center (AMK), pointed out that this had helped to get more direct feedback from each other and that SAMLOK had increased the overall understanding of each other's organizations and tasks. In a way, it both established a joint mental model and increased the base of information on how to cooperate, defined the boundaries of each organization and what could be expected of each other. S13 stated:

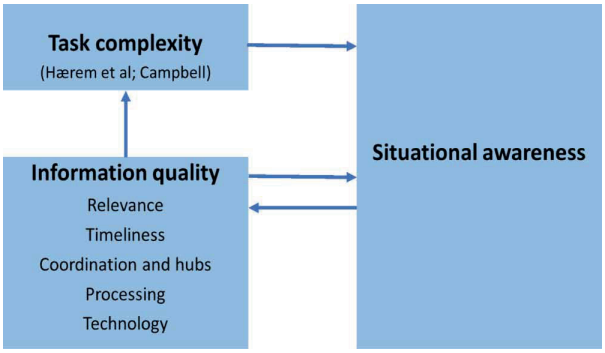
Ja det er jo ting de ikke forteller oss og vi har jo ting vi ikke kan fortelle dem. Vi hadde et sånn… sist gang vi hadde kursdag så hadde en sånn samling med politi, brann og vi fra AMK-sentralen [som er alle del av SAMLOK]. Og det blir jo nyttig, fordi at vi hadde vår advokat, politiet hadde sin advokat. Og det er klart at begge parter har nytte av å skjønne at man har forskjellig regelverk eller lovverk å forholde oss til. Men av og til så blir jo politiet litt overgitt at de ikke får informasjonen de trenger. Eller de føler de trenger. De føler de skal ha. Men enkelte ganger har ikke vi lov å opplyse om noe. Og det er klart at de kan bli sinte, men det er det som vi må forholde oss til. [Yes, there are things they do not tell us and we have things we can not tell them. We had one issue like that ... the last time we

had a training day, we had such a gathering of police, fire and us from the AMK Central [which are all part of SAMLOK]. And it will be useful, because we had our lawyer, the police had their lawyer. And it is clear that both parties benefit from recognizing that we have different regulations or laws to deal with. But sometimes the police are a little surrendered that they do not get the information they need – or they feel they need – they feel they should have. But sometimes we are not allowed to disclose anything. And it's clear that they can get angry, but that's what we have to deal with].

DISCUSSION

The present study analyses *SA* under task complexity. It establishes a model (see Figure 1) where the variable 'information quality' plays a more central role for *TC* than has previously been indicated by studies such as Hærem et al. (2015) and Campbell (1988). The first part of the findings enabled us to modify and extend the model by Hærem et al. (2015) and Campbell (1988) in the context of situation awareness. The second section postulated the importance of looking more in depth at information when discussing the model of task complexity.

Figure 1. Situation awareness under task complexity–the role of information quality



How Situation Awareness Connects to Information and Task Complexity

Looking back at the studies by Seppänen et al. (2013), Hærem et al. (2015) and Campbell (1988), it becomes clear that the variables 'task complexity' and 'situation awareness' should be dependent of an information variable. We have endeavoured to illustrate this point clearly in the present study. Findings include the description of an avalanche operation where S11 mentioned how the different actors, even after some time, *"ville sitte med forskjellig situasjonsforståelse"* [would have different situation awareness]. In addition, the set of sub-tasks by several actors - which needed to be performed to actually acquire enough information to understand some aspects, e.g. *"at det var trygt"* [that it was safe]- was crucial. In other words, one string of information can be connected to an awareness of the overall joint mental model of the situation for all the involved actors compare (Coffey, 2012; Rimstad et al., 2014). At the same time, information may contribute to connect to a multitude of tasks for the organizations and sub-tasks which need to be performed by individuals depending on assessed criticality and *SA* (Gerdtz & Bucknall, 2001).

The study is consistent with literature in areas where additional *SA* capability is needed (Chung, 2005; Endsley, 2017; Gerdtz & Bucknall, 2001), or at least potentially needed. The "potentially needed" seems to be a key aspect to the performed research study, as actors constantly needed to assess criticality and how urgent tasks were. They had to update their assessment on capabilities and

gain an awareness of what the worst case scenario could look like. In general, the study also confirms what (Coffey, 2012; Rimstad et al., 2014) state, namely that the networks of actors (both within and with other sub-organizations) are important sources of information to gain situation awareness.

