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SARex3

**Evacuation to shore, survival and
rescue**

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The SARex3 report "SARex3 - Evacuation to shore and rescue" is a joint venture between the Norwegian Coast Guard, University of Stavanger and GMC Maritime.

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1 Preface

The report from 2018 SARex3 is hereby made available to authorities, companies and private readers. The report is the third in a series of reports from search and rescue exercises arranged by the Norwegian Coast Guard, the University of Stavanger and the company, GMC of Stavanger, over three consecutive years. All exercises have been conducted in realistic cold temperature conditions off Northwestern Spitzbergen, in Norwegian territorial waters. The Governor of Svalbard, representing the Norwegian administration of Svalbard, has been involved in the planning of the exercises. This year, Maritime Forum North, Narvik, has also contributed with funds and support. The need for search and rescue training in polar waters is obvious, with the large increase in sailings in these waters, as the ice retracts, and as more and more daring cruise traffic comes to the area. Important background for the exercises is the implementation of IMO's Polar Code.

The Norwegian Coast Guard has used the exercises for training in possible search and rescue situations that might be met in Arctic conditions. The exercises have all been based on voluntary support from official Norwegian authorities like the Norwegian Mar. Authority and the Petroleum Safety Directorate. Private companies wishing to test their equipment in addition to building and sharing knowledge have contributed in kind with standard SOLAS approved equipment and latest state of art equipment. We also succeeded to draw a wide participation from academia. All involved have been eager to learn how to train for possible emergency situations. Gaps have been identified, as reported in all SARex reports.

The locations have been carefully selected to ensure both the relevance of the exercises and the safety of all involved in them. For all activities during the exercises, hazard identification meetings have been held and risk mitigation measures implemented. The safety measures implemented might have limited the results; however, all involved in the exercises have put "safety first". As commanding officer on board the exercise vessel, NoCGV Svalbard, this approach has been of the utmost importance. In all exercises, guards have been involved, for example to watch for polar bears, to ensure that no interaction with wildlife would interrupt the exercises.

During this year's exercise, we simulated the conditions following the rescue to shore of the passengers and crew of a vessel with different group- and personal- protection equipment. The transfer to shore was not part of the exercise. The differences in the usefulness of the protection packages were surprisingly large, leading to recommendations in the present report. Following the onshore survival exercise, a second activity related to the rescue of those who had "survived" the stay was carried out. The identification of gaps should be taken as important learning points, to improve the training for rescue personnel.

The SARex exercises in Svalbard waters have been successfully carried out, with the enthusiastic participation from all involved. The contribution from companies involved in the planning and management of the exercises is much appreciated. Finally, I would like to thank my good and inspiring colleagues in the SARex project: Professor Ove Tobias Gudmestad from the University of Stavanger and Knut Espen Solberg from the company, GMC in Stavanger, for coming up with the SARex idea in 2015.

It is hoped that this SARex3 report will lead to discussions, the implementation of learnings and the improved planning of training exercises. The report may also lead to updates of the Polar Code, possibly with the preparation of an informative annex, to ensure a common standard for rescue equipment in polar waters.

Commander Endre Barane, Commanding Officer, NoCGV Svalbard

2 Executive Summary

The SARex3 exercise was conducted in May, 2018 in Fjortendjuli Bukta, North of Ny-Ålesund. Significant players within the industry was present, including flag state, vessel operators, vessel owners, equipment suppliers, emergency response providers and academia.

It is important to acknowledge that the findings from SARex are to be representative of a best-case scenario associated with an incident in the polar waters. This implies that the participants were on average fitter than the average seamen or passenger, and the metocean conditions were not to be extreme.

The first part of the exercise assessed the mechanisms associated with survival during an evacuation to shore. Compared with the findings from the SARex1 and SARex2 it was evident that there was a significant improvement of the survival rate when evacuating onto the shore, compared with a prolonged stay in a survival crafts.

The participants were supplied with a water ration of 1 liter per person per day, which proved insufficient in a 5-day survival perspective.

The project was also to assess the functionality provided by the different PSK (personal survival kits) and GSK (group survival kits) provided. This proved to be an impossible task due to great variations with regards to activity levels conducted by the individual participants to compensate for a heat loss caused by lack of insulating abilities in the equipment. It is of importance that IMO defines a level of heat loss that is regarded as acceptable for the human body to maintain for the *expected time to rescue*, a minimum of 5 days. Based on a predefined heat loss figure, equipment and combinations of equipment can be assessed in a transparent way. Utilizing this methodology also opens up for approval of alternative solutions.

During SARex3 phase 2 of SARex3 about 50 casualties were to be evacuated from a remote beach onto the vessel Polarsysse (owned by the Governor of Svalbard). The operation was led by representatives from the Governor of Svalbard and was executed by Røde Kors (Red Cross), Longyearbyen. The additional challenges represented by a large number of casualties should be addressed in the Operational Assessment (as defined in the IMO Polar Code) for vessel of relevance. The additional challenges should further be mitigated to maintain a reasonable risk profile, as time is a critical element in a survival situation in cold climate. Triage, transportation and treatment of a large number of casualties takes time, and requires a significant effort by the emergency response providers in addition to imposes additional strain on equipment, communication systems and the human element.

During SARex3 phase 3 Maritime Broadband Radios were tested. A remote relay station was erected at Enjåbåstrand. The signals were beamed from the exercise area, via the relay station, to Ny Ålesund, and further transmitted to Longyearbyen and Oslo. The system proved reliable and live video feeds that were watched in Oslo in real time and live news updates were sent on the national tv-channel TV2. Representatives from Sysselmannen tested a software for increasing common operational picture between the different emergency response providers.

The MBR system proved reliable, but significant technical expertise was needed to initiate the system. As most “line of sight” systems it is necessary with base stations, connecting the data feed onto commonly utilized communication carriers like the internet. It is important to acknowledge the reduction in bandwidth (50%) for each relay station needed. This reduces the effective bandwidth provided by the system.

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4 Acknowledgements

We would like to thank Ola Storrø and Milan Cermack for contributing to organizing and executing the medical topics relevant for the project. Their efforts on the exercise site, including assessing and comforting the participants was greatly appreciated by the participants and the exercise organizers.

We would also like to express gratitude to Einar Jenssen from Telenor. Without his enthusiasm and effort to obtain permits, organize logistics and establish the MBR network, this part of the exercise would have been extremely difficult to conduct.

Espen Olsen, the representative from the Governor of Svalbard, has been indispensable, organizing local resources like the Red Cross Longyearbyen, Polarsyssel and the software platform used to obtain a common operational picture. We appreciate how you get things organized within the very short timeslot we had available.

We are grateful for the help and support obtained from Bodil Pedersen, Jan Reinert Vestvik, Anita Strømøy and Turid Stemre at the Norwegian Maritime Authority. Their contribution ensured the project scope and findings were addressing issues relevant for the marine industry.

Without the equipment from Viking-Life and Survitec the survival part of this exercise would not have been possible. Also sharing your experience across all of the maritime industry has been greatly appreciated by the project.

Without the enthusiasm from Tor Husjord, Maritimt Forum Nord, funding for this project would never have been obtained. Sharing the knowledge and experiences you have gathered, after being an active part of the maritime industry for the last 50 years, is greatly appreciated.

We would also like to thank the crew and officers onboard KV Svalbard for providing great support and participation in SARex3.

Lastly, we would like to thank Endre Barane who went on his last voyage as a commander onboard KV Svalbard during SARex3. Barane was one of the individuals that took initiative to the SARex exercises and has been participating and organizing all the previous exercises. Barane has been a major contributor to the project and has molded it into the shape it has today.

5 Introduction

The SARex legacy started 3 years ago as a joint cooperation between Endre Barane (Norwegian Coast Guard), Ove Tobias Gudmestad (University of Stavanger) and Knut Espen Solberg (University of Stavanger/GMC Maritime). Personal ambition on addressing and quantifying issues related to marine in a cold climate environment/the Arctic to reduce risk and increasing safety has been fueling the project through the recent years.

The aim of the project has been to address issues where lack of knowledge and documentation hindered further development and implementation of rules, regulations and procedures. Many of the issues of interest requires a wholistic methodology. Due to the complexity and non-linearity experienced between the interacting mechanisms, a multi-disciplinary approach is preferred.

Through a high level of knowledge, practical experience and scientific integrity the SARex projects has gathered and analyzed data that otherwise would have been unknown. The findings from the SARex projects have had a profound effect on the maritime industry, and has contributed to shape the discussions among vessel operators as well as within IMO. The findings has also been utilized by a variety of emergency response providers for increasing their understanding of the mechanisms at play in a maritime incident in a cold climate environment.

SARex1 (Solberg, Knut Espen; Gudmestad, Ove Tobias; Kvamme, Bjarte Odin, 2016) and SARex2 (Solberg, Knut Espen; Skjærseth, Eivinn; Gudmestad, Ove Tobias, 2017) addressed survival in survival crafts, in addition to complementary issues. SARex3 wanted to focus on the next step in the survival process, survival on-shore. The IMO Polar Code identifies this as a potential option for vessels operating within the area of application for IMO Polar Code. However, there have been few scientific projects directly aimed towards survival onshore preceding a marine incident involving a substantial number of casualties.

6 Motivation

The risk assessment conducted in the Polar Water Operation Manual (PWOM) defines the equipment required in the Personal Survival Kits (PSK) and Group Survival Kits (GSK) as the IMO Polar Code only mentions items that are to be considered (guideline). As the weight, volume, capacity and price associated with the equipment puts an additional strain and restrictions on the vessel operator, there are many examples where the risk assessment has been “tailored” to promote marginal PSK and GSK.

Harmonization of the PSK and GSK seen in relation to the risk assessment is the main criteria utilized by flag states and classification societies in the approval process. As a result, there are large variations between the functionality of the approved equipment. This causes concern not only with regards to the kits’ ability to promote survival, but also adds an additional layer of uncertainty to all levels of the industry.

There is limited communication between the survival equipment suppliers and the SAR providers. As they both work on saving lives at sea, SARex will function as a forum, enhancing communication and generating a mutual understanding of the processes involved.

7 Exercise Objectives

The objectives of the SARex3 exercise are to:

Phase 1:

- Develop a common understanding between all layers of the industry, including regulators, on how the IMO Polar Code is implemented today.
- Study the gap between typical Personal Survival Kits (PSK) and Group Survival Kits (GSK) as provided by the industry with regards to survival on ice/land and the requirement of minimum 5 days survival as defined in the IMO Polar Code.
- Develop survival strategies
- Identify equipment improvement points
- Assess the mechanisms determining survival
- Develop recommendations for implementation of the IMO Polar Code

Phase 2:

- Study the additional challenges when rescuing a large number of people from life land/ice in cold climate conditions.
- Assess the time required to evacuate a large number of immobile personnel
- Identify improvement points
- Train SAR-personnel on emergency procedures/operation in cold climate conditions
- Develop recommendations for emergency response providers in the Svalbard region

Phase 3:

- Assess the functionality of utilization of MBR radios for developing an improved common operational picture among the different emergency response providers.

7.1 Execution of the SARex3 exercise

There are many pitfalls when conducting full scale exercises. In most full-scale exercise scenarios a major part of the participants are supernumeraries, contributing by being casualties and providing the logistics required for the execution of the exercise. To ensure that most of the SARex participants had a learning outcome of the exercise, SARex3 was divided into 3 main parts.

The following parts were conducted:

Survival – The aim of this part was to assess the survival rate when evacuating passengers/crew to shore. At the same time personal/group survival kits along the lines defined in the guidelines in the IMO Polar Code were evaluated.

Triage and evacuation – the aim of this part of the exercise was to triage and evacuate casualties from the shore to a SAR vessel in a large-scale marine accident/incident.

Assessment of marine operational patterns in Kongsfjorden – AIS loggers were deployed on designated spots in Kongsfjorden. The loggers were retrieved at the end of the cruise ship season. The data was analyzed to assess the risk associated with the marine activity in the area.

Underwater sound loggers – underwater sound recorders were deployed. The data was analyzed to assess the impacts from marine activities on the underwater sound scape.

Test of Maritime Broadband Radio (MBR) – The test was conducted to assess the efficiency and robustness associated with utilization of MBR in an emergency response setting, and communication lines were established between the scene of the accident in Kongsfjorden and Oslo.

By dividing the exercise into different parts, different aspects of the marine activity in the area could be assessed. However, managing and organizing a diversified group of people, with different agendas represents a challenge. The following challenges were identified prior to the exercise and mitigated during the execution:

- Expectation management – as all participants had their own reasons to participate, time was utilized during the first day to clarify expectations and a common goal.
- Different cultures – Different nationalities, military, police, voluntary organizations, industry, academia, regulators/public servants and media represent different cultures. Some of the participants had little prior knowledge of the roles represented by the different institutions. Generating an environment that enabled close and efficient cooperation within the limited time available was identified as a challenge and mitigated through informal discussions.
- No-play risks – conducting full scale experiments involving more than 100 persons in the Arctic environment represents a risk. To mitigate for this risk multiple limitations were introduced, e.g. limit the exercise area and continuous monitoring of personnel by medical staff.
- Unpredictable weather – rapid changing of weather conditions could result in abortion of the exercise. Continuous monitoring of local weather and implementation of risk reduction measures was conducted on a continuous basis.
- Adjust learning targets – due to the uncertainty represented by diversified level of relevant competences, uncertainty with regards to equipment functionality, no play risk and unpredictable weather the learning targets were to be adjusted and calibrated on more or less a continuous basis.

8 Program

The following tasks were to be completed during the exercise:

Activity	Organizational tasks	Required Human Resources	Required Logistics/Equipment
Coordination	UiS/GMC, Knut Espen Solberg, OT Gudmestad	Medical team Assistance from MSc students	Coastguard – Polar bear guard/no play safety
Survival Survival Group 1	Group leaders	Min 5 participants Medical team	PSK&GSK - minimum
Survival Survival Group 2	Group leaders	Min 5 participants Medical team	PSK –heavy, GSK-very light
Survival Survival Group3	Group leaders	Min 5 participants Medical team	PSK light, GSK-Tarp
Survival Survival Group 4	Group leaders	Min 5 participants Medical team	PSK heavy, GSK-Tarp
Survival Survival Group 5	Group leaders	Min 5 participants Medical team	PSK light, GSK-Raft
Survival Survival Group 6	Group leaders	Min 5 participants Medical team	PSK heavy, GSK-Raft
Survival Survival Group 7	Group leaders	Min 5 participants Medical team	PSK heavy, GSK-tent, with sleeping mat
Survival Survival Group 8	Group leaders	Min 5 participants Medical team	PSK heavy, GSK-tent, No sleeping mat
Rescue from land/ice (in cooperation with Polarsyssel)	Evaluators, doctors, Sysselmannen, Longyearbyen Røde Kors	All Medical team Polarsyssel	Makeup artists for participants. Coastguard – Polar bear guard/no play safety
Additional elements: 1. Deployment of ais/underwater noise loggers 2. Testing of MBR	Knut Espen Solberg Einar Jenssen (Telenor)		Mob boat
Synthesizes	KE Solberg, OT Gudmestad,		Reports from individual project participants.

For description of PSK and GSK packages, please see relevant appendixes.

9 Exercise Schedule

Departure Longyearbyen 07.05.2016, 16.00.

The exercise was divided into the following phases:

Phase	Activity	Time/Date
	Embarkation KV Svalbard Safety brief KV Svalbard	Day 0 - 07.05, 14.00
Phase 0	Transit to exercise area Equipment preparations WS Preparations: <ul style="list-style-type: none"> - Clarify expectations - Current status, how is the polar code requirements handled today - Lessons Learned from SARex1&2 	Day 0
Phase 1	WS Preparations for exercise Phase 1: <ul style="list-style-type: none"> - Development of survival strategies (group work) - Exercise risk analysis (no play risks) - Polar bear brief (conducted by KV) <p>Exercise Phase 1: Survival – is 5 days survival onshore achievable with the existing equipment?</p> <p>WS Evaluation Phase 1:</p> <ul style="list-style-type: none"> - evaluation of utilized equipment (group work), Identification of key survival parameters - Definition of prescriptive minimum equipment requirements 	Day 1,2,3,4
Phase 2	Exercise Phase 2: Evacuation by rescue vessel, including triage and pre-medical treatment. <p>WS Evaluation Phase 2:</p> <ul style="list-style-type: none"> - Evaluation of evacuation exercise together with rescue crew. - Evaluation of evacuation exercise (only SARex crew), identifying key areas for a successful evacuation and potential equipment improvements. <p>Transit to LYR (some participants will be onboard Polarsyssel)</p>	Day 5
Phase 2 Wrap-up	WS Evaluation of exercise Phase 2: <ul style="list-style-type: none"> - Identify key areas for a successful evacuation and potential equipment improvements. <p>WS Report:</p> <ul style="list-style-type: none"> - Define “Table of Contents” for main report: - Define individual contributions <p>WS: SARex evaluation: What could be done to improve SARex:</p> <ul style="list-style-type: none"> - Preparations - Implementation - Report <p>13.00 Departure KV Svalbard</p>	Day 6 - 13.05
Phase 3	Deployment of loggers	Day 4

9.1 Exercise Day 00 – Monday

The preliminary exercise plan was developed in the planning process. The schedule was adjusted during the exercise to accommodate the varying metocean conditions encountered.

Phase 0 - Preparations

Time	Ex. Activity	Ex. Organization	KV Svalbard
14.00	Embarkation KV Svalbard	All	
16.00	Safety brief from KV Svalbard	All	
16.45	Dinner	All	
18.00	WS: Prepare all exercise personnel for the exercise: <ul style="list-style-type: none"> - Participant round table introduction. - Clarify participant expectations. - Walk through of exercise time table 	All	
19.30	WS: Current status, how is the polar code requirements handled today: <ul style="list-style-type: none"> - Presentation of issue supplier from suppliers point of view - Presentation from class point of view - Presentation from NMAs point of view 	All	
ENO	Check equipment	Equipment Suppliers	

9.2 Exercise Day 01 - Tuesday

Phase 0 – Preparations & Phase 1 - Survival

Time	Ex. Activity	Ex. Organization	KV Svalbard
08.30	<p>WS Findings from SARex 1&2:</p> <ul style="list-style-type: none"> – Lessons learned – scientific results – Lessons learned – political implementation – Lessons learned – exercise implementation. – Lessons learned – safety <p>WS Exercise Phase 1 scope and execution.</p>	All	Optional
10.00	Group work – develop survival strategies. Present Group results – survival strategies	All/divide into groups	Lifeboat/life raft captain
11.45	Lunch	All	
12.30	Group work - risk assessment (no play) Present Group results - risk assessment (no play)	All/divide into groups	
13.00	Preparation: <ul style="list-style-type: none"> – Safety meeting – Establish safety schedule. – Verify exercise area. 	SARex Organizers	Safety meeting.
14.00	WS Presentation/discussion scientific measurement plan.	All	
15.30	Prepare equipment	All	
16.45	Dinner	All	
18.00	Prepare to “abandon ship”: Instrument participants. Deliver personal protection aid to participants. Put on personal protection equipment.	Meet in hangar. All participants are expected to participate as casualties except medical crew.	All safety system, including medical facilities operational.
19.00	Controlled transportation onto shore	All participants are expected to participate as casualties except medical crew.	Transportation by Mob boat to shore/ice. Initialize polar bear guards.
20.00	Survival: Continuous monitoring of body temperature throughout the exercise. Observe. Prepare to abort exercise for participants with signs of hypothermia. Medical check and interviews of aborted participants.	All participants are expected to participate as casualties except medical crew.	Establish safety camp. Safety team/mob boat in place. Maintain safety perimeter. Continuous safety monitoring.

Continuous	Define baseline - Evaluate the physical condition of participants	Medical team	Onboard medical doctor
ENO	KV Svalbard working in polar regions safety brief.	All	Crew

9.3 Exercise Day 02 - Wednesday

Phase 1 - Survival

Time	Ex. Activity	Ex. Participants	KV Svalbard
07.30	Safety meeting		Safety meeting
	<p>Survival:</p> <p>Continuous monitoring of body temperature/functionality throughout the exercise.</p> <p>Observe.</p> <p>Prepare to abort exercise for participants with signs of hypothermia.</p> <p>Medical check and interviews of aborted participants.</p>	<p>All participants are expected to participate as casualties except medical crew.</p>	<p>Safety team/mob boat in place. Maintain safety perimeter.</p> <p>Continuous safety monitoring.</p>

9.4 Exercise Day 03 - Thursday

Phase 1 - Survival

Time	Ex. Activity	Ex. Participants	KV Svalbard
07.30	Safety meeting		Safety meeting
	Survival: Continuous monitoring of body temperature/functionality throughout the exercise. Observe. Prepare to abort exercise for participants with signs of hypothermia. Medical check and interviews of aborted participants.	All participants are expected to participate as casualties except medical crew.	Safety team/mob boat in place. Maintain safety perimeter. Continuous safety monitoring.

9.5 Exercise Day 04 - Friday

Phase 1 – Survival

Time	Ex. Activity	Ex. Participants	KV Svalbard
07.30	Safety meeting		Safety meeting
08.00	Break off exercise for remaining participants: <ul style="list-style-type: none"> - Remaining participants to be transported onboard KV Svalbard. - Medical check. 		Safety team/mob boat in place.
10.00	Start group work: <ul style="list-style-type: none"> - Evaluation of exercise - Fill in evaluation document 	All	Crew exercise participants
11.45	Lunch	All	
12.30	Group work	All	
12.30	Mount loggers	SARex organizers	Mob boat
13.00	WS – Exercise evaluation Preliminary presentation of medical results	All	
13.30	WS - Exercise evaluation: <ul style="list-style-type: none"> - Presentation of group work results - Identification of key survival parameters - Definition of prescriptive minimum equipment requirements 	All	Lifeboat/liferaft captain
16.45	Dinner	All	
18.30	WS – Preparation Evacuation Exercise: <ul style="list-style-type: none"> - Introduction to scope - Introduction to exercise elements - Introduction to timeline - Define injuries - Define locations - Define evaluators - Define groups/group leaders - No-play safety 	All	
20.00	Rest	All	

9.6 Exercise Day 05 - Saturday

Phase2 – Evacuation from ice/land

Transit to LYR

Time	Ex. Activity	Ex. Participants	KV Svalbard
08.30	Preparation: <ul style="list-style-type: none"> - Prepare injuries (makeup). - Put on personnel protection equipment. - Prepare onshore facilities. 	Participate as casualties/observers.	Safety team/mob boat.
09.30	Transportation to shore: All participants are to be transported on shore/onto ice.	Participate as casualties/observers.	Safety team/mob boat.
10.30	Arrival of first group of SAR providers establishing on scene commander/communication and preliminary first aid.	Participate as casualties/observers.	Safety team/mob boat.
TBD	Evacuation of participants to Polarsyssel.	Participate as casualties/observers.	Safety team/mob boat.
TBD	Clear/demobilize exercise area.		KV Svalbard crew.
TBD	Onboard (Polarsyssel) medical treatment/transport to LYR.	Participate as casualties/observers.	Safety team/mob boat.
19.00	Evaluation/ Debriefing (onboard Polarsyssel) <ul style="list-style-type: none"> – Evaluation of rescue exercise together with rescue crew. – SAR vessel first impressions. – Medic impressions. – Identifying key areas for a successful evacuation – Identify potential equipment improvements 	Only exercise evaluators as the exercise is still ongoing.	

9.7 Exercise Day 06 – Sunday

Phase2 – Evacuation from ice/land evaluation

Departure.

Time	Ex. Activity	Ex. Participants	KV Svalbard
07.00	Arrival LYR/Transportation to KV Svalbard	All	
08.00	Breakfast		
08.30	Evaluation/ Debriefing: <ul style="list-style-type: none"> - Introduction by evaluators, inc medic - Participants first impressions. - Identify lessons learned - Identify lessons identified 	All	
10.00	Define “Table of Contents” for main report: Define individual contributions	All	
11:00	SARex evaluation: What could be done to improve SARex: <ul style="list-style-type: none"> - Preparations - Implementation - Report 	All	
11:45	Lunch	All	
ENO	Departure KV Svalbard	All	
ENO	Prepare equipment for shipment	Equipment suppliers.	

10 MAIN REPORT

11 On-shore survival

11.1 Background

The IMO Polar Code Part I-A regulation 1.5.4 states that in order to establish procedures or operational limitations for sailing in Polar Waters, an assessment of the ship and its equipment shall be carried out, taking into consideration the potential for abandonment onto ice or land. Further, chapter 8.2.3.3 states that: *“Taking into account the presence of any hazards, as identified in the assessment in chapter 1, resources shall be provided to support survival following abandoning ship, whether to the water, to ice or to land, for the maximum expected time of rescue.”*

Part I-A, Chapter 8.3.3.3 states what is required to comply with 8.2.3.3. If abandonment onto land or ice is an option, group survival kits are to be carried by the vessel. The chapter also states that the crew shall be trained in the use of both the Personal Survival Equipment (PSK) and the Group Survival Equipment (GSK).

Part I-B Chapter 9 provides additional guidance to chapter 8, “Life-saving appliances and arrangements”. 9.1 provides a sample of resources to be considered in a PSK:

Suggested Equipment
Protective clothing (hat, gloves, socks, face and neck protection, etc.)
Skin protection cream
Thermal protective aid
Sunglasses
Whistle
Drinking mug
Penknife
Polar survival guidance
Emergency food
Carrying bag

Further, chapter 9.2 provides a sample of resources to be considered in a GSK:

Suggested Equipment	
Shelter – tents or storm shelters or equivalent – sufficient for maximum number of persons	Emergency food – sufficient for maximum number of persons ashore and maximum anticipated time of rescue
Thermal protective aids or similar – sufficient for maximum number of persons	Flashlights – one per shelter
Sleeping bags – sufficient for at least one between two persons	Waterproof and windproof matches – two boxes per shelter
Foam sleeping mats or similar – sufficient for at least one between two persons	Whistle
Shovels – at least 2	Signal mirror
Sanitation (e.g. toilet paper)	Water containers & water purification tablets
Stove and fuel – sufficient for maximum number of persons ashore and maximum anticipated time of rescue	Spare set of personal survival equipment
	Group survival equipment container (waterproof and floatable)

11.1.1 SARex interpretation of IMO Polar Code Part I-A Chapter 8.2.3.3

During the previous SARex expeditions (2016 and 2017) a consensus has been established regarding what the functional requirements defined in the IMO Polar Codes are trying to achieve. The overarching goal is defined as:

The survivors are to maintain a functionality that enables rescue after a stay in the survival craft for a minimum of 5 days/maximum expected time of rescue.

This further implies:

- Survival is not a waiting game – survival requires active participation.
- Implies a “normal” functionality level.

To be able to actively participate in the survival phase, the survival equipment is to provide the following functionality:

The equipment required by the Polar Code is to provide functionality that enables the casualty to maintain motivation for survival and the ability to safeguard individual safety, which further means to maintain cognitive abilities, body control and fine motor skills, in addition to prevent development of fatigue for the maximum expected time of rescue.

11.2 Objective

Assessment of the PSK and GSK seen in relation to the Operational Assessment conducted along the lines defined in IMO Polar Code Part I-A regulation 1.5, is utilized by flag states and classification societies in the approval process of compliance with the Polar Code requirements for life-saving appliances and arrangements. As both the Operational Assessment and the risk mitigation measures are based on subjective considerations, large variations are observed between the functionality of approved equipment. This causes concern not only with regards to the kits' ability to ensure survival, but also adds an additional layer of uncertainty to all levels of the Polar shipping industry.

The objective of the on-shore survival phase of SARex3 was to assess the following topics:

1. Does evacuation to shore promote an increased probability of survival compared with on-water survival in survival crafts?
2. What are the governing mechanisms at play in an on-shore survival situation?
3. How can the functional requirements defined in the IMO Polar Code be implemented in a sustainable, transparent and consequent way?
4. What is to be regarded as essential equipment for on-shore survival?
5. To what extent will leadership of the on-shore group affect the survivability?

11.3 Plan

Finding a suitable location for the activity is of key importance. As the exercise was striving for a “best case” scenario, the location was not to be exposed to high winds, extreme low temperatures and extreme precipitation. At the same time the location was to be safe from polar bear attacks when utilizing the polar bear taskforce provided by the Coast Guard.



Figure 1 Assessment of provided equipment prior to being evacuated on to the shore

The participants were divided into 8 different groups. Each group were equipped with different levels of PSK and GSK, ranging from the least equipped group only wearing SOLAS approved life jackets, to the best equipped group having tents and polar rated sleeping bags. Group leaders were appointed prior to abandoning the ship, and the groups were given one hour to prepare for the exercise, Figure 1. The group leaders had very different experience with Polar conditions and with management training.

During the exercise the participants were monitored continuously for signs of loss of functionality and hypothermia. The safety of the participants was given the highest attention.

11.4 Execution of the exercise

Following a hazard identification assessment (see report from SARex1 (Solberg, Knut Espen; Gudmestad, Ove Tobias; Kvamme, Bjarte Odin, 2016) and SARex2 (Solberg, Knut Espen; Skjærseth, Eivinn; Gudmestad, Ove Tobias, 2017)), all groups were deployed onto dry land to assess for how long a period they were able to stay on shore maintaining core functionality. All participants were transferred to land by the rescueboat of the exercise vessel and were left dry and relatively warm onshore.

For safety reasons (polar bears) the exercise area was a confined area. All groups were situated within a predefined confined area on the northern part of a peninsula. Within the area they were free to move around or stay in their “local” camp with the rest of their group. Each group was to be self-sustained and was not permitted to receive any help from the other groups.

Medical personnel were present continuously to evaluate the health situation for each individual by objective measurements and continuous personal contact.

11.4.1 Location

The location chosen for the exercise was the 14th July Bay, (Norsk Polar Institutt, u.d.), 79° 06' N and 11° 48' E, North of Ny-Ålesund, Figures Figure 2 and Figure 3. The exercise area was located on the tip of a small peninsula at the southern entrance to the bay. This enabled the Coast Guard Vessel to keep a lookout for swimming polar bears to the North, while the shore crew from the Coast Guard had defined a perimeter the participants were not allowed to cross on the Southern side. From nearby hills the polar bear guard had a full overview of the exercise area and approaches.



Figure 2. Map showing the area of operation. The exercise area is marked with a yellow star (Norsk Polar Institutt, u.d.)



Figure 3 Map showing details of the exercise area. The arrow is pointing at the site where the survival and evacuation activities were conducted (Norsk Polar Institutt, u.d.).

The different groups were given the freedom to establish their camp wherever they wanted within the exercise area. The ground was level over the whole area and the ground consisted of sand and pebbles. The permafrost was identified to be about 40 cm under the surface level.

11.4.2 Demographics of participants

Totally 41 individuals participated in the exercise. They were all in good health. None had any contraindications to participate based on interview and clinical examination before deployment.

Age: 19-58 years. Mean age was 32 years, including 24 males and 17 females. 28 of the participants reported some level of experience with wintry or arctic conditions. The lack of elderly persons and persons with mobility constraints does not qualify the exercise participants to be a representative group from a Polar Cruise, however, the group could be representative for an adventure tour group. The results reported from the “survival” should be seen in the light of the status of the participants, and is to be regarded as a “best case”.

11.4.3 Measurements of participants conditions

Direct interaction with the participants, observing their physical and mental condition were the most important variable in deciding when to evacuate individuals from the exercise area.

Before participation, we registered medical history, medication, chronic disease; together with gender, weight, height, blood pressure and measurements of grip strength and pinch strength.



Figure 4 Medical team measuring SARex participants

There were continuous measurements of core temperature estimated as eardrum temperature measurements (Figure 4), SpO₂, pulse readings, blood-pressure readings, grip strength and pitch strength throughout the period onshore.

Deployment to shore took place approximately at 2100h on 08 May 2018 and lasted for 48 hours.

11.4.4 Rations

Each individual was supplied with rations typically provided together with SOLAS approved equipment. In the exercise this was defined to be 1 liter of water per person per day and one packet of emergency rations per person per day. The rations were distributed to each individual, and all were encouraged to consume both water and food relatively frequently throughout the exercise, e.g. drink and eat every couple of hours. Most of the participants choose to follow this recommendation, while a few individuals choose to have marginally larger rations during the day-time, and less during night-time.

11.4.5 Equipment

The participants were divided into 8 different groups. Each individual group was equipped with homogenous equipment packages, Figure 5. The contents of the equipment packages are listed in the appendix from Viking and Survitec respectively. The variations in equipment between the different groups included variations within PPE, PSK and GSK. The least equipped group was only equipped with warm winter clothes and a life west, while the best equipped groups had warm winter clothes, tent

shelters (Figure 6 Establishing shelters), sleeping bags rated for winter conditions and sleeping mattresses.



Figure 5 Unique PSK packages were supplied to the individual groups

Some of the better equipped groups were also supplied with general survival gear, such as, shovels, knives, and saws. These groups were also equipped with stoves for melting of snow. The stoves were not put in use to melt snow/ice because this would inflict with the scientific measurement with regards to survivor water consumption.



Figure 6 Establishing shelters

11.4.6 Weather conditions

The temperature onshore varied from a maximum of 3°C to a minimum of -3°C during night. The weather conditions were favorable with very little wind. There was light snow with some wind at the start of the exercise, but temperatures increased a little and the snow melted during day 2 of the exercise. We had a little drizzle of rain for a short period during day 2.

11.4.7 Evacuation criteria

All exercise participants were involved in the exercise on a voluntary basis. This meant that they could withdraw from the exercise at any time.

A participants were pulled out of the exercise and evacuated back to KV Svalbard as soon as one or more of a predefined abortion criterion was met. The predefined abortion criteria were defined as:

- Loss of cognitive abilities.
- Loss of body control (e.g. uncontrollable shivering).
- Loss of fine motoric skills.

Based on experience and recommendations from the medical team, functional based protocols were preferred as there are large individual and diurnal variations with regards to body core temperatures. From a survival perspective this also makes sense as “the start of the end” is not initiated by low body core temperatures, but by lack of functionality. The loss of functionality was induced by multiple factors, e.g. dehydration, fatigue, with the overarching factor being hypothermia.

After exercise abortion each participant was brought to the ships hospital for a thorough medical examination. Local frostbite on ears, nose, fingers or toes would have been a reason for evacuation, but the weather conditions during the exercise did not make this a dominant risk or probability.



Figure 7 Extracting participants out of the exercise when the evacuation criteria was met

A core temperature below 35.0 C was an absolute criterion for evacuation.

The reasons for withdrawal of participants was documented in each individual case.

11.5 Findings

11.5.1 Heat loss

The first part of a survival situation can be described by the following phases (Figure 8):

- Cooling phase – when entering a survival situation, it is assumed that the survivors are warm and relatively well fed. During the first phase the casualties “consume” their aggregated resources. During this phase, the participants became accustomed to their situation. Strategies for staying warm were developed, and the social structure within the group was established.
- Stabilization phase – During this phase the participants with equipment not fulfilling their individual needs for survival/functionality, e.g. not having adequate levels of insulation resulted in development of hypothermia, and these participants had to leave the exercise. There were also examples of individuals being unlucky, e.g. getting wet feet during the landing on the shore who had to be evacuated back to the ship during this stage of the exercise.
- Survival phase – After about 24 hours most groups reached the survival phase. Reaching this phase indicated that they had adequate insulation, taking into account the governing conditions and the activity levels required to mitigate for the heat loss. Reaching this phase proved that their survival strategy worked and several individuals expressed that they felt they mastered the situation.

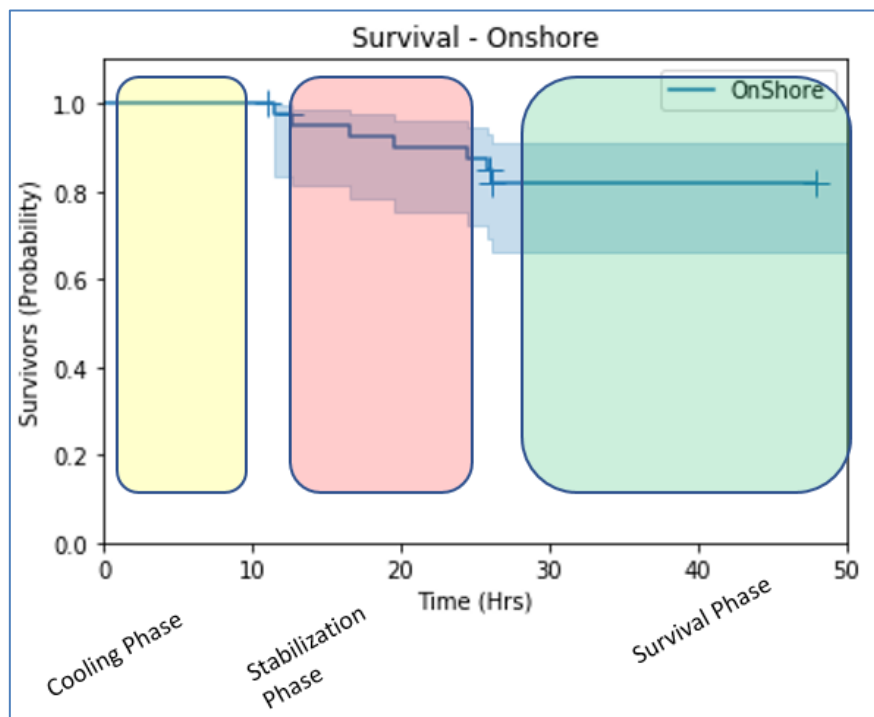


Figure 8 Exercise phases, Legend Kaplan-Meier Survival Plot

As soon as the different groups were transported to the exercise area, they started to implement their survival strategy. The strategies depended to a large degree on equipment they had available, their knowledge of polar survival and the leadership within the groups.

Most groups put a large effort into developing a shelter. The groups that were to accommodate the life raft carried it ashore (Figure 9), anchoring it to rocks. Some groups pitched the tents supplied in the GSK packages.



Figure 9 Bringing the life raft ashore to be utilized as a shelter

Other groups with little or no equipment identified sheltered locations, dug pits to get out of the wind and piled rocks for wind walls.

After about 12 hours the first participants were brought back to the vessel. The first to be brought back were mainly complaining on lack of insulation in their clothing and on lack of shelter.

Based on the Kaplan-Meyer Survival plot (Figure 8) it is evident that the first 12 hours of the exercise is to be defined as the *cooling phase*. During the next 12 hours participants gradually were pulled out of the exercise, and this is to be defined as the *stabilization phase*. During these 12 hours almost 20 % of the 41 participants had to leave the exercise. The reason for pulling these individuals out of the exercise was mainly hypothermia. Especially one group had an extremely low level of insulation (underwear, thin layer of insulation and a waterproof/non-breathable outer layer). Condensation formed inside the outer layer, making the insulation moist/wet, reducing the insulating properties even further. This applied to a total of 7 persons.

One individual had to leave the exercise due to an ear infection caused by the hood of the survival suit, while another had got wet feet during the landing at the start of the exercise and showed early signs of frostbite.

For the remaining 24 hours of the exercise, no individuals left the exercise. Knowing that the exercise only was to last for a limited time, some individuals were engaged in high activity levels for 50 minutes every hour. Maintaining such high activity levels for the relatively short duration of the exercise (48

hours) was possible, but extrapolating this effort into 5 days (3 more days after the end of the exercise) would be questionable.

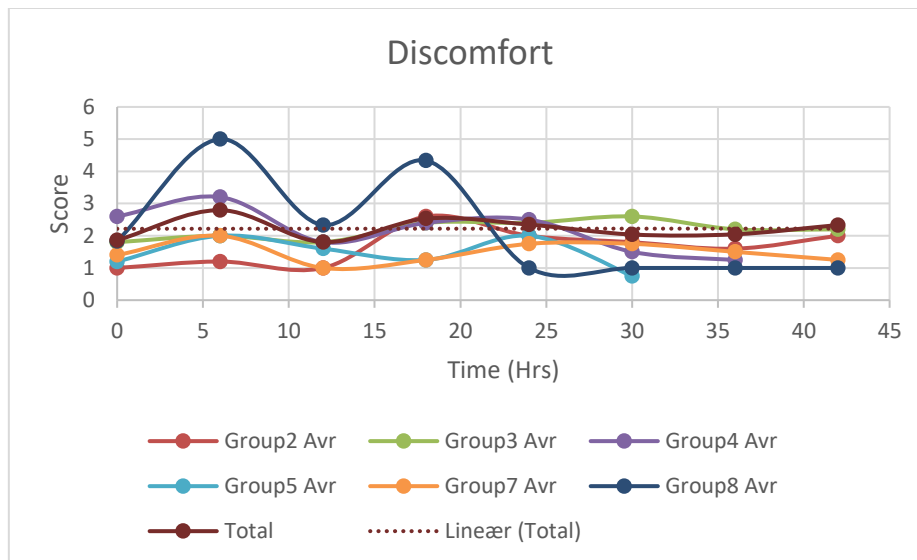


Figure 10 The discomfort reported by the participants

Based on dialog with participants and referring Figure 10, it is evident that after about 24 hours into the exercise a majority of the groups felt they were managing the situation. After about 24 hours each group's rating of discomfort stabilizes. After 24 hours the groups have obtained an understanding of the mechanisms at play and are imposing mitigation measures on the environmental stressors present, e.g. to conduct high intensity activities to prevent development of hypothermia.

11.5.1.1 Activity levels

Increasing activity levels and raising metabolism is a way of mitigating an excessive heat loss inflicting on the thermal equilibrium where a body temperature of 37 degrees Celsius is the normal.

The participant metabolism can be divided into 2 different levels of activity, :

- Resting level – the survivor is laying down, having a large surface area in contact with the cold ground/snow, combined with a low metabolism
- Activity level – the survivor is purposely conducting an activity to increase metabolism or to conduct necessary tasks, e.g. to build/improve shelter or to exercise.

Ideally the participant should be in thermal equilibrium during both activity levels.

Lack of insulation in the thermal protective equipment resulted in high heat loss among some of the participants. The heat loss was compensated for by increasing the level of activity to increase metabolism.

Activity Description	W/m ²	W (body surface area 1.8 m ²)
Sleeping	46	83
Standing	70	126
Walking (2km/hour, level ground)	110	198
Walking (5km/hour, level ground)	200	360
Swimming	348	624
Running (15km/hour)	550	990

Figure 11 Effect of conducting different activities (Engineering Toolbox, 2004)

The most obvious finding was that the groups onshore, without shelter, were not able to rest due to the high heat loss experienced when laying down. As a result, they deteriorated much faster on group level compared to the groups with tents or a covered raft. At the same time, some of the individual participants without shelter were physically able and motivated to conduct continuous relatively brisk activities by walking and doing physical exercises more or less continuously, and only sleeping for shorter periods (e.g. 5 minutes every hour). Due to this activity pattern they were able to remain in the exercise for the full 48 hours. This, however, required an enormous physical and mental effort beyond what could be expected from normal ship crew/passengers.

No participants had a core temperature below 35.0 C at any time during the exercise. One individual's body temperature fell to 34.9 C in the sick bay on the ship after evacuation, but he recovered rapidly, rising the temperature to 35.9 in 30 min.

For a majority of the participating individuals, core temperature remained constant or even increased during deployment onshore. As the exercise evolved, the participants developed increasingly efficient survival strategies, e.g. balancing the time used for rest and the time used for conducting high intensity activities. The increase in core temperatures came as a direct result of this improvement in strategy.

Grip strength and pinch strength tended to decrease moderately, probably due to cold hands and fingers.

11.5.2 Rations

The importance of food and water intake in low temperatures to prevent hypothermia is well known. By keeping up an adequate metabolism, body temperature is preserved, and both physical and mental energy is sustained. All groups had the same amount of food and water from the start, and each individual was responsible to administrate the rations along the recommendations from the medical crew. That is very demanding when developing fatigue, feeling cold and unwell. Not all the participants were able to manage the resources in a sustainable way. Some started to "save" water and food from the beginning, and some ate and drank more than their rations permitted. Both strategies of behavior are equally harmful to survival. Group behavior and leadership is essential to avoid these challenges, and we observed considerable differences between the groups in this respect.

The body weights of the participants were measured before and after the exercise, Figure 12 Total weight loss (kilograms) for all participants, excluding those who aborted the exercise early.. The loss of body weight experienced by most of the participants was mainly due to inadequate water rations, resulting in dehydration.

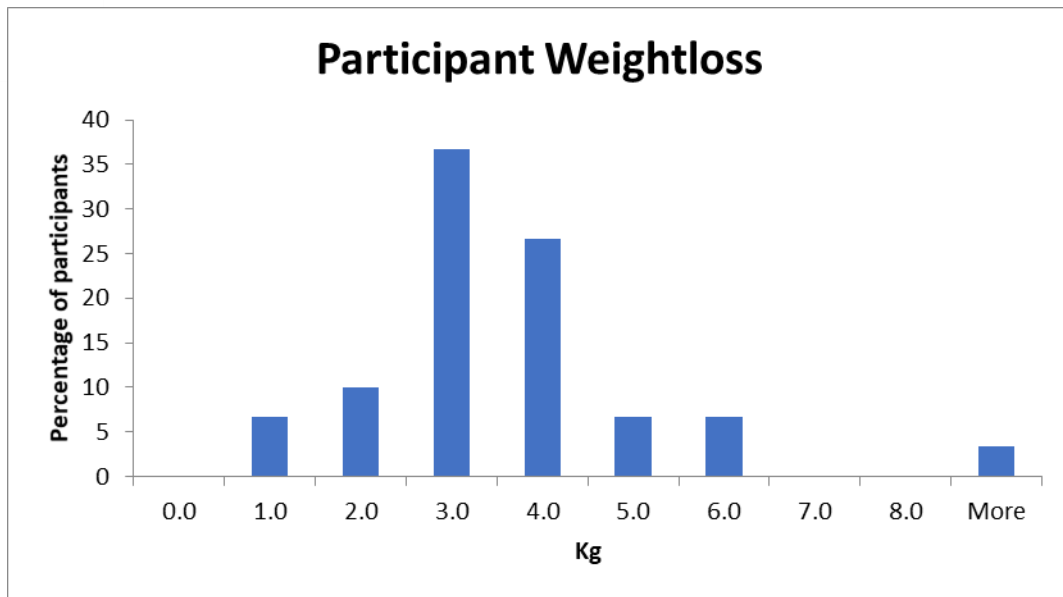


Figure 12 Total weight loss (kilograms) for all participants, excluding those who aborted the exercise early.

Based on the plot above, it is evident that more than 80% of the participants lost 3kg or more during the 48 hrs. exercise.

The total body water (TBW) content in a human is contained in various fluid compartments, e.g. blood, tissue and bones. For average males the TBW is about 60%, while for females the TBW is about 50%.

Level of dehydration is often expressed as a percentage decrease in TBW. Most people can tolerate a 3% to 4% decrease in TBW without any difficulty or adverse effects. 5% to 8% will in most cases result in fatigue and dizziness. A loss of TBW of more than 10 % will cause deterioration of physical and mental capabilities, in addition to an extreme feeling of thirst. Death due to dehydration typically occurs with a loss of TBW of between 15% and 25%. ((Wikimedia Foundation, u.d.))

All participants were weighed before and after the exercise. When assuming an average TBW of 55% of total body mass, the TBW was calculated for each individual participant, Figure 13 Dehydration levels for participants completing the full 48 hours exercise.. Only participants that competed the full 48 hours exercise were considered in the analysis.

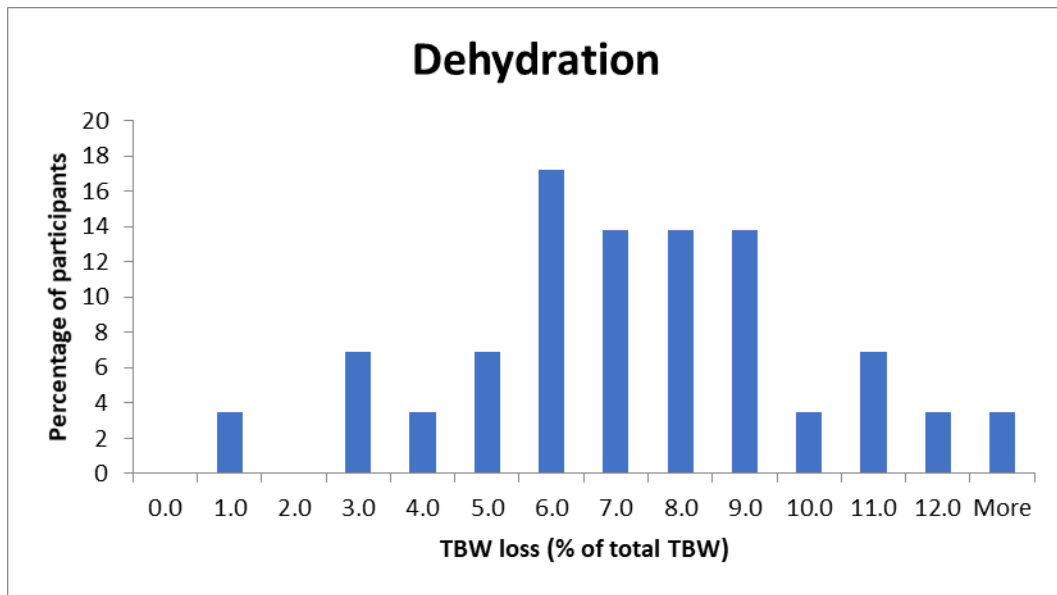


Figure 13 Dehydration levels for participants completing the full 48 hours exercise.

After 48 hours on standard rations (1 liter per day), about 50% of the participants had a reduction in TBW of 7% or more. After surviving on standard rations for 48 hours several of the participants were showing symptoms of deterioration.

It is not possible to extrapolate from 48 hours into 5 days as the body water consumption will decrease as the body gets dehydrated. Based on the results, it is however clear that a majority of the participants will have a reduction in TBW well beyond 10% after 5 days. Their functionality would be significantly reduced and their ability to safeguard themselves and maintain their cognitive abilities would have deteriorated. It is not unlikely that some of the individuals also would decrease due to the direct effects of dehydration.

High metabolism/activity levels were necessary for most of the participants to mitigate the effects of heat loss. In a 5-day perspective, the fatigue and lack of functionality generated from dehydration would to a high degree influence the participants' ability to maintain a high metabolism/activity level for the duration. It is expected that these individuals would not be able to maintain their metabolism/activity level and most likely decrease from hypothermia. The direct cause of death would be hypothermia, but one of the underlying root causes, enabling development of the hypothermic condition, would be dehydration.

11.5.3 Training

There were large variations with regards to relevant knowledge, training and leadership between the different groups.

As previously observed in SARex1 and SARex2 it was evident that good leadership within the group was important for survival. The main tasks of the leaders were to:

- Manage the material resources within the group
- Manage the rations among the group members
- Manage the intellectual (knowledge/experience) within the group

- Ensure that the participants maintained an activity level sufficient for compensating for the heat loss
- Develop and maintain a shelter/place to rest
- Prohibit development of fatigue/encourage positive thinking

Survival on a beach in the Arctic will for most people be a new and frightening experience. The normal structures and routines are not in place and for some the ordeal is experienced as chaotic. Based on our observations it seemed that one of the overarching tasks for the leader was to develop routines and structures that was recognizable for the group members. This helped to “normalize” the situation and increased the individual participant motivation.

An example of a group where leadership played a major role was Group 1. This group had virtually no group protection equipment although they had good clothing, mainly using woolen socks and gloves. The group members coped very well, mainly due to good leadership. They had good discipline on eating and drinking, and kept up a relatively high level of physical activity among all persons in the group. They also had equal and relatively short periods of rest. They kept up a remarkable high spirit in the group with frequent physical activity and exercises, together with social interaction where all members of the group were included.

11.5.4 Fatigue

Fatigue is usually present in the development of hypothermia. It is characterized by increasing passivity, social isolation, mood disturbances and a feeling of general discomfort, including feeling constantly cold. We observed development of fatigue among some of the participants as a consequence of the cumulative effect of freezing, dehydration, high activity levels and marginal rest or sleep. No leadership or guidance from other group members was a typical finding when we interviewed these persons. Strong leadership or a “buddy-system” would probably have reduced the probability of development of fatigue.

11.6 Discussion

The observation time was only approximately 48 hours. Theoretically, the observation time should have been extended to 5 days along the lines defined in the IMO Polar Code. The overall feeling of discomfort in the group, in addition to practical constraints made the administrators decide to end the survey after 48 hours. It is reasonable to assume that further observations of the group would have led to severe discomfort, dehydration and hypothermia for a majority of the participants. The administrators also agreed that an extension of the time could go beyond the safe and responsible conduct of the exercise.

11.6.1 Heat loss

The exercise followed the same phases as identified in the previous SARex exercises (2016 and 2017). This can be regarded as a sign of realism in the exercise. Each phase proved longer than in the previous exercises, in addition a higher “survival rate” was observed at the end of the exercise. This is regarded as an indication that the participants to a greater degree was able to compensate for the heat loss through increasing metabolism in combination with higher insulation levels. Compared with staying for a prolonged time in a survival craft, where increasing metabolism was impossible, the participants were able to move and conduct high intensity activities when required. Through movement, discomfort as a result of inactivity was neglected, e.g. back pains and “sleeping” feet as observed in the earlier SARex exercises. The ability to move was also observed to increase spirits and motivation.

The cumulative effect of the above-mentioned parameters will increase the probability for survival when evacuating on to land/ice compared to staying in the rescue crafts. We consider this to be an important finding from the exercises.

Prevention of local frostbite is very important to be able to conduct an adequate physical activity

11.6.1.1 Activity levels

The main observed differences were between groups with or without shelter. The groups without any shelter were not able to rest more than short periods due to the high heat loss experienced while resting. This implies that a tent or other form of shelter in combination with high insulation (e.g. sleeping bag) and insulation from the ground (e.g. sleeping mat to reduce the conductive heat transfer to the ground) is essential for long term (5 days) survival under Arctic conditions, even in summer conditions.

A majority of the participants experienced a high heat loss due to inadequate insulation layers in the equipment. To compensate for the heat loss, it was essential to maintain a high level of metabolism/activity. Brisk walking (Figure 14), squats and push-ups with regular intervals will produce 100-300 Watt depending on the intensity. This can be continued for a very long time for fit individuals, but it is obvious that elderly people, people with disabilities, or persons in a bad physical shape, will have a considerable disadvantage in this respect, with a reduced survival prognosis in cold climate.



Figure 14 Conducting activities to compensate for heat loss

The average vessel crew or passenger would not be able to conduct high level activities (producing several hundred watts), with minimal rest for a duration of 5 days. To increase survival rates for all individuals it is essential that the individuals are equipped with equipment that provides enough insulation, not requiring high intensity activities to compensate for the heat loss.

11.6.2 Rations

The ability of a person to survive on a restricted diet is difficult to predict. A person in normal or good physical condition can survive for several days on sufficient water intake alone. Feeling hungry as a stressor is very subjective, depending on former experience, motivation and mental condition. For some persons, however, hunger leads to anxiety and hopelessness, reducing their active participation in survival activities and preservation of body temperature.

Given a heterogenic group regarding age, sex, health, physical capacity and former experience with cold climate and limited food-supply, it is probably a good principle to provide quite generous food-rations, if possible.

More importantly the water rations proved to be too small as documented above. If the exercise participants were to survive for another 3 days (5 days in total), dehydration would be a significant issue. Most of the participants would have a loss of TBW (total body water) level well beyond 10%. This would significantly influence the outcome of a 5-day survival scenario. Some individuals would most likely perish as a direct consequence from dehydration, while the majority would not be able to safeguard themselves, with development of hypothermia as a direct consequence of the low total body level.

11.6.3 Training

A prominent finding was the importance of individual personal resources, particularly the ability to maintain an adequate body temperature by regular and frequent physical activity at an appropriate level. Short and frequent sleep periods proved better than sleeping for longer periods.

There was only little correlation between core temperature and reports of feeling cold. This can be attributed to former experience with cold weather and Arctic conditions, and hence a tolerance to feeling cold without much notice. Motivation and mental state as being in a “survival mode”, or not wanting to be perceived as “weak” or complaining can be another explanation of this finding.



Figure 15 The group leader has an important role with regards to maintain a positive attitude within the group

It was observed that some group leaders were able to identify individuals within the group that were developing fatigue and hypothermia. Quick reaction and initiation of “tailor defined” activities enabled these individuals to regain their body temperature and remain in the exercise.

It was also observed that the group leaders that achieved the group to work as a unified entity was able to maintain a higher motivation among the participants. Based on dialog with the individual members of the relevant groups, they expressed that they felt they were included (Figure 15), accepted and appreciated among the other group members.

Utilization of the survival equipment is also to be included in the training of group leader personnel. During favorable conditions one of the groups used more than one hour to pitch a tent. Under unfavorable conditions this could have resulted in loss of several group members due to not being able to get shelter from the elements.

11.6.4 Fatigue

Addressing heat loss, low rations and training without addressing fatigue is difficult. Fatigue is to be regarded as symptom of the cumulative effect of inadequacy within the above-mentioned elements. Quantifying fatigue from a scientific perspective is difficult. It is however clear that symptoms of fatigue were emerging as the exercise progressed.

Prohibition of development of fatigue would be one of the main tasks for the group leaders. It is of vital importance that the group leaders have an understanding of both the effects and the underlying causes for development of fatigue. Through this understanding the group leaders could guide the fellow survivors and modify survival strategies to adapt to the situation. This would be a constant dynamic process, taking into account elements like:

- Available equipment
- Available rations
- Available human resources
- Changing weather conditions

11.7 Recommendations

Assessing “survival” based on the regulatory framework defined in the IMO documentation is a difficult task as “survival” is not defined from a medical perspective. From a medical perspective “survival” can take the following simplified forms:

1. Survival with no permanent damage
2. Survival with transient damage, e.g. frostbite, renal or circulatory problems.
3. Survival with permanent damage, e.g. amputation, permanent lung damage or loss of mobility
4. Death in situ and death post-recovery

The outcome of the survival scenario will also to a high degree depend on the resources available during the rescue. Adequate available medical resources during the rescue phase will enable improved recovery of the casualties, reducing the probability of transient or permanent damage.

Unfortunately, it is to be acknowledged that most vessels operating in the waters of relevance have limited medical resources to handle a large number of heavily injured casualties, e.g. the Norwegian Coast Guard vessel KV Svalbard could possibly accommodate several hundred casualties, but only treat 2 or 3 heavily injured. Even if the casualties are brought to Longyearbyen the medical capacities are very limited with regards to treatment of more than a few heavily injured casualties.

To mitigate this, the vessel operators need adequately dimensioned survival gear to ensure that the casualties only require limited medical treatment at the time of rescue.

A governing principle within the marine and offshore industry is that all vessels and activities are to operate within the same risk level. An implication of the above-mentioned mechanism is that the survival equipment provided on high passenger capacity vessels will need to be better dimensioned (providing a higher degree of survival) than the equipment provided on smaller passenger capacity vessels.

11.7.1 Survival on-shore versus survival in survival craft on-water

Caution has to be used when comparing the different SARex exercised due to variations in metocean conditions, variations in participants’ demographics and variations in participants’ knowledge.

Based on the general impressions from the medical team, where several individuals had been involved in previous SARex exercises, the functionality of the participants were greatly improved when staying on-shore compared with the functionality of the participants after both SARex1 (utilizing normal SOLAS equipment) and SARex2 (utilizing modified SOLAS equipment).

The metocean conditions were relatively similar between SARex1 and SARex3, while during SARex2 high wind speeds (up to 20 m/s) was experienced.

Plotting the survival rate (Kaplan-Meier plot) for SARex 1 (utilizing normal SOLAS equipment) for both lifeboat and life raft and SARex3 (evacuation on to shore, utilizing GSK and PSK) reveals great improvements with regards to survival rate when evacuating on to the shore, Figure 16.

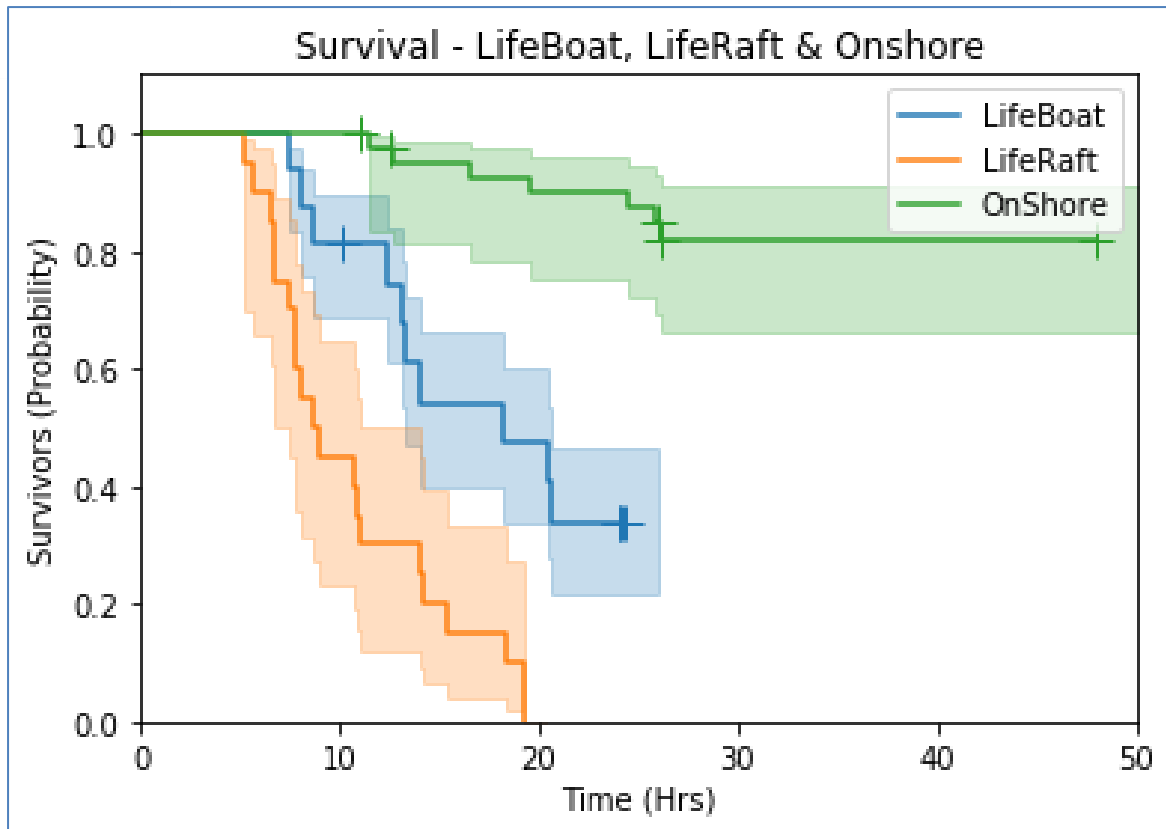


Figure 16 Survival rate (Kaplan-Meier plot) for SARex 1 (utilizing normal SOLAS equipment) for both lifeboat and life raft and SARex3 (evacuation on to shore, utilizing GSK and PSK)

The main difference between evacuation to shore versus staying in a rescue craft was the ability to increase activity levels/metabolism on shore. This was done to compensate for the heat loss induced by inadequate insulation in the PPE, GSK and PSK. When staying in the rescue crafts increasing activity levels/metabolism was impossible due to the restricted space.

