Universitetet
i Stavanger

FACULTY OF SCIENCE AND TECHNOLOGY

MASTER'S THESIS

Study programme/specialisation: Offshore Technology / Risk Management	~~Spring /~~ Autumn semester, 2017 Open/~~Confidential~~
Author: Konstantinos Trantzas	…………………………………… (signature of author)

Programme coordinator:

Supervisor(s): Ove Tobias Gudmestad

Title of master's thesis:

A Risk Analysis and the Insurance Policies for the Cruise Ships in the Arctic

Credits: 30 ECTS

Keywords: Arctic Risk Analysis Preliminary Hazard Analysis Arctic Cruise SARex 2 Insurance Cost Drivers	Number of pages: …123…………… + supplemental material/other: …-……… Stavanger, 15/12/2017 date/year

Title page for Master's Thesis
Faculty of Science and Technology

A Risk Analysis and the Insurance Policies for the Cruise Ships in the Arctic

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Master Thesis Project

Offshore Technology

Faculty of Science and Technology

Stavanger, December 2017

ABSTRACT

The need of human to explore new areas, the climate change and the growing worldwide demand have led to an increasing popularity of the Arctic region the last years. Cruise industry is continuously evolving in this area, creating an important need for more research on the Arctic Ocean.

In this thesis report, the main characteristics of the Arctic region and the cruise ship industry trends for high north voyages are presented. The International Code for Ships Operating in Polar Waters (The Polar Code) was implemented on January 2017. An overview of the relevant chapters of the existing regulatory framework, The Polar Code and SOLAS, is given.

The challenges associated with the cruise ship voyages in the Arctic and the hazards surrounding and evacuation in the Arctic environment are identified through the participation in a real scale Search and Rescue Exercise (SARex 2) conducted in waters north of Svalbard. A risk analysis is prepared, where the identification and the weighting of the hazards, as well as different risk mitigation approaches are presented in order to reduce their probability of occurrence and/ or the severity of their consequences.

The expected utility theory is used to stress the importance of the insurance and to define the proper level of investment between safety measures and insurance. The Arctic cruise insurance policies that, in our opinion, should be followed are mentioned and the limitations on obtaining insurance coverage on the Arctic are identified. Following, the main cost drivers of an insurance premium for the Arctic cruise ship industry are given.

The hazards, the insurance policies and the gaps are discussed through the findings from the literature review, the risk analysis and the search and rescue exercise. The thesis also highlights the contribution of the author to the SARex 2 project report through a preliminary hazard analysis and actively participating in the all the stages of the exercise.

Keywords: *Arctic, Risk Analysis, Preliminary Hazard Analysis, Arctic Cruise, SARex 2, Full-scale exercise, Insurance, Arctic Cruise Insurance, Cost Drivers, Insurance Premium*

ACKNOWLEDGMENETS

First of all, I would like to thank my supervisor at UiS, Professor Ove Tobias Gudmestad, for helping me define the topic of this thesis based on my interest. His valuable knowledge and experience contributed remarkably in the development this report. Apart from being my supervisor, he assisted me throughout my efforts in Norway, both academically and personally. His professionalism and spirit to help students succeed has been a motivation to me since I first met him. I am truly grateful that I had the opportunity to meet and cooperate with him.

I would also like to thank all the participants of the SARex 2 exercise, for the valuable experience and the discussions on technical issues. The commanding officer of KV Svalbard, Endre Barane, and the crew members deserve my gratitude, for sharing their knowledge in the Arctic region and for providing and excellent accommodation and care during the SARex 2 in May 2017.

Furthermore, I would like to express my gratitude to my friends and especially Dimitrios Kostopoulos, Konstantinos Pappas and Maximos Loukas Katsenis that have been by my side throughout these years.

Finally but most importantly, I would like to express my very profound gratitude to my family, Georgios, Georgia and Christina for providing me with unfailing support and continuous encouragement throughout all my years of study. This accomplishment would not have been possible without them. Thank you for everything.

Konstantinos Trantzas

December 2017, Stavanger

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1. INTRODUCTION

1.1. Background

The recent years, Arctic is gaining more and more popularity due to the extraordinary environmental and developmental changes that take place in this region. The growing worldwide energy demand has turned attention to the Arctic natural resources, making the region a potential significant contributor to the global economy.

Meanwhile, climate change has led to extensive thinning of sea ice, making marine access in the Arctic Ocean much easier. It is obvious that this ice reduction extents to all seasons of the year, giving the maritime industry the opportunity for extended seasons of navigation and access to new areas that were previously difficult to reach. The coastal and marine transport is increasing to support the exploration of new oil and gas fields. At the same time, global marine tourism is rising and a place of extraordinary beauty like Arctic could not stay unaffected by this trend. The potential impacts of these new marine uses - social, environmental and economic - are unknown, but will be significant.

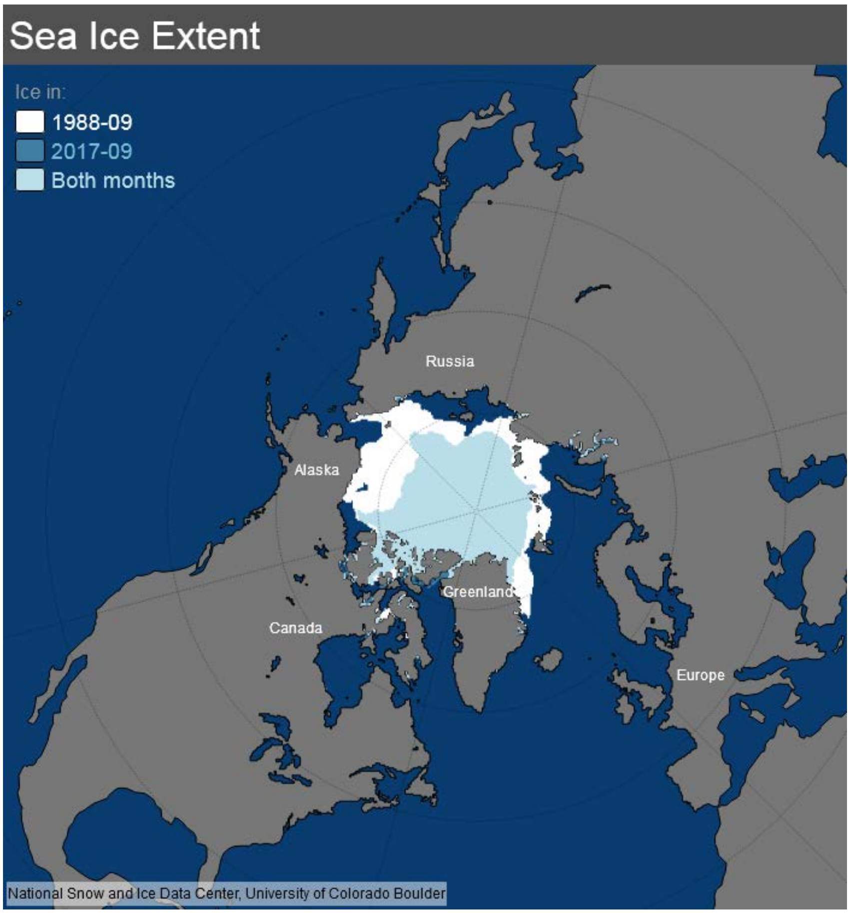

Figure 1: Arctic Sea Ice extent comparison (National Snow & Ice Data Center, 2017)

According to the Strategic Assessment of Development of the Arctic (SADA) report published by the Strategic Environment Impact Assessment of development of the Arctic (Strategic Environmental Impact Assessment of development of the Arctic, 2014), worldwide the number of passengers carried by cruise ships has grown about 7% per year since 1990, and continued growth is expected. Thus, it is considered of high importance to understand the hazards and the challenges that cruise ships face in the Arctic region.

The polar code, which came into force on January 2017, provides the main directions for the Arctic operations and the specific requirement of the maximum expected time of rescue as five days will demand better life-saving appliances and planning of the survival procedure in the Arctic waters.

In order to identify the underlying risks of the Arctic shipping operations and to analyze the functionality of the Polar code, the author was invited to participate in a full scale Search and Rescue Exercise (SARex 2). The exercise was conducted off north of Svalbard with the participation of the Norwegian Coast Guard, the University of Stavanger, the Norwegian Maritime Authority and other leading experts from governmental organizations, the academia and the industry.

However, except from the cruise ship owners' interest in the Arctic voyages, there is also a great interest from the insurance companies regarding these trips. As during any other operation, when planning a cruise, especially in an unfriendly environment like the Arctic, both the ship owners and the passengers have to be insured. Thus, marine and travel insurance companies are keen to increase their involvement in the Arctic cruise and this thesis aims to give an overview of the insurance policies that should be followed in the Arctic region.

1.2. Scope of the thesis

As Arctic cruise tourism is increasing its reputation among tourists, there is a growing need to ensure safe voyages for the passengers of those cruises. The main scope of this thesis is exactly this - to identify the risks related to the Arctic cruise and the evacuation procedures in case of an accident. In addition, we will suggest mitigation measures in order to reduce either the probability or the consequence or both of hazard that could have negative impacts for the passengers in case of an accident.

Another objective of this thesis report is to give an overview of the cruise insurance industry and to identify the main factors that could increase the cost of an insurance premium. Finally, we discuss the importance of the well-structured cruise insurance policies, both for the passengers and the vessel owners in the Arctic waters.

1.3. Thesis structure

The thesis structure is as follows:

Chapter 1 – Introduction

In this chapter an introduction is presented. The background of the thesis is described and the motivation behind the thesis topic is explained. The chapter also contains the scope and the objectives of the thesis and its overall structure.

Chapter 2 – Literature review

This chapter includes all the information related to the literature review. The basic definitions and methods that are used or referred to during the thesis are explained. The main characteristics of the Arctic region and some preliminary information regarding the Arctic cruise industry are presented. Finally, the existing legislative framework of the Arctic operations is reviewed.

Chapter 3 – SARex 2 research trip overview

All the relevant information with respect to the SARex 2 trip are given in the third chapter. We present the objectives of the exercise and the motivation for this trip, as well as a small summary of the results of the exercise. There is also a reference to the author's participation objectives and his contribution to the SARex report.

Chapter 4 – Quantitative risk analysis

This chapter encloses the quantitative risk analysis that is carried out. The adequacy of the method used to conduct the analysis is discussed and the some examples of the risks identified are presented. The full findings of the quantitative risk analysis are included in Appendix A. Weighting of the described risks, also takes place, and a comparison of the impact of the implication of the risk mitigation measures in the risk picture is given.

Chapter 5 – Risk mitigation policies

In this chapter the different polices that can be used to mitigate risk are discussed. We use as a basis for our analysis the expected utility theory to conduct a comparison of the optimal level of investment between the traditional risk mitigation measures, identified in the previous chapter, and the insurance. In this way, the necessity of the insurance is proven.

Chapter 6 – Insurance

Here the principles of the cruise insurance are initially presented. The division of the cruise insurance in marine and travel insurance is explained and the fundamentals of the two types are given. Finally, the costs that could influence the price of an insurance premium specifically in the Arctic are discussed.

Chapter 7 – Discussion

The scope of the thesis is discussed on this chapter. The findings of our analysis and the experience obtained from the SARex II research trip are used to support our discussion on the risk related to the Arctic voyages. Some remarks on the implication of the insurance in the Arctic cruise industry and its related policies are finally considered.

Chapter 8 – Conclusion

The last chapter consists of the conclusions of the thesis and some suggestions for further research.

2. LITERATURE REVIEW

The starting point of every analysis is to better understand the terms and definitions used in this. The scope of this chapter is exactly this, to give an overview of the scientific terms used in our analysis. Moreover, at this chapter the main characteristics of the Arctic region and the cruise ship industry are presented.

2.1. Basic definitions

In this subchapter, the basic definitions of our risk analysis are presented as these were introduced by previous authors. For each term there are usually more than one interpretations used in the scientific literature, thus it is important to highlight which one is used as a basis for our work. (Italics font is used for definitions taken by other authors).

2.1.1. Probability

There are two basic types to describe probability.

2.1.1.1. Frequentist probability

A probability is interpreted as a relative frequency P_f: the relative fraction of times the event occurs if the situation analyzed were hypothetically "repeated" an infinite number of times. In this case, P_f is referred to as a frequentist probability. The variation in the outcomes of the "experiment" that generates the true value of P_f, is often referred to as aleatory (stochastic) uncertainty. Following this definition, we produce estimates of the underlying "true" (unknown) frequentist probability P_f. (Aven and Hiriart, 2011)

2.1.1.2. Subjective probability

A probability P is a subjective measure of uncertainty about future events and consequences, seen through the eyes of the assessor and based on some background information and knowledge: this is the Bayesian perspective. The probability is referred to as a subjective (knowledge-based, judgmental) probability. For instance, if we assign a probability of 0.4 to an event A, we compare our uncertainty (i.e. our degree of belief) of A occurring with a standard event like drawing a red ball from an urn having 10 balls where four are red. The uncertainty (degree of belief) about A and in the standard event is the same. The assignments are judgments based on the assessor's background knowledge, which we denote by K. To show the dependency on K, we write P(A|K), where A is the event of interest. The background knowledge could be based on hard data and/or expert judgments. Assumptions are also included, for example related to the use of specific models. (Aven and Hiriart, 2011)

2.1.2. Risk

Risk is defined by Aven (2015) *considering an activity, real or thought-constructed, for a specified period of time. The activity leads to some future consequences C that are not known, thus they are uncertain (U). These two components, C and U, constitute risk:*

The risk concept (C, U) covers (i) that the activity leads to some consequences C, and (ii) that these consequences are not known (U).

