



Information sharing and emergency response coordination

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ABSTRACT

In recent years there has been an increase in commercial activities in the Arctic, including maritime traffic. This increase has led to economic development but may increase the risk of unwanted incidents. Concerns have been raised regarding the emergency response capacity of states to respond to maritime incidents effectively. Efforts from several agencies and also from neighboring countries may be needed. The coordination of such operations is facilitated by established incident command systems that define managerial roles, responsibilities, and information flows between individuals and organizations participating in rescue-work in large-scale crises. However, because of contextual challenges in the Arctic, the tactical and operational management-levels may have to adapt and improvise both their organizational structure and tasks to function efficiently.

This paper has focused on how the different managerial roles influence information sharing between the participants in a complex rescue operation. The study is based on an in-depth case-study of a rescue operation in the waters around Svalbard, that is, the high Arctic. We demonstrate how information-sharing, coordination mechanisms, and managerial roles may need to be adapted during rescue operations to handle volatile operational conditions. The implications of our findings for the planning of mass rescue operations are reflected upon, in particular, the need for adaptive approaches to emergency response.

1. Introduction

Emergency response is characterized by the need for speed of action, the efficient use of available resources, and a high degree of precision. Search and rescue (SAR) operations involve a wide range of physical and human resources, provided by civilian and public actors, and military agencies. It includes vessels, SAR helicopters, airplanes, and satellite imagery coordinated through various communication platforms (Sydnes et al., 2017; Borch et al., 2018). The effective co-operation between participating emergency response units is, therefore, crucial and puts a massive strain on the incident commanders (Borch et al., 2016c). The collective situational awareness is crucial for effectiveness in joint operations where scarce resources have to be allocated within a very narrow timeframe (Weick & Sutcliffe, 2015). The timely access to information and appropriate informational infrastructure among emergency organizations is crucial for the efficiency of the system in critical incidents (Comfort & Kapucu, 2006).

Joint response operations in the Arctic Ocean are challenging because of limited resources, vast distances, fast-changing, and cold weather conditions, and technical limitations on equipment

functionality in cold climates (Andreassen et al., 2018c; Sydnes et al., 2017). However, a question on effective joint maritime emergency response is timely in the Arctic region. In recent decades there have been changes in industrial activities both on land and at sea. In particular, changes in maritime traffic patterns in terms of frequency, volumes, sailing-routes, and cargo may challenge the capacities of the emergency response agencies. This challenge includes large cruise vessels and numerous smaller expedition cruise vessels. Fishing vessels are operating further north as the ice ridge is moving and opening new fishing grounds. There is also an increase in inter-regional traffic in dangerous goods such as petroleum products (Borch et al., 2016a,b). Even though the safety of vessels has been improved, the emergency response agencies of the Arctic have to be prepared for accidents that may acquire significantly scaled responses in remote areas. In remote Arctic regions with limited infrastructure, it may take a long time before the resources are mobilized and arrive at the scene. Adaptation and re-arranging in the organization of capacities as well as management improvisation in operational mode may be needed within the established emergency preparedness systems (Andreassen et al., 2018a; Marchenko et al., 2018).

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In unpredictable environments, coordination may be challenging. Information sharing between emergency agencies may be hampered by diverging information flows, limitations in communication infrastructure, and a general lack of information to create a collective situational awareness (Chen et al. 2008). Volatility is characterized by the lack of understanding of the cause-effect relations during emergency operations. In this study, we focus on how managerial roles and information-sharing may need to be adapted and reconfigured in volatile environments in order to maintain the ability to coordinate joint emergency operations. First, we analyze how the operational environment affects coordination through established managerial roles and information-sharing. Second, we investigate how limited information and situational awareness influence the management and coordination of joint response operations. Finally, we discuss the need to adapt and reconfigure managerial roles as a response to the operational environment. The theoretical focus is on coordination, managerial roles, and information sharing.

2. Theory

Emergency response operations commonly involve a wide range of actors with specialized tasks. The main challenge for incident commanders during joint response operations is, therefore, the coordination of the participating actors and their available resources (Sydnes and Sydnes 2017). Coordination can be regarded as an emergent process, in which different interdependent action trajectories are synchronized (Wolbers et al. 2017). Coordination is accomplished through integration; that is, the process of bringing together a set of differentiated activities into a unified arrangement. This coordination has to consider the different elements of the organizations, their structures, roles, and tasks to perform jointly effectively. Whether these elements are conflicting or not will have an impact on the effectiveness of the response operation (Sydnes and Sydnes 2011).

Coordination processes are commonly planned and formalized as standard operating procedures, mechanisms, or rules (Okhuysen & Bechky, 2009). Standard operating procedures may enhance the effectiveness of response operations in stable environments by streamlining actions (ibid.). Incident commanders will then coordinate and control response operations through specified routines according to their roles, standard operating procedures, and tasks based on the formal incident command systems. The range of managerial tasks has to be matched by adequate coordination and control mechanisms (Bigley & Roberts, 2001).