Another observed difference was the mental aspects of being able to remain in activity and conduct what was regarded as meaningful tasks, e.g. improve shelters. When staying in a rescue craft there was very little the participants could actively do to improve their situation. Being able to conduct meaningful tasks contributes to the participants feeling “on top” of the situation, which again results in a higher motivation and reduces the development of fatigue.

It is important to note that the above-mentioned graph (Figure 16 Survival rate (Kaplan-Meier plot) for SARex 1 (utilizing normal SOLAS equipment) for both lifeboat and life raft and SARex3 (evacuation on to shore, utilizing GSK and PSK)) cannot be extrapolated to 5 days. When entering the exercise all participants were well fed, rested and had an adequate total body water level. When these resources are depleted the body utilizes different mechanisms to compensate for the stress induced by the survival situation, e.g. the body starts to burn fat and muscle to enable the high activity levels required for survival.

In all SARex exercises the medical crew reported development of fatigue among the participants. For SARex3 – evacuation to the shore, fatigue developed because of the combined effect of:

- Not adequate water rations to combat dehydration
- High level of physical activity/increased metabolism to mitigate for the heat loss caused by not adequate insulation in GSK and PSK.

- Not adequate food rations to compensate for the high activity levels.

Due to the combined effect of inadequate rations and inadequate insulation, a large number of the participants would most likely have deceased or survived in a severely degraded health state in a 5-day scenario.

Based on the observations in the SARex exercises, it is to be recommend striving for evacuating on to ice/shore in a real marine incident scenario. Evacuation on to the ice/shore will greatly improve the probability of survival.

It should also be commented that any needed visit for toileting is considerably easier on land than in a rescue craft and will inflict much less stressful situations onshore.

Evacuation to land or ice, will also give the possibilities for use of stoves/portable heat sources in or close to a habitat. On most coastlines in the Arctic there are easy accessible drift lumber/wood pieces which can be burned and will radiate heat to nearby survivors in fair weather conditions.

11.7.1.1 Ability to evacuate to the shore

As most marine incidents happen in relatively close vicinity of the shore, it is likely that the lifeboats/life rafts in many cases will drift ashore/on to shoals during a period of 5 days unless active measures are taken. To mitigate the risk associated with shoals/shore both basic navigation equipment and a propulsion system is required.

Some cruise operators are identifying evacuation to shore as not an option due to vessels operating too far from the shore line, e.g. outside 24 nautical miles from the shore. In a 5-day perspective this argument is invalid as traveling/drift with even as little as 1 knot will provide the survivors with 24 hours of transportation and 4 days on shore, which is a significantly better option than spending 5 days in a survival craft.

Arguments like there are no on-shore areas to evacuate on-to due to steep cliffs or calving glaciers is also to be considered invalid. During the approaches to the destination there will be areas where evacuation will be possible. It is to be recognized that even the smallest patches of land make a big difference. In a standard lifeboat the standard area available for each person is less than 0,46 m² per person. Any small patch of land providing a higher area than 0,46 m² per person is to be preferred.

It is also worth to mention that most vessels operating within the IMO Polar Code area of application is in a destination trade (entering ports within the IMO Polar Code area of application). This means that the vessels per definition will travel in the vicinity of land for parts of the journey as most attractions are close to shore or in the sea ice margin zone. A grounding accident based on lack of reliable hydrographic data is the highest risk probability for Arctic shipping would also most likely occur in coastal areas or within the archipelago.

A survival time of minimum 5 days implies that the probability of drifting ashore/onto shoals is eminent. This has to be taken into account in the Operational Assessment, implying implementing risk mitigation measures.

Due to the high increase in probability for survival when evacuating to shore, it is recommended that evacuation on to shore is a valid option for all vessels traveling to ports within the IMO Polar Code area of application.

11.7.2 Compliance with the functional requirement

Most of the current maritime regulations are prescriptive, defining requirements for specific themes. The requirement for survival for minimum 5 days or to the “expected time to rescue” in the IMO Polar Code is a functional requirement. When assessing this functional requirement, the cumulative effect of rescue craft, PPE, PSK and GSK has to be assessed.

Much of the challenge of today’s interpretation of the IMO Polar Code is a result of the marine industries’ tradition of assessing each component individually through a “prescriptive” mindset. The IMO Polar Code has a functional requirement that involves the cumulative functionality provided by several different components combined. An example of this can be seen in the complexity involving heat loss. The effect of heat loss is highly affected by the cumulative effect of the following components

- PSK
- GSK
- Survival craft
- Food and water rations
- Ability to conduct activity (with space and equipment restrictions)
- Ability to conduct activity (physical (human body) restrictions)
- Leadership

Maintaining the prescriptive mindset, assessing each component individually, when trying to comply with a functional set of rules is not a sustainable way of approaching the challenge. Currently the operators and equipment suppliers develop survival crafts, PPE, GSK and PSK packages through a prescriptive approach. This equipment is further to be assessed by the flag states and classification societies and flag states for compliance of a functional set of rules addressing the cumulative effect of the equipment. This is an impossible task. As a result, we see large variations with regards to what is being approved and regarded as adequate for 5 days survival. A suggested way forward for a sustainable implementation of the functional requirements is to define a few key parameters that enable flag states and classification societies and flag states to verify equipment packages in a transparent way, and at the same time open up for development of alternative solutions.

11.7.3 Unified approach - the governing mechanisms for survival

One of the most important parameters for most survival situations is heat loss. Heat loss is the energy lost to the ambient environment from the human body due to our body temperatures being 37 degrees, while the ambient air and water temperature is significantly lower when present in a cold climate environment.

There is a direct connection between heat loss and the level of activity needed to be performed by the survivors to increase the metabolism to mitigate for the heat lost. Other relevant parameters like water consumption and CO₂ production can further be derived from the level of activity/metabolism.

There is currently not defined an acceptable level of heat loss for an average crew/passenger in the marine industry. This should be seen in conjunction with typical values for human energy production, Figure 11 Effect of conducting different activities .

The maritime industry should agree on:

- Acceptable level of heat loss (HL) that could be maintained for a duration equal to the “maximum time to rescue” or a minimum of 5 days, without decreasing from physical extortion (e.g. 83 Watts/m² or 150 Watts per person (1.8 m² per person))
- Ambient windspeed to be utilized in heat balance calculations (e.g. 20 m/s)
- CO₂ concentration levels (e.g. 5000 ppm)
- Water required for survival (e.g. 2.5 liters per person per day)

The above parameters utilized in conjunction with the Polar Service Temperature (already defined in the IMO Polar Code) and other parameters relevant for the issues of interest, the following parameters could be further elaborated based on simplified formulas:

- Insulation levels – the cumulative insulation levels included in the PPE, PSK, GSK and rescue vessel. This would further define much of the specifications associated with the equipment supplied.
- Rations – the amount of food and water required for the “maximum time to rescue” or minimum 5 days
- Ventilation levels – ventilation levels required for rescue crafts to promote survival for the “maximum time to rescue” or minimum 5 days

A methodology for calculating ventilation requirements is illustrated in Appendix B.

11.7.3.1 Level of insulation

There are many standards and methodologies publicly available that addresses issues like work environment, clothing and insulation layers. Many of these documents are well recognized by both governmental bodies and industry. Examples of these standards are (PH/3/1, 2017) and ANSI/ASHRAE Standard 55-2010 (American Society of Heating, 2010).

The paper “A Comprehensive Data Base for Estimating Clothing Insulation” (E.A. McCullough, E.W. Jones, J. Huck) provides a comprehensive study of the insulating abilities of different types of clothing. The more recent ANSI/ASHRAE Standard 55-2010 (American Society of Heating, 2010) has a comprehensive approach to the issue indicating a simple methodology for calculation of heat loss operative temperatures. The standard also has a list of insulation abilities for standard clothing. The methodology indicated in ANSI/ASHRAE Standard 55-2010 (American Society of Heating, 2010) could be used for the part of the body exposed to air.

Many of the above standards uses phrases like “Comfort temperature”. From a thermodynamic perspective it is important to acknowledge that this does not necessarily address “Comfort”, but it addresses the temperature where there is a thermodynamic equilibrium between heat lost and heat produced for a certain combination of environmental conditions and certain levels of insulation.

In the heat balance calculations, it is important to take into account all relevant modes of operation applicable for the survivor activities. This includes:

1. Sitting in a survival craft
2. Walking/movement on shore when evacuation to shore is identified in the IMO Polar Code risk assessment.
3. Laying down on shore when evacuation to shore is identified in the IMO Polar Code risk assessment. This activity can be conducted inside a shelter if provided.

For mode of operation first and secondary additional insulation on the back of the body will be required due to the conductive heat transfer mechanisms present. This insulation will have to have the ability to maintain its insulation when being compressed when sitting/laying.

From a survival perspective it is the cumulative insulation level that determines the total heat loss per person. This includes the insulation caused by PPE, PSK, GSK and survival craft. The following parameters defines the heat loss from human:

- Metabolic rate
- Clothing insulation
- Air temperature
- Radiant temperature
- Air speed
- Humidity

Most of the current standards utilize a variation of the formula stated below to express the heat balance for a human:

$$M - W = E_{\text{res}} + C_{\text{res}} + E + C + R + K + S$$

M =	Metabolic rate	E =	Evaporative heat exchange
W =	Effective mechanical power	K =	Conductive heat exchange
E_{res} =	Respiratory evaporative heat loss	R =	Radiative heat exchange
C_{res} =	Respiratory convective heat loss	C =	Convective heat exchange
		S =	Body heat storage rate

11.7.3.1.1 Practical application in a cold climate survival perspective

From a practical applicational perspective related to a cold climate marine survival situation the equation can be simplified. Some of the elements can be removed as they have little impact on the results. For simplicity, and to compensate for the removal of elements as well as uncertainties regarding the assignment of values to the elements, a safety factor should be utilized.

The following elements could be removed from the equation without significantly affecting the result to simplify the calculation:

- W – Effective mechanical power can be assumed to be 0 and removed from the calculation.
- E – Evaporative heat exchange can be assumed to be 0 as long as the survivors does not get wet or start sweating. (It could be commented that any evaporation will be absorbed momentarily if woolen underwear be used so the possible evaporation will not cause any stressful situation with subsequent cooling of body temperature).
- R - Radiative heat exchange can be assumed to be 0 as it will have relatively low values in a cold climate environment.
- S – Body heat storage rate will be irrelevant as the survivors are to maintain the heat balance for a long duration, minimum 5 days.

This simplifies the formula into the following:

$$M = (E_{\text{res}} + C_{\text{res}}) + C + K$$

$E_{res} + C_{res}$ - The respiratory evaporative heat loss and respiratory convective heat loss is the heat loss caused by breathing. The loss can be estimated according to the empirical formula:

$$E_{res} + C_{res} = 0.014 M (34 - T_a) + 0.0173 M (5.87 - Pa) \text{ (Oğulata, 2007)}$$

Where M = metabolic rate (W/m^2), T_a = temperature ambient ($^{\circ}C$) and Pa = partial vapor pressure (pa), = Relative humidity/Saturation pressure water. The partial vapor pressure for water for sub-zero temperatures is assumed to be 0.

This reduces the formula to:

$$E_{res} + C_{res} = 0.014 M (34 - T_a) + 0.101551M$$

For a parameter study, see Figure 17 Respiratory evaporative and convective heat loss for different metabolic rates (W/m^2).

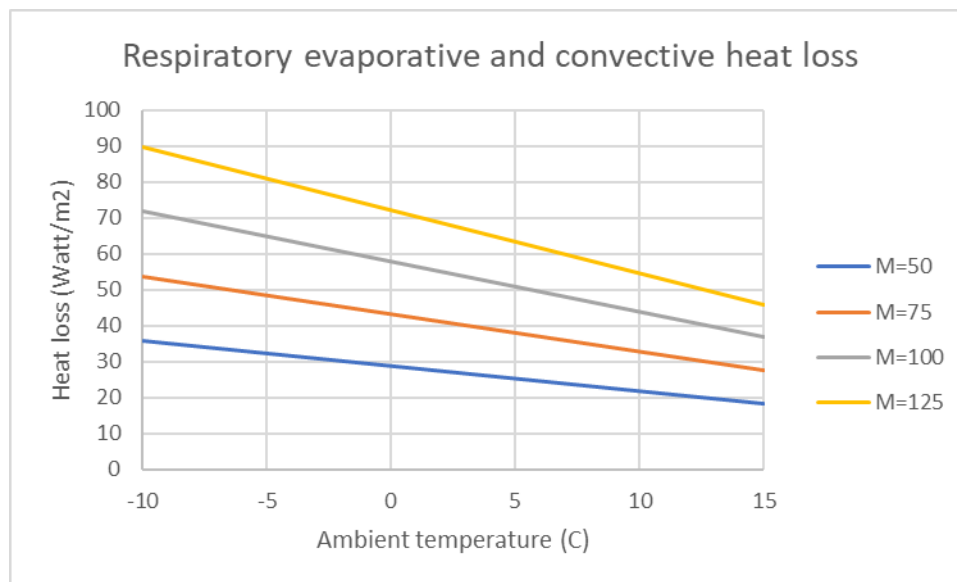


Figure 17 Respiratory evaporative and convective heat loss for different metabolic rates (W/m^2)

11.7.3.1.1.1 C - Convective heat exchange

The heat transferred through the clothes through conductive heat transfer, is further transferred to the ambient air through convective processes. Based on this statement,

$$C_{\text{conductive to surface garment}} = C_{\text{convective to air}}$$

The convective heat loss is given by the following formula:

$$C = fcl * hc * (Tcl - Ta)$$

Disregarding the radiative heat transfer processes, the surface of the garment (T_{cl}) is given by the following formula:

$$T_{cl} = \frac{T_{skin} + R_{cl} * f_{cl} * h_c * T_a}{(1 + R_{cl} * f_{cl} * h_c)}$$

$T_{skin} =$	Skin surface temperature = 35.7 - 0.0275 metabolic rate	$f_{cl} =$	Clothing area factor = 1.05 + 0.1*thermal insulation (clo value) of clothing
$R_{cl} =$	Insulation of clothing = 0.155*clo value	$h_c =$	Coefficient of convective heat transfer = Sqrt(12.1* wind speed in m/s)
		$T_a =$	Ambient temperature

11.7.3.1.1.2 K - Conductive heat exchange

When walking or standing most of the heat transfer processes is going to the air. In a survival situation the casualties are expected to be sitting on the more or less non-insulated floor of the life raft or laying down when resting. When conducting these activities there will be conductive heat transfer processes going from the body, into the sea water or ground. It is important to note that in the Arctic the permafrost is very close to the surface, e.g. in SARex3 the permafrost was identified to be less than 40 cm from the surface. The surface can be estimated to have 0 degrees C, also in the summer months. The conductive heat transfer process can be estimated through the following formula:

$$q_{cond} = U * A * dT = \frac{k}{s} * A * dT$$

Where:

$q_{cond} =$	conductive heat transfer (Watt)	$dT =$	Delta temperature ($t_{skin} - t_{water}$)
$U =$	coefficient of heat transfer (W/m ² K)	$k =$	Thermal conductivity of material (W/mK)
$A =$	Area (m ²)	$s =$	Thickness of material (m)

When sitting/laying down, insulation of the clothes worn will obtain reduced insulating abilities when compressed between the body and the life raft floor/ground. It is important to utilize special insulation materials like closed foam (that is maintaining its insulating abilities when compressed) to mitigate the effect of this.

A case study for heat balance studies in a life raft is shown in Appendix A. The case study reflects the reduced heat loss in a life raft with a different degrees of insulation.

11.7.3.1.2 Uncertainties

The simplified calculations illustrated above has limitations. The following elements are to be considered:

- Simplification removing W, E, R and S reduced the accuracy of the calculation. This will contribute to reduce the theoretical heat loss compared with a real scenario.
- The calculations do not take into account the effect of survivors being located inside a shelter. Under a shelter, with restricted ventilation, much of the energy associated with $E_{\text{res}} + C_{\text{res}}$ will remain inside the canopy, increasing the internal temperature. This will contribute to increase the theoretical heat loss compared with a real scenario.
- In a real situation many of the survivors will huddle together. Obtaining body contact between the survivors will reduce the efficient surface area exposed to the elements. Reducing the area exposed to the elements will reduce the heat loss. The effect of reducing the heat loss by huddling together is not captured in the calculation.
- The biometric variability among a group of survivors, e.g. body surface area, will affect the heat loss experienced in a real scenario.
- Much of the methodology is based on empirical formulas. The methodology is recognized in industry and standards, but does not capture individual behavior and local phenomena, e.g. the heat loss associated with standing with the arms horizontal will increase the heat loss compared with keeping the arms vertical, along the side of the body.
- The methodology assumes the insulation layers remains dry at all times. Based on the observations from the different SARex exercises most participants were combating moisture in the insulation layers. This uncertainty will reduce the theoretical heat loss compared with a real case scenario.

11.7.3.1.3 Level of insulation – summary

Based on the above methodology the following generic statements are valid:

- There are currently no recognized standard or methodology used when assessing PPE, PSK and GSK equipment associated with the IMO Polar Code. As a result, there is observed large discrepancies associated with approved equipment.
- Excessive heat loss is mitigated through increasing activity levels which again increases the metabolic level.
- Regulators needs to define an average heat loss value that survivors can maintain for a prolonged period of time (minimum 5 days or maximum time of rescue). This value has to take into account resting periods with low metabolic levels.
- There are many recognized industry standards specifying a methodology that can be utilized when calculating heat loss. Examples of these standards are (PH/3/1, 2017) and ANSI/ASHRAE Standard 55-2010 (American Society of Heating, 2010).
- Ambient conditions in addition to an acceptable level of heat loss is required when defining insulation levels.
- Calculating the heat loss associated with survival is possible and a necessity when class/flag states are to do realistic and transparent evaluations of the equipment required for survival, e.g. PPE, PSK and GSK.
- The cumulative effect of all insulation layers for all modes of survivor activity are to be considered when conducting heat balance assessments.

11.7.3.2 Ventilation - Oxygen consumption/CO₂ production

For a discussion of Ventilation - Oxygen consumption/CO₂ production see Appendix B. This information is relevant for assessment of ventilation in tents or other enclosed shelters.

11.7.3.3 Water Rations

In a simplified perspective the human body water consumption consists of 3 major mechanism, XX. (4hinitiative, u.d.):

- **Insensible water losses** – Insensible water losses includes perspiration and respiratory losses. These losses will be greatly influenced by the level of activity and air humidity. Typically, about 750 ml is lost through this mechanism during normal day activities
- **Sweat loss** – The water losses through sweat will vary greatly, depending on activity level, air temperature and humidity.
- **Fecal losses** – Fecal losses contributes with about 200 ml per day.
- **Urine losses** – Urine losses will vary depending on how much water is consumed. There is however a minimum limit of about 500 ml per day. The minimum limit is required by the body to maintain essential body functions, e.g. kidney functionality.

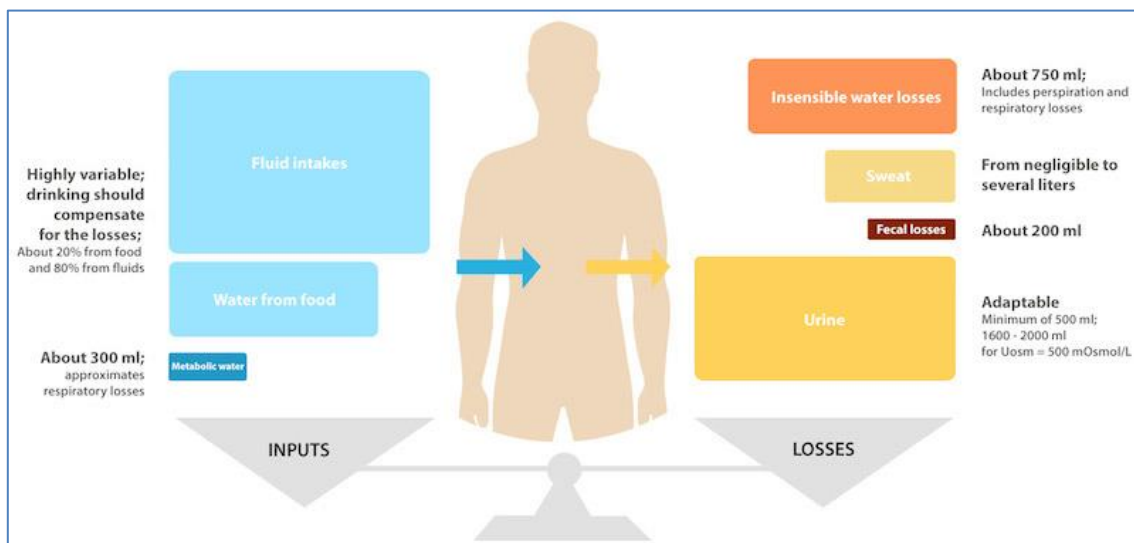


Figure 18 Human water balance (4hinitiative, u.d.)

In a cold climate environment where the survivors are combatting hypothermia, the effects of sweat will be limited. During all SARex exercises however, condensation inside survival equipment, leading to wet insulation layers, with a following loss of insulation was observed. Based on these observations and expert judgement a loss in water through sweat is estimated to be around 200 milliliters per person per day. Based on the above figures the body consumes about 1.65 liters per day at rest.

There are variations with regards to human body water consumption rate. Under ideal conditions, with a low level of activity, a body water consumption rate of 2.5 liters/day is regarded as typical. With an increase in activity level a body water consumption rate of 3.7 liters/day is more appropriate, and a body water consumption rate of 3.7 liters/day is a level recommended by the World Health Organization.

The level of dehydration after n days would be given in the following formula:

$$dehydration_{percent} = \frac{waterLost}{totalWeight}$$

$$dehydration_{percent} = \frac{(waterConsumedPrDay - waterIntroducedPrDay) * noDays}{totalWeight}$$

Where:

$dehydration_{percent} =$	Level of dehydration (percent)
$waterConsumedPrDay =$	The water the body is consuming in 24 hrs (liter)
$waterIntroducedPrDay =$	The water introduced to the body (drinking) in 24 hrs (liter)
$noDays =$	The duration of the survival period (days)
$totalWeight =$	The weight of a person (kilogram)

Assuming an average person of 80 kg, introducing 1 liter of water per day and a body water consumption of 3.7 liters per day revealed the following the results (Figure 19 Dehydration level when drinking 1 liter of fluid per day):

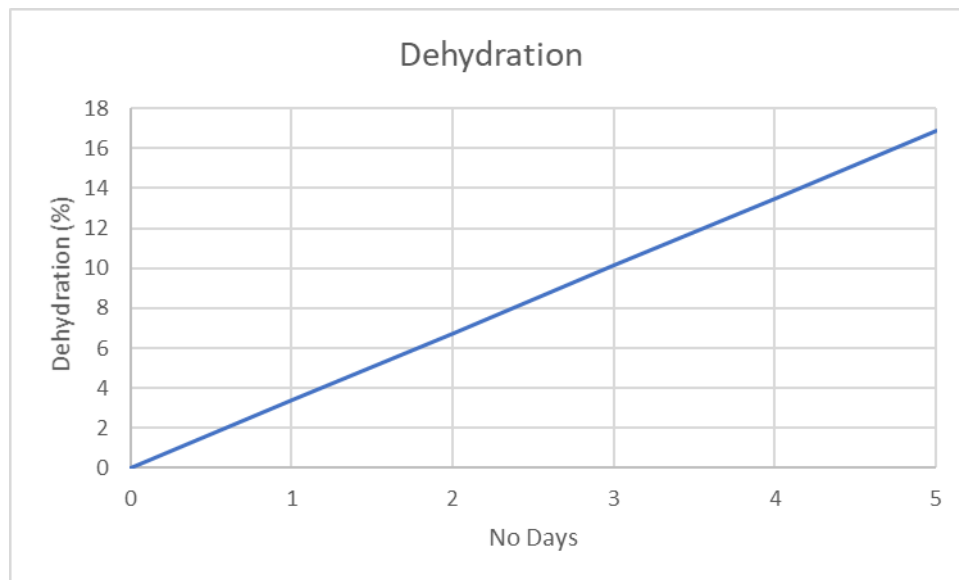


Figure 19 Dehydration level when drinking 1 liter of fluid per day

After 2 days the survivors are to be 6.75 % dehydrated according to the above formula, which correlates well with our results, where a total of 30% of the survivors had a total body water loss of 6% and 7%. It is important to note that as the body gets dehydrated, the body water consumption required by the body will decrease, reducing the rate of dehydration.

Already at a dehydration level of 5% - 8% fatigue and dizziness will be dominating symptoms (Wikimedia Foundation, u.d.), reducing essential functionality levels (Shaun K Riebl, Brenda M. Davy,, 2013) and the probability of survival. In a 5-day survival scenario these symptoms will highly affect the ability to contribute with active participation which would be required for survival. During SARex3 more than 90% of the participants had a body water consumption of more than 2 liters per person per day, more than 50% had a body water consumption of 2.5 liters per person per day or more, and about 20% had a body water consumption of more than 3 liters per day, Figure 20 Human body water consumption rates measured under SARex3.

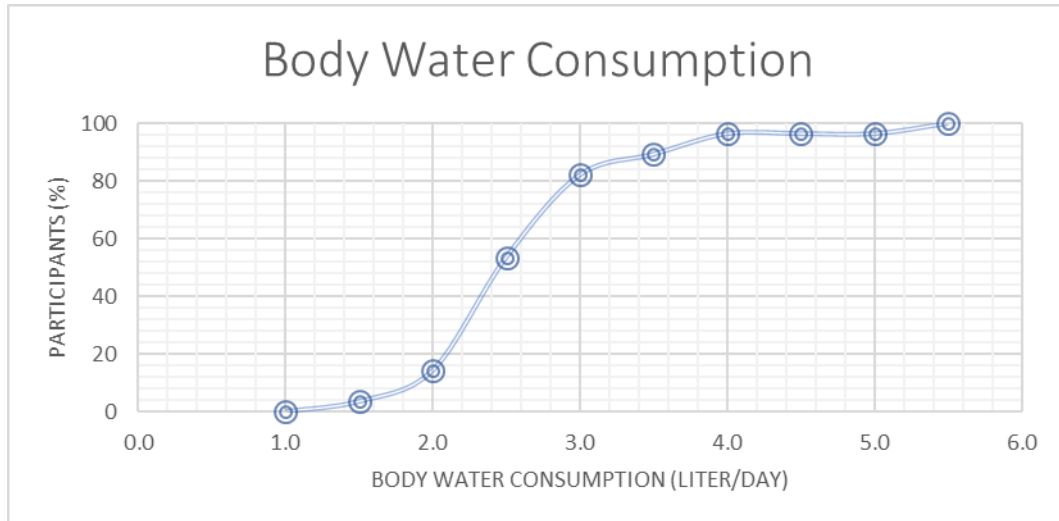


Figure 20 Human body water consumption rates measured under SARex3

If the survivors are to maintain their cognitive abilities and mitigate the symptoms of dehydration that will have fatal consequences, a dehydration level of about 5% is regarded as an acceptable limit after a stay of 5-days in a survival situation. Based on the variation rates in body water consumption experienced in SARex3, the probability of survivors exceeding a 5% dehydration threshold after a 5-day survival scenario can be plotted for different size water rations, Figure 21 Percentage of survivors not exceeding %5 dehydration rates after 5 days based on the consumption rates measured during SARex3.

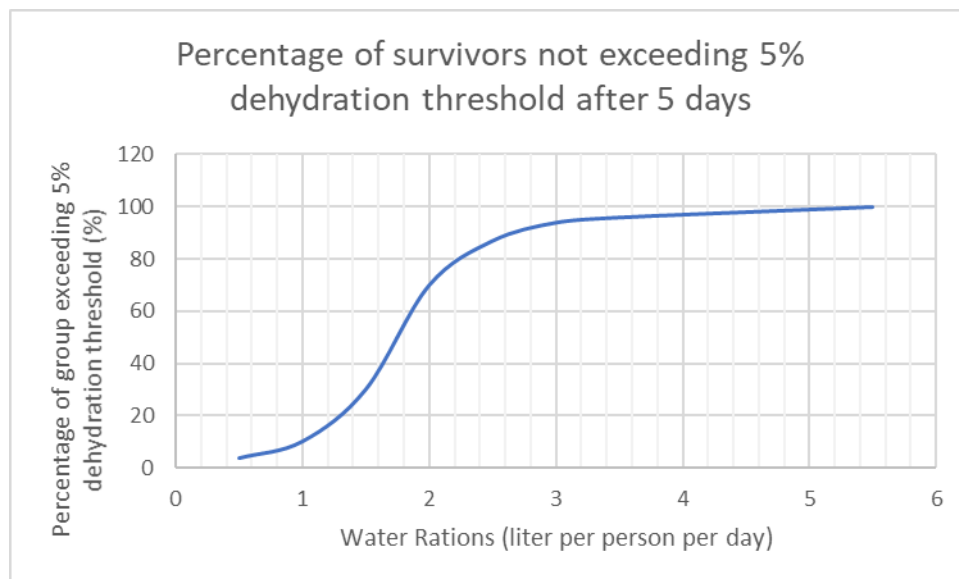


Figure 21 Percentage of survivors not exceeding %5 dehydration rates after 5 days based on the consumption rates measured during SARex3

Based on the above plot it is evident that 90% of the survivors after a 5-day survival scenario would exceed the 5% dehydration threshold with the “normal” water rations of 1 liter per person per day. With water rations of 2 liters per person per day 70% of the survivors would not exceed the 5% dehydration threshold, while if the rations were increased to 2.5 liters per person per day, almost 90% of the survivors would not exceed the 5% dehydration threshold.

11.7.3.3.1 Uncertainties

In the above-mentioned calculation there are uncertainties. A male having a weight of 80 kilogram and a body water consumption rate of 3.7 liters per person per day (based on the recommendation from the World Health Organization) and alternatively a body water consumption of 2.5 liters per person per day was used in the calculation. These values can be questioned. Moreover, at higher dehydration levels the body's water consumption would be reduced due to the body's ability to adapt to the situation and conserve as much water as possible.

However, these uncertainties will be overshadowed by the biometric variations experienced in the crew/passengers age, weight, metabolism (including the increase in metabolism induced to compensate for lack of insulation provided by the equipment), breathing frequency/oxygen uptake, level of dehydration before entering a survival scenario, ambient air humidity.

A relatively large variability is evident in the data gathered during the SARex3 exercise. Despite the relatively homogenous biometrics present among the SARex participants, there was observed a range from less than 2 liter to more than 4 liters per day, with an average of about 2.5-3 liters per person per day of body consumed water.

11.7.3.3.2 Water rations summary

Based on the above methodology the following generic conclusions can be made:

1. For the survivors to maintain cognitive abilities that enables survival and mitigate symptoms of dehydration that will have fatal consequences on the survivors, a total body water loss (dehydration level) exceeding 5% should be avoided.
2. A water ration of 1 liter per person per day is not adequate to mitigate symptoms of dehydration that will have fatal consequences for the survivors in a 5-day perspective.
3. To ensure a majority (almost 90%) of the survivors not exceeding a 5% dehydration threshold during a 5-day survival scenario, each survivor should be supplied with not less than 2.5 liters of water per day.
4. Utilization of stoves for melting of snow to provide water should in most cases be disregarded as an option because:
 - The water needs to be available in the survival craft in case the survivors are not able to evacuate on to the shore
 - Utilizing a stove (with a flame) in a survival craft will involve great risk unless a purposely built arrangement is available
 - Utilizing a stove (with a flame) requires additional training of the crew
5. The uncertainty associated with the study is overshadowed by the variations in the biometrics and ambient conditions present in a survival scenario. This further indicates that utilizing the argument "further research is needed" before the marine industry can conclude on reasonable values is invalid.

11.7.3.4 Food rations

Determining the food rations required for survivors in a 5-day survival scenario is difficult. Providing the survivors with food rations has several implications on survival. The major effects on of food is:

- Provide the human body with the energy required to maintain an acceptable metabolism

- Give the survivors a mental task to occupy themselves with. This includes something to look forward to (the meals).
- Fulfill the mental expectation of the survivors that food is required for survival
- Mitigate development of fatigue

The human body can sustain for a long period without food. Based on the experiences from the previous SARex exercises, food is important mainly to mitigate the probability of development of fatigue. A high calorie diet will enable the survivors to conduct high intensity activities and maintain a higher spirit for an extended duration, increasing the probability of survival.

11.7.4 Alternative solutions

Following the above-mentioned methodology based on defining key values like acceptable heat loss, acceptable CO₂ concentrations and adequate water rations, will generate a regime that is possible for the flag states and classification societies to verify the fulfillment of the Polar Code requirements in a transparent and consequent way. It will thus ensure that the goals of the functional requirements defined in the IMO Polar Code are met.

As this would be a guide line/recommended methodology, operators are free to develop alternative solutions. Operators would, however, have to prove the feasibility and effectiveness towards the benchmark values mentioned above.

11.7.5 Essential equipment

All equipment provided in a survival situation is to serve a special purpose. The technology required is well known, and all equipment needed for survival for 5 days or more is available “off the shelf”.

SARex3 utilized standard PSK and GSK packages that the suppliers provided to the industry. Based on discussions with suppliers, classification societies and flag states it is obvious that much of the marine industry is hesitant to pay the price with regards to cost, space, maintenance and training associated with survival equipment that provides the functionality required for 5-days survival. As a result, we see many vessels equipped with not only insufficient equipment packages, but also insufficient food/water rations (based on findings in SARex1, SARex2 and SARex3).

11.7.5.1 Assessment of Personal Survival Equipment and Group Survival Equipment

Flagg states and classification societies have to evaluate PSK and GSK packages. A large variation is observed with regards to both quality and functionality for what is being approved.

One of the aims of SARex3 was to evaluate different levels PSK and GSK packages. To do this from a scientific perspective proved to be an impossible task due to the following rationale:

1. Lack of insulating abilities is compensated for by increasing the metabolism/activity levels.

2. There are large variations between individuals with regards to how high metabolism/activity levels they are able to conduct over a prolonged period of time, e.g. people with low oxygen uptake will not be able to achieve high aerobic activity levels.
3. There are large variations between individuals with regards to how long (time) high metabolism/activity levels can be maintained, e.g. a marathon runner can maintain a high level of aerobic activities longer than a sprinter.
4. There is no consensus or defined metabolic rate that an average crew/passenger can maintain for a duration of 5 days or for the expected time to rescue.

Due to the above-mentioned rationale we saw individuals wearing equipment with high insulation levels being pulled out of the exercise long before individuals wearing equipment with low insulation levels.

To be able to validate equipment packages with regards to a 5-day survival scenario, it is vital to define an average level of metabolism/aerobic-activity that an average person can maintain for the duration of the survival situation. The predefined metabolism value to be used together with wind speed and the Polar Service Temperature (PST) will define the level of insulation needed for survival.

There were, however, some observations made that were common for all groups participating in the exercise:

- Venting possibilities or breathing materials of clothing is important to reduce the build-up of condensation. Condensation reduces the insulating abilities of the materials, resulting in an increased heat loss.
- Cotton garments proved not to fulfill their intended functionality due to moisture build up.
- The equipment packages must provide a water proof layer to mitigate the risk of getting wet from precipitation. This can be provided by the shelter or by the PSK package.
- The equipment provided must enable the survivors to get ashore without getting wet as drying of equipment is extremely difficult.
- Adequate insulation on the extremities (head, hands and feet) is important to avoid local frostbite to maintain the ability to walk and use fingers. This also includes insulated watertight shoes with proper soles, winter hats and winter gloves.
- The equipment must enable the survivors to rest/lay down. This includes insulation against the cold ground and a high degree of insulation to the air (e.g. typically closed cell foam mats and sleeping bags).
- The equipment must enable the survivors to move/walk. This is important because the survivors must go to the toilet, conduct activities to compensate for a possible heat loss, and movement is required for developing and maintaining a shelter. Being able to move also enables the survivors to improve their situation. This is important from a mental perspective.
- Flexibility/multifunctionality; much of the equipment proved to be more efficient when utilized in a manner not intended by the manufacturers, e.g. thermal protection aids were used as jackets and life vests were utilized as sleeping mats. It is encouraged that equipment like knives, sewing equipment, shovels and tarps are included in the survival packages.
- Sizes – “one size fits all” proved not to function. When utilizing equipment in too small sizes, the blood circulation is inhibited. When utilizing equipment of too big sizes, the insulation abilities were not functioning as intended.
- Very few of the equipment packages provided enough insulation, and most of the participants had to compensate for this by increasing the activity levels. Only proper winter clothes, hats, gloves and shoes provided sufficient insulation.
- The space associated with each individual is considerably less in a life raft/lifeboat than what is allocated in the tents provided.
- All equipment is to be simple to use and requiring minimal training for use. Water proof instructions needs to be provided for all equipment.

12 Evacuation from the shore – preparedness for emergency response

12.1 Background

Preparedness for emergency response is defined as “Technical, operational and organizational measures that are to prevent an incident to develop into an accident, or that is to prevent or reduce the impact from an accident or crisis situation”. In the high North the availability of human resources, knowledge and critical infrastructure is more limited than in more populated areas. The preparedness for emergency response will have to handle a variety of situations and the ability to adapt and utilize the available resources in constructive and creative ways is importance for success.

12.1.1 Dimensioning

In Norway the governing principle with regards to dimensioning of the emergency response is that it is to be risk-based. Risk expresses the probability and consequences related to accidents/incidents. In areas of high traffic densities there is a higher probability of an incident. In these areas the emergency response service is to be better dimensioned than in areas of low traffic densities. The risk associated with lack of bathymetric data, as well as lack of maritime navigational aids is also to be reflected in the dimensioning of the emergency response system

12.1.2 Basic principles for preparedness for emergency response in Norway

The Norwegian model on how to handle preparedness for emergency response is based on 4 basic principles. The principles are:

1. **Principle of responsibility** – the entity that has an area of responsibility during normal operation is also responsible for preventing, mitigating and operation during times of extraordinary events.
2. **Principle of equality** – the entity is to maintain its organization to the largest degree possible during times of extraordinary events.
3. **Principle of proximity** - during times of extraordinary events the support to the event is to be handled as low as possible in the organizational hierarchy.
4. **Principle of joint cooperation** – all public agencies, private entities and the government is responsible for productive joint cooperation between relevant organizations to ensure efficient prevention, emergency response and crisis management.

On an operational level each emergency response provider has their own area of expertise, e.g. the medical personnel handle medical issues, the helicopter crew flies the helicopter and the coastguard provides a marine platform. The areas of expertise are complementary and at times overlapping. Cumulatively the resources are to fulfill the resource needs and manage the situation in the best manner.

The different resources are typically managed by the Joint Rescue Coordination Center on behalf of the police in the early phases of a marine incident, when rescuing lives is the priority. At a later stage in the incident development, when managing environmental issues, e.g. oil spill, the Norwegian Coastal Administration is managing the relevant resources.

12.1.3 Robustness

Prior to an event there are many possible solutions on how to retain an event from escalating and treat/handle the casualties. In the early phases of an event there is usually limited information available to the Joint Rescue Coordination Center. As time progress, more information reaches the decision makers, and defining a solution becomes an easier task (see Figure 22 Available resources, solutions and knowledge). Due to the time lag from an event emerges until information of importance reaches the Joint Rescue Coordination Center, the decision to deploy relevant emergency response units is in many cases taken with very limited information available. Due to the nature of this process there is a risk that the first resources that reaches the scene of the accident arrives at an event that requires knowledge, experience and resources beyond their level of training.

A crisis is to be defined as an event that is beyond what has previously been trained for by the

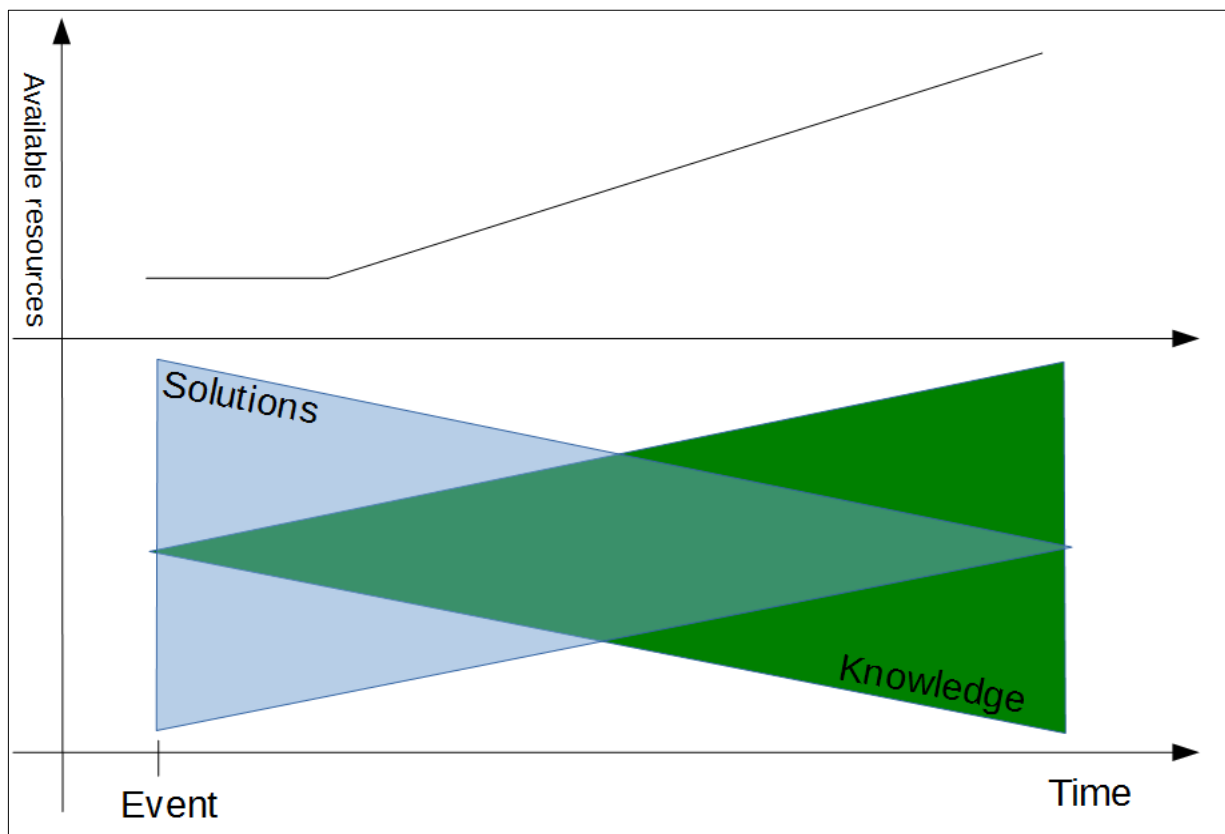


Figure 22 Available resources, solutions and knowledge

emergency response units. During a crisis scenario the responders will have to adapt and conduct tasks that are outside their areas of responsibility and beyond their level of training. This is not an ideal scenario and is a situation that should be avoided as efficiency will be reduced, with potential of losing lives. A crisis situation also exerts extreme pressure on the responders at the scene of the accident, which in turn could jeopardize the safety of the

responders. Post-traumatic stress reactions have been observed on responders being exposed to crisis situations.

It is however, to note that in a remote Arctic environment the resources available are limited. Having the same specialization, volume of infrastructure and emergency response providers as present in the more inhabited areas of the country is not to be expected. This means that the responders deployed to an incident will be challenged in a variety of cross-disciplinary tasks, beyond what is typically observed in the more inhabited parts of the world.

12.1.4 Types of cooperation

Each emergency response provider has their own competence, culture and procedures. Cooperation between the different providers is essential for solving the assigned task, by utilizing their complementary fields of expertise. Obtaining efficient cooperation in a non-controlled environment where the time factor is essential can be challenging.

Different ways of cooperation between the different emergency response providers has been observed.

The methodology of cooperation can roughly be divided into the following types (Figure 2):

- **Sequential Cooperation** - Each provider completes their own task, and then transfer the case to the next resource, e.g. when the Red Cross is finished with pre-medical treatment and transportation of the casualties to the local hospital, medical personnel takes over the treatment and responsibility of the patient. During the transfer of responsibility, it is of importance that communication of vital parameters is conducted between the different parties.
- **Parallel Cooperation** - The SAR providers work "shoulder by shoulder". Each provider is focused on their own task. It has been experienced that the providers are concerned that they are not acting beyond their area of responsibility. When this type of cooperation is taking place, obtaining an overall, updated picture of the situation can be hard for the incident commander/joint rescue coordination center.
- **Synchronized Cooperation** – Synchronized cooperation is based on free flow of resources, little management and a flat organizational structure. When the first responders reach the scene of the accident there are too few SAR resources available and typically not enough expertise to solve the assignment. In this type of chaotic situation whatever resources available, all will do whatever they can to stabilize the situation, disregarding their rank and area of responsibility. An example of this type of situation is when the ambulance personnel is first to arrive on the scene and has to unarm a violent person before they can start the medical treatment, despite this is a task that is to be covered by the responsibility of the police.

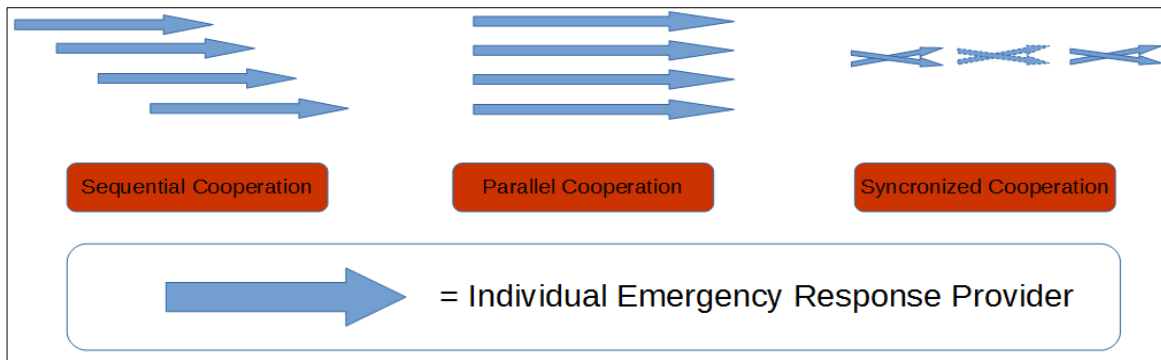


Figure 23 Methodologies of cooperation

To achieve an efficient cooperation between the different emergency response providers it is important for all levels of the organization to be aware of the following pit-falls:

- Area of responsibility – each emergency response provider has their own mandate, area of responsibility and level of competence. Even internally among the emergency response providers each individual has their own area of responsibility. To have a general understanding of the roles and structure at both the scene of the incident/accident and the roles represented by logistical and organizational resources will in many cases increase the comprehension of the mechanisms at play. The increased understanding will reduce the potential for conflicts and enhance efficiency.
- Operational procedures – many organizations will have their own operational procedures. There will be differences between the procedures and how they are implemented among the different emergency response providers. Especially when conducting sequential cooperations, it is important to have an understanding of the operational procedures of the other parties as it reduces the need and uncertainty related to communication during the transfer of responsibility.
- Level of competence/expectations – every emergency response provider has their own level of expertise within different fields. In many cases this competence is anchored at a personal level, and only visible from inside the organization. It is of utmost importance that this level is communicated as this clarifies expectations and the potential need for deploying additional resources.
- Organization structure – different organizations are organized in different ways. Especially for voluntary organizations a flat structure is typical, while at the other end of the scale, the military is organized in a hierarchical way. This affects the way people act and communicate.
- Culture – the internal culture will affect cooperation and expectations with regards to external organizations. Being aware of cultural differences is important to generate an environment that enhances efficient cooperation. If casualties are to contribute to the effort at the scene of the accident, cultural differences are to be considered.
- Clarification of concepts – many concepts are interpreted differently by different organizations. In a situation where time is critical, a common understanding of concepts relevant for the organization is critical.

12.1.5 Why conduct exercises - building efficient emergency response

To enable the emergency response providers the ability to solve the assignment within their respective areas of responsibility in an efficient manner a stepwise approach to proficiency (Figure 24 Step wise approach to proficiency) is recommended.

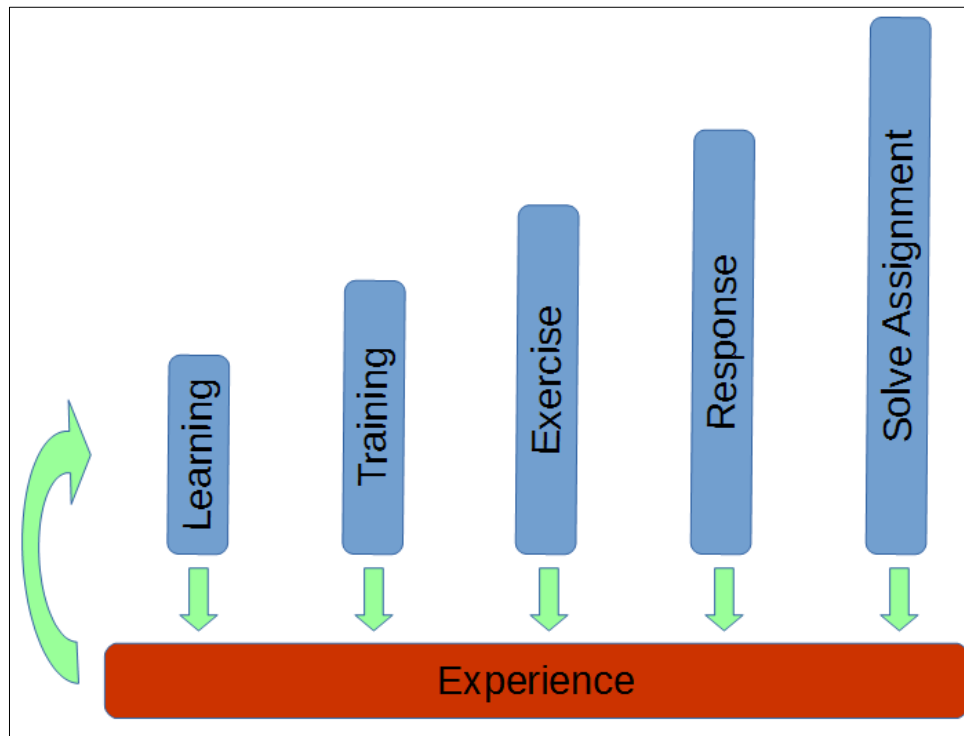


Figure 24 Step wise approach to proficiency

A typical approach for obtaining a robust and efficient emergency response service is by implementing the following steps, ref **Feil! Fant ikke referansekinden.**:

- **Learning** – Learning is important to obtain the basic knowledge required to be able to solve the assignment in an efficient manner. Learning is typically taking place in a “classroom” environment, where an instructor explains how a certain task is to be executed.
- **Training** – During training the students are to conduct the task themselves. During training it is common to break down a complex task into smaller manageable elements, that is each trained/drilled individually. Training should also be utilized when refreshing knowledge obtained at an earlier stage.
- **Exercise** – During an exercise the different elements that have been drilled during the training step are combined together to a more realistic scenario. An exercise can address challenges on all levels, from an individual level (e.g. stretcher carrying) to a high international level, involving resources from several nations.
- **Response** – all providers of emergency response services are to maintain a system that is to care-take their responsibilities. This includes every aspect relevant for them to be able to respond to events and cover their areas of responsibility, e.g. equipment, logistical solutions and personnel.

- **Solve assignment** – solving the assignment is the overarching goal of the emergency response provider. If all the above-mentioned steps have been followed the personnel is adequately equipped and competent to solve the assignment together with other emergency response units in an efficient and robust manner.

Depending on scope/pre-defined areas of interest the approach described above can be utilized for building robustness on:

- A personal level for the personnel within a SAR organization
- For a group level within an emergency response provider
- For the total of all emergency response suppliers, including cross SAR-provider cooperation.

12.2 SARex objective

Contrary to most regular activities in our society, emergency response providers only have one chance to make the right decisions or lives can be lost. Both competence and experience are important factors for success. To build an efficient and robust emergency response system, a high level of competence and experience is to be strived for.

The main motivation behind SARex3, *Evacuation from shore* was to generate learning. Learning is defined as relatively permanent change in behavior resulting from practice or experience. This implies that a change is inevitable, which again means former procedures, attitudes and knowledge have to be discharged.

Part of the learning process includes evaluating the current state of affairs against new and different knowledge. As this can reveal delusions, it can by some be experienced as a painful process. As a result, many organizations and individuals are reluctant to participate in the evaluation processes, and it has been experienced that organizations try to define an exercise scope that is well inside their comfort zone. Identification of deficiencies can happen on all levels, including technical, organizational, knowledge, logistical and human aspects. It can not only reveal that emergency response organizations do not full fill their mandate/responsibilities, it will further force organizations into change processes that can be both expensive and time consuming.

During an exercise, learning takes place on different levels. On the individual level exercises contribute to generate a toolbox which will help the individual to be more robust and enhance the understanding of the mechanism at play in a real situation. This toolbox is often regarded as experience.

On an organizational level exercises contribute to generate an understanding of weaknesses and strength internally in the organization, and in cooperation with other emergency response providers.

The SARex3 full scale exercise *Evacuation from shore* was conducted to address the following topics:

- Test and train plans and procedures.
- Test and train personnel.
- Test and train the cooperation between the personnel and between the different entities involved in the exercise, including the element of joint cooperation.

The main focus was the improvement of plans and training of personnel as the topics relevant in a large marine incident had previously not been a focus area for the Red Cross, Longyearbyen.

It is also important to appreciate the value of personal relationships across the traditional silos emerging in an exercise environment. These relationships can play a vital role in further development of emergency response services and relevant technologies.

12.3 Exercise plan

The exercise plan was developed in tight cooperation between the SARex3 management, The Governor of Svalbard (Sysselmannen) and the Norwegian Coastguard along the lines defined in “Veiledning I planlegging, gjennomføring og evaluering av øvelser” (Direktoratet for samfunnssikkerhet og beredskap, 2018). The *SMART* (Direktoratet for samfunnssikkerhet og beredskap, 2018) model was utilized in the planning process.

Part of the *SMART* model is that the topics explored are to be specific and measurable. Due to time limitations, the scope was narrowed down to cover a limited number of elements.

12.4 Execution

The execution of the evacuation phase was to consist of the following phases:

Preparation – prepare the exercise area and the participants. This included clearing the area for polar bears, putting on makeup on the participants and distribute the participants in a realistic manner over the exercise area.

Triage – as training was a large part of the SARex3 project, the Red Cross did three runs where they were to triage the patients. Each time the different Red Cross members had different tasks. Between each run the exercise was reset back to start. After the third time, the exercise progressed in a real time manner.

Establishment of reception facilities on the beach – after/during the triage, the Red Cross established a reception facility. This consisted of tents/treatment facilities and as a base for equipment.

Transportation of casualties to reception facilities - All casualties were brought to the reception facility, either by their own means (walking) or by being carried on stretchers where required.

Activities at reception facility – at the facility the casualties were registered, examined and obtained pre-medical treatment when required. The reception facility also functioned as a waiting area before the casualties were transported to the vessel (Polarsyssel).

Transportation to Polarsyssel – the casualties were transported by a polar-circle boat from the beach/reception facility to Polarsyssel.

Reception at Polarsyssel – upon arrival at Polarsyssel, the casualties were divided into their respective group based on their triage status.

Further medical treatment/waiting – each group had special requirements and needs that needed to be attended (mainly based on their medical condition). When all casualties were onboard Polarsyssel, the exercise was ended.

During the exercise the role the on the scene commander was executed by a representative from the Governor of Svalbard. He communicated with Polarsyssel. Onboard the vessel officers from the Governor of Svalbard had established and manned an operational command center. This center was

communicating directly with the Governor of Svalbard in Longyearbyen and the headquarter in Oslo. To enable this, Marine Broadband Radio was utilized.

12.5 Evaluators

During the exercise the activities were constantly evaluated and recorded by SARex resource personnel, coast guard resource personnel and medical personnel. All evaluators were briefed prior to the exercise on focus areas, and some were given special tasks to assess. The evaluators were also provided with an evaluation form. Due to the uncertainty associated with how the exercise participants handled the given tasks, the evaluation form was only to serve as a guide line.

After the exercise all evaluators and exercise “casualties” gathered onboard KV Svalbard. The aim of this gathering was to agree on and reach consensus with regards to improvement points/findings valid for the predefined focus areas. All improvement points/findings were to be specific and there was to be a consensus within the group that the improvement point/finding was representative for the group/the operation, not linked to a single individual.

12.6 Findings

The following findings were reported from the team of evaluators in cooperation with the experience gathered from the “casualties”:

1. Technical systems, e.g. communication system between on-scene coordinator and Polarsysssel, steals attention. In a critical situation, distractions should be minimized to ensure focus on the key issues.
2. In a potentially challenging environment, especially during operations involving a large number of people, covering a large area, maintaining a constant control of SAR-personnel is important.
3. At the scene of the accident it can be stressful. Clear and distinct leadership is crucial. However, it is also important that the leadership encourages the personnel to take initiatives.
4. When conducting special tasks, e.g. triage, it is important to use enough time to ensure the task is done in a consistent manner as “sloppy” work can result in additional work down the line (reduces efficiency of the operation).
5. It is to be acknowledged that the operational procedures related to triage is different for the Red Cross compared to what is regarded as best practice by medical personnel or the methods utilized by the Coast Guard. The differences are to be transparent and there should be a mutual understanding on how the different organizations conducts a triage. This is very important for efficient cooperation across several organizations to prevent the effort and resources associated with possible re-triage of the patients.
6. All personnel should be equipped with a radio, both for communication relevant for an efficient operation and to ensure their own safety.
7. In a cruise ship scenario many of the casualties will most likely have a medical history. It is important to reveal this as far as possible before commencing any medical treatment.
8. Due to the long lag-time associate with large incidents/accidents and remoteness, one must request need for additional resources as early as possible. This applies both internally on the scene of the accident and externally when requesting resources from the Joint Rescue Coordination Center.
9. Carrying stretchers put a lot of strain on the stretcher carriers. For longer distances it is important that each stretcher team consists of more than 4 people.

10. The casualties that are to walk themselves have to be organized and followed by a Red Cross representative to ensure they are going to the right place or a deterioration of their condition is causing problems during the transportation.
11. It is important to acknowledge the large gaps internally in the Red Cross with regards to knowledge and experience. To manage the resources in an efficient way, allocate resources to different tasks based not only on availability, but also base the allocation on individual knowledge and experience.
12. A pilot ladder for entering Polarsyssel is not suitable for use by casualties.
13. Develop and train on an efficient system for transportation of immobile patients from the shore and onto the mob-boat.
14. Coordination between shore party and reception facilities onboard Polarsyssel is important to ensure a swift movement of patients away from the mob-boat dock (Polarsyssel) to treatment/resting facilities onboard Polarsyssel.
15. Maintain personnel control of both Red Cross members and personnel from the Governor of Svalbard, in addition to casualties when entering Polarsyssel.
16. Polarsyssel to have adequate manning for continuous operation of 2 mob-boats including launch and recovery systems with qualified personnel. This will also serve as a contingency and backup if there is an operational or technical outage on one of the boats deployed.
17. Do not use the upper bed if cabins are to be used for medical treatment.
18. Small cabins are not ideal for neither medical treatment or as waiting areas for a large number of people. Large tents under the helipad/on deck could accommodate a large number of people.
19. Preparations of reception facilities to be conducted prior to arrival at the scene of the accident.
20. Due to potentially long waiting times, keep the uninjured casualties occupied if possible. This can be done in a combination of ways, e.g. in assisting the operation, have them organize and make food/drinks and/or implement system where they take care of each other (extended buddy system).
21. Ensure the uninjured casualties are kept informed of relevant information at regular intervals, preferably from a single point of contact from the SAR-providers.
22. Maintain a representative from the Red Cross in the waiting area at all times for assessment of medical deterioration and support of the uninjured casualties.
23. Deployment of trained medical personnel together with the Red Cross is essential for medical treatment/assessment of situation, especially when casualties have a medical history.
24. Onboard Polarsyssel clear leadership and a clear line of commands, distributing responsibilities is essential for an organized and efficient operation.
25. It is important to acknowledge the challenge represented solely by the fact that there are many casualties. This challenge is to be addressed in the operational procedures, and the additional tasks are to be identified.
26. The additional challenges represented by a large number of casualties will require additional human resources among SAR-personnel.
27. It is important to communicate the limitations of the emergency response provider to Governor of Svalbard/the Joint Rescue Coordination Center with regards to issues like:
 - Available personnel
 - Medical competences/limitations
 - Duration (time) an operation can be conducted in a sustainable manner
 - Logistical limitations
 - Equipment limitations
 - Level of training
 - Human aspects (e.g. level of mental robustness/experience when utilizing non-professional personnel)

28. The limitations mentioned above should be addressed ahead of any incident/accident, which enables the responsible authority to acquire and deploy resources that are fit for purpose.
29. It is to be acknowledged that operability and knowledge deteriorate quickly. Conducting regular training and exercises addressing the topics of relevance is required to maintain a high level of functionality. Performing these activities require economic funding and will consume a significant amount of time.