The consequences are with respect to something that humans value (e.g. health, the environment, assets, etc.). The consequences are often seen in relation to some reference values (planned values, objectives, etc.), and the focus is normally negative, undesirable consequences.

Often we split consequences into events A (e.g. a disease, a gas leakage, a terrorist attack) and their consequences C. Risk is then for short written (A, C, U). The definitions (C, U) and (A, C, U) are equivalent. The notation (C, U) does not represent any loss of generality as C expresses all the consequences of the activity including the events A. (Aven, 2015)

2.1.3. Risk description

According to Aven (2013), risk *is described by specifying events/consequences C and using a description (measure) of the uncertainty Q. Specifying events/consequences means to identify a set of events/quantities of interest C' that characterizes the events/consequences C. Examples of C' are the profit from an investment and the number of injuries in a safety context. Depending on the principles adopted for specifying C and the choice of Q, we obtain different perspectives on how to describe/measure risk. As a general description of risk we are led to the triplet (C', Q, K), where K is the knowledge that C' and Q are based on. The most common tool for representing or expressing the uncertainties U is probability P, but other tools also exist, including imprecise (interval) probability and representations based on the theories of evidence (belief functions) and possibility.*

2.1.4. Risk management principles

In general, there are different practices to handle risk. In this subchapter we give the definition of these used in our project.

2.1.4.1. ALARP

The ALARP principle means that risk should be reduced to a level that is As-Low-As-Reasonably-Practicable. According to the ALARP principle, a risk-reducing measure should be implemented provided it cannot be demonstrated that the prevention costs are grossly disproportionate relative to the gains obtained (i.e. the burden of the proof is reversed) (Aven and Hiriart, 2011).

The most commonly used approach when applying the ALARP principle is to consider three regions as shown in the figure below:

a. The first region where risk is low and considered negligible or at least broadly acceptable.
b. The second (intermediate) region where the ALARP principle is extended.
c. The third region where the risk is high and considered intolerable.

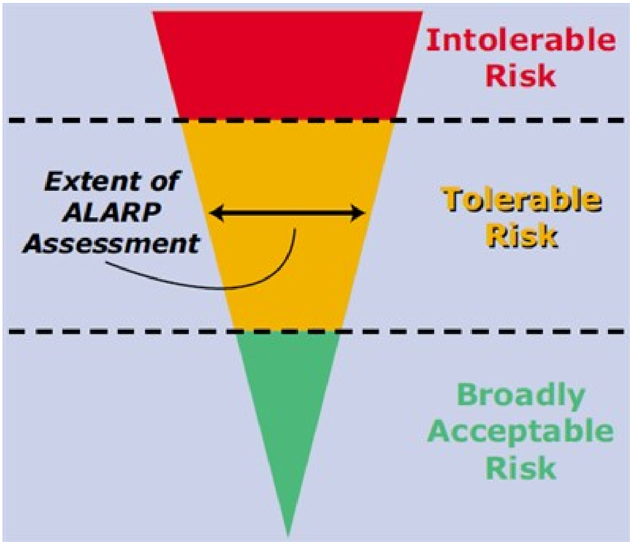

Figure 2: The three regions that risk is divided (Leggat et al., 1999, Risktec, 2017)

2.1.4.2. Risk acceptance criteria

If the risk is lower than a pre-determined value, then the risk is acceptable (tolerable). Otherwise the risk is unacceptable (intolerable), and risk-reducing measures are required. Risk acceptance criteria are defined as these pre-determined values (Aven, 2008).

2.1.5. Risk analysis methods

There are different risk analysis methods that are used when someone wants to identify and categorize the risks of a system, such as the Preliminary Hazard Analysis (PHA), the Fault Tree Analysis (FTA) and the Event Tree Analysis). In this thesis, the PHA was selected as the most appropriate risk analysis method that covers better the needs of our scope. The definition of the used method is given in the next subchapter.

2.1.5.1. Preliminary hazard analysis (PHA)

According to Vincoli (2014), the Preliminary Hazard Analysis (PHA) is an analysis of the generic hazard groups present in a system, their evaluation, and recommendations for control. The PHA is usually the first attempt in the system safety process to identify and categorize hazards or potential hazards associated with the operation of a proposed system, process, or procedure. The purpose of this method is the identification of hazardous undesirable events, which takes place before an accident occurs. In order to do this, we examine the elements of an installation and the activities involved to look for the sources of danger and examine the possibility of occurrence of undesirable events (Flaus, 2013). In many instances, however, the PHA may be preceded with the preparation of a Preliminary Hazard List (PHL). The identification of hazards on a PHL can occur through the use of a variety of methods such as but not limited to:

- Checklists,
- Hazard matrices,
- The lessons learned process,
- Equipment descriptions,
- Accident/incident report data,
- Past operational history of similar tasks, and/or
- Review of other historical records.

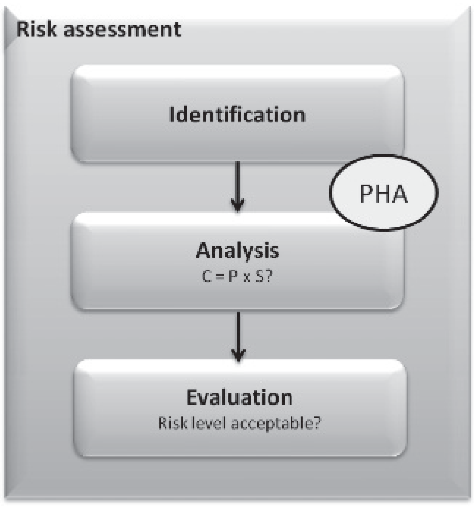

Figure 3: PHA in the risk assessment process (Vincoli, 2014)

During the PHA it is common to split the analysis object into modules to give a clearer picture of the different stages. A flow chart showing the methodology of a PHA is illustrated in the figure below:

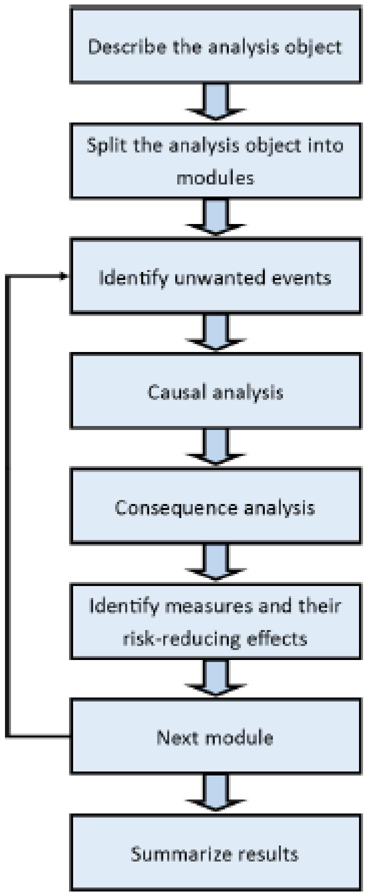

Figure 4: PHA methodology (Aven, 2008)

2.1.6. Decision analysis tools

Different tools are used when it comes to decision analysis. These that were decided to be used in our report are the Expected Utility Theory that helps us identify the importance of the insurance in the shipping industry and the Risk the Cost-benefit Analysis and the Risk Matrix that is used during the weighting of the identified risks. The decision analysis tools that are used are defined below.

2.1.6.1. Expected Utility Theory

The expected utility theory developed by Von Neumann and Morgenstern in 1944, is based on five basic axioms. These axioms have been presented in slightly different ways in different articles and textbooks. The presentation of the axioms here is closely related to the original work of Von Neumann and Morgenstern and is presented in detail from Abrahamsen and Aven (Aven, 2008).

Axiom 1

Weak order

The decision-maker's preferences over uncertain outcomes (lotteries) are:

I. *Complete—that means that the decision-maker can state whether a lottery X is preferred to a lottery Y (we write X>Y) or whether a lottery Y is preferred to a lottery X (Y>X), or whether both are equally attractive (X∼Y).*
II. *Transitive—that means that if a lottery X is preferred to a lottery Y, which is in turn preferred to a lottery Z, then the lottery X is preferred to the lottery Z.*
III. *Reflexive—that means that the decision-maker must be indifferent between two identical lotteries, X∼X.*

Axiom 2

Continuity

Assume we have three different lotteries X, Y and Z, that are strictly preferred to each other, X>Y>Z. Then we can combine the most and least preferred lottery (X and Z) such as we are indifferent between the compound lottery of X and Z and lottery Y. In mathematical terms this can be written as follows: $Y \sim pX+(1-p)Z$. There exists one and only one value of p, between 0 and 1, which makes the decision-maker indifferent between Y and the compound lottery.

Axiom 3

Preference increasing with probability

Consider two lotteries X and Y both with only two states with the same outcomes a and b, where a>b. The probability of the outcome a is p in the first lottery and q in the second. The decision-maker will then prefer lottery X to lottery Y if and only if p>q.

Axiom 4

Compound probabilities

Axiom 4 states that any lottery having further lotteries as its outcomes can be reduced to a one-stage lottery. A decision-maker should for example be indifferent between a simple lottery with a $100 prize and a 25% chance of winning and a two-stage lottery with a $100 prize and a 50% chance of winning at each stage. In both of these instances the decision-maker has a 25% chance of winning $100 and a 75% chance of winning $0.

The axiom asserts that the decision-maker rationally evaluates the probabilities of ultimately obtaining the outcomes, and is not at all affected by the two (or more) stages of gamble.

Axiom 5

Independence

Assume that we have three lotteries X, Y and Z. If lottery X is preferred to a lottery Y, then a compound lottery consisting of lottery X with probability p and lottery Z with probability 1−p, (X, p; Z, 1−p), will be preferred to a compound lottery consisting of Y and Z with the same probabilities, (Y, p; Z, 1−p).

The axiom states that the choice between (X, p; Z, 1−p) and (Y, p; Z, 1−p) depends only on how they differ, that is on X and Y, and not on the common lottery Z. Replacing Z in both compound lotteries by some Z2 or Z3 should have no impact on choice (Aven, 2008).

2.1.6.2. Cost-benefit analysis

A cost-benefit analysis is an approach to measure benefits and costs of a project. The common scale used to measure benefits and costs is a country's currency. After transforming all attributes to monetary values, the total performance is summarized by computing the expected net present value E[NPV]. The main principle in transformation of goods into monetary values is to find out what the maximum amount society is willing to pay to obtain a specific benefit. According to this approach, a measure should be implemented if the expected net present value is positive, i.e. if E[NPV]>0 (Aven, 2008).

2.1.6.3. Risk matrix

The risk matrix first described by Electronic System Center, US Airforce in April, 1995 to assess the risk in the life cycle of purchase project, is a structured approach that identifies which risks are more critical to a program and provides a methodology to assess the potential impact of a risk, or set of risks (Garvey and Lansdowne, 1998).

A risk matrix is a tool that presents a visualization of the risk. To produce a risk matrix, some basic rules should be followed according to Ni et al (Ni et al., 2010).

- The basis for risk matrix is the standard definition of risk as a combination of severity of the consequences occurring in a certain accident scenario and its probability. That means only two input variables are required to construct a risk matrix. The output risk index is determined only by the severity of the consequences and its probability.
- The severity of consequences, probability and output risk index can be divided into different levels, respectively, with qualitative descriptions and scales.
- The calculation process of matrix producing is presented by the logic implication as: IF probability is p AND severity of consequence is c THEN risk is r.

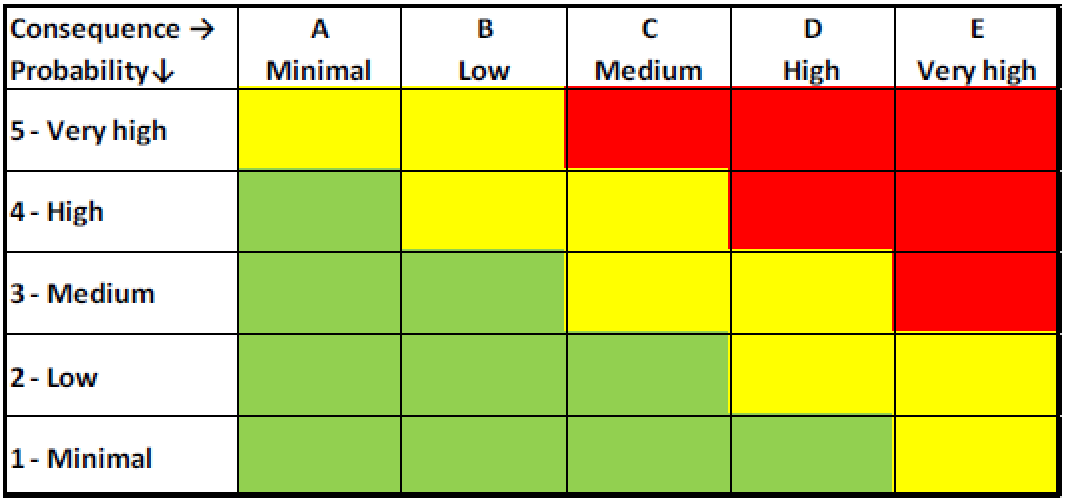

Figure 5: Risk matrix example

2.2. Main characteristics of Arctic region

In this subchapter, the main characteristics of the Arctic region are presented. These include the location and geography of the Arctic, the oceanography, the climate and the wildlife of the region.