There is a long-standing debate within emergency management literature on how to achieve effective coordination and response. The conventional 'command and control' approach (Dynes, 1994) is based on clearly defined objectives, tasks, and formal structure (Schneider, 1992). As such, it is considered to be rigid, centralized, and not well suited for adaptation (Dynes, 1994). The so-called "problem-solving model" has a focus on the role of multi-actor coordination, improvisation, collective decision-making (Dynes, 1994). However, in reality, it may not have to be a trade-off between the two models (Skar et al., 2016). A critical success factor for emergency response is often to balance the two to combine 'discipline' focusing on formal structure, doctrines, and standard operating procedures and 'agility' emphasizing creativity, improvisation, and adaptability (Harrald, 2006: 257).

In volatile environments, the availability of response actors and resources, the suitability of response technology, competence of actors may all be limited in some way. In such cases, a hierarchical division of tasks and authority may hamper the coordination of emergency response operations, as the situation may require more informal and flexible structures for on-the-spot decision making and coordination (Faraj and Xiao, 2006; Kapucu, 2005; Owen et al., 2013). There is a need for concepts facilitating the expedient mobilization and coordination of the often limited response capacities available. Such adaptive coordination is achieved by adapting structures, role

switching, and other structuring mechanisms (Bigley & Roberts, 2001). In volatile and complex environments, coordination is less dependent on design than on the ongoing tasks that emerge in response to imminent challenges (Isabelle et al., 2012). In an upscaling situation, it is difficult to predict which organizations will engage in the response operation, and what tasks, resources, and expertise are needed at different times. The operational and tactical management may have to improvise and work on reconfiguration, including new action patterns, repositioning resources, and linking up to other roles and processes (Borch & Andreassen, 2015). Therefore, it is important to consider how the formal incident command system and contingency plans have to be adapted to specific operational contexts, such as the Arctic.

2.1. Managerial roles

The on-scene command of response operations relies on managers to fulfill a range of roles related to information sharing, decision-making, and front-end personal command (Bigley & Roberts, 2001). Managerial roles are sets of action types and responsibilities that can be separated conceptually into three groups: interpersonal, decisional, and informational. (Mintzberg 1973, 2003, 2009). The formal incident command system (in our case) is the starting point for the authority and roles of those involved.

Interpersonal roles include that as the leader and the liaison role, the latter essential to inter-organizational coordination (Bigley & Roberts, 2001). Informational roles include monitoring the situation, disseminating information internally, and acting as a spokesperson towards outside actors (Mintzberg, 2003). In emergency response, managing the information needed for situational awareness and decision-making is crucial (Paton and Flin, 1999; Turoff et al., 2011). Decisional roles include both short- and long-term decisions. The latter include improvisation and entrepreneurial processes to initiate new actions based on the operational context and the information received. Further, it involves handling unpredicted problems and the negotiator's duties to create optimal inter- and intra-organizational interaction (Mintzberg, 2009; Cosgrave, 1996; Paton & Fin, 1999).

Within emergency management, we may find a specific set of managerial roles assigned to the coordinators within formal incident command systems. However, tasks may become more complex, and role patterns disturbed in complex and volatile operational environments (Hossain & Uddin, 2012; Bigley & Roberts, 2001). For example, the individual holding a specific formal role or an organization/agency providing a specific response service may not be available because of a wide range of factors that occur more frequently in the Arctic (available human or technical resources, infrastructure, environmental conditions, etc.) To improve the flexibility of the system, role switching, authority migration as well as structure elaboration and system resetting are processes that may be considered (Bigley & Roberts, 2001; Buck et al., 2006; Bharosa et al., 2010). This approach implies the redistribution of tasks and roles between individuals or organizations, within or beyond the formal framework established by the incident command system, as an adaptation to operational context. This ability to mobilize, redistribute, and improvise is often crucial in high ambiguity settings (Borch & Andreassen, 2015). Adapted managerial roles may then be necessary to provide a platform for an adequate emergent coordination mechanism. In this process, access to adequate information and situational awareness are crucial.

2.2. Information sharing and situational awareness

Informational infrastructure and access to information are crucial to decision-making and effective emergency response (Comfort & Kapucu, 2006; Bharosa et al., 2010; Rimstad et al., 2014). Information needs to flow through the command structure between all levels of organization (Chen et al. 2008). Information sharing channels are included in the established incident command systems following the chain-of-

command (Wolbers & Boersma, 2019). The information flow is managed through specified roles and functions. Consequently, the defined managerial roles and functions influence information-sharing. Meanwhile, challenges of information-sharing, in turn, influence the coordination of joint emergency responses.

The information-sharing processes increase situational awareness but may slow down decision-making. In response to challenges posed by complex operational environments, emergent coordination patterns may arise. As demonstrated in a previous study on responses in the Arctic, this may be because of the lack of broadband communication capacities, polar lows, etc., coordinators may have to rearrange their roles, authority structures, and procedures (Andreassen et al., 2018b).

In joint emergency operations, where available resources are scarce, and decisions have to be made within a narrow timeframe, collective situational awareness is crucial. An adequate informational infrastructure contributes to joint situational awareness and effective decision-making. It is important to differentiate between different types of coordination. We may divide between short-term (mini-seconds) and long-term (many-seconds) coordination cycles during the incident response phase of emergencies (Chen et al., 2008; Wolbers & Boersma, 2019). Short-term coordination is reactive, takes place on the scene; it aims at communication and timely information between operative responder groups flow. Long-term coordination is pro-active and more reflective. It includes communication through the formal chain of command, between command centers, response units, etc. As such, the long-term cycle provides for the integrated and improved information, global operational picture, complete situational awareness, and, therefore, collaborative information sharing.