Yet, the other aspect which was often raised first, is safety and risk awareness of the actors. This part of *SA* provides additional important strings of information that in the end make the actors' tasks more complex. Procedures and communication standards, such as those for potential chemical, biological, radiological and nuclear (CBRNE) material, as well as personal security-related aspects (e.g. ongoing life-threatening violence(PLIVO)), shall provide additional support. Co-dependency of actors (e.g. "*både egen og gruppesikkerhet er viktig*» [both one's own security and group security is important] *(S11)*) increases. While the theory related to *SA* does not refer to safety, studies such as Endsley (2001) and Wright et al. (2004) pinpoint the importance of *"elements in the environment"*.

Finally, it is also via Endsley (2001) and Wright et al. (2004) that the connection between information, *TC* and *SA* can be explained. The connection is by a large degree determined by a dynamic element (Gaba et al., 1995), as was also stated in our material by S04: "*Det er jo å gjøre de samme vurderingene på nytt flere ganger gjennom et oppdrag*" [It is, after all, to make the same assessments again several times through a mission.]. Information from the environment, the current situation and the potential future situation (Wright et al., 2004) acquired by the actors provide understanding of the *TC* and of what potential tasks are. Further, this will feed the *SA* variable (within the ambulance network), which in turn itself is dependent on a set of other actors' task complexities as well as on the information which is already available in the system. The accumulated *SA* will consequentially convey more and new information to the actors.

Understanding Task Complexity

Central to *TC* by (Campbell, 1988; Hærem et al., 2015) are path-, tie- and goal dependency. The current study is equally capable of demonstrating how these attributes contribute to task complexity. Particularly when it comes to path- and goal dependency, the findings shed light on how the organization is exposed to, and has to handle, *TC* – as it is exemplified by all the procedures that are in place to streamline the potential paths and increase goal awareness (cfr S05 "*vi tenker veldig sånn systematisk abcde… enkelt"*) [we think very systematically abcde ... easy].

In addition, the findings offer considerable insights into the multitude of actors involved, the array of actions they undertake, as well as the myriad of sub-structures (e.g. land- and sea-based operations during exercise Nord) and sub-goals. These factors divide the complex system into several complex tasks for sub-groups (e.g. trauma-team in the emergency room) and individuals, who at times are competing for the same resources and stating clearly how critical their task is. There is a distinct echo of Campbell (1988) here, where both conflicting interdependence and presence of uncertain or probabilistic links are part of what defines task complexity.

The existence of information cues is discussed by Hærem et al. (2015). Even though they somewhat integrate information into tie-dependency, they also hint – somewhat controversially -that, theoretically speaking, information cues should be a variable besides task complexity. The current study agrees to this statement, as the multitude of the findings show how *TC* can be influenced by information cues going far beyond what is discussed by Hærem et al. (2015). To be more precise, Hærem et al. (2015) seem not to take account of the double-edgedness of the information variable; perhaps this is the reason why they refrain from adding information to their formula, and use ties instead. However, the findings of this study compel us to dig deeper into the apparent information variable, and into the role of *SA* under task complexity.

Establishing the Information Variable

Our type of assessment is similar to the discussion by Schoonhoven et al. (1980), who point out that the role of information, when confronted with a complex task, is to acquire more knowledge about the actual objective of the task. In our material, this can be questions related to sub-goals, such as 'Is it

safe here', 'is the patient or the group of patients in a critical situation', 'are there available resources, when will they arrive', 'who is responsible for what', etc. The established procedures or processes already provide a base of information designed to handle parts of the *TC* at hand.

Whereas Weick and Sutcliffe (2015) demand that these processes be not overly simplified the present study only agrees to some extent. Yet, our sources do include statements such as "så lenge du har det [base av prosedyrer] så har du muligheten til å være kreativ og finne løsninger som ikke passer inn i det verket, så lenge du har det i bunnen" [But as long as you have the procedures you have the opportunity to be creative and find solutions that do not fit exactly to the procedure. As long as you have the procedure as a basis.] (S05). However, in case of increase of the TC and shortage of time, several informants also mention how in such situations the procedures help to get the most done "så fort som mulig" [as quickly as possible], so the procedures should be as simple as possible.