12.7 Recommendation

The SARex exercise gave the evaluators an insight into the condition of the current SAR providers present in the Svalbard area. It is difficult to define clear recommendations as these recommendations will have large political and economic implications beyond the scope of the SARex3 project. There are, however, some topics that the project would emphasize. It is recommended that the following topics are considered with regards to dimensioning and designing an emergency response plan for marine incidents in the Svalbard area:

1. Technologies like MBR (Marine Broadband Radios) and drones are important assets for SAR operations. It is, however, important to train and acquire experience about the human interface (man/machine) in addition to the implications caused by cold climate/remoteness. Due to these effects regular training, including documentation of improvement points should be considered.
2. There is a significant difference with regards to response time and *time to rescue* for smaller incidents, e.g. a fishing boat, compared with an event that involves several hundred casualties. The resources available in Longyearbyen are limited (e.g. number of hospital beds), and is dimensioned to handle up to medium size incidents. In an incident involving several hundred casualties, much of the resources have to be acquired from the mainland, resulting in extended *time to rescue*. According to the IMO Polar Code all vessels are to assess the *maximum expected time to rescue* (which can be more than 5 days) and have to dimension their equipment to maintain survival for the duration. Vessel operators are encouraged to consider the effect a large number of passengers have on response time/*time to rescue* in their Operational Assessment, and mitigate the undesirable effects in the dimensioning of the survival crafts, PSK and GSK kits.
3. Currently the Red Cross Longyearbyen is a substantial part of the emergency response service available in Longyearbyen. Being a voluntary organization there are limitations with regards to:
 - i. Available personnel
 - ii. Medical competences/limitations
 - iii. Duration (time) an operation can be conducted in a sustainable manner
 - iv. Logistical limitations
 - v. Equipment limitations
 - vi. Level of training
 - vii. Human aspects (e.g. level of mental robustness/experience when utilizing non-professional personnel)

The issues mentioned above has to be acknowledged and communicated. Being an important SAR provider recognized by the official authority in Svalbard, both the Red Cross Longyearbyen and the Governor of Svalbard are responsible to at all times have an understanding of the current situation within the limitations mentioned above. This is especially

important due to the dynamic nature of the citizens of Longyearbyen, and most of the Red Cross members are only part of the organization for a limited period of time.

4. Due to limited available resources in the area and potentially long response time, the first responders arriving at a scene of an accident can get into a situation that is beyond their level of training. Robustness and flexibility are extremely important factors that enables emergency response providers to manage new and unfamiliar situations. The implications of this must be reflected in both the practical training and in the mental preparations.
5. As most Red Cross members are only part of the Red Cross as a hobby, they have limited availability and time for training/exercises. Utilizing the Red Cross for “random” tasks, e.g. patrolling after the avalanche (2015) is to be considered on an individual basis. It is however important to recognize that these activities contribute to consuming time that otherwise could be utilized for training.
6. All Red Cross members are having basic first aid training. Some members could be allocated for a special task force that is to specialize in marine incidents along the same lines as currently being done in Bregruppa and Skredgruppa. This will contribute to raise knowledge level and increase the SAR robustness.
7. The Red Cross Longyearbyen is an extremely low cost emergency response resource. If their area of responsibility is to increase/being allocated new tasks, further training of personnel will be required. The costs associated with this should be covered by governmental funding if the Red Cross Longyearbyen is to be a part of the official emergency response units.

13 Communication

13.1 Terms and abbreviations

MBR	Maritime Broadband Radio
MF	Medium Frequency
HF	High Frequency
VHF	Very High Frequency
LTE	Long Term Evolution (Cellular radio technology)
DMR	Digital Mobile Radio
QoS	Quality Of Service
LOS / NLOS	Line Of Sight / No Line Of Sight
VLBI	Very Long Baseline Interferometry
UAV	Unmanned Aerial Vehicle
IP	Internet Protocol
TDM	Time Division Multiplexing
FDD	Frequency Division Duplex
MBR	Maritime Broadband Radio

13.2 Background

How to cope with maritime crises and emergencies is one of the major challenges emerging due to the increased shipping activity in the polar regions. Through the International Convention on Maritime Search and Rescue (SAR) and Global Maritime Distress and Safety System (GMDSS), the maritime nations around the world have gathered through the auspices of IMO to handle maritime disasters. The SAR convention came into force in 1979 to prove a global system for responding to emergencies and the GMDSS was established to provide the SAR convention with the efficient communication support it needed to succeed for saving lives, environment and properties from accidents at sea. Both the SAR and GMDSS are crucial to the maritime safety and to ensure that any emergency at sea will result in a distress call and a response that will be immediate and effective (IMO, 1999).

The GMDSS is a worldwide network for emergency communications among ships at sea. This means that all ocean-going passenger and cargo ships above 300 tons must be equipped with radio and satellite facilities to alert and communicate with respective on-shore search and rescue authorities and other ships in vicinity in case of a distress situation. The GMDSS system has divided the ocean into smaller sea areas. The system has limitations with respect to coverage, and it defines a minimum standard of equipment for vessels for compliance within each of area. For vessels operating within the area of the polar region as defined in the Polar Code, they have as starting point to be approved with GMDSS certificates for Area A4 since most of the areas of the polar regions are within this area. There are also areas in the polar regions which only have A1, A2, or A3 coverage, Table 1.

GMDSS areas and equipment.		
	Communication coverage	Communication equipment
A1	Within continuous VHF (Very High Frequency) DSC (Digital Selective Calling) coverage from a CRS with follow on VHF RT (Radio Telephony) (about 20 - 30 NM from the coast)	VHF radio – DSC and RT NAVTEX receiver - Automatic reception of MSI (Maritime Safety Information)
A2	Outside Sea Area A1 Within continuous MF (Medium Frequency) DSC coverage from a CRS with follow on MF RT (about 100 NM from the coast)	MF radio – DSC and RT Plus, the equipment included for Sea Area A1
A3	Outside Sea Areas A1 & A2 Within INMARSAT (International Maritime Satellite Organization) coverage, that is between 70° North and 70° South	HF (High Frequency) radio – DSC Or INMARSAT – Satellite Communication Plus System for reception of MSI in Sea Area A3 (EGC or Radio Telex) Plus The equipment included for Sea Areas A1 & A2
A4	Outside Sea Areas A1, A2 & A3 Above 70° N and below 70° S	HF radio – DSC Plus, the equipment included for Sea Areas A1 & A2

Figure 25 GMDSS areas and related equipment.

The Polar Code, chapter 10, requires equipment for a) ship-shore voice and data communication, b) telemedical assistance services and equipment for receiving ice and meteorological information, c) ship-to-ship voice and data communication and d) maritime aeronautical two-way voice on-scene and search and rescue communications. To some extent, the existing regulations of the GMDSS can be used to meet the requirements in the Polar Code, such as ship-shore voice communication, maritime safety information and SAR communication. Nevertheless, the requirement of voice to voice communication is difficult to fulfill with GMDSS. The traditional MF/HF equipment carried onboard ships relies on shore stations that can handle this type of communication (Plass P., Clazzer F., Bekkadal F., M.Manzo, 2014). There are also a diminishing number of skilled operators both onshore and onboard the vessels that have experience with MF/HF communication. To succeed with communication the mariners onboard the vessels have to be trained with the communication equipment they are using. As most ocean-going routes today are within the limits of area A3, most mariners are not using MF/HF stations or the telex stations on a regular basis, as required within area A4. Furthermore, communication units onboard ships vary greatly in quality and condition.

In addition to the requirements of reliable voice communication, the Polar Code requires data communication enabling vessels to receive meteorological forecast, ice conditions, satellite imagery and the ability to conduct telemedical assistance. In a report by SARINOR (Persson, Ø.R. and T. Sætrum, 2014) the low reliability and low bandwidth available to telemedicine communication was identified as one of the main challenges in an accident scenario. The GMDSS needs to be modernized especially for vessels working outside sea area A3 which means they are outside the geostationary footprint. Several technologies exist today and new are emerging that can fulfill the Polar Code requirements, but as long as unified and common regulations for these satellite systems does not exist, there will be no common platform that works across all land and sea-based stations.

The Iridium system has global coverage, including the polar areas. From 2020 the Iridium system will be part of the GMDSS. It has however a very limited data rate. The Iridium Next constellation (70 LEO satellites) which is now operational claims to have a data rate of 1,5Mbs, which is a substantial improvement compared with the traditional Iridium system.

Satellite based VDS (VHF Data Exchange System) is currently being tested. The system would enable basic data communication, allowing communication of information like navigational warnings, weather forecasts and simple ice charts. The system allows two-way communication, and could be utilized by the emergency response providers.

Today's systems such as the Inmarsat, does not have coverage north of 80°, and have limited coverage and reliability between 70° and 80° North. Another satellite constellation is the Low Earth Orbiting Satellites, but also this constellation has not proven either reliability nor data rate in the areas north of

70° (Dyrkornen E., Berge T.E, 2014). One emerging technology that can be viable is the High Elliptical Orbit (HEO) system which both is to have coverage beyond 70° North and can deliver a sufficient data rate to fulfill the requirements in the Polar Code. Nevertheless, satellite communication systems represent a proven solution, common for them all is that they are subject to atmospheric and ionospheric disturbances. In the northern and southern hemisphere, this activity can be relative intense. Figure 26 Communication systems performance in the Arctic and Figure 27 Communication challenges in the Arctic (K. Fjørtoft, B. Kvamstad and F. Bekkadal, 2012) below, extracted from (K. Fjørtoft, B. Kvamstad and F. Bekkadal, 2012), summarize the available and unavailable systems, and their common communications challenges.

	System	Characteristics	Polar (>80°N)	Sub-Polar (70°N - 80°N)	Other (<70°N)
Terrestrial systems	HF, MF	Safety related messages and voice communications	OK, but unsuitable for digital communications	OK, but unsuitable for digital communications	OK, but unsuitable for digital communications
	VHF, digital VHF, GSM, 3G	Line-of-sight, voice and low data rate communications	No base stations, ship-to-ship OK	Few base stations, ship-to-ship OK	VHF is OK close to the coast, GSM/3G limited coastal coverage
Satellite systems	GEO satellites, including Inmarsat.	Medium capacity. Low to medium latency.	Not available	Potential problems with quality and availability	OK (except in fjords and similar special areas)
	LEO satellites; Iridium <u>OpenPort</u>	Currently max. 128 kbps. High and variable latency.	Potential problems with quality	Potential problems with quality	OK, except for areas around equator
	HEO satellites	Properties comparable to GEO. Currently unavailable.	Expected to provide good coverage, capacity and quality in the Polar and Sub-Polar areas. Spare capacity can be used in other sea areas. Not yet implemented.		

Figure 26 Communication systems performance in the Arctic (IMO, 1999)

Challenge	Cause	Consequence
Low elevation angles	Geostationary orbit satellites	Signal loss due to shadowing, low signal strengths. Signal loss when combined with heavy roll, pitch and heave of vessels.
Additional signal transit distance	Geostationary orbit satellites	Signal attenuation and degraded quality due to atmospheric (for frequencies > 10 Gz) and <u>ionospheric disturbances</u> (for frequencies < 1GHz).
Icing on antennas	Ice accumulation from sea spray and air humidity	Signal attenuation and degraded signal quality ³ .
Signal delay and latency variations	Lack of earth stations/gateways	Real time requirements are difficult to achieve

Figure 27 Communication challenges in the Arctic (K. Fjørtoft, B. Kvamstad and F. Bekkadal, 2012)

To be able to cope with future requirements in Arctic Shipping, the GMDSS system and sea area A4 needs to be modernized and designed for multiple functional requirements. Especially alternatives to HF communications are need as well as a common platform to ensure reliability and x-platform communication between vessels and between vessels and shore.

13.2.1 Basic challenges

Different types of functional requirements are identified when managing a marine incident. The different requirements will demand different communication solutions. It is of importance that all parties involved in the incident is equipped to meet their internal demands and that there is compatibility between the different systems obtained by the different emergency response providers. This enables not only communication between the emergency response providers, but also enables the Joint Rescue Coordination Center to obtain an adequate situational awareness to enable management of available resources in a sustainable manner.

In most of the Arctic there is limited coverage by shore based communication systems. The challenges faced due to the effect of the above is summarized below.

13.2.1.1 Communication between emergency responders

Voice communication is not always accessible with MF/HF/VHF-radios. The topography with alpine terrain and long fjords prevents line of sight. At high latitudes access to the geostationary Inmarsat system is limited or non-existing. Already at 60 degrees latitude low satellite elevation angles can make communication challenging during inshore passages due to the shadowing effect caused by geographical features e.g. mountains.

The Iridium system has worldwide coverage, including the Arctic region. This system provides voice communication and a usable data speed of 2 400 baud. 2 400 baud is regarded as a relatively low data speed by today's standard and limits the usability of the system.

The limitations of today's communication systems reduces the ability of the emergency responders to provide and communicate information to the Joint Rescue Coordination Center.

Planes and helicopters has been utilized as communication relays (VHF band) as they maintain a line of sight to the VHF base stations at high altitudes.

13.2.1.2 Data access

For the best possible situation awareness, the exchange of data is a key factor. The amount of available data bandwidth defines the opportunities be available.

Low data bandwidths only allow for basic voice services such as VHF and exchange of small sized documents and pictures without affecting the downlink and uplink to a high degree.

High data bandwidths allow for multi voice services, exchange of bigger documents and pictures, live video, etc.

Increased data access opens up for a whole range of other possibilities, increasing the common operational pictures, enabling activities like e.g. environmental surveillance and increased coordination of resources.

13.2.1.3 Mass communication

Emergency responders need to communicate with the people in distress. The ability to reach and communicate with variety of emergency response resources and casualties spread over a large geographical area is limited. Portable HF radios and satellite phones is not considered part of the normal LSA equipment, and is not carried by most life rafts/lifeboats.

The use of standard cellular devices, which is owned by almost everyone, can be used to gather intelligence of all terminals in the area, sending mass messages to all terminals connected a specific base station. It will also enable people to notify emergency responders without having special types of terminals or emergency locator beacons.

13.3 Objective of the communication test

Due to the lack of communications channels, many emergency response providers look to the use of Marine Broadband Radios for establishing communication in the Svalbard area.

The objective of this part of the exercise was to implement the use of Maritime Broadband Radios (MBR) in SAR operations. It was of importance to assess the following parameters:

1. Practical implementation challenges associated with initiation of relay stations
2. System reliability
3. Practical implementation challenges associated with utilization of system for communication in SAR operations.

13.4 Planning

Before the exercise commenced, Telenor Svalbard and Kongsberg Seatex initiated a base station located in Ny-Ålesund. This station was further connected to the internet via the fiber optic cable system.

A relay station located on Enjalbalstranda was established. Establishing the relay station included the following tasks:

- Provide station power supply (generator)
- Erect antennas
- Initiate MBR module
- Verify signal strength and coverage area

Polarsyssel communicated directly with the relay station at Enjalbalstranda, which forwarded the data to the MBR station located in Ny-Ålesund.



Figure 28 The exercise area located in the Northern part of Svalbard

13.4.1 Permits

The area around Ny-Ålesund has strict radio regulations due to sensitive scientific instruments and has radio silence for all not-approved transmitters within a 20km radius operating at 2 – 32GHz. The reason behind this is due to the Norwegian Mapping Authority's VLBI station listening at quasar pulses at very low signal strengths.

A request to the Norwegian Telecommunications Authority and Norwegian Mapping Authority was made with the request of establishing temporary transmitters with a center frequency at 5862MHz. A permit was granted on a rather short notice, allowing us to have active transmitters in the exercise area.

Other frequencies used did not require a special permit since we operated outside the 20Km radius and since Telenor has a spectrum license for LTE1800 at Svalbard.

The location of the exercise area demanded a relay station placed between each end. We applied a permit from the Governor on Svalbard placing a temporary transmitter with a small generator on land.



Figure 29 The radio link from Ny-Ålesund to the exercise area

13.5 Execution

The establishment and calibration of the communication system was executed by representatives from Kongsberg Seatex and from Telenor Svalbard. They were “self-sufficient” and the activity was taking place parallel with survival exercise in Fjortende Julibukta.

13.5.1 Logistics in the operations area

Getting around at Svalbard is complicated, especially at the time of year when neither small boats or snow mobiles are available. The activities were not to disturb the planned survival- or the rescue phase of the exercise. Transportation to Ny-Ålesund was pre-arranged early to provide a couple of days for establishment and testing of the system before the equipment was to be utilized in the evacuation phase of the exercise. In Ny-Ålesund, both the Norwegian Polar Institute and Kings Bay AS was helpful and arranged transportation and logistics locally. Cooperation with local players for handling logistic operations is a key factor for success.

13.6 Network planning and testing

The Norwegian Coastal Administration had available radio equipment stored locally at Svalbard allowing us to conduct the setup without waiting for shipments from the mainland Norway.

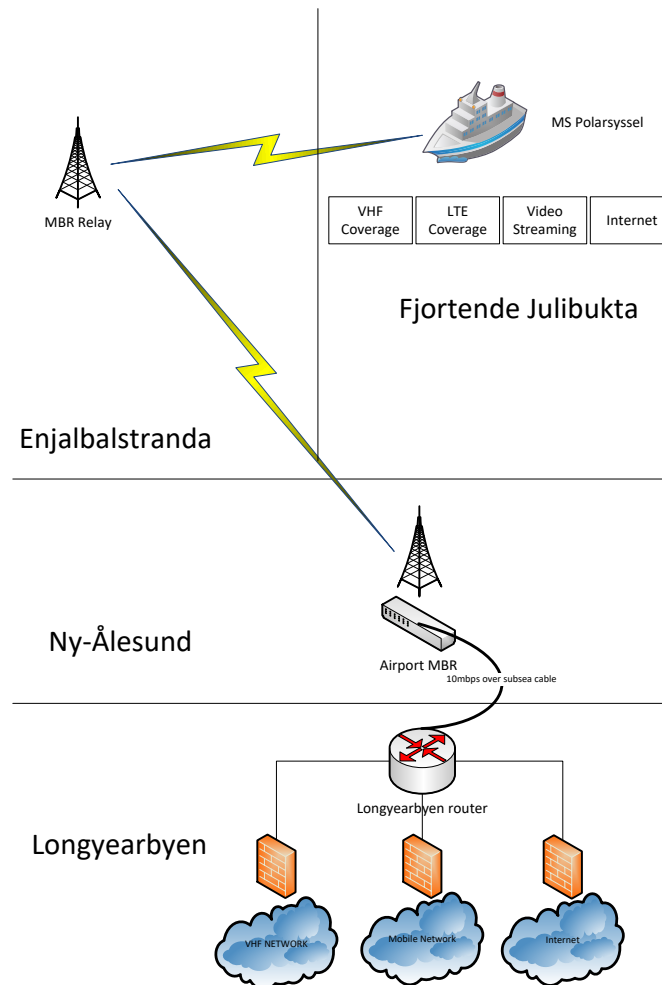


Figure 30 The communication channel from Longyearbyen to Fjortende Julibukta

The Governor of Svalbard's vessel Polarsyssel had earlier this year been fitted with a MBR, sponsored by the Norwegian Coastal Administration.

Together with the Governor of Svalbard and Kongsberg Seatex, the intended network was locally setup and tested in Longyearbyen prior to departure. The following services were provided over the MBR network:

- Motorola DMR VHF Base Station with backhaul to the rest of the Governors VHF network
- Huawei BTS3912E LTE1800 (4G) Small Cell with backhaul to Telenor's mobile network
- Live video stream from the search camera aboard the Governors vessel MS Polarsyssel through a streaming server provided by Telenor Svalbard AS
- Live video stream from UAV with zoom and thermal camera using KSI Missioncaster and Missionkeeper
- Internet access through Telenor Svalbard AS internet gateway

Tests were performed locally and at the operations area and results were as expected. All services were operational providing VHF, LTE, live video and internet access.

13.6.1 Operations during the rescue exercise

13.6.1.1 From the service providers perspective

At approximately 05:00AM UTC the 12th of May 2018, the network was operational with local VHF coverage and running live video to the internet. LTE was put into service around 06:00AM UTC. The network kept operational throughout the day with some minor downtimes both due to equipment faults and due to prioritizing the various services. The network was kept running all day until approx. 16:00PM UTC until it was shut down intentionally.

13.6.1.2 From the end user perspective

The network was tested with multiple services, and the outcome was satisfying. During the rescue operation, the network had some failures and could not be fixed by other than the technical personnel. This is a concern as such resources will not be available during a real scenario. Even so, the mobility and future turnkey systems open up for communication from most areas around the archipelago of Svalbard that has been difficult, or even impossible previously.

13.7 Findings

13.7.1 MBR as a multi service backhaul system

MBR has so far proven to be the most promising solution for providing communication services in remote areas. Its point to multipoint capabilities is delivering a stable network according to the specifications. The short period of preparations did not provide time to establish necessary QoS rules or other traffic prioritizing mechanisms.

A common misconception is to interpret broadband as an unlimited network resource. This is not the case, and the available network bandwidth must be taken into consideration. A network using relay stations has clear limitations, as each relay station reduces the effective bandwidth by 50%. The beta release of the firmware does not support mesh networking. Future releases aim at supporting mesh networking which enables the radios to find the best network path when communicating to several other stations, possibly increasing the effective bandwidth. With a total capacity at 3.25Mbps both ways, we could have all services running together, with only small disruptions in voice and video.

Deployment is simple as the phased array with beamforming does not need any special antenna setup or adjustments. The radio will find its “targets” and beam the RF signal in the right direction without any human involvement. This makes the MBR radio a flexible and highly mobile system.

13.7.2 Best use of the MBR radio

By using the MBR radio as a direct point to point network allows for more network bandwidth. A network with many enabled radios have to take the timeslot usage and the configuration of resources into consideration, as each radio will occupy network resources. A single hop between two radios will allow for up to 15Mbps one way and will provide more possibilities than in a large network setup.

Multi-hop relayed networks will have limitations as the bandwidth will be cut in half over each hop. Each relay must have at least the double number of timeslots than given to each endpoint. This can be avoided using two radios back to back with separate frequencies to maintain the benefits of a point-to-point network.

The long reach LOS and partial NLOS capabilities of the MBR radio are preferred when you have the best possible height of the antenna. Stationary land based sites will give the best coverage when placed in high terrain.

13.7.3 Local services

In this demonstration, all data services were accessed over the internet. All the traffic was routed from Fjortende Julibukta to Oslo, to the internet, and was then transferred back to the exercise area again. VHF was accessed in Longyearbyen. LTE Voice was accessed in Oslo.

The LTE network was accessible quite far away from where it was installed at MS Polarsyssel, allowing people to communicate from the Coast Guard vessel KV Svalbard and emergency responders on shore.

The Governor of Svalbard tested GIS applications for making a real-time situation map for all attendees, including emergency response providers in Oslo. This increased the situational awareness and enables Joint Rescue Coordination Centres to manage resources in an improved manner. The loading of map

tiles and other information was quite data demanding. It would be preferable if the map data was cached or accessed locally. This would require only communication of new gathered data, which would preserve network bandwidth.

The same also applies to the LTE network, which should maintain the ability to exchange data and voice calls over the local LTE network. This can be achieved by setting up a local mobile core.

13.7.4 Public access

In a real emergency situation, public internet access would not be allowed to preserve bandwidth. Being able to communicate to everyone with a cellular handset would however be preferable. The internet access could be restricted by a firewall which could only allow certain services for the emergency responders. The traffic itself could also be shaped by QoS to prevent it from interfering with the prioritised voice and video transmission.

13.7.5 Live video streaming

High definition live video streaming is bandwidth consuming, especially with the traditional H.264 encoding. A 720p 25fps video stream will demand at least 1800kbps for the picture to be clear. This harmonized with our observations when streaming video from the exercise area to the internet.

The newer H.265 encoding (HEVC) only use half the bitrate and can stream high definition videos under a rate of 1000kbps. This would be the preferable solution in low bandwidth scenarios.

We also conducted a test using the MBR144 personal radio with a H.265 helmet camera. This was only streamed locally and shows the capabilities of streaming live video from emergency responders back to the on-scene commander/vessel.

13.7.6 Operational and usability

The MBR network and systems must seamlessly work together as a turnkey solution for the end user. Operations and management of that network should be done remotely. It's very important to identify failures early to do the necessary measures, especially in time critical situations.

The user interface should be safe explanatory, and the emergency responders must have equipment that can easily be switched on and off without the need of any configuration to make that equipment work. It is also to be recognized that training by emergency response providers in both establishment and use of the system is to be required for reliable operation.

13.8 Further development of communication on Svalbard

There are currently many different technologies delivering the functionality required to improve communication around Svalbard. Common for most of the “line of sight” technologies are the infrastructural demands for base stations. This is also valid for MBR. MBR is a datalink which has some unique properties with regards to range and flexibility. It is however important to acknowledge that development of communication utilizing MBR radios will require further infrastructural development of a network of base stations.

Improving the communication abilities is not a question of technology, but mainly of political willingness and funding. This includes the cost induced by organizations that can service the infrastructure. The organizations need to have local competence and the ability to physically visit the infrastructure at regular intervals.

To cover the cost associated with further development of the communication around Svalbard a privat/public joint venture model is recommended. There is currently a relatively high cost associated with a MBR communication system and there are few users outside the emergency response providers in the Svalbard area. To make further development of communication infrastructure economically feasible there is only a marginal cost associated with equipping potentially new base stations with additional technologies like LTE enabling mobile phone/data communication.

LTE (4G) backhaul can provide capacities of 70mbps at 100km both ways, and 5G will enable even higher data rates. This is a significant improvement compared with the data rate provided by the MBR technology, especially when utilized in locations where several hops/relay stations would be required.

Having a system that enables utilization of existing equipment, e.g. marine VHF and cellular phones, makes the system available for a wider audience and increases the potential for generating income. LTE is utilizing standard protocols. This opens up for a variety of services and equipment providers, providing the end users a higher flexibility and ability to utilize standard equipment.

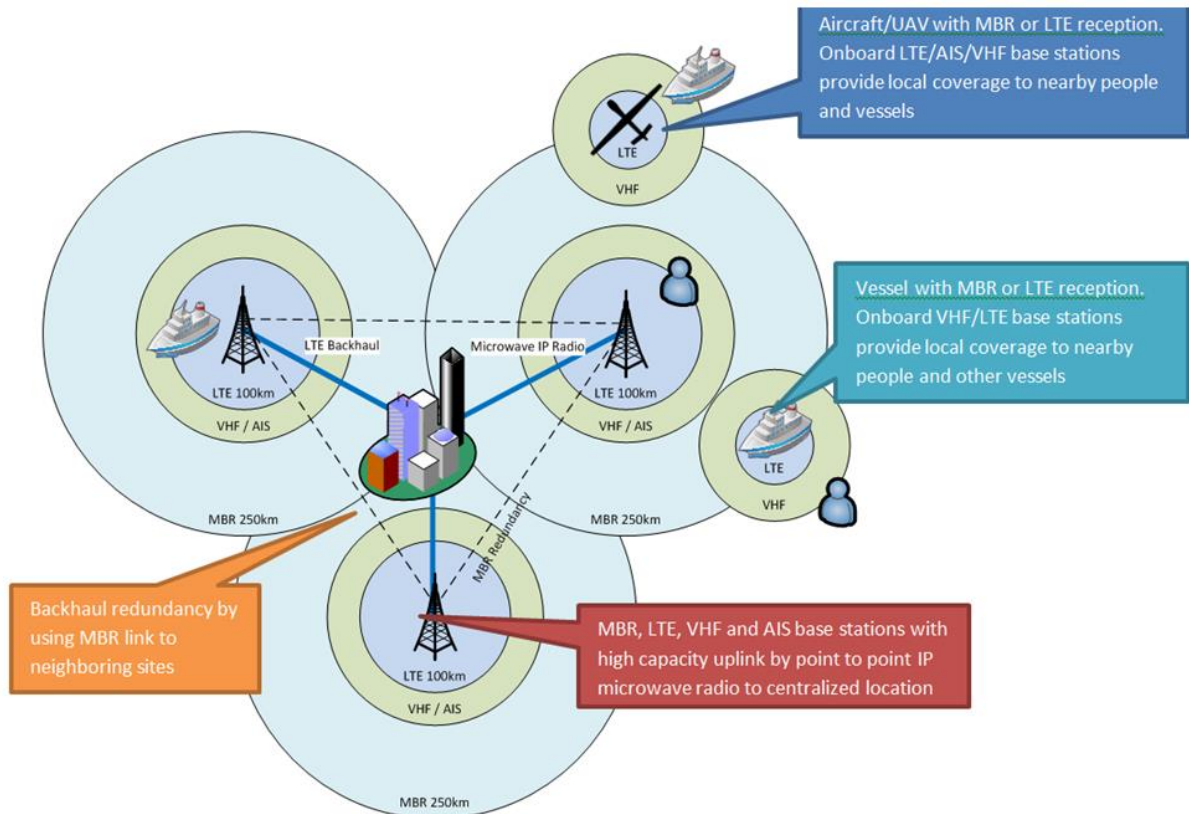


Figure 31 Potential within development of communication.

Designing a “line of sight” system that combines different technologies will increase key elements important for success:

- Increase the potential for commercial operation
- Increase redundancy
- Increase robustness
- Ability to be modified to meet technological advancement
- Adapt to future demands, e.g. an increase in traffic

In the future development of communication in Svalbard it is of importance to have a long term perspective and consider the above elements to define a sustainable solution.

13.9 Recommendations

Maritime communications at the Svalbard archipelago is currently based on MF, HF, VHF and satellites.

MF- and HF-radios provides long reach coverage of voice, DSC and NAVTEX. In good conditions they will act as a minimum for communications between vessels and the Norwegian Coastal Radio stations. VHF provides better quality voice, but at a shorter coverage area. All stationary maritime MF, HF and VHF radio communications are operated by Telenor Coastal Radio on behalf of the Norwegian authorities.

Geostationary satellite constellations are available with a line of sight to the south. LEO constellations such as Iridium are available most of the time. Common for these systems, they are vulnerable for topographic-, ionospheric-, and geomagnetic conditions. The latency is relatively high and data bandwidth low.

In the area around Isfjorden and Van Mijenfjorden, cellular network coverage is also an option. The main part of Isfjorden has 2G (GSM) and 4G (LTE) capabilities. Cellular networks based on LTE have the reach of approximately 100km with line of sight. The data bandwidth is at 150mbps per carrier (frequency bandwidth), which is significantly higher than the bandwidth provided by the LEO constellation.

The Norwegian Coastal Administration has the last years looked into a product, from Kongsberg Seatex AS, named Maritime Broadband Radio (MBR). This is a product family was originally intended as a vessel to vessel communication system. The Norwegian Coastal Administration needed a system to use as backhaul for AIS transceivers where no other communications carriers were available. This resulted in a MBR deployment at Svalbard, mainly around Isfjorden and Van Mijenfjorden. MBR has the capability of running up to 15mbps one way (downlink or uplink) or divided by the two directions, with up to 250km reach with a free line of sight. It can operate towards stationary and mobile objects without the need of readjusting the antennas.

The Governor at Svalbard together with local emergency responders has stated that communications during rescue operations are critical for emergency response operations. To enable development of a reliable and robust common operational, based on the observations done at SARex3, the following is recommended:

- Identify the communication needs for Svalbard based on demand from current and potential future users, utilizing existing communications technology, including MBR. Based on demand identified, establish required stations and infrastructure. Each station should be equipped with multiple types of communication services depending on demand.
- Develop a standardized rapid deployable communication package, including a front end, e.g. LTE and Emergency/Marine VHF. The unit will be utilized by the emergency response providers to establish communication locally, in the area of an incident. Utilizing established and well proven front-end systems enables the emergency response providers to utilize existing and well proven equipment seamless with technologies such as the MBR system, LTE backhaul and existing and future satellite constellations. The unit should be turn key solutions and have a simple user interface. This system should consist of both ship mounted and mobile/portable packages. It is also important to acknowledge the need for defining and formalising system owners, service supplier's maintenance providers and users through long term agreements to minimize the need for technical personnel in the field.
- Train emergency response providers, especially the first responders, in establishment/use/limitations of the emergency communication package described above.

- Establishment of consensus between the emergency response providers with regards to a user-friendly software package, delivering a common platform for generating common situational awareness. The software package should be generic and should be available for different platforms, e.g. pc's and tablets/phones and not linked to a specific communication carrier. The software should take into consideration the communication systems available and the limited bandwidth.
- Develop a long-term strategy for development of communication in the Svalbard area as a joint venture between industry and public players. The plan is to capture opening of new geographical areas for commercial operation, future demand from emergency response providers and the industry and the potential represented by new technology.

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16 Appendixes

Appendix A. Level of Insulation

Appendix B. Ventilation – Oxygen consumption/CO₂ production

Appendix C. Contributions from SARex participants

Appendix A. Level of insulation

Utilizing the methodology illustrated in the SARex3 report, the heat balance for different metabolic rates can be plotted, Figure A1. Note that we are assuming a sitting position in a life raft where, 25.5% of the body is in physical contact with the floor of the raft. To maintain survival, it is important that the heat balance is above 0, as a negative heat balance will result in development of hypothermia.

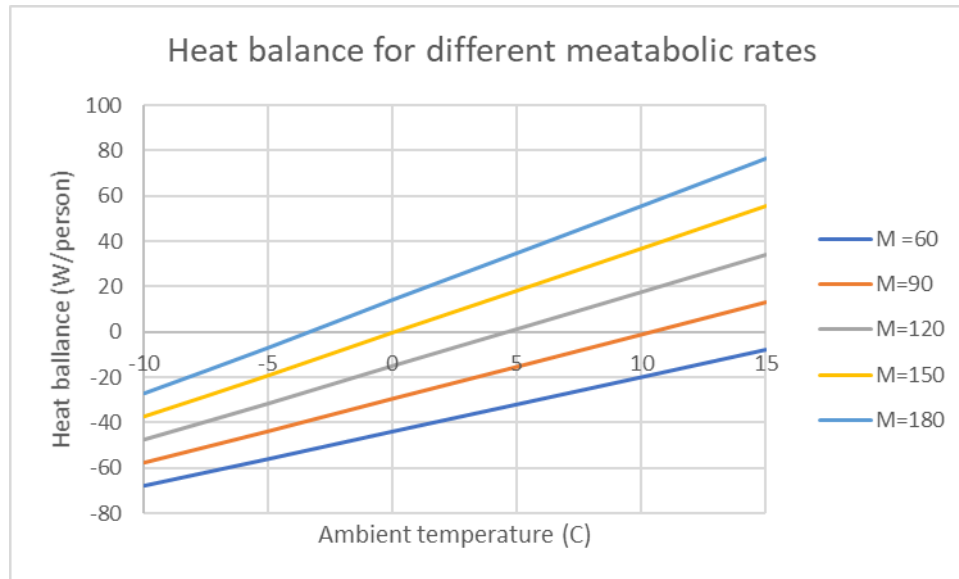


Figure A1 Heat balance for different metabolic rates. Insulation of clothes = 3 cloe, Heat transfer coefficient bottom (k) = 0.13 with a raft bottom thickness of 10 cm (significantly reducing the heat loss to the sea), windspeed = 0.1 m/s.

Utilizing the same model for the conditions and equipment utilized during SARex1 reveals the following results, see Figure A32 Heat balance per person. Insulation clothes = 3 cloe, Heat transfer coefficient (k) through bottom = 0.13 with a raft bottom thickness of 0.5 cm, windspeed = 0.1 m/s. Ambient air temperature = 0°C. and Figure A33 Heat balance per person. Insulation clothes = 3 cloe, Heat transfer coefficient (k) through bottom = 0.13 with a bottom thickness of 0.5 cm, windspeed = 0.1 m/s. Metabolic rate 100 Watt/m².

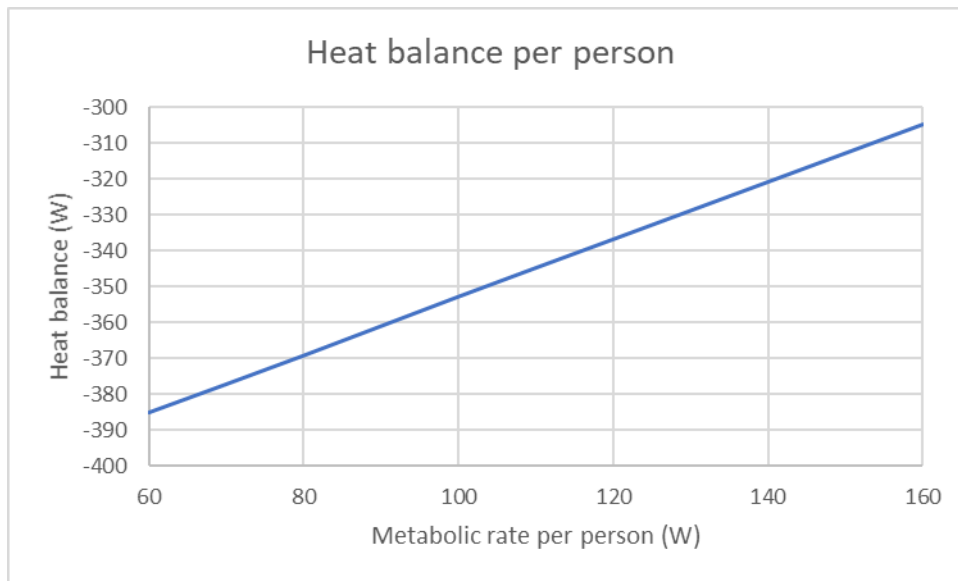


Figure A32 Heat balance per person. Insulation clothes = 3 cloe, Heat transfer coefficient (k) though bottom = 0.13 with a raft bottom thickness of 0.5 cm, windspeed = 0.1 m/s. Ambient air temperature = 0°C.

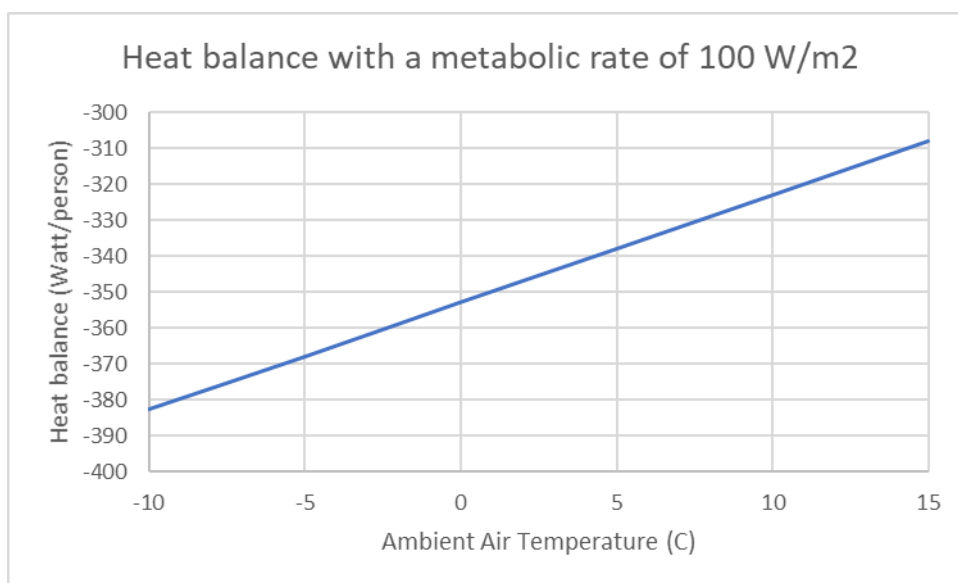


Figure A33 Heat balance per person. Insulation clothes = 3 cloe, Heat transfer coefficient (k) through bottom = 0.13 with a bottom thickness of 0.5 cm, windspeed = 0.1 m/s. Metabolic rate 100 Watt/m2.

The calculation does not take into account the shelter provided by the double canopy provided in SARex2. To compensate for the shelter provided by the canopy the windspeed is set to 0.1 m/s. Between 75% and 80% of the heat loss is being lost through the bottom of the life raft. This harmonizes well with the observations done by the exercise participants in SARex1. As participants were being pulled out of the exercise, space became available and several individuals reported that they were standing inside the raft to reduce the surface area in contact with the cold bottom. Due to the strain experienced while standing and individual physical limitations, the duration they were able to maintain a low contact area with the bottom was very limited.

The insulation level chosen for the simulation, 3 clo, is higher than what was worn by most of the participants, especially when considering the effect of wetness of the insulation (reducing the insulation). With a negative heat balance of more than 300 Watts per person it is not a surprise that the

last participant left the raft after only 19 hours. Based on these calculations it is evident that expecting to maintain survival in a life raft for 5 days with the equipment provided and with the conditions present in SARex1 is to be considered as utopia, and can be regarded as a suicide mission.

Heat loss simulations

An advanced model of a standard 20-person life raft has been developed. Verification measurements were carried out at Nutec, Nesodden during November 2017. Based on a random date in January 2017, hindcast data for wind, water temperature, and air temperature was downloaded from. As seen from the plots (Figure A4), there is low pressure activity around Iceland and there is a low pressure situated in the middle of the Atlantic, East of Newfoundland.

The hot water supplied to the North East Atlantic from the Golf stream is also visible. The metocean data was inserted into the model and heat loss per person was calculated for 10 survivors wearing thin clothes and SOLAS approved LSA located inside a 20-person life raft. Depending on area, the heat loss per person ranged from 150 Watts/person for the southerly areas, while in the northerly areas the heat loss per person is estimated to be above 450 Watts/person.

The insulation of a 20 mm closed cell mat was inserted in the bottom of the life raft and implemented in the model. This reduces the heat loss to the sea substantially, and puts the heat loss per person in the range 50 Watts/person to about 300 Watts/person.

In the next simulation, the survivors were wearing polar gear with high insulation factors. This further reduced to the heat loss per person in the range from about 40 Watts/person to 170 Watts/person. With a heat loss of 40 Watts/person the individuals need to increase the heat loss to reduce the sweating, and in a real scenario most of the survivors would open the polar gear and life raft to induce air circulation and cool down the survivors.

In the last plot we filled the life raft not only with half its capacity (10) people, but with 75% of its capacity, 15 people. This further reduced the heat loss to the range 35 Watts/person to 145 Watts/person.

The assumptions for the simulation addressed here require substantial effort. However, it proves that reducing the heat loss per person to acceptable levels is possible through realistic and simple means.

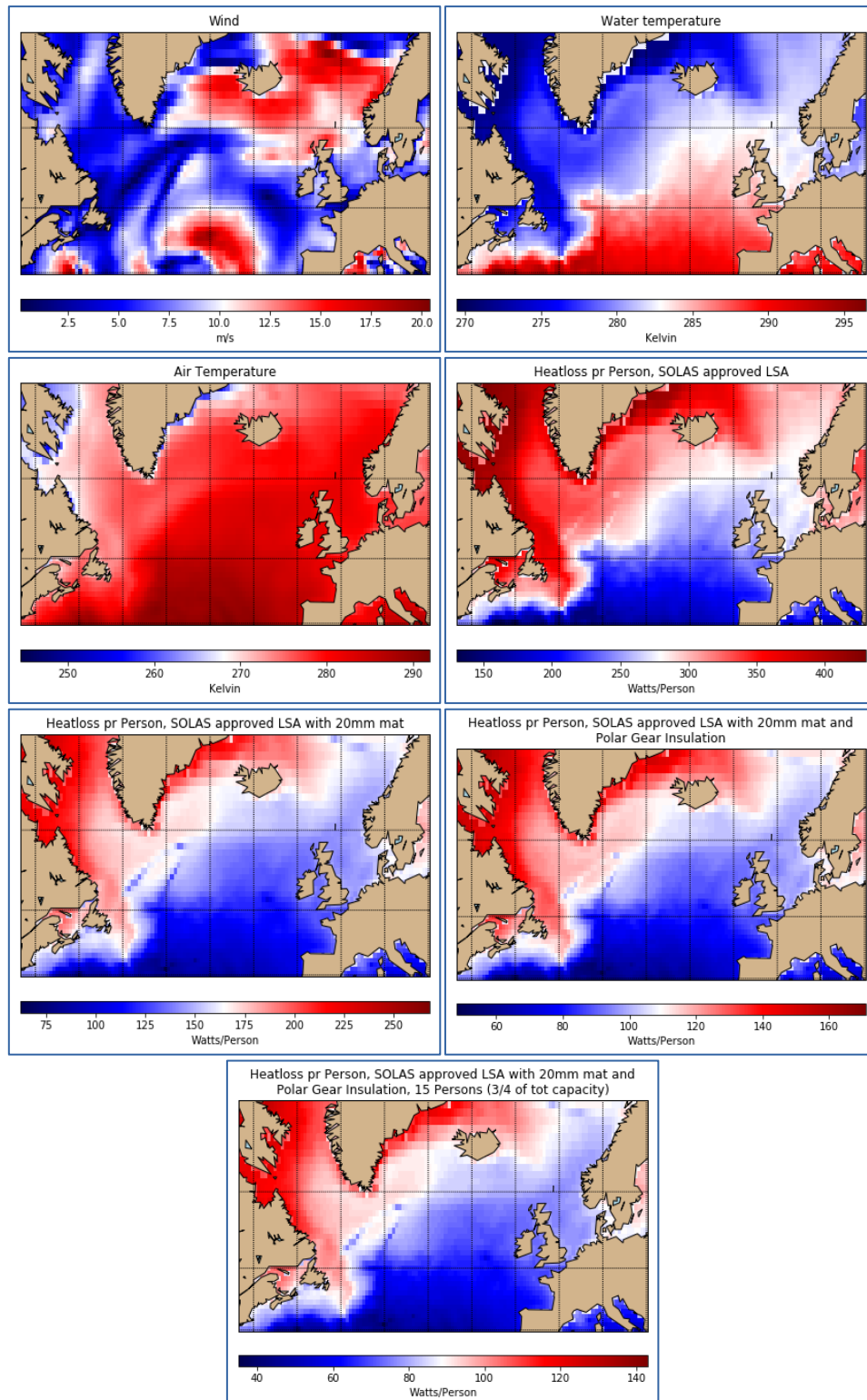


Figure A34 Heat loss simulations for life rafts in the North Atlantic in the winter time

Appendix B. Ventilation - Oxygen consumption/CO₂ production

In a cold climate environment, survivors would close off as much ventilation as possible to reduce the heat loss from the survival craft. The oxygen (O₂) consumption and carbon dioxide (CO₂) production by the survivors is a function of the number of individuals inside a rescue craft and their metabolism level.

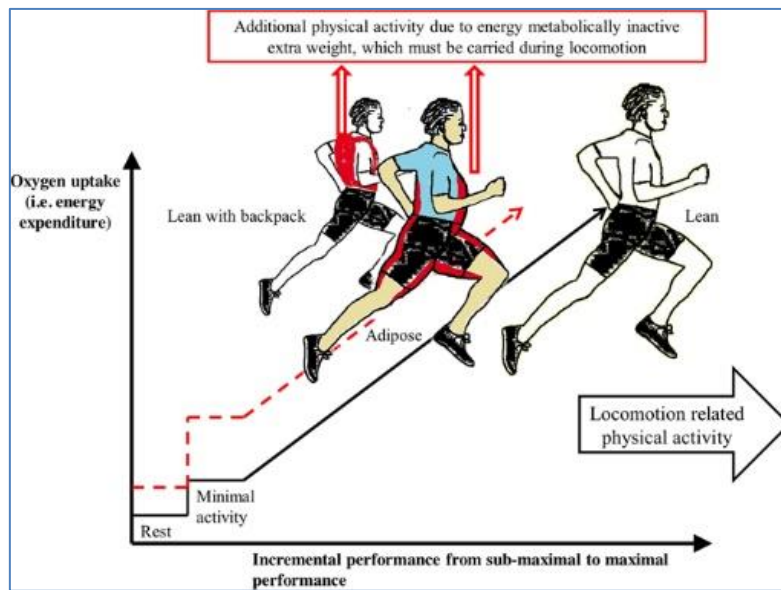


Figure B1 Oxygen uptake vs activity level (Frontiersin, u.d.)

The oxygen consumption (Figure B1) and the CO₂ production could directly be derived from the HL/activity level defined (or required to compensate for the heat loss). Several scientific studies have identified the oxygen consumption associated with different activities.

According to Nelson (Nelson, 2004) the energy released, oxygen (O₂) consumed and carbon dioxide (CO₂) produced associated with the different types of food is given in Table B1.

Food	EnergyReleased (kcal/g)	EnergyReleased (WattHour/g)	OxygenRequired (liters O ₂ /g)	CO ₂ produced (liters CO ₂ /g)
Carbohydrate	4.1	4.7683	0.81	0.81
Fat	9.3	10.8159	1.96	1.39
Protein	4	4.652	0.94	0.75
Alcohol	7.1	8.2573	1.46	0.97

Figure B2 Energy released, oxygen (O₂) consumed and carbon dioxide (CO₂) produced associated with the different types of food

For the calculation shown in Figure B2 Energy released, oxygen (O₂) consumed and carbon dioxide (CO₂) produced associated with the different types of food, a typical diet consisting of 40% carbohydrates, 40% fat, 20% protein and no alcohol has been utilized. This reveals that 7.16 Watt/gram food is released, 1.30 liters of O₂/gram food is consumed and 1.03 liters/gram food of CO₂ is produced.

This further uncovers that 0.18 liters of O₂ is consumed and 0.14 liters of CO₂ is produced for each Watt produced.

Table B2 Relationship between energy released, food required, O₂ needed and CO₂ produced

Watt	GramsFoodRequired	O2 liters req/hr	CO2 liters prod/hr
100	13.95852643	18.09025025	14.37728222
200	27.91705285	36.1805005	28.75456444
300	41.87557928	54.27075075	43.13184666
400	55.83410571	72.36100099	57.50912888
500	69.79263213	90.45125124	71.8864111

Based on the trials from SARex2 it is evident that the buildup of CO₂ is the dimensioning factor with regards to rescue craft ventilation requirements. This is due to the low human acceptable exposure limits to high CO₂ concentrations. It was also observed a substantial increase in O₂ consumption and CO₂ production within the lifeboat when the survivors were conducting highly intensive physical activities (high metabolism).

For an individual breathing in an air cavity of 1 m³, the CO₂ concentrations would increase according to this simplified approach along the lines defined in *Figure B3 Relationship between time and metabolism and CO2 produced* below.

Hr	CO2 liter/cubic - 100 Watt	% concentration - 100 Watt	CO2 liter/cubic - 200 Watt	% concentration - 200 Watt	CO2 liter/cubic - 300 Watt	% concentration - 300 Watt	CO2 liter/cubic - 400 Watt	% concentration - 400 Watt	CO2 liter/cubic - 500 Watt	% concentration - 500 Watt
0.00	0.33	0.03	0.33	0.03	0.33	0.03	0.33	0.03	0.33	0.03
1.00	14.71	1.47	29.08	2.91	43.46	4.35	57.84	5.78	72.22	7.22
2.00	29.08	2.91	57.84	5.78	86.59	8.66	115.35	11.53	144.10	14.41
3.00	43.46	4.35	86.59	8.66	129.73	12.97	172.86	17.29	215.99	21.60
4.00	57.84	5.78	115.35	11.53	172.86	17.29	230.37	23.04	287.88	28.79
5.00	72.22	7.22	144.10	14.41	215.99	21.60	287.88	28.79	359.76	35.98
6.00	86.59	8.66	172.86	17.29	259.12	25.91	345.38	34.54	431.65	43.16

Figure B3 Relationship between time and metabolism and CO₂ produced

It is important to note that some of the higher levels indicated in this study would not be realistic as the human body would decrease before reaching these high levels.

Based on the plot *Figure B4 Plot of relationship between time and metabolism and CO2 produced* below, it is evident that the level of metabolism has a large impact on the production of CO₂.

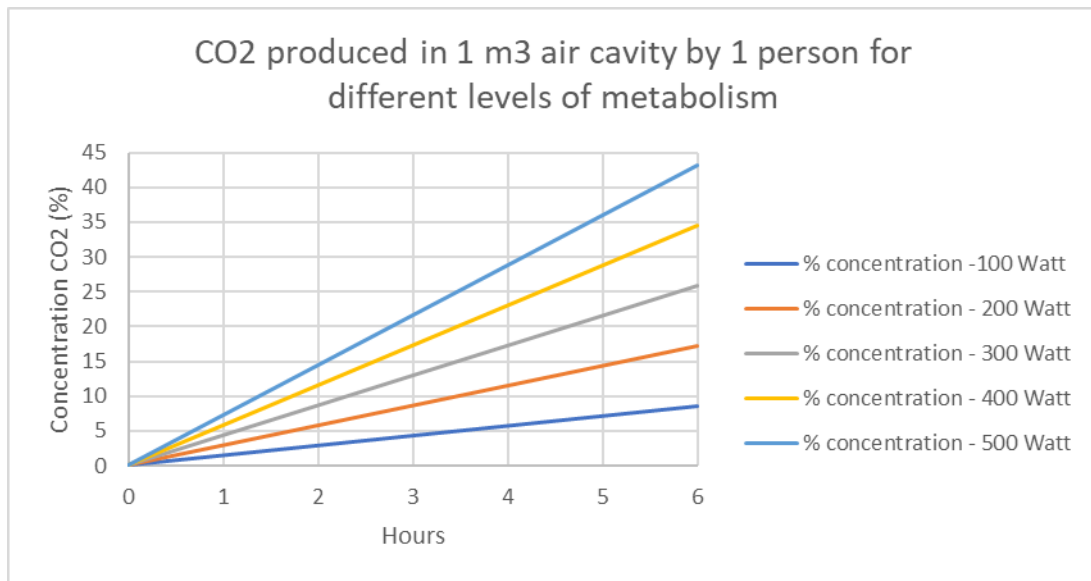


Figure B4 Plot of relationship between time and metabolism and CO₂ produced

The effect of a high metabolism was highly visible in the lifeboat trial conducted in SARex2, see Figure B5 CO₂ production during lifeboat trial in SARex2

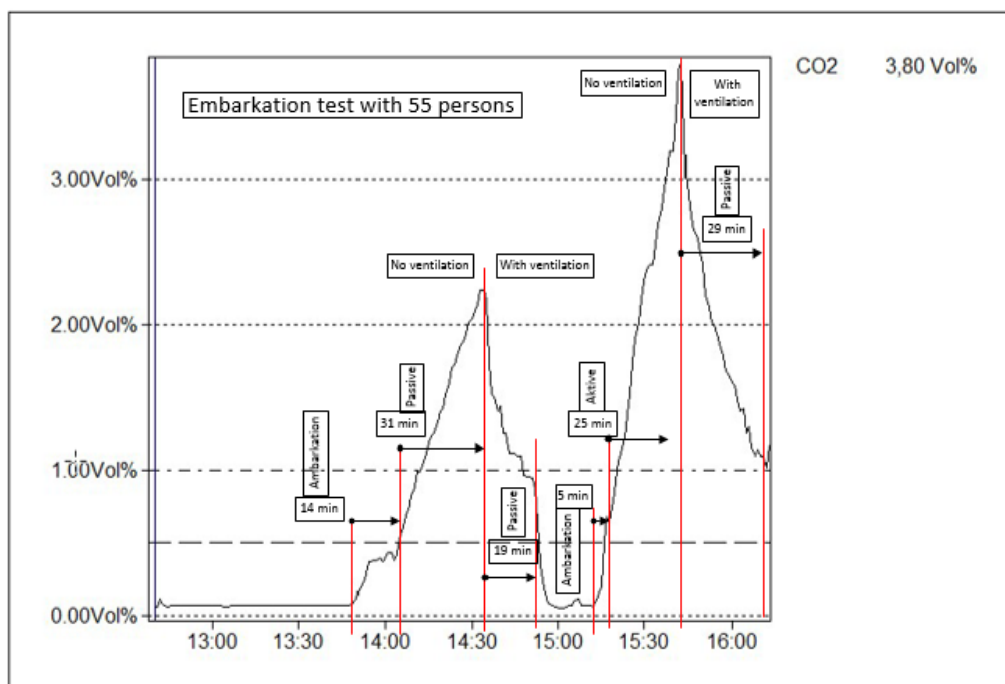


Figure B5 CO₂ production during lifeboat trial in SARex2

During these tests an air cavity (internal volume of the lifeboat) of 30 m³ was filled with 49 persons with an estimated total volume of 2.16 m³, giving 27.84 m³ of free air. This equals 0.568 m³ free air per person.

Based on the simplified approach indicated above the increase in CO₂ as observed in SARex2 can be modelled according to the following formula:

$$CO2_{conc} = \frac{CO2_{prodPrHuman} + CO2_{airIntroduced}}{AirCavityVolum_{prHuman}}$$

$$CO2_{conc} = \frac{Metabolism * CO2_{productionRatio} + CO2_{airIntroduced}}{AirCavityVolum_{prHuman}}$$

Where:

$CO2_{conc} =$	CO2 concentration (%)	$AirCavityVolum_{prHuman} =$	Air cavity available for each human (liter)
$CO2_{prod} =$	CO2 produced by each human	$CO2_{airIntroduced} =$	The ambient level (0.033%) of CO ₂ in the atmosphere (liters present in the air Cavity)
$CO2_{productionRatio} =$	0.143 liter/Watt produced		
$Metabolism =$	The metabolism of the survivors (predefined)		

For an air cavity of 0.568 m³ of free air per person (as present in the SARex2 trials), the CO₂ concentration inside the lifeboat is estimated based on the above methodology and plotted in Figure B6. The measured values (green dots in Figure B4) are the values measured in SARex2, indicating the high intensity trial (at 3.8% CO₂) and the low intensity trial (2.28% CO₂). The above-mentioned methodology indicates that the participants were on an average in the low intensity trial having a heat loss of a bit more than 100 Watt each. This harmonizes with the activity levels experienced.

Immediately before the high intensity trial all participants were conducting high intensity exercises to increase their metabolism. This was continued inside the lifeboat as far as possible within the space available. From a practical perspective this meant supporting the body weight with the knees bent 90 degrees and with the back against the back rest or lifting the body weight with palms against the seat rest. Based on the calculations the average metabolism was around 300 Watt per person. 300 Watt is equal to the metabolism associated with walking 5 m/s on level ground.

It should also be mentioned that everyone tried their best to raise their metabolism as much as possible and put a high effort into the task. Due to the space restrictions this was not an easy task and involved a high level of discomfort for the participants. 300 Watt per person was the maximum we were able to achieve within the space available.

It is also to note that the numbers indicated in Figure B6 below includes the boarding of the lifeboat. If measurements were taken from the hatches were closed, an increased rate of CO₂ production would have been visible in the plot.

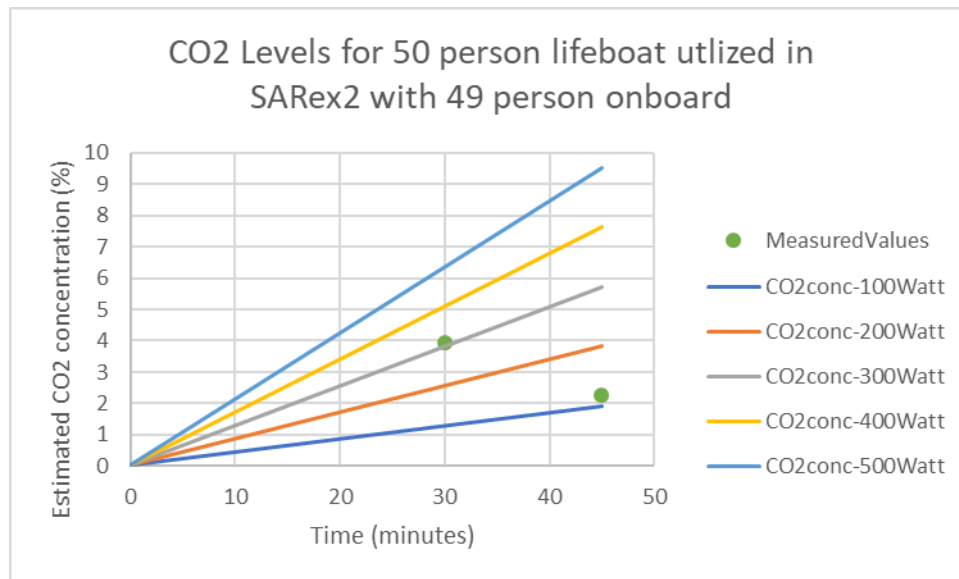


Figure B6 CO₂ values inside lifeboat, calculated and measured values

If a value of 5000 ppm (0.5%) is defined as a maximum limit for CO₂ concentration within the lifeboat utilized, and only 49 people (not full capacity) was to board the vessel and close the hatches, the time available before the ventilation system is to be initialized would only be a matter of minutes. The time available would highly depend on the metabolism of the individuals entering the lifeboat. In a stressful environment, under cold climate conditions the metabolism would be expected to be relatively high. See Figure B7 CO₂ concentration inside lifeboat with 49 people onboard for different levels of metabolism and time from closing the hatches for details.