2.3. Analytical propositions

In this section, we have argued how the Arctic, with its unpredictable weather conditions, equipment limitations, lack of emergency resources, and infrastructure, low population poses specific challenges to emergency response. To summarize the main propositions made in this section:

- In volatile operational environments – such as the high Arctic – formal incident command systems and contingency plans may need to be adapted to the contexts of the rescue operations. Coordination is then less dependent on formal design, such as standard operating procedures than on handling tasks that emerge because of imminent challenges.
- Managerial tasks and roles may under such conditions be redistributed as adaptations to operational conditions.
- Information-sharing and situational awareness is less reliable in the Arctic because of the lack of infrastructure and environmental conditions, which requires a high degree of adaptability in coordination mechanisms and managers' roles.

3. Method

The study builds on a qualitative in-depth case study of a search and rescue operation in the Svalbard sea areas. The SAR-incident case took place on December 28, 2018, with the Norwegian fish trawler Northguider grounding in the Hinlopen-Strait in the remote northern part of the Svalbard archipelago.

Data was collected through qualitative semi-structured interviews with key personnel within SAR operations, the SAR mission coordinator responsible for the SAR operation, and the Coast Guard. The overview of the informants (Table 1) is presented according to the national protocol of the three levels of command for SAR operations in Norway – tactical, operational, and strategic (Hovedredningssentralen 2018, p.63). The informants represent the leading organizations in the Norwegian incident command system and all three levels of management. The data from the interviews were transcribed and coded by the first

and second authors.

The study further includes secondary sources obtained from the Joint Rescue Coordination Northern Norway and the Governor of Svalbard: the SAR operation log, the evaluation report of the Northguider incident by the Governor of Svalbard, and the internal evaluation report of the Northguider case by the Joint Rescue Coordination Center.

Unless otherwise referred, the case presentation is based chiefly from the SAR operational log by JRCC and the evaluation report of the Northguider by the Governor of Svalbard.

In addition, news reports were used as secondary sources for the case description. Among those interviews with the captain, the crew and expert opinions of the Governor of Svalbard, the Joint Rescue Coordination Northern Norway, Police, Norwegian Coastal Administration, Norwegian Coast Guard, all published by the Norwegian radio and television public broadcasting company NRK (Krogtoft & Eriksen, 2018; Sveen et al., 2018; Rommetveit & Nøklung, 2019; Olsen et al., 2019). To ensure validity and reliability, the case description presented in Section 4.2, “The case MV Northguider” was verified by representatives of the Governor of Svalbard, Lufttransport, and the Joint Rescue Coordination Centre North.

4. Results

4.1. The maritime incident command system and communications

The procedures for the maritime incident command system and communications are defined by the International Aeronautical and Maritime SAR Manual (IAMSAR Manual) on which the Norwegian system is based (IMO and ICAO, 2016). According to the IAMSAR manual, the search and rescue system has three levels of coordination; the SAR coordinator (SC), the SAR mission coordinator (SMC), and the on-scene coordinator (OSC) in addition to the search and rescue units. The SMC normally appoints one of the captains on the search and rescue units as an OSC. The OSC operates on a tactical level coordinating search and rescue units, aircraft, and other assisting units or vessels arriving on the incident site. The OSC works closely together with the distress vessel master and the crew (IMO and ICAO, 2016). At the distressed vessel, the captain will be in charge as long as he is on board.

Specific responsibilities will be assigned to the OSC, considered the capabilities of the OSC and operational requirements. According to the SAR Cooperation plan between SAR-services and passenger ships in an emergency (JRCCs Northern and Southern Norway, 2019), the OSC shall perform the following tasks:

- Assume operational co-ordination of all SAR facilities on scene
- Receive the search action plan from the Joint Rescue Coordination Center (JRCC)
- Modify the search action plan based on prevailing environmental conditions and keeping JRCC advised of any changes to the plan
- Provide relevant information to the other SAR facilities
- Monitor the performance of other units participating in the search
- Coordinate safety SAR facilities involved.
- Make consolidated situation reports (SITREP) to the JRCC, and report destination, number and names of survivors aboard each unit and request additional assistance from JRCC when necessary, such as medical treatment/evacuation of seriously injured survivors.

An Aircraft Coordinator can be appointed by the SAR mission coordinator to coordinate aerial units arriving at the incident site. The On-Scene Coordinator and the Aircraft Coordinator may cooperate closely, and the same vessel, for example, a coast guard vessel, may be given both roles. The Aircraft Coordinator activities aim at the effective coordination of aircraft for inbound and outbound surveillance, logistics, and rescue. The Aircraft Coordinators follow strict routines in executing

Table 1
The overview of Informants.

Informant	Organization	Level of management
Informant 1	Joint Rescue Coordination Center Northern Norway	Operational
Informant 2	Joint Rescue Coordination Center Northern Norway	Operational
Informant 3	Joint Rescue Coordination Center Northern Norway	Strategic and operational
Informant 4	The Governor of Svalbard	Strategic and operational
Informant 5	Lufttransport AS Svalbard	Tactical
Informant 6	Lufttransport AS Svalbard	Tactical
Informant 7	Norwegian Coast Guard	Tactical

their tasks (JRCCs Northern and Southern Norway, 2019).