Nonetheless, what is most prevalent in the current study is connected to information quality, on a par with (Lee et al., 2002; Nelson et al., 2005), as well as to the discussion in the theory section of how processed the information is at different stages (see Wood (1986), Campbell (1988) and (Xia & Lee, 2005). The findings in our material show that a diversity of attributes connected to information also can impact *TC* in different ways.

It is the term of *IQ* as presented by Lee et al. (2002) that can describe this diversity. While many categories have been created for framing *IQ* (Lee et al., 2002), it appears that the one with the upmost priority in this study is the category of contextual information. Relevance of information is also a central category. This is why specific knowledge elements stored within the actors are so important. They will feed in information based on "erfaringer, utdanningen, personlighet, kombinasjon av mennesker, hvor mange mennesker, altså kompleksiteten" [it is the experience, the education, the personality, the combination of people, how many people, that is the complexity] (S05), rather than overwhelming the other actors with irrelevant information as described by Wood (1986) and Campbell (1988). Likewise, the findings show that trained authority, legitimization and understanding of the *TC* at hand can help if there is actually a chance for overwhelmedness due to too much non-relevant information ("nå må dere slutte å prate til oss […] vi er opptatt med å fly, maskinisten og systemoperatøren er opptatt med å heise, og lege og redningsmann er opptatt med å heise inn eller heise ut" [now you have to stop talking to us [...]we have to fly, the machinist and the system operator are busy hoisting, and the doctor and rescuer are busy hoisting or hoisting out.] (*S11*). Hereby, *SA* of one actor's capabilities and understanding of the joint mental model seems to support the legitimization to declare what is relevant and what is not.

This resonates well with the timeliness aspect of information, as time seems to be connected to the relevance of the information. This means, for instance, that the very same information which the helicopter crew would cut out during the lifting operation in the above example, a few minutes before or after could have been very relevant, or at least receivable in different manners (compare Wright et al. (2014)). Timeliness seems rather subjective, as the actors themselves may be differently in need of a certain information at a certain time. However, what appears to be of great importance in order to frame *SA* connected to a joint mental model is the timely, first acquisition of information on the site of an incident. S15 states: "Og da vil igjen det være en eksponentiell effekt av det, hvis situasjonsforståelsen kommer kjempetidlig så vil en [uklart] 38:20 tidlig, og bli oppfattet av flere" [And then again it will be an exponential effect of that, if the situational understanding comes at a timely pace then understanding will be early, and will be perceived by several early. And it is crucial to succeed really.].

However, how do actors make use of this timely information. In order to keep track of the relevant information and to inform actors in a timely manner, the present study enables us to observe the importance of the role of information-hubs. These hubs have several functions, including the decrease of *TC* by coordinating sub-tasks. Actors per sub-network become fewer, procedures of each other's organizations become more familiar and ways of working more predictable. All of this also activates

increased capability for *SA* on one field, but decreases *SA* of the system on some levels as a whole (the sum of several hubs).

These information hubs can be very centralized sub-organizations (Ambulance communication center (AMK) and Joint Rescue Coordination Center (JRCC)), they can be certain actors/individuals (Incident leader health (ILH)) or they can be a form of technology. What they all have in common is that they are intersections where processed and unprocessed information gets sorted and is made available for other actors. Processed information of quality stands in contrast to the information cues description by Hærem et al. (2015), Wood (1986) and Campbell (1988), as the latter will rather decrease the potential *TC* of the actor. This may be illustrated by the contrast between the first, processed on-site report that will convey processed information to the network of actors, versus each actor having to process everything again themselves.

Technology emerges as a major aspect. Two streams on technology described in the theory section come into play. The first technology are procedures and checklists ("Du må jo alltid ha prosedyreverk i bunnen som sier noe om hvordan det skal gjøres." [You always have to have procedures at the bottom that say something about how to do it.] (S05)) which support goal orientation and the understanding of the work to be performed (Schoonhoven et al., 1980). The second type of technology (Gorman et al. (2000) is related to assuring a focus on increased IQ and larger capability to manage information. The barrier-free fusing of these technologies ("jeg tror veldig mye informasjon rett og slett forsvinner i og med at man ikke bruker det samme." [Because I think a lot of information simply disappears as one does not use the same.] (S6)) is an ongoing process connected to mobilization of information technology (Hajiheydari & Hanafizadeh, 2013). In succession to this, finalizing the ongoing digitalization process and understanding when and where support tools can bring better task management for complexity and higher degree of situation awareness, are ongoing processes. Such processes, and initiatives such as SAMLOK (joint planning headquarters by ambulance, police, fire brigade) also increase the potential of the shared mental model. Our findings indicate that an actor has only a certain amount of capability to make use of further information per body-sense (e.g. visualization tools, Nødnett [emergency net], etc) and information technology can help to make use of all these, particularly when exposed to *TC* and to the need for greater situation awareness.