Time (min)	CO ₂ conc-100Watt	CO ₂ conc-200Watt	CO ₂ conc-300Watt	CO ₂ conc-400Watt	CO ₂ conc-500Watt
0	0.0	0.0	0.0	0.0	0.0
1	0.1	0.1	0.2	0.2	0.2
2	0.1	0.2	0.3	0.4	0.5
3	0.2	0.3	0.4	0.5	0.7
4	0.2	0.4	0.5	0.7	0.9
5	0.2	0.5	0.7	0.9	1.1
6	0.3	0.5	0.8	1.0	1.3
7	0.3	0.6	0.9	1.2	1.5
8	0.4	0.7	1.0	1.4	1.7
9	0.4	0.8	1.2	1.6	1.9
10	0.5	0.9	1.3	1.7	2.1
11	0.5	1.0	1.4	1.9	2.4
12	0.5	1.0	1.6	2.1	2.6
13	0.6	1.1	1.7	2.2	2.8
14	0.6	1.2	1.8	2.4	3.0
15	0.7	1.3	1.9	2.6	3.2
16	0.7	1.4	2.1	2.7	3.4
17	0.7	1.5	2.2	2.9	3.6
18	0.8	1.6	2.3	3.1	3.8
19	0.8	1.6	2.4	3.2	4.0
20	0.9	1.7	2.6	3.4	4.3
21	0.9	1.8	2.7	3.6	4.5
22	1.0	1.9	2.8	3.7	4.7
23	1.0	2.0	2.9	3.9	4.9

Figure B7 CO₂ concentration inside lifeboat with 49 people onboard for different levels of metabolism and time from closing the hatches

Ventilation

From a simplified perspective, ventilation can be regarded as a technical solution that increases the air void available for each passenger. A predefined level of metabolism is required to be able to calculate the O₂ required and the CO₂ produced. A threshold for CO₂ is also a vital part of the dimensioning parameters. The required CO₂ concentration can be calculated based on the following formula, which expresses the equilibrium between CO₂ concentration and the sum of the CO₂ produced and the CO₂ introduced to the system (ambient air) through ventilation.

$$CO2_{conc} = \frac{Metabolism * CO2_{productionRatio} + CO2_{airIntroduced}}{AirCavityVolum_{prHuman}}$$

Where:

$CO2_{conc} =$	The threshold for CO ₂ concentration (%) defined by IMO	$AirCavityVolum_{prHuman} =$	Air cavity available for each human (liter)
$CO2_{productionRatio} =$	CO ₂ produced by each human, 0.143 liter/Watt	$CO2_{airIntroduced} =$	The ambient volume (0.033%) of CO ₂ in the atmosphere (liters present in the airCavity)
$Metabolism =$	The metabolism of the survivors (predefined)		

Example calculation

Defined parameters:

- The metabolism of the individual survivors is defined to be 150 Watt.
- Ventilation = air introduced = 5 000 liter/hour
- The original air located inside the lifeboat is neglected as it only represents a fraction of the required air volume to maintain a habitable environment.

A flow of 5 000 liters of fresh air per person, and a metabolism of 150 Watt per person will give a CO₂ concentration of 0.462% when the individual is in an enclosed air-tight space, Figure B8.

$$((150 \text{ Watt} * 0.143 \text{ liter CO}_2/\text{Watt} + (0.033/100) * 5\,000 \text{ liter CO}_2) / 5\,000 \text{ liter CO}_2) * 100 = 0.462\%$$

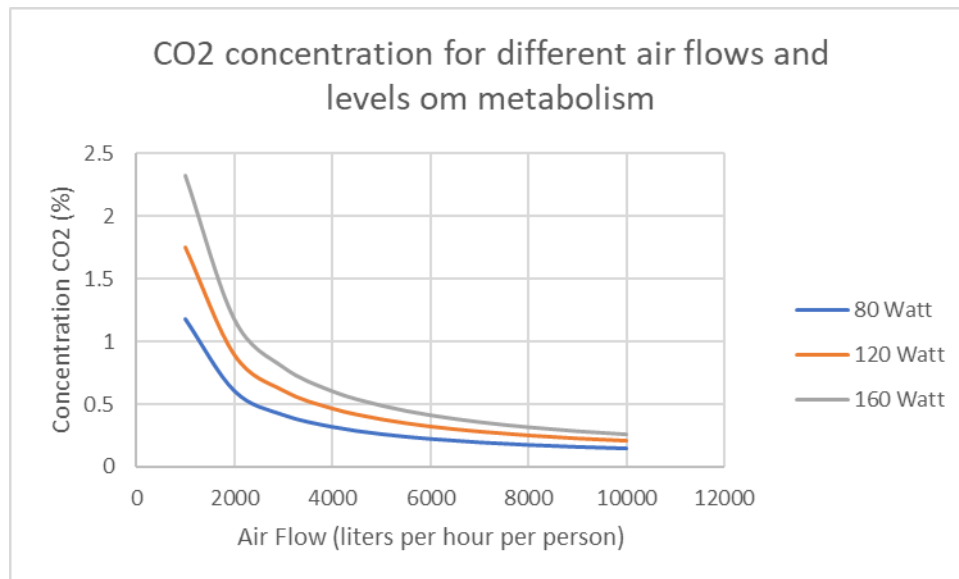


Figure B8 CO₂ concentration for different air flows for different levels of metabolism

From the above plot it is evident that a CO₂ level of 0.5 % (5000 ppm) is fully achievable with a reasonable flow that is technically achievable. It is also evident that the level of metabolism is an important element affecting the calculation, especially at lower flow rates. This emphasizes the importance of a high level of insulating abilities for the PPE, reducing the heat loss, when staying in the lifeboat.

It is also important to note that the costs associated with installation of a ventilation system is not directly proportional to the flow. A well dimensioned ventilation system will also reduce moisture levels and decrease the probability of development of fatigue for the survivors inside the rescue craft.

Uncertainties

All calculations involving the human element involves uncertainty and variability. The uncertainty related to the above simplified calculations can be summarized as follows:

- There is an uncertainty associated with the values expressing the relationship between energy produced (metabolism), O₂ consumed and CO₂ produced.
- In our calculations we have utilized a standard diet of 40% carbohydrates, 40% fat and 20% proteins. The survivors might not have had a diet of the above constituents. In our calculations we have used a CO₂ production of 0.144 per Watt produced. A theoretical diet consisting of only burning fat would result in 0.129 liter CO₂/Watt produced while the other extreme would be a diet consisting of only protein, resulting in 0.161 liter of CO₂/Watt produced. The variability between the both theoretical extremes only represents a range of 19.8%. It is however important to note that these extremes are only theoretical and the practical range is significantly less.
- The ability to conduct energy intensive activities to increase metabolism is highly individual. This is a function of age and physical fitness.
- The ability to generate energy is dependent on space available and functionality of the PPE, PSK, GSK and rescue craft.
- The heat loss (which affects the metabolism and CO₂ production) from a survivor is proportional with the body surface area. The body surface area varies between individuals.

- Practical implications like mixing of air internally in the survival craft and conduction of essential high intensity tasks (e.g. lifting of stretcher and handling environmental stressors) will affect the average metabolism level.
- Insulation levels represented by the individual survivor's cloths will affect the heat loss, which again affects the metabolisms (if increasing activity levels is possible from a practical perspective), which again affects the CO₂ production.
- The uncertainty and variability associated with the biometrics among survivors is significantly larger than the uncertainty associated with the theoretical calculation.

Ventilation summary

Based on the above methodology the following generic statements are valid:

- The ventilation rate is correlated to number of persons inside the rescue craft and their average metabolic rate.
- Utilizing prescriptive requirements values like "air exchanges" does not give the suppliers the flexibility required when developing alternative solutions, promoting other variables relevant for survival.
- Ventilation should be commenced relatively few minutes after entering the rescue craft to prevent build-up of CO₂.
- CO₂ alarms are essential for any survival craft to ensure a habitable environment and prevent CO₂ poisoning.
- Achieving CO₂ concentration values of 5000 ppm (0.5 %) inside a rescue craft is fully achievable with the current technology.
- The majority of the uncertainty associated with CO₂ concentration calculations in a survival scenario is related to the biometric variability among the survivors.
- Further research will not generate any major improvements in the understanding of the mechanisms at play and an increase in the accuracy of the calculations is irrelevant (from a survival perspective) due to the extremely biometric variability present among a group of survivors.
- The marine industry in cooperation with medical experts has to agree on acceptable CO₂ concentrations and metabolic rates for survivors inside the survival craft. The values associated with CO₂ concentrations and metabolic rates has to consider the duration of exposure.
- Due to the uncertainty and lack of data associated with the effects of long-term exposure to high CO₂ levels, utilizing well recognized values like 5000 ppm is recommended as this will have limited impact on the cost, space and weight associated with installation of ventilation systems.
- Without defining metabolic rates and CO₂ concentrations, consistent implementation of the functional requirement associated with "habitable environment" is extremely difficult.
- Utilizing a methodology defining metabolic rates and CO₂ concentrations, enables the industry to develop alternative solutions, promoting other variables relevant for survival.

Appendix C. Contributions from SARex 3 participants

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C.4 Gaps in material and procedures in Arctic on-shore survival

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Theme 4. The rescue situation, continued

C.10 Training and crisis response in cold climate conditions – the SARex 3

Bjørn Ivar Kruke, Associate Professor, University of Stavanger

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Embla Kirkemoen, MSc student, University of Tromsø, The Arctic University of Norway

C.12 Group activities in a simulated long-term survival situation.

Hilde Sandhåland, Associate professor

Western Norway Univ. College of Applied Sciences, Department of Maritime Studies

Theme Theme 5. Reports from companies attending the SARex3 exercise

C13. SAR in the Arctic. Overview of hazard identification

Erik Johan Landa, Norwegian Maritime Authority (NMA).

C14. Life-saving appliances on cargo vessels and fishing vessels

Anita Strømøy and Signe Meling, Norwegian Maritime Authority (NMA).

C15 SARex 3

Trond Sundby, Norwegian Petroleum Safety Authority

C16 Emergency preparedness in the Arctic

Magda Kopczynska,
Director for Waterborne (DG Mobility and Transport) European Commission
C17 Møkster's arctic survival package

Hans Kvadsheim, Simon Møkster Shipping AS

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C18 Rescue of stranded passengers in the Arctic
Annette Meidell, Professor dr. ing UiT The Arctic University of Norway, Campus
Narvik and member of the board in Maritime Forum Nord in the North of
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Steve Olsen, Captain (N) and Deputy Commander in the Norwegian Coast
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Bjørnar Raaen, MSc, University of Stavanger

C23 Marine Insurance

Anna Loiko, Norwegian Hull Club

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Norway University College of Applied Sciences

Objectives of Appendix C

The objective of this Appendix is to include the participants' own impressions from the exercise. All participants were asked to contribute with different themes and the appendix presents the papers and notes the different participants have contributed. This part is not a part of the official report and the views are not necessarily the views of the authors of the report, however, we find the contributions to be an important part of the reporting from the exercise.

Theme 1. Summarizing impressions from SARex 1 and 2

C.1 Survival in a cold-water environment – an offshore petroleum regulatory perspective.

Jan Erik Jensen, Norwegian Petroleum Safety Authority

C 1.1 Abstract

Through participation in SARex 1 in 2016 and SARex 2 in 2017, useful lessons have been learned in relation to survival in a cold maritime environment. The scenario of the exercises was a mass evacuation from a stranded cruise ship in Arctic waters. The exercises provide valuable lessons beyond the cruise industry; they are also relevant for any cold climate maritime activity. This article focuses on the relevance for the oil and gas industry in the Norwegian sector, particularly in respect of the regulations and competence needed to survive an offshore incident after an evacuation from an oil installation, using either lifeboats or life rafts.

SARex I and II were rescue exercises carried out north of Spitzbergen by industry, regulators and academia during the spring of 2016 and 2017, respectively. The Norwegian Coast Guard, the University of Stavanger and GMC, Stavanger, organized the exercises.

Experience from participation in SARex exercises in the Arctic has provided valuable knowledge, relevant from an offshore petroleum regulator's point of view in two ways: firstly, in terms of the importance of testing the viability of new regulatory requirements, and, secondly, regarding the dependence on leadership and competence to enable the use of cold climate survival equipment and, consequently, group survival.

There are many heroic accounts of sealers and fishermen being stranded in their rescue craft for prolonged periods. Knowledge and equipment have been key factors in their survival. Technology related to Arctic survival equipment has evolved, and improvements have been made. The key question in this project report is:

- Is the competence amongst the crew in the Norwegian offshore petroleum industry sufficient to enable a prolonged survival phase?
- Is the equipment sufficient to sustain a prolonged survival phase in the most remote and northern parts of the Norwegian sector?

The regulations governing the Norwegian offshore oil and gas industry are mostly functional requirements. The Petroleum Safety Authority found it important to participate in SARex I and II, to better understand the factors enabling success in a cold climate survival situation.

The survival tests in lifeboats and life rafts during SARex 1 and 2 showed the necessity of having trained and competent leadership on board. This issue has perhaps been neglected, compared to the development of equipment to avoid hypothermia, where technology has made considerable progress. Some key factors for survival success were:

- Organizing and teaching the function of various items of safety equipment on board the rescue craft.
- Operating the rescue craft at sea, watch routines, operating hatches/venting routines.
- Maintaining warmth and mental awareness and motivation.
- Organizing water and food rations.

The rescue craft leader used effective techniques to engage the survivors on board the life raft, e.g. giving each individual responsibilities and tasks. He also ensured mental awareness by creating activities throughout the time on board.

Overall learning from SARex 1 and 2 is that survival is dependent on active participation from the survivors. This means that there needs to be sufficient competence amongst survivors to micro-manage all the details required for survival. The mental factors following fatigue and seasickness, in addition to hypothermia, make leadership and competence in a cold maritime climate essential for survival.

C 1.2 Introduction

There has been a renewed interest in exploration in the Barents Sea, since the opening of licensing blocks further north and east more than a decade ago. These areas are further from the coast than existing discoveries in this region, thus creating new challenges compared to the more mature areas developed for oil and gas in the Norwegian sector. Today, resources for handling emergency situations are considerably scarcer in the Barents region.

The basis for SARex 1 and 2 was the International Maritime Organization's (IMO) new Polar Code¹ with a five-day survival requirement in the Arctic.

There is no similar regulatory requirement in the oil and gas industry, as most of the requirements are functional. However, the industry has set its requirements through analyses of the different major accident scenarios, e.g. maximum 120 minutes² for the rescue of 21 persons from the sea after helicopter incident and personnel forced to evacuate directly into the sea; 8 min³ to recover man overboard and 50 min⁴ for detection of ship on collision course. These requirements are intended for areas with emergency response cooperation but have been regarded as industry standard throughout.

The survival requirement is established by IMO, based on the time of rescue in remote polar areas. These are applicable to all maritime activities under the flag regime, other than oil and gas activities.

The focus of the regulations and the industry has been on technical inventions, to ensure success in handling escape and evacuation during emergency scenarios in polar waters, and not on the survival phase. In an emergency, where evacuation is necessary, one is exposed to the following phases:

Escape – Evacuation – **Survival** – Rescue

Specifically, courses for emergency duties on board ships and oil installations focus mostly on the escape and evacuation but much less on the survival and rescue.

SARex 1 and 2 have shown the importance of validating technical requirements versus towards functional requirements. This article will show some of the challenges experienced in these two expeditions, in the frigid waters around Svalbard, held in spring 2016 and 2017. It also presents some theory relevant for survival in a cold marine environment and refers to some historical events along the way.

One of the worst-case scenarios to put the search and rescue resources to the test is assumed to be the sinking of a cruise liner in polar waters. The *TS Maxim Gorkiy* incident, in which a cruise ship with nearly 1000 passengers hit drift ice on the evening of 19 June 1989 outside Svalbard, was such a scenario.

¹The International Code for Ships Operating in Polar Waters.

²Norwegian Oil & Gas Association Guideline 064 – chap. 6.3 and 7.3, respectively.

³Same reference as above – chap. 5.3

⁴Same reference as above – chap. 8.3.1

SARex 1 was performed with the standard type of conventional lifeboat and life raft. In SARex 2, the same lifeboat was significantly modified, and the life raft was more of a high-end type. The lifeboat had installed a diesel heater and the life raft had a double-bottom layer and tent.

In both SARex 1 and 2, the same naval officers from KV Svalbard led the operations during the tests. In addition to the naval officers, the participants in the lifeboat and -raft in both years consisted of privates, researchers, students, civil servants and others. None of the participants were survival specialists, although a few of the participants had maritime and professional and/or academic backgrounds that would be beneficial in a survival situation.

In a real scenario, it could well be cruise passengers that would be evacuated. In that respect, the exercise participants can be assumed to be significantly more competent, than the average cruise passenger, to sustain survival in a lifeboat or -raft in the Polar Regions. However, there were no lectures, courses or other education about the use of the evacuation means, but the manufacturer had its representatives in both the lifeboat and -raft in SARex 1 and 2.

In a real scenario, the officers and crew embark the lifeboats and life rafts last and in separate units. This is true on both oil installations and cruise ships. This makes competence to survive even more important, to increase the chances of survival. Compared to cruise passengers, crew working on offshore installations need to pass health requirements and emergency training.

This report looks into the regulations, competence and equipment that are in place today, relevant for a survival situation in the northernmost areas of the Norwegian sector. It also includes recommendations, after reviewing relevant theory of human cold climate responses, historical events and experiences from exercises, SARex 1 and 2.

C 1.3 Background

Most of the requirements in the previously mentioned regulations and the progress in technology have been in the evacuation process, with the introduction of free-fall lifeboats and marine escape chutes. With the prolonged survival phase being most likely to occur in northern waters compared to the more southern regions of the Norwegian continental shelf, it would be most relevant to look further into the evacuation means' ability to sustain survival, and to verify whether regulatory requirements are sufficient. Survival suits, and particularly helicopter transport suits, have improved greatly over the last decade.

Statistics⁵ from the Second World War found that two thirds of the over 30,000 British Royal Navy fatalities occurred during the survival phase. This study stimulated research and development that eventually led to today's life jackets, inflatable life rafts and sea survival rations /1/.

The Polar Code was implemented in January 2017 and is applicable to all vessels covered by the IMO in Arctic and Antarctic waters. These requirements are not applicable for offshore installations in the oil and gas industry, but they may be in the future⁶. There have been exploration activities to date in The Polar Code area (Korpfjell), but only outside the harshest winter season.

C 1.4 Methods and materials/theory

The study, which is the basis for this article, will present the regulations that govern the requirements related to competence in survival in the oil and gas industry in the Norwegian sector. The course content

⁵ Statistics following the investigation, led by Rear Admiral A.G. Talbot RN, into causes of the loss of life of naval personnel at sea during WWII.

⁶ Personal communication. Åse Waage, the Norwegian Maritime Authority.

in safety courses required for work in the offshore industry in Norway will be compared to regulatory requirements and lessons learned from SARex 1 and 2. Some historical events will also be presented, together with some relevant theory on sea survival.

C 1.5 Limitations and assumptions

This project assessment report has investigated the most relevant regulations for a survival scenario relevant for the offshore petroleum activities on the Norwegian continental shelf and compared how these requirements will support survival and rescue in a cold climate survival situation. Not all requirements related to emergency response are covered in this report.

The exercises were conducted with the leadership of naval officers with special training in leadership in emergency situations, in both the lifeboat and -raft. This competence would not be available in the case of civil vessels or oil and gas installations. The exercise participants also had personnel with special competence in the equipment used, with vendors' representatives on board. The privates onboard K/V Svalbard, civil servants and academics also had relevant knowledge to some extent.

There was also the continual presence of medical personnel on board during SARex 1 and partial presence during SARex 2. This can be assumed to produce less stress for the participants, compared to a real case, where it is unlikely that there would be medical personnel on board.

The exercises were held in sheltered waters.

C 1.6 Regulations

The key regulations governing offshore petroleum activities are provided in the health, safety and environment regulations /2/ that consist of the following:

- The Framework regulations
- The Management regulations
- The Facilities regulations
- The Activity regulations

The regulations covering requirements for escape, evacuation and rescue means, and competence and training can be divided into different groups of barriers, which are all covered by the Norwegian offshore industry HSE-regulations; cf. the Management Regulations Section 5 about the different types of barrier elements:

- Technical
- Operational
- Organizational

“WHO is doing WHAT with what EQUIPMENT” illustrates the organizational, operational and technical barrier elements, respectively. All these types of barrier elements need to be in place, to ensure safe operations and a robust emergency preparedness in the offshore industry's operations. The Norwegian Petroleum Authority has written guidelines on how to interpret these requirements⁷ /3/. Note, however, that most of the technical barrier elements offshore consist of automated safety systems. Also, it is worth noting that necessary governing documentation shall be established to control these barrier elements to the extent that it has a relevance for the safety of operations and emergency preparedness; cf. the Management Regulations Section 6 about the management of health, safety and the environment.

⁷ Available at this link: <http://www.ptil.no/getfile.php/1319891/PDF/Barrierenotatet%202013%20engelsk%20april.pdf>

Most of the offshore petroleum regulations in the Norwegian sector are of a functional rather than descriptive/technical nature. This is not the case for the maritime regulations. However, there is an exception with the recently introduced IMO Polar Code. Most of these requirements are of a functional nature, e.g. the five-day survival requirement mentioned in the introduction. The Polar Code is described in more detail in a section below.

Maritime regulations

On the Norwegian continental shelf, offshore mobile units can follow the maritime technical requirements in the design and equipment of maritime systems on board; cf. the Framework regulations Section 3. This includes the design of escape ways and all emergency response equipment on board. The maritime regulations related to petroleum activities offshore are stipulated through the Norwegian Maritime Authority (NMA) regulations or other flag state regulations to a similar or higher safety level. Where the other flag state requirements are below the NMA's regulations, then the NMA's regulations are to be followed. The NMA normally refers to the IMO requirements but, in some cases, has additional requirements. So, in practical terms, the NMA regulations form the basis for the design of mobile offshore units, including the evacuation equipment. As of today, mobile units include semi-submersible and jack-up installations used for drilling or purely accommodation services (often referred to as "floatels"), Floating Production and Storage vessels (normally referred to as "FPSO") and light well intervention vessels (ship-shaped). Note that the mobile units need to fulfill flag state regulations other than the technical requirements, in order to be issued with flag state certificates.

The relevant regulations for the mobile offshore units are in the "red book", issued by the NMA /4/. In this collection of different regulations are the NMA regulations of 2 February 2016 No. 90 on evacuation and life-saving appliances on mobile offshore units (Rescue regulation), which gives the requirements for the design, placement and numbers of necessary life-saving equipment on board. In particular, the NMA Rescue regulations Chapter 4 (numbers and placement of evacuation and life-saving equipment) and Chapter 5 (design requirements) state the requirements for mobile units in terms of evacuation equipment. These regulations refer, to a large extent, to the IMO Life Saving Appliances Code (LSA-Code) /5/.

With regard to life rafts, the LSA Code has some requirements that are seemingly useful features. However, the experience from SARex 1 and 2 has shown that the requirements have not been sufficient. For instance, there is not an absolute requirement of a double bottom in life rafts. The requirements are stated in Chapter 4.2.2.2 in the LSA Code:

The floor of the life raft shall be waterproof and shall be capable of being sufficiently insulated against cold either:

1. *By means of one or more compartments that the occupants can inflate, or which inflate automatically and can be deflated and re-inflated by the occupants; or*
2. *By other equally efficient means not dependent on inflation.*

The latter has in practice become a thin neoprene layer with silver foil/heat reflective material on the top. The first requirement could be a double bottom, which in SARex 2 proved a lot better than the solution chosen by following item 2 above. However, the most common life raft type used on offshore installations today is the single bottom with a thin insulating layer.

The IMO Polar Code

The IMO Polar Code /6/ is a set of functional requirements that are adapted to the specific challenges of operating and handling emergency situations in polar regions. It covers the complete aspect of operating in these regions, but the most relevant sections related to emergency response are:

- Chapter 1 Definitions:

- 1.2.4 *Habitable environment* means a ventilated environment that will protect against hypothermia.
- 1.2.7 *Maximum time of rescue* means the time adopted for the design of equipment and systems that provide survival support. It shall never be less than 5 days.
- Chapter 8 Life-saving appliances and manning: That evacuation equipment shall function in the adverse conditions during maximum time of rescue. There is also Chapter 8.2.3 covering *survival*. Amongst several requirements, then the means of escape shall provide a habitable environment.
- Chapter 12 Manning and training: This chapter has the goal of ensuring that ships operating in polar waters are appropriately manned by adequately qualified, trained and experienced personnel.

However, there are no specific STCW⁸ courses for emergency preparedness in open waters. This is something that should be considered for offshore industry activities in the Norwegian sector that are taking place within the area of the Polar Code.

An overview of the area in which the IMO Polar Code applies is given in the figure C.1.1 below.



Figure C.1.1. The maximum extent of the IMO Polar Code in the northern hemisphere⁹.

⁸ STCW= International Convention on Standards of Training, Certification and Watch-keeping for Seafarers, 1978 was adopted on 7 July 1978 and came into force on 28 April 1984. The main purpose of the convention is to promote safety of life and property at sea and the protection of the marine environment, by establishing in common agreement international standards of training, certification and watch-keeping for seafarers.

⁹ Source: www.imo.org

Offshore petroleum industry

Within the petroleum industry, the most relevant regulations governing the evacuation means are stipulated in the following regulations:

- Framework regulations Section 20 about coordination of emergency preparedness resources, which state the operator's responsibility to establish and coordinate the emergency preparedness for an offshore operation.
- Management regulations Section 5 about barriers.
- Management regulations Section 14 about manning and competence, which, for instance, are relevant for ensuring that offshore personnel are competent to work in an Arctic environment (including emergency situations).
- Management regulations Section 17 about risk analysis and emergency preparedness assessments.
- Facility regulations Section 44 about means of evacuation, which again refer to the requirements in NORSOK S-001 Chapter 21 and for the design of free-fall lifeboats DNVGL-ST-E406.
- Facility regulations Section 45 about survival suits and life jackets, etc.
- Activity regulations Section 17 about transport to and from the offshore installations.
- Activity regulations Section 21 about competence of offshore personnel, including the handling of situations of hazard and accident.
- Activity regulations Section 23 about training and drills, which require that personnel are trained and equipped to handle situations of hazard and accident in an efficient manner.
- Activity regulations Section 73 about the establishment of emergency preparedness, which state that there shall be a strategy for emergency preparedness in hazardous and accident situations. Also, the emergency preparedness strategy shall be established on the basis of risk analysis and emergency preparedness assessments.
- Activity regulations Section 75 about emergency preparedness organization, which state that this organization shall be robust, so that it is able to handle hazard and accident situations in an efficient manner.
- Activity regulations Section 76 about emergency preparedness plans.
- Activity regulations Section 77 about handling hazard and accident situations. Sub section c) here states that measures shall be taken so that personnel can be rescued during accident situations.

None of the regulations above are specific about requirements for the survival phase of an emergency situation. However, the requirements related to equipment, competence and emergency preparedness situations are all intended to ensure survival and rescue after an evacuation. As stated in the Activity regulations Section 77, item c): "*Measures shall be taken so that personnel can be rescued during accident situations*". This means that equipment, organization and personnel competence need to be sufficient to enable the fulfilment of this requirement.

Standards and guidelines

The industry has developed standards and guidelines for the design of evacuation and safety equipment. NORSOK S-001 /7/ states requirements related to lifeboats and life rafts in Chapter 21.4.3. However, there is no specific mention of requirements related to a prolonged cold-water survival phase. Survival suits are also covered here in NORSOK S-001. When it comes to the design of lifeboats, reference is made to the standard, DNVGL-OS-E406 /8/. For life rafts, SOLAS and flag state requirements are referred to. Chapter 21.4.4 covers requirements for survival suits. It also refers to SOLAS requirements.

The Norwegian Oil and Gas Producers Association (NOG) has also developed guidelines for both helicopter transport suits (A) and survival suits available at lifeboat stations (B) in their NOG guideline GL094. This guideline refers to the standard:

- NS-EN ISO 15027-1:2002 Immersion suits; Part 1, Constant wear suits, requirements including safety.
- NS-EN ISO 15027-2:2002 Immersion suits; Part 2 Abandonment suits, requirements including safety.

According to NOG GL094, both types of suits shall fulfill the requirements in the LSA Code (except item 2.3.2.1, where special Norwegian requirements apply). The suits shall be able to sustain a survivor's body heat and prevent drowning and near drowning for a period of at least 120 minutes. This is the performance criterion that the operator's emergency organization shall be dimensioned, trained and equipped for. It is given in NOG GL064 /9/ about area emergency preparedness. In Chapter 3.9, the guideline pays special attention to activities in the Barents Sea region. Other than recommending that special consideration be given to the performance criteria in this region, it does not find any reason to establish individual requirements for this region on a scientific basis. This statement can be understood based on the capacities of today's helicopter transport suits and specifications for the alternative IMO suits, but it does not mention anything about a most likely longer survival time during winter operations in the most distant parts of this region. The lack of daylight, the polar lows and significantly colder waters in the north-eastern part are not considered. *The industry has not yet established a common performance criterion for the survival time!* However, BaSEC¹⁰ group has suggested a criterion for rescue in the Barents Sea of 24 hours¹¹.

C 1.7 Climate in the Barents Sea

The weather and sea temperatures do not alter significantly, when coming from the Norwegian Sea to the Barents Sea from the south. However, when reaching the mid to northern parts of the Barents Sea then there can be a more adverse environment that could reduce survival possibilities. Less light, more frequent polar lows, lower sea temperatures and possibilities of sea ice can be relevant for periods of the winter. These factors are additional to the lesser infrastructure and fewer available rescue resources in this region.

The three different sources of water in the Barents Sea are coastal water (green arrows in figure below), Atlantic water (red arrows) and polar water (blue arrows). The typical pattern is given in Figure C.1.2 below, but it varies from season to season and every other year. Sometimes there are certain patterns that remain for up to seven years at a time /10/.

Figure C.1.4 shows the lowest surface temperature in the sea, with an annual probability of exceedance of 10⁻². The lowest sea temperatures typically are 2° less than those of the North Sea and Norwegian Sea, unless activities are entering the area of polar water that has significantly lower temperatures (< 0° C).

Figure C.1.3 shows the different polar low pressures that were registered over the period between 2000 and 2009. For the Barents Sea region, there are, on average, four polar low pressures a year. They are difficult to predict and have fierce winds over short fetches. Depending on the fetch and speed of the polar low pressure, it can create rough seas beyond the normal wave prediction models /10/. Such conditions would provide additional challenges during a survival situation:

¹⁰ BaSEC= Barents Sea Exploration Collaboration - established by Statoil, Eni Norge, Engie (GDF Suez), Lundin and OMV, in April 2015

¹¹ Personal communication Sigurd Robert Jakobsen, the Norwegian Petroleum Safety Authority

- Strong short fetch winds from different directions will create chaotic seas with an impact on the ability to cope with the survival situation inside a lifeboat and -raft due to motion sickness.
- Water integrity of lifeboat and -raft.
- Icing that could alter the function of hatches, stability, antennas, zippers on life rafts, sprinkler systems and air intakes of lifeboats, etc.

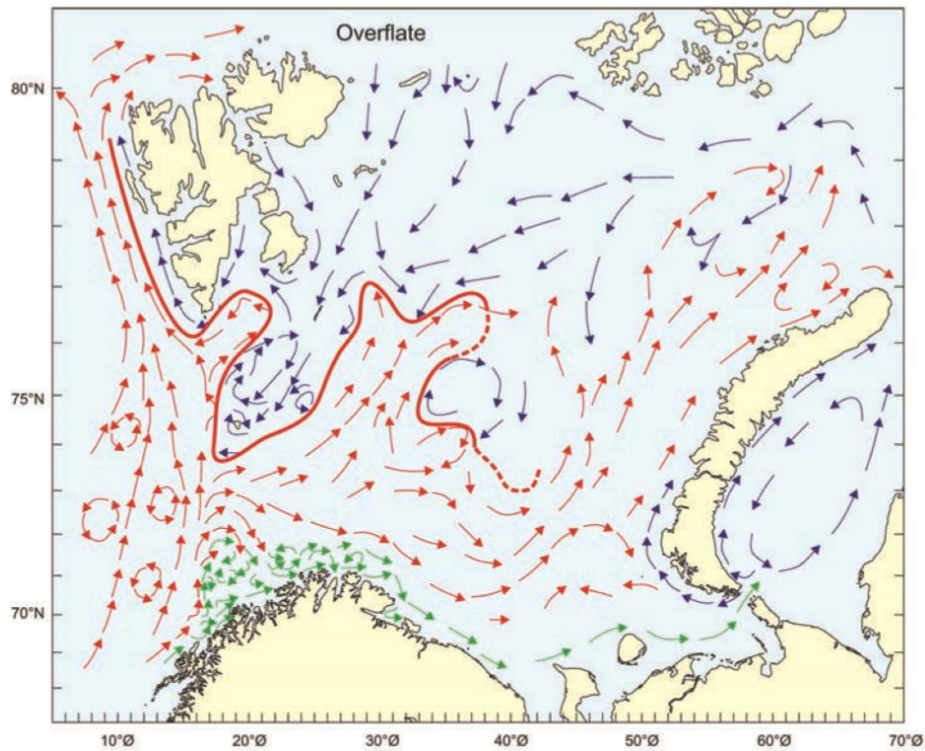
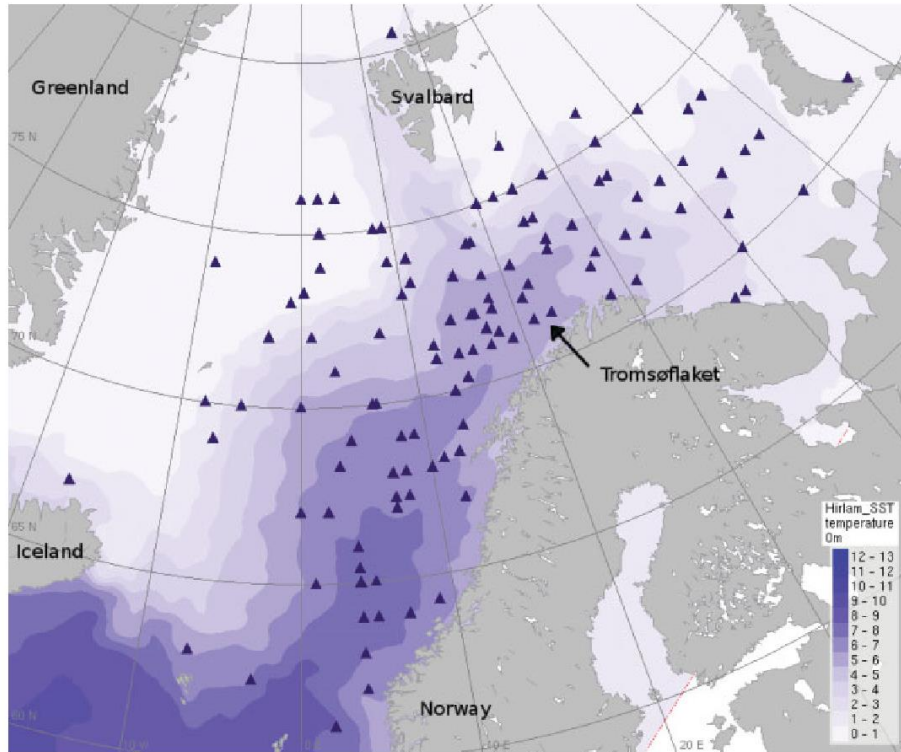


Figure C.1.2 Overview of the different sources of water in the Barents Sea. Green arrows: Coastal water. Red arrows: Atlantic water entering from the south west with the North Atlantic drift $> 2^{\circ} \text{C}$. Blue arrows: Polar water $< 0^{\circ} \text{C}$. Source: G. Noer et al. (2011)/11/.



C.1.3 Position of polar lows 2000-2009. Blue shading shows the climatological mean sea-surface temperatures for January (in °C). Source: G. Noer et al. (2011) /11/.

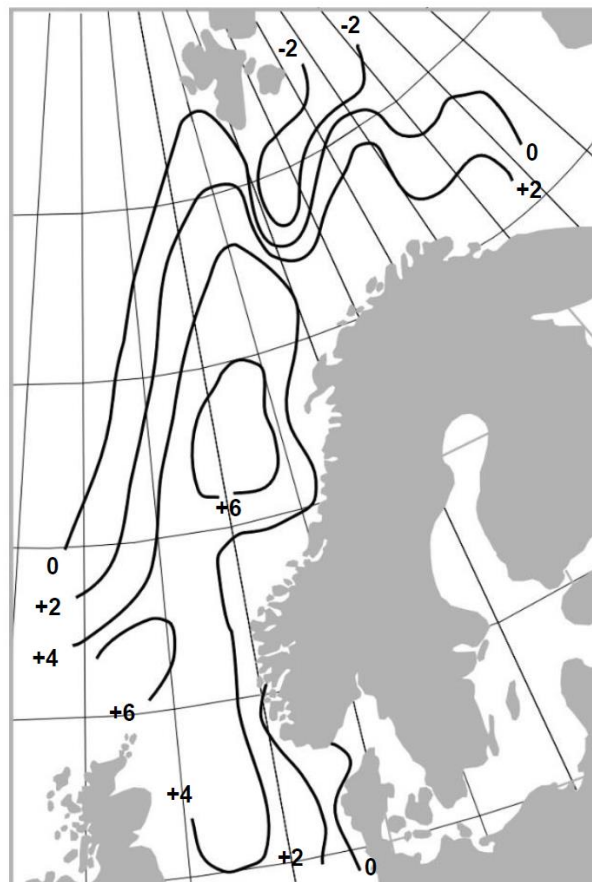


Figure C.1.4 Lowest surface temperature in the sea with an annual probability of exceedance of 10^{-2} (the temperatures are given in °C). Source: Norsok N-003 /12/.

C.1.8 Review of typical responses and cold climate exposures in a survival and rescue situation in cold waters

The obvious requirement and wish will be to have a dry evacuation in all offshore emergency situations. This is based on the physical nature of water, with thermal conductivity being 24 times that of air, and its volume specific heat capacity being approximately 3500 times that of air /1/. Therefore, compared to air, water has a much greater capacity to extract heat. Water on towards skin and clothes, especially inside clothes, but also outside has a huge effect on the body's ability to sustain heat. The body usually loses heat to the surroundings in the following ways /13/:

1. Transfer of heat by *direct contact with cold water or other materials*. Heat passes from your body, which is at a relatively high temperature, to a substance which is lower in temperature. Certain substances are better conductors of heat than others. As mentioned earlier, water conducts heat more than 20 times faster than air.
2. Transfer of heat by *air or water currents*. Moving air is far cooler to the body than still air. Cooling by wind is known as the "wind-chill effect". Similarly, disturbed or moving water around your body is more chilling than still water at the same temperature.

The different physical processes of heat exchange are as follows (Figure C.1.5):

- Radiation (R) – thermal radiation energy from any object, the rate being decided by effective radiation surface (e.g. arms and legs spread vs. fetal position). This energy needs to be trapped by using clothes.
- Convection (C) – e.g. warmed-up air molecules will rise and be replaced by colder molecules. This is dependent on air or water movements in surroundings and temperature gradient of skin to environment.
- Conduction (K) – heat exchange between skin and surrounding surfaces in direct contact. Sitting in a lifeboat or life raft, body areas in contact with surfaces will be subject to this mechanism of heat loss.
- Evaporation (E) – energy transfer in transformation of liquid to gas, e.g. water on skin that evaporates. Also breathing is subject to this, as vapor is formed in the lungs and released to open air.

To maintain body temperature, the heat produced by the body through metabolism (M) and work (W) must be balanced with the physical process of heat loss given above. Considering a person's heat storage (S), the heat balance equation can be illustrated as follows (unit W/m²):

$$M - W = E \pm C \pm K \pm R \pm S$$

If thermal balance is maintained, the terms of the equation should sum to zero and the body temperature should remain stable (i.e. S = 0).

NOTE: There are also several other important factors that are not unique to cold waters such as dehydration due to sea sickness and ventilation /13/ in enclosed lifeboats and life rafts (which is the only type on the Norwegian continental shelf). This is not reviewed in this report, but the ventilation issue was important in SARex 1 and 2 on Svalbard.

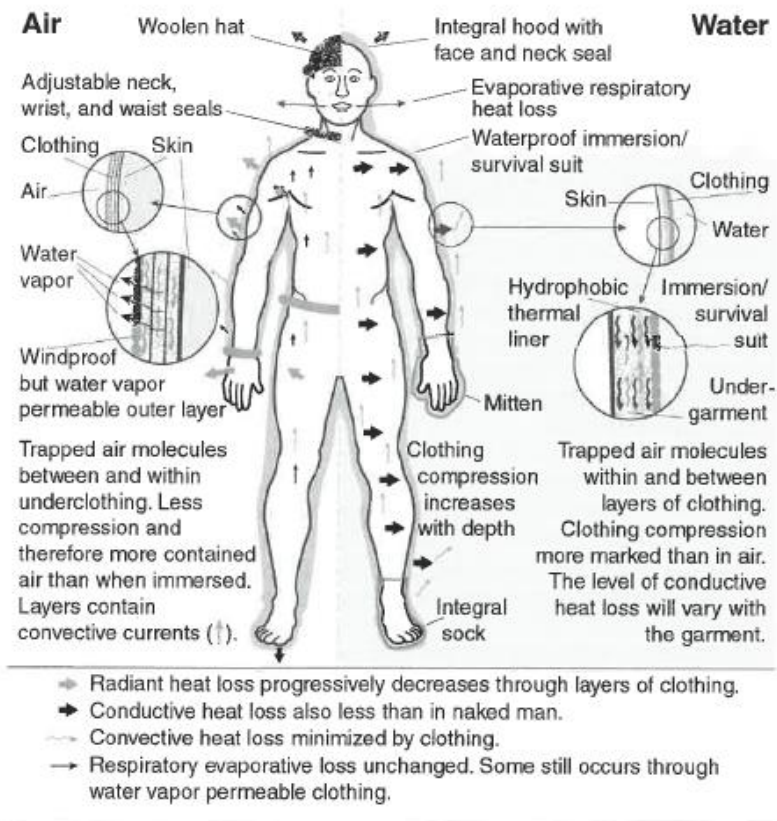


Figure C.1.5 Different routes of heat loss in air and water in a cold marine environment. Source: Golden and Tipton (2002) /1/.

Below are some essential human reactions in a survival situation in a cold marine environment /1/.

Hypothermia

The definition of clinical hypothermia is a core body temperature of 35° C or less. The figure C.1.6 below shows the different symptoms typically associated with the lowering of body temperature. Note that a body immersed in cold water experiences an initial increase in core body temperature due to increased heat production by shivering and peripheral vasoconstriction¹².

¹² Peripheral vasoconstriction **occurs when** the blood vessels in the outer skin layer of the body **retract** from the outer layers and **concentrate** blood in the inner organs of the body.

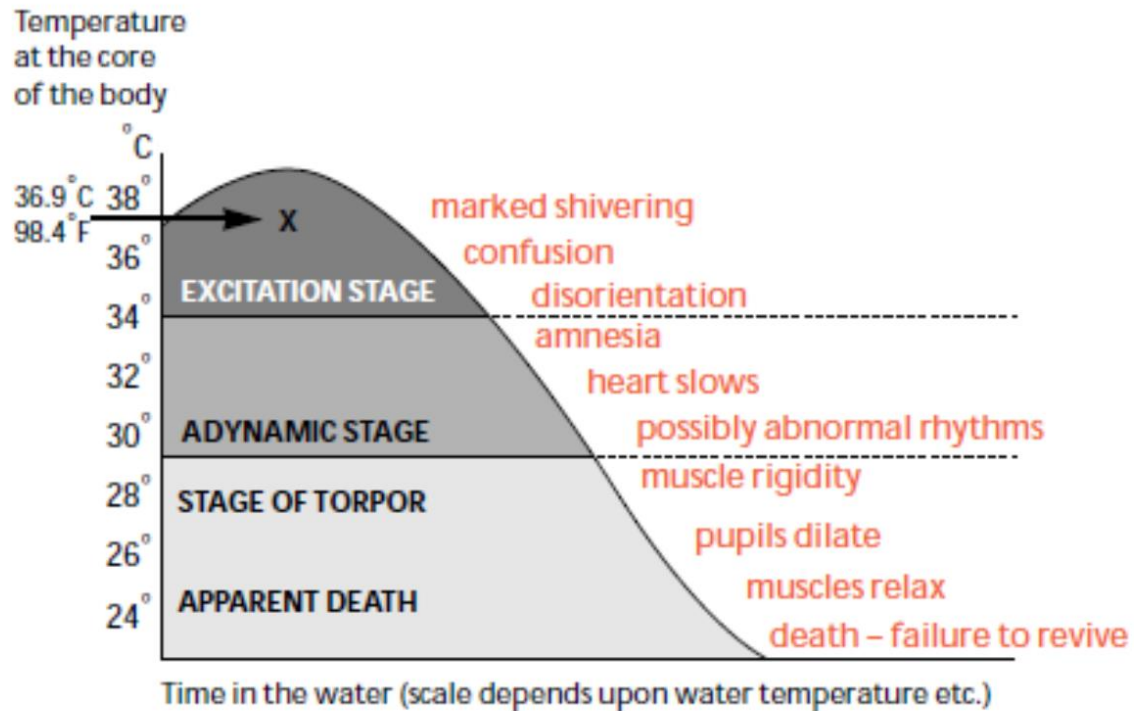


Figure C.1.6 Curve showing the fall of body temperature against time with corresponding symptoms¹³.

A distinction is often made between rapid-onset “acute” and slow-onset “chronic” hypothermia. The latter is what is usually experienced by survivors in a lifeboat or life raft at sea. Chronic hypothermia will usually be associated with depletion of energy reserves and body fluid loss, as survivors are trying to compensate for the drop-in body temperature, either by automated responses such as shivering or by being active. The two different categories are important in terms of treatment. For instance, in a chronic case, there may not be enough body fluids left to warm up the victim.

The most important effect in a survival situation related to hypothermia is that, below a core body temperature of 35° C, consciousness starts to decline and has an impact on behavior. The progressive deterioration of physical and mental capabilities will eventually make survivors less able to help themselves. Below a body temperature of 30° C, there is a threat of losing consciousness. By the time one reaches a body temperature of 28° C, then there is a serious risk of cardiac arrest, either through ventricular fibrillation or, later in relaxation, when the cardiac muscle itself becomes paralyzed by cold.

The head and neck are particularly exposed to heat loss, due to the lack of fat and the rich supply of blood vessels in this area of the body. The blood vessels on the scalp do not vasoconstrict, thereby increasing the heat loss by forced convection and evaporation of water if the head is wet. Fifty percent of heat loss can happen through this area of the body. Due to the differences in specific heat capacities between air and water, it is of the utmost importance to keep skin as dry as possible. Heat loss when immersed in water is 20-30 times greater than when only exposed to air /13/. In addition, any movements of the survivor in either water or in air, the currents or wind will increase heat loss through convection. This is caused by breaking the micro boundary layer of slightly heated air or water outside the skin or garments worn.

The effect of wind, which is referred to as the “wind chill effect”, is illustrated in the table C.1.1 below.

Table C.1.1 “Efficient” temperature as a function of wind strength at a given temperature (ISO 15743) /15/.

¹³ Source: <http://oceansurvivor.eu/blog/HYPOTHERMIA>

Actual Air Temperature T_{air} (°C)

Wind Speed V_{10m} (km/h)	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50
5	4	-2	-7	-13	-19	-24	-30	-36	-41	-47	-53	-58
10	3	-3	-9	-15	-21	-27	-33	-39	-45	-51	-57	-63
15	2	-4	-11	-17	-23	-29	-35	-41	-48	-54	-60	-66
20	1	-5	-12	-18	-24	-30	-37	-43	-49	-56	-62	-68
25	1	-6	-12	-19	-25	-32	-38	-44	-51	-57	-64	-70
30	0	-6	-13	-20	-26	-33	-39	-46	-52	-59	-65	-72
35	0	-7	-14	-20	-27	-33	-40	-47	-53	-60	-66	-73
40	-1	-7	-14	-21	-27	-34	-41	-48	-54	-61	-68	-74
45	-1	-8	-15	-21	-28	-35	-42	-48	-55	-62	-69	-75
50	-1	-8	-15	-22	-29	-35	-42	-49	-56	-63	-69	-76
55	-2	-8	-15	-22	-29	-36	-43	-50	-57	-63	-70	-77
60	-2	-9	-16	-23	-30	-36	-43	-50	-57	-64	-71	-78
65	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79
70	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-80
75	-3	-10	-17	-24	-31	-38	-45	-52	-59	-66	-73	-80
80	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81

Protection against hypothermia

There are several techniques that can be used to minimize heat loss, depending on the situation. Assuming a dry evacuation into lifeboats or life rafts, it is important to keep the habitat inside as dry as possible. Having proper survival suits, preferably with non-compressible insulation and or clothes, will significantly increase survival chances in a cold-water survival situation. The helicopter transport suits used in the Norwegian offshore industry today are the Helly Hansen “SeaAir” or “SeaAir Barents” type suits, Figures C.1.7 and C.1.8. In addition, there shall be life vests and certified (according to SOLAS requirements¹⁴) immersion suits available at each lifeboat station on offshore installations. In a cold-water survival situation, the insulated life vests have little value for survival, unless worn with the survival suits.

¹⁴ SOLAS=The *International Convention for the Safety of Life at Sea* is an international maritime treaty which sets minimum safety standards in the construction, equipment and operation of ships and mobile offshore units.



Figure C.1.7 Helly Hansen SeaAir Barents¹⁵ helicopter transport suit used in the Norwegian offshore petroleum industry. This is the primary suit for offshore personnel. Sprayhood is not done up on photo. Source: HH homepage.



Figure C1.8 Viking one-size-fits-all immersion suit, typically available at lifeboat stations on offshore installation in the Norwegian sector. It offers six hours of thermal protection according to SOLAS regulations. This is a back-up suit if the helicopter transport suit cannot be taken to the mustering station or means of evacuation. Source: HH homepage.

Cold shock & gasping effect

An investigation of historical incidents involving marine evacuations and immersion in cold water shows that hypothermia is not the main cause of death, but rather a contributing factor, disabling survivors' abilities: for instance, to keep afloat. One of the main causes eventually leading to drowning/death is the cold shock response that is an uncontrolled physical response, meaning breathing

¹⁵ Source: <https://hansenprotection.no/redningsdrakt-overlevelsdrakt/sea-air-barents/index.html>

mechanisms (hyperventilation) and muscular contractions are out of the individual's control. This mechanism will in turn lead to, for example, inhaling water into the lungs. This mechanism can be triggered from a temperature of 15 °C and below /1/.

Today's practice of flying offshore with the zipper down should be reconsidered in helicopter travel during times with low sea temperatures. When evacuating from an offshore installation, it is also of the utmost importance that the survival suits fits and is worn correctly, to prevent sea water entering and to avoid cold shock responses. The breath-hold time can be less than 10 seconds, making evacuation from a capsized helicopter or raft impossible. In 1973, the US Coastguard reported that two out of eight of the crew on a capsized vessel drowned while attempting a very short underwater swim /1/.

Drowning and near drowning

Aspiration of as little as ¼ to ½ liter of sea water in the lungs can lead to severe complications and death. Therefore, the sprayhood on a survival suit provides essential protection against sea spray and water during gasping episodes. The general rule is that a survivor, being submerged with associated hypoxia for less than three minutes, will have excellent survival chances, given the correct first aid (re-establishing ventilation and circulation). From between three to five minutes, survival may still be likely, if effective ventilation and circulation are re-established. However, in these scenarios there will be a major risk of brain damage. If submerged for more than five minutes, survival is not likely.

There are many factors that change survival chances; for example, was the patient conscious or not before being submerged with the potential of sea water filling the lungs? Some rapid-onset chronic hypothermia cases, where the diving reflex¹⁶ and vasoconstriction of peripheral blood vessels have taken place, can lead to some remarkable cases of the resuscitation of victims spending a long time submerged.

Injuries and psychological trauma

In addition to the direct effects of being in a cold marine environment, there is also a need to evaluate whether there may also be injuries or psychological trauma, either:

- As a direct consequence of the accident leading on to an evacuation or
- Through exposures during the survival phase

Through exposures during the survival phase. This should also be considered in the design of the means of evacuation and the training of personnel in handling evacuation and the survival phases. For example, it is common to have technical measures in place in modern enclosed lifeboats to facilitate carrying a stretcher. There is no training amongst lifeboat coxswains today in Norway which prepares them to handle the kind of trauma that can be experienced in such events.

C.1.9 Events from the past relevant for cold water survival

Oil rigs

In the Norwegian and UK offshore petroleum industry, the most relevant events involving escape to sea happened during the 1980s with the Alexander Kielland accident on 27 March 1980 and the Piper Alpha incident on 6 July 1988. In the Alexander Kielland accident, 123 of

¹⁶ Diving reflex is a set of physiological responses to immersion, especially amongst aquatic mammals, but also to some degree humans. Some of the most noticeable effects are reduced heartbeat, redirection of blood to the vital organs to conserve oxygen and the release of red blood cells stored in the spleen, thus enabling extended breath holds while immersed (source: Wikipedia).

212 people were killed and, in the case of Piper Alpha, 167 of 226 were killed. Both catastrophes involved personnel going into the sea. In recent decades, there have been no major accidents where personnel have had to evacuate to sea in the Norwegian sector.

On 15 February 1982, the mobile offshore oil rig, Ocean Ranger, was struck by a rogue wave off the coast of Newfoundland, Canada, and sank with the loss of all 84 crew.

In other cold water areas of the world, the jack-up rig, Kolskaya, which was under tow during a fierce storm, capsized and sank on 18 December 2011 in the Sea of Okhotsk, during a tow in ice-infested waters outside Sakhalin. A search and rescue effort began as soon as the rig sank and was halted five days later on 22 December. Of the 67 people known to have been aboard Kolskaya, 14 were rescued and 36 more were listed as missing. Only 17 bodies were recovered. With 53 declared missing or dead, it is the greatest number of casualties in an accident that the Russian oil sector has ever experienced.

The most common evacuation strategy for all offshore installations is dry evacuation, using helicopter taking crew on board via the helicopter deck. In none of the above-mentioned disasters was this possible, due to the presence of gas, stability issues or movements on the helicopter deck. In some of the incidents, lifeboats and rafts were deployed. The lifeboats and life rafts are still today's best alternatives to evacuation by helicopter.

Helicopter transport

There have also been several disasters related to the transport of personnel to and from offshore installations, in both the Norwegian and British sectors. In Norway, there have been two major accidents related to helicopter traffic to offshore installations: The Brønnøysund/Norne disaster, 8 September 1997, in which 12 passengers were lost, and the Turøy disaster of 29 April 2016, with the loss of 13 lives.

On 23 August 2013, a CHC Eurocopter AS332 Super Puma Mk 2 crashed into the sea 2 nm from Sumburgh in the Shetland Islands, Scotland, while en route from Borgsten Dolphin oil platform. The accident killed four of the passengers; 12 other passengers and two crew were rescued. On 1 April, in the same year, a Eurocopter AS332L2 Super Puma Mk 2 G-REDL of Bond Offshore Helicopters suffered a mechanical failure and crashed into the North Sea off the coast of Aberdeenshire. All 16 people on board were killed. On 16 July 2002, Sikorsky S-76A G-BJYX of Bristow Helicopters crashed into the North Sea off the coast of Norfolk, following the loss of its rotor head in flight. All 11 people on board were killed.

The Cougar Helicopter Flight 491 accident in Canada

In Canada, on 12 March 2009, a Sikorsky S-92 C-GZCH, operating Cougar Helicopters Flight 491, suffered a mechanical failure and ditched in the Atlantic Ocean off the coast of Newfoundland, Canada. Seventeen of the 18 people on board were killed. The fact that one person survived this accident makes it particularly interesting, in terms of lessons for helicopter transport emergency preparedness in cold waters.

The Canadian Transport Safety Board published an investigation report /16/ that has several useful lessons related to cold-water survival. Amongst others, the importance of wearing gloves, to even be able to evacuate out of a helicopter after being submerged in cold water:

“The Medical Examiner noted that each individual had properly donned their immersion suits (i.e., zipped up with hoods on) indicating that they were prepared to ditch. The survivor testified at the Offshore Helicopter Safety Inquiry 13 (OHSI) that he recalled the crew advised the passengers they were ditching and then eventually told the passengers to brace themselves just prior to impact. The passengers had not donned their gloves. They had been taught that donning their gloves could interfere

with their ability to release their safety harnesses and egress from the helicopter. The survivor testified that by the time he reached the water surface, the cold water had caused him to lose all feeling in his hands and he was therefore unable to don his gloves or raise his spray hood.”

The single survivor was an experienced dingy sailor, who was accustomed to cold water and was believed to have been better able to control cold shock responses such as the gasping effect. This has led to research in Canada, which is looking into acclimation of personnel going offshore in Eastern Canadian waters /17/. Other measures are being evaluated, such as wearing thin neoprene gloves at all times during helicopter flights, to prevent the initial numbing of fingers and hands, which are needed to operate the safety harness, in escaping through helicopter windows, to raise the sprayhood, etc.

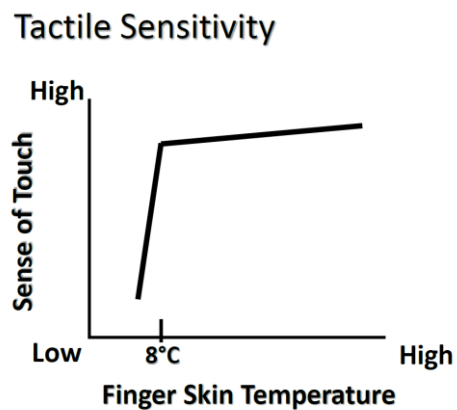


Figure 9 *The effect cold water has on tactile sensitivity of fingers when immersed /15/.*

According to Heather Carnahan, Ph.D., at the Memorial University at Newfoundland, there are suggestions of introducing a regulatory requirement to wear thin neoprene gloves during the duration of helicopter flights when sea temperatures are below a certain level¹⁷.

C.1.10 Competence requirements for emergency response in the offshore petroleum industry

Onshore competence training

The onshore training centers in Norway provide a Basic Safety Training (GSK¹⁸) course for all personnel traveling to offshore petroleum installations in the Norwegian sector. On this course, there are only some basics on survival and rescue from lifeboats and life rafts, which are repeated in the refresher courses held at regular intervals (every fourth year).

The participants on these courses have an equipment demonstration at an inflated life raft and there are exercises in the sea, involving the turning of a capsized life raft. There is also a demonstration of launching mechanisms, either by davit-operated rafts or by using the marine escape chute system, which is the most common life raft system in the Norwegian sector. There is also an evacuation exercise through the escape chute. Regarding lifeboats, the focus on these courses is also on the escape into lifeboats and evacuation; participants must take part in lifeboat lowering or a drop-in free-fall lifeboats.

¹⁷ Communicated in her presentation at Arctic Frontiers Conference 23 January 2018 (Title of presentation: *Peripheral Cold Water Exposure and Manual Performance*)

¹⁸ GSK = Nor. Grunnleggende Sikkerhetskurs Eng. Basic Safety Training course)

There is also practical training and an exercise in evacuation from a capsized submerged helicopter (HUET¹⁹). However, one can withdraw from participating here and obtain an N-notation on the Basic Safety Training certificate. This notation means that the person is permitted to travel offshore in the Norwegian sector but not in other North Sea nations' sectors. The HUET is done in swimming pools, where the temperature is about 18° to 20° C. Given the lessons learned from the Cougar helicopter 491 accident in Canada, it would be very beneficial to expose participants to considerably colder water during HUET. One should also consider removing the option of not participating in this training.

The lifeboat coxswain courses are mostly concerned with the functionality of the lifeboats, from mustering at the lifeboat stations to preparing for launching, launching techniques and moving away from the offshore installations, avoiding collision and re-entry. A minor part of the course focuses on operational/organizational factors after entering the sea in a lifeboat:

- Get an overview on board, take care of passengers
- Keep the command and initiative, get an overview – provide information
- Delegate tasks to passengers (equipment, first aid, emergency systems)

However, these subjects are not elaborated to a large extent and, as from the lessons from SARex 1 and SARex 2, they are an important contributor towards increasing survival chances. These lessons are presented in a later chapter in this report.

At the end of the lifeboat coxswain courses, this is the expected learning²⁰:

- Recognize 10 items from the lifeboat equipment package
- Highlight position using available equipment
- Know the lifeboat's six emergency systems and be able to use these
- Maneuver, also by means of emergency tiller
 - Using compass heading
 - Towards objects in the sea
- Launching of marine escape chute
- Prepare davit-operated life rafts for launching
- Recognize the most common stress reactions in an evacuation situation

As a conclusion, there is *very little or no focus, in either the Basic Safety Training courses or the Lifeboat Coxswain Training courses, on the knowledge needed for survival of a prolonged survival time in cold waters in lifeboats or life rafts!*

Offshore competence training

The requirements related to training on site at each individual installation are stated in the Activity regulations Section 23 about training and drills. They require that each individual team member in an emergency team on board trains a minimum of once per offshore trip for each role he or she has in an emergency response team. The Norwegian Oil and Gas Producers organization (NOG) has focused on making the onshore training more efficient and reducing the time spent on these courses, while emphasizing the importance of local training on each installation. NOG has developed a set of modules²¹ to ensure that important aspects of handling different hazard and accident situations are covered in the training sessions offshore.

¹⁹ HUET=Helicopter Underwater Escape Training

²⁰ Source: Ann-Elèn Sævareid at Falck-NUTEC, Norway

²¹ <https://www.norskoljeoggass.no/drift/opplaring/treningsmaterieell-for-beredskapslag/>

C.1.11 Lessons learned in relation to survival in SARex 1 (2016) and SARex 2 (2017)

This section is based, to a large extent, on the author's contribution to the SARex report /16/.

Introduction

SARex 1 and 2 provided valuable insight into challenges in an emergency involving a prolonged stay on lifeboats and -rafts. The venue was further north than today's exploration and production of oil and gas activities. However, several lessons learned are relevant for where the oil and gas activities are situated today on the Norwegian continental shelf. The environment in which the oil and gas industry is situated is in some ways harsher during winter time activities (as opposed to cruises in the summer, which was the basis for the SARex 1 and 2 scenarios), with an open ocean environment, darkness and more precipitation than north of Svalbard.

The key relevant lessons learned are especially related to the need for proper equipment and competence, to increase chances for survival in a prolonged stay in lifeboats and -rafts in Arctic or close to Arctic conditions. There is a considerable need for competence related to cold climate survival, including leadership in the lifeboats and rafts. In addition to specific requirements for evacuation equipment, survival clothing needs to be adequate and worn correctly. Heat generating and brain stimulating activities also needs to be performed to remain cognitive abilities needed for operating and handling survival equipment.

Note that this article does not provide a full list of experiences from SARex 1 and 2 but, rather, highlights those that are identified as particularly relevant for Norwegian offshore petroleum activities, as well as personal experiences.

SARex 1 and 2 in brief

SARex 1 and 2 (Figure C.1.10) considered evacuation and survival for maritime emergencies in Arctic waters. The scenario on both expeditions was an emergency on a cruise ship, involving evacuation. This section will look into lessons learned from SARex 1 and 2, which could be relevant for the oil and gas industry on the Norwegian continental shelf.