Communication among SAR facilities depends upon local infrastructure, the structure of SAR services within the search and rescue region, and available resources. The communication systems use different frequency bands, which have different characteristics and are allocated to different types of use. Communications to and from Rescue Coordination Centers and Rescue Sub-Centers (local/regional) should be as timely and reliable as possible, and sufficient to handle the diversity and volume of communications for the worst potential scenarios (IMO and ICAO, 2016). The Global Maritime Distress and Safety System (GMDSS) is a worldwide network for emergency communications among ships at sea. It is a set of internationally approved safety procedures, equipment types, and communication protocols to increase safety and make it easier to carry out rescue operations with vessels and aircraft.

The International Maritime Rescue Federation (2016) addresses to communication difficulties in highly complex situations, like mass rescue operations. The master of the ship in distress is responsible for the vessel's crew and passengers' safety for all types of acute emergency and preparedness incidents. He may be busy leading the on-board response to the emergency. However, he is expected to communicate with the company crisis management team ashore too, reporting on the situation, assess the conditions of the vessel and the incident site in order to make the best decisions for passengers' safety, as well as communicate with the Rescue Coordination Centre who is leading the SAR response (Andreassen et al., 2019). The potential for overload is obvious. The SAR Mission Coordinator, On-Scene Coordinator, and Aircraft Coordinator should have clear control of the relevant communications and maintaining radio discipline (The International Maritime Rescue Federation, 2016).

The High North consists mostly of ocean areas far from the coast, providing limited access to coastal communication systems. The following options provide communications in the High North:

- MF (Medium Frequency) radio communication systems are available but have limited capacity, used mostly only for short-range voice communication. HF (High Frequency) radio communication is not available on Svalbard. Two land-based HF stations are planned to be built at Svalbard and on mainland Northern Norway in Hammerfest during 2020 (Telenor Kystradio, 2019; Trygstad & Kristoffersen, 2019)
- VHF (Very High Frequency) radio station has a shorter range and only reaches vessels in the vicinity (ibid.)
- Land-based mobile communication is limited in the sea areas
- Geostationary satellite communications systems are limited and have some blindspots. In the areas north to Svalbard, there is inadequate satellite coverage
- The Iridium Low-Earth Orbit satellites provide global coverage but have limited capacity, mostly offer narrow-band capacity (Gulbrandsen et al., 2017).

In the polar regions, The Global Maritime Distress and Safety System (GMDSS) may have limited coverage, among others, because of few HF stations, and satellite and broadband communications are not

available in some areas. Communications systems used for short-range SAR operations, relying on direct 'line of sight' between a transmitter and receiver, may not be suitable for long-range communications between units on scene and the Rescue Coordination Center. The following alternatives may be considered:

- position tracking systems, including those that enable two-way communications
- the use of high-flying aircraft to relay VHF radio communications between the Rescue Coordination Center and units on-scene
- relay of information to and from SAR aircraft through Air Traffic Service units
- relay of information by ships at sea able to communicate with SAR aircraft on marine band VHF frequencies, while a shore-based Rescue Coordination Center uses satellite, MF or HF communications to communicate with the relaying ship(s)
- relay of information by surface units positioned between the scene and the Rescue Coordination Center (IMRF, 2016).

Communication alternatives in the High North are insufficient (Gulbrandsen et al., 2017). Coordinators have to rely on the available communication channels. The challenges can also be solved by sending up a surveillance aircraft of the Armed forces that can lie high and be a relay station. It is also possible to use a coast guard vessel in between to receive mayday relay if it is the voice that is used (Informant 7). A huge step forward in communications in the High North will be HEO (Highly Elliptical Orbit) satellites that are approved by the government and planned for 2022 (Informant 1, High North News, 2018).

Information-sharing and situational awareness is less reliable in the Arctic because of the lack of communication capacities. Because of possible limitations in information sharing, this operational context may influence the standard procedures and patterns of handling the tasks. In order to obtain a common situational awareness, there will be a need to be adapt management according to imminent challenges.

4.2. The case MV Northguider

On December 28, 2018, at approx. 13:00 the Norwegian fish trawler Northguider was fishing for shrimps in the Svalbard archipelago when it grounded in the narrow strait at Hinlopen. The Northguider had set out from mainland Norway almost two weeks earlier and was now trawling the northern part of the Hinlopen Strait, between the main island of Svalbard, Spitsbergen, and Nordaustlandet (North East Land), at 79°53 N, 18°4, E. There were no other ships in the vicinity.

A north-westerly gale strength wind was blowing with heavy snow showers. This time of the year, there is no daylight with 24 h polar nights, so the grounding happened in utter darkness. The wind and the freezing temperature of minus 22 °C forced the crew to remove icing on deck to maintain workplace safety and vessel stability. After turning the vessel to a Northern course in the mouth of the Hinlopen Strait, the wind and current took the ship and drove it towards the shoreline. The force of the massive trawl made maneuvering difficult. The captain lost control over the ship, and Northguider grounded at 13:00. The engine stopped causing loss of electricity and a blackout on board. The crew of

14 gathered on the bridge. The vessel rolled slowly when the waves hit the hull. It was, therefore, difficult to keep the balance in the wheelhouse. The crew struggled to take on the safety suits (NRK interviews).