CONCLUSION

Our findings reveal that an information variable plays a significant role when describing a model for *SA* under task complexity. Also, *SA* acts as a mediator in the model, since it is connected to the information. This study describes such connections by considering the literature on *TC* on the one hand (Campbell, 1988; Hærem et al., 2015), and on *SA* on the other hand (Endsley, 2001; Wright et al., 2004). We have presented these findings in the model in Figure 1: "Situation awareness under *TC* – the role of information".

Our research shows that some factors do have an effect on *TC* and situation awareness: particularly, information relevance, information timeliness, the existence of information coordination and information hubs, processed information and information technology. We gather all of these factors within the *IQ* variable. As regards situation awareness, the concept of shared mental models comes in, showing that the overall awareness of goals as well as the resources and work processes within the system (including across sub-organizations) can indeed have an impact on the actors' information basis.

The case concerns the ambulant organization of Nordland hospital (with its sub-organizations and actors) and included the observation of their participation at exercise Nord 2019. A limitation is that conclusions from such a type of case study may not be generalized (Eisenhardt & Graebner, 2007). Nevertheless, several of the findings can be expected to be promising within other areas, such as research on mental models, emergency management literature and IT studies.

First, our study points out how shared mental models in guidelines, rituals and procedures - but also elements specifically stored by each actor - can widen *SA* under task complexity. *SA* may

increase the basis of what type of information can be regarded as relevant. Second, the study describes the dynamic element of a constant need for gathering timely and relevant information for situation awareness, in order to handle task complexity. Third, the study unveils how information technology feeds information with relevant quality to the actors, and – in this respect - how important the right choice and means of technology is.

There are, of course, limitations as well as room for future studies. For instance, this study does not come to grips in any in-depth manner with the concept of learning, whereas further insights on this process could provide further knowledge related to *SA* and task complexity, and ways in which organizations may prepare for it. Also, although the theory section as well as some of the findings touches upon the role of professionalization, a choice had to be made not to pursue this strand any deeper, as it would go beyond the limits of the study. Future research should look at a potential professionalization variable in relation to a *TC* model.

Finally, this study has established the role of information in the light of *SA* under task complexity.

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Emergency Management Capability under Task Complexity: The Role of Knowledge Transfer Mechanisms

The ability to successfully execute highly interdependent tasks is important when organisations are responding to emergencies and different types of crises. Organisational capabilities for emergency management have become an important asset, particularly for high-performance organisations, enabling them to quickly adjust their operations and structures.

When complexity is increasing and organizations need to perform more and more interdependent tasks, the needed emergency management capability may not match the one that is in place. Factors that may narrow this potential emergency management capability gap include resource allocation, legislation, and knowledge transfer mechanisms.

The thesis extends our understanding by identifying the roles of knowledge transfer mechanisms in relation to task complexity and emergency management capability. Emergency management capability is described by the organisation's preparedness level, where the availability of procedures and situation awareness provide the basis for acting on available decision-making strategies. Task complexity may lead to non-linear cause–effect correlations while implying uncertainty, knowledge asymmetry and lack of knowledge.

Establishing preparedness capability, such as by creating standards, regulations, and routines, is part of the knowledge transfer mechanisms (knowledge codification). Knowledge transfer mechanisms also aim to assist in adequate routines, increase flexibility and make knowledge more explicit and more widely usable (knowledge articulation). Knowledge articulation is becoming increasingly important. Individuals, groups, and sub-organisations serve as producers, curators, transmitters, and receivers of knowledge. They carry, increase, and develop capabilities on behalf of larger organisations. Knowledge transfer mechanisms are regarded as vital when building necessary emergency management capabilities adequate for a prevailing context predominated by task complexity.

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