Although the expedition was on higher latitudes than the present oil and gas activities in the Norwegian sector, there were several lessons relevant for emergency preparedness in any cold, harsh-climate waters.

The author of this paper was an active participant in the tests. Participation in the survival tests in both SARex 1 and 2 took place in the life raft. Of course, the best learning came from direct participation, which were the raft survival tests, the evacuation of the lifeboat by KV Svalbard personnel, helicopter evacuation from the lifeboat with the SAR-rescue helicopter and the use and testing of emergency equipment for maritime casualties in the Arctic. Also useful was witnessing other tests, such as lifeboat survival, use of different types of PPE (Personal Protection Equipment), testing of AIS-SART²² and EPIRB²³, use of infra-red camera to identify casualties and simply being on a vessel exposed to low sea and air temperatures.

²² AIS-SART: Automatic Identification System – Search and Rescue Transmitter

²³ EPIRB: Emergency Position-Indicating Radio Beacon



Figure C.1.10 Red circles indicate areas for SARex 1 and 2 activities.

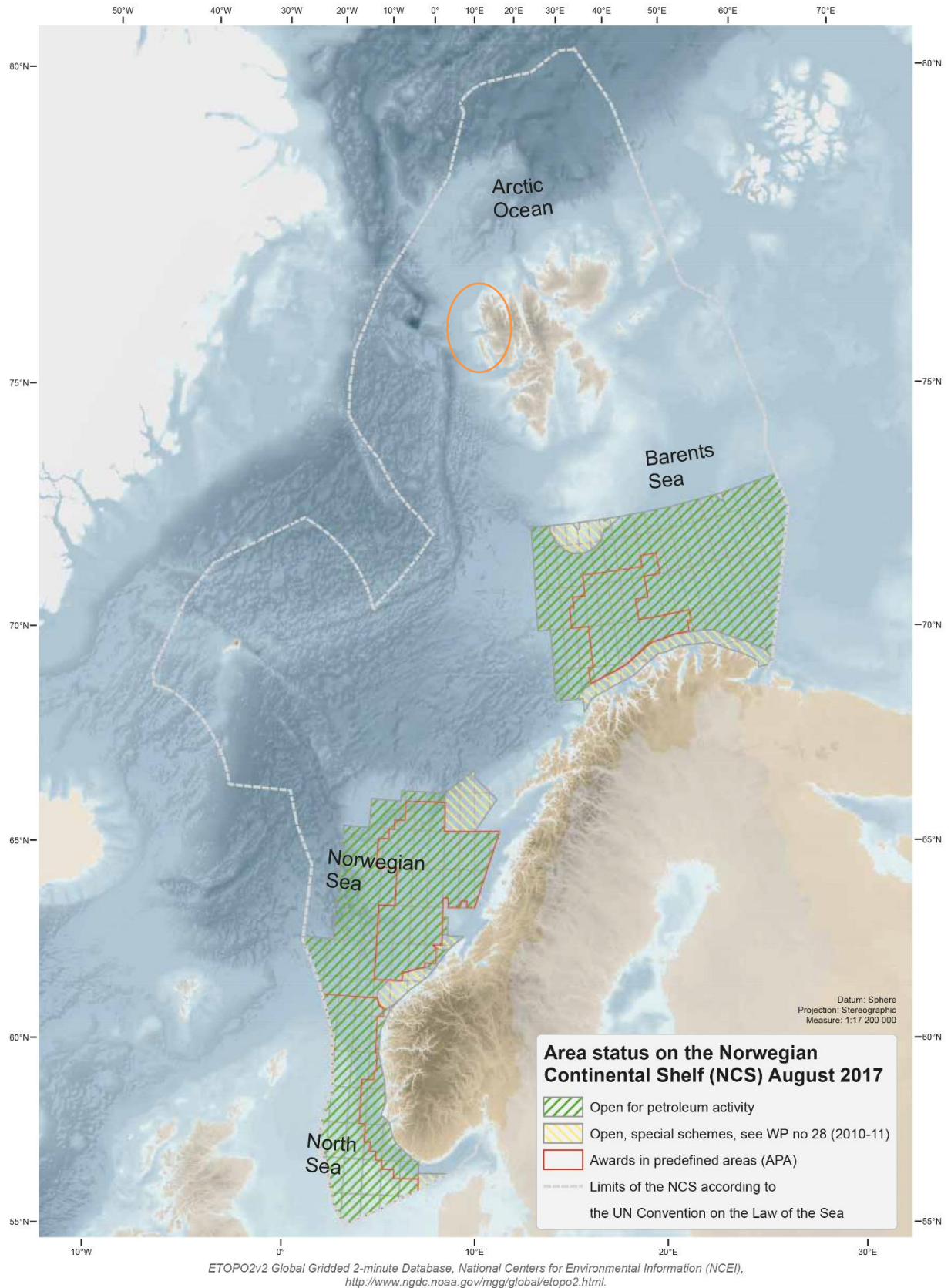


Figure C.1.11 Illustration of the areas open for petroleum activity, compared to areas of SARex 1 and 2 marked by a green ellipse on the northwest of Svalbard. Source: www.npd.no.

Climatic relevance

Relevance of technical, operational and organizational barriers

Technical barriers

The equipment put to the test for both SARex 1 and 2 was, for the most part, relevant for the offshore oil and gas industry, i.e.:

- Lifeboats
- Life rafts
- Survival equipment, survival suits and life vests
- Personal Protective Equipment (PPE), clothing underneath suits and life vests, hoods and gloves
- EPIRB and SART – detection equipment

Operational and organizational barriers

Several operational barriers were tested during both SARex 1 and 2:

- Leadership in survival exercise on board life raft and lifeboat.
- Rescue of people from lifeboat to KV Svalbard with the use of a MOB boat (SARex 1).
- Rescue of people from lifeboat to shore with the use of a helicopter (SARex 2).

Differences and similarities in the exercise scenario of SARex 1 and 2, compared to potential oil and gas-related accident scenarios

There are some key **differences** between the scenario of SARex 1 and 2 (a large-scale mass evacuation scenario in the northern part of Svalbard) and the accident scenarios possible in the petroleum industry:

Distance from shore-based resources: Today's distances from shore-based rescue resources to the offshore facilities, even in the furthest exploration areas, are considerably less than that of a potential cruise ship evacuation north of Svalbard. However, in the newly opened areas for exploration, distances are much greater than in the more developed areas of the Norwegian continental shelf. One example is Korp fjell (in block 7435), where there was exploration drilling in 2017.

Number of persons to be rescued: The number of personnel on board an oil installation is considerably lower than the number of passengers on a cruise ship (even though there are restrictions on how many passengers are allowed on board cruises in the most remote areas around Svalbard). However, there are also mobile offshore hotel (flotel) facilities that support projects on fixed installations. The flotels can host up to 450 guests, in addition to the personnel on board the fixed installation. Normal manning levels on fixed and mobile offshore facilities are typically in the order of 50–120.

Threat of solid ice: No areas on the Norwegian continental shelf with exploration drilling (or production) suffer an imminent threat of either sea- or glacial ice. There is year-round presence of ice around Svalbard, except for parts of the west coast.

Other environmental differences: The areas chosen for SARex 1 and 2 were in an area with:

- limited fetch, i.e. well protected, as opposed to the offshore oil and gas industry, which is present in open, long fetch ocean areas. Hence, it is a completely different environment, particularly with regard to waves and currents.
- low average precipitation compared to areas of the offshore oil and gas industry.
- lower sea water temperature, although, in the areas furthest north for exploration, there can be seasonal temperatures similar to those in SARex 1 and 2.

- wildlife threats (polar bears and walruses).

Presence of daylight: The expeditions were performed in the spring, which in these latitudes means 24 hours of daylight. This is also typical for the cruise industry in these areas. The offshore industry will, in many cases, operate through the dark winter months, which, together with higher likelihood of wind, waves and precipitation makes SAR operations far more difficult.

Availability of emergency preparedness resources: The offshore oil and gas industry is obliged by regulations to sustain emergency preparedness resources dedicated to each specific operation, whereas the cruise industry relies on public resources.

Emergency preparedness training: The offshore oil and gas industry provides emergency response training for all personnel traveling to an offshore installation (Basic Safety Course), in addition to interactive courses before traveling offshore, heliport safety briefing and introductory safety briefings, lasting for about an hour, on board each facility. Cruise passengers receive a safety briefing on board most cruises, as well as performing an emergency response exercise, but it is reasonable to believe that this training is not of the same standard as on an offshore installation.

Average health of cruise passengers vs. offshore workers: All offshore workers need to have passed certain health requirements and received a certificate of proof to be fit to work offshore. Similar strict requirements are not common for cruise passengers.

There are also some key **similarities** between the scenarios and equipment used in SARex 1 and 2 and what is relevant for the offshore oil and gas industry on the Norwegian continental shelf:

Means of evacuation: Both cruise vessels and offshore oil and gas facilities use enclosed lifeboats and life rafts. However, the mobile offshore units in the Barents Sea are of a semi-submersible type, where the most common lifeboat type is free fall.

Emergency preparedness organization: The dedicated emergency response personnel on board both an offshore facility and a cruise ship are certified and have received training in their emergency response role.

Survival suits and life vests: The insulated survival suits used in SARex 1 and 2 are assumed to have an insulation capacity reasonably comparable to that of the helicopter transport suits used on the Norwegian continental shelf. However, the helicopter transport suits are available in several sizes and, thereby, functionality is increased. The insulated suits used in SARex 1 and 2 are typically found in cabinets in the lifeboat muster areas. The life vests used in SARex 1 are like those used on mobile offshore units.

Air and sea temperatures: The air temperatures during the expedition were similar to those that can be experienced during winter seasons in some parts of the Norwegian continental shelf. Water temperatures in the north/north-eastern part of the Norwegian continental shelf can seasonally drop to the temperatures experienced (at least in SARex 2, where the sea temperature was 1.5° C).

Crew taking part in SARex 1 and 2: Although the crew on board KV Svalbard and many of the participants on these expeditions were specialized in emergency response, on average, the composition of participants in the survival tests was comparable to offshore crew. The need for communication and leadership would be similar in both a cruise ship and offshore industry evacuation.

Learning and recommendations from SARex 1 and 2

Technical barriers

Lifeboats

See also SARex Spitzbergen Report April 2016 /18/, Chapter 2.2.4 “*The lifeboat’s capabilities and capacity during the Phase 1 exercise*” and similar chapter from SARex 2 /19/.

1. Ice formation in vents in SARex 1. The low-pressure release valve that activates when the engine is running (using air inside) clogged up with ice. DNVGL-ST-E406 Chapter 3.6.1.2 states that ice formation shall be taken into account when designing a lifeboat. It also refers to DNVGL-OS-A101.
2. Ventilation – an issue related to condensation and also low O₂ plus high CO₂ levels. Part of DNVGL-ST-E406 Chapter 8.3.3. There was a CO₂ meter that indicated the need for ventilation. This, in turn, caused the lowering of temperatures inside and condensation.
3. Diesel heater provided temperatures too warm for wearing survival suits. Use of diesel heater needs to be such that survival suits could be worn in the case of need for quick evacuations. There is not enough room to store survival suits in a secure and proper manner. Part of DNVGL-ST-E406 Chapter 8.3.3.
4. Ability for lifeboat captain to communicate with passengers at the opposite/far end of the vessel. The captain is often located at the helm, which was a raised seat in the aft of the lifeboat. There was additional noise from engine, wind, wave motion, etc., which made it difficult to make direct commands. A speaker system inside the lifeboat would be of great help. This subject is not covered by DNVGL-ST-E406.
5. Evacuation to helicopter from lifeboat rooftop not realistic in open seas, due to wave motion and risk of hooking into deluge system. Some sort of removable railing, together with anti-skid cover, would be a great asset to aid standing on lifeboat roof.
6. Toilet facility useful. Covered by DNVGL-ST-E406 Chapter 8.3.5.

SARex 1 and 2 had the same type of lifeboat, being a conventional lifeboat. The lifeboat used in 2017 was an improved version of the one used in the previous exercise, e.g. insulation on seats (Styrofoam), toilet (type “Porta Potti”) and diesel heater. These two improvements alone provided a huge impact on comfort and estimated survival rate on board.

Life rafts

See also SARex Spitzbergen Report April 2016 /18/, Chapter 2.2.6 “*The life raft’s capabilities and capacity during the Phase 1 exercise*” and similar chapter from SARex 2 /19/.

1. The SARex 2 life raft also had near standing height and an air-filled beam to keep the tent in position, which provided support to hold on to during times of wave motion and when it was necessary to move around the raft.
2. The SARex 2 life raft, with features such as a double bottom and double tent, provides a major improvement, in terms of insulation from the single bottom and tent version used in SARex 1.
3. The SARex 2 life raft had a welded double bottom; the welds themselves created cold bridges.
4. The SARex 2 life raft also had some leaks in the seams that created a small but constant flow of sea water into the raft. This was removed by using sponges throughout the exercise.
5. Although the raft was not filled to maximum certified capacity, there was very little room to move. It was a similar experience in both SARex 1 and 2. However, personnel pulled out of the experiment at a far faster rate in SARex 1, leaving much more room to move. This room was used effectively last year to perform exercises, in order to produce heat. This was not possible to the same extent in SARex 2, where almost all participants lasted the whole duration of the experiment.
6. The zipper on the outside of the tent froze when waves hit the raft’s tent. Over a prolonged stay in a raft, this could be an issue with oncoming hypothermia.

7. The radar reflector was not easily mounted on the raft ceiling outside. The reflector was also lost when the wind reached gale force.
8. There were too few waterproof torches on board for a winter situation with complete darkness. Then, it would be essential to have sufficient lighting to ensure all necessary activities and operations.

Survival suits & life vests

See also SARex Spitzbergen Report April 2016 /18/, Chapter 2.2.7 “*The capabilities of personal protection equipment the Phase 1 exercise*” and similar chapter from SARex 2 /19/.

1. Compared to SARex 1, all participants in SARex 2 wore full suits. Three participants in the survival test wore uninsulated suits, the rest fully insulated suits. Some of the insulated suits also had extra insulation/padding in areas that had contact with the raft floor, when in sitting or lying positions. The insulated suits were comparable to the commonly used helicopter transport suits used on the Norwegian continental shelf. The expected time of rescue in the case of an oil and gas-related incident on the Norwegian continental shelf is about 24 hrs, although this is not an established dimensioning criterion. Together with wool clothing, these suits would most likely provide enough insulation, in a dry environment inside a double-bottomed/double tent type raft, to sustain body temperature in an Arctic environment.
2. The “one size fits all” suits that were used in SARex 1 and 2 do not have pockets, which could be useful for storing safety equipment and food rations.
3. The personnel on board used suits differently. It was obvious that some basic competence related to routines for opening the zipper to let moisture out would have been useful. The suits are water- and airtight. There is a build-up of moist inside the suits. How long time the suit was unzipped and how far down the zipper was seemed essential for the ability to maintain heat and stay dry. In addition, the use of the hood influenced the cold experienced. Those persons without an integrated hood noticed cooling at an earlier stage than those with integrated hoods.
4. The Velcro around the ankles and the waist strap was an essential feature for smaller persons using the “one size fits all suits”.
5. Those participants with uninsulated survival suits without integrated hood, but separate hood, noticed a distinct cooling of the neck area.
6. All suits had separate gloves or mittens. The types provided were either three-fingered type crab-claw neoprene mittens or five-fingered thin (2 mm?) neoprene gloves. The crab-claw mittens are far warmer but impossible to wear while performing the simplest tasks.
7. It is a requirement of the NMA to have life vests with a light, which automatically starts in contact with water. Lights on life vests might not be sufficient to detect personnel in the sea in snow or fog. See section below about detection equipment. There were no lights either on the “one size fits all” type survival suits used in this experiment.
8. The pontoons around the raft in SARex 2 provided a good bench, removing the need to sit on the cold – and at times wet – raft bottom.
9. The ballast tanks underneath the raft bottom provided a lot of stability, together with the very strong winds and short period wind-waves (chop) towards the end of the experiment. Nevertheless, there was sincere concern, when the winds reached more than 20 m/s, that the wind could have toppled the raft. At this time, the personnel on board the raft were taken on board KV Svalbard. The situation at least showed the importance of stability measures in place, particular for an open ocean situation.
10. When performing the helicopter pick-up, the inflatable life vest²⁴ popped, as it should. However, it was not possible for the rescuer to thread the sling either from above or below. The blown-up floatation device on the life vest had to be cut open by the rescuer, using a knife.

²⁴Type of life vest with a salt tablet dissolving once in contact with sea, releasing air into the life vest

Personnel Protection Equipment (PPE)²⁵

1. There are no protective gloves with insulation for Arctic conditions that enable the operation of valves or small items in either a normal work or emergency situation: operating VHF-radio, zippers, fastening and mounting radar reflector, emergency flare, etc. The personnel on KV Svalbard used conventional Arctic clothing; however, this equipment did not provide protection against crush injuries.
2. The personnel on KV Svalbard used balaclavas combined with goggles to provide adequate protection in e.g. operating the MOB boat in a considerable wind chill. They also used Gore-Tex waterproof working suits with neck seal.

Detection equipment²⁶

AIS-SART and EPIRB provided excellent opportunities for the detection of either individuals, when attached on survival suits, or lifeboats. The coverage of satellites at these high latitudes is rather poor, and part of SARex 2 was to perform trials to identify weaknesses.

Visual aids (of which there are a lot in a SOLAS life raft – mirror reflectors, smoke and flame flares) can prove useless in the dark winter months and in snowfall on the northern Norwegian continental shelf. It should, therefore, be elementary to look at other means to identify evacuated personnel.

Organizational and operational barriers

Leadership

See also SARex Spitzbergen Report April 2016 /18/, Chapter 2.2.8 “*Leadership on board life raft during Phase 1 exercise*”, Chapter 2.2.9 “*Leadership on board lifeboats during Phase 1 exercise*” for lifeboats and similar chapter from SARex 2 /19/.

The participation in the life raft survival tests showed the necessity of having good leadership on board: for both physical and mental aspects. The life raft leader on both SARex 1 and 2 was one of the Navy’s own officers, with the ability to organize the evacuated personnel to ensure:

1. Activities to sustain heat/warmth.
2. Operating the life raft at sea, watch routines.
3. Organizing water and food rations.
4. Organizing various safety equipment on board the raft.
5. Activities to maintain awareness, encouraging people to take responsibility, to come forward with good ideas and provide entertainment.

The life raft leader ensured that:

1. All survivors on board had responsibility for at least one or two pieces of equipment, making all persons on board explain the function and usage of the designated equipment.
2. Other tasks were distributed amongst the survivors, e.g. distribution of food rations, control of timing, taking turns on watch.
3. Bonding and engaging activities took place on board: introduction of each individual survivor onboard, games, etc.

Competence and fitness

Based on the operation of the life raft and the function of various pieces of equipment, it proved important to have either a competent life raft leader or competence amongst the evacuated passengers

²⁵ Trials done by Norwegian Maritime Authority and Memorial University of Newfoundland, St. John’s.

²⁶ Trials done by Norwegian Maritime Authority

to operate the life raft and associated equipment. Knowledge on cold climate survival would also be an important asset in terms of increasing survival chances: activities for keeping warm, how to minimize exposure to cold surfaces (e.g. raft floor).

C.1.11 Other lessons and recommendations for the offshore oil and gas industry in cold and remote waters

Technical measures

- Wearing thin neoprene gloves in emergency situations during helicopter flights and before embarking, and underneath the mittens permanently attached on most helicopter transportation suits. Stricter guidance on wearing correct size suits to ensure too large suits are not given to passengers.
- Wearing hood zipped up during flights in cold waters, not only during take-off and landing as seen practiced in the Norwegian sector. It is common practice to not wear the hood during take-off and landing, only zipping up the neck seal. However, it is usual to see passengers not zipping up, even when instructed to do so by the pilot before take-off and landing. The argument for keeping the hood down is to maximize the effect of hearing protection. The question can be asked: Would it be better to die with good hearing than not to die at all?
- The industry should develop performance criteria and efficient patents to ensure better ventilation in lifeboats and life rafts, without affecting the watertight integrity. This is also to meet the functional requirement in the IMO Polar Code Section 8.2.3.3, sub-item .1: *“...resources shall be provided to support survival following abandoning ship, whether to water, to ice or to land, for the maximum expected time of rescue. These resources shall provide a habitable environment”*. *“Habitable environment”* is defined in Section 1.2.4 *“...a ventilated environment that will protect you against hypothermia”*.

Operational/organizational measures

- Consider removing the N-notation on the GSK certificates in the Norwegian sector for offshore travel.
- Ensure cold water acclimation before offshore helicopter transport in cold waters, e.g. introduce real scenario temperatures in HUET training or add an additional module for acclimation.
- Establish performance criteria for the Norwegian offshore oil and gas industry, in relation to maximum time until rescue by either helicopter or vessel, where necessary first aid treatment can be given; cf. BaSEC recommendations.
- Introduce specialized courses for oil and gas operations within the Polar Code area that educate participants in all aspects of emergency preparedness, especially in the survival and rescue phase, which is not part of the other safety courses available. This should include the management of a lifeboat/life raft, trauma handling, survival techniques, etc.

C.1.12 Conclusions

The lack of regulatory requirements and focus from the industry to date, in relation to cold water survival, can mainly be attributed to the relatively short length of rescue times expected for the more established and developed areas of the Norwegian continental shelf. At least in theory. However, considering the exploration activities and possible new field developments in the more remote northern parts of the Norwegian sector and the lessons learned from SARex 1 and SARex 2, one must consider the extraordinary challenges that these marine environments impose on a marine survival situation.

Given the complexity of extended survival in cold waters, the petroleum activities taking place in the areas where the IMO Polar Code is applicable should consider adhering to these requirements. Otherwise, compensatory measures need to be in place to obtain a similar safety level to that of petroleum activities in the more southerly parts of the Norwegian continental shelf. For example, if not considering the five-day survival requirement for the polar regions, then additional rescue resources should be in place to considerably reduce rescue time. To achieve a similar rescue time to that in the more southern parts of the Norwegian sector will be a difficult task, considering the limited infrastructure; therefore, effort needs to be put into developing individual requirements and equipment for operating in these areas. Due consideration needs to be given to technical, operational and organizational measures in this aspect, to maximize survival chances during petroleum activities within the area applicable for the IMO Polar Code.

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Theme 2. The SARex 3 Exercise

C.2 Self-evaluation of equipment for SARex 3 supplied by VIKING Life-Saving Equipment

Lasse Boesen, Viking

C.2.1 Delimitation

This paper only focuses on product performance. Although they certainly have an impact on survivability, the interaction between the group members, and the different groups' capacity to cooperate, are not taken into consideration.

C.2.2 Equipment supplied by VIKING

VIKING supplied equipment for four groups. To create a good benchmark situation, the same type of shelter was provided for two of the groups and another type of shelter was provided for the two remaining groups.

The remaining equipment, shared and individual [Group Survival Kit (GSK) and Personal Survival Kit (PSK)], was then differentiated between each of the groups with identical shelters. One of the groups received GSK and PSK with a relatively high specification/quality content, while the other group received relatively low specification/quality equipment. This was done to achieve a clearer benchmark for evaluation purposes.

The equipment supplied was deliberately not of a high and already polar-proven standard. Instead, the equipment was of a standard where polar-suitability was unproven. Table C.2.1 gives a general overview of the product scope for the different groups.

Table C.2.1 Product scope for different groups

	GSK	PSK
Group 3	<u>High spec.</u> with following highlights: Shelter: portable storm shelter Mattress: self-inflatable Sleeping bag: heavy-duty Cooking system: MSA (gas-driven)	<u>High spec.</u> with following highlights: Base layer: Merino wool Outer layer: elite jacket and trousers Socks/head protection: wool Gloves/boots: heavy-duty
Group 4	<u>Low spec.</u> with following highlights: Shelter: portable storm shelter Mattress: reflective foam Sleeping bag: blizzard (alu-foil) Cooking system: gel-fuel driven	<u>Low spec.</u> with following highlights: Base layer: cotton Outer layer: standard/light jacket and trousers Socks/head protection: cotton Gloves/boots: thermal mittens/neoprene boots
Group 5	Standard GSK shared with group 6 No sleeping bag Shelter: inflatable life raft (from SARex 2)	VIKING PS5002 multilayer immersion suit
Group 6	Standard GSK shared with group 5 Blizzard survival bag as sleeping bag Shelter: inflatable life raft (from SARex 2)	<u>Low spec.</u> with following highlights: Base layer: cotton Outer layer: standard/light jacket and trousers Socks/head protection: cotton Gloves/boots: thermal mittens/neoprene boots

For detailed item description, see attachment.

Groups 3 and 4 were given the same type of shelter (portable storm shelter), with group 3 being allocated high specification GSK and PSKs, and group 4 having low specification GSK and PSKs.

Groups 5 and 6 shared an inflatable life raft as shelter, as well as a standard GSK. Group 5 had a multilayer immersion suit as PSK, while members of group 5 had a low specification PSK (the same as group 4).

C.2.3 Findings

Groups 3 and 4

When comparing the overall experience of group 3 and group 4, it is very clear that the high specification equipment that group 3 was given had a very positive impact on their survival experience. Group 4, on the other hand, was more challenged, due to the low specification equipment they were given. Consequently, one person from group 4 left the exercise after approx. 24 hours.

The portable storm shelter works when the total number of people the shelter is manufactured for is inside AND when at least three, preferably four, are sitting up to erect the shelter. The remaining people can then lie down, sleeping or resting. It is, however, not realistic for the three to four people erecting the shelter to maintain that position over a longer period. They will get cold and suffer from the lack of opportunity to move. When fewer people were inside the portable storm shelter, or when everyone wanted to sleep, the portable storm shelter worked more like a tarpaulin. With the lack of possibilities to erect a tarpaulin on the exercise area (a flat beach) and considering that the whole group seldom managed to be in the portable storm shelter at the same time, the portable storm shelter was not found suitable.

The portable storm shelter is suitable to provide shelter for shorter periods, when sleeping and/or lie-down resting is not required. When sleeping and/or lie-down resting is required, a tent should be used.

As for clothing (PSK) for group 4, the cotton base layer and the rather low specification outer thermal layer were not suitable – even in the rather mild test conditions. The survivors struggled to stay warm and, especially during exercising (to gain heat), the clothes failed to keep the heat trapped.

Further, the neoprene boots were found to be clearly unfit for polar purposes. Some of the users had early developments of trench foot, which, over time, could turn into severe injuries.

Group 4 had to improvise to make their equipment perform better. As examples, pieces of the foam sleeping mattresses were used to insulate the neoprene boots, and ropes/tarpaulin strips were used as waist belts to make the clothes fit.

The blizzard survival bags, which were provided to group 4 as the only choice of sleeping bag, turned out to be sufficient. The low weight and volume make it a good choice as an emergency sleeping bag. The blizzard survival bags, however, are not breathable, so moisture will build up, risking the survivor getting wet. In colder conditions, an actual sleeping bag is recommended.

Group 3 participants mentioned that they could have accomplished the exercise with lower specification equipment. For instance, with the high level of insulation from the clothes, a lighter sleeping bag would have been acceptable. Alternatively, a lighter version of insulating clothes would have been acceptable with the high specification sleeping bag.

The tools, such as shovel and machete, turned out to be very useful: shovels when the camp had to be set up and the machete when driftwood was cut up for the bonfire. The fuel for the gel-fired stove proved to be useful when the bonfire was to be ignited.

Both groups found the hand-warmers, providing ‘heat on demand’ for a few hours, useful as a means of heat-boost for hands, feet and/or neck, when those body parts were becoming too cold.

Dark colours should not be used for the clothes, sleeping bag and other equipment, as they reduce visible recognition for the SAR teams. Instead, the equipment should be provided in high-visibility colours.

As for stoves, only the MSR gas-fired stove in group 3's GSK was tested. It was, however, not tested for melting snow (which is the main purpose of this equipment). The feedback from the group result is that the MSR gas-fired stove worked very satisfactorily. It can be argued, however, that such a stove requires an experienced user.

Groups 5 and 6

When comparing the overall experience of group 5 and group 6, it is clear that the multilayer immersions suits used by group 5 provided better thermal protection than the low specification PSKs handed out to group 6. This is concluded, even though both groups lost a team member during the first 24 hours.

The inflatable life raft was used as a shared shelter by groups 5 and 6. It turned out to be a very suitable shelter – especially with the inflatable floor elevated from the surface. Since the life raft was already inflated, hardly any resources were used to set up the camp. With only 10 persons in the two groups and the life raft being a 25-person life raft, everyone could lie down. It is recommended that not more than 50% of the life raft's capacity uses the life raft as a shelter.

Both groups also shared a GSK. However, with the life rafts making a high-performance shelter, quite a range of the equipment was not used. Like group 4, group 6 struggled with the PSKs' lack of thermal protective performance (the two groups had identical PSKs).

The multi-layered immersion suit used by group 5 provided sufficient insulation, and the water-resistant outer layer made it a very suitable clothing choice. When sleeping, the survivors used the suit as a sleeping-bag, by pulling the arms out of the sleeves.

After approx. 24 hours, moisture build-up in the suit became an issue. The thermal layer of the suit started to become wet from moisture building up on the outer layer. This was especially an issue for those team members who had not ventilated the suit properly.

All participants were dressed in their own provided woollen base layers.

C.2.4 Recommendations and takeaways

Guidelines or clearer requirements in respect of the standard of equipment outlined in the Polar Code are needed. Such requirements could be uniform standards (where possible) for the individual content and/or be more closely related to the MELD/PST in the Polar Code or linked together with the Polar Classes of Polar-Code-approved vessels.

A holistic approach to the equipment is needed, rather than individual item-by-item assessment. In the case of clothes with a high degree of insulation, a sleeping bag with a lower degree of insulation can be accepted.

It is hard/impossible to hand out proper-sized clothes for everyone. It is therefore important that clothing is fitted with the possibility for size adjustment (waist belt etc.).

Duct tape, rope or other means to build, secure, and strengthen structures and equipment is very useful.

Inflatable life rafts are suitable as a shelter – if capacity is scaled down by 50%.

Multilayer immersion suits are suitable as thermal protection (part of PSK). However, frequent ventilation by the user is needed.

Emergency rations from life rafts/lifeboats are a suitable food source. Soup or other nutritious substances that can be mixed with hot water are recommended, to provide a psychological boost to survivors.

Wherever possible, products will be delivered in bright and visible colours.

SAREX 3 - GSK content, VIKING (27th March 2018)		Group 3		Group 4		Group 5		Group 6	
	Item	Units	Item	Units	Item	Units	Item	Units	Item
Each group consist of 5 persons	Storm-She lters (8 pers)	1	Storm-She lters (8 pers)	1	Liferaft (VIKING 25DKSN - from SAREX2)	1	Liferaft (VIKING 25DKSN - from SAREX2)	1	Gear to secure liferaft to ground/ice. Snow pegs, (8) hammer (2), ice screws (8) and guy line/rope (8)
	PSK 'high level' (all XL/45)		PSK 'low level' (all XL/45)		Survivor to be dressed in regular warm clothes, and:		PSK 'low level' (all XL/45)		
	- Long-johns (wool)	5	- Long-johns (cotton)	5	Insulated immersion suit (VIKING P55002)	5	- Long-johns (cotton)	5	
	- Long sleeved top (wool)	5	- Long sleeved top (cotton)	5	- Socks (thick extreme cold)	5	- Long sleeved top (cotton)	5	
	- Insulated jacket (-20 comfort)	5	- Insulated jacket	5	- Insulated boots (neoprene)	5	- Insulated jacket	5	
	- Insulated trousers (-20 comfort)	5	- Insulated trousers	5	- Snow goggles	5	- Insulated trousers	5	
	- Socks (thick extreme cold)	5	- Socks (polyester)	5	- Hat (waterproof beanie)	5	- Insulated trousers	5	
	- Hat (waterproof beanie)	5	- Hat, (cotton)	5	- Socks (polyester)	5	- Socks (polyester)	5	
	- Balaclava (wool)	5	- Balaclava (cotton)	5	- Hat, (cotton)	5	- Hat, (cotton)	5	
	- Inner glove (wool)	5	- Inner glove (polyester)	5	- Balaclava (cotton)	5	- Balaclava (cotton)	5	
	- Mittens (-20)	5	- Mittens (thermal)	5	- Inner glove (polyester)	5	- Inner glove (polyester)	5	
	- Insulated boots (Tundra -40)	5	- Insulated boots (neoprene)	5	- Mittens (thermal)	5	- Mittens (thermal)	5	
	- Polarized sunglasses	5	- Snow goggles	5	- Insulated boots (neoprene)	5	- Insulated boots (neoprene)	5	
	- Hand warmers (pair, 7 hrs.)	30	- Hand warmers (pair, 7 hrs.)	30	- Snow goggles	5	- Insulated boots (neoprene)	5	
	Sleeping bag (-20)	3	Blizzard survival bag	3	Sleeping bag (-20)	5	- Snow goggles	5	
	TPA	5	Blizzard survival bag	3	Hand warmers (pair, 7 hrs.)	3	Blizzard survival bag	3	
	Sleeping mat - inflatable	3	Sleeping mat - reflective	3	TPA	5	TPA	10	
	Stove, crusader (for snow melting)	1	Stove, crusader (for snow melting)	1	Sleeping mat - reflective	3	Sleeping mat - reflective	5	
	Fuel gel, 1 ltr, for stow	1	Fuel for stow	1	Stove, crusader (for snow melting)	1	Stove, crusader (for snow melting)	2	
	Fuel blocks (6X27 gr.)	2	Fuel blocks (6X27 gr.)	2	Fuel for stow	1	Fuel for stow	2	
	Matches	1	Matches	1	Fuel blocks (6X27 gr.)	2	Fuel blocks (6X27 gr.)	4	
	Water purifying tablets	2	Water purifying tablets	2	Matches	1	Matches	8	
	Water container, bottle	2	Water purifying tablets	2	Water purifying tablets	2	Water purifying tablets	2	
	Water container, bladder	1	Water container, bottle	2	Water container, bottle	2	Water container, bottle	4	
	Drinking cup	5	Water container, bladder	1	Water container, bladder	1	Water container, bladder	2	
	Snow shovel	1	Drinking cup	5	Drinking cup	5	Drinking cup	10	
	Commando wire saw (ice-cutting)	1	Snow shovel	1	Snow shovel	1	Snow shovel	2	
	Wind-up torch	1	Snow saw (ice-cutting)	1	Snow saw (ice-cutting)	1	Snow saw (ice-cutting)	2	
	Polar Survival Guide A-B-C	1	Wind-up torch	1	Wind-up torch	1	Wind-up torch	2	
	Polar Survival Guide A-B-C	1	Polar Survival Guide A-B-C	1	Polar Survival Guide A-B-C	1	Polar Survival Guide A-B-C	1	

Theme 2. The SARex 3 Exercise, continued

C.3 Self-evaluation of equipment for SARex 3 supplied by Survitec

Nigel Parkes and Solveig Rødset, Survitec

Survitec Personal Survival Kit (Light)		
Quantity	Description	COMMENT
1	MERINO WOOL LONG JOHNS	Satisfactory for conditions. Wool is the best option as it retains warmth when wet.
1	MERINO WOOL LONG SLEEVED TOP	Satisfactory for conditions. Wool is the best option as it retains warmth when wet.
1	MERINO WOOL SOCKS	They must be a tight knit & dense pile. Wool is the best option as it retains warmth when wet. These have no issues for sizing
1	INSULATING JACKET	Correct Sizing is a big issue for these items which must provide protection from rain, snow and wind – whilst providing full thermal protection. These jackets featured adjustable hoods, waists, cuffs, a fleece neck ruff and pockets. The main body insulation was satisfactory for the conditions but the arm lining was not and must be hydrophobic and not gather moisture which reduced insulation.
1	TROUSERS	Due to the limited rain and relatively mild low temperatures these were satisfactory for the conditions. Addition of a belt would extend size range.
1	FLEECE BEENIE	Cut of these hats was far too short limiting coverage; they proved limited wind protection
1	THERMAL HEAD AND NECK PROTECTION - GREEN SNOOD	Dual use saves space, could be adapted to protect many areas on the body. Some comments made on comfort of fabric due to limited elasticity.
1	THERMAL GLOVES / MITTS	Ok, seams were not waterproof and as such got wet/moist. The wool style lining was ok but modern Thinsulate™ or similar would be better and lighter
1	THERMAL LINER GLOVES	These were synthetic elasticated lining gloves and gave little thermal protection. The short wrist length sections gave rise to a rapid thermal loss.
1	SNOW BOOTS	The sole provided very little thermal protection. The sizing was satisfactory, and although comfort was ok for the design of the boot and they survived from a quality perspective the comments were tempered due to the quick thermal loss through the sole.
1	VASELINE	Not used, however comments on ease of opening of packaging were raised
1	THERMAL PROTECTIVE AID	Most used item – and used to provide additional protection over ill-fitting garments against wind. However, these were not very robust and were easy ripped and ideally required a different shape for more flexible / dual use. Material should be heavy duty with two-way zippers and arms if possible

1	SUNGLASSES	Satisfactory for conditions
1	WHISTLE	Satisfactory for conditions
1	VESSEL DRINKING GRAD	Satisfactory for conditions
1	FOLDING SIT MAT	Provided limited protection due to the fabric which soaked with water. Was very difficult to dry
1	FLOATING KNIFE	Not satisfactory.
1	ARCTIC POLAR BOOK	Writing too small, a lot of irrelevant information. Valid as entertainment. Needs to be written to encompass the kit supplied and use thereof.
1	EMERGENCY FOOD 500g	Quantities to be considered along with water rations. Additional supply of dried soups / coffee should be supplied as long as heating systems allow.
1	60L DRY BAG WITH INSPECTION WINDOW	Satisfactory for conditions, however consideration to weight and bulk – should determine the carriage methods which should be improved.

Group Survival Kit (Light)		COMMENT
Quantity	Description	
2	TENT (3 PERSON TENT)	Tent not adequately designed for conditions. Weak pole system, no ice pegs, poor protection against wind, wasted space in vestibule
6	THERMAL PROTECTIVE AID	See comments before
3	SLEEPING BAG	Quite bulky when packed but provided comfortable thermal insulation. The combination of both the bag and mat must be considered to provide highest degree of protection.
3	SLEEPING MAT	Good but bulky.
2	FOLDING SNOW SHOVEL	Satisfactory for conditions
6	TOILET PAPER ROLL	Poorly packaged – require protection, suggest folded paper in sheet form as saves space
1	FASTBOIL COOKING SYSTEM	Good and quick and intuitive to use – tested with gas and boils 1 liter of water in 1-2 minutes. Gas system not used during SARex.
3	THERMAL FLASK	Not keeping heat well when cold. Losing a lot of heat when whole lid must be removed to drink
1	WATER PURIFICATION TABLETS 2 x 50	Not used
10	RATIONS 500g	See comments before
1	TORCH - FULL PACK	Midnight sun so not used
1	SOLAS WHISTLE	See comments before
3	HAND SANITIZER	Satisfactory
1	SIGNALLING MIRROR 4" STAINLESS	Not used
3	100L DRY BAG WITH INSPECTION WINDOW	See comments before
2	SOLID FUEL BLOCKS (6units per box)	Fumes emitted can limit alternative uses. Need complimentary equipment to utilize correctly. Good fire lighting potential for use with scavenged materials.
2	GEL FUEL 1L	Limited burn time and heat generated. Need complimentary equipment to utilize correctly. Fumes emitted can limit

		alternatives uses. Good fire lighting potential for use with scavenged materials.
2	WINDPROOF MATCHES	“Igniting material” seemed to be worn down quickly. External striker suffered from damp. Not all matches struck and lit.

Personal Survival Kit (Heavy)		COMMENT
Quantity	Description	
1	MERINO WOOL LONG JOHNS	Heavier weight than light kit and satisfactory for conditions
1	MERINO WOOL LONG SLEEVED TOP	Heavier weight than light kit featuring a turtle neck. Satisfactory for conditions
1	MERINO WOOL SOCK	Heavier weight than light kit and satisfactory for conditions
1	INSULATING JACKET	See comments from before.
1	INSULATING SALOPETTES	Heavier weight than those supplied in light kit and found satisfactory for conditions. Especially liked the zipped trouser section for medical purposes and donning/doffing. Issues with sizing were better due to nature of being salopettes and the adjustment afforded by the shoulder straps.
1	FLEECE BEENIE	See comments before
1	THERMAL HEAD AND NECK PROTECTION - SNOOD	See comments before
1	THERMAL MITTENS	See comments before
1	THERMAL LINER GLOVES	See comments before
1	SNOW BOOTS	See comments before
1	VASELINE	See comments before
1	THERMAL PROTECTIVE AID	See comments before
1	SNOW GOGGLES	Heavier weight than light kit and satisfactory for conditions. Provided good face protection – mirrored lenses may not be suitable for all light levels.
1	WHISTLE	See comments before
1	THERMAL INSULATING MUG	No comments
1	FOLDING SIT MAT	See comments before
1	MULTI TOOL	Satisfactory for conditions
1	ARCTIC POLAR BOOK	See comments before
1	EMERGENCY FOOD 500g	See comments before
1	Hand warmer (pair)	Satisfactory for conditions, more would be good.
1	Floating Knife	See comments before
1	60L DRY BAG WITH INSPECTION WINDOW	See comments before

Group Survival Kit (Heavy)		COMMENT
Quantity	Description	
2	HEAVY TENT (3 PERSON TENT)	Heavy tent suffered collapse due to snow fall, not adequately designed to afford complete protection in these conditions. Weak poles, no ice pegs, poor protection against wind, wasted space in vestibule
6	THERMAL PROTECTIVE AID	See comments before
3	SLEEPING BAG (High performance Down style)	Although containing down and very packable these were too light – heavier weight/denser insulation required. Design was not robust enough.
3	SLEEPING MAT	See comments before
2	FOLDING SNOW SHOVEL	Quite small and short shaft. Not good for snow – but very suitable for ice or hard ground.
6	TOILET PAPER ROLL	See comments before
1	FASTBOIL COOKING SYSTEM	See comments before
3	THERMAL FLASK	See comments before
1	WATER PURIFICATION TABLETS 2 x 50	Not used
10	RATIONS 500g	See comments before
1	TORCH - FULL PACK	See comments before
1	SOLAS WHISTLE	See comments before
3	HAND SANITIZER	See comments before
1	SIGNALLING MIRROR 4" STAINLESS	See comments before
3	100L DRY BAG WITH INSPECTION WINDOW	See comments before
1	Tarpaulin	Quite small – need bright colours for safety
1	Exotac Candle	No comments
35	Hand warmers (pairs)	See comments before
1	Spare Personal Kit (Heavy)	See comments before
2	SOLD FUEL BLOCKS (6units per box)	See comments before
2	GEL FUEL 1L	See comments before
2	WINDPROOF MATCHES	See comments before
1	GSK -Group Survival Kit - Heavy c/w PSK	

Summary – the kits must be customized with each customer / for sizes and to encompass environment / area of operation. Problems with providing the sizing range for protection garments needs to be overcome – to ultimately allow these garments to provide /to afford best the thermal protection against cold including heavy rain, snow, wet and windy conditions. The protective garments provided within these kits must be considered as “in addition to” any normal clothing that would be worn in this environment.

Theme 2. The SARex 3 Exercise, continued

C.4 Gaps in material and procedures in Arctic on-shore survival

Milan Cermack, M.D.

C.4.1 Summary

The increase of circumpolar marine tourism presents significant challenges to SAR infrastructure in both Arctic and Antarctic. The efficiency and final outcome of rescue operations will depend on the variables between the emergency event and the retrieval of personnel and assets into safety conditions. Some of the most important factors are:

- Location and transport distances
- Environmental conditions
- Self-assistance capability of tourist vessels, including training of guides
- Technical equipment, training standards, and temporal availability of SAR resources
- International variability and compatibility of SAR procedures
- Awareness of tourism operators and their customers about potential hazards
- Available protection equipment on board of tour ships and staff ability to use it
- Strategies and resource use by survivors in the emergency situation
- Means of on-site assistance and of evacuation

The focus of SAREX III exercise was on the survival techniques **on the shore** of the Arctic Ocean and on the methods of assistance, triage, retrieval and transportation of casualties to the designated treatment facilities. These aspects are briefly discussed below and some recommendations are presented. For issues related to survival in life-rafts and life-boats please refer to the report from SAREX II, 2017.

C.4.2 Equipment standards

No universal arctic survival kit exists for several reasons. First, the environmental conditions vary with the season and with the geographic location. Second, many items designed for ocean survival, like food supplies, survival suits and life rafts can be used on land as well. Third, only the military, the exploration parties and sporting expeditions have been usually active on the land in the High Arctic. They all have their equipment tailored to specific needs and are trained to use it. Only very few polar cruises' passengers have even seen the sea ice before, pitched a tent in freezing rain, or walked for days in strong winds and drifting snow.

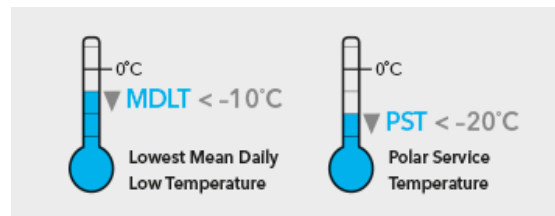
The IMO requirements in section 8.3.3, pertinent to the portable individual and group survival kits, are so vague that most of the material available on the market will be comfortably compliant with them, regardless of its usability under real conditions. For instance, the PSK required "Protection against frostbites" will depend more on the individual physiological status, activity, individual behavior and on type of exposure, rather than on winter gloves or shoes, claiming their protective status. The same applies to underwear, jackets and other garments. The "Protection against wind chill" requirement, for instance, does not specify the ambient air temperature or the wind velocity.

In the absence of better-defined standards, the confusion among the suppliers of personal and group survival kits (PSK, GSK) and among tour ship operators is understandable. The result of that is significant variability in a design and performance of protective devices, which are sometimes only marginally useful. There will always be a trade-off between protective equipment's performance, its cost and the realistic probability of using it, but this consideration should not jeopardize the survival chances.

The Polar Code clearly defines the Polar Service Temperature:

A ship intended to operate in low air temperature means a ship intended to undertake voyages to or through areas where the lowest Mean Daily Low Temperature (MDLT) is colder than -10°C . For such a ship, a Polar Service Temperature (PST) shall be specified and shall be at least 10°C colder than the lowest MDLT for the intended area and season of operation in polar waters.

The Polar Code contains specific requirements for a ship intended to operate in low air temperature. These include general requirements that systems and equipment required by the Code must be fully functional at the PST. **Survival systems and equipment also must be fully operational at the PST during the maximum expected time of rescue**



Polar service temperature definition example (Courtesy DNV-GL)

Technically, any item from the PSK or GSK should be defined as “survival system and equipment” and should therefore adhere to the same principle. The specific reference temperature for these protective devices can be set according to the geographical area and the intended period of operation. The testing of such equipment can be easily carried out in climate simulation laboratories, under standard protocol conditions. Upon successful completion of the test, the equipment would be labeled as “Polar Code compatible” within a specific temperature limits. The temperature range, postulated by some sport equipment manufacturers, is often more a result of wishful thinking, rather than of a systematic testing.

This certification procedure would also *a priori* eliminate the use of unsuitable materials, like cotton underwear, thin neoprene shoes without soles, and of poorly fitting outer garments with little wind protection and/or without hoods, as seen during the SAREx 3 field tests.

C.4.3 Individual wearable protective garments

The participants of SAREX 3 were exposed for over 48 hours to the ambient temperatures around 0 degrees C on a flat exposed beach, with little precipitation and with light wind. They were divided into groups with different levels of protection. Some of them were only lightly dressed for the environmental conditions, in their own clothes and could not use any shelter. Some of them had to deal with disadvantages of poorly designed supplied items; approximately a half of the group had the advantage of both good shelter and suitable individual protection gear. In spite of these deficiencies, no significant adverse health effects were observed (see separate report health report on this), but this must be interpreted with caution: The test group had significantly higher fitness level than the average cruise customers, most of the test subjects were professionals with previous arctic survival experience, the conditions were almost ideal and the exposure time was about a half of that stipulated by the polar code. Worse outcome could be realistically expected with real cruise passengers.

The exercise also examined the use of the maritime survival gear on land, in particular of insulated immersion suits and life rafts. The design of insulated suits aims primarily at the protection during immersion and is already rigorously tested by the manufacturers. However, their thermal insulation properties on land, including protection against wind chill, are quite satisfactory and superior to most of the clothing contained in the PSK used during the exercise. The key element of their protective properties, wet and dry alike, is a good size fit and the use of proper synthetic underwear. With no shelter available, the insulation properties of an immersion suit alone would be superior to any other winter clothing which was supplied to SAREX field test. The exception to that was comparison with an individual polar/mountain expedition outfit, but this was not a SAREX test item, would not be available on tour ships and would be totally unsuitable for any immersion situation.

There is an important difference between equipment design for performance sport and for survival. Most of the generic principles in individual survival garment selection are very obvious and include:

Material selection

Cotton shall be avoided in underwear, in shirts, socks and pants; synthetic materials for underwear and fleece for sweaters and jacket inlays shall be used instead. Materials that dry rapidly and retain some insulation properties when wet must be selected. The outer layer must offer a good wind protection, which is in Arctic survival more important than material's breathability. However, the use of non-breathable vapor barrier, worn close to the skin, shall be avoided.

Fitting and functionality

Since a custom fit is hard to expect, the garment must be easily adjustable to individual sizes, with a tendency to over-sizing, rather than too tight. The 3-layer principle shall apply (first insulation close to skin, main insulation layer in the middle, wind and abrasion protection on the top.) Any jacket must have a hood, extending well in front of the face when deployed and shall extend downward below the seat of the pants. Zipper and other closures must be overlapping, sleeves shall extend down to the fingers. Trousers shall have suspenders and shall cover the abdomen and lumbar region. Shoes shall be about one number larger than normally worn, hard enough for walking on the rocks and on the ice and be waterproof, at least in the bottom half. The headwear shall be preferably fleece, balaclava type, covering the neck. Mittens are preferable to gloves (possibly combined with thin gloves for manual tasks if necessary) and shall be connected together with a string, worn around the neck. Sunglasses, when supplied, shall be of protection factor 4, preferably polarizing and with side-flaps.

C.4.4 Group survival items

Shelters

The on-shore survivors will depend either on

- Improvised shelters, constructed from materials available on-site, e.g. snow trenches, igloos, ice-walls and driftwood structures
- Survival equipment and other suitable material directly related to the vessel like survival rafts and boats
- Items contained in group survival kits.

Except for shelters made of snow and for a life boat, all other options have been tested.

Life raft

Regarding structural stability, thermal and wind protection volume to surface ratio, and inside comfort, a fully inflated, double floor life-raft anchored on land would be superior to any other type of survival shelter listed above.

The tested GSKs equipment included:

Tents

The available models, were double-wall, family camping style tents of A-frame and of tunnel type. Both would have only marginal use in real situation. Awkward design and building sequence of first model resulted in unacceptable delays before it became functional. The second was faster to build, but collapsed under less than 10 centimetres of snow, with minimal wind velocities. None of them should be considered an "Arctic" or "Survival" tent.

The selection process shall consider previous polar experience and some new design trends. While the expedition geodetic tents (e.g. North Face or Hileberg) would be too expensive and not really necessary, a single-wall, rectangular, pyramid-shape tent with one central pole and with an integrated floor is a simple and cost effective solution in situations where simplicity and speed counts. The pyramidal design was widely used at the beginning of the 20th century in the polar exploration, almost forgotten at the beginning of the 21st, but is re-emerging again. Mass manufacturing and sizing is simple and relatively cheap and the design and size can be easily customized. Another alternative are inflatable tents. These

are more expensive and must be well anchored, but are more spacious and can be modular in design. Smaller tents can be easily inflated manually. Norwegian manufacturer NorLense has an extensive experience in this field.

Tarps

Tarps can be used for wind protection or as insulation against ground moisture, but have no inherent thermal insulation properties. Tarps handling in windy conditions is difficult and ventilation can be a problem when they are used as surface cover.

Sleeping bags

Sleeping bags in the design and price range for ship survival kit make really sense only in combination with a ground mat, tarp, or a tent, since they require a protection against the ground moisture and precipitation. If these conditions are met, even relatively cheap sleeping bags, with temperature rating from -10°C to 0°C , can make survival comfortable.

Bivouac sacs

Bivouac sacs are probably the most versatile means of thermal protection. Properties of different models vary from very good to useless. Their design should allow the individual to walk while wearing the sac, but be long enough to cover the feet when necessary. "Get in and sit" type should not be used, except as temporary cover for a sleeping bag when no tent is available. The walking bivouac sacs tested in the exercise were thin, yet with quite satisfactory insulation effects when worn over the full clothing. Properly designed sacs, with built-in thermal protection layer can function as an equivalent of tarps, sleeping bags and tents together. An example of commercially available product is Norwegian Jervenduken (Jervenduken AS), which has been already used by military and special forces of different countries. This model was not included in the tested kits, but – together with other similar products – deserves more attention as a simple, multi-functional and effective protection against the environment.

Stove

The stove can be of a normal, backpacking type, running either on kerosene, or other liquid fuel. For safety reasons, it must have as few detachable components as possible and the handling must be extremely simple, so that it can be safely operated by persons, who never did it before.

Fire starting packs

Fire starting packs. Contrary to popular perceptions, there is often enough driftwood on the shore to start the fire. A positive effect of carefully management fire is not only thermal: it can also improve the morale of the survivors. The fire starter was not available in the kit and its addition should be considered. (The stove was used as a starter during the exercise.)

Drinking water

Drinking water supply and management is critical in the open ocean, but on the Arctic shores and on the ice, the water is usually present as snow, or flowing. Thus, water purification tablets and/or reverse osmosis hand pump shall be standard survival items.

C.4.5 Assistance on site

Guidance and leadership.

The test group was monitored and supervised in well controlled conditions by the NCG officers and by experienced Arctic experts. It can be reasonably expected that the relevant experience of the cruise ships' crew members will not be equivalent. The standards in survival training of personnel on cruise ships operating in polar waters shall be defined and enforced, with emphasis on proper handling of the survival equipment, situation management and knowledge of the environment. This should include proper observation, protection and defensive strategies in wildlife encounters, including a use of defensive weapons if necessary. Completely incompetent handlings of polar bear encounters by official tour guides within the last two years support this argument.

On-site presence of properly trained S&R professionals, who assist and manage the survivors, can significantly improve the outcome. The positive effect of their presence is organizational as well as psychological. Small S&R teams can either be delivered to the accident site by a helicopter, or parachuted from fixed-wing aircraft together with the supply material, a technique which has been successfully used by the Canadian and Russian forces. Tele-monitoring and tele-advisory would be a temporary supplement to S&R physical presence. In the High Arctic the emphasis shall be on communication by the Iridium portable, hand-held terminal. (For more details about communication and alarm systems please see SAREX II report.)

Location and identification

Head-count the survivors, who may be scattered along the rugged coastlines, or wandering away in confusion after several days of waiting for rescue, might pose a challenge. The RFID tags used on board of ships would not work in such situation. A possible solution in search of dispersed individuals would be the RECCO system, which has been routinely used in skiing and winter mountaineering. Its operation is based on harmonic radar reflection principle: A small passive reflector (diode) is worn by the person, typically embedded in a garment or in a shoe. The active, sending detector can be located on board of a helicopter, of a rescue craft, or be hand-held. The range of RECCO system exceeds 200m.

C.4.5 Retrieval and transport

Airborne

Retrieval from the survivors' camp can be either to a nearby rescue vessel (land-loading, deck-unloading), or to a remote triage and treatment facility on land, e.g. Longyearbyen. Only very rough approximation can be made as an example, bearing in mind that the specific situation can be quite different:

Assumption: 2 helicopters, one Super Puma, loading capacity 15, one MI 8, loading capacity 20, combined 35. Effective operating time for each helicopter 18/24.

Land – vessel transfer, direct loading and unloading:

Assumed time per rotation 20 minutes = 105 px/hr x 18 = **1890 px/day**

Land – land transfer:

Assumed time per rotation 180 minutes = 6 rotations a 35 px = **210 px/day**

Note: Time limits and capacity of airborne evacuation from the life raft (hoist) to ship (direct unloading) have been measured during SAREX II and analysed in SAREX 2017 report.

Land-to-ship using rescue craft

The evacuation times will vary significantly with the topography of the shoreline, type and capacity of rescue craft and with the experience of their crew. Regardless of the above, it would be very difficult to load survivors with impaired mobility or on stretcher into any rescue craft, especially into those provided by the local S&R services. For safety reasons, this transfer was not tested during the exercise, despite fairly calm sea without any shore ice. It is an **essential technical issue** that shall be solved as soon as possible. The proper equipment shall be selected and/or designed and practically tested during the next SAREX.

Triage and evacuation

Proper primary triage of survivors by arriving rescue teams is a crucial step in retrieval strategy and sufficient time must be allocated to that process. The accuracy is more important than speed; the allocation of S&R human and material resources will be based on the triage results. Various computer simulated accident triage models exist

The capacity of the rescue vessel provided by Longyearbyen S&R for survivors' transport was not tested and is unknown. The vessel design offers little protected space; triage and treatment capabilities were limited and the planned ship-borne transfer of "victims" to Longyeabyen was therefore abandoned. On the other side, the KV Svalbard would be capable of transporting larger number of survivors, would enable an organized triage and provides medical resources at the ALS (Advanced Life Support) level.

C.4.6 Conclusions and recommendations

Mass tourism in the Polar Regions is relatively new trend and the land survival is not a core expertise of the IMO or of the ship operators. Thus, SAREX and similar exercises are essential for testing and evaluation of equipment and optimal operational procedures.

Personal protection equipment

The PPE shall be better standardized in its design, material selection, functionality and required performance for specific areas of operation. Internationally binding certification is recommended. Immersion suits of insulation design can be successfully used for thermal protection on land.

Shelters

The life rafts with proper anchoring system provide a good land-based shelter and this option shall be further pursued. Tents, if used, shall be of simple design, preferably with a single central pole. Use of inflatable survival tents shall be further investigated and tested. More attention shall be directed toward modular, multi-layer bivouac sacs for personal protection; these can be used instead of tents, sleeping bags and tarps.

Other equipment

Water purification tablets, reverse osmosis pump, stoves and fire-starting kits shall be mandatory. Instruction on all survival items shall be pictorial, rather than textual and large enough to be seen also in low ambient light. Military experience in protective equipment and survival procedures on land shall be considered wherever applicable. Means of search and location of individual survivor on shore shall be tested.

Procedures

Better methods and techniques for survivors' transfer from shore into the rescue craft shall be developed and tested. Training standards in survival management for ship crew and for individuals acting as guides on polar voyages shall be implemented. Arctic accident simulation models with different variables (location, resources, number of survivors) should be further developed and used in training. Realistic assessment of outcome in different accidents, based on physiological status of average passenger and on environmental conditions, shall be made. An international consulting group on polar survival, including Arctic and Antarctic, shall be established.

Theme 2. The SARex 3 Exercise, continued

C.5 Experience Transfer from SARex 3

Ann Christin Auestad, Arctic Safety Center, Longyearbyen

C.5.1 Exercise phase 1

Pre-phase:

The Arctic Safety Centre received information and an invitation to participate in the exercise in good time. As well as practical information, the invitation included information about all participants. It was useful to have these documents prior to the start-up of the exercise. Furthermore, during the course of the exercise, the Arctic Safety Centre received relevant and practical updates. The undersigned, Ann Christin Auestad (here after 'ACA'), participated in the exercise on behalf of the Arctic Safety Centre.

Planning on board:

The planning phase on board KV Svalbard was organized in a structured manner. The participants were divided into groups, and roles were assigned. This was a structured way of organizing the exercise, to ensure a better learning outcome. One participant in each of the groups was assigned the role of an observer. ACA's role was to be the observer for the group she was assigned to. Collectively, the observers planned their work before the exercise formally started. The observers agreed upon several parameters that were to be measured during the exercise, deciding that the status of each group should be checked every four hours. The status check involved assessing the following parameters: stress, cold, hunger, thirst, tiredness and motivation. Additionally, the observers were to monitor the function and communication within the group.

ACA was assigned to group two, which was provided with PSK light. PSK light included the following equipment: tent (1), sleeping bags (2), clothes (cotton pants, polyester jacket, hat, gloves and cotton buff for each group member), a pair of snowmobile shoes for each group member and yellow bags. A group leader was assigned to the group.

Health:

Medical checks were carried out by medical personnel twice every 24 hours. Saturation, pulse, temperature and muscle strength were measured.

Start of exercise at the beach:

After group two was set ashore, the group leader efficiently collected information regarding the group's level of experience related to outdoor life and camping. Each group member was assigned tasks aligned with their level of experience. The group leader made it a priority for each group member to introduce him- or herself to the rest of the group. This was useful, as it created an open atmosphere within the group. The group leader used the buddy system and paired each group member with a second group member. The group found this very useful.

The group worked efficiently with setting up the tent and organizing camp routines. Every morning we started with a morning meeting, where the group organized the day, and, every four hours, the group had a short briefing regarding the status of the parameters. From a Participant's perspective, group two had a good dynamic. The whole group stayed on the beach for the duration of the exercise.

Measure of parameters:

- Hunger – Every group member ate the food that was distributed at the beginning of the exercise. The group members did not experience feelings of hunger. However, after 24 hours, some group members lost their appetite and had problems eating all the food they were given. Had we stayed longer on the beach, this could have been a problem.
- Thirst – Each group member drank 1 liter of water every day. After 24 hours, most of the group members experienced a headache due to dehydration. Thirst was one of the parameters that was most challenging for the group.
- Motivation – The group was very motivated at the beginning, when agreeing upon tasks that had to be carried out to make the campsite better. After 24 hours, the motivation decreased. This was not communicated by group members but was visible to the observer. After 36 hours, the motivation increased, and the group became creative regarding keeping warm and how to sleep.
- Stress – The group members expressed little or low levels of stress.
- Tiredness – The energy level was high in the group from the beginning, and some group members stated that they had used too much energy and got a headache. The group had decided upon a rotating sleeping routine, in which each group member slept for six hours. The experience within the group was that after 24 hours, each group member had slept 12-18 hours per day. This was also a parameter in which the group was most successful.
- Cold – For the first 24 hours, the group did not experience much cold. Later, it was more difficult to stay warm, especially after waking up. After 36 hours, the group started rotating who slept in the middle, and that was effective for keeping warmer.