At 13:22, some twenty minutes after the grounding, the captain and first mate sent out a distress signal on the maritime radio HF/MF DSC-digital selective calling. DSC is an automatic signal sent with information about the vessel and its position. You may also add the number of persons on board and type of distress. They also released the satellite-based EPIRB-Emergency Position Indicating Radio Beacon, sending vessel ID and position.

The MF (Medium Frequency) DSC distress signal and the EPIRB-satellite signal were received by the Joint Rescue Coordination Center North Norway (JRCC NN) and the Maritime Radio North located in Bodo, North Norway shortly after (Informant 2). It was beneficial for the situation that they sent both of the alerts because that was perceived as a big red flag for JRCC, as it was obviously not a false alert coming from two different systems at the same time (Informant 1).

The captain at Northguider had also contacted the shipowner via Iridium satellite telephone informing him about the critical situation and the need for immediate response.

Maritime Radio North in Bodo tried to reach the Northguider via MF-maritime radio but did not succeed communicating with Northguider¹. The SAR mission coordinator (SMC) at JRCC then tried to reach Northguider via Iridium satellite telephone, again without success (informant 1, 2).

At 13:30, JRCC contacted the shipowner. The owner confirmed that the vessel had grounded and needed assistance. The number of persons on board was first expected to be 15 but was after some time corrected to 14 persons.

While waiting for rescue, the crew released the two life rafts on board to have an option if they had to evacuate. However, the line broke in the strong wind, and one of the life rafts disappeared. The others stayed on the lee side, but because of the listing, it was very difficult to climb down to the life raft. The crew, therefore, decided to stay on board. The vessel was rolling heavily, and the risk of capsizing was present, so the crew was ordered by the captain to stand outside on the deck in the freezing cold. The chief officer continued to call for help on the MF maritime distress channel without any response for a long time (NRK interviews).

At 13:32, both of the SAR helicopters at Longyearbyen were scrambled by the JRCC SAR mission coordinator (SMC) via the Governor of Svalbard's office (Informant 3). JRCC reflected that it could be critical if both helicopters were not dispatched at the same time, as there were some critical factors to the rescue operation because of weather, dark, high winds, much icing, and poor communication (Informant 2).

The JRCC also checked out the position of other vessels in the region through the Automatic Identification System (AIS) system. There were AIS-signals from several vessels in the waters south of the Svalbard-archipelago. However, the closest ship was 18 h away from the distressed vessel. The JRCC was also in contact with the closest Norwegian Coast Guard Vessel (NoCGV) Barenshav located near the Bear Island in the Barents Sea some 24 h away (Informant 3).

From the ice charts, an additional problem showed up as ice floes were coming down the Hinlopen Strait from the North. This situation called for icebreaker assistance for a potential rescue operation from the seaside. However, the only coast guard vessel with ice breaker class was at the mainland base, and the crew was off on the Christmas holiday.

As an option, the SAR mission coordinator asked the Norwegian

¹ HF-maritime radio with a longer range was closed down at Svalbard in 1999. In September 2019, the Norwegian government decided to re-open the HF sender at Svalbard, acknowledging that the MF maritime radio and Iridium satellite coverage was not good enough in emergencies.

Joint Headquarters of the Armed Forces for support from the Orion patrol airplane out of Andoya. The plan was to have the Orion to serve as a communication link and as the Aircraft Coordinator. They also discussed landing at Longyearbyen and load rescue drop kits with rescue tools if the crew would be stranded onshore for a long time. However, the Orion had to go to the Andoya base for fueling. The Orion request was therefore canceled.

JRCC informed Emergency Medical Communication Center (EMCC) and the hospitals in Longyearbyen and Tromsø about the emergency at an early stage. The medical call center prepared for medical treatment at Longyearbyen, and the transfer from Svalbard to the mainland hospitals if needed.

In Longyearbyen, the police force at the County Governor's office informed the local hospital and arranged for the crew to be taken care of upon arrival to Longyearbyen. The local government in Longyearbyen established a reception center with support from the local Red Cross Search and Rescue Corps. The local government also established a psychological specialist team prepared to take care of the distressed vessel crew upon arrival.

The shipowner established a next of kin call center at their headquarter in Austevoll on the west coast of mainland Norway.

The JRCC issued a press release and took care of the increasing media interest through their media advisor. The media was informed about the incident, and information was given to the next of kin, and the public.

All the mobilized resources and stakeholders required more information to be well prepared for action and response.

At 13:40, the mate at Northguider made contact on MF radio with the NoCGV Barentshav serving as a relay station between the JRCC and Northguider. NoCGV Barentshav could inform the crew on board Northguider that the helicopters were estimated to arrive in 40 min. The captain of the distressed vessel informed that the conditions on board were getting worse. The vessel suddenly tilted. The crew had to move out of the wheelhouse to the deck to avoid being trapped if the vessel capsized. The added listing to 20° caused the second and last life raft to be stuck under the vessel superstructure. If they had to leave the vessel now, they would have to swim in the icy water towards the ice flow and beach some fifty meters away. The crew might have had to jump in the water and try to climb up on an ice flow in powerful waves and darkness. This maneuver would be precarious in the heavy sea with icing, and the wind could blow them away from the shore. The risks of drifting away and freezing to death or be severely wounded were imminent (Informant 4).

The crew was waiting on deck for approximately half an hour. The reserve generators that kicked in after the main engine stopped also failed, and the crew was sitting there in utter darkness. They tried to keep their spirit up through singing (NRK interviews).