2.2.1. <u>Location and geography</u>

The Arctic took its name from the north polar constellation “Arktos” (Άρκτος) which is the Greek word for “bear. It has a size of 14.5 million km^2 and has been inhabited by humans for close to 20,000 years. THE Arctic region extends to all the ice-covered Arctic Ocean and the surrounding land of Greenland and Spitsbergen and the northern parts of Alaska, Canada, Norway, and Russia. As stated by the Polar Discovery Institution, its boundary is defined by either the northern limit of stands of trees on land, the line of average July temperature of ~10°C, or the Arctic Circle, an imaginary line of latitude located at 66 degrees 33 minutes North. North of this line, the sun never sets on the summer solstice (June 21st) (Polar Discovery, 2016).

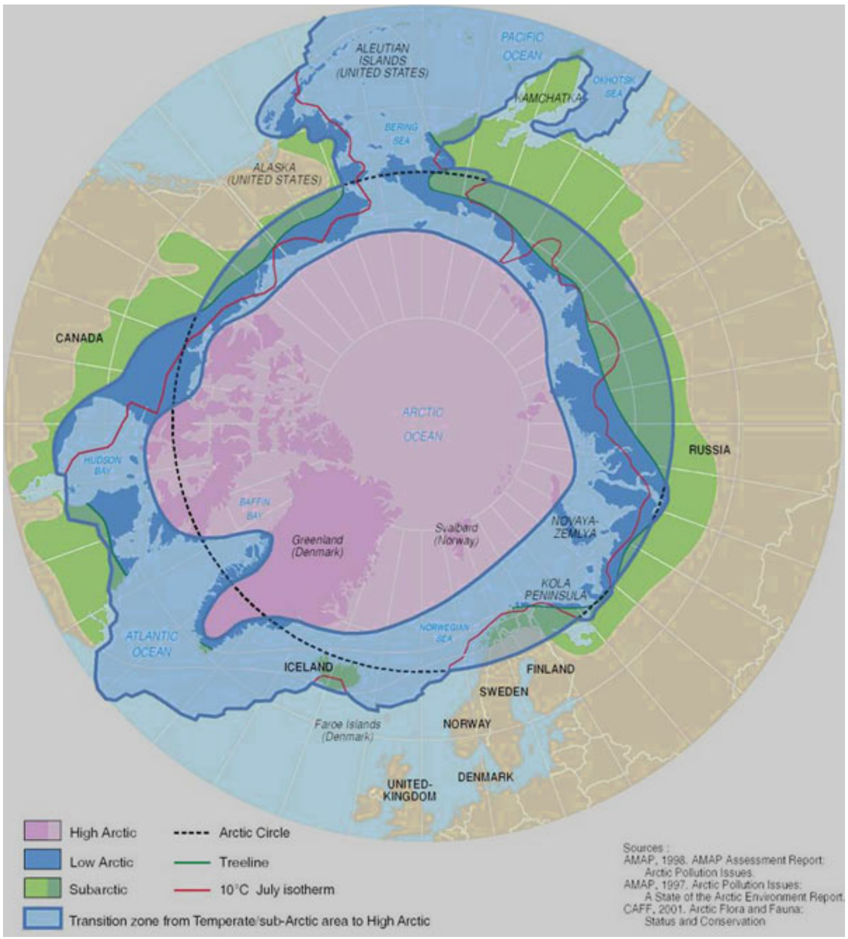

Figure 6: Different boundaries of the Arctic (Polar Discovery, 2016)

Figure 7: Polar Code Arctic boundaries (IMO, 2016)

2.2.2. Oceanography

The Arctic Ocean has a roughly circular shape and it covers an area of 14.5 million km^2 and has an average depth of 987 meters. It includes several seas and those that usually are considered to be included are: Barents Sea, Beaufort Sea, Chukchi Sea, East Siberian Sea, Greenland Sea, Hudson Bay, Hudson Strait, Kara Sea, Laptev Sea and White Sea. It is connected to the Pacific Ocean by the Bering Strait and to the Atlantic Ocean through the Greenland Sea and Labrador Sea. Countries bordering the Arctic Ocean are Russia, Norway, Iceland, Greenland, Canada and the United States (Wikipedia, 2016b).

There are several ports and harbors around the Arctic Ocean. In Alaska, the main ports are Barrow and Prudhoe Bay. In Canada, Churchill in Manitoba, Nanisivik in Nunavut, Tuktoyaktuk or Inuvik in the Northwest territories, in Greenland, the main port is at Nuuk, in Norway, Tromsø, Kirkenes and Vardø are ports on the mainland and Longyearbyen on the island of Svalbard. In Russia, major ports sorted by the different sea areas are: Murmansk in the Barents Sea, Arkhangelsk in the White Sea, Labytnangi, Salekhard, Dudinka, Igarka and Dikson in the Kara Sea, Tiksi in the Laptev Sea, Pevek in the East Siberian Sea (Wikipedia, 2016b).

Figure 8: Arctic Ocean map

2.2.3. Climate

The climate of the Arctic is characterized by long, cold winters and short, cool summers. Some parts of the Arctic are covered by ice (sea ice, glacial ice, or snow) all year, and nearly all parts of the Arctic experience long periods with some form of ice on the surface. Average winter temperatures range from −34 °C to 0 °C. Average summer temperatures range from −10 to +10 °C. Wind speeds over the Arctic Basin between 4 and 6 m/s (14 and 22 km/h) in all seasons. Stronger winds do occur in storms, often causing whiteout conditions, but they rarely exceed 25 m/s (90 km/h) in these areas (Wikipedia, 2016c).

During all seasons, the strongest average winds are found in the North-Atlantic seas, Baffin Bay, and Bering and Chukchi Seas, where cyclone activity is most common. On the Atlantic side, the winds are strongest in winter, averaging 7 to 12 m/s (25 to 43 km/h), and weakest in summer, averaging 5 to 7 m/s (18 to 25 km/h). On the Pacific side they average 6 to 9 m/s (22 to 32 km/h) year round. Maximum wind speeds in the Atlantic region can approach 50 m/s (180 km/h) in winter (Przybylak, 2003).

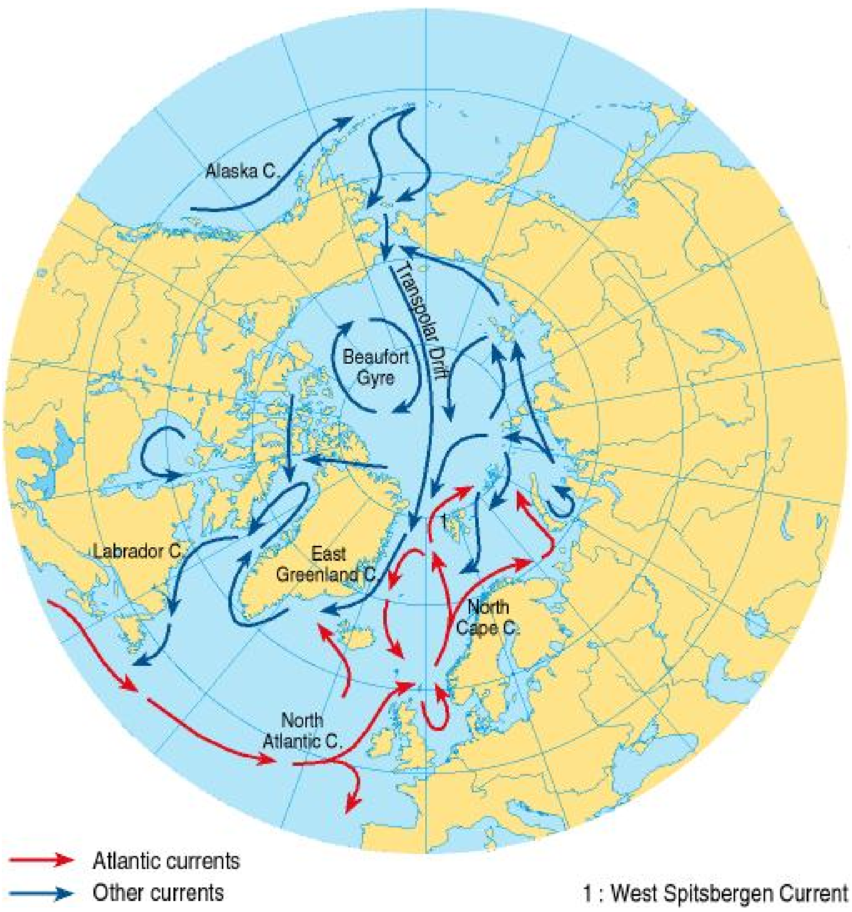

Figure 9: Surface ocean currents in the Arctic (Rekacewicz, 1997)

2.2.4. Wildlife

Arctic vegetation is composed of plants such as dwarf shrubs, graminoids, herbs, lichens and mosses, which all grow relatively close to the ground, forming tundra. As one moves northward, the amount of warmth available for plant growth decreases considerably. Arctic has no trees growing, but in its warmest parts, shrubs can be found. In the coldest parts of the Arctic, much of the ground is bare. The Arctic Ocean has relatively little plant life except for phytoplankton (Wikipedia, 2016a).

Herbivores on the tundra include the Arctic hare, lemming, muskox, and caribou. They are preyed on by the snowy owl, Arctic fox, Grizzly bear, and wolf. The polar bear is also a predator, though it prefers to hunt for marine life from the ice. There are also many birds and marine species endemic to the colder regions. Other land animals include wolverines, ermines, and Arctic ground squirrels. Marine mammals include seals, walrus, and several species of cetacean—baleen whales and also narwhals, killer whales and belugas (Wikipedia, 2016a).

Figure 10: Polar bear in the Arctic (Allen, 2013)

2.3. Cruise industry

The cruise industry in the arctic region is experiencing a blossom in the last years. More and more passengers are joining these cruises to discover the beauty of the Northern part of the earth. In this subchapter, an overview of the cruise industry is presented and the main routes used in the arctic are examined.

2.3.1. Arctic routes

There are three main routes used by vessels in the Arctic Ocean, namely the Northeast Passage (NEP), Northwest Passage (NWP) and the Central Arctic Ocean Route (CAOR).

Due to the presence of sea ice neither of these transportation passages can offer ships a single set channel to follow. In practice, ships are forced to follow the channel that offers the best ice and navigational conditions at any one time and place. In sum, the three corridors occupy the whole of the Arctic Ocean. No commercial cargo ship has yet crossed the central Arctic Ocean. There are huge uncertainties and variations between different climate models that are trying to predict the development of ice conditions. In terms of any regular shipping on these routes, however, simulations indicate that the ice will be too heavy and the calculated costs too high for any regular transport. Models indicate that the ice conditions will continue to be heavy during winter and spring seasons, even in 2050, and the route is not expected to be completely ice free in summer. (Multiconsult, 2011)

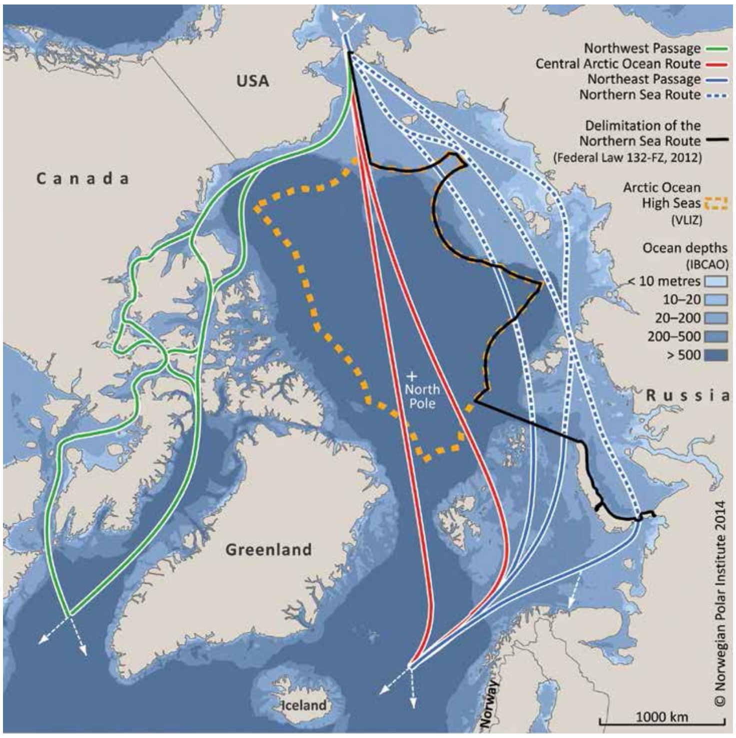

Figure 11: Arctic Maritime transport routes (Strategic Environmental Impact Assessment of development of the Arctic, 2014)

The information regarding the Northeast Passage and the Northern Sea Route, and the Northwest Passage that follow are described by Østreng et al. (2012) and Multiconsult (2011) and thus described in italics:

The Northeast Passage (NEP) and the Northern Sea Route (NSR)

According to political perception and legal regulations in Russia, the NSR stretches from Novaya Zemlya in the west to the Bering Strait in the east. The establishment of the NSR as a separate part of the NEP was decided by the Council of People's Commissars of the USSR on 17 December 1932, which marks the beginning of the NSR as an administered, legal entity under full Soviet jurisdiction and control. It comprises the main part of the NEP, which, with the addition of the waters of the Barents Sea, connects the Atlantic and Pacific Oceans along the entire length of the northern coast of Eurasia. The NSR is a series of different sailing lanes, and ice conditions at any one time and place will decide the sailing course to be set. The route covers some 2200 to 2900 nautical miles of ice-infested waters. It consists of a series of marginal seas – the Kara Sea, the Laptev Sea, the East Siberian Sea and the Chukchi Sea – which are linked by some 58 straits running through three archipelagos – the Novaya Zemlja, the Severnaja Zemlja and the New Siberian Islands (Multiconsult, 2011) (Østreng et al., 2012).