Debrief:

All exercise participants underwent a debrief session after returning to the vessel. This session was useful and gave the participants the opportunity to reflect on what had worked effectively on the beach. Those participants with the role of observer could have organized themselves more effectively, and that would have increased the learning outcome even more.

Summary:

It was very interesting to be part of an exercise of this scale and one with an element of realism to it. This increased the learning outcome. Furthermore, it was clear from the exercise that what you have within the PSK kit would increase or limit your chance of survival.

The group leader's role is important; he/she has to work well within the group and must communicate well with the team. The group leader needs to build on the group's strengths, and this is a key factor for survival. It is important to ensure that the group uses the buddy system.

Avoiding getting cold is a key factor to success. As soon as one gets cold, motivation is quickly lost, which limits the chances of surviving.

C.5.2 Exercise phase 2

Planning:

The participants were divided into groups, and each participant had a role to play at the beach. This part of the exercise was somewhat unclear, regarding goals and objectives. Prior to the exercise, the participants did not receive much information about what to do.

At the beach:

The person in charge was effective in organizing a search and starting to triage the injured people. This was done three times, which was useful, since it allowed every participant to train for the different roles. One important lesson was that means of communicating are important, as the injured were spread over a large area.

The patients were then transported to Polarsyssel by smaller work boats.

At Polarsyssel:

At Polarsyssel, the patients were hoisted by a stretcher. There was not a good system in place for the reception of patients, who were left unsupervised for a long time, with the risk of their condition deteriorating.

In addition, there was no system in place with regard to helping the most critically injured patients first. Furthermore, it took a long time to define an area on deck at Polarsyssel, where patients could be placed while waiting for medical attention.

Theme 2. The SARex 3 Exercise, continued

C.6 Comparison between SARex 3 and Canadian SAR exercises

Robert Brown, Marine Institute, Memorial University of Newfoundland.

See: https://www.researchgate.net/profile/Robert_Brown52

Theme 3. Leadership during the exercise

C.7 Leadership ashore

Simen Strand, Norwegian Coast Guard

C.7.1 Background

Representing the crew on KV Svalbard, my role during SARex 3 was as a leader for exercise group one. As a professional mariner and ship officer, you are likely to be assigned a leadership position in any part of an evacuation or survival phase after abandoning your vessel. The exercise was an opportunity for me to experience and test my skills as a leader for a shipwrecked group with limited equipment in the Arctic.

C.7.2 Discussion

Group one was assigned to wear winter clothing of their personal choice. No further equipment was provided, except water and food rations according to SOLAS regulations. Prior to the exercise, the groups were given the opportunity to be updated on known issues regarding the environment and the provided equipment. Based on this, we presented a strategy for how we would face our expected challenges throughout the exercise. My goal was to establish a way of living that would benefit from the collective effort of the group. In this way, I wanted to prove how little equipment you would need to survive in the Arctic climate.

Group one identified the following issues and measures, prior to the exercise:

1. Hypothermia due to the Arctic climate and lack of shelter
 - a. All participants in the group would dress as a tourist with some knowledge about clothing in an Arctic environment: three-layer clothing with wool as the base layer. We would also be wearing cap and mittens. The provided life vest would also serve as protection.
 - b. We would initially gather materials and establish a shelter with what we could find at the location.
2. Fatigue due to lack of shelter and staying active being a “must” to prevent hypothermia
 - a. Resting would be prioritized during the warmest period of the day, in order to maintain a higher activity level if needed during the night or colder periods.
 - b. The group would rest at the same time and remain close together, to benefit from body heat and provide more shelter.
3. Dehydration and lack of energy due to low rations and high activity level
 - a. The group would consume water and food at the same time and within specific intervals. The provided rations allowed us 125ml water every third hour and one bar of emergency rations every six hours.

In the initial phase of the exercise, my concern was to stay dry and establish a shelter. Our main shelter was, in general, provided by a stranded iceberg, possibly from the nearby glacier. We improved the shelter with blocks of ice and stranded pieces of wood. It was necessary to improve the construction throughout the exercise, due to changes in wind direction. The shelter would not always serve as our preferred location for resting. As the sun was warmer during the day, we tended to find spots where we could rest in the sun. I experienced the hours in the sun as the time where we could get quality rest. Most of the participants had several continuous hours of sleep during this period. While resting on the ground, we all used the life vests to lie on.

After the shelter was provided, I gathered my group to allow all members to introduce themselves. I considered this as a part of the initial phase after establishing a shelter. We also used this opportunity to set our schedule for daily routines, as agreed prior to the exercise. We would all fall into the same rhythm regarding daily activities. I pointed out one person who was responsible for gathering the group and dividing the rations. The group gathered every third hour throughout the exercise to drink water or eat. It was mandatory for all participants to consume their given ration at the same time. We quickly experienced that our temperature rapidly decreased as we stayed passive in the shelter. It was crucial to stay active, to maintain a comfortable body temperature. This limited the time we could rest before we needed to move. We also felt the benefit from resting close together, lying on the life vests as insulation from the ground. This gave us more shelter and passive heat from each other's body heat. It was surprisingly noticeable if some left the group while we were resting close together on the ground. Every time the group split to stay active, we agreed on a time to meet for the next rest. Our main activity to maintain core temperature was slow walking along the beach and keeping spirits up by socializing.

C.7.3 Conclusion

It is essential that the established routine is applicable to all. The group must fall into a rhythm, in which all participants rest, eat and stay active at the same time, to maximize the advantage of the number of people in the group. My biggest challenge as a leader throughout this exercise was to motivate the participants to strictly follow our routine. However, you will constantly need to monitor the effect of your established routines: a change in conditions can create the need to alter them as you go along. The knowledge and experience amongst your group members can also improve your way of living, while you await rescue.

It is important to get as much rest as possible, to save the energy you will need to maintain your body temperature. Higher temperature during the day makes this the preferred time for sleeping. Lower temperature at night will force you to stay more active. It makes a great difference to rest closely together with insulation from the ground. You will experience more shelter from the wind and the advantage of the body temperature of the other group members. If only one member of a group feels s/he does not need to rest, this will affect the others who might need the rest. Personal preferences must be set aside, to maintain the best conditions for the group as a whole. My experience was that the less you have, the more you make of it. My life vest was my only equipment, besides my personal clothing. This allowed me to be insulated from the ground and rest in a horizontal position. It also gave me protection from the wind and kept me dry.

Theme 3. Leadership during the exercise, continued

C.8 Survival ashore

Anders Johan Christensen, Norwegian Coast Guard

C.8.1 Background

As a navigator at sea, it is expected that you should be able to lead others in an emergency situation. Initially, this will be to evacuate the ship safely, but also during the further survival in a lifeboat or on land

In addition to my education as a navigator, I have leadership education through the Norwegian Armed Forces. Experience from former SARex exercises had also given me knowledge I could use in my role as leader of my group of five. To our advantage, we knew that this was an exercise that would extend over a given period of time and we were healthy, rested and motivated at start-up; a number of factors that simplified my role as a leader significantly.

C.8.2 Leadership

As a leader in an emergency situation, it is important to be able to vary the leadership style along the way; so-called situation-based management. In the initial phase, it is appropriate that the leader should be determined and direct, while being careful and including the others in the decisions will be correct in the later phase. The exercise did not include any dramatically initial phase and landing took place in controlled forms. Thus, our first challenge was to get the tent up.

We had also been divided into groups a few hours before the start of the exercise and given time to plan our stay on the beach. Thus, we had already gone through some planning. We also knew how much food and water we would have available. A success factor from former SARex has been to ration food and water to certain pre-set time in order to maintain common meal routines. In addition, meals can easily control the condition of the individual and common routines will ensure that the food and water are actually consumed by all. I made it clear that this was a solution I came to use.

Our group was relatively well equipped and we had two tents and three sleeping bags at our disposal. The clothing itself, on the other hand, was not particularly good. Living in an arctic climate with minimal clothing and equipment is challenging. Especially when access to food and water is minimal. We therefore expected that we would gradually weaken throughout the exercise. This emphasizes the importance of establishing, as soon as possible, good practices and following them. I pointed out one of the participants as material manager, another responsible for the tent setup. I think it's important to share responsibility both for activating the others while also taking advantage of the skills in the group.

We were therefore ready for some of the main points before the start of the exercise. We should work in the beginning of the exercise to work as little as possible at later stage. We also discussed the importance of not getting wet on the legs during the access to the shore or getting sweaty. This approach we followed throughout the whole exercise.

C.8.3 Hypothermia

While in the fleet there was limited space to move, you could quickly increase your body temperature through activity onshore. Here, however, we learned that this way of keeping the heat up would require a lot of energy and it would not be appropriate as the primary method of keeping the heat. We quickly found out that by laying 3 persons in the sleeping bags in the tent we managed to keep the body temperature up. I therefore advised the group that the sleeping bags should be in use at all times. The tent was the perfect place to spend time, which could be for several hours at a time. The limited factor therefore was how long those who had no place in the sleeping bags could wander around outside. I

landed on a solution with 4-hour guards. Since we were 5, there would always be an 8-hour period in the bag every day. By spending 4 hours, all were available for distribution of water and food at the agreed time for meals. This was a scheme that worked well, although someone thought it was boring to lie down so much in the tent.

The second tent we used to store equipment while eating the meals there. To sit in a tent only wearing the sparse clothing handed out was quickly too cold and I tried to keep these meetings as short as possible. I called on the others on the team at the first meeting to look at opportunities for improving our equipment. It did not take long before the creativity gained momentum. The perhaps most important modification was to cut up some yellow hypo thermos bags to ponchos as protection from the wind. These bags were also cut up and put into the shoes as extra insulation. We also insulated with sand around the bottom of the tents to prevent drafts. I instructed the team that at all times all were as to oversee the tents and to correct by any hint of problems.

I furthermore divided this group into buddy pairs, a method where the individual is responsible for a mate, he will follow extra well through the exercise. This includes everything from face and foot checks following signs of frost damage to follow up food intake and toilet visits.

C.8.4 Conclusions

Survival in the Arctic climate is challenging. It requires that equipment and personnel be prepared for the reality you meet far up in the north. A reality that changes quickly and where one can feel the sun warm for one moment, while just a few minutes afterwards, having to seek shelter for a snow storm. Our group of 5 was in good health, we were motivated and had dry clothes. We also spoke the same language and could communicate. That way, we could always discuss good solutions for everything from clothing to watchmaking. I could also spend time with each one to control the general state. These were factors that made me feel in good control of the situation. I could happily observe that the group saw what had to be done and measures were implemented without any particular interference from me. This is completely in line with what you could expect in the leadership role in such a situation; namely that you initially set requirements and control the group into a routine that will provide the basis for survival while allowing everyone's input so that this routine can be optimized. Just this ability to think about the use of equipment and show willingness to correct is something that surprised me positively through this exercise.

Theme 3. Leadership during the exercise, continued

C.9 The captain's role in ensuring SAR resources among staff

Andreas Kjøl, Viking Ice Consultancy

C.9.1 Introduction

This year's successful exercise focused on important issues related to Polar Code requirements. Shipping is driven by the cost-benefit principle, and many operators only follow the minimum requirements. Polar Code compliance surveys and approvals are, in many cases, carried out by class on behalf of a flag state, and we see different levels of accepted equipment and solutions on board. As always, the big question is whether a technical upgrade is required, or the gap can be filled by a less expensive operational procedure.

National, international and industrial regulations for the training of seafarers have a strong focus on equipment and how to use it. A vessel's crew follows the training and retraining procedures connected with retaining their Certificate of Proficiency, often described in the training matrix, which is the part of the operators' compulsory ISM system.

Onboard drills, including fire and abandon ship, are required by SOLAS and must be performed a maximum of 24 hours after embarkation. However, how these drills are planned, performed, and evaluated is often up to the master and the onboard senior officers and can be of varying quality. The compulsory onboard drills are often described in the operators' Emergency Training and Drill Manual, also part of the operators' ISM system.

Ensuring reliable SAR resources could be very challenging for the master on board, due to the different individual responses to a chaotic evacuation and survival phase. This is not unique to operations in the polar area, but remoteness, longer time for rescue and cold/harsh environment will certainly increase the severity and magnitude. It is very hard to create a drill scenario on board, to an extent which will enable the master to select the best leaders, who can handle a crisis.



Fig. C.9.1 Realistic long-term drills and exercises, such as SARex, are very important for understanding how the operational and individual factors will affect prolonged survival in a cold/harsh environment.

C.9.2 Important factors for survival (prolonged)

A combination of technical and individual skills, as described in figure C.9.2 below, will be the successful parameters for prolonged survival to achieve compliance with the code maximum time of rescue requirement, which should be never less than 5 days.

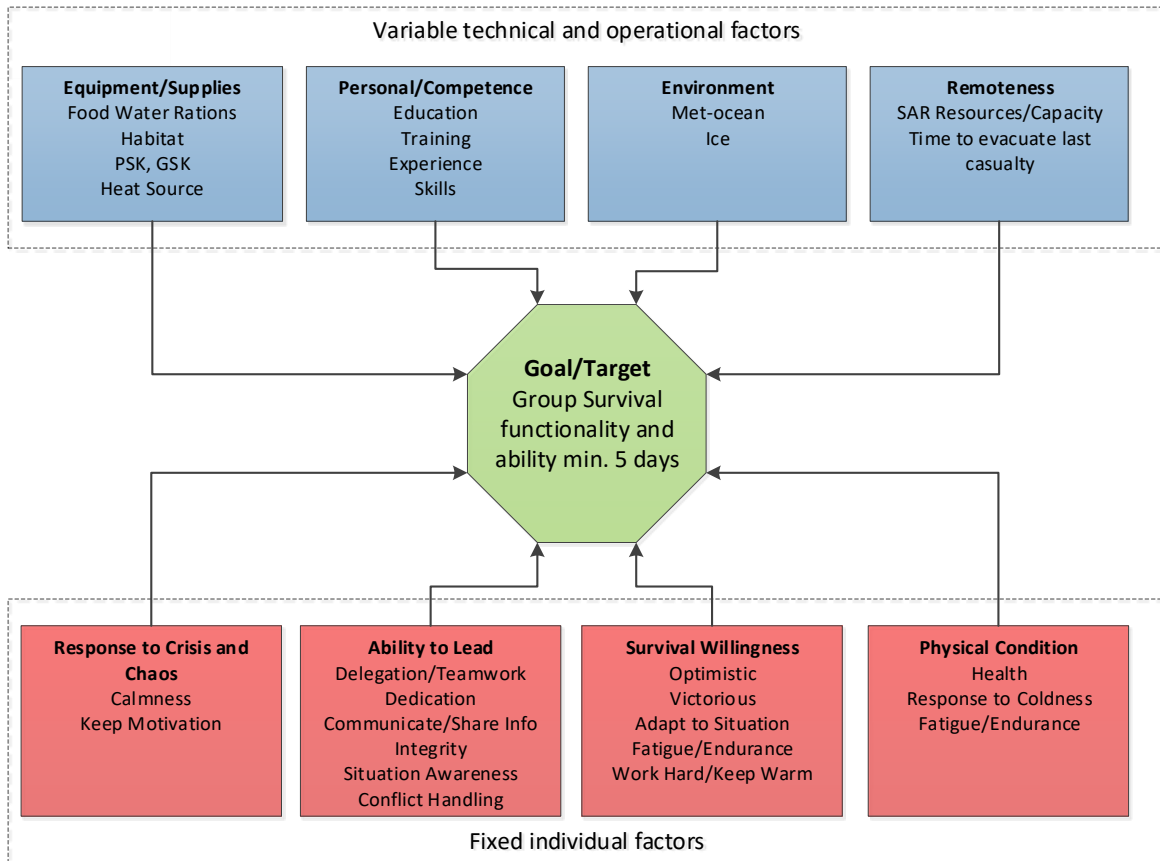


Fig. C.9.2 Factors for survival.

The onboard master often has no influence in the process for hiring seafarers. There is no special/additional training requirements for junior officers in the polar code, who are frequently the survival craft commanders. The situation is often that the same onboard position is responsible for a certain lifeboat or raft, regardless of the personal skills, special training or experience of crisis and/or survival situations.

For cargo vessels and tankers with a limited number of crew and few survival crafts, this may not be a big issue. There is no insurance that the master is the best to lead in such a situation, but after a while, whoever has the strongest leadership abilities in the group will be visible and can assist the master. In this case, a strong team might also already be built on board after many years of collegueship and can be beneficial to the survival situation.

Larger cruise and expedition vessels have multiple survival crafts. To ensure good leadership and integrity in each craft during survival phase could be very challenging for the master, fulfilling the required duration of functional survival.



Fig. C.9.3 Large passenger ship with 18 catamaran survival crafts/tenders.

C.9.3 Processes for ensuring strong and reliable SAR personnel on board (passenger vessel)

To really understand and manage the new requirements in the code, it is necessary for the operator's management to be involved, act and allocate funding. The flowchart below (Figure C.9.4) describes how this process can work.

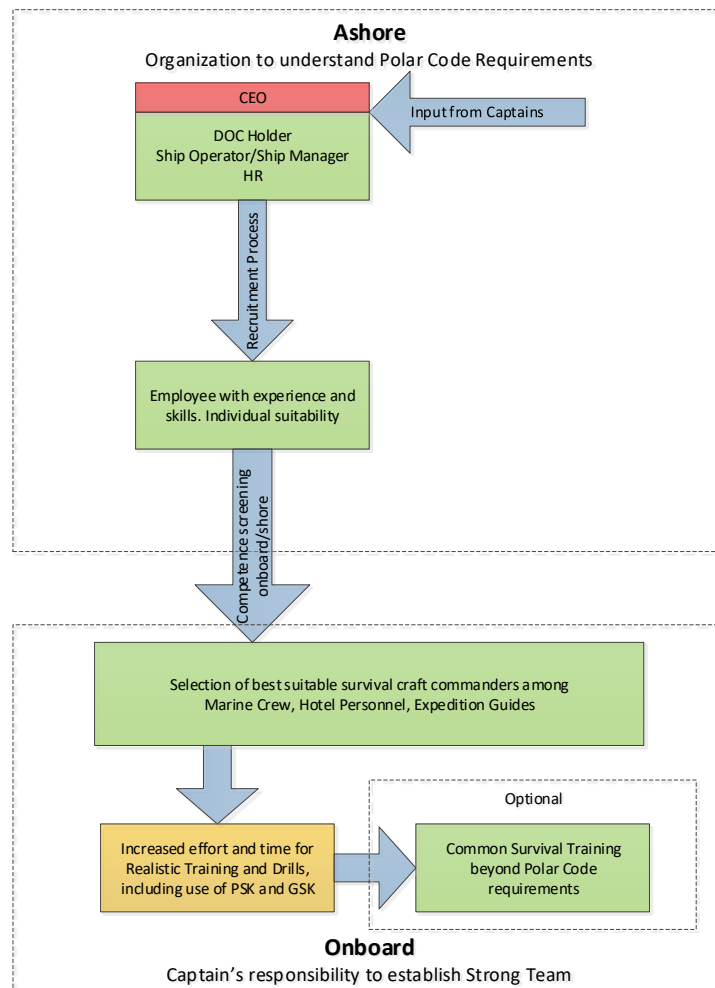


Fig. C.9.4 Suggestion for a process with a greater focus on survival skills.

C.9.5 Summary and conclusion

For the captain, with overall responsibility for the safety of the ship, it is obviously a large burden to carry alone and s/he must be supported from the shore organization. It is important that more time is allocated on board for muster and abandon ship drills prior to departure and for special drills involving use of (PSK/GSK) before entering polar areas. Enhanced survival training beyond STCW requirements, including muster station leaders and survival craft commanders, can also be a way to establish a strong team.

The CEO and operator's management team must be hands-on in this work and take the Polar Code compliance work seriously, participating in the operational assessments.

For larger passenger vessels, compliance with the code can be very complicated and highly expensive and a wise mitigation measure is not using this kind of ship in polar areas. It could also be necessary to charter backup vessels (icebreaking/SAR capacity) and shore airborne resources in the area for the purpose of medevac and equipment drop. This will increase the operational costs and reduce profit.

Theme 4. The rescue situation, continued

C.10 Training and crisis response in cold climate conditions – the SARex 3

Bjørn Ivar Kruke, Associate Professor, University of Stavanger

C.10.1 Introduction

The aim of this chapter is to discuss experiences from SARex 3 in relation to the requirements specified in the Polar Code, regarding equipment, manning and training of personnel that may face a need to evacuate a ship in polar waters. The findings in this chapter are mainly based on my experience as an exercise participant in a team/group during SARex 3. The findings are also based on discussions with members of other teams/groups, with different personal and group survival kits.

Exercise location

Phase 1 of the SARex 3 exercise took place 8th -10th May 2018 on a spit of land opposite a glacier in the Fjortende Julibukta, a small fjord (inshore) on the west coast of Spitsbergen, Svalbard. SARex 3 was part of a one-week expedition on board KV Svalbard for the testing of personal and group survival kits related to emergency evacuation of ships in polar waters.

Exercise scenario

The exercise participants were grouped into eight teams/groups. The different teams were then given different personal- and group survival kits. One team was only equipped with regular cold weather clothes and a life vest, whereas the other teams were equipped with various types of both personal- and group survival kits. In a controlled “abandon ship” operation, the exercise participants (consisting of both crew members from KV Svalbard and civilians) were transported ashore onto a spit of land on the south side of the Fjortende Julibukta.

Exercise conditions

Exercise start 8th May 1900hrs: +2 degrees Celsius air temperature, some wind and rain.

Exercise end 10th May 2000hrs: +2 degrees Celsius air temperature and dry weather.

The exercise took place on a beach on a spit of land south of Fjortende Julibukta.

Weather conditions shifted from rain and some wind to sun and no wind. Overall, even though the air temperature was just above 0 degrees Celsius, the weather conditions were fairly good, not exposing the exercise participants to extreme conditions.

Exercise management

The overall management of the exercise was conducted by the captain and crew on board KV Svalbard. The scientific part of the exercise was managed by Professor Ove Tobias Gudmestad, University of Stavanger, Norway.

The exercise staff were also represented ashore, by a duty system, with a post and tent in an adjacent area, mostly to conduct polar bear surveillance, but also to maintain some contact with the exercise participants.

Exercise objectives

The objectives of phase 1 of the research program were to:

- Workshop – develop a common understanding between all layers of the industry, including regulators, on how the IMO Polar Code is implemented today.
- Study the gap between typical survival kits [both Personal Survival Kits (PSK) and Group Survival Kits (GSK)] as provided by the industry, with regard to survival on ice/land, and the requirement of a minimum of five days' survival, as defined in the IMO Polar Code.
- Develop survival strategies.
- Identify equipment improvement points.
- Define a minimum PSK & GSK package that enables survival for a minimum of five days.

The exercise participants were divided into eight teams or groups and given various types of personal survival kits (PSK) and group survival kits (GSK).

My section of the report is primarily based on experiences from group 1, with only a minimum of equipment, consisting of regular cold weather clothes and a life vest.

Teams and equipment

Group	Equipment Description	Topic of Interest	No Persons	Supplier
Group 1	Minimum SOLAS requirements Regular cold weather clothes + life vest	Does PSK/GSK make a difference?	5	KV/Personal equipment
Group 2	PSK Heavy, GSK very light		5	Survitec
Group 3	PSK Light, GSK-Tarp	Effect of PSK + Tarp vs. Raft	5	Viking-Life
Group 4	PSK Heavy, GSK-Tarp	Effect of PSK + Tarp vs. Raft	5	Viking-Life
Group 5	PSK Light, GSK-Raft	Effect of PSK + Tarp vs. Raft	5	Viking-Life
Group 6	PSK Heavy, GSK-Raft	Effect of PSK + Tarp vs. Raft	5	Viking-Life
Group 7	PSK Light, GSK-Tent	Effect of sleeping bag/mat	5	Survitec
Group 8	PSK Heavy, GSK-Tent	Effect of sleeping bag/mat	5	Survitec
	Total		40	

C.10.2 International Code for Ships Operating in Polar Waters (IMO POLAR CODE)

Before we consider the main issues in question in this chapter, we need to briefly examine the defining expectations found in the International Code for Ships Operating in Polar Waters (IMO Polar Code).

Sources of hazards (Chapter 3)

The Polar Code considers hazards, which may lead to elevated levels of risk due to increased probability of occurrence, more severe consequences, or both:

- Ice, as it may affect hull structure, stability characteristics, machinery systems, navigation, the outdoor working environment, maintenance and emergency preparedness tasks and malfunction of safety equipment and systems;
- low temperature, as it affects the working environment and human performance, maintenance and emergency preparedness tasks, material properties and equipment efficiency, survival time and performance of safety equipment and systems;
- extended periods of darkness or daylight as they may affect navigation and human performance;

- high latitude, as it affects navigation systems, communication systems and the quality of ice imagery information;
- remoteness and possible lack of accurate and complete hydrographic data and information, reduced availability of navigational aids and seamarks, with increased potential for groundings compounded by remoteness, limited readily deployable Search and Rescue (SAR) facilities, delays in emergency response and limited communications capability, with the potential to affect incident response;
- potential lack of ship crew experience in polar operations, with potential for human error;
- potential lack of suitable emergency response equipment, with potential for limiting the effectiveness of mitigation measures;
- rapidly changing and severe weather conditions, with the potential for escalation of incidents; and
- the environment, with respect to sensitivity to harmful substances and other environmental impacts, and its need for longer restoration.

Polar Service Temperature (para 1.4.3)

For ships operating in low air temperature, survival systems and equipment shall be fully operational at the Polar Service Temperature (PST) during the maximum expected rescue time. The PST means a temperature specified for a ship which is intended to operate in low air temperature, which shall be set at least 10 degrees centigrade below the lowest Mean Daily Low Temperature (MDLT) for the intended area and season of operation in polar waters.

Manning and training (Chapter 12)

Ships operating in polar waters are appropriately manned by adequately qualified, trained and experienced personnel.

Maximum expected time of rescue (para 1.2.7)

The maximum expected time of rescue is specified as “the time adopted for the design of equipment and systems that provide survival support. It shall never be less than 5 days”. In other words, this is the standard which the equipment and rescue resources must meet. This is also the dimensioning requirement for personal survival after a shipwreck, that is to say, the period in which survival is down to the activities of the survivors themselves, prior to the arrival of rescue organizations.

Polar Code – Summary

The particular hazards of polar waters are dimensioning factors for survival equipment and preparedness activities for organizations operating in these waters. Cold climate, remoteness, huge distances, shifting weather conditions, fewer available rescue resources and capacities, and communication challenges are issues making preparedness and rescue operations particularly important and challenging. The maximum expected time of rescue of five days is a dimensioning factor, not only for lifesaving equipment but also for training and exercises: for both ship crews and passengers.

C.10.3 The exercise

The presentation of findings from the exercise mainly relates to experience gained by members of team 1.

Exercise participants

Crew members from KV Svalbard served as leaders of the various teams/groups. As indicated in the table above, we planned for five team members in each of the eight teams. The teams consisted of both crew members from KV Svalbard and civilian exercise staff. Team 1 consisted of three crew members from KV Svalbard and two civilian exercise participants.

Medical team

A team of medical doctors monitored medical condition and, in particular, body temperature of team members at regular intervals during the exercise. They also conducted other tests (cognitive and physical tests). They were given the authority to abort the exercise for participants with signs of hypothermia.

When leaving the exercise, team members underwent medical tests on board KV Svalbard.

Exercise area

The exercise area was a spit of land opposite a glacier in the Fjortende Julibukta, specifically a narrow part of the spit of land. We were restricted from movement outside this area. The exercise management team had a small base outside our assigned area.

The exercise area was flat and sandy, right next to the sea.

Startex

The exercise started with dressing in KV Svalbard's hangar. The team members were provided with personal- and group survival kits, according to which team they belonged to (see table above). Team 1 members came with their own regular cold weather clothing:

- Two layers of underwear (preferably woolen).
- Winter trousers and jackets of varying quality.
- A hat/cap and gloves or mittens.

In addition, each team member had a life jacket from KV Svalbard. After being dressed, KV Svalbard's MOB boats transported the team members ashore. The actual exercise then started around 2100 hours on 8th May 2018 on the beach in Fjortende Julibukta.

Landing on the beach

Team 1 was the last team to go ashore. The other teams had initiated work to establish their respective camps. When team 1 landed on the beach, most of the sites were occupied. There was a cold wind and some rain. A natural initial campsite for the team was behind a big block of sea ice on the beach. The block of ice was located some 5-6 meters from the sea. The block of ice gave some shelter from the wind and also the rain. We collected smaller blocks of ice to construct small walls on two sides of the big block of ice, to make the shelter bigger and better. In this way, we were sheltered from some of the rain and wind from several directions.

Organization of activities

After constructing the shelter, the team structure was the first to be organized. The team leader, an officer from KV Svalbard, presented himself (He was also officer in charge of the lifeboat during SARex 1 in 2016 and SARex 2 in 2017). We then, in turn, introduced ourselves. An important part of the initial organization was to become familiar with everyone in the team.

The team leader asked everyone to present himself/herself and include knowledge they thought could be relevant for the situation in which we found ourselves. It was important to get all team members engaged in the activities, to stay focused and motivated. Utilizing the knowledge, expertise and capacities among the passengers may be crucial for survival in a real shipwreck. Taking part in the various activities ashore may also be important for maintaining the cognitive and physical capacity required for survival over a longer period of time. This initial presentation was followed by the organization of some core activities in the team:

- The buddy system: the team consisted of five team members. We did not split into pairs but agreed that we all had responsibility for looking after each other.

- Medical responsibility. One crew member from KV Svalbard was given the responsibility for medical issues in the team.
- Cook: One of the civilian staff was given the responsibility for distributing biscuits. She was given the title “cook”. The team did not have drinking water. The exercise staff organized a water distribution point on the beach, where all teams could collect the minimum amount of water.
- Sleeping routines: The team had several approaches to sleeping routines. Firstly, we had the spoon system, where all team members slept together in a spoon system. Then we had individual members, or a couple of team members, sleeping, with one team member responsible for waking them up again after an agreed time (normally 30 minutes).

Overview of equipment brought by team members

Since team 1 was only equipped with regular cold weather clothes and life vests, we did not have much equipment. We did have a bag, a sweater, a book, etc. Although we did not have much with us, it was important for the team to make sure that all relevant equipment was considered and made available for the team during the exercise.

Eating and drinking routines in team 1

Drinking and eating the rations may be crucial for the passengers’ cognitive and physical ability to take part in the various activities and thereby to maintain body temperature. We had fixed timings for eating and drinking in team 1:

Drinking	1.5 dcl every three hours
Eating	One biscuit every six hours

Eating and drinking at fixed timings were mandatory in team 1, and all activities in the team were organized around these drinking and eating routines.

I believe no one in the team complained about being hungry. Even though the biscuits were not of a high culinary standard, they gave the necessary nutrition. Gathering for the meals was a good team activity.

The water rations were limited. I believe most team members started to get a slight headache after 24 hours. The water rations were too small to sustain a good physical condition. The physical activities related to staying warm added to the need for more drinking water.

Water collection was not an option due to movement restrictions and the fact that team 1 did not have any group survival kit. We did, however, have a bag. It could have been an option to use the bag to collect melting water from the sea ice. We also did not explore the possibilities of finding fresh water ponds, due to the limitations of the exercise area.

Shelter

This chapter is, as mentioned initially, based on experiences from team 1, only equipped with regular cold weather clothes and life vests. As previously mentioned, the team chose a big block of ice, next to the sea, for shelter, mainly due to the wind and rain when we landed on the beach.

Although the chosen shelter initially looked like a good choice, it had several deficiencies. The shelter was located next to the sea. It is likely that the air temperature was colder next to the sea. This is because the sea temperature was approximately 1 degree Celsius. Our experience was that the big block of ice had a similar effect. Although the block of ice gave shelter, it was cold to sit or lie down close to the ice. What initially appeared to be a good idea for shelter, later turned out not to be the best solution.

We therefore quickly realized that we needed another shelter. That was not easy to find in the local area. We often slept on dry sand on top of the beach, close to another team’s campsite. That worked because

we did not have rain. The availability of timber in the area could have been a solution for us to construct a shelter. That was not possible during this exercise, due to the restrictions imposed by the exercise staff. I do, however, think that this option of a timber shelter could have been a possible solution. A plastic tarpaulin (garbage) would have been an extra bonus for the roofing.

The campfire

As mentioned above, the exercise participants were restricted from moving outside a small exercise area. That meant that we did not find much to help us on the beach, except ice, stones and sand. Outside the exercise area, there were some cultural sites (old settlements) and a beach with a lot of timber (old timber from the mainland washed ashore). On the second day of the exercise, some teams started to test their equipment (GSK). One team made a small campfire, using some pieces of wood and jelly fuel for a field cooking set. This turned out to be very popular among the exercise participants.

Later, another team asked for permission to collect some timber for another campfire. A polar bear guard then escorted some of the exercise participants to a beach close by with a lot of timber. Several logs of timber were then carried back to the exercise area for a larger campfire.

The impact on the morale of the exercise participants was notable. A group of exercise participants “grouped” around the campfire more or less for the rest of the exercise. The campfire created a lot of activities:

- Several exercise participants dug a pit for the campfire and seating arrangements
- Several exercise participants walked over to another beach to collect more timber
- The timber was cut into appropriate pieces (a lot of effort with the available knives)
- The campfire had to be maintained.

All these activities created a lot of spirit among the exercise participants and helped in staying warm. The campfire itself also helped participants to stay warm.

Staying warm

The main activities during the exercise were eating, drinking and sleeping. However, the principal challenge was to stay warm. All focus was more or less related to these activities.

Sleeping meant heat loss. Long sleeps were therefore out of the question. The routine then boiled down to a maximum of 30 minutes (power nap) sleeping, followed by walking and other forms of physical training, to regain body heat. There were some discussions about the need to sleep. I believe everyone was tired after the first night on the beach, but not too tired. We all managed to get some sleep. However, after sleeping, most of us were cold and needed to regain body temperature.

Thus, a main activity was to “stroll on the beach”, for hours: day and night. It was not an issue about limiting physical exercise because of inadequate amount of food and water. The main issue in question was to maintain body heat.

Endex

The exercise ended after approximately 48 hours. The teams were transported back to KV Svalbard to undergo medical tests and take part in discussions on lessons learned. The next day, we also started preparations for the next exercise on the research program: an evacuation exercise involving exercise participants from Longyearbyen.

Artificialities

As in most exercises, we also had some artificialities in exercise SARex 3. Some of the objectives of phase 1 of the SARex 3 research program were to develop a common understanding between all layers of the industry, including regulators, on how the IMO Polar Code is implemented today; to study the gap between typical survival kits [both Personal Survival Kits (PSK) and Group Survival Kits (GSK)] as provided by the industry, with regard to survival on ice/land, and the requirement of a minimum of

five days' survival, as defined in the IMO Polar Code; and to develop survival strategies, identify equipment improvement points and define a minimum PSK & GSK package that enables survival for a minimum of five days. Is it fully relevant to "test" the IMO Polar Code on prepared exercise participants?

An important question related to transferability of the findings is the relevance of the findings from the exercise, compared to the situation faced by people (tourists on board cruise vessels and others) after a real shipwreck in Arctic cold climate conditions. Both crew members of KV Svalbard and civilian exercise participants were fairly motivated to take part in the exercise; we were in fairly good physical condition and prepared for the situation in which we found ourselves during SARex 3. It is therefore likely that we were in a much better position than would be the case with the standard cruise passengers and tourists visiting Spitsbergen.

During the start of the exercise, the exercise participants went ashore with one of KV Svalbard's MOB boats. We were therefore able to conduct a dry evacuation and landing. Only one of the team members got wet, on one foot, during the landing on the beach. That meant that none of the exercise participants experienced a wet rescue from the sea. During shipwrecks, it is likely that some of the passengers and crew members will experience a wet evacuation and rescue. In cold climate conditions, this could be a matter of life and death. The dry landing of the team meant that the chances of hypothermia during the initial stage of the exercise were less.

Another point worth mentioning is the close proximity of KV Svalbard. This may have had an impact on the morale of the exercise participants, in both positive and negative ways. First, it is possible that exercise participants could use the presence of KV Svalbard to abort the exercise earlier than necessary. Second, it is possible that the presence of KV Svalbard made it possible for some exercise participants to push the limits, maybe longer than was good for some exercise participants.

C.10.4 Conclusions

Members of team 1 only had warm weather clothing and a life vest. The team could therefore not give much input into the study of the gap between typical survival kits [both Personal Survival Kits (PSK) and Group Survival Kits (GSK)] as provided by the industry, with regard to survival on ice/land, and the requirement of a minimum of five days' survival, as defined in the IMO Polar Code. However, the team could provide some input to both the IMO Polar Code requirement of a minimum of five days' survival, regarding possible survival strategies on a beach area in Arctic waters, and a minimum PSK & GSK package that enables survival for a minimum of five days.

SARex 3 was a very important exercise for understanding the challenges of sustaining a sort of livelihood on a beach in Arctic waters after a shipwreck. Survival on a beach in Arctic waters in May, without anything more than cold weather clothing, a life vest, water and emergency biscuits, is possible for a short period. However, it is a constant struggle to maintain body heat.

The Norwegian Coast Guard personnel on board KV Svalbard showed professionalism of a high standard, making KV Svalbard the ideal platform for the exercise. With KV Svalbard nearby, and with experienced and professional crewmembers in the exercise area, it was possible to conduct the exercise in these rough conditions, without putting exercise participants' lives at stake.

Theme 4. The rescue situation

C.11 Motivation in a survival situation – essential, but not given

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C.11.1 Background

This report discusses the role of motivation in survivors during SAR operations in the Arctic. The focus is set on the survival phase: after the accident has occurred and the survivors have evacuated onto ice, land or a life raft or lifeboat. The observations made in this report are my own observations and notes from the exercise, but I also rely on information from the reports from SARex1 and SARex2. I have included theory from survival psychology to structure the observations and findings regarding this particular topic. In this report, I will address the role that motivation or “will to live” plays in such scenarios, including what happens when it is not present, factors that might affect it, and how motivation can be increased for a higher chance of survival. I will also reflect on how representative the SARex is in understanding these questions, and on thoughts regarding further research needed.

It is a common assumption that, in a survival-scenario, most people would do everything and anything to stay alive for the longest possible time, that they are somehow biologically “equipped” with the will or motivation to live. Yet, over and over again, we see that there have been incidents in which the people who did not survive neither had life-threatening injuries nor were ill-equipped to survive, and yet they perished. How could that be? It is a known phenomenon called “do-nothing-sickness” (Leach, 2011). In our everyday lives, we are used to structure and purpose, and most people are very sensitive to changes in this pattern (Leach, 2016). A survival scenario would naturally be a major disruption to anyone. One might face hunger, thirst, hypothermia, sleep deprivation and lack of sensory stimuli. Under such extreme conditions, it is essential to structure the days and take some sort of control of what they are going through (Maundalexis: Mounsalexis, McKneely, Fitzpatrick & Scheffer, 2011). There is a biological process to this phenomenon that I will not elaborate on, but the point is that, under extreme mental and physical strain, many people experience cognitive paralysis, in which lack of action becomes their undoing (Leach, 2011). This makes it very important to have skilled and trained leaders that can trigger people’s motivation and the will to do what it takes to survive, to establish routines, activities and systems to prevent people who actually have a chance of survival from perishing unnecessarily, due to cognitive paralysis.

C.11.2 Motivation / will to live and the importance of routines

Because of the lack of infrastructure in polar areas, the Polar Code states that equipment should be provided for the passenger to survive for at least five days before the SAR resources arrive. Five days might not seem like a long time, but as all the SARexes have proven, this truly is a great challenge even for the participants of the exercise who were in a good mental and physical condition. All three exercises had to be aborted early because of the state of the participants – it would not be ethical research to continue. The participants’ survivability is closely linked to their functionality and body temperature. “A survival time of 5 days will require the participants to maintain a high level of functionality throughout the survival period” (Kennedy et al., 2013, quoted in Solberg, Gudmestad & Kvamme, 2016, p.95). From my own personal experience from the exercise, survival for five days will require the participants to actively take measures to stay warm and functioning, since none of the equipment provided would enable participants to passively survive for five days. It requires an effort from the participants to maintain cognitive function and avoid hypothermia, as pointed out in the

SARex2 report: “*It is clear that individual motivation and knowledge play an important role in a survival scenario*” (Gudmestad, Solberg & Skjærseth, 2017, p. 266). It was also pointed out that a competent leader was essential.

The participants of the exercise were divided into groups to test different kinds of personal survival kits (PSK) and group survival kits (GSK). Each group had to fill out a form three times per day, in which they rated their level of motivation, comfort and hunger, amongst other things. Motivation was measured by simply asking the participants to rate their motivation on a Likert scale. This report will not include discussion of the scores but, rather, the concept of motivation in relation to survival. Then, of course, “measuring” motivation amongst the participants has to be put into the context of the setting of this exercise; a few of the participants from the Coast Guard expressed that they were not super excited to join the exercise in the first place, but they still put in a great effort to participate, as long as they were comfortable with it. And, of course, there was never any real threat to lives. Polar-bear guards were keeping the area safe, the Coast Guard ship was always nearby, and anyone could leave the exercise at any time. I think it is fair to say that the motivation the participants experienced was rooted in the wish to push oneself through this special experience, as well as team spirit and the desire to do it for the sake of the research – which is a collective effort. An exercise will never be able to replicate the stresses of a real-life scenario, but a full-scale exercise like this is as close as one can get without endangering the participants and still obtain a lot of important data and observations.

There are many terms used when talking about how people react to such extreme situations; resilience, endurance, robustness and hardiness are some of them. Some people will naturally be more resilient to extreme physical and mental pressure than others. The thing is, this is a factor that it is impossible to control when dealing with passenger ships. One will just have to assume the worst. Most of the passengers will most likely be old, in bad physical shape to begin with, and with little to no previous experience in this kind of situation. This puts additional strain on the equipment and leadership. Five+ days will be a very long period of time for them to survive. Survival in an Arctic climate with scarce resources takes a toll on the human body, more so for the elderly. This puts a lot of strain on the PSK and GSK, as well as the crew, who should be trained and prepared to act as leaders in such a scenario. It is unimaginable that those who survive the evacuation must feel some sort of relief when arriving onshore – they have “made it”. The adrenaline has worn off and reality kicks in. It could be quite a shock to grasp that help is not waiting for them onshore and might not be arriving anytime soon – that a lot more challenges lie ahead. I imagine this has a serious effect on people’s motivation and mindset.

It cannot possibly be easy to motivate yourself to start planning when to eat, sleep and keep active. Shelter would probably be a first thought in such a situation, but motivating oneself to structure the days by establishing and following routines might not seem so important. To “eat when hungry” or “sleep when tired” and “move when feeling cold” might not be sufficient to spur motivation in fatigued individuals, and it is therefore important to externally motivate by establishing behavioral patterns or routines important for survival. Routines such as sleeping in shifts can prevent sleep deprivation, which is known to have a detrimental effect on several cognitive functions, motivation, body temperature regulation and sense of hunger. Reduction in body temperature regulation can lead to uncontrollable shivering, as well as reduced functionality of extremities, which, in the last SARex exercise, were factors shown to be detrimental to participants’ chance of survival (Solberg, Brown, Skogvoll & Gudmestad, 2017). When you establish routines, you gain a sense of purpose and control, through having some things that you can control and predict, as we are used to in our daily lives (Leach 2016). When exposed to several types of stress, as one would in such a survival situation, you get a cluster effect (Leach, 2016). In this case, you have a lot of single stressors that might seem manageable for some time, but when you add in sleep deprivation, thermal stress, disorientation, physical pain, etc., it can be severely damaging to the cognitive abilities you want to maintain.

One of the factors that differed in this year’s SARex from the previous ones is that the scene of the exercise was on a beach area, not inside a raft or boat. This gave the participants the chance to wander about to keep warm and stretch their legs and get sensory stimulation, but, in my experience, people

were bored, despite this. Boredom is not to be taken lightly, as it was reported after the first SARex: *“Boredom is an underestimated issue. As long as there is nothing to do but wait, without purpose it is much more common to focus on ‘how cold one is feeling’. Doing is forgetting. Simple activity equipment like a deck of cards could help keep mental health”* (Solberg et al., 2016, p.120). *“Staying mentally fit is also important for the ability to generate the motivation, and prevent the development of fatigue, required for survival. There is a strong relationship between loss of cognitive abilities and reduction of body core temperature”* (Gudmestad et al., 2017, p.13). The groups had different content in their GSKs and PSKs. The point was initially that the groups would not interact too much, but it was not too long before they did. One of the activities that collected people from pretty much all groups was building a fire. Of course, there are no trees on Spitzbergen, but there is driftwood. While one group had some sort of saw, another had a knife, and then another group had a burner, some matches, etc. This might not have been optimal for the sake of the quality of the research, but, as far as I could tell, no group alone would have been able to make such a big fire. What was interesting was the positive effect the fire had. Everyone started joking and singing and helping each other keep the fire alive. Of course, the fire brought heat, but I think it worked really well as a goal to work towards, some sort of purpose and distraction from the situation.

I have personally experienced hypothermia more than once and am familiar with how I react in such cases: after a while, I give up. I have a shovel to make myself a shelter, I even have some more clothes to put on, but I just stand still. I can really relate to the term “cognitive paralysis” that I mentioned earlier. I need to be forced to do something. It is really quite scary. It is as if the brain stops thinking forward. You just wait for it to pass. Even though it was not freezing cold at the time of SARex3, it does not take much to get cold, especially if your clothes are wet. *“(…) regaining heat is difficult but also because the development of fatigue accelerates when the survivor is in a mild hypothermic state. It is of great importance that the survivors never reach even a mild hypothermic state, as recovery will be difficult”* (Gudmestad et al., 2017, p.13). This demands rapid action from leaders and the survivors when the survival phase begins: to regain heat and avoid hypothermia straight away, not to wait until you are feeling very cold to do something, because that might be too late. Older people do not produce heat well and do not have the same ability to sense cold. This is important to keep in mind, as most cruise passengers are older people.

When yet another day passes, and no SAR-resources are in sight, you keep facing new challenges, and the hunger, pain and thirst are getting worse, it is fair to assume that the motivation to continue the routines might decrease. I registered something related to this within the group I was in; some were sticking to their routines, while others did not. Some slept when it was “scheduled”, others whenever they felt like it. The importance of routines under extreme conditions has been pointed out countless times – in war, in a plane- or ship accident that required a period of survival, or in imprisonment (Leach, 2016). Even though the circumstances are different in a maritime accident in the Arctic, humans react in certain ways and have the same needs; since we know this, it should be possible to consider it when training crew, who will have to take on a leadership role in such a scenario. To know what kinds of reactions and behavior are normal in a survival scenario, even though they might seem irrational, might help in taking control and managing things the best way to ensure that as many people as possible survive.

It was fun to see how the participants in this year’s SARex got creative with the equipment handed out to us, how they combined different equipment to make improvements related to functionality or comfort. Some had very cold neoprene shoes that got wet and very cold quickly – some cut out soles for their shoes from the sleeping mats. This kind of creativity could be very smart in a real-life situation, but most likely the people trying to survive will not have any “extra” motivation to spend on creativity and smart solutions. One of the groups had a tent as a shelter. The group who were issued with this tent were familiar with camping and had put up tents before, but this tent turned out to be very difficult to put up – I am not familiar with the details of this tent, but I would imagine that the equipment needs to be very easy to use – as intuitive as possible. The challenges are many enough already; badly functioning equipment will, of course, be unfortunate in general, but also very demotivating and frustrating.

To survive until rescue is one accomplishment, but then the victims must be in shape to also survive the evacuation. To barely be alive for this might not be enough to get back home alive. The last phase of the SARex was a triage exercise for the Red Cross Longyearbyen. They were supposed to take control on scene as well as evacuate us. I will not go into detail on this part of the exercise, but it is my impression that if, as a survivor, you are in a critical state at the time of the evacuation, you might not be able to survive this. One might have to be carried on a stretcher for some time, be lifted into a helicopter, dragged onto a boat, etc.

C.11.3 Concluding remarks

In a real-life survival situation, there will be very little that people can control. The weather is what it is, you have been provided with a PSK and a GSK. One would think that all one can do in such a situation is to wait. But survival under such extreme conditions is not a waiting game: one must adapt and adjust quickly, to increase the chance of survival.

One of the conclusions from the SARex2 report was this (page 14): “*The equipment required by the Polar Code is to provide functionality that enables the casualty to maintain the motivation to survive and the ability to safeguard individual safety, which means to maintain cognitive abilities, body control and fine motor skills, in addition to preventing the development of fatigue for the maximum expected time until rescue.*” This really highlights how motivation, maintaining cognitive abilities and survival are connected and should be taken into consideration.

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Theme 4. The rescue situation, continued

C.12 Group activities in a simulated long-term survival situation.

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C.12.1 Introduction

A well-known example of a long-term survival situation at sea is Ernest Shackleton's expedition in the Arctic. His vessel "Endurance" was trapped in the ice and drifted for ten months before being crushed in the pack ice. Shackleton and his crew survived on ice floes for several months before they finally were able to rescue themselves. The way Shackleton and his crew maintained their daily routines is highlighted as crucial for the rather fortunate outcome. By taking scientific measurements, swabbing the decks, hunting, socialising in the evening, and so on, they were able to keep up the spirit. Another example of a long-term survival situation at sea is the sinking of the fishing vessel "West I". In order to rescue themselves the crew of eight split into two life rafts. Under leadership of the third mate on board "West I", the crew on raft A implemented a strict regime with regards to daily routines. The crew stood watches, the raft was swabbed regularly and food and water was rationed and issued to each crewmember publicly. On raft B routines were absent and each crewmember had to care for themselves. After two weeks the crew on "West I" were rescued by a naval vessel, and it was reported that the crew on board raft A were able to climb the boarding ladder themselves while the crew on raft B were confused and had to be brought on board (Sissey, 1988 as cited in Leach, 1994). Even though the case of "Endurance" and the case of "West I" do not provide evidences for routines and activities as a prerequisite to survival it is an interesting perspective to further explore and discuss.

The objective with this report is to present observations on group activities in eight groups that participated in the long-term-survivor exercise SAREX III. The first part of the report contain a short description of the SAREX III exercise. In the second part, observations of group activities in the SAREX III exercise is analysed in light of Tuckmans's (1965) theory of "group development" and Antonovsky's (1987) "sense of coherence" theory. In the final part, a concluding remark is presented.

C.12.2 The SAREX 3 exercise

The SAREX 3 exercise aimed to simulate a long-term survival situation in an arctic environment. In total 40 shipwrecked persons organised in eight groups of five persons was brought ashore aiming to survive with limited access to survival gear. The participants in the exercise was recruited from organisations within the maritime industry and public sector such as suppliers of maritime survival gear, shipping companies, educational institutions, authorities and the coast guard. Each group had appointed a group leader which all were enlisted persons serving on board KV Svalbard. Each group was also assigned a package of both personal and group survival gear provided by two different suppliers. However, one of the groups did not receive any gear – their task was to survive wearing their own clothes and a life vest.

The exercise was going on for 48 hours and the participants had access to water and food rations facilitated by the organisers. The main task for the participants was to do their best to maintain body temperature, to distribute food and water rations and to maintain motivation.

Some of the group members knew each other on forehand, either because they worked together or had participated in previous SAREX exercises. However, the participants did not have any previous

experience from a similar exercise. This implies that the group members were inexperienced with respect to both the task they should perform, the structuring of the group and interpersonal relationships within the group in the given context. The central task for the group members was to figure out how they should interact and organise in order to provide shelter and to utilize the allocated equipment in the best possible way.

C.12.3 Task activity and structuring of the groups

According to Tuckman (1965) task activity and structuring of groups typically develop through four stages. The first stage in Tuckman's theory is defined as **"testing and dependence"** and **"orientation to the task"**. In this stage, the group members aim to define what kind of tasks and problems they have to solve and to identify the group members' resources that are relevant for the tasks. According to Tuckman, the group members will also test other group members in order to discover what kind of behaviour that is acceptable within the group. In the SAREX III exercise all the groups prioritized to get an overview of available gear and to establish a camp. The ability to provide a decent shelter varied however substantially between the groups. Some of the groups were assigned tents, tarps or liferafts while others had nothing – or close to nothing to provide them shelter. They therefore approached the task by building shelter of stones, ice and sand from the surrounding environment. In this respect, providing shelter was identified as the most important task among all the groups. Some of the groups considered however the establishment of routines as an important task in the initial phase of the exercise. The following description illustrates the routines in one of the groups which, had two tents, three sleeping bags and three sleeping mats divided on the five persons in the group:

- A set time schedule where two and two group members had access to a sleeping bag and a sleeping mat. The other sleeping bag and sleeping mat circulated between the group members. The arrangement secured that each group member had at least four hours sleep during daytime and six hours sleep at night.
- The food and water rations were distributed on set hours and the rations were issued to the group members publicly.
- In order to detect any dissatisfaction and problems within the group, meetings were held at regular intervals.

According to one of the group members the routines, as described above, were adhered to throughout the whole exercise. However, some of the groups did not see the establishment of routines as an essential task in the initial phase of the exercise. The following description illustrates the arrangement in one of the groups which, among other things had a tarp, three sleeping bags and three sleeping mats divided on the five persons in the group:

- The sleeping bags and the sleeping mats were available for every group member at any time. When the group members were sleeping, they were able to sleep as long as they wanted. This in turn implied that the group members awake did not know when they were able to sleep.
- The food rations for the group were stored in a bag and each group member picked up their food rations whenever they wanted.
- There was limited communication between the group members concerning the exercise and how to approach the task at hand.

The second phase in Tuckman's theory is **"intragroup conflict"** and **"emotional response to task demands"**. In this phase, the group members react emotionally to any discrepancies between the different group members' orientation towards the task. The lack of unity is a typical feature and the group members may express negative feelings towards each other. In this phase of the SAREX III exercise there were at least some group members that expressed negative feelings regarding the behaviour of fellow group members. The dissatisfaction concerned mainly inadequate follow-up of routines and rules that the group initially had agreed upon.

The third phase in Tuckman's theory is label **“development of group cohesion”** and **“open exchange of relevant interpretations”**. In this phase the group members start to accept the group and fellow group members. The group becomes an entity and the establishment of new group generated norms insure the groups' existence. Considering that the SAREX III exercise only lasted for 48 hours it is difficult to say if and how this phase may have been applicable. However, some of the group members that were dissatisfied with the activities and the structuring of the group said that “had the exercise lasted for a longer time I would have told them” or “had the exercise lasted for a longer time we would have to establish some routines”. Such quotes indicate that at least some of the group members would have expressed their feelings to fellow group members aiming to come to an agreement regarding the activities and structuring of the groups.

The fourth and final stage of Tuckman's theory is recognised by **“emergence of solutions”** and **“functional role relatedness”**. Typical for this phase is constructive attempts to complete the task successfully and the group members adopt roles that enhance the task activity of the group. Apparently, some of the groups had a functional structure and assigned roles from the start of the exercise (e.g. routines and firm leadership). Whether or not the other groups would have established structure by time is not possible to say. However, it is easy to imagine that banding together through routines and structure in life-threatening situations may prevent despair, promote motivation and help the group to attain a desired outcome.

C.12.4 The sense of coherence

Tuchman's (1965) theory provide a useful framework when it comes to the analysis of group development in the SAREX III exercise. However, the theory do not provide an opportunity to discuss how the structuring of the groups and activities in the groups may influence the individuals' perception of stress. A theory that may contribute to discuss this aspect is Aaron Antonovsky's (1979) theory of “sense of coherence”. Antonovsky developed the “sense of coherence” theory in the late 70's and seeks to answer the question “how do people manage stress and stay well?” The theory focuses on the resources, mechanisms and interactions that are involved when humans have to adapt to a stressful situation (Griffiths, Ryan, & Foster, 2011). The “sense of coherence” is formally defined as “the extent to which one has a pervasive, enduring though dynamic, feeling of confidence that one's environment is predictable and that things will work out as well as can reasonably be expected” (Antonovsky, 1979, p. 16). According to Antonovsky (1987) “sense of coherence” consist of three components: comprehensibility, manageability and meaningfulness. The first component, **comprehensibility** refers to whether external stimuli makes sense by the humans. That is, whether the information is “ordered, consistent, structured, and clear – and hence predictable” (ibid, p. 156). In other words, it refers to our ability to understand what will happen in the future. However, even though the information is comprehensible it is not sufficient if the humans' resources to meet the demands are insufficient. The second component, **manageability** is thus about to what extent that we feel that the resources that we have available are adequate and sufficient to meet the demands from our environment. When it comes to manageability Antonovsky (1987) stresses that it do not matter whether the human him/herself controls the resources or a reliable person in the network such as a leader or a friend. The third and final component in the concept of “sense of coherence” is **meaningfulness** and refers to the extent that the individual feel that things make sense – that the challenges that are encountered are challenges rather than burdens (Antonovsky, 1987). How is the “sense of coherence” relevant for the SAREX III participants? Humans that find himself or herself in a long-term survival situation is in a stressful situation. As pointed out by Antonovsky (1987), the perception of comprehensibility, manageability and meaningfulness influence our ability to tackle stress. When it comes to the “compensability” component of the “sense of coherence” it could be argued that implementation of routines within the groups have increased the participants understanding of what is going on and what will happen next. It is easy to imagine that knowing what to do next increases predictability and increases uncertainty in a stressful situation. The “manageability” component in the “sense of coherence” was unequal distributed between the groups due to the fact that the group was assigned different survival gear. However, the distribution of resources within the groups may be relevant. The feeling of “meaningfulness” is the last

component in the “sense of coherence” concept. In many ways, it is meaningless to talk about meaningfulness in a long-term survival situation. However, the participants in the SAREX III exercise engaged in several activities that may have contributed to the “meaningfulness” component. For instance, some tried to catch fish, some played boccia with stones, some was engaged in making a bonfire, some was going for walks with other participants, some was reading books and others reported to have used humour to keep up the spirit. It could be argued that such activities contributed to some sort of meaning in a stressful situation.

C.12.5 Concluding remark

In this report, I have presented observations from the SAREX III exercise regarding the structuring of the groups and task activities within the groups. In light of Antonovskys’ (1987) “sense of coherence” theory, I argue that establishments of routines and social activities may increase predictability and meaningfulness – which in turn may reduce stress. In the SAREX III exercise there were however several factors present that influenced whether the participants completed the exercise or whether they had to withdraw. Factors such as initial motivation and the equipment itself have influenced the results. It is however reasonable to assume that routines and social activities contribute in a positive way when it comes to our ability to handle stress in a long-term survival situation.

Theme 5. Reports from companies attending the SARex3 exercise

C13. SAR in the Arctic. Overview of hazard identification

Erik Johan Landa, Norwegian Maritime Authority (NMA).

Definitions

TPA – Thermal protective aid

PSK – personal survival kit

GSK – Group survival kit

FRC – Fast rescue boat

Maximum expected time of rescue – the time adopted for the design of equipment and system that provide survival support. It shall never be less than **five** days.

Habitable environment - A ventilated environment that will protect against hypothermia.

Rescue craft - Lifeboats and life rafts.

Disclaimer

The views expressed in this report are solely based on personal experience from Sarex, and does not necessarily reflect the official view of the Norwegian Maritime Authority (NMA).

C.13.1 Background

During the past years we have experienced a steadily increasing number of cruise vessels visiting the Svalbard area, and this trend is expected to continue through the coming years. It's a variety of passenger vessels operating in the area. Smaller vessels operating in the Svalbard area throughout the summer season, and bigger cruise vessels arriving with irregular intervals. The size of these vessels varies from 100 to 7000 passengers. Some of them with ice class and some without. The total number of passenger visiting Svalbard during the season is somewhere between 50 and 100 000.

This gives a large potential for accidents, and big challenges related to maintaining the passenger and vessels safety.

The most visited areas is the west coast of Svalbard, including "slow cruising" in the Isfjord basin, but it's also a number of smaller expedition vessels visiting the fjords and islands on the North side. Mainly to have view of the glaciers.

The main goal with Sarex 2018 was to test out various compositions of GSK and PSK. To start with I will briefly try to describe some of the challenges likely to meet when abandonment is a fact and onwards to the situation where it would be possible to enter shore, solid ice or ice floe.

C.13.2 Overview of hazard identification

Crew experience

To reduce the risk of running into dangerous situations causing damages leading to an abandon ship situation, some important factors needs to be in place.

- Qualified crew with experience related to the kind of environment and challenges you will face, including experience from operation in ice and knowledge of the ice physics. Operating in Polar waters is somewhat different, as you will face rapidly changing weather, ice covered

waters, unreliable charts, cold climate with icing, 24 hrs of darkness or 24 hrs with daylight, poor visibility.

- Crew with good training and knowledge of passenger handling and crisis management under the expected conditions. (a challenge since this part is not included in the standard training).
- Voyage planning, taking into consideration the poor quality / accuracy of available charts, thorough evaluation of the ice coverage and risk of meeting drifting ice and growlers. The availability of SAR resources in the planned area of operation.
- Contingency plan if unexpected situations occurs.

Passengers' physical shape

The typical cruise passenger will normally not be prepared for the physical and psychological strain a abandon ship situation in Polar waters will cause. High age, and poor physical shape will cause a major challenge during evacuation and after the abandonment into rafts and lifeboats. It should be expected that a number of passengers already at the first phase onboard a rescue craft will have a need for extra attention and treatment. The possibility for this is somewhat limited and it will require a strong leadership in each craft to keep some kind of control. The appointed craft leader must expect to be challenged in many ways by passengers of higher social rank and “besserwissers”. A average cruise passenger will start to feel discomfort after short time in rescue craft, and their cognitive functions will degrade, putting their life in danger after few hours. The awareness of how to activate the passengers both in a physical and psychological way is imperative. One should not expect that this knowledge is adequate among ship crew today, as the standard training courses do not have any focus on this aspect.

Rescue crafts.