At 13:54, JRCC informed the Norwegian Coastal Administration responsible for the national oil spill response and salvage about the incident. The Northguider grounded in a nature reserve with a severe risk of oil pollution.

Around 14:00, 35 min after the alarm call from the JRCC, the first Super Puma SAR-helicopter lifted from Longyearbyen with a crew of six, including a doctor and the paramedic-educated SAR tech. The second helicopter followed after fifteen minutes with extra fuel. The helicopters were fueled for a respectively 3 ½ and 4-hour operation as the pilots were first informed that the crew might have entered the life rafts. This detail meant that a longer search time would be needed, and the lifting operation could be more demanding.

The SAR-helicopter crews did not have much information about the conditions of the persons in distress. If the crew had to jump in the sea, they would suffer from hypothermia in a very short time, and maybe drift away in the strong wind and waves. The risk of injuries would also be imminent.

Because of the communication challenges, the Rescue Sub-center (RSC) Svalbard agreed with the JRCC SAR mission coordinator that the

RSC took care of the communication with the helicopters during their operation.

The accident happened 105 nm from Longyearbyen. The Super Puma has a maximum range of 260 nm under ideal conditions. With the heavy headwind and fully loaded, the range is reduced. Also, the time hovering, when positioning and lifting the crew, would reduce range. If only one helicopter had been available and the helicopters had to spend time searching for persons in the water, they would have to fuel from one of the fuel depots at the archipelago. There was an extra depot located at the old research station Kinnvika not far from the scene. However, this fueling process could be hampered by bad weather, ice, and snow and take time.

The first helicopter (SAR 1) took the operational command. The first information indicated that the crew had evacuated in a life raft. This fact meant that a search operation could be needed and had to be coordinated. With limited visibility, the coordination and control of the search operation had to be tight.

At 15:05, SAR 1 informed the incident commander at the Governor's office's local rescue coordination center that the weather was quite extreme with dense snow showers, minimal visibility and wind up to 30 knots. The air temperature was minus 26°. They expected difficulties in finding the vessel in the darkness and positioning on-scene (Informant 4). They informed that there would be limited time to communicate with RSC Svalbard once they had entered the "hot zone" and started the rescue maneuvering.

At 15:15, SAR1 was on the distress vessel position given after more than one hour of flying time. The snow and total darkness made it difficult to find Northguider. The pilot and the vessel captain communicated through the handheld VHF radio at the dedicated vessel- to-air frequency. The vessel also launched a flare showing the position of the vessel.

The pilots also had problems finding the reference points when approaching for lifting because of the weather. They had to use some time on maneuvering. It was not possible to inform the RSC about these challenges because of time limits and weather demanding all the capacities of the pilots (Informants 4, 5 and 6).

In a SAR operation like this one, the communication between the pilots and the distressed vessel captains is critical for planning the rescue, the number to be lifted, the positioning of the crew, the number of wounded persons, etc. Prioritizing tasks is critical. In addition to the communication, the pilots had to fly the helicopter, search for the distressed vessel, position the helicopter during the lifting, and coordinate with the other air units (Informant 2). While SAR 1 started the lifting, SAR 2 flew towards the nearby fuel depot in Kinnvika and the neighboring refuge cabins to check the conditions and prepare for evacuation to the location, in case that would be needed. They then returned to the scene lining up for the final pick-up.

The paramedic SAR-technician was launched down to the deck and informed the crew about the procedures. He then started air-lifting the crew members. Ten of the crew were rescued by the first helicopter, SAR 1. The last four persons had to wait for SAR 2 to position itself. At this time, they lost communication with the helicopters as the handheld Airband- was out of power. The batteries did not last long in the cold weather (NRK interviews).

At 16:19, SAR 2 reported that the final crew was rescued. The operation of lifting the crew of 14 with the two helicopters took approximately one hour. The whole SAR operation took approximately four hours from the distress signal was sent from Northguider.

At 17:00, the helicopters were back in Longyearbyen, and the crew was taken care of by medical personnel.

Because of the weather conditions on the scene, the operational challenges of the helicopter pilots and the critical situation for the distress vessel crew, the Governor of Svalbard in her evaluation report summarized the operation as follows:

"Under the circumstances with the weather conditions on-scene, the

helicopter crew balanced close to the limits to save lives² (Governor of Svalbard, 2019, p.8).

5. Discussion

In this section, we discuss the findings of the Northguider case concerning the research topics focusing on the operational environment, coordination and managerial roles, and information-sharing and situational awareness. A particular focus is on how procedures, roles, and information-sharing needed to be adapted to the operational environment in order to maintain the capacity to coordinate the emergency operation.

5.1. Operational context

The Northguider case demonstrates the limitations of information that may be caused by operating under extreme conditions. Northguider had MF/HF-radio, Satellite telephone and VHF radios on board, but none of these worked well this far to the North. The communication between the JRCC had to be arranged by liaisons first at the coast guard vessel and then with the LRS in Longyearbyen, increasing the complexity of the rescue operation. Typically, in such situations, an Orion aircraft from the Armed Forces would serve as a relay station. The communication challenges in the Northguider case were present from the beginning of the operation. From the perspective of the JRCC, the success factors for communication were that both the MF digital selective-calling (DSC) and the EPIRB emergency beacon functioned, and the JRCC was alerted immediately. However, the amount of information channeled through these sources is limited mainly to the position and name of the vessel in distress. Luckily, the coast guard vessel Barentshav succeeded in communicating with the crew, informing that the help was underway.