Ice conditions are in general more difficult along the eastern extremity of the route than in the west. The eastern sector is also the part of the route with the most shallow shelf areas. The East Siberian Sea has an average depth of 58 meters and the Chukchi Sea of 88 meters. The shallowness of the shelf have minimum depths of 8 meters. The ocean areas west of the Yamal Peninsula are fortunate in having a slightly deeper shelf and lighter ice conditions in average than the eastern sector. This is partly due to the circumstance that the Kara Sea is to the north surrounded by several archipelagos, which usually prevent heavy multi-year ice from the Central Arctic Ocean from penetrating into these waters. Multi-year ice, which is extremely hard and consequently a serious obstacle to navigation, has survived the summer melt season and is typically 1 to 5 meter thick. The eastern sector lacks this kind of land protection and is more open to the influx of multi-year ice from the Central Arctic Basin (Multiconsult, 2011) (Østreng et al., 2012).

The Northwest Passage (NWP)

The Northwest Passage is the name given to a set of marine routes between the Atlantic and Pacific Ocean, spanning the straits and sounds of the Canadian Archipelago, the Davis Strait and the Baffin Bay in the east and the Beaufort Sea in the west. Like the Northeast Passage it is a transportation corridor channeled through islands occupying broad expanses of water and land in the north-south direction. The base of the archipelago stretches some 3000 km along the mainland coast, and the tip of Ellesmere Island is less than 900 km from the geographic North Pole. The Archipelago is one of the largest in the world and consists of a labyrinth of islands and headlands of various sizes and shapes. There are 73 major islands of more than 50 square miles in area, and some 18 114 smaller ones. If islets and rocks are included, the Archipelago comprises approximately 36 000 pieces of dry land above sea level, making it one *of the most complex geographies on Earth. In recent summer seasons most of the archipelago was so called ice free, promising to open the NWP to high volumes of intercontinental commercial shipping. Though, the inter-annual variability in sea ice conditions within the Canadian Archipelago will continue to be extreme (Multiconsult, 2011) (Østreng et al., 2012)*

2.3.2. Overview and trends

Cruises are offered by operators in all the three passages. However, the passenger volumes in the Arctic vary from region to region, with Svalbard and Greenland having the largest number of cruise tourists. Cruise ships have become larger and the biggest vessels in Svalbard can carry 3300 passengers. On the other end of the spectrum, the region is frequented by smaller expedition cruises using vessels carrying anywhere from five to 300 passengers. In Svalbard, this segment accounts for approximately 20 – 25% of the total number of visitors.

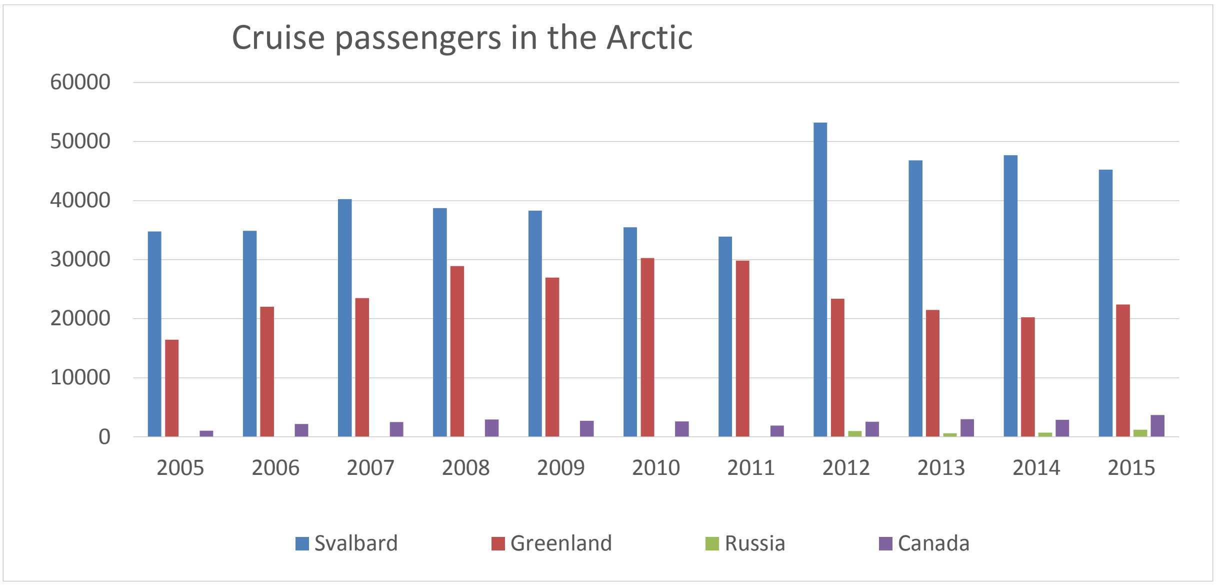

Figure 12: Cruise tourism in arctic areas by number of passengers (Lawton, 2017)

In Norway, there is approximately a 700% increase on cruise tourism between 1995 and 2014 , as shown in Figure 13 with the passengers that have cruised to Norway in 2014 exceeding the 650000.

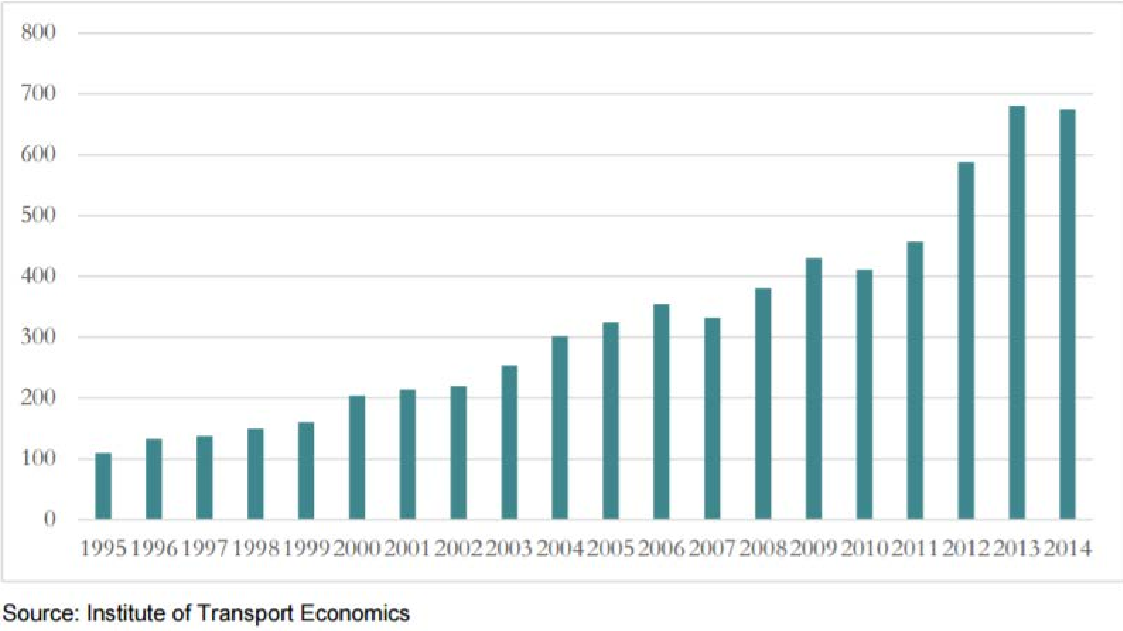

Figure 13: Cruise tourism in Norway by number of passengers (in 1000) (Lawton, 2017)

The development of cruise ship activities in the ports of Greenland and Longyearbyen are shown in the figures below. The number of arrivals of cruise ships in Greenland ports has increased by an average of 48,9 % per year from 2005 to 2008. The average growth rate for Longyearbyen for the period 2001-2008 of passengers arriving is 14% per year.

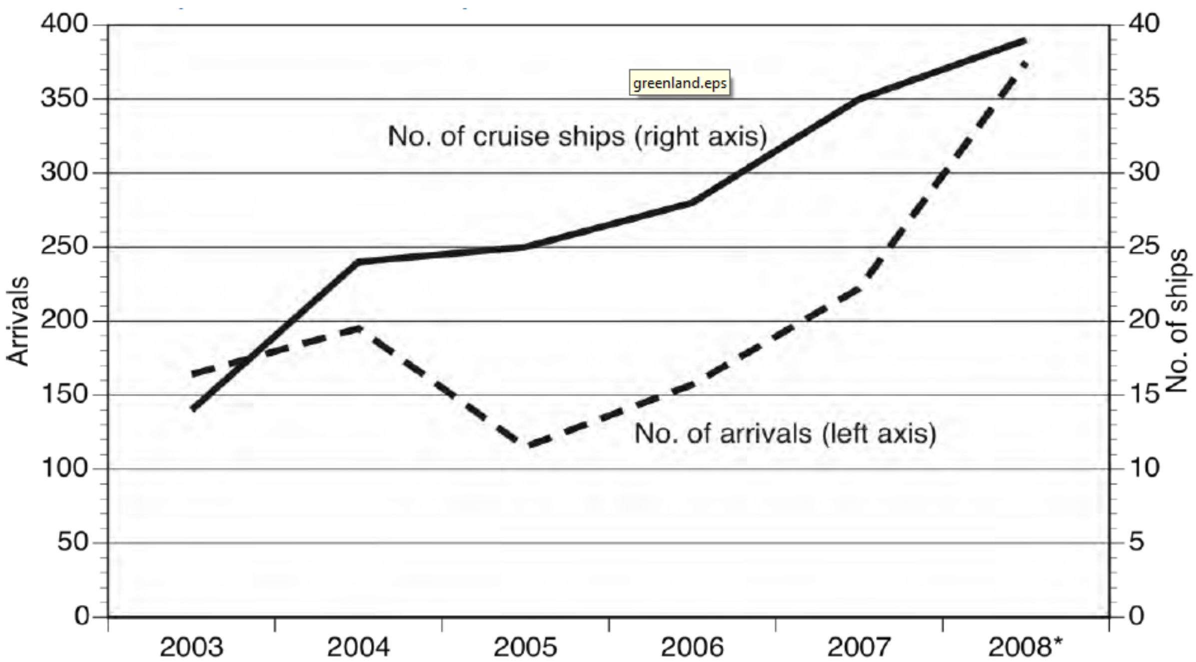

Figure 14: Cruise ship arrivals in Greenland ports and harbors 2003-08 (Multiconsult, 2011)

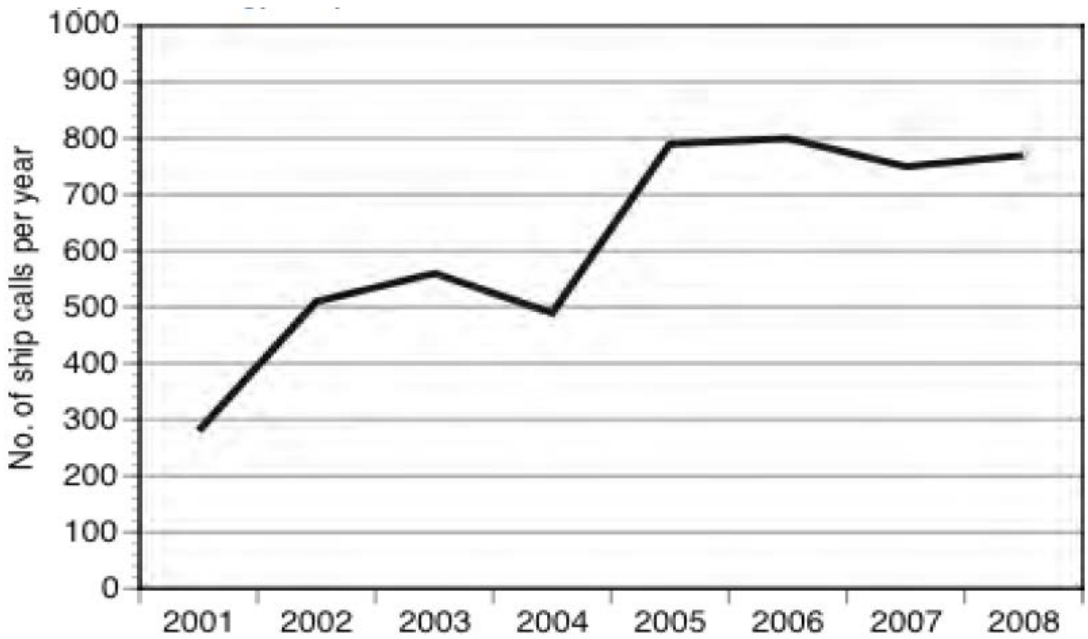

Figure 15: No. of ship calls in Longyearbyen 2001-2008 (Multiconsult, 2011)

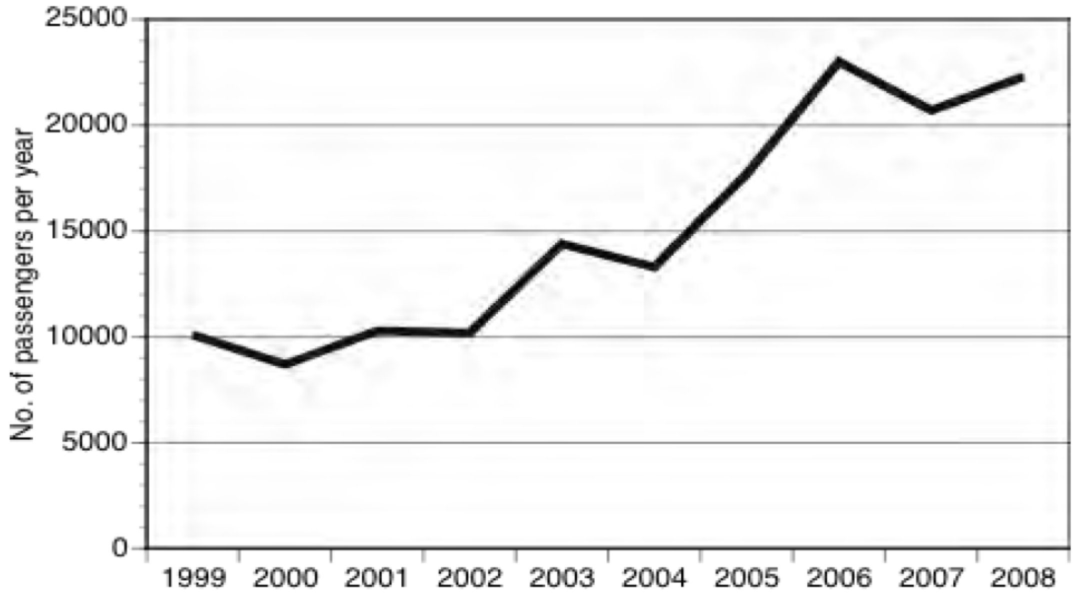

Figure 16: No of Cruise Passenger arriving Longyearbyen 1999-2008 (Multiconsult, 2011)

From all the above-mentioned figures we can clearly see an upward trend in the cruise ship industry in the arctic region, which highlights the need of better understanding the related risks and how these risks could be mitigated.