The Sarex exercises has proved that it will be difficult or nearly impossible to fill up the existing lifeboats and life rafts with the number of persons they are certificated for, and further expect survival for the maximum expected time of rescue, or minimum 5 days. The situation will be even worse when you take into consideration the PSK to be brought onboard, and the additional fuel, food, water etc. needed for a 5 days stay. It is obvious that the capacity needs to be reduced for each rescue craft when operating on Polar areas.

Additional modifications are also needed to be done related to ventilation, heating / insulation both for lifeboats and life rafts. (The ventilation issue has already been addressed in IMO, and a work group are looking into how the rescue crafts can be further improved).

It is a challenge to create habitable environment and space enough for passengers to move their limbs to keep up the cognitive abilities, as this together with loss of body temperature will be the first challenges to overcome.

Experience from previous Sarex`s shows that at least following modifications needs to be done to life rafts and lifeboats in order to allow survival over time.

Life raft

- Double bottom to improve insulation between floor and sea surface
- Double tent canvas in order to reduce condensation problems from ceiling, and to allow venting without losing too much heat inside
- Bailing system to allow for rapid removal of seawater
- Bigger volume inside the tent, allowing more movement and change of sitting position.

Lifeboat

- Improved heating system
- Improved ventilation system
- Better layout and insulated seats
- Toilet facilities

- Space to lay down
- Reinforcement of hull and keel to withstand ice impact and icing.

Evacuation

The main task for the cruise vessel management and crew, must be to avoid putting passengers and vessel into a situation with risk of accidents of any kind. Operation of large passenger vessels in polar area will always be a high-risk operation due to the special and harsh environment in the area of operation.

An abandoned ship's alarm will cause chaos and the result is very dependent on the skills and behaviour of the crew. There will be panic among the passengers and same may be expected to be the situation for a number of crewmembers.

Clear procedures, training and awareness among crew and passengers are vital for a successful abandonment.

The safe launch of rescue crafts depends on the area of operation and the status of ice coverage. In open waters launching should be a routine operation, but the launching needs to be done inside solid ice or drifting ice consisting of ice floes and growlers, the possibility of safe launch needs to be thoroughly evaluated.

A lifeboat will normally have a weight between 10 and 30 tons with passengers onboard. This weight might be sufficient to ensure that the ice floes will be pushed away or brake up and allow the lifeboat to be launched, but there are several factors to be taken into consideration after the lifeboat is afloat.

Depending on wind and current there is a risk that the lifeboat may be squeezed by ice floes pushing towards the shipside. The ice floes may start to build up on top of each other and may enter into the lifeboat as they penetrate the hatches or lifeboat hull, ice being pushed under the keel may damage propeller and rudder, or the lifeboat may be forced down by the weight of ice building up. Ice pressure on the lifeboat hull is not taken into consideration during the lifeboats design and approval.

It's obvious that the ice conditions will play an important role for safe launching.

If still operational, main propellers and thruster should be engaged attempting to push the ice away from the launching area. As soon as lifeboats are launched, they should be maneuverer to areas with open water if possible.

Launching of life rafts under the above described conditions needs even more consideration as they most likely will be damaged by the ice pressure when launched. They should only be used to evacuate passengers if it is possible to launch in open areas or onto solid ice / ice floe. A MES system allowing for controllable descend of the raft should be the standard onboard vessels operating in arctic areas. This will reduce the risk of damage to the raft during deployment in ice-covered waters.

As the risk of abandonment in areas where it would not be possible to utilize the raft as an option for evacuation is fairly high, it needs to be discussed whether or not it is a need to review the established practice of allowing reduced lifeboat capacity compensated by extra life rafts when operating in arctic areas. (Ref. SOLAS Ch. III Reg. 21).

Anyway, even if it should not be possible to evacuate passengers by use of rafts, all the rafts should be launched, and if possible towed away by lifeboats / rescue boats in order to transfer people from lifeboats to raft at a later stage and / or use them as shelter when / if a solid ice floe or a coastline is within reach.

Transfer of passengers from rescue crafts to SAR vessels / Helicopters.

Following an abandonment, a very stressful and uncomfortable stay inside the rescue crafts will follow. It is likely that you are located several hours away from the coast, and SAR resources will be limited and several hours away. In worst case 5000 or more passengers are in need of immediate assistance.

In best case, help is 5 to 10 hours away (coast guard or other passenger / fishing vessels). In the worst case no other vessels will be in the area, and the coast guard vessel will be located at the home base in Norway which means in best case 36 hours away.

In Longyearbyen there are 1 supply vessel and 2 helicopters with 30 min response time available, further helicopter assistance may be engaged from the mainland 2 hours away.

To put this in some kind of perspective it may be mentioned that during a SAR exercise held at Spitsbergen in 2014, where the vessel in distress was positioned approximately 25nm from Longyearbyen, it took 8 hours to rescue 86 persons by use of helicopter.

The Coast guard vessel normally operating in the Spitsbergen area may in best case be able to rescue 1000 passengers.

The passengers will need to be transferred from the rescue craft or the sea by use of FRC's with a max capacity of 10 passengers each trip. Pick up by helicopter may be ongoing simultaneously. These transfer operations will be a high-risk operation, as the rescue crafts are not arranged for such kind of operations.

Hospital capacity in Longyearbyen is limited to 6 beds. It will be necessary to move medical personnel from the mainland to Longyearbyen by use of air transport, and large number of survivors will have to be transported from Longyearbyen to the mainland for treatment.

Conclusion is that even in a best-case scenario, one must expect that a rescue operation will go on over several days before all survivors are rescued.

Equipment for transfer of personnel from rescue craft to SAR vessel is not satisfactory for safe and efficient transfer.

Rescue craft should at least be equipped with:

- Standard connection system for efficient and safe connection of gangway
- Sufficiently sized hatches to allow efficient evacuation from lifeboat to gangway.
- Sufficient handholds.
- Effective means to keep the surface free of ice.
- Lifting lugs with sufficient SWL to allow SAR vessel to lift the rescue craft with passengers.

Transfer from rescue craft to shore / solid Ice

The first thing to be done when in position to establish camp either on a solid ice floe or on the beach is to establish a polar bear watch, and to agree about how to act in case of a Polar bear or walrus threat. This will be a challenge since there will be limited means available to defend the group against an attack. If possible, the camp should be installed at a place where the topography allows early detection.

If possible, the transfer of passenger to shore / ice should be arranged allowing a dry transfer. If you manage to stay dry, the chance of survival will be increased.

Transfer to an Ice floe will be challenging as the ice edge may break by the weight of embarking passengers. As soon as the ice floe has been entered, you should move away from the ice edge.

This should also be kept in mind when trying to pull the raft onto the ice. Establishing a camp on an Ice floe is risky, as there always will be a risk that the ice breaks up. This may be due to weight of people, tensions created by wind and waves, or ice melting.

If the Ice floe is the best option it could be considered instead of establishing a camp on the ice, to move the rescue craft to the Ice floe and use it as an alternative to walk and keep up the cognitive abilities. This will allow better space in the rescue craft and possibility to move and sleep on rotational basis.

The best option will always be to be able to reach the coastline and establish camp ashore. A dry transfer to shore is important, but may be challenging depending on the shape of the shoreline. If it is possible to pull rafts ashore this should be done, and they should be used as a place to keep warm and sleep. Lifeboats should if possible be secured in a way allowing people to use it as a place to keep warm and sleep.

If the shape of the shoreline is such that it do not allow for the rafts to be taken onshore, the possibility to moor the raft in a position where it allows people to climb ashore for exercising, a rotational arrangement allowing for rest in the raft and exercise at the shore should be arranged for.

The main focus should always be to stay dry, keep warm and move your limbs.

C.13.3 PSK / GSK

The Polar code gives the following samples related to the content of PSK and GSK

Sample personal survival equipment

Suggested equipment
Protective clothing (hat, gloves, socks, face and neck protection, etc.)
Skin protection cream
Thermal protective aid
Sunglasses
Whistle
Drinking mug
Penknife
Polar survival guidance
Emergency food
Carrying bag

Sample group survival equipment

Suggested equipment
Shelter – tents or storm shelters or equivalent – sufficient for maximum number of persons
Thermal protective aids or similar – sufficient for maximum number of persons
Sleeping bags – sufficient for at least one between two persons
Foam sleeping mats or similar – sufficient for at least one between two persons
Shovels – at least 2

Sanitation (e.g. toilet paper)
Stove and fuel – sufficient for maximum number of persons ashore and maximum anticipated time of rescue
Emergency food – sufficient for maximum number of persons ashore and maximum anticipated time of rescue
Flashlights – one per shelter
Waterproof and windproof matches – two boxes per shelter
Whistle
Signal mirror
Water containers & water purification tablets
Spare set of personal survival equipment
Group survival equipment container (waterproof and floatable)

Sarex 2018 focused on how to survive ashore with the PSK and GSK provided.

The Polar code gives samples of what kind of equipment PSK and GSK should at least consist of, but it does not say anything about the quality of the equipment

The following interpretation of the requirement for functionality is reasonable:

The equipment required by the Polar Code is to provide functionality that enables the casualty maintain motivation for survival and the ability to safeguard individual safety, which means to maintain cognitive abilities, body control and fine motor skills, in addition to prevent development of fatigue for the maximum expected time of rescue.

It is likely to believe that the focus in many cases related to PSK / GSK is to minimize the volume of the units. This is understandable due to the space constraint on many vessels and inside rescue crafts.

It is important that this focus on volume do not contradict with the need for good quality equipment.

Sarex 2018 clearly showed the importance of selection of correct and high-quality equipment suitable to ensure survival over time.

For the Sarex exercise several different sets of PSK and GSK was provided. Some with light equipment, some with heavy equipment. In my opinion, none of the kits as supplied would provide the functionality as described above, but if the best of each different kit were put into a PSK and GSK we would be close to kits that would allow survival as described in the Polar code.

Below is a table describing the equipment (PSK/GSK) available to our group with some comments and suggested improvements related to the different equipment.

Personal Survival Kit (Light)		COMMENT	IMPROVEMENT
Quantity	Description		
1	MERINO WOOL LONG JOHNS	OK, for high temperatures (MDLT -10)	
1	MERINO WOOL LONG SLEEVED TOP	OK, for high temperatures (MDLT -10)	
1	MERINO WOOL SOCKS	Not supplied in Wool, cotton socks should never be used for survival equipment	Proper Wool Socks to be supplied
1	INSULATING JACKET	Not wind proof, not breeding garment collecting a lot of moisture in arms and upper part of torso. This had led to a major hypothermic issue if we not could convert/utilize the TPA as outer jackets Hood and neck protection OK	A combination of inner fleece jacket and wind/rain proof outer shell jacket is better, may be a zippable system. Most probably this has no impact on packing volume. Color should be easially detcted with reflective parts. Color should also be absorbing sun radiation.
1	TROUSERS	2 types was supplied in same kit. The type with suspending straps was OK. Good air circulation, and hands could easily be warmed inside trousers and in pockets The other cotton trouser not sufficient rain and wind protection	Cotton type not to be supplied
1	FLEECE BEENIE	Too short and too wide. Not expandable material	Wool balaklava with shoulder extension to be supplied
1	THERMAL HEAD AND NECK PROTECTION - GREEN SNOOD	OK, for high temperatures (Summer operation)	Wool material to be considered
1	THERMAL GLOVES	Not Supplied	
1	THERMAL LINER GLOVES	Cotton gloves not sufficient	Wool material gloves and outer gloves of windproof material to be used in combination
1	SNOW BOOTS - TRESPASS	Useless, no insulation from soles, collecting humidity rapidly. Participants cold on feets always using the boots	Boots to be insulated towards sole, and breathable with water proof garments. Fire proof :-)
1	VASELINE	Not used	Non waterbased ointment with sun block to be supplied
1	THERMAL PROTECTIVE AID	Poor Quality, zippers broke very easily. Zipper only worked from outside operation. This was really crucial equipment for Group to maintain core temperature when not in sleeping bags.	Silver fabrick, more ruggdize type which can withstand windfatigue to be supplied. A type to weared while moving around to be considered.
1	SUNGLASSES BOLLE	OK	
1	WHISTLE	OK	
1	VESSEL DRINKING GRAD	OK	
1	FOLDING SIT MAT	OK	Silver foiled type to be considered to get return heat radiation.
1	FLOATING KNIFE	Life raft knife not sufficient.	Heavy Duty knife with saw to be supplied
1	ARCTIC POLAR BOOK	Book not very relevant	Tailor made water proof survival poster with relevant information for use of supplied equipment to be delivered
1	SEVEN OCEANS EMERGENCY FOOD 500g	OK	
1	60L DRY BAG WITH INSPECTION WINDOW	OK	

Group Survival Kit (Light)		COMMENT	IMPROVEMENT
Quantity	Description		
2	OMEGA 350 TENT (3 PERSON TENT)	OK. Plugs not suitable for sand/snow	Plugs to have fishhook design. Inner and outer part to be assembled before delivery. Instruction to be in survival poster. Water collector to be considered. Reflective tape.
6	SURVITEC BRANDED THERMAL PROTECTIVE AID	Poor Quality, zippers broke very easily. Zipper only worked from outside operation. This was really crucial equipment for Group to maintain core temperature when not in sleeping bags.	Silver fabric, more rugged type to be supplied. A type to wear while moving around to be considered. Gaffa tape to be included in kit
3	SUMMIT 300 SLEEPING BAG	Not sufficient insulation.	For light kit (MDLT -10 Standard SOLAS Equip) Comfort Temp -10
3	SLEEPING MAT	OK	
2	FOLDING SNOW SHOVEL	Too small blade	Larger area on blade
6	TOILET PAPER ROLL	Not used	
1	FASTBOIL COOKING SYSTEM	Not tested. Burning gas not supplied	
3	THERMAL FLASK	Not Tested	
1	WATER PURIFICATION TABLETS 2 x 50	Not tested	
10	SEVEN OCEANS RATIONS 500g	OK	
1	FLAM TORCH - FULL PACK	Not Supplied	
1	SOLAS WHISTLE	OK	
3	HAND SANITIZER	OK	
1	SIGNALLING MIRROR 4" STAINLESS	Not Tested	Lens to make a fire to be considered
3	100L DRY BAG WITH INSPECTION WINDOW	OK	
2	SOLD FUEL BLOCKS (6units per box)	Not Supplied	
2	FIREDRAGON FUEL 1L	Not Supplied	
2	WINDPROOF MATCHES	Not supplied	

C.13.4 Learning points.

It is important if possible, to ensure a dry transfer from the rescue craft to shore. If you manage to stay dry, the chances for survival increases.

After a successful transfer to a shore-based camp, a group leader should be pointed out. It is important to work out routines for eating / drinking and sleeping, and stick strictly to these routines.

Regular supply of food and water rations is important to maintain physical and psychological health, and vital for survival. Same goes for regular sleep and exercise. Fixed routines will also be a help to make the time fly.

In our case we were a fairly small group of survivors, and to pick a leader was not a big challenge. It could be far more challenging to control and lead a large group of passengers from a passenger ship. To my knowledge no training covering such aspects are available for the officers and responsible onboard any vessel today.

When established ashore next step is to arrange proper shelter where it is possible to keep the cold away, and stay dry. Normally a tent is a part of the GSK, and needs to be assembled and secured. For trained personnel this is normally an easy task, but for untrained passengers it could be a challenge or impossible task.

The assembly of a tent needs to be self-explanatory, consist of as few pieces as possible and have a design, which reduce the exposure to wind, and prevent snow to build on the roof.

The tent provided in our GSK had a good layout but was not strong enough to withstand accumulation of snow.

The normal tent plugs are useless to secure the tent in snow or sand. Heavy duty fishhook type of plugs needs to be supplied. In our case we used heavy stones as anchor for the tent straps, but they will not always be available. Blocks of ice could be used instead of stones.

As a proper shelter has been established, rotational sleeping should be arranged for. Short periods of sleep combined with periods of physical activity is recommended.

The sleeping bags provided in our GSK (3 pcs) did not hold a sufficient standard for the actual area of operation, but we managed to keep warm keeping all gear on, and laying close together. Sleeping bags needs to be of high quality, and the zips should be arranged to allow zipping them together. This way it will be possible for more people inside and better heat recovery.

Without correct build-up of under / outer wear making it possible to cover up 100% of your body, you will struggle to survive over time.

Our group was supplied with woolen underwear which was good, but cotton socks in combination with boots without insulation in the soles caused heat loss which we had to prevent by use of other insulating materials used as inner soles.

The insulating Jacket supplied was not windproof, and had no breathing garment. This caused heat loss and collection of humidity. In order to keep warm we had to modify the thermal protective aid and use it as an insulating poncho on top of the other clothes. This modification was the key for us to be able to maintain a normal body temperature during the 48 hrs spent ashore.

The key for survival is to allow rest, activity, and protection from the environment. The PSK and GSK needs to consist of good quality clothing, and protection from the environment combined with good quality tools which make it possible to dig snow or sand, chop wood, and make up fire.

The kit provided for our group did not fulfil our expectations related to content and quality. We managed to maintain our body temperature above 36 degrees during the exercise. This was mostly due to good coaching and ability to adapt and find solutions to problems arising, and not at least the fact that the weather was reasonably good. Wind combined with rain / snow over time, would have changed the situation and reduced the survival time drastically.

The time to rescue is a waiting game. This time should be used to figure out how to improve your situation, and prepare for worse conditions.

If it's possible to build walls to protect your tent to be blown away by increasing wind, you should do so. If you have wood around, it should be collected and fire should be made up if possible, and snow should be melted to increase the water supply.

Make your camp as visible as possible for SAR resources both air and seaborne.

Never underestimate the risk of polar bear / walrus attack. Make arrangement for early detection and strategy to escape (Raft / lifeboat) or to scare him away. You will not have any arms available.

Theme 5. Reports from companies attending the SARex3 exercise, continued

C14. Life-saving appliances on cargo vessels and fishing vessels

Anita Strømøy and Signe Meling, Norwegian Maritime Authority (NMA).

Definitions

IMO – International Maritime Organization

SOLAS – Convention for the Safety of Life at Sea

LSA Code – Code of Life saving appliances

Administration – the administration of the flag state

New vessel – vessels built on or after the regulations have entered into force

TPA – Thermal protective aid

PSK – personal survival kit

Disclaimer

The views expressed in this report are solely based on personal experiences from SARex, and do not necessarily reflect the official views of the Norwegian Maritime Authority (NMA).

C 14.1 Background

Vessels are regulated both by national and international legislation. When there is an international agreement this is implemented into the national legislation.

SOLAS

In general, SOLAS applies to cargo ships of 500 gross tonnage and upwards engaged on international voyages. The Convention is divided into chapters, each describing requirements on a specific subject (construction, equipment etc.).

Chapter III Life-saving appliances and arrangements describes the number and type of life saving appliances a ship shall carry.

Chapter XIV Safety measures for ships operating in polar waters applies to ships operating in polar waters and requires these ships to comply with the requirements of the safety-related provision of the introduction and with part I-A of the Polar Code²⁸.

The Polar Code

The goal of the Polar Code (the Code) is to ensure safe ship operation and to protect the polar environment by addressing risks present in polar waters. Ships certified in accordance with SOLAS chapter 1, on international voyages operating in polar waters shall be surveyed and certified according to the Polar Code²⁸.

The Code consists of Introduction, parts I and II. The Introduction contains mandatory provisions applicable to both parts I and II. Part I is subdivided into part I-A, which contains mandatory provisions

²⁸ SOLAS XIV/2, Polar code 1.3.1 and 1.3.2

on safety measures, and part I-B containing recommendations on safety. Part II is subdivided into part II-A, which contains mandatory provisions on pollution prevention, and part II-B containing recommendations on pollution prevention.

To achieve the goal to ensure safe ship operation and to protect the polar environment, the mandatory provisions of part I-A includes additional requirements on ship structure, subdivision and stability, watertight and weather tight integrity, machinery installations, fire safety/protection, life-saving appliances and arrangement, safety of navigation, communication, voyage planning and manning and training.

The goal of chapter 8 on life-saving appliances is to ensure safe escape, evacuation and survival.

The Polar Code part I does not apply to fishing vessels. This poses certain challenges and possible means of increasing safety for fishing vessels in polar waters are currently being discussed in IMO.

Fishing vessels

Most chapters of SOLAS do not apply to fishing vessels and there is no legally binding international agreement for fishing vessels.

The Torremolinos protocol is meant to be an international set of regulations applying to fishing vessels. The Cape Town agreement would ensure that the Torremolinos protocol would enter into force. If this were the case the safety of fishing vessels, regardless of area of operation, would be significantly improved. As of today only 10 countries have signed the Cape Town agreement²⁹ and 12 more are needed in order for the Torremolinos protocol to become legally binding.

The Torremolinos protocol applies to seagoing fishing vessels of 24 metres in length or over, and certain chapters apply only to those of 45 metres in length or over. The protocol differs from SOLAS in several ways, most prominently in that it widely accepts differing solutions as long as they are to the satisfaction of the Administration of the Flag State.

EU/EEA member states are bound to the Torremolinos protocol through EU-directive 97/70/EF. Aside from the EU/EEA member states it is up to the national authorities to define national regulations for fishing vessels.

In Norway the Torremolinos regulations have been implemented into the national legislation. Certain regulations have a wider scope and apply to fishing vessels from 15 metres in overall length and upwards.

C.14.2 Life-saving appliances on board

The table below shows what equipment is required to be carried on board cargo vessels and fishing vessels, according to international legislation. It is not a complete overview, but the items thought to have a direct impact on safety in an evacuation have been mentioned.

	Cargo (SOLAS requirement)	Fish (Torremolinos requirement)	Comment
Lifeboat	Shall be provided on cargo ships with a length of more than 85 m. ³⁰		
Liferaft	Shall be provided, either as an addition to the lifeboats, positioned on each side of the ship, or as a standalone	New vessels 45 m +: Capacity to rescue all persons on each side of the vessel ³²	Fishing vessels: Instead of survival craft on either side, vessels may carry one or more lifeboats capable of being free-fall launched over the stern of the

²⁹ <http://www.imo.org/en/About/Conventions/StatusOfConventions/Documents/StatusOfTreaties.pdf>

³⁰ SOLAS III/31

³² Torremolinos regulation VII/5 (3) (a)

	survival craft with an overcapacity to rescue all persons on each side ³¹		vessel of sufficient capacity to accommodate the total number of persons on board and with life rafts of sufficient capacity to accommodate the total number of persons on board. (Regulation VII/5 (4))
Rescue boat	Shall be provided ³³	New vessels 45m +: Shall be provided ³⁴	Fishing vessels: Not necessary if the vessel is provided with a lifeboat which fulfils the requirements for a rescue boat and which is capable of being recovered after the rescue operation. (Regulation VII/5 (2) (a) and (3 (b)))
Immersion suits	Shall be provided for every person on board the ship ³⁵	Shall be provided for rescue boat crew and every person not assigned a place in a lifeboat, davit-launched life raft or life raft which can be boarded without entering water ³⁶	Fishing vessels: The extra immersion suits to be brought in every lifeboat, and TPA for every person in a lifeboat who does not have an immersion suit. (regulation VII/9 (3))
Lifejackets	Shall be provided for every person on board the ship ³⁷	Shall be provided for every person on board ³⁸	

Life rafts

Most vessels today choose self-inflatable life rafts rather than rigid inflated life rafts or lifeboats. This means that for both types of vessels there will usually be life rafts with capacity to rescue 100 % of the persons on-board on either side of the vessel.

The SARex 3 experiment showed that life rafts are well suited to be used as shelters on land. They are safer and more comfortable than tents and no special skills are required in order to mount them correctly. The two groups that shared a life raft in the experiment had two very different levels of PSK and yet both groups coped well. This shows that if a group of survivors are able to reach land with their rafts, their chance of survival will be greatly increased.

Lifeboats

Cargo ships with a length of more than 85 metres, oil tankers, chemical tankers and gas carriers are required to carry lifeboats, either on each side of the ship or free-fall lifeboats on the stern³⁹.

Experience shows that available space on board a lifeboat is limited, and when it is filled up to its maximum capacity with persons there is very little space left for additional equipment. The air quality quickly becomes poor, the temperature is difficult to regulate, and it is difficult to move around inside it to maintain blood circulation. Per today there is work going on in IMO on developing interim guidelines on life-saving appliances and arrangements for ships operating in polar waters and this work is planned to address some of these concerns. The guidelines aim to describe conditions to consider and measures to take when operating in low-air temperatures, in ice, in high latitudes and in extended

³¹ SOLAS III/31

³³ SOLAS III/32.2

³⁴ Torremolinos regulation VII/5 (3) (b)

³⁵ SOLAS III/32.3

³⁶ Torremolinos regulation VII/9 (2)

³⁷ SOLAS III/7.2 , III/32.2

³⁸ Torremolinos regulation VII/8 (2)

³⁹ SOLAS regel III/31

periods of darkness. The guidelines also address additional recommendations to the equipment used on board, life-saving appliances included, based on the conditions and area of operation. For a lifeboat, it is amongst other things recommended to downscale the number of persons permitted, to give space for additional equipment and for persons to be able to move inside the lifeboat.

The interim guidelines are planned to be a guidance to the Polar Code and on some points specifying parts were the Code may be unclear.

There is also work going on in IMO to develop new requirements for ventilation in survival crafts.

Immersion suits and TPA

Immersion suits are considered imperative to survival. They are the only piece of equipment that can ensure that the wearer stays relatively dry and warm. Over time condensation inside the suit will present a problem.

TPAs can reduce heat loss and help protect against the wind, but are not as durable or waterproof as an immersion suit and greatly reduce the mobility and agility of the wearer.

Immersion suits on fishing vessels

Although the Torremolinos protocol for fishing vessels only requires immersion suits for those who do not have an assigned place in a lifeboat, davit-launched life raft or life raft which can be boarded without entering the water, most vessels have self-inflatable life rafts and will therefore also be required to carry immersion suits for all persons on board. In addition, life rafts are required to be equipped with TPAs for at least 10 % of the number of persons the raft is permitted to accommodate or two, whichever is greater⁴⁰. However, the immersion suits are not required to be of the insulated type, though they can be. As a minimum, the suits required are meant to be worn with warm clothing and a lifejacket, and shall then ensure that when it is worn for a period of 1 hour in calm circulating water at a temperature of 5°C, the wearer's body core temperature does not fall more than 2°C⁴¹. The requirements for the insulated type ensure a higher level of safety, requiring that the body core temperature does not fall more than 2°C when worn for a period of 5 hours in calm circulating water at a temperature of 0-2°C⁴². However, both types of suits require that a person should be able to pick up a pencil and write after spending 1 hour in water at a temperature of 5°C⁴³.

Immersion suits on cargo vessels

An immersion suit shall be provided for every person on board the ship and the LSA Code requires these suits to have thermal protection, either made of material with inherent insulation, or marked with instructions that it must be worn in conjunction with warm clothing.

The immersion suits worn on the exercise had a thermal insulating liner, detachable gloves and integrated buoyancy. An immersion suit with such characteristics makes the user stay relatively warm and dry. The insulating liner and the buoyancy aid can be removed from the suit and the suit will still provide shelter from wind and rain. If the insulating liner gets wet, for example due to condensation, it can be removed from the suit and dried, allowing the user to stay dry and warm for a prolonged period of time.

By taking out the buoyancy aid from the back of the suit, the person's mobility improved, and the aid could then be used as a sleeping mat or a pillow. With detachable gloves one can both keep the hands warm inside the gloves and perform tasks that requires bare fingers.

⁴⁰ Torremolinos Regulation VII/20 (5) (a) (xxiv)

⁴¹ Torremolinos Regulation VII/25 (2) (a) (ii)

⁴² Torremolinos Regulation VII/25 (2) (b)

⁴³ Torremolinos Regulation VII/25 (2) (c)

The exercise showed that the participants wearing immersion suits kept warm and dry longer than those who didn't.

lifejackets

Lifejackets shall be provided for every person on board both cargo and fishing vessels. SARex3 showed that in dry conditions and if worn in conjunction with warm clothing, a person wearing only a lifejacket may survive in cold climate. The person must keep moving and sleep for short periods of time only, huddled close to others. It is however unlikely that a person will manage to stay dry for an extended period of time, especially when boarding or disembarking a lifeboat. In our opinion it would not be possible to stay dry if inside a life raft. The probability of survival if equipped with only a lifejacket would therefore be very low.

Rescue boat (MOB boat)

A rescue boat can be used to manage a set of life rafts, and possibly tow them to a shore or a large ice floe. SARex3 in comparison to SARex1 and 2 showed that rate of survival greatly increases on shore, though not taking into consideration the possibility of people getting wet whilst on board the raft, or when moving from the raft onto shore.

Food and water

Without taking into account the number of days spent in a life raft or a lifeboat, the LSA Code and Torremolinos require a food ration consisting of not less than 10,000 kJ (2,400 kcal) for each person a life raft or a lifeboat is permitted to accommodate⁴⁴. The amount of water required is 1,5 litres in life rafts and 3 litres in lifeboats, with individual adjustments if there are means for producing fresh water or not⁴⁵.

As the maximum expected time of rescue never shall be less than five days⁴⁶ for ships operating in polar waters, the required amount of food and water is discussed in IMO in conjunction with developing the guidelines on life-saving appliances and arrangements for ships operating in polar waters.

Until proofed numbers on the amount of food and water a person actually needs in a survival phase is present, no conclusion has been made. It will most probably be an 'amount per person, per day'-approach to this, differently from the LSA Code that describes a total amount per person regardless of time spent.

In the exercise each participant was equipped with one box of emergency food, equalling 10,000kJ. With the rationing regime the two groups in the life raft implemented, this would have lasted for 3 days, and is as such not sufficient to satisfy the requirement of the Polar code. The same applies to water, where each participant was allowed litre water per day. The 1.5 litres per person in life rafts or 3 litres in lifeboats, it would be difficult to survive 5 whole days.

The participants complained about headaches hunger throughout the exercise, suggesting that the amount of food and water was at a minimum.

C 14.3 What would any of this mean in case of a serious incident?

The following discussion is a thought experiment to see what would happen on board a fishing vessel or a cargo vessel during a serious incident in the Arctic or Antarctic, like a grounding or fire with evacuation as a result.

⁴⁴ LSA Code 4.1.5.18, LSA Code 4.4.8.19, Torremolinos VII/17 (8) (xii), Torremolinos VII/20 (5) (a) (xviii)

⁴⁵ LSA Code 4.4.8.12, LSA Code 4.4.8.9, Torremolinos VII/17 (8) (ix), Torremolinos VII/20 (5) (xix)

⁴⁶ Polar Code 1.2.7

Incident on board

Each vessel (both cargo and fishing) has a muster list with clear instructions for each member of the crew for different situations that may occur. The crew are required to train regularly through safety courses on shore and drills on board, and so it is safe to assume that they would be able to handle most situations on board. They are familiar with the vessel and the use of its equipment.

Evacuation

Should the vessel need to be abandoned, the crew have all been trained in the entering and use of survival craft. They would all know where to go and how to act in such a stressful situation. The Polar code requires that all exposed escape routes shall remain accessible and safe, taking into consideration the potential icing of structures and snow accumulation⁴⁷. This is also good seamanship, and we assume that fishing vessels would handle this the same way as a cargo vessel even if there is no explicit requirement regarding ice or snow accumulation. All vessels are required to ensure that their life-saving appliances are ready for use at all times to ensure safe evacuation of persons⁴⁸.

Survival

In a survival situation there may be a difference between the two types of vessels. The crew of a cargo vessel would be equipped with insulated immersion suits as this is a requirement in the Polar code⁴⁹, whereas the crew of a fishing vessel may have suits that are not insulated but intended to be worn in conjunction with warm clothing. This would certainly have an effect on the probability for survival.

One thing that cargo vessels and fishing vessels generally have in common is the lack of passengers. The crew will for the most part know each other quite well and there is a well-implemented hierarchy, meaning that there should be no question as to who's in charge. The psychological effect of being with peers would probably lead to a higher survival rate. All crew are required to have a medical health certificate⁵⁰, meaning that there is a minimum level of health amongst the crew. All this would mean that a life raft or lifeboat with a ship's crew on board would probably have a better chance of survival than the same craft with passengers and one or two crew members.

⁴⁷ Polar code 8.2.1.1 and 8.3.1

⁴⁸ Torremolinos VII/6 (1) and (3), and SOLAS III/20.2

⁴⁹ Polar code 8.3.3.1.2

⁵⁰ STCW I/9 and section A-I/9

Theme 5. Reports from companies attending the SARex3 exercise, continued

C15. SARex 3

Trond Sundby, Norwegian Petroleum Safety Authority

C.15.1 Introduction:

The Petroleum Safety Authority (PSA) previously participated in SARex 1 and 2, which considered evacuation and survival for maritime emergencies in Arctic waters. The scenario in both exercises was an emergency on a cruise ship with evacuation. The exercises provided valuable insight into challenges in an emergency situation, involving a prolonged stay on lifeboats and life rafts, and addressed challenges with equipment to be used for survival and how to manage the days of survival before rescue.

The exercises were located in a typical Arctic environment nearshore and onshore Svalbard. This is further north than any area in Norwegian waters that is open to the exploration and production of petroleum products today. However, there are similarities, when it comes to temperature, climate and so on.

The objectives of this year's SARex (3) were to:

- develop a common understanding between all layers of the industry, including regulators, on how the IMO Polar Code is implemented today;
- to study the gap between typical Personal Survival Kits (PSK) and Group Survival Kits (GSK), as provided by the industry according to the IMO Polar Code;
- to develop survival strategies and identify equipment improvement points.
- In addition, an exercise in rescuing a large number of people from land/ice in cold climate conditions was carried out and evaluated. The goal here was to give practical training and identify improvements to equipment, and procedures/routines.

The IMO Polar Code is a set of functionally based rules to mitigate the additional challenges associated with operation in the Arctic/Antarctic region. The Polar Code considers hazards, which may lead to elevated levels of risk, due to the increased probability of occurrence, more severe consequences, or a combination of both.

Typical scenarios in the exercises have been incidents/accidents involving cruise ships in polar waters. These are activities that are typically carried out in the summer months of the relevant region. That means full or close-to-full daylight all day and night and, in general, a less harsh climate than can be experienced in the year-round petroleum activities in Norwegian waters. The IMO Polar Code has been developed for polar waters around the world. In the report from last year, Jensen elaborated on specific challenges in the Svalbard environment and the relevance of these exercises for the PSA and the petroleum activities.

The main reasons for PSA's participation in projects like SARex are to be involved in and to gain operational experience in emergency and rescue operations in polar waters; to contribute to experience transfer and knowledge sharing in the area; and to take part in the updating of relevant standards.

The PSA does not refer to the Polar Code in our regulations or guidelines today. The requirements for emergency preparedness and evacuation in the petroleum activities in Norway are mainly formulated as functional requirements and depend on the location and the type of activities. They can be found in our regulations, guidelines to the regulations and certain standards and industry-recommended

practices. It is of great importance for PSA to take part in projects like SARex to gain operational experience with the means of rescue, the equipment, and routines for emergency preparedness in polar waters. In addition, it is important to establish competence in these matters and to contribute with our experience, in the updating of standards that can be relevant for petroleum activities in Norway.

C.15.2 Regulations

The PSA is responsible for developing and enforcing regulations which govern safety and the working environment for petroleum operations on the Norwegian Continental Shelf (NCS) and associated facilities on land. The regulatory principle in the petroleum activity in Norway today is founded on a performance-based approach. Performance-based regulation involves specifying the performance or function to be attained or maintained by the industry. The regulatory role here involves defining the safety standards, which companies must meet and checking that they have the management systems, which permit such compliance. The companies are given a relatively high degree of freedom in selecting good solutions, which fulfill the official requirements. In general, maritime and class regulations tend to be somewhat more prescriptive than the approach chosen in the Norwegian petroleum industry.

Our Framework regulations state that *the activities shall be prudent based both on an individual and an overall assessment of all factors of relevance for planning and implementation of the activities as regards health, safety and the environment*. Further, it states that *a high level for health, safety and the environment shall be established, maintained and further developed*. These requirements are applicable for all involved parties in the industry and in all phases of the petroleum activities. This is an example of overall, generalized requirements that are also valid for emergency preparedness.

In the Management regulations, there are requirements for emergency preparedness analyses and assessments for defining hazard and accident situations, stipulating performance requirements for the emergency preparedness and selecting and dimensioning emergency preparedness measures. In principle, this means that the responsible party is obliged to make proper evaluations of relevant hazard and accident situations, identifying measures to reduce the risk of such incidents occurring, and to establish a system for managing hazard and accident situations. Examples of situations can be the handling of an oil spill or a gas leak on an offshore facility, the evacuation of personnel from an offshore facility or the rescue of personnel from the sea after an offshore incident. The guidance to the regulations refers to NORSOK Z-013 for methods and requirements related to the analysis of risk and emergency preparedness.

In the Facilities regulations, Chapter VI regarding emergency preparedness stipulates requirements that facilities shall at all times have available equipment for the quick and prudent rescue of personnel who fall into the sea, and that personnel on facilities shall be able to evacuate quickly and efficiently to a safe area under all weather conditions. It also contains requirements regarding survival suits, life jackets, etc. There are references to the Activities regulations and to standards such as NORSOK S-001.

In the Activities regulations, Chapter XIII about emergency preparedness contains, among other things, requirements for the establishment of emergency preparedness, emergency preparedness plans and the handling of hazard and accident situations. As the requirements are performance-based or functional, they do not give any details on how to evacuate, evacuation times, equipment, etc., but they state that necessary evacuation and/or rescue shall be quick and efficient at all times. NORSOK standard S-001 provides some details on emergency preparedness, together with other standards and guidelines. Comparing the requirements for personnel involved in the offshore Norwegian petroleum activities and personnel on cruise ships regarding protective clothing, all personnel involved in the petroleum activities shall have a survival suit available. This will probably not be the case for personnel on cruise ships.

C.15.3 Results

In the SARex 2 report from 2017, Jan Erik Jensen elaborated on the relevance of the climate and of technical, operational, and organizational barriers. When it comes to survival for five days and survival on land after an incident, these are probably less important for PSA and the petroleum operations in Norwegian waters. Nevertheless, there are important learnings related to how various types of equipment perform in a real situation, and generalized results from the physiological examinations can help to gain a better understanding of human operations in a cold climate. In addition, there are important learnings on the operational and organizational barriers. One learning from this year's exercise can be the need for operational routines to manage and handle critical situations: how to use the available equipment, how to organize in a critical situation and operational routines that can improve survival.

The exercise revealed weaknesses in equipment that has already been accepted by the Polar Code. That is valid for both the usefulness and functionality of the equipment – inadequate clothing (neoprene shoes, jackets and trousers without proper weather protection etc.). It also raised some fundamental questions on what the personal and group specific packages need to contain and how to organize various phases of an emergency. Some simple guidance on operational routines (one page of laminated instructions on how to improve survival) can be a simple but effective contribution in an emergency. Examples of simple routines could be as follows:

- Organize the group and appoint one responsible person/leader
- Delegate tasks (manage rations, motivate people to get active, guards, explore the area, etc.)
- Get an overview of available equipment and resources
- Check the health condition of each individual immediately and at regular intervals (short checklist of typical symptoms)
- Establish camp (tent or shelter if provided, if not – make shelter of what is available)
- Establish routines for rest and activity to maintain body heat and possible mental activities to fight boredom and keep up the morale
- Explore the area and guard for polar bears if in Arctic waters
- Test stove and cookware if provided or look for firewood and make a fire
- Try to locate where you are and the possibilities of rescue
- Establish a plan for survival until rescue

Access to drinkable water is crucial for survival over several days, and there is a question regarding how this should be handled – a supply of water packages in the equipment, stoves with fuel and cookware for the melting of snow and ice or a combination of the two alternatives.

It is also obvious that the geographic location is important to consider when specifying equipment packages and operational routines. During the exercise, it was discussed that the need for a five-day survival scenario at Svalbard is less likely, as there are resources in the area that can locate survivors from an incident and give some sort of support in the early phase of a possible grounding scenario. In Antarctic waters, in many accident cases, the five days' survival might not be sufficient.

No matter how equipment (and training) are specified geographically, there could be a way to organize bringing equipment on board ships temporarily when they are going into polar waters. Discussions are also needed as to whether some of this equipment (proper clothing) should be mandatory for passengers on cruise ships operating in polar waters (part of the cruise package).

Theme 5. Reports from companies attending the SARex3 exercise, continued

C16. Emergency preparedness in the Arctic

Magda Kopczynska,
Director for Waterborne (DG Mobility and Transport) European Commission

In its first Communication on the Arctic, The European Union and the Arctic Region¹, published in 2008, European Commission clearly recognized the clear link and impacts of European policies upon the Arctic region. While the potential of new opening sea routes crossing the Arctic will have clear economic benefits, EU's interests will require, among other, promotion of stricter safety and environmental effects. The role of enhanced maritime surveillance capabilities in the far North, also for emergency response is recognized, and the Commission declares support for further work to enhance IMO environmental and safety standards, applicable to Arctic waters.

4 years later, in 2012, a new Communication Developing a European Union Policy towards the Arctic Region², progress since 2008 and next steps, was published, together with a very detailed assessment of all areas of European policies that have an impact upon the Arctic region. Commitment of the EU to continue to support IMO work on the Polar Code was firmly stated in that document. In addition, the European Commission declared support to the work of the Arctic Council on emergency preparedness, prevention and response measures as well as following up on the recommendations on maritime safety from the 2009 Arctic Marine Shipping Assessment³. The Communications also recalls that the need for additional cooperation and effort with regards to search and rescue operations was also pointed to in the 2010 study on the Legal Aspects of Arctic Shipping⁴.

The accompanying Staff Working Document⁵ details actions undertaken since 2008, also with regards to the involvement of European Commission and European Maritime Safety Agency experts in the work of IMO bodies when progressing with the Polar Code. Taking account of the discussions held in the framework of the Arctic Council's Task Force on SAR and the legally binding agreement on Cooperation in Aeronautical and Maritime Search and Rescue adopted at the Copenhagen Ministerial meeting on 12 May 2011, European Commission recalls that the EU can provide technical and surveillance assistance upon request of a third country in the case of an accident, through systems and services offered by the European Maritime Safety Agency. Similarly so, once operational, Galileo satellite based services will allow for additional search and rescue capacity in the Arctic region. The European Commission held numerous discussions on possible initiatives for risk reduction in the Arctic with the cruise ship industry and other relevant actors.

In 2016 Communication, An integrated European Union policy for the Arctic⁶ European Commission again confirmed the need for the EU to enhance the safety of navigation in the Arctic, including through support of international efforts to implement the International Polar Code. Enhanced Search and rescue in the Polar Regions is specifically mentioned. The cooperation between European Coast Guard Functions Forum and the Arctic Coast Guard Forum is encouraged in order to help in fostering safe, secure and environmentally responsible maritime activity in the Arctic.

The importance of strengthening Search and Rescue capacities in the Arctic, including in view of increasing tourist activities, was strongly advocated by various actors in the context of EU consultations of stakeholders in the Arctic region on investment priorities for EU support and ways of streamlining EU funding programmes⁷. An important follow up was provided during the First Arctic Stakeholder Forum, organized by the European Commission in Brussels on 17 September 2018.

The need to facilitate cooperation and exchange of best practices between relevant actors, to strengthen the preparedness in the Arctic region for increased maritime traffic and the possible impacts on safety and security, was reflected in opening a call for Common Support Action in the framework of Horizon2020 in spring 2017⁸. 3.5 million euros, granted in 2018, will contribute to further enhancing search and rescue capacities in the Arctic in the framework of the ARCSAR project. 21 international partners will join forces to establish the first formal Arctic and North Atlantic Security and Emergency Preparedness Network, the new ARCSAR network. The project will run for five years and includes a live exercise on a cruise vessel in a bid to strengthen cooperation and innovation in security and emergency response in the Arctic and the North Atlantic.

¹ COM(2008) 763 final <https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0763:FIN:EN:PDF>

² JOIN(2012) 19 final http://eeas.europa.eu/archives/docs/arctic_region/docs/join_2012_19.pdf

³ <https://www.pame.is/index.php/projects/arctic-marine-shipping/amsa>

⁴ <https://webgate.ec.europa.eu/maritimeforum/en/node/2396>

⁵ SWD(2012) 182 final http://eeas.europa.eu/archives/docs/arctic_region/docs/swd_2012_182.pdf

⁶ JOIN(2016) 21 final <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016JC0021&from=EN>

⁷ Summary report: <https://publications.europa.eu/en/publication-detail/-/publication/6a1be3f7-f1ca-11e7-9749-01aa75ed71a1/language-en/format-PDF/source-60752173>

⁸ <https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/sec-21-gm-2016-2017.html>

Theme 5. Reports from companies attending the SARex3 exercise, continued

C17. Møkster's arctic survival package

Hans Kvadsheim,

Simon Møkster Shipping AS

C.17.1 Background.

In 2010 Simon Møkster Shipping AS made a decision that our future within PSV operation should be in the northern regions, such as Barents Sea rather than Brazil and other places in warmer climates. Based on this, all our PSV ordered and built since then have been of a winterized type. The company now operates four PSVs which are all winterized:

Stril Polar. Class notification: DEICE and Ice(C)

Stril Luna. Class notification: Winterized (basic) and Ice (1C)

Stril Barents. Class notification: Winterized (basic) and Ice (C)

Stril Mar. Class notification: Winterized (basic) and Ice (1C)

Stril Polar and Stril Luna have both received their Polar Code Certificate issued by DNV-GL on behalf of NMA.

Stril Polar received its polar code certificate 2017 as the first NOR registered vessel.

C.17.2 Risk assessment

Before deciding on content and type of equipment to be included in the PSK and GSK a risk assessment was performed.

The starting point for the type of equipment to be used is the requirements in the Polar Code Part I-B Additional guidance regarding the provisions of the introduction and Part I-A. Chapter 9 Additional guidance to chapter 8.

Equipment available on board:

Immersion suits;

Stril Polar: Helly Hansen N6 Nordic

Stril Luna: Viking PS 5002 insulated immersion suit.

Life rafts;

Life rafts Stril Polar: Viking 16DK+.

Life rafts Stril Luna: Viking 35DK+.

All designed for operations in cold climate (-25°C operation, -30°C storage.)

Other items influencing on the PSK and GSK:

Air Temperature:

The vessels are not intended or certified to operate in “low air temperature”.

Polar code definition; “*Ship intended to operate in low air temperature*”; means a ship which is intended to undertake voyages to or through areas where the lowest Mean Daily Low Temperature (MDLT) is below -10°C.

Polar code ship category:

Based on the Polar code and the requirements in this, our vessels are defined as “*Category C ship*”.

External information/reports:

The information provided in the reports from Sarex 2016 and Sarinor WP 4 rescue and WP 5 rescue and survival in cold climates were extensively used during the R/A

It was noted that an important learning from Sarex 2016 was the major loss of heat through the bottom of the life raft.

Clothing:

Winter clothing, including underwear etc., is available to the crew as this is part of the work wear supplied by the company during vessel operations in cold climates.

The immersion suits and winter clothing available on board is the primary source of clothing.

Result from the RA:

The immersion suits and winter clothing available on board is first choice of clothing to be used during a situation where the vessel has to be abandoned. If case a person gets wet inside the immersion suit a complete set of warm clothing must be available in the PSK.

Both PSK and GSK should be of a size and weight making it possible to be handled by one man and kept dry and floating if falling into the water.

The life rafts on board is the primary source of shelter and the intention is to use these both on land and on water. An additional shelter of Lavvo type to be provided in the GSK.

All clothing to be made of wool.

As far as practical possible the equipment and clothing to be vacuum packed.

The PSK may also be used as a ground sheet when seated in the life raft to reduce loss of heat through the bottom. If the clothing is used there should be a separate groundsheet in the PSK.

No need for jackets, winter boots etc. as the immersion suits is to be used at all time.

C.17.3 PSK and GSK

PSK;

Based on equipment both personal and shipborne available on board, operational area, temperature in which the vessels are to operate in and other factors the outcome off the RA was that an extra set of wool clothing and a groundsheet shall be provided. The clothing and groundsheet to be packed together, vacuum packed and contained in a watertight bag. The bag with content can then be used as a groundsheet to reduce loss of heat through the bottom of the life raft. If the wool clothing has to be used there is still a groundsheet available but not with the same thickness and insulating property.

Some of the suggested equipment described in the Polar Code was not relevant for the operation area in which the vessels is expected to operate and is therefore not supplied. This is; Skin protection Cream, Sunglasses, Polar survival guidance.

GSK;

The recommendations for Group Survival Kit in the Polar code is to be followed.

Content in PSK (Personal survival kit) and GSK (Group survival kit).

PSK (Personal survival Kit);

1 x pair socks.

1 x complete set of underwear, long arms and legs.

1 x pair gloves.

1 x woollen cap.

1 x sitting pad

4 pcs hand warmer

1 x waterproof and floatable bag



Fig C.17.1 PSK's ready for use

GSK (Group Survival Kit) for 10 persons:

1 x Tent accommodating 10 persons

5 x sleeping bags

5 x foam sleeping mats

1 x gas burner and 2 x gas bottles (low temperature type)

1 set kitchen utility

2 boxes waterproof and weatherproof matches

1 x flashlight, Dynamo powered (no batteries)

2 x rolls toilet paper

1 set water purification tablets

1 x collapsible water container

1 x foldable shovel

3 x 75 litre waterproof and floatable bags



Fig. C17.2 One complete GSK for 10 persons.

On our vessels with crew up to 28 persons there will be 3 complete sets of GSK on board

Emergency Food and drinking Water:

There is available emergency food and water rations in the life rafts stored on each side of the vessel. The food and water rations in the life rafts on one side of the vessel gives a daily ration as follows:

Emergency food: App. 0.2 kg (1000 Kcal) per person per day (5 days)

Drinking water: App. 0.6 litre per person per day. (5 days)

The rations are calculated for the maximum number of crew/persons the vessels are allowed to carry (app. 28). Normally the number of persons on board are up to 15.

Additional survival-equipment stored in each Life raft

- 6 x parachute-flares
- 6 x hand flares
- 2 x smoke signals
- 1 x signalling lamp with spare batteries and lightbulb
- 1 x whistle
- 1 x signal mirror
- 1 x scissor
- 2 x knife
- 1 x can-opener
- 1 set fishing-gear
- 1 set first aid equipment
- 1 x bailer

Storage on board.

PSK:

The PSK is stored together with the immersion suit in a heated compartment close to the muster station.

When the crew are dressed in their immersion suit each crew member grabs one PSK and bring this along.

The bag in which the PSK is stored is of a waterproof and floatable type.

GSK:

The GSK is stored in a heated locker close to the muster Station.

The bags used is of a size, weight and type making it possible for one man to handle them. These are also waterproof and floatable when containing equipment.

Theme 6. Rescue of stranded persons

C18. Rescue of stranded passengers in the Arctic

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Steve Olsen, Captain (N) and Deputy Commander in the Norwegian Coast Guard

C.18.1 Introduction

Since we (the authors) could not be a part of the whole SARex 3 exercise this year, we joined the expedition later than the rest of the participants. We gladly accepted the invitation from the Governor of Svalbard, Kjerstin Askholt, and her staff in Longyearbyen to join their service vessel, MS Polarsysssel, to meet The Norwegian Coast Guard's vessel, (NOCGV) Svalbard, at the location where the last part of the SARex expedition would take place. MS Polarsysssel and the Governor of Svalbard's staff would this year participate in this last part of the SARex 3 exercise with the aim to prepare and handle the situation of a large number of stranded passengers in the Arctic. In this part of SARex 3 exercise, the rescue group from Longyearbyen Red Cross would also participate and practice in this search and rescue (SAR) exercise; see [1]. The governor of Svalbard is both the chief of police and accorded the same authority as a county governor on the mainland. Rescue service is one of the governor's tasks, and the governor normally leads all rescue missions in Svalbard. The Joint Rescue Coordination Center (JRCC) North in Bodø has the overall operational responsibility during search and rescue operations north of 65 degrees north. The operations are coordinated either directly from JRCC North or through the Governor of Svalbard. For more information concerning this, see [2].

This report will focus on the search and rescue (SAR) exercise from the point of view of the "late arrivers" (as we were called throughout the rest of the SARex 3 expedition).

C.18.2 "Thinking" Svalbard and cold climate

Even though the authors live in the northern part of Norway, north of the Polar Circle, we soon noticed that living and staying on Svalbard is very different compared to living on the "Arctic" mainland. Examples

- the importance of distinguishing between indoor and outdoor shoes;
- the different ways of giving a "thumbs up" or an "ok sign", where you for instance put the whole hand on the head/helmet instead (since large gloves on the hands make it difficult for the thumbs to be seen);
- the fact that preparedness includes always having the gasoline tank of your snow mobile filled up and always bringing polar bear protection with you;
- the long distances at sea from the mainland and around Svalbard that make rescue operations extremely difficult – emphasize the difference.



Figure C.18.1. At Longyearbyen, we were introduced to snow mobiles very early. Photo: Annette Meidell.

Also, bearing in mind that, in the hospital in Longyearbyen, the number of employees and the amount of space and equipment are limited, the volunteers in Longyearbyen Red Cross, are important and play a great role in rescue operations regarding accidents in and around Svalbard.

In order to stay safe in Svalbard, the governor of Svalbard, in cooperation with Visit Svalbard, The University Centre in Svalbard (UNIS), Norwegian Polar Institute and Longyearbyen Red Cross, has published a brochure on safety in the field in Svalbard; see [3]. The brochure focuses on safety in the field for visitors who choose to go hiking in Svalbard. Nevertheless, there is a lot of important information that also applies to “stranded passengers” or tourists experiencing unwanted accidents in the Arctic Sea “nearby” Svalbard. Some of the equipment that they suggest that all hikers should take with them when hiking in Svalbard should also be available to potentially “stranded passengers”. For instance, they clearly state that it is necessary to always take warning aids, intimidation aids (pyrotechnical aids) and weapons for polar bear protection, and they also suggest different equipment and means of communication necessary to be able to report accidents. It is also suggested that the shoes and clothing you wear should be large enough to fit in extra insulating layers (if you get into an evacuation situation).

In [4], information will be found on how to operate ships in the Arctic and nearby Svalbard. In the folder, “Information for non-residents in Svalbard” in [5], more information may be found concerning, for instance, that one must be aware of glaciers that may calve icebergs, the low sea temperature, unsafe sea ice and the fact that extreme weather conditions can occur very rapidly.

All the information presented above gives the feeling that it is important to visit and stay in Svalbard with a kind of special focus of “thinking” Svalbard and the cold climate, when enjoying a stay there.



Figure C.18.2. The view from KV Svalbard at Fjortende Julibukta north of Ny-Ålesund was beautiful, but one must also be aware of the glacier that might calve icebergs. Photo Annette Meidell.

With all this in mind, the settings and limits for a SAR exercise in connection with Svalbard appears somewhat different from at sea near to the mainland, and especially compared to SAR activity in warmer regions. With the large distances between the mainland and Svalbard and the enormous cold sea area with possibly extreme weather conditions, the importance of training and competence transfer in SAR is extremely important.

C.18.3 Joining MS Polarsyssel for preparation

Finally, after a very pleasant meeting with the governor of Svalbard and some of her staff, we were kindly escorted to MS Polarsyssel, where we were given a great guided tour.



Figure C.18.3. On our way to MS Polarsyssel at Kullkaia in Longyearbyen. Photo: Annette Meidell.

We also met the 16 members from the Longyearbyen Red Cross (LRKH), who would participate in SARex 3 and also use MS Polarsyssel as a training and preparation area during the whole weekend, and as a field hospital during the SARex exercise.

The time taken to sail to the place where the exercise would take place was devoted to training and preparation for the exercise the next day. Both staff from the governor of Svalbard and professional medical staff from the hospital in Longyearbyen participated and helped to prepare the participants for the next day's exercise. The Red Cross members were given important lectures and information by the Governor of Svalbard's staff and Deputy Commander Steve Olsen in the Coast Guard, concerning different accidents and rescue operations in the Arctic, and guidance and support by medical personnel from the hospital in Longyearbyen. In addition, internal Red Cross guidance in rescue operations was provided. LRKH members were given a lecture on how to use the priority method "triaging" to determine the severity of the condition of patients. They also planned the area of scenes that the patients should be put into, according to the priority areas. The discussions afterwards were also very important. The focus on rescuing in the Arctic Sea requires different handling than rescue operations in the mountains or mainland, especially when it comes to the rescue of large numbers of stranded people, which was the theme for this exercise.

The boundaries for the use of MS Polarsyssel as a field hospital were set in advance: I.e. only, a few of the cabins should be used as a "hospital" and MS Polarsyssel's crew should be "invisible". The strain for the members of the Red Cross should be minimized during the exercise; hence, as little lifting and carrying as possible should be performed. This exercise would give the Longyearbyen Red Cross members training in e.g. logistics, learning how to take control of the scene and to practice the triage of patients, in order to determine the priority of the treatment of wounded people, based on the extent of their condition: a kind of "wounded priority" exercise.

C.18.4 Rescued by the Longyearbyen Red Cross

The Longyearbyen Red Cross (LRKH) members did not know what to expect at the scene of the exercise, how many people were participating in the exercise as casualties (markers), or what condition they would be in. Since everything at the scene was unknown, they prepared for several scenarios, regarding wounds, conditions, need for treatment and equipment, etc. The different scenarios would lead to different rescue operations and treatments.



Figure C.18.4. Some of the Longyearbyen Red Cross members waiting to start the exercise. Photo: Steve Olsen.

The leadership of such a rescue operation is a very important part of the Red Cross operation. The success rate of the rescue operation will largely depend on good organization of the scene, such that the handling and treatment of patients will be successful. Therefore, it was of great importance that several Red Cross members also had the opportunity to practice this part of the exercise. Thus, the “discovery” of the stranded passengers and organization of the area was repeated several times, using different “leaders” from the Red Cross each time.

The discovery of the stranded passengers

What the Longyearbyen Red Cross did know was that the exercise would start the following morning. After a good meal and a good night’s sleep aboard MS Polarsysse, early the next morning, on an island in the Fjortende Julibukta north of Ny-Ålesund, we found the “stranded passengers”.

Dressed in their suits, with their personal “first aid backpack” and other equipment at their side, the Red Cross members were ready to start the exercise. The “stranded passengers” were, of course, the other participants in the SARex 3 exercise, as well as some of the crew of KV Svalbard; in total, over 40 people acted as “stranded tourists”. The “stranded tourists” had been given different “conditions” as patients and acted accordingly. Some of them had been exposed to “fire and explosions”, some had “heart problems”, some had trauma, while others were suffering from hypothermia, etc. Although 40 is not a large number, an exercise with this number of “stranded people” will, at least, identify some issues that must be taken into consideration for even larger rescue operations.



Figure C.18.5. The scene of the “accident”. Photo: Amette Meidell.

The members from the Longyearbyen Red Cross very soon and professionally started their work. Since they had planned that several of their members would have the opportunity to “lead” the rescue exercise, they repeated the start of the exercise several times and discussed what strategies would be best during the exercise.

Since the LRKH members had discussed the different scenarios for how the area should be used, the patients were put into different places according to the priority areas that had been decided. They practiced the triage method at the “accident” scene and at MS Polarsyssel for a large number of different conditions. At the scene of the “accident”, the “patients” were registered, briefly examined and given labels with the priority of their condition. Since this exercise was mainly a maritime Arctic “area” and “method” exercise, on this occasion lower priority was given to whether the patients received the correct diagnosis or not. Diagnosis/priority practice can easily be provided regularly at the Red Cross “home” base, since there are continually many new members that require this.

We were impressed by the training and effort that the Red Cross displayed, and they informed us that they had not previously practiced such an operation from an Arctic maritime point of view and found it very important. They were grateful to have been given the opportunity to be a part of the SARex 3 exercise, together with the Governor of Svalbard, Kjerstin Askholt, and her staff at Longyearbyen; see [1], in which the exercise is described in detail from their perspective.

The logistics

Logistics are of great importance to achieve a successful rescue operation in the Arctic Sea. Since you may only reach the accident area by boat, or by helicopter (if the distance is not too far from the service station to get fuel), you also must consider whom to bring to the area first, as well as what equipment to bring, based on what casualties there might be. It is not possible to bring all the first aiders, emergency medical technicians and equipment required for the situation at once. In addition, the logistics are of importance when it comes to which of the wounded people to treat first and how to treat them. Both MOB (man over board) boats and helicopters have only a limited space to hold and transport wounded people. The transfer of wounded people from an island or beach (as was the case in this exercise) to the “field hospital” at MS Polarsyssel requires intermediate transport from the island, via a MOB boat and then to MS Polarsyssel and then, perhaps, to the hospital in Longyearbyen.



Figure C.18.6. The MOB boat transporting equipment and rescuing people to the island and bringing wounded people to the “field hospital”, MS Polarsyssel. Photo: Annette Meidell.

Since the MOB boat used in the exercise also has restricted space, only a limited amount of equipment and number of people could be transported to and from MS Polarsyssel during the time at which the exercise was used as a field hospital.



Figure C.18.7. The MOB boat loaded with wounded people. Photo: Annette Meidell.

Choosing which first-aiders, medical personnel and patients should be transported to and from the accident scene is of huge importance, and skills in deciding this, in the different scenarios of an accident in the Arctic Sea, are very important.

Innovation and equipment

In this operation, it is not only the logistics and priority questions that are of importance; as we witnessed, the technical equipment for handling wounded people clearly has the potential for development. The processes of bringing cold, wet and wounded people across bumpy land by carrying and sliding, and of lifting to maneuver those who were attached to stretchers at all different angles to enter and fit into the MOB boat, are neither easy nor comfortable. The operation to get the wounded people from the beach to the MOB boat identified some difficulties; since this procedure included lifting people and stretchers relatively high, there was also a risk of dropping the wounded people onto the floor, into the water or onto the ground. In addition, the effort involved for the rescuers could lead to different injuries (back pain, shoulder pain, etc.).



Figure C.18.8. The transfer of wounded people onto the MOB boat is difficult. Photo: Annette Meidell.