Initially, the SAR mission coordinator only knew the type of distress and the number of persons on board. It took a long time before communication with the distressed vessel was established with the coast guard vessel NoCGV Barentshav as radio link. By using the terms presented by Chen et al. (2008), the communication between command centers and response units at the long-term coordination cycle was hampered. According to the formal chains of command, this cycle should be based on integrated and improved information and complete situational awareness. In this case, the limited information made that SMC had to rely on judgments and perceptions of the risks in the decision-making. At some point, the crew was informed that helicopter support was on its way. At the same time, the SAR mission coordinator was informed about the difficult state for the crew. This point in the long-term coordination cycle is important because of the situational awareness gained to some extent. The coordination became proactive.

With no other vessels on-scene, the SAR mission coordinator had to rely on the two SAR-helicopters out of Longyearbyen and their crew of six. Because the power was gone at and in complete darkness, it was challenging to locate the Northguider. The helicopters had fuel enough for a clean pick up. However, if there was a need for a broader search, they might have to fuel from a nearby depot. This task would take extra time. Not having sufficient information created an extra burden for the mission coordinators and helicopter crew who had to plan for multiple scenarios, i.e., crew in rafts or to be rescued from the sea. The SAR mission coordinator also had to plan for a larger search operation, mobilizing more air assets like the Orion military patrol plane, and air units from neighboring countries. On the level of short-term coordination (Chen et al., 2008), timely information is the ground for reactive coordination. Difficulties in this information cycle influenced

² Author translation: In Norwegian: "Med de rådende værforholdene på havaristedet balansertehelikoptermannskapene på grensen av det forsvarlige for å berge liv.»

uncertainty for decisions for OSC on site.

5.2. Information sharing

The limited information and situational awareness during the rescue operation made both short- and long-term coordination cycles challenging. In the long-term cycle, the difficulties influenced both the ability to pass on appropriate information from the tactical level (on-scene) to the operational level coordinators at the JRCC and to receive and monitor the information flow. This information flow severely hampered the informational roles (Mintzberg, 2009) of the SMC to work with incoming information constantly. This approach resulted in focusing on the interpersonal roles, performing the duties of contacting and coordinating with the liaisons, and other external organizations. The informational roles had to be taken care of by liaisons on board the coast guard vessel and at the rescue sub-center Svalbard in Longyearbyen. In the short-term coordination cycle, we have also identified challenges with communication on-site among group flows.

Difficulties with taking on the informational roles also had a ripple effect for the decisional roles for both coordination on the scene and the mobilization and coordination of extra resources at the operational level. In response to the challenges of a complex Arctic environment, the slowed-down information flow caused changes in the formal chain of command.

The decision roles of SMC included negotiator duties to create optimal inter-organizational interaction (Mintzberg, 2009; Cosgrave, 1996; Paton & Fin, 1999). The decisional duties were, to a great extent, redistributed to the tactical level with a short-term coordination cycle. The shift from formal structure to ad hoc problem-solving coordination with more decisions at tactical level happened because of difficulties in information sharing both on the local, ad hoc short-term coordination, and long-term coordination cycle at the operational level. On-scene coordinators had to operate and make decisions without excellent communication or timely information flow from the helicopter pilots on the short-term coordination cycle.

As to the long-term coordination cycle, and the information flow towards the JRCC, the decisions about resource allocation also had to be taken with limited information from the on-scene level. One solution was to mobilize as many resources as possible, including military resources available.

5.3. Managerial roles

With no other vessels in vicinity that could help out coordinating the on-scene mission, and with limited communication between the SAR mission coordinator at the JRCC and the helicopter pilots, the captain of the first SAR-helicopter on-scene (SAR 1) had to serve as both SAR rescue unit and as tactical level on-scene-coordinator (OSC). While maneuvering the helicopter, the pilots had to communicate with the captain of the distressed vessel and direct him. Communication also had to take place with the SARtech, the other helicopter, and channel the available resources. At the same time, in the darkness and the heavy snow and wind, performing the essential role of flying and positioning the helicopters was putting a massive strain on the pilots.

In the standard operating procedure, an air coordinator is to be appointed (IMO and ICAO, 2016). In this situation, the pilots also had to serve as air coordinator (ACO) taking care of the safety of the two helicopters in action. This phenomenon may be seen as authority migration and role switching mechanisms of Bigley and Roberts (2001) that, in this case, help to reorganize the communication structure (Bigley & Roberts, 2001).

The lifting operation was in itself a challenge. Meanwhile, the team had to reflect on the safety of the crew being rescued, and the long-haul SARtech being lifted down to the ship. Onboard the helicopters, the doctor had to prepare for serving as "incident commander health" doing triage and treat the wounded crew from the vessel coming on board.

Again, role switching and structure elaboration (Bigley & Roberts, 2001; Bharosa et al., 2010) contributed as mechanisms for a more flexible command system. With limited space and equipment available, this would have been a very challenging task if the crew had suffered from severe injuries and hypothermia. If the situation had worsened, one option would have been to take the rescued persons to a close-by abandoned research station.