The Association of Arctic Expedition Cruise Operators (AECO), which represents capacity of ships of more than 25% of the total number of cruise passengers in the Arctic, foresees an increase of almost 100% in their arctic cruise passengers during the next three years, doubling the total number of people that are travelling in the Arctic. In the figures below we can identify the steep increase on the total amount of passengers as described and forecasted by AECO.

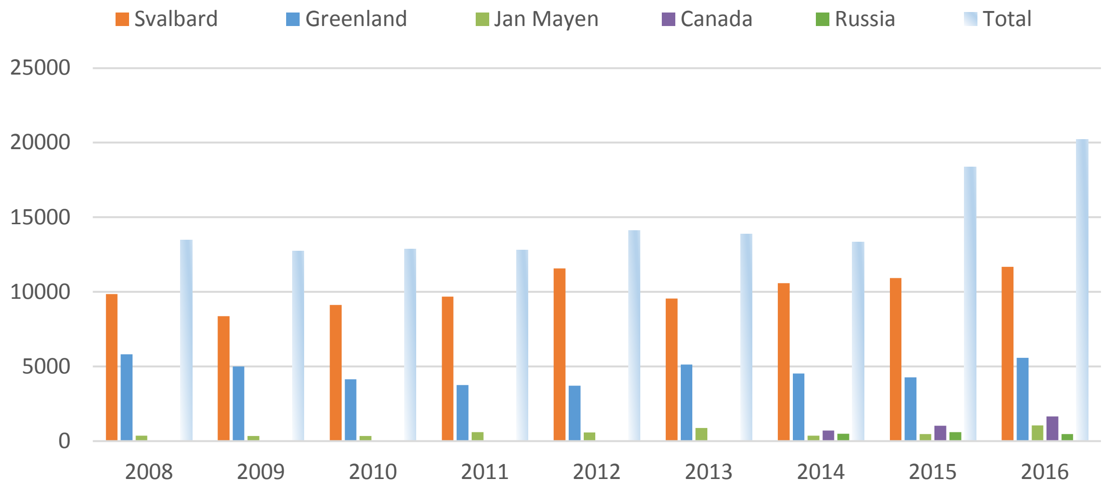

Figure 17: AECO cruise passengers in arctic areas by number of passengers (Lawton, 2017)

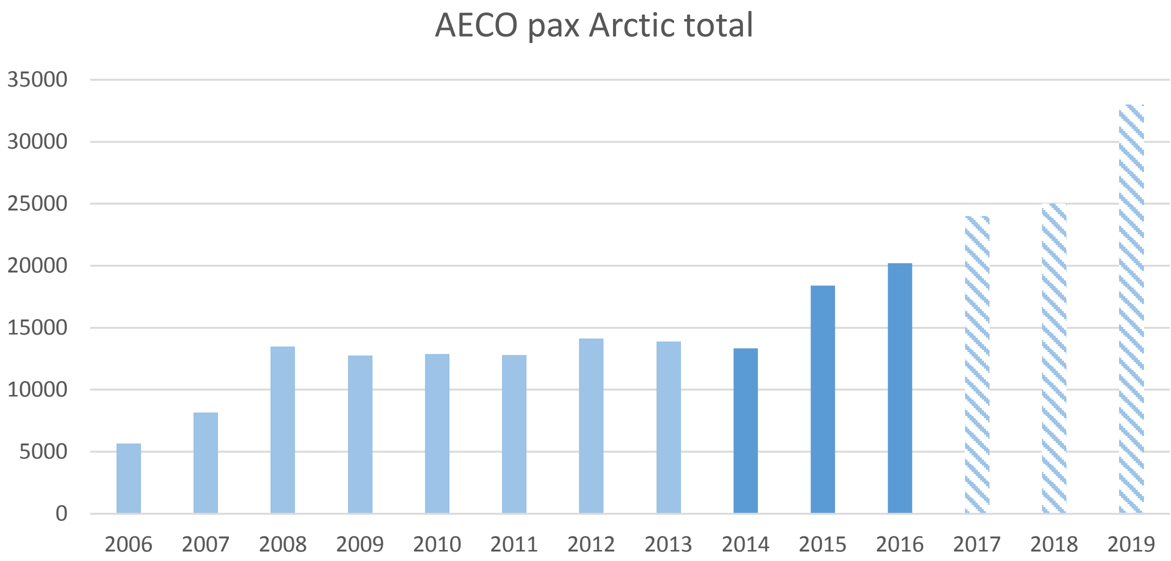

Figure 18: AECO forecast for cruise passengers in arctic areas by number of passengers (Lawton, 2017)

2.4. Regulations review

In this subchapter, a review of the relevant regulations takes place. The relevant chapters of the Polar Code and the SOLAS are presented and discussed.

2.4.1. Polar Code

The International Code for Ships Operating in Polar Waters or Polar Code is an international regime adopted by the International Maritime Organization (IMO) in 2014. The Code sets out regulations for shipping in the Polar Regions, principally relating to Ice navigation and ship design and it came into force on January 2017. The Polar Code is intended to cover the full range of shipping-related matters relevant to navigation in waters surrounding the two poles – ship design, construction and equipment; operational and training concerns; search and rescue; and, equally important, the protection of the unique environment and eco-systems of the polar regions (IMO, 2017).

The Code will require ships intending to operating in the defined waters of the Antarctic and Arctic to apply for a Polar Ship Certificate, which would classify the vessel as Category A ship - ships designed for operation in polar waters at least in medium first-year ice, which may include old ice inclusions; Category B ship - a ship not included in category A, designed for operation in polar waters in at least thin first-year ice, which may include old ice inclusions; or Category C ship - a ship designed to operate in open water or in ice conditions less severe than those included in Categories A and B (IMO, 2017).

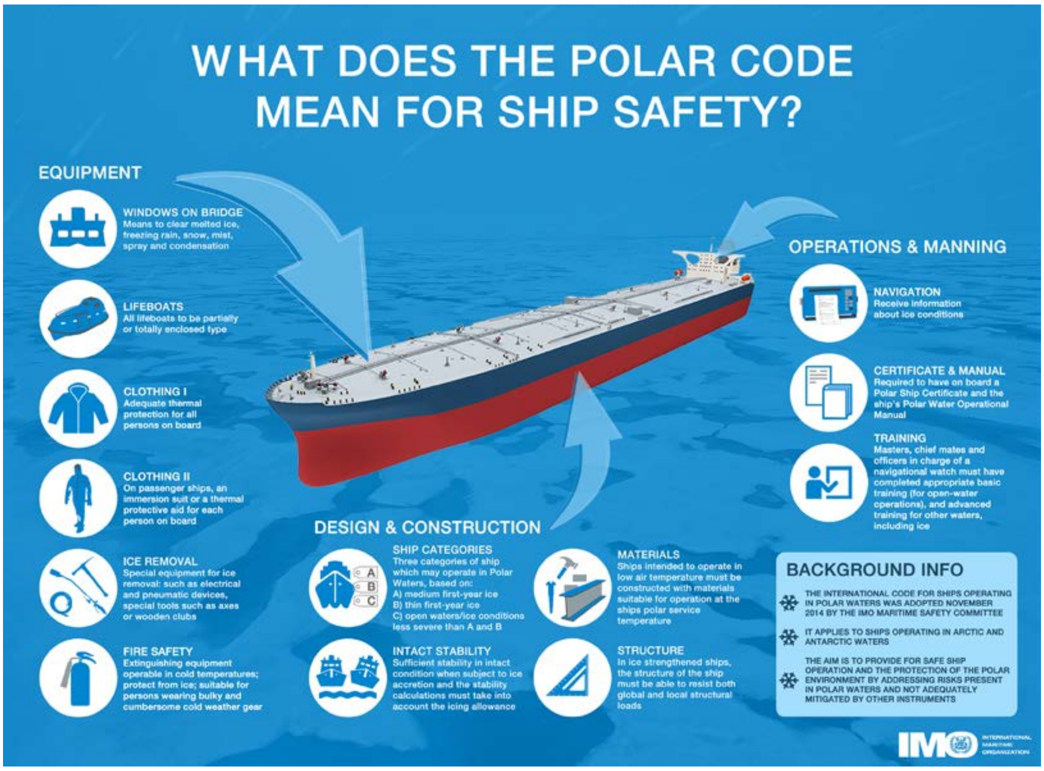

Figure 19: Polar Code Infographic (IMO, 2017)

In addition, ships will need to carry a Polar Water Operational Manual, to provide the Owner, Operator, Master and crew with sufficient information regarding the ship's operational capabilities and limitations in order to support their decision-making process.

The chapters in the Code each set out goals and functional requirements, including those covering ship structure; stability and subdivision; watertight and weathertight integrity; machinery installations; operational safety; fire safety/protection; life-saving appliances and arrangements; safety of navigation; communications; voyage planning; manning and training; prevention of oil pollution; prevention of pollution form from noxious liquid substances from ships; prevention of pollution by sewage from ships; and prevention of pollution by discharge of garbage from ships (IMO, 2017).

Furthermore, according to the Polar code the voyage and passage plan in remote areas should include the following factors: safe areas and no-go areas; surveyed marine corridors, if available; and contingency plans for emergencies in the event of limited support being available for assistance in areas remote from SAR facilities. In addition, the detailed voyage and passage plan for ships operating in Arctic or Antarctic waters should include the following factors: conditions when it is not safe to enter areas containing ice or icebergs because of darkness, swell, fog and pressure ice; safe distance to icebergs; and presence of ice and icebergs, and safe speed in such areas (IMO, 2017).

The relevant chapters of the Polar Code for the purpose of this thesis are included in the Appendix B including the definition of the polar code for the maximum expected time of rescue that shall never be less than five days (IMO, 2016).

2.4.2. SOLAS

The International Convention for the Safety of Life at Sea (SOLAS) is an international maritime treaty, which requires signatory flag states to ensure that ships flagged by them comply with minimum safety standards in construction, equipment and operation. It was adopted on November 1st 1974 by the International Conference on Safety of Life at Sea, convened by the International Maritime Organization (IMO). It came into force on May 25th 1980 and since then there have been several amendments of the code.

The SOLAS Convention in its successive forms is generally regarded as the most important of all international treaties concerning the safety of merchant ships. According to the code (SOLAS, 2009)

Passenger ships engaged on international voyages, which are not short international voyages, shall carry:

a) Partially or totally enclosed lifeboats complying with the requirements of the Code on each side of the ship such aggregate capacity as will accommodate not less than 50% of the total number of persons on board. The Administration may permit the *substitution of lifeboats by liferafts of equivalent total capacity provided that there shall never be less than sufficient lifeboats on each side of the ship to accommodate 37.5% of the total number of persons on board. The inflatable or rigid liferafts shall comply with the requirements of the Code and shall be served by launching appliances equally distributed on each side of the ship, and*

b) *In addition, inflatable or rigid liferafts complying with the requirements of the Code of such aggregate capacity as will accommodate at least 25% of the total number of persons on board. These liferafts shall be served by at least one launching appliance on each side which may be those provided in compliance with the requirements.*

Furthermore, according to the Code, *all survival craft required to provide for abandonment by the total number of persons on board shall be capable of being launched with their full complement of persons and equipment within a period of 30 min from the time the abandon ship signal is given* (SOLAS, 2009).

3. <u>SAREX 2 RESEARCH TRIP</u>

This chapter includes all the information relevant to the SARex 2 trip in Svalbard, which provided the author with valuable hands on experience and helped on the better understanding of the hazards that the Arctic poses.

3.1. General Information

During April 2016, the first Search and Rescue exercise (SARex 1) was organized as a joint collaboration between the Norwegian Coast Guard, experts from industry, governmental organizations and academia and conducted north of Spitzbergen. The objective of the first exercise was to identify the gaps between the functionality provided by the existing SOLAS (International Convention for Safety Of Life At Sea) approved safety equipment and the functionality required by the Polar Code (Solberg et al., 2016)

The Norwegian Coast Guard, the Norwegian Maritime Authority and the University of Stavanger decided in late 2016, after the successful conducting of SARex 1, to plan a second search and rescue exercise in order to investigate whether improved rescue equipment would substantially increase the probability of 'long-term survival' in a lifeboat or a liferaft in Arctic waters.

The exercise scenario was the same as in the 2016 SARex 1 exercise: A mass evacuation from a cruise vessel in distress in Arctic waters. The SARex 2 took place from 3rd to 4th of May 2017 in Krossfjorden, a 28 km long fjord (inshore) on the west coast of Spitzbergen on Svalbard, just north of Ny Ålesund. The exact location of the exercise is indicated with a red circle in Figure 20 below.

The exercise was mainly organized by Knut Espen Solberg (GMC/DNV GL), in close cooperation with Ove Tobias Gudmestad (University of Stavanger), Endre Barane (Norwegian Coast Guard) and Eivinn Skjærseth (Norsk Luftambulanse), who was in charge of the development and execution of the medical tests/observations and documentation of the medical results. As part of the exercise, Norwegian Coast Guard's vessel KV Svalbard accommodated the participants and served as the base of all the phases of SARex 2.

The overall objectives of the exercise as stated in the report published on November 2017 are (Gudmestad et al., 2017):

- Investigate the functional requirements as defined in the International Code for Ships Operating in Polar Waters (IMO Polar Code)
- Study the adequacy of modified lifeboats, life rafts and Personal Protective Equipment (PPE) for use in cold climate conditions
- Assess helicopter evacuation in a cold climate environment
- Assess the reliability of EPIRBs and Personal Location Beacons (PLBs) in a cold climate environment

- Train Norwegian Coast Guard personnel on emergency procedures in cold climate conditions, with particular reference to evacuation and rescue from cruise ships

In the exercise, there were participants from the industry, governmental organizations and academia, as well as civilians and crew members from KV Svalbard. The full list of SARex 2 participants and their areas of responsibility are presented in Appendix C.

Figure 20: SARex II test location, indicated with a red circle (Norwegian Polar Institute, 2017)

The structure of the research trip was in work packages as shown in Figure 21. The work packages related to the lifeboat, liferaft, the Personal Protective Equipment (PPE) and the training would be evaluated and conclude to a synthesized work package. The findings of the later work package led to the publishing of the SARex 2 report (Gudmestad et al., 2017).

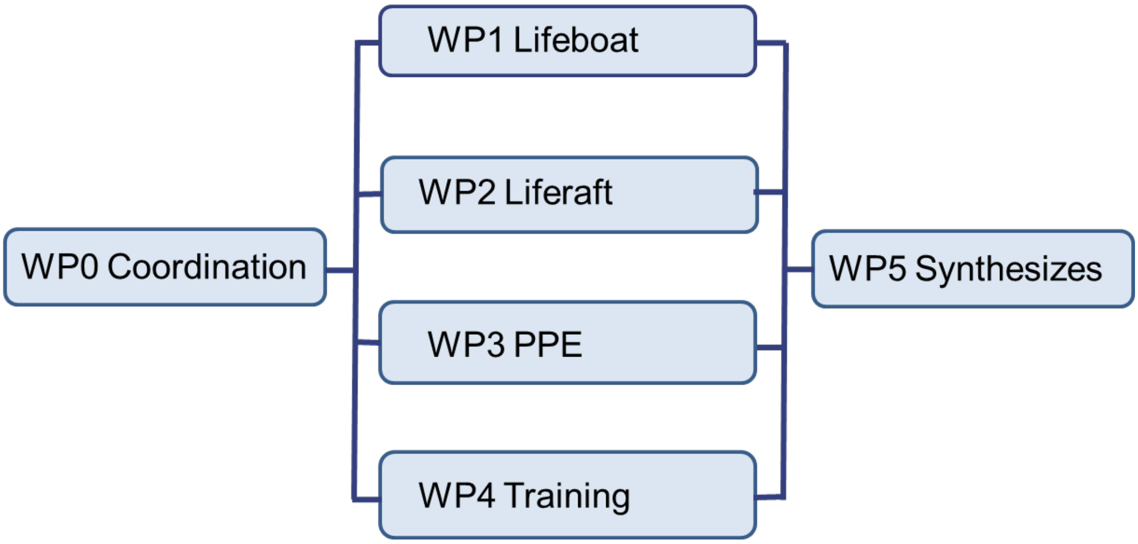

Figure 21: SARex II research program structure

3.2. Tests

The research trip conducted north of Spitzbergen consisted of three different tests. The findings and the conclusions of the three tests led to the overall conclusions of the research trip that were published on November 2017 in the SARex 2 report.

3.2.1. Air quality and ventilation test

The air quality and ventilation test was the first test conducted during the research trip. The aim of the test was to assess the need for ventilation while on board a survival craft.

The test took place in the lifeboat while stored on the deck of KV Svalbard. The lifeboat was embarked with 49 participants (maximum capacity of the lifeboat) and the hatches were closed during the test. The overall test was divided in two phases. During the first phase the participants had normal pulse while for the second phase the participants did physical exercise prior to entering the lifeboat to increase the heart rate. Physical activity was conducted during the test (within limited space in the lifeboat) to maintain the high heart rate. Both phases were aborted after approximately 60 mins each.

Figure 22: Boarding of lifeboat for the air quality and ventilation test @Jan Erik Jensen

3.2.2. Survival test

The second test conducted during the trip was the survival test. The goal of this test was to assess the impact caused by modified and improved SOLAS equipment on the functionality of survivors in a real-case survival situation (Gudmestad et al., 2017).

During this test, one lifeboat and one liferaft were filled by the civilian exercise participants and crew members from KV Svalbard and were launched in the Krossfjorden area. Two officers from KV Svalbard served as captains in the lifeboat and the liferaft. The author was decided to participate in the liferaft crew. Different activities were conducted while on board with the participation of all the passengers under the leadership of the officers.

To assess the condition of the participants, different medical tests and measurements were conducted throughout the exercise by the medical team that was visiting the survival crafts at regular time intervals. The medical measurements included measurements of heart rate, systolic blood pressure and ear temperature. The medical tests included: a) a penny transfer test, where the participants had to transfer a specific amount of pennies from a board to a cup in a predetermined time to evaluate the motor skills of participants, b) a grip strength test, where the participants had to use a baseline hydraulic hand dynamometer to assess their strength and c) a subtraction test where the cognitive skills of the participants were evaluated. All the tests were conducted prior to the exercise and several times during the course of the survival test to obtain better comparative results. Furthermore, different factors were measured from the medical team with a self-reporting test, namely cold, fatigue, hunger, thirst, discomfort, positivity, nausea.

The test was aborted after almost 30 hours and was determined by the captain on board KV Svalbard due to challenging weather conditions. The waves and the strong wind made it extremely difficult for the MOB boats to come alongside the survival crafts and the moving between the MOB boat and the lifeboat and liferaft became very difficult, thus the test had to be aborted.

Figure 23: Transfer of passengers from liferaft to mob-boat @Jan Erik Jensen

3.2.3. <u>RF Location Beacons test</u>

During this phase, the aim was to test different communication devices. The devices used were three EPIRB (Emergency Position Indicator Radio Beacon), two AIS SART (Automatic Identification System Search and Rescue Transponders) and two radar transponder from the lifeboat.

The signals from the EPIRB were homed from the bridge of KV Svalbard, and the signal strength were measured. The test started with KV Svalbard at a distance of 0.9 nm off the lifeboat, and all equipment was tested in the three positions before KV Svalbard moved to two nautical miles from the lifeboat. Then it moved to three nautical miles and thereafter to four nautical miles off the lifeboat.

3.3. Personal contribution

This subchapter describes the author's motivation behind participating in the SARex 2 exercise and his personal contribution in the SARex 2 report.

The rationale behind the author's interest in participating in the SARex 2 research trip was to better understand the challenges that the Arctic waters could pose for a cruise vessel. After a discussion with Professor Ove Tobias Gudmestad from University of Stavanger, the author was invited to participate in the research trip.

Participating in the SARex 2 exercise made it possible for the author to get a first-rated practical experience that helped him fully understand the risks of the Arctic environment. The author's responsibility was to conduct a risk analysis on the evacuation of a cruise ship in distress, in the Arctic. Thus, the main participation of the author was focused on but not limited to the second phase, the survival phase described in subchapter 3.2.2. The author participated in the exercise as a passenger of the liferaft, gaining invaluable insights from his stay in the Arctic waters for approximately 30 hours. During SARex 2 the author participated in an additional test with a helicopter, where all the passengers were hoisted and evacuated by helicopter from the lifeboat to KV Svalbard.

During the planning stages of the project, the author prepared a Preliminary Hazard Analysis (PHA) that could be used as a basis on the research trip. The PHA was then enriched during the SARex 2 trip with additional hazards and risk reducing measures that were identified during a risk assessment work group that was conducted before the exercise and a summarizing meeting after the exercise. In both meetings, the analysis group consisted of all the participants from the SARex team.

Figure 24: Transfer of personnel from rescue craft to mob-boat was difficult and involved a substantial risk with increasing wind and waves. @Jan Erik Jensen

4. <u>QUALITATIVE RISK ANALYSIS</u>

In this chapter, a qualitative risk analysis is conducted. First, a hazard identification takes place, where the different challenges of an evacuation of a cruise ship industry in the arctic region are presented. Then, these risks are weighted according to their probability of occurrence and the severity of their consequences using the risk matrix analysis.

4.1. Hazard identification

Arctic region remains an area of the planet that poses many challenges for the vessels operating due to the extreme weather conditions. There is sufficient knowledge and many studies stressing out the risks related the cruise ships in normal waters, but our knowledge so far is poor when it comes to Arctic. Thus, this chapter presents the risk analysis related to the evacuation of the vessels in the Arctic waters. To conduct the risk analysis, we will use a Preliminary Hazard Analysis (PHA).

The PHA of this chapter was initially prepared during the planning stages of the project. During the SARex 2 trip, a risk assessment work group was conducted before the exercise and a summarizing meeting after the exercise, where the initial PHA was enriched with additional hazards and risk reducing measures. In both meetings, the analysis group consisted of all the participants from the SARex team.

The Preliminary Hazard Analysis (PHA) is a qualitative or semi-quantitative analysis that is conducted to:

1. Identify the potential hazardous events related to a scenario
2. Rank the aforementioned hazardous events according to their severity
3. Identify possible risk reducing measures

During the PHA it is common to split the analysis object into modules to give a clearer picture of the different stages. A flow chart showing the methodology of a PHA is illustrated in the figure below:

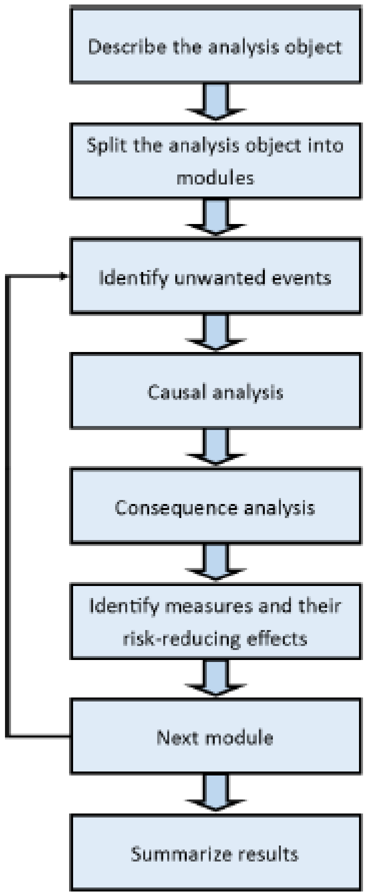

Figure 25: PHA methodology, presented from Aven (2008)

The analysis object of our case is the evacuation of a cruise ship in the arctic waters after an accident. In our scenario, the passengers had to perform an evacuation from a cruise ship in the Arctic, using lifeboats and liferafts and survival suits, and survive for at least five days.

The analysis object was split into five phases, to simplify the process. The separation of the phases was conducted according to the time, dividing the period from the "Alarm" to the "Rescue" into five phases and is presented below:

- Phase one: Alarm to Muster station
  The Phase one includes all the hazards identified from the time that the Alarm begins till the passengers reach the Muster station.
- Phase two: Boarding (Lifeboats and Liferafts)
  The Phase two covers the risks related to the boarding of the passengers to the evacuation means, both lifeboats and liferafts.
- Phase three: Launching of Lifeboat or Liferaft
  Phase three consists of the challenges that can occur while launching the evacuation means (lifeboat and liferaft).
- Phase four (a): Operation and Survival (Lifeboat)

Phase four is divided in three sub phases that happen at the same time period. Phase (a) describes the risks of the lifeboat while it operates and the risks related to the passengers of the lifeboat.

- Phase four (b): Operation and Survival (Liferaft)
  Phase (b) describes the risks of the liferaft while it operates and the risks related to the passengers of the liferaft.
- Phase four (c): Survival Logistics
  Phase (c) refers to the challenges of the logistics between the system of lifeboat and liferafts while they operate.
- Phase five: Rescue
  The last Phase contains the hazards identified during the rescue of the passengers from the lifeboats and the liferafts from either a helicopter or by a rescue vessel.

After describing our analysis object and splitting the object into module (the aforementioned phases), we will have to identify the unwanted events – the underlying risks – for each module. The experience of participating to the full-scale exercise had a decisive importance in identifying the hazards. The table below includes the hazards for each phase:

Table 1: Hazard identification for each phase

	Hazard code	Hazard
Phase one: Alarm to muster station	**1.1**	Passengers attend wrong muster station or cannot find the muster station
	1.2	Slippery/ crowded/ blocked passageways, stairs and other routes used on evacuation
	1.3	Unavailability of a muster station
	1.4	Inadequate passenger evacuation equipment (e.g. survival suits, inappropriate/ not woolen clothing, PSK, GSK, etc.)
	1.5	Insufficient number of lifeboats/ liferafts or lack of capacity
Phase two: Boarding (Lifeboats and Liferafts)	**2.1**	Passengers not capable of evacuating without assistance
	2.2	Panicked passengers
	2.3	Lifeboats/ liferafts not usable

	2.4	Not enough officers for boarding in each lifeboat/ liferaft (at least one is recommended to lead each evacuation mean)
	2.5	Injuries of passengers while boarding
	2.6	PSK/ GSK not brought along in lifeboat/ liferaft by the evacuated passengers
Phase three: Launching of Lifeboat or Liferaft	**3.1**	Mechanical failure (Lifeboat)
	3.2	Failure of inflating system (Liferaft)
	3.3	Impossible launching of the lifeboat/ liferaft
	3.4	Uncontrollable movements of lifeboat during lowering
	3.5	Power shutdown for the launching procedure
	3.6	Passengers jumping into the sea to board in the liferafts
Phase four(a): Operation and survival (Lifeboat)	**4a.1**	Engine failure
	4a.2	Fire
	4a.3	Discomfort due to sitting position
	4a.4	Condensation
	4a.5	High temperature inside the lifeboat
	4a.6	Low temperature inside the lifeboat
	4a.7	Insufficient/ blocking of ventilation system
	4a.8	Poor visibility
	4a.9	Maneuvering and navigation difficulties
	4a.10	Sea spray
	4a.11	Icing

	4a.12	Internal communication
	4a.13	External communication
	4a.14	Lack of sleep
	4a.15	Seasickness
	4a.16	Injuries while using the pyrotechnics
	4a.17	Insufficient/ obsolete and loose equipment
	4a.18	Insufficient/ obsolete medical equipment
	4a.19	Lack of diesel fuel or clogging of the filter
	4a.20	Potentially dangerous wildlife (e.g. polar bear, whale, etc.)
	4a.21	Lack of food/ water
	4a.22	Operational management
Phase four(b): Operation and survival (Liferaft)	**4b.1**	Discomfort due to sitting position
	4b.2	Condensation
	4b.3	Water leakage from the floor or the roof
	4b.4	High temperature inside the liferaft
	4b.5	Low temperature inside the liferaft
	4b.6	Poor visibility
	4b.7	Maneuvering and navigation difficulties
	4b.8	Sea spray
	4b.9	Icing
	4b.10	External communication
	4b.11	Lack of sleep
	4b.12	Seasickness

	4b.13	Injuries while using the pyrotechnics
	4b.14	Potentially dangerous wildlife (e.g. polar bear, whale, etc.)
	4b.15	Insufficient/ obsolete and loose equipment
	4b.16	Insufficient/ obsolete medical equipment
	4b.17	Operational management
	4b.18	Lack of food/ water
Phase four (c): Survival logistics	**4c.1**	Lifeboats and liferafts spread around uncontrollably
	4c.2	Lack of communication
	4c.3	Lack of officers and / or doctors in a lifeboat or liferaft
Phase five: Rescue	**5.1**	Transfer of people from lifeboat/ liferaft to rescue vessel or helicopter

After identifying the hazards of each module (Phase), the next step is the causal analysis. During this analysis, we present the different causes that can create the risks. It is quite often that one consequence can lead to more than one unwanted events. Next, is the consequence analysis, where the consequences of each risk are examined and presented. Finally, identifying measures and their risk reducing effects on our module is the last step, before moving on the next module. All those results are included in the Preliminary Hazard Analysis. Due to the vast extent of the PHA, only a one-page example is presented below. The rest PHA is enclosed in the Appendix A.

Table 2: Example sheet of the PHA

Phase one: Alarm to muster station						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
1.1	Passengers attend wrong muster station or cannot find the muster station	- Lack of information before starting the cruise - Poor information regarding evacuation routes onboard - Lack of clear thinking from the passengers due to dangerous/ stressful situation	- Delay on evacuation - Passengers do not reach the correct muster station	**Probab.: 3 Conseq.: B**	- Proper passengers' training programs (e.g. via e-learning) - Better crew training - Posters showing the evacuation routes	**Probab.: 2 Conseq.: B**
1.2	Slippery/ crowded/ blocked passageways, stairs and other routes used on evacuation	- Wet or iced surfaces caused by atmospheric or sea spray - Nonfunctional areas due to smoke, accidents, etc. - Overcrowded areas	- Passengers get trapped and do not reach the muster station - Injuries from falling	**Probab.: 3 Conseq.: C**	- Sheltered and heated outside areas (passageways, muster stations, etc.) - Friction materials used on the floor of outside areas - Wider passageways that can serve more passengers at the same time	**Probab.: 1 Conseq.: C**
1.3	Unavailability of a muster station	- Blocked route to the muster station - Muster station damaged and nonfunctional	- Not enough space in the other muster stations -Not enough evacuation means and equipment in the other muster stations (lifeboats/ liferafts, personal equipment, etc.)	**Probab.: 2 Conseq.: C**	- Alternative plan to organize passengers in the other muster stations - Extra evacuation means and equipment in each muster station	**Probab.: 2 Conseq.: B**

4.2. Risk Weighting

After identifying the possible threats for a cruise ship and its passengers in the Arctic region and suggesting mitigation measures for each one of them (Appendix A), in this subchapter we are weighting the different risks according to their probability of occurrence and their severity of consequences.

We use the risk matrix analysis to categorize our risks and identify those that are critical for the cruise ship and for the passengers.

The risk matrix is used to assess the risk in a structured approach that identifies which risks are more critical. A risk matrix is a tool that presents a visualization of the risk. To produce a risk matrix, some basic rules should be followed according to Ni et al (Ni et al., 2010).

- The basis for risk matrix is the standard definition of risk as a combination of severity of the consequences occurring in a certain accident scenario and its probability. That means only two input variables are required to construct a risk matrix. The output risk index is determined only by the severity of the consequences and its probability.
- The severity of consequences, probability and output risk index can be divided into different levels, respectively, with qualitative descriptions and scales.
- The calculation process of matrix producing is presented by the logic implication as: IF probability is p AND severity of consequence is c THEN risk is r.

Consequence→ Probability↓	**A Minimal**	**B Low**	**C Medium**	**D High**	**E Very high**
5 – Very high					
4 – High					
3 – Medium					
2 – Low					
1 – Minimal					

Figure 26: Risk matrix

The probability was ranked from 1 to 5, which stand for minimal to very high. The consequences where ranked from A (minimal) to E (very high). The assessment of the probability and the consequences in included in the PHA. Based on the assigned probability and level of consequence each hazard was placed in a 5x5-risk matrix to better illustrate its risk. Depending on the placement, it can be in the green, yellow or red area. The colors indicate the different levels of risk.

For simplicity, a code is assigned to each hazard. The risk matrix below illustrates the level of risk for each hazard:

Consequence→ Probability↓	A Minimal	B Low	C Medium	D High	E Very high
5 – Very high	2.2	2.1, 4b.8	4b.3	4a.21, 4b.18	
4 – High	4a.3, 4a.10, 4a.12, 4b.1, 4b.7	2.5, 4a.5, 4a.8, 4a.14, 4b.6, 4b.11, 4c.3	3.6, 4a.15, 4a.19, 4a.22, 4b.5, 4b.12, 4b.17, 4c.1, 4c.2	1.4, 5.1	
3 – Medium	4a.4, 4a.17, 4b.2, 4b.15	1.1, 4a.9, 4a.11, 4b.4, 4b.9	1.2, 2.6, 3.4, 4a.1, 4a.6, 4b.10	1.5, 3.1, 3.2, 4a.18, 4b.16	
2 – Low		4a.7	1.3, 2.3, 3.3, 4a.13	3.5	4a.2, 4a.16, 4b.13
1 – Minimal			4a.20		4b.14

Figure 27: Risk Matrix, pre risk reducing measures

Risk reducing measures were suggested for all the potential hazards. A new level of probability and consequence severity was assigned to each hazard after the implementation of the risk reducing measure. the new risk levels are pictured in the risk matrix in the figure below:

Consequence→ Probability↓	A Minimal	B Low	C Medium	D High	E Very high
5 – Very high					
4 – High	2.4	3.6, 4b.8			
3 – Medium	2.2, 4a.3, 4a.10, 4a.11, 4b.1, 4b.7	1.4, 2.1, 2.5, 3.4, 4a.5, 4a.8, 4a.14, 4b.3, 4b.5, 4b.11, 4c.3	4a.19, 4a.22, 4b.17, 4c.1, 4c.2	5.1	
2 – Low	4a.4, 4a.17, 4b.2, 4b.15	1.1, 1.3, 2.3, 3.3, 4a.1, 4a.6, 4a.9, 4b.4, 4b.6, 4b.9	2.6, 4a.2, 4a.15, 4a.18, 4b.10, 4b.12, 4b.16	4a.21, 4b.18	
1 – Minimal	4a.12	4a.7, 4a.20	1.2, 4a.13	1.5, 3.1, 3.2, 3.5, 4a.16, 4b.13, 4b.14	

Figure 28: Risk Matrix, post risk reducing measures

5. RISK MITIGATION POLICIES

We have previously conduct a qualitative risk analysis for the cruise ship industry in the Arctic region. Furthermore, we have identified and weighted the hazards that can pose danger to passengers' lives and propose risk mitigation measures to reduce either the probability of occurrence or the severity of the consequences of an unwanted event.

In this chapter, we will investigate the risk mitigation policies and how a company could minimize the consequences of an accidental event.

To begin with, when a company needs to manage the negative consequences of an accident, it can:

a) Take all the consequences if/when an accidental event occurs.
b) Reduce the probability for an accident and/or its consequences by safety measures.
c) Transfer the consequences of the occurrence to parties better able to carry them (i.e. buying insurance).

A combination of the three aforementioned approaches is usually followed. Most of the times, there will be risks that a company cannot transfer or reduce their probabilities, thus the consequences of these risks should be managed by the company.

Furthermore, there are different institutions that are willing to take over part of the consequences that can be divided in two main categories.

i. Governmental institutions that through measures (unemployment benefits, medical treatment, etc.) transfer part of the consequences of an accident from a company to the society.
ii. Market institutions that through derivatives and insurance transfer part of the consequences of an accident from a company to them. The insurance premium is a claim of compensation that one can buy for specific potential future losses in exchange of a periodic payment.

For simplicity, in our analysis when referring to "insurance", this should be considered as term containing both types of transferring the consequences to parties better able to carry them.

The first case, where the company decides to take all the consequences is not going to be examined further as it is clear that when the company decides to take the consequences it takes the cost of them as well. Here, we are considering the influence of accessing an insurance market on the investments in safety measures. We are also using the expected utility theory to define the optimal level of investment of a cruise company in safety measures. Our analysis is based on the previous work presented by Abrahamsen and Asche (2010) (2011).

Different ways of modelling these approaches exist. One way is by using the traditional cost-benefit analysis according to which the company should choose the alternative with the highest expected net present value (ENPV). For this approach, all the comparable consequences of an accident have to be transformed to one comparable unit, usually money. This is strongly criticized in the risk literature and is avoided by many safety experts as it is regarded unethical.

Therefore, we use as a basis of our analysis the expected utility theory, which is considered the backbone for all economic thinking. According to this, the alternative with the highest expect utility shall be used and there is no need of transforming all the non-economic variables into one comparable unit.

5.1. Investment only in safety measures

5.1.1. Risk mitigation safety measures

In chapter 4, we presented some possible risk mitigation measures that the company could invest in that could either lead to the reduction pf the probability of occurrence of an accidental event, or reduce the severity of the consequences if the event occurs.

5.1.2. Optimal level of investment in safety measures

In this subchapter, we use the expected utility theory to define the optimal level of investment from a company. The model used for our analysis described by Abrahamsen and Asche (2010) assumes that there are only two states at the world. These are if the accidental event does not occur, when the company's assets are y_1 and if the accidental event occur, when the company's assets will be reduced to y_2. We, also assume that the cost of reducing the consequences of an accident increases the more the risk is reduced. The possible combinations for the company's assets are described by the opportunity frontier curve illustrated in Figure 29 below.

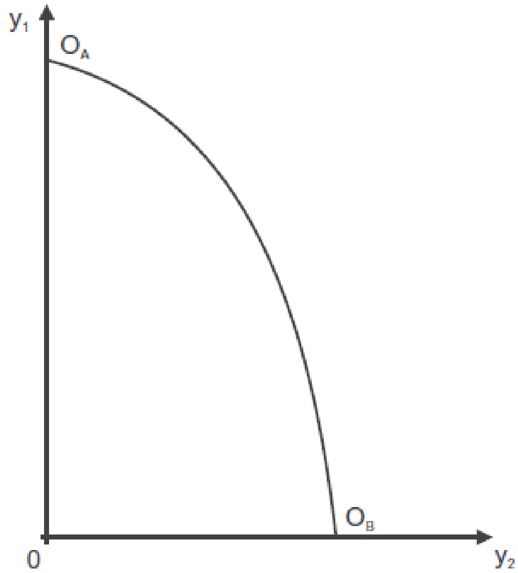

Figure 29: Opportunity frontier for the company's assets (Abrahamsen and Asche, 2010)

Point O_A represents the extreme situation where no money is spent on the consequence reducing measures, which will save more resources for the company if the accident does not occur. Point O_B represents the extreme situation where all the money is spent on the consequence reducing measure, which will lead to the maximum profit if the accident occurs.

We use the indifference curves to represent the company's preference. There are infinite number of indifference curves for each different level of satisfaction for a company. Each line provide the company with the same level of satisfaction (Figure 30).

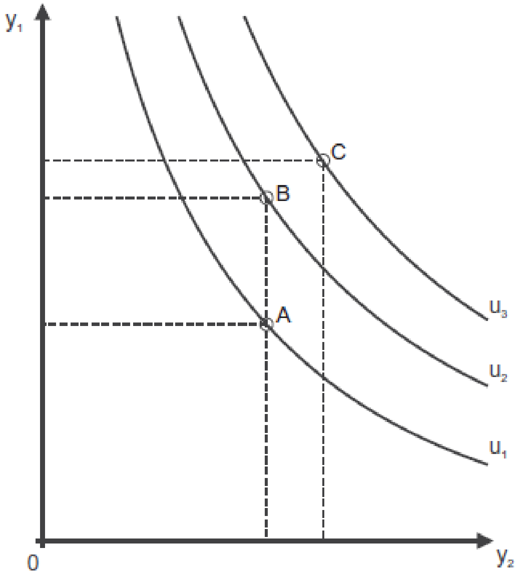

Figure 30: Indifference curve map between y_1 and y_2 (Abrahamsen and Asche, 2010)

The higher the indifference curve is located on the graph above the more satisfaction for the company. So curve U_3 is preferred from curve U_2 and U_1. The optimal level of investment in safety measures for the company can be identified by combining the opportunity frontier and the indifference curves. Such a combination is shown in the Figure 31:

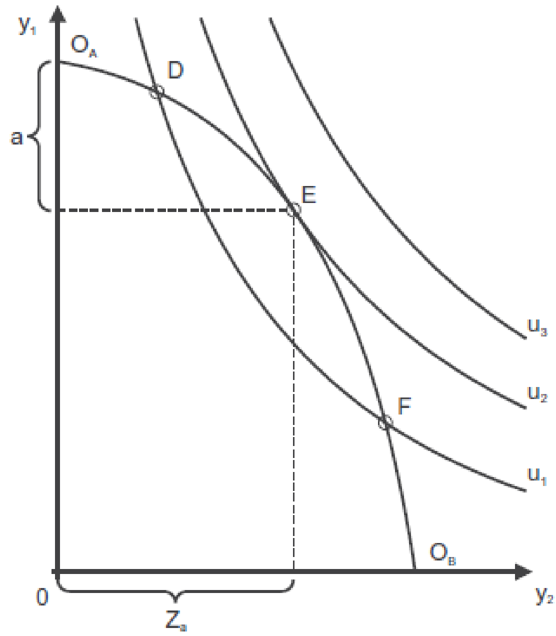

Figure 31: Optimal investment in safety measures (Abrahamsen and Asche, 2010)

From the Figure 31, we can see that point D is not the preferred one as the company can receive more satisfaction, meaning move to a higher utility curve by spending more money in the safety measures. The optimal level for this occasion is point E where the tangent of the opportunity frontier meets the tangent of an indifference curve. The total investment that should be made by the company is a and the total profit for the company in case of an accident event is Z_a.

5.2. *Investment only in insurance*

The same logic is used when assessing the option of investing on insurance rather than safety measures. The relation between the insurance premium and the payment is assumed as constant, meaning that the insurance market is fair and that there is no administration cost. Therefore, the possible combinations here of the company's assets are described by a straight line and presented below (Figure 32):

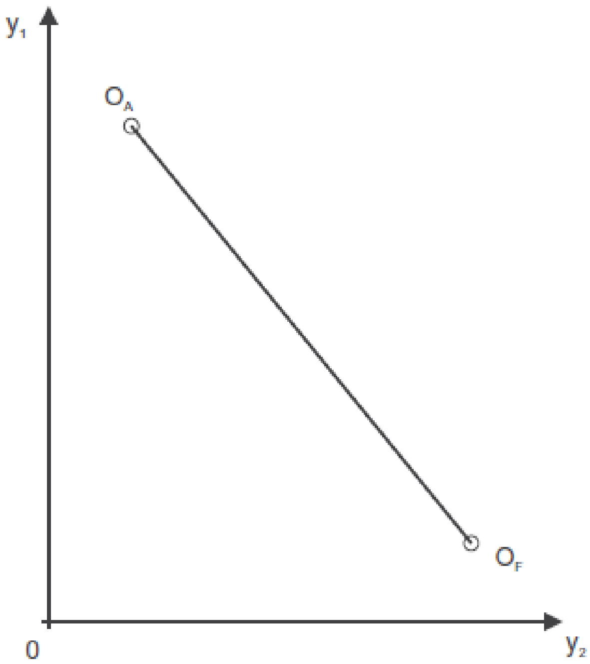

Figure 32: Possible combinations of the company's assets (Abrahamsen and Asche, 2010)

Point O_A here represents the situation that the company invests no money in insurance whereas point O_F represents the maximum investment on insurance by the company. To define the optimal point of investment on insurance by the company we combine the Figure 32 with the indifference curves as illustrated below (Figure 33):

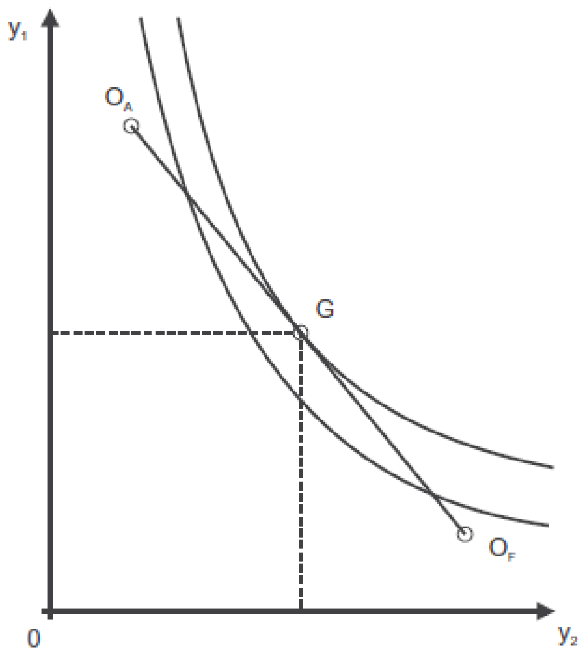

Figure 33: Optimal investment in insurance (Abrahamsen and Asche, 2010)

As in the case of investing in safety measures, same here the optimal level can be identified where the two lines have the same tangent (here the line of the combinations is a straight line, thus this is the tangent). Therefore, from the Figure 33, point G is the one representing the highest satisfaction for the company.

5.3. Investment both in safety measures and insurance

After identifying the optimal level of investment for the two cases separately (invest in safety measures and invest in insurance) we are ready to combine the two situations. This is the alternative that is commonly used in real life; as usually investments in both directions are preferred by the companies.

Combining Figures 29 and 30 in Figure 31 we can understand the influence of an insurance market when deciding the optimal investment in safety measures (Figure 34).

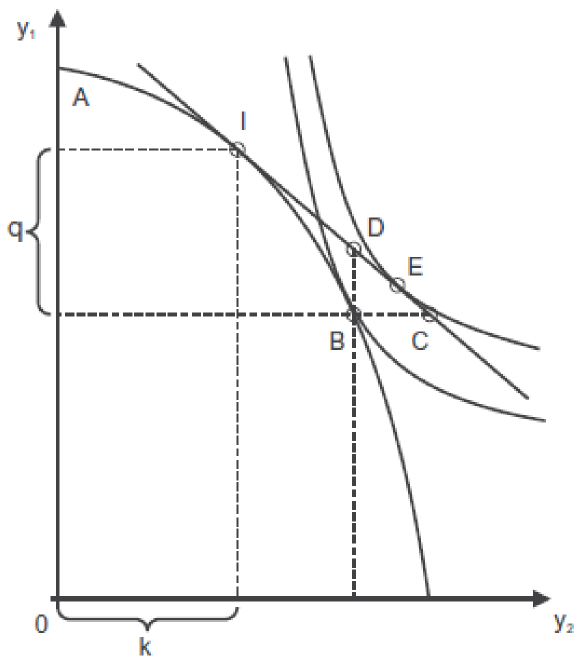

Figure 34: Optimal investment in consequence reducing measures in situations with access to an insurance market. (Abrahamsen and Asche, 2010)

A company's decision not to take any measures is represented by point A in the Figure 34. If the company decides to undertake some attempts, it should start by investing in safety measures until the point I. After this point investing further in safety measures is more expensive than investing in insurance (slope of the opportunity frontier is steeper than the insurance line's). With the same resource used, the company can get the difference between point C and B if the accident occurs and they have decided to invest in insurance. Also, if there was no access to insurance the company's maximum level of satisfaction would be point B whereas existence of insurance allows the company to move to a higher level of satisfaction, point E.

6. <u>INSURANCE</u>

In this chapter, we refer to the insurance industry principles. First, an introduction to the insurance in the cruise ship industry is presented. Then the specifications and the limitations of the insurance for the cruise ships in the Arctic region are discussed before finally, introducing the factors that could drive the cost of an insurance premium in the Arctic waters.

6.1. Introduction to insurance in the cruise ship industry

The cruise industry was always considered a milestone of the tourism industry. Thousands of passengers are travelling every year by cruise vessels all around the world. Thus, there was always a significant interest by both ship-owners and insurance companies on how to create some standardized methods on insuring the ships and the passengers on those voyages.

However, there is an irregularity here, as cruise insurance is not considered marine insurance (Burke, 2000). To better describe cruise insurance we will have to divide that in two categories.

- The marine insurance, that includes the insurance related to the vessel and the non-human goods that are transferred by the ship.
- The personal travel insurance, which includes the insurance of the passengers that are travelling with the ship.

Figure 35: Cruise Insurance

6.1.1. <u>Marine Insurance</u>

Marine insurance is not of a recent origin. Its roots can be traced down to several centuries. The first form of marine insurance derives from Chinese merchants back to the year 3000 BC. However, the law concerning marine insurance took a definite shape with the English Marine Insurance Act on 1906.

With the term marine insurance, we mean a contract whereby the insurer undertakes to indemnify the assured, in manner and to the extent thereby agreed, against marine losses, that is to say, the losses incident to marine adventure (Marine Insurance Act, 1906)

6.1.1.1. Marine insurance types

There is a definite categorization of various types of marine insurance and of marine insurance policies, as the area of marine insurance is very broad. According to the needs and the requirements of the assurer, one or more types of marine insurance and marine insurance policy can be selected.

The marine insurance types are:

- Hull insurance
- Cargo insurance
- Protection and Indemnity insurance (P&I)

Hull Insurance

The hull and machinery insurance is to protect the ship owner's investment in the ship. It is basically, a property insurance, which covers the ship itself the machinery and the equipment. Furthermore, the insurance covers some liabilities, normally collision liability with another ship and sometimes, also liability for colliding with other objects (Wilhemsen, 2010) (Talley, 2011).

Typical claims include:

- Total loss of the ship
- Damage to the ship, engines and equipment
- Explosion and/ or fire
- Collisions – damage sustained to the ship and sometimes liability towards the other ship (if the colliding object is another ship)
- Grounding
- Etc.

Cargo Insurance

According to the marine hull clauses, cargo on a vessel is excluded, as it does not form part of a vessel. The cargo or marine cargo insurance covers physical damage to, or loss of the ship owner's goods while in transit by land, sea and air. It also includes the belongings of a ship's voyagers. The owner of the goods shipped through waterways uses it. If the cargo is ruined, the owner gets the indemnity from the insurance company (Wilhemsen, 2010) (Talley, 2011)

Typical claims include:

- Total loss, shortages or damage at the port
- Total loss, shortages or damage during the voyage
- Salvage charges of goods
- Export and import shipments by ocean
- Damages from bad weather
- Seawater or freshwater flooding
- Etc.

Protection and Indemnity Insurance (P&I)

Protection and Indemnity insurance, or P&I as it is usually called, is a ship owner's insurance cover for legal liabilities to third parties. Third parties are any person, apart from the ship-owner himself, who may have a legal or contractual claim against the ship. Protection and indemnity insurance is usually arranged by entering the ship in a mutual insurance association, usually referred to as a club. Ship-owners are members of such clubs. Legal liability is decided in accordance with the laws of the country where an accident takes place. The P&I insurance cover for contractual liability is agreed at the time the owner requests insurance cover from the club and is usually in accordance with the owner's responsibility under crew contracts or special terms relating to the trading pattern of the vessel.

Other risks covered include liability for stowaways, liability for oil pollution and other types of pollution and legal liability for wreck removal if the ship sinks and is blocking free navigation for other vessels. In short, P&I insurance is a very comprehensive type of insurance cover which makes it easier for a ship owner or charterer to trade in international shipping transportation.

P&I insurance also covers the owner's liability for loss of crew belongings in cases of shipwreck or fire on board. The cover only applies to items which are deemed to be reasonable for any crew member to have with him on board. A crew member travelling with unusually expensive items, such as laptop computers, gold watches etc. should make sure that he has such items separately insured (Jaiswal, 2016)

6.1.1.2. Marine insurance policies

Another important parameter of an insurance contract is defining the insurance policy that is going to be followed by the insurer and the ship-owner. Some common policies identified in the bibliography are (Marine Insurance Act, 1906) (Giaschi, 2010) (Jaiswal, 2016):

- *On the basis of time period*

a) Time policy
b) Voyage policy
c) Mixed policy

- *On the basis of value of the insured subject matter*

a) Unvalued or open policy
b) Valued policy

- *On the basis of description of insured ships, goods or subject matter*

a) Unnamed policy
b