This rescue operation clearly identified the need for different designs or new products that can help in rescue situations. By observing the rescue exercise and following the operation closely, we observed that a systematic procedure for registering findings should be generated. This would also include suggestions for how to follow up the findings, in order to close the gap between findings and necessary solutions. To further develop the necessary equipment, it is important to publish such registered “findings”, and anyone should be able to make inputs to such a “findings list”. The “findings list” should be available to the public, so that anyone can solve the problems that are published therein. The “public” challenges and unsolved questions should be open and published at e.g. Maritimt Forum Nord (MFN)’s home page, so that companies, students, researchers or other interested parties can work on these challenges. Next, there should be systematic cooperation with, for instance, innovative R&D (Research and development) institutions (e.g. universities) that can use “findings” as projects for students or researchers, in order to design or redesign such “non-commercial”, new or improved helpful aids for use in such Arctic maritime environments.



Figure C.18.9. The MOB boat from KV Svalbard also helped to transport people to and from the scene of the "accident". Photo: Annette Meidell.

MS Polarsyssel can lift stretchers from sea level and up onto the boat. The next challenge was to handle the wounded people inside MS Polarsyssel. The Longyearbyen Red Cross found that handling stretchers with wounded people inside the service vessel was neither easy nor comfortable.



Figure C.18.10. The Longyearbyen Red Cross members maneuvering a patient on a stretcher on board the field hospital. Photo by courtesy of LRKH.

For instance, we identified that improvements in the shape of a lightweight stretcher system with flexible and multi-task properties will be welcome.

We also think that new technologies such as different apps for mobile phones (and other electronic network devices) that could easily give and exchange information across institutions involved in the operation are welcome as helpful aids in SAR operations. The Longyearbyen Red Cross tested such a system in the exercise, and their experience in this will be important for further developments. In addition, different robust drone systems and communication systems in these areas where there is limited ordinary network connections could give important information and be helpful in such SAR operations.

Tide and weather conditions

Although we were lucky, having fair weather conditions during our SARex exercise, with temperatures of approximately 4°C in both water and air, we would have suffered from hypothermia, without good protection (clothes, tents, etc.). We saw that the “stranded passengers” felt cold, even though they were not in a “real” evacuation situation and were not even wet. They were happy to be offered something hot to drink. The worst “wounded” passengers were put to rest in a nice hot tent, where they were protected from the wind, snow and rain. Of course, there was not space in the tents for everybody, but clearly this kind of protection would make a big difference to the condition of the patients. Such protective shelters with heaters and other equipment must be brought to the scene of the accident, and, due to transport and logistics to and from the area, it may be difficult to obtain all the shelters and equipment needed or desired. New types of lightweight shelters and other equipment, as well as new, better insulating products/materials, may be helpful in these situations. Also, in real situations, the weather conditions may, of course, be much more extreme than we experienced, with wind, snow, rain and waves, in addition to much lower air temperatures. In such conditions, it will be important to have the possibility to keep warm.



Figure C.18.11. A hot tent is a good place to be. Photo: Annette Meidell.

Be aware of the tide

In addition to always being prepared for the possible rapid oscillating and extreme weather conditions, there is also the issue of the tide. The tidal range, which describes the vertical difference between the high tide and the following low tide, in the northern part of Norway and Svalbard must be taken into consideration when rescuing persons that e.g. are stranded on shore. The tidal range can fluctuate by as much as approximately 2.5 m in the northern part of Norway and 2.0 m in Svalbard; see for instance [6] and [7]. In SARex 3, we observed these fluctuations in detail. In particular, the MOB boat could not approach the same place on the beach during the whole period of the exercise. Thus, the place where the MOB boat should have approached the stranded passengers to transport them to MS Polarsysse had to be varied for some hours. Sometimes a ladder could be used to enter and leave the MOB boat when the water was low, since the level from the shore to the boat was higher, but sometimes it was necessary to change the place where the boat had to anchor; hence, the patients also had to be moved to the new place.



Figure

C.18.12. At this time, a ladder had to be used in order to transfer people onto and out of the MOB boat at a different sea level. Photo: Steve Olsen.

It was very interesting to observe the rescue operation, and we noticed some things that may be improved and make the operation smoother and less stressful for both rescue personnel and patients. Clearly, however, we did not notice everything, so obviously there are other areas that could also be improved.

Both members from the Red Cross and other participants in SARex 3 experienced the need for the redesign and development of different equipment, and we think that an even more systematic registration of these kinds of findings and suggestions for improvements should be included in the next SARex exercise, in order to process these issues further. Industry, researchers, academic institutions and other participants can make important contributions to solve these questions, along with the public (tourists, society, etc.), and everyone will benefit from the development of such equipment.

C.18.5 Findings and suggestions for the next exercise

There is a need to redesign and develop different equipment connected with rescue operations in the Arctic Sea. Based on our observations, we have collected some suggestions that may be included in the next SARex or may be put in a “finding list” for further development. For instance, we saw that:

- A more systematic registration of the findings and suggestions for improvements should be included, in order to process these issues further.
- A systematic procedure on how to follow up the findings should be generated, in order to more effectively close the gap between findings and necessary solutions.
- The development of new – or the redesign of existing – technical equipment for handling wounded people (e.g. stretcher systems, sliding systems) could be helpful in the SAR operations.
- The development of new technologies and communication systems, such as different apps for mobile phones to more easily exchange information in SAR operations, would be good.
- New types of lightweight shelters and other protective equipment, and new, better insulating products/materials could increase the number of survivals in SAR operations and would be helpful.

- Developing functional prototypes of new improved products to use in rescue operations and test them in a new SARex “real-life” exercise would increase the success of SAR operations.

We think that using a systematic process to register findings will bring new ideas forward. In this way, identified findings, challenges and problems should be made available to the public through an open website. Then, anyone can give input to different problems and challenges, and anyone can “take” one of these identified problems and work with it in different projects. The ongoing process and suggested solutions must be registered in order for them to be developed into real-life solutions and products that can be tested in the next SARex exercise. Such a systematic process will contribute to achieving successful rescue operations in the Arctic Sea in the future, since this will give new improved solutions. Many of these kinds of projects may solve important gaps between necessary solutions and existing solutions; closing this gap is important for both society and individuals. Many of these gaps are “non-commercial” questions. This means that few commercial companies will make an effort to develop solutions to the problems, since there is little prospect of earning a lot of money (there is a limited market that will buy these products). Naturally, the universities may be interested in R&D in such identified problems, since they have the possibility to perform R&D activities connected to such non-commercial problems. Also, there will be no distortion of competition connected to these product-development projects because of the non-commercial issues.

C.18.6 Some final remarks from Maritimt Forum Nord

Every year many people move to and from Svalbard, and the members of the Longyearbyen Red Cross will therefore continually change: more so than in equivalent groups on the mainland. Therefore, it is especially important that everyone receives necessary and relevant training in different situations and that they get to know each other well, since these kinds of rescue operations require a strong sense of trust in each other. Hence, we understand that, for the people living in and visiting Svalbard, exercises like SARex are particularly important, in order to be as well prepared as possible should different types of disasters or unwanted accidents occur. In addition, the increase in tourism and other activities in connection with Svalbard will increase the risk of experiencing such unwanted accidents.

SARex 3 is the third search and rescue exercise involving Svalbard. Maritimt Forum Nord (in the north of Norway) greatly appreciates the contribution and efforts of the Norwegian Coast Guard (NORCG) in the SARex expeditions. We especially thank the leader of the Coast Guard Competence Center, Commander S.G. Endre Barane, and Captain (N) Steve Olsen (Deputy Commander in the Norwegian Coast Guard) for their involvement and participation in SARex exercises, along with the rest of the staff and crew in NORCG.

The Norwegian Coast Guard has a lot of experience, and their genuine interest in also including participants in e.g. SARex, and providing training and transfer of competence, is highly appreciated and of great importance for all those of us who are exposed to the Norwegian harsh, but beautiful, environment in the Arctic Sea. For more information concerning The Norwegian Coast Guard and Maritimt Forum Nord, see [8] and [9], respectively. We also thank all the other participants, for their input in the exercise, and the driving forces: Professor Emeritus Ove Tobias Gudmestad and Senior Researcher Knut Espen Solberg for their efforts and their willingness to contribute their skills and knowledge. Finally, we thank Steve Olsen for arranging the special “late arrivers” trip, which made it possible for Maritimt Forum Nord, this year represented by Annette Meidell, to participate.



Figure C.18.13. Steve Olsen (left) and Endre Barane, Commanding Officer of KV "Svalbard" in the SARex 3 exercise. Photo: Annette Meidell.

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Theme 6. Rescue of stranded persons, continued

C19. Organization of the rescue of wounded passengers from rescue means

Øyvind Jonassen, Norwegian Ship Owner's Association

C.19.1 Background

I was one of the passengers "diagnosed" with severe hypothermia. During the first triage evaluation, there was some confusion regarding the diagnosis, though not more than may be expected of the crew in a scenario with so many injured and great pressure regarding time. The crew was not equipped with enough means of communication, and it was both exhausting and inefficient that some of the crew had to run back and forth over quite long distances to give messages, provide stretchers and so on.

The transportation back to the designated meeting point was efficient but did not take into consideration the health condition of those with hypothermia. The crew carrying stretchers had to walk quite far, and, for a period, they chose to drag the stretchers in the snow. It became very cold from underneath, which in a real scenario would not have benefitted the patient. Back at the meeting point, I was placed in a good position, relatively well wrapped up. However, it was not until person no. 3 came to manage me that my severe diagnosis was discovered, and only then did they start prioritizing the remaining patients.

Due to security reasons, we did not have stretchers during the crossing to Polarsysssel. This seemed to be a good choice and did not affect the focus of the exercise.

On board the Polarsysssel, I experienced the organization as quite chaotic. A lot of this was due to conditions the crew were unable to influence. This mainly involved very inappropriate facilities for first aid and medical treatment. Apparently, there was a desire to not use too many of the facilities on board, to avoid spending too much time cleaning afterwards.

This resulted in only a few cabins being used for this purpose. These were again overloaded with patients with serious diagnoses, without the person responsible for the area being even close to having enough resources to obtain an overview. For my part, the diagnosis given had a great risk of leading to cardiac arrest, but I was still placed in a top bunk, where performing CPR would have been almost impossible. There were also patients lying on the floor, which meant that it would take a good amount of time from a cardiac arrest being discovered until one could start medical treatment.

Main learning points:

C.19.2 Unsuitable treatment site

If that many patients are to be supervised, with a reduced capacity of medical personnel, these must be gathered in one place. They should all be placed on the same level, giving the possibility to keep track of several patients at the same time. The possibility to perform CPR on patients in danger of cardiac arrest must be taken into consideration.

Theme 7. Communication in the Arctic

C20. SAR and communication means in Arctic navigation

Magne-Petter Sollid, University of Tromsø

As the Arctic sea ice retreats, new possibilities emerge for the shipping industry. The way is open for new trade routes for the commercial shipping industry, for cruise vessels operating in both the explorer and the mass-tourism market, for oil and gas operations and for many other segments seeking new possibilities and economic growth in one of the most remote and vulnerable areas on earth. These new opportunities in the Polar Regions result in an increased maritime risk that has been dealt with through the Polar Code, which came into force in 2017.

One of the major challenges addressed for the increased shipping traffic in the Polar Regions is how to cope with maritime crises and emergencies. Through the International Convention on Maritime Search and Rescue (SAR) and the Global Maritime Distress and Safety System (GMDSS), the maritime nations around the world have gathered through the auspices of the IMO to handle maritime disasters. The SAR convention came into force in 1979, to provide a global system for responding to emergencies, and the GMDSS was established to provide the SAR convention with the efficient communication support it needed to succeed in saving lives, the environment and properties from accidents at sea. Both the SAR and GMDSS are crucial for maritime safety and to ensure that any emergency at sea will result in a distress call and a response that will be immediate and effective [1].

The GMDSS is a worldwide network for emergency communications among ships at sea. This means that all ocean-going passenger and cargo ships above 300 tons must be equipped with radio and satellite facilities to alert and communicate with respective onshore search and rescue authorities and other ships in the vicinity in the case of a distress situation. The GMDSS system is divided into smaller sea areas, which have limitations with respect to coverage, and it defines the minimum standards of equipment the ships must comply with for operating within these areas, Table C.20.1. Ships operating within the area of the Polar Regions, as defined in the Polar Code, must, as a starting point, be approved, with GMDSS certificates for Area A4, since most of the areas of the Polar Regions are within this definition. There are also areas in the Polar Regions which have only A1, A2, or A3 coverage.

GMDSS areas and equipment		
	Communication coverage	Communication equipment
A1	Within continuous VHF (Very High Frequency) DSC (Digital Selective Calling) coverage from a CRS with follow on VHF RT (Radio Telephony) (about 20 - 30 NM from the coast)	VHF radio – DSC and RT NAVTEX receiver - Automatic reception of MSI (Maritime Safety Information)
A2	Outside Sea Area A1 Within continuous MF (Medium Frequency) DSC coverage from a CRS with follow on MF RT (about 100 NM from the coast)	MF radio – DSC and RT Plus the equipment included for Sea Area A1
A3	Outside Sea Areas A1 & A2 Within INMARSAT (International Maritime Satellite Organization) coverage, that is between 70° North and 70° South	HF (High Frequency) radio – DSC Or INMARSAT – Satellite Communication Plus system for reception of MSI in Sea Area A3 (EGC or Radio Telex) Plus the equipment included for Sea Areas A1 & A2
A4	Outside Sea Areas A1, A2 & A3 Above 70° N and below 70° S	HF radio – DSC Plus the equipment included for Sea Areas A1 & A2

Table C.20.1. GMDSS areas and related equipment

Chapter 10 of the Polar Code requires equipment for a) ship-shore voice and data communication, b) tele medical assistance services c) for receiving ice and meteorological information, d) ship-to-ship voice and data communication and e) maritime aeronautical two-way voice on-scene and search and rescue communications. To some extent, the existing GMDSS regulations can be used to meet the requirements in the Polar Code, such as ship-shore voice communication, maritime safety information and SAR communication. Nevertheless, this simple requirement regarding voice communication is difficult to fulfill with GMDSS; the traditional MF/HF equipment carried on board ships relies on shore stations that can handle this type of communication [3]. There is also a diminishing number of skilled operators, both onshore and on board the ships, who can work on MF/HF circuits. To succeed with communication, the mariners on board the vessels have to be trained with the communication equipment they are using. As most ocean-going routes today are within the limits of area A3, the mariners have not received very much training in using, for example, MF/HF stations or the telex stations that are required within area A4. In addition, communication units on board ships vary greatly in quality and condition. In addition to the requirements for reliable voice communication, the Polar Code requires data communication to have the means for receiving meteorological forecasts, ice conditions and satellite imagery, as well as the ability to conduct tele medical assistance. In a report by SARINOR [2], the low reliability and low bandwidth associated with telemedicine communication was identified as one of the main challenges in an accident scenario. The GMDSS needs to be modernized, especially for vessels working outside sea area A3, which means they are outside the geostationary footprint. Several technologies exist today, and new ones are emerging, that can fulfill the Polar Code requirements, but, until there are unified and common regulations for these satellite systems, there will be no common platform that works across all land- and sea-based stations.

Today's geostationary systems, such as the Inmarsat, do not have coverage north of 80° and have limited coverage and reliability between 70° and 80° North. Another satellite constellation is the Low Earth Orbiting Satellites, but this constellation also has neither proven reliability nor data rate in the areas north of 70° [4]. One emerging technology that can be viable is the High Elliptical Orbit (HEO) system, which has coverage beyond 70° North and can deliver a sufficient data rate to fulfill the requirements in the Polar Code. Nevertheless, satellite communication systems are a proven solution; common to them all is that they are subject to atmospheric and ionospheric disturbances. In the Northern and Southern Hemispheres, this activity can be relatively intense. Tables C.20.2 and C.20.3 below, extracted from [5], summarize the available and unavailable systems, and their common communication challenges.

	System	Characteristics	Polar (>80°N)	Sub-Polar (70°N - 80°N)	Other (<70°N)
Terrestrial systems	HF, MF	Safety related messages and voice communications	OK, but unsuitable for digital communications	OK, but unsuitable for digital communications	OK, but unsuitable for digital communications
	VHF, digital VHF, GSM, 3G	Line-of-sight, voice and low data rate communications	No base stations, ship-to-ship OK	Few base stations, ship-to-ship OK	VHF is OK close to the coast, GSM/3G limited coastal coverage
Satellite systems	GEO satellites, including Inmarsat.	Medium capacity. Low to medium latency.	Not available	Potential problems with quality and availability	OK (except in fjords and similar special areas)
	LEO satellites; Iridium OpenPort	Currently max. 128 kbps. High and variable latency.	Potential problems with quality	Potential problems with quality	OK, except for areas around equator
	HEO satellites	Properties comparable to GEO. Currently unavailable.	Expected to provide good coverage, capacity and quality in the Polar and Sub-Polar areas. Spare capacity can be used in other sea areas. Not yet implemented.		

Table C.20.2. Communication systems performance in the Arctic [5]

Challenge	Cause	Consequence
Low elevation angles	Geostationary orbit satellites	Signal loss due to shadowing, low signal strengths. Signal loss when combined with heavy roll, pitch and heave of vessels.
Additional signal transit distance	Geostationary orbit satellites	Signal attenuation and degraded quality due to atmospheric (for frequencies > 10 Gz) and <u>ionospheric</u> disturbances (for frequencies < 1GHz).
Icing on antennas	Ice accumulation from sea spray and air humidity	Signal attenuation and degraded signal quality ³ .
Signal delay and latency variations	Lack of earth stations/gateways	Real time requirements are difficult to achieve

Table C.20.3. Communication challenges in the Arctic [5]

The GMDSS system and sea area A4 need to be modernized and designed for multiple functional demands, to be able to cope with future requirements in Arctic Shipping. Alternatives to HF communications are especially needed and with a common platform to ensure reliability and platform independence among the ships.

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Theme 8. The Polar Code and further needs

C21. Report following SARex 3

Sveinung Toppe, Hurtigruten

SARex 3 was aiming at finding answers to what equipment and expertise are needed to meet the Polar Code's requirements for survival on land for up to 5 days after an accident in the operating areas covered by the Polar Code.

The experience is little, and is based to a large extent on SARex 2, where it was tested how long time one could survive in a life raft with existing equipment.

Participants of SARex 3 came from many environments who work with the Polar Code daily. Both from academia/ the research community, shipping companies, public agencies (Norwegian Maritime Directorate), oil / offshore / supply, insurance, equipment suppliers and me from the cruise industry.

C.21.1 Objective

The largest part of the program was represented by practical implementation of survival in groups on the shore having different types / amount of equipment, both in terms of personal survival equipment (PSK) and group survival equipment (GSK).

Workshops and discussions, both in advance and after the exercise were central, looking at existing regulations and giving thoughts to what requirements one can expect as a result of the Polar Code.

The background for my participation in SARex 3 is that Hurtigruten wishes to participate and be an active part of the development of the Polar Code. My personal expertise lies first and foremost on Arctic survival; how to survive as far as possible on land in Arctic regions. And I have some clear ideas about what will be needed with respect to equipment and expertise in order to survive for up to 5 days in case of an accident in Polar Regions.

C.21.2 Practical completion of the exercise.

The exercise itself was conducted in 8 groups with 5-6 participants in each group.

- The food and drink daily rations were one liter of water and biscuits of the type found in lifeboat / raft. During the 2 days experience, it was evident that there is enough food (hard to eat, though) but somewhat too little amount of water if one wants a minimum of activity.
- Equipment: Each group had different quality and amount of equipment, both PSK and GSK. But since the weather was relatively fine and we finished after 2 days I'm not sure how well one can conclude solely on the basis of this exercise. However, based on experience, I will come up with some point of view / recommendations in the final section of the report.
- All groups were assigned a site on the beach where we would "survive" with equipment for up to 5 days. There was no time given for completion of the exercise. In my group we had assigned a lightweight PSK (top-to-toe cotton lingerie, ok windproof pair of trousers, a thin "down jacket", not windproof nor waterproof, a light bath type of shoe with a special thong and a thin hat and mittens). We also had a lightweight GSK ("storm shelter" / cover, 3 thin bed sheets of foil and paper, 3 vacuum-packed aluminum bags and some single cookware, knives etc.). The strength of the equipment was only we as a group could use our "storm shelter" to protect us from the wind and weather. But since the shelter was not a tent it could only be used when the whole group was standing upright inside, supporting the shelter with the bodies. The weakness was that nothing of the equipment gave enough thermal protection to stay warm over time without moving. The clothes were so bad that they were acceptable

only since the weather was pretty good. Several times a day we were followed by a physician who checked how the body reacted to the strain it was exposed to. In each group, there were major differences in experience and how to respond to this type of load. Both physical and mentally.

C.21.3 Experience

The simple conclusion is that those who have access to the most and best equipment will do better than those with little or no equipment. But it also turns out that much of the equipment that is best (good tents, ovens, etc.) can be difficult to use correctly and safely for users who do not know this equipment from before. And then you touch into something that is especially important to us in the cruise industry: tourists will probably not be able to use professional equipment on their own. And then we talk about assisted survival (that crew and guides are those who have to know the equipment and ensure a safe use of this).

I have no doubt that assisted survival is the only sensible way to implement this in the cruise industry. If you compare experience with SARex 2, there is no doubt that if you want to survive for 5 days, you must strive to land and not stay in the fleet at sea. In the case of the fleet tests, the last person was retrieved after 19 hours. When we were on land, about 80% remained and in good shape after 2 days.

What type of equipment do you need to survive on land in such a situation? In short, you need:

- To warm up (warm clothes, sleeping bags etc.)
- Cover (Tent or raft. Lifeboat is not very suitable since it is impossible to get it on land. So, in a lifeboat there should be a tent packed!)
- Fluid (There must be water and food rations in all boats and rafts!!) In areas with snow, ice and water levels, water will freeze. Then there is the need for a kind of cooking equipment that works)

There will be many strong opinions about which equipment will perform well enough in such a situation. This should take into account both costs, volume, ease of use, etc.

I have a clear opinion regarding the equipment I think will be good enough, which is both cheap, takes up little space and will be flexible in use. (Both for sleeping, rainwear, taking care of injured person, etc.).

The challenge in the cruise industry is that we cannot plan that our guests will be able to cope without assistance. And what competence and training holds crew and guides?

However, if crew and guides are trained in survival with the specific equipment found on board, there is no doubt that good knowledge of the equipment could significantly increase safety. I also believe that a high level of competence among crew members can provide the most appropriate equipment regardless of whether it is very easy to use or if it requires more than certain minimum knowledge.

It is not automatic that the most expensive equipment will be the best equipment in a casualty situation. But it's important to have thought through how many of the casualties should use the equipment at the same time (Should there be room for sleeping for half the group, for one third ... etc.)?

If you are interested in my thoughts and experiences specifically regarding equipment, capacity and function, so contact me concerning details

In the cruise industry, it would be appropriate to focus on clothing that guests already wear. A jacket can be provided and a packing list / information to guests in advance of the cruise can focus on the fact that personal items such as good shoes, hat, mittens and warm clothes must be taken by the guests themselves. In case of an alarm on board, please note that this is clothing that is to be taken on at evacuation of the ship. It will probably not be practical to hand out a personal package of just the right size to hundreds of passengers.

C.21.4 Polar Code Requirements

In the future there will be given more specific requirements for equipment in the Polar Code. However, as the Maritime Directorate points out, it will not be possible to impose special Norwegian requirements that are stricter than international requirements.

Furthermore, The Norwegian Maritime Directorate does not wish to contribute to the requirements being so strict that it is barely possible to meet these. Particularly demanding, it would be to implement large amounts of safety / emergency equipment on ships built before the Polar Code was applicable. That would be both expensive, impractical and commercially impossible.

Possible specifications on equipment may in the future be

- Requirements for thermal protection on equipment in case of accident
- New requirements for rafts / lifeboats (fewer passengers to accommodate sufficient equipment)

However, NMD states that they are bound by EU directives and international agreements, so this will take time and there will not be excessive requirements in the future.

Questions discussed are whether to differentiate between the requirements for which operating area you are going to sail in. There is no doubt that in case you are going to sail the Northwest Passage, you may be unable to get help for up to a week if you are unlucky, both from other ships and SAR resources. In those areas, it will be an option to operate a following boat to secure safety.

A small project will also be launched to try to map SAR resources both in the Antarctic and in the Arctic outside Svalbard. There are some resources in the areas. However, what capabilities the Russians have, we unfortunately know too little about.

This is very interesting as there may be requirements to the equipment that also take into account which SAR resources are found in the operating areas

C.21.5 Final words

I am also challenged to contribute to the final report for SARex 3. And my contribution should be something about how the Polar Code can be implemented by a cruise line (Hurtigruten).

I am a little uncertain about what I will write here since I have very little knowledge of the work done in the company in relation to this. Are we looking for higher requirements in certain operating areas when we build new ships and rebuild existing ships to improve the explorer the product?

I hope that the Hurtigruten will not only be the largest on expedition cruising, but also the best! And then it will be natural for us to be a pioneer in relation to safety, implementation of the Polar Code and the awareness of the operating areas to sail in.

Obviously, it is a great challenge to deal with an accidental situation in a polar area with ships of the size that Hurtigruten operates with. And I am convinced that crews / guides on board must practice situations that go beyond evacuating all passengers to lifeboats / rafts. Increased competence is what will best contribute to survival for up to 5 days. And equipment that shall be on board will also be better utilized when the crew has some expertise to use the equipment and to survive in arctic regions.

Theme 8. The Polar Code and further need, continued

C22. Regulations applying performance-based requirements and the importance of their guidelines

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This article focuses on the benefits of developing a guideline to the Polar Code. The regulations make extensive use of performance-based requirements, making a guideline more beneficial than a regulation, which applies prescriptive requirements. A guideline is strongly recommended, as it entails that the requirements put forward by the Polar Code are more easily understood by those subjected to the regulation and, further, facilitate compliance. This article focuses on the practical implications associated with using performance-based requirements and compares these to those associated with the use of prescriptive requirements. A challenge often faced when applying performance-based requirements is the increased level of knowledge and competence necessary to be able to ensure compliance. Since the Polar Code concerns safety, it is crucial that those subjected to the regulation are *able* to comply. Hence, one of the motivations for developing a guideline to the Polar Code is argued to be the possibility to recommend existing industry standards that are considered to comply with the requirements put forward by the regulation. Further, a guideline enables the regulators to elaborate and specify the requirements put forward by the Polar Code, hence, reducing the necessary competence among those subscribing to the regulation.

C.22.1 Introduction

The importance of regulating ship activity in polar waters through legislative means has become more significant in recent decades. The increased melting of sea ice, in addition to an increased number of vessels capable of manoeuvring through sea ice has led to increased activity in polar waters. A significant part of this increase is due to new shipping routes and cruise tourism. The necessity of a functioning legal framework is emphasized, as new actors face new hazards and risks. The Polar Code shall ensure that those operating in polar conditions do so in a safe manner without harming the environment. As actors previously unfamiliar with the challenges posed by cold climate, sea ice and reduced means of communication move further north and south, it is paramount that safety is given great attention.

One of the most important legal documents regulating safety challenges faced in polar waters is the Polar Code, developed by the International Maritime Organization (IMO). The regulation came into force in January 2017 and its scope is to provide for safe ship operations and protect the polar environment (Polar Code, 2017). The Polar Code consists of two parts, the first of which provides safety provisions, whilst the second part contains provisions on pollution prevention. Given the important role the Polar Code plays in ensuring safe operations in polar waters, it is important that the regulation present an unambiguous legislative framework that assists relevant stakeholders in maintaining and further improving safe conditions on-board.

C.22.2 Performance-based vs. prescriptive requirements

The Polar Code makes extensive use of so-called performance-based requirements in order to ensure that an acceptable level of safety is attained. This type of requirement is goal-oriented, meaning compliance is determined by whether desired goals are achieved or not. Performance-based requirements do not specify *how* to attain a certain level of safety but stipulate *what* level of safety is deemed acceptable. As performance-based requirements are goal-oriented, it is neither easy nor

beneficial to put forward technical and specific requirements. As a result, the requirements are flexible, in regard to which solutions are adopted, as long as they achieve the desired goal.

Prescriptive requirements are considered to represent a counterpart to performance-based requirements. Prescriptive requirements specify *how* to attain a desired level of safety but not the goal itself. A natural consequence is that prescriptive requirements are often more detailed and specify the solutions themselves, necessary to assure compliance. The rigidity associated with prescriptive requirements might be desirable, as it simplifies enforcement of the regulation and ensures that an established desired level of safety is achieved.

C.22.3 Space for action

Both performance-based and prescriptive requirements have their benefits and disadvantages, for both regulators and those subjected to the regulations. For instance, the lack of flexibility associated with the use of prescriptive requirements often leads to the inability to keep up with technological innovations and advancements. Also, adopting solutions deemed more effective than those stipulated by the prescriptive requirements will lead to noncompliance. This issue is not encountered to the same degree when applying performance-based requirements. Figure C.22.1 illustrates how space for action depends on whether the requirements are performance-based or prescriptive.

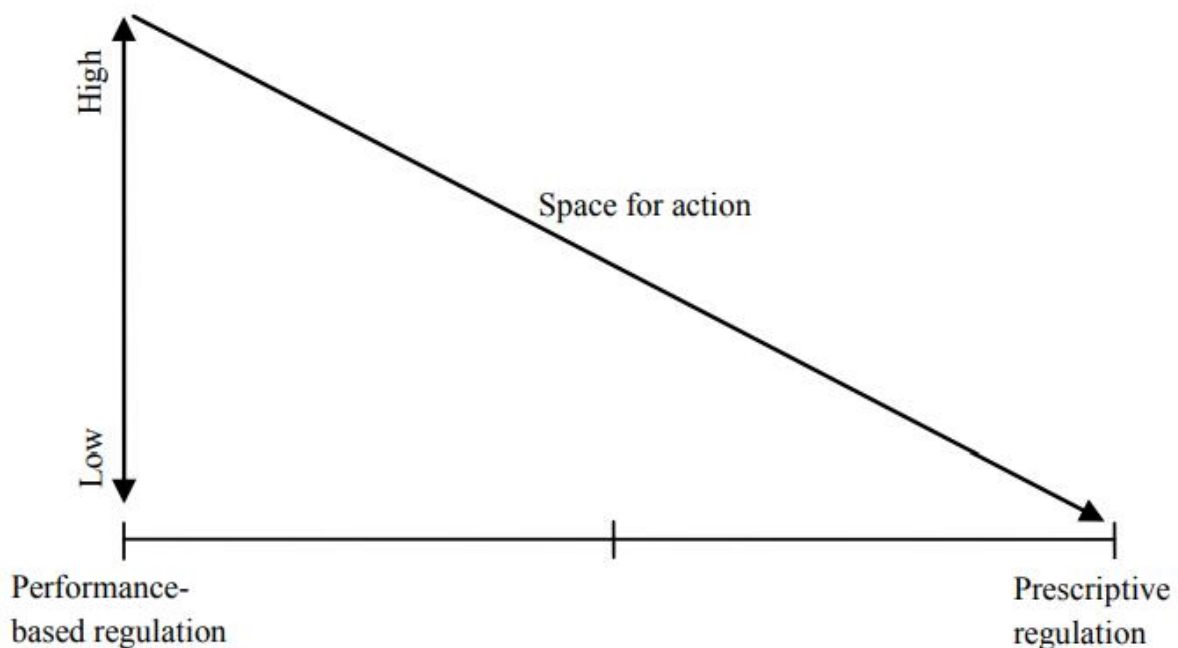


Figure c.22.1: Space for action for prescriptive and performance-based regulation (Olsvik, 2015)

According to Olsvik (2015), prescriptive and performance-based requirements both mark the extremes on a scale when considering “space for action”. She defines space for action as the freedom for those subjected to the regulation to choose *how* to comply with requirements. At one end, prescriptive requirements allow for no, or limited, space for action, while, at the other end of the scale, performance-based requirements permit a larger space for action. Olsvik (2015) emphasizes that the scale presented in Figure 1 is merely a theoretical scale, and the two endpoints are considered “ideal types”. Legislative requirements will normally lie somewhere in between the two endpoints.

There are numerous benefits of allowing a larger space for action. For instance, it allows organizations to adopt those solutions deemed most effective, considering their operations and their size. It is not

deemed reasonable for an organization operating huge tankers to be regulated identically to small fishing boats. Hence, the large space for action avoids a “one-size-fits-all” regulation and is therefore able to encompass organizations of different sizes, carrying out different operations in an effective manner (Engen et al., 2013). This benefit is greatly reduced when applying prescriptive requirements, where the same detailed and technical requirements often apply to all organizations and vessels.

As mentioned, prescriptive requirements are less flexible than performance-based requirements. As a result, the regulation might be unable to encompass technological advancements. In order to counteract this, there is a greater need to revise the regulation more often than is the case with regulations applying performance-based requirements, such as the Polar Code.

C.22.4 Required knowledge and competence

There is considered to be a strong correlation between the use of performance-based requirements and the level of knowledge and competence necessary to ensure compliance. Firstly, compared to prescriptive requirements, it is more complicated to understand, and sometimes interpret, the requirements put forward by performance-based requirements. Due to the general and non-specific nature of such requirements, it is often challenging to understand their ramifications, as well as how to meet them. This effect is further enhanced if those trying to comply are not familiar with the challenges posed by polar waters. Secondly, in order to adopt the solution that best fits the organization or their vessel, they must be aware of the strengths and weaknesses of different existing solutions. Larger organizations should also possess the necessary competence to develop new solutions that are customized to their needs.

Further, those subjected to performance-based requirements will, to a greater extent, need to verify that their adopted solution actually complies with the requirements they are subjected to. Given that certain solutions only constitute minor parts of a greater system for ensuring acceptable levels of safety, it will be necessary to evaluate the entire system in order to ensure compliance. This system-oriented method of ensuring that all requirements are met will generally require in-depth knowledge and specialized competence about the systems. This challenge posed by performance-based requirements will not be as challenging for smaller systems that are less complex. However, in order to ensure that the goal-oriented performance-based requirements are met, it will be necessary to evaluate entire systems, applying a holistic perspective.

The required level of knowledge and competence might be considered to be a great motivation for organizations to acquire the expertise necessary to ensure compliance. However, it becomes detrimental to the entire regulatory regime if actors subjected to the regulation are incapable of either understanding the requirements or how to meet them. It is therefore important that tools such as guidelines to the regulations exist. Guidelines allow the regulators to further elaborate and explain the content of the regulations. Guidelines may also suggest existing solutions that are preapproved by the regulators. Such suggestions typically refer to industry standards.

C.22.5 Enforcing performance-based requirements

As mentioned, the enforcement of prescriptive requirements is considered to be less complicated, compared to enforcing performance-based requirements. As performance-based requirements are goal-oriented, regulators must be able to assess the attained level of safety, using a holistic perspective. Whilst checklists might be sufficient when ensuring compliance with prescriptive requirements, performance-based requirements demand that the regulators assess the performance of the solutions adopted. These solutions must be considered in relation to each other, in order to assess the level of safety for the entire system. There will obviously be possibilities to assess the safety of components or sub-systems, but even though all components or sub-systems are deemed safe, it is not certain that the entire system is safe. By developing a guideline that refers to industry recognized standards ensuring compliance with the regulation, operators may prove their compliance by referring to different

certifications obtained. This is common practice in several industries, such as the Norwegian petroleum industry. This will reduce the workload of the regulators.

There are also great benefits of enforcing a regulation applying performance-based requirements. The Norwegian Petroleum Safety Authority states that the enforcement of prescriptive requirements often does not encourage regulators to investigate underlying causes of accidents and nonconformities. However, uncovering these causes comes more naturally when enforcing performance-based requirements, as entire systems must be assessed, in order to ascertain compliance.

C.22.6 Conclusion

To summarize, there are several advantages and disadvantages when applying performance-based requirements. The flexibility of the requirements allows for those subjected to the regulation to adopt new technology and choose those solutions they deem most effective for their operations. The same flexibility also reduces the need to periodically revise the regulation. Applying performance-based requirements also allows the regulation to encompass operators carrying out different activities, and operators of different sizes.

The flexible nature of performance-based requirements often increases the knowledge and competence needed to ensure compliance. This might prove challenging for new operators not familiar with the hazards and risks associated with polar waters. It is therefore important that these operators fully understand what the Polar Code requires. Further, performance-based requirements might come across as vague and nonspecific. It is therefore argued that a guideline will further assist those trying to meet the requirements put forward by the Polar Code. The guideline will provide an opportunity for the regulators to elaborate and explain the requirements, as well as offer suggestions as to how compliance is achieved. Reducing the required knowledge and competence to ensure compliance is not considered negative, if it contributes to a more effective legislative framework promoting safe operations.

It should be noted that the Polar Code does provide some additional guidance to the requirements it puts forward. This is, however, limited to certain chapters. Given that there are several new hazards and risks faced when operating in polar waters, it is important that those subjected to the Polar Code are able to comply with its requirements. The additional guidance is not considered to fully compliment the role of a guideline. This is mainly due to the restricted elaboration of the requirements, as well as limitations regarding proposed solutions that the regulator considers adequate, in order to ensure compliance.

In conclusion, developing a guideline to the Polar Code has several advantages. It gives the regulator the possibility to recommend existing solutions considered to comply with the requirements. It also contributes to ensuring that those subjected to the Polar Code know what the requirements entail and how compliance is achieved.

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Theme 8. The Polar Code and further need, continued

C23. Marine Insurance

Anna Loiko, Norwegian Hull Club

Marine insurance is a very wide and encompassing topic, with definite categorizations of various types of products and different types of policies. Considering the type of marine operation, the needs, requirements and specifications of the transporter, a suitable type of marine insurance should be selected.

Any insurance is designed to manage risks in the event of unfortunate incidents like accidents, damage to the property and environment or loss of life. When it comes to ships, the stakes are higher, as all factors are involved in the operation, i.e. the risk of losing valuable cargo or expensive ships, the risk of damage to the environment due to oil pollution, and the risk of losing the precious lives of seafarers due to accidents (<https://www.marineinsight.com/maritime-law/different-types-of-marine-insurance-marine-insurance-policies/>).

Hull and machinery insurance usually covers loss or damage to the vessel caused by major named perils such as collision, grounding, fire and explosion, as well as general perils of the sea (<https://www.cii.co.uk/knowledge/reference-resources/classes-of-insurance/marine-hull-and-machinery/>). The hull cover for vessels is defined by International Navigation Limits and, in the polar regions, by trading warranties, which exclude defined geographical areas. These exclusions are seasonal or all year round and depend on the policy. For instance, both the Nordic Insurance Plan and the English Institute Warranties define the Baltic Sea and the St. Lawrence River as seasonal exclusions, while Antarctica and the Arctic Regions are all-year-round exclusions.

As for the insurance terms, the ship-owner is required to give notice to the hull underwriter before the vessel is to enter trading areas outside International Navigation Limits, to obtain permission for the operation. This will often result in an additional premium, which the owner needs to pay for the underwriter's increased risk. It can be organized as one voyage cover, as well as seasonal premiums, and negotiated with the client (<https://www.swedishclub.com/loss-prevention/trading-area/polar-regions/>).

In addition, the authorities will often require that the vessel has valid P&I (protection and indemnity) insurance. Unlike hull underwriters, the P&I clubs do not have the same requirements and do not differentiate between any specific trading limits. They operate with "alternation of risk" provisions, meaning that, if the trading pattern brings greater risk, it may be a reason for a higher premium. The ship-owner therefore needs to inform the P&I club if they are planning to transit to Antarctica or the Arctic Regions; otherwise, liabilities, costs and expenses arising out of the transit may fall outside the P&I cover. Both insurances will also normally be able to assist the insured generally in assessing the risks involved (<https://www.swedishclub.com/loss-prevention/trading-area/polar-regions/>).

Historically, insurers found it difficult to insure vessels that operate above 70 degrees north latitude. This could be explained by the lack of knowledge and lack of international guidelines for operations in icy water, as well as little experience in handling situations that may occur in such areas and how, therefore, to determine vessels' operational limits. This challenge, together with many others, was addressed when developing the Polar Code, by adopting a risk-based approach in determining the scope and a holistic approach in risk mitigation.

According to the International Union of Marine Insurance (IUMI), a new Polar Code, a code of practice for ships operating in the Arctic and Antarctic, which came into force on 1 January 2017, will provide critical risk mitigation directives and support to underwriters writing marine risk in polar waters. The key element of the Polar Code is the requirement for any ship operating in polar waters to have a Polar

Waters Operational Manual (PWOM), which sets out how the crew will respond in a worst-case scenario in the anticipated conditions that may occur on the planned voyage. If the PWOM is appropriate, only then should the operator receive a Polar Ship Certificate from their flag state (<https://www.lloyds.com/news-and-risk-insight/press-releases/2017/01/polar-code-sets-new-industry-standards>).

The Polar Code is a risk-based instrument and an important element for improving ship insurability; however, it has only limited capacity to assist underwriters in assessing risks while insuring vessels. The main issues for the marine insurer are the lack of data and the high pending uncertainties, leading them to exercise extreme caution in Arctic risk appraisal (<https://www.tandfonline.com/doi/full/10.1080/03088839.2018.1443227?scroll=top&needAccess=true>).

Insurers are not interested in insuring bad risk and thus losing money. Successful underwriting requires a high degree of risk assessment to set fair insurance policy conditions, resulting in the great importance of safety records. In general, the better the safety records are, the lower the premium. Despite a number of standard systems and pricing models, there still seems to be a wide price range. Underwriters consider the polar experience of the crew, the availability of icebreakers and the distance to port in the case of emergency, as well as ice class and weather conditions, to set their premiums for polar-going ships. One should also remember that marine insurance operates in a very competitive environment or so-called client market, meaning that insurance rates are historically low, and underwriters need to balance business willingness and high-risk operations (<http://arctic.blogs.panda.org/default/arctic-shipping-insurance/>).

Although some companies voluntarily adhere to stricter loss-prevention measures, it is not common for the industry as such to follow higher standards than those required by relevant regulations.

With regard to navigation and operation in ice waters, documents from IACS and the International Maritime Organization (IMO), including the Polar Code, are the main sources used by insurers in determining reasonable requirements of coverage for ships wishing to transit the Arctic seaways. The IMO, together with the International Union of Marine Insurance (IUMI), Lloyds, the Nordic Association of Marine Insurers (CEFOR), Lloyds Register, in cooperation with Arctic and Antarctic states, have been working on guidance for risk mitigation and have established a single ice regime system (POLARIS) for when operating in polar waters. This guidance, which should be used in pre-planning and during polar operations, covers a range of situations that may occur and how to handle them.

Moreover, insurers' loss prevention activities help their customers to identify safety weaknesses and fix them before they lead to incidents and claims. These practices can promote higher shipping standards.

Theme 8. The Polar Code and further need, continued

C.24. Arctic sailings: past, present and future.

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C.24.1 The Past: the history of Arctic sailings

Arctic sailing has long traditions; the sailing of Ottar from Hålogaland (from the Kvaløya area?) of Norway to Bjarmeland in the White Sea area was followed by his report to the King of England around the year 870. Then we may mention the explorations by the Vikings to Greenland and Vinland (Figure C.24.1), the present Newfoundland, and possibly further south around the year 1000. Their ships represented the state of the art at that time, as they were designed for speed and stability, although they had no specific design feature to resist ice. Thereafter, the expeditions of the Dutch, led by Wilhelm Barents (from 1594 and onwards, see Figure C.24.2), came to high latitudes. On Spitzbergen (at 78 degrees north), whale hunting and the extraction of oil from whales were developed into an industry with many seasonal settlements north of present-day Ny Aalesund. Many historical documents provide accurate information about these explorations.

Nansen's expeditions to the north (Figure C.24.3) are well known to all those interested in the Arctic, and all teachers referring to the design of vessels for the Arctic will mention the design of the expedition ship, Fram. She has a rounded form (Figure C.24.4) that causes her to lift up onto the ice when subjected to ice pressure. The force caused by the horizontal ice pressure has a component normal to the hull and an uplifting vertical component. Since then, this design has been followed for all Arctic vessels. Notice that, when a ship moves into the ice, it is lifted up and a vessel exhibiting the Fram geometry will thus break the ice and can, thereafter, move forward.



Figure C.24.1. The "Vinland Map", possibly the first map showing America, is at present in Yale University's Beinecke Rare Book and Manuscript Library (courtesy of Yale University Press). The paper on which the map is drawn dates to approximately 1434 A.D. or nearly 60 years before Christopher Columbus arrived in the West Indies.



Figure C.24.2. A 1598 map of the three Arctic voyages (1594–1596) by Willem Barentsz: “Delineatio cartae trium navigantium per Bataves, ad Septentrionalem plagam, Norvegiae, Moscoviae et novae Semblae Autore Wilhelmo Bernardo”.

The fishermen living from fisheries along the Norwegian coast used smaller vessels, and it was not until the seal hunting expeditions moved into the ice that vessels were strengthened for Arctic conditions (Alme, 2009, Gudmestad and Alme, 2015). The vessels generally hunted for the seals together so a “buddy effect” was present, in case some of the vessels got into distress. The ice pressure exerted on the vessels during the closing of open leads, however, caused many vessels to be squeezed, so that they eventually sank. Even ships made of steel were damaged to the extent that they had to be abandoned. In these situations, the crew gathered on the ice and was, in most cases, rescued by other vessels in the area. On the way to the hunting areas, however, all vessels were exposed to the same meteorological conditions and the loss of lives in some situations was exceptionally high. The conditions in 1917, when seven vessels were lost in Vestisen, were characterized by a heavy storm from the northeast, together with cold temperatures and polar low pressure; similar conditions were encountered in 1952, when five vessels were lost. Following these events, nothing was heard or found.

Of particular concern for sailing in the Arctic waters is the drifting ice. Outside the ice edge, the ice floes drift on the waves and can cause great harm to equipment on board vessels; see Figure C.24.5. Glacier ice floes or multiyear ice floes may have very damaging effects, as the “ice foot” (Figure C.24.6) is hidden below the waterline and may not be avoided by the person on duty on the bridge. The seal hunters were particularly concerned about the potential of being hit by such an ice feature. Further to the records by Alme (2009), Marchenko (2009) has prepared a full review of the experience of Russian Arctic navigation, listing the loss of vessels navigating the route from Kara Gate to Bering Strait during the last hundred years. She also discusses the reasons for the accidental loss of vessels and documents concerns due to uncertainties during ice navigation.



Figure C.24.3. “Kart over Dr. Fridtjof Nansen's Polarexpedition 1893–1896”. Map drawn by: [Knud Bergslien](#), Kristiania 1896. Norwegian National Library's collection of maps, Oslo.

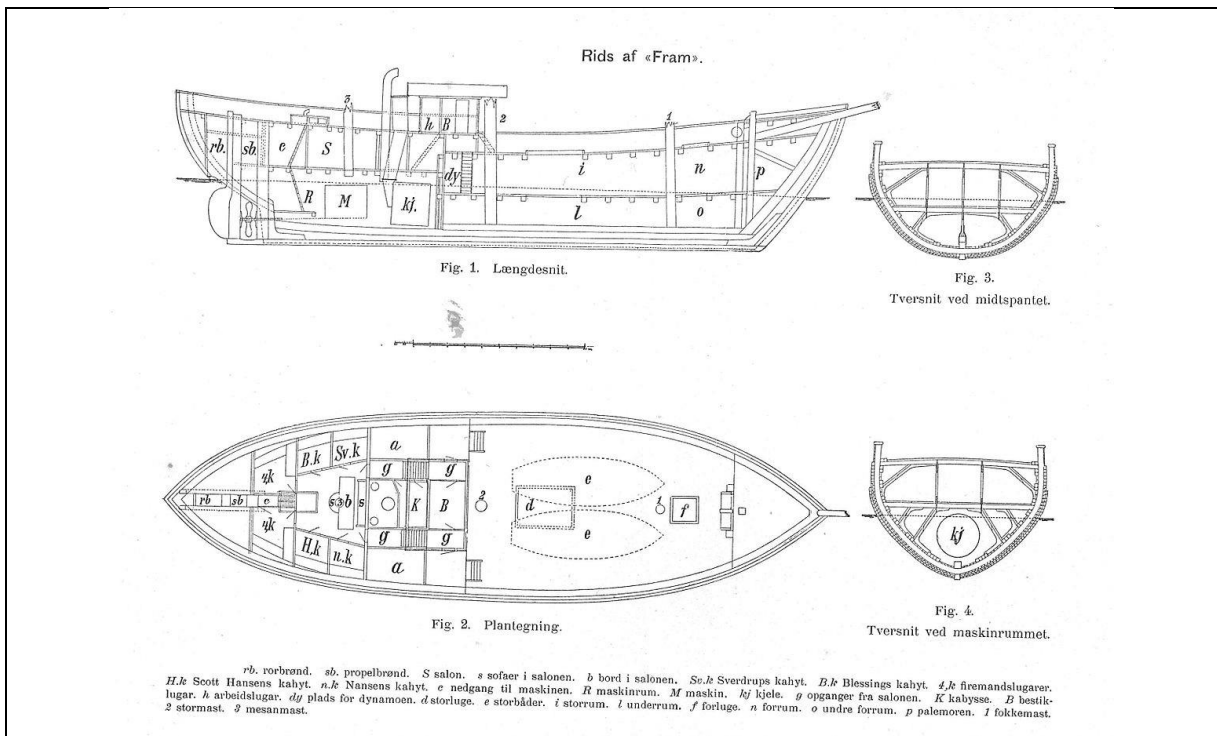


Figure C.24.4. "Fram". Illustration by: [Fridtjof Nansen](#): *Fram over Polhavet* (Kristiania, 1897).



Figure C.24.5. The situation outside the ice edge of Vestisen: Large waves, swells and moving ice on the surface. Photo: Wenche Warholm. From Alme (2009).

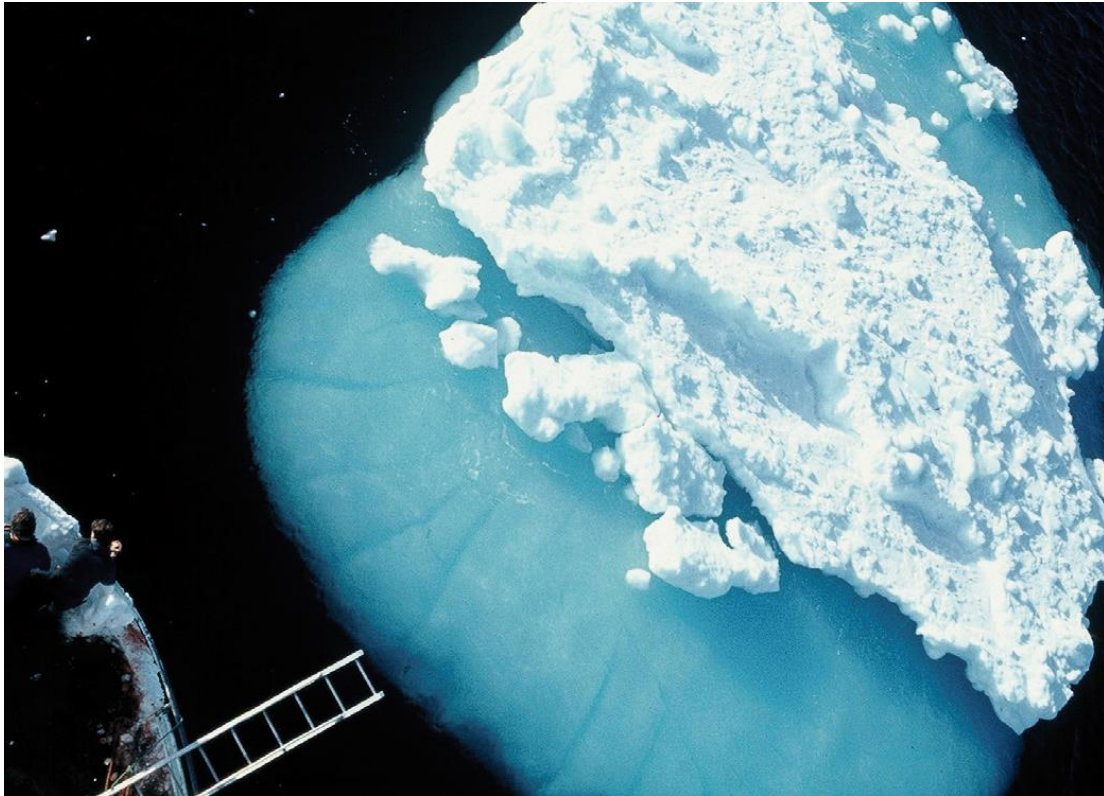


Figure C.24.6. The “ice foot” near the bow of a vessel. Note the blue colored multiyear ice. Photo: B. Kvernmo. From Alme (2009).

The accidents called for design standards for vessels navigating Arctic Seas. The ice class notation for ships was developed by several classification societies (see Table 1). The first Finnish ice class rules were developed in 1890. The Finnish ice class rules published in 1932 introduced ice classes 1A, 1B and 1C for ships strengthened for navigation in ice, ice class 2 for ships classified for unrestricted service but not strengthened for navigation in ice, and ice class 3 for other vessels. The ice class requirement has considerably reduced the risk of navigating the Arctic Seas. For modern ice class rules, see, for example, the DNV “Ships for Navigation in Ice” (2013) and Mejlænder-Larsen (2015).

The Present: the status regarding Arctic sailings

The Soviet ocean liner, Maxim Gorkiy, ran into ice with more than 950 people aboard on June 20, 1989. All were saved by the Coast Guard vessel, Senja (Hovden, 2012); Figure C.24.7. The Coast Guard vessel happened to be relatively close to the ship in distress and arrived on location within a few hours. All were safe, due to very favourable conditions: call it luck.

The understanding of the author is that, in the Russian part of the Arctic, the authorities are becoming more concerned about the strength of vessels using the Northern Sea Route and that the Russians are strengthening the requirements regarding icebreaker assistance. While sailing in the Matisen Strait on September 4, 2013, an ice floe hit the “sea-river” type tanker, Nordvik. The tanker got a hole in one of the ballast tanks on portside. The vessel with an ice class of Ice1 was loaded with 4944 t of Arctic diesel fuel and was following the route from Ob Bay to Khatanga: <http://www.arctic-lio.com/node/206>. The captain of the vessel was in violation of the permit's requirements when the ship entered the water area with medium ice conditions.

Table C.24.1. Correspondence between the Baltic ice class (Finnish-Swedish Ice Class Rules) and the ice classes of other classification societies; http://www.bsis-ice.de/material/table_iceclasses.pdf

Classification Society	Ice Class				
Finnish-Swedish Ice Class Rules	IA Super	IA	IB	IC	Category II
Russian Maritime Register of Shipping(Rules 2007)	Arc 5	Arc 4	Ice 3	Ice 2	Ice 1
Russian Maritime Register of Shipping(Rules 1995)	UL	L1	L2	L3	L4
Russian Maritime Register of Shipping(Rules 1999)	LU5	LU4	LU3	LU2	LU1
American Bureau of Shipping	IAA A1	IA Ao	IB	IC	D0
Bureau Veritas	IA SUPER	IA	IB	IC	ID
CASPPR, 1972	A	B	C	D	E
China Classification Society	Ice Class B1*	Ice Class B1	Ice Class B2	Ice Class B3	Ice Class B
Det Norske Veritas	ICE-1A* ICE-10	ICE-1A ICE-05	ICE-1B	ICE-1C	ICE-C
Germanischer Lloyd	E4	E3	E2	E1	E
Korean Register of Shipping	ISS	IS1	IS2	IS3	IS4
Lloyd's Register of Shipping	1SS	1A	1B	1C	1D
Nippon Kaiji Kyokai	IA Super	IA	IB	IC	ID
Registro Italiano Navale	IAS	IA	IB	IC	ID

During a voyage through the Northwest Passage, the Russian cruise ship, Akademik Ioffe, ran aground with 162 passengers on board on Friday August 24, 2018 (Humpert, 2018). The vessel has ice class Baltic 1A. Nearly 20 hours after the accident, the sister ship, Akademik Sergey Vavilov, appeared on site to transfer the passengers, with the use of Zodiac boats, thereby overloading the rescue vessel so that she exceeded her capacity to safely carry 270 passengers. The Canadian Coast Guard arrived later on August 25. The passengers were transferred to the Nunavut community, Kugaaruk, which has very limited capacity to house more than 100 guests. As all went well during this incident, the learning is that long distances and limited capacity pose strict restrictions on rescue means in the Arctic cruise industry.

The IMO Polar Code (IMO, 2017), which was developed to ensure safer sailing in polar waters, came into force on January 1, 2017. The Polar Code sets common standards for vessels and rescue means to navigate the Polar Regions. It was developed from the SOLAS Convention (IMO, 2001), regarding safety for navigating in the Polar Regions, and the MARPOL Convention (IMO, 1983), for the prevention of pollution from ships navigating the Polar Regions. It should be noted that the Polar Code does not apply to fishing vessels. Ships sailing in ice conditions with ice coverage less than 1:10 are exempted from ice class rules.

Due to the large increase in Arctic cruise tourism, the Norwegian Coast Guard, the University of Stavanger, the commercial company, GMC of Stavanger, and Maritime Forum North have conducted three exercises in the Svalbard area, investigating search and rescue operations in Arctic waters, as well as personal and group survival equipment. A brief review of the exercises follows:

- 2016: Use of standard SOLAS rescue means (IMO, 2001) with findings that there was insufficient heating in the lifeboat, and insufficient insulation in the life raft (Solberg et al., 2016).
- 2017: Use of improved rescue means (insulated life raft with double bottom and heated lifeboat). The findings were as follows: General fatigue due to lack of space, leakage from life raft floor, increased CO₂ in rescue means and conclusion that the use of helicopters has a low level of efficiency (Solberg et al., 2017).

- 2018: Survival onshore after rescue. The findings can be summarized as follows: Standard SOLAS personal protection equipment (PPE) is insufficient (certain types of PPE provided very poor protection). The rations of water were, furthermore, far too low, causing dehydration; woolen clothing did better than specialized clothing; the shelter capacity was too limited; and, finally, it was obvious that training of rescue ships' personnel was essential.

We furthermore, concluded from the exercises that the typical cruise passenger would have problems using standard rescue equipment and that the challenges for the rescue vessels are huge.



Figure C.24.7. Coast Guard personnel comforting passengers from Maxim Gorkiy after the accident in the waters off Spitzbergen in 1985. The passengers were requested to go onto the ice floe, as the lifeboats were considered unsafe, due to ice forces acting on the boats. <https://svalbardposten.no/bilder/nyheter/nyhetbig/5710.jpg>

During recent years, use of the Arctic navigation routes has increased. The cruise ship, Crystal Serenity, sailed through the Northwest Passage in 2016 with more than 1000 people onboard. The Maersk container ship, Venta Maersk, sailed from South Korea to Europe in August/September 2018; see Figure C.24.8; <http://www.highnorthnews.com/maersk-container-ship-transits-arctic-ocean-with-icebreaker-escort/>.

In July of 2018, the LNG carrier, Christophe de Margerie, set a record for non-escorted ship transit from Sabetta in Ob Bay to China of 18.5 days; <https://gcaptain.com/icebreaking-lng-carrier-christophe-de-margerie-sets-new-northern-sea-route-record/>.



Figure C.24.8. The Venta Maersk container ship following behind the nuclear icebreaker 50, Let Pobedy, through icy waters on the Northern Shipping Route, 2018. (Photo: Rosatomflot)

From the experience of the short-term application of the Polar Code by the classification societies, which qualifying vessels, rescue means and training of personnel to be in accordance with the Polar Code requirements, gaps have emerged that should be rectified by adapting the Polar Code with amendments and corrections. It is particularly of concern that the Polar Code is a functional code with large areas that are open to interpretation. However, there are no guidance notes regarding how the requirements of the code potentially could be satisfied.

C.24.3 The future for Arctic sailings

There is expected to be a large increase in marine activity in the Arctic region in the coming years:

- Increase in marine traffic, due to oil and liquefied gas transportation
- A general increase in transshipment of cargo, due to reduction in ice cover
- Increase in cruise traffic, as Arctic Cruises are advertised as “adventure tours”
- Increase in number of passengers on board cruise ships, making rescue a more and more challenging task
- Increased fishing activity in the region
- Lack of coastal nations’ capability to rescue large group of persons, in particular from cruise ships navigating “exotic Arctic locations” (Sollid et al., 2018)

For the Antarctic region, an increase in cruise traffic is expected, while other commercial activities may not see a rise, unless exploration for oil and gas becomes important in the region.

Due to this expected increase in sailings in the Polar Regions, it is considered necessary to strengthen the Polar Code, by providing an Informative Annex on how the requirements of the Polar Code can be satisfied. By issuing such a document, IMO will avoid competition between classification societies, regarding the least expensive ways to satisfy the requirements of the code. Similar concerns are valid regarding the required training of ships’ officers. In the SARex reports (Solberg et al., 2016 and 2017), we have demonstrated that the competence of the leaders of the means of rescue represents an important asset for the safety of those being rescued.

Furthermore, there should be a discussion on whether fishing vessels should be covered by the Polar Code requirements, as the number of persons involved in fishing in the Arctic regions is in the order of thousands, and their lives are as precious as those of personnel on vessels and passengers on cruise ships.

The responsibility for rescue operations should be further clarified. Captains who decide to sail in uncharted waters, far away from rescue means and without contact with other vessels, should not expect rescue vessels to arrive within days. The Polar Code's requirement of five days' survival, while the rescue means are on their way, is realistic. It may be advisable for the coastal nations to issue a disclaimer note, clarifying the limitations in rescue capabilities and the expected rescue time for ships sailing in Polar Regions. This will limit the possibility of the coastal nations being brought to court because of limited rescue capacity and capability.

The role of insurance companies is also important. How will the insurance companies ensure that they will not be eligible to pay out compensation in the order of billions of dollars? Only in the case where the risk is small will the insurance industry agree to insure passengers and vessels, as well as the environmental clean-up after a potential accident. This will call for improvements in the cruise industry.

Finally, the responsibility of the ship owner should be stressed. Note also that the captain of the ship, the commander, has the most important role in deciding whether the sailing has a sufficiently low risk. It will be a brave task for a captain to go against the decision of the vessel owner; however, the captain will eventually be brought to court, in the case of an accident, to document that the risk of the sailing was as low as reasonably practicable.

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