The Northguider case demonstrates how improvisation was needed to establish communication, to gain a certain level of situational awareness in a time-critical operation, and to coordinate the operation on site. Throughout the operation, we have identified more roles that had to be adapted because of the operational conditions. The structuring mechanisms that enabled that adaptation made the whole standardized system flexible. Especially authority migration and role switching (Bigley and Roberts, 2001) were emerging. The local rescue coordination center at the local police /county governor's office had to take care of local communication during the hours that there was no direct contact between SAR Mission Coordinator at the Joint Rescue Coordination Center and the helicopters. The helicopter crew had to take on more roles on-site than usual because of the dire situation, including the On-Scene-Coordinator and Air Coordinator Role. A team on the scene had to be formed among the distressed captain, the pilots, the SARtech paramedic, and the doctor on board. With failing air band VHF radio at the vessel, this communication was also hampered. Decisions had to be taken single-handedly by the persons involved on-scene, with limited decision-support and in a noisy, windy, and dark environment.

As to the long-term coordination cycle, and the information flow towards the JRCC, the decisions about resource allocation also had to be taken with limited information from the on-scene level. One solution was to mobilize as many resources as possible, including military resources available. If the delegation of tasks is to take place, the decisions must be logged in order to pass the appropriate information to the decision-makers.

6. Conclusion

In this study, we have discussed the management of emergency response in volatile operational environments. We have focused on three sets of factors when discussing the performance of emergency response operations: the complexity of the context, information sharing, and managerial roles. We have highlighted the operational challenges in a complex environment like the Arctic region. The challenges of emergency response in this context are related to the severe Arctic weather, long distances, the communication infrastructure, and limited rescue resources. The slow-down of the informational flow happens both when the decision-makers do not receive all appropriate information to allocate resources, and also when the coordination between the information cycles is hampered through limited equipment functionality.

The case demonstrates how, because of the operational context and the information-sharing limitations, the established pattern of managerial roles may need to be reconfigured to maintain the necessary coordination and control of the resources involved in the operation. A shift away from the formal structure based on international regulations, to an ad hoc managerial role transfer, was necessary because of the lack of resources on-scene, and because of difficulties of information sharing both within short-term cycle (on-scene) and long-term cycle (operational level) cycles (Chen et al., 2008). This conclusion largely reflects on previous findings on the limitations of formalized command-and-control during emergency response and the need to more informal and problem-solving approaches (Dynes, 1994; Faraj & Xiao, 2006; Owen et al., 2013) On-scene coordinators may have to operate and make decisions without the appropriate communication-channels available or timely information flow. As to the long-term (many-second) information cycle, and the information flow to the SAR mission coordination at

the joint rescue coordination center, the decisions regarding resource allocation also was taken with limited information from on-scene. This case called for improvisation in terms of communication channels and resource configuration to overcome the contextual challenges and reduce response time.

As noted, the Northguider case reflects the need for operational and tactical management, improvisation, adaptation, including new action patterns, repositioning resources, and re-assigning roles and processes (Bigley and Roberts, 2001; Borch and Andreassen, 2015). However, these processes do not alter the need to assign roles and perform the specific tasks that have been planned and formalized as standard operating procedures. Instead, it is a question of who (at what level) is assigned the different formalized roles (OSC, ACO, etc.) and performs what tasks (coordination, information, etc.), with the resources available, and during the different stages of an emergency operation. As such, adaptation and improvisation does not alter the goals and standards of the response operation, but rather the strategies adopted to implement them. This study is one reflection on achieving the balance between formal discipline and informal agility, as discussed by Harrald (2006).

In the study, we have seen how the operative environment directly because of the weather conditions and vast distances, and indirectly because of the lack of communication infrastructure and available resources, required an adaptation to the formal incident command system in order to conduct the response operation. Finally, let us return to the research topics and theoretical propositions formulated for this study. First, the study has demonstrated how the operative environment directly because of the weather conditions and vast distances, and indirectly because of the lack of communication infrastructure and available resources, required an adaptation to the formal incident command system in order to conduct the response operation — maintaining the functions and roles of the operation required that the formal structure of the incident command system was set aside in the face of handling the tasks that emerged on site. In the Northguider case, this was handled successfully by taking a problem-solving approach (Dynes, 1994). This circumstance led to adaptations in both the managerial roles and the patterns of information-sharing among the participating response actors. As such, there is a precise verification of the propositions made regarding the challenges the operational environment may cause for coordinating joint operations in the Arctic and proposed means by which they may be overcome.

6.1. Implications for further research and practice

The practical implication of this study is that personnel in a challenging operational context like the Arctic should be trained for taking on different roles from what they usually are practicing. They should also prepare for having limited equipment available, for example, situations with a fallout of communication and navigation tools. The study also highlights the challenges regarding communication infrastructure in the high Arctic. In terms of information-sharing and situational awareness, the lack of communication infrastructure increases the risks of maritime operations in the region.

We recommend further multi-case studies of emergency response operations and full-scale exercises with more in-depth, longitudinal, and comparative studies with a special focus on information sharing and decision-making during the different phases of the operation in a range of contexts. Further focus on emergent mechanisms, processes that aligned information exchange, and situational awareness are in particular of interest. This study highlighted focus on information needs in different roles. Theoretical approaches within decision-making in complexity would be useful to look at the roles perceptions and judgmental decision processes in conditions of limited information flow. Such studies will be valuable in developing training and educational concepts for emergency managers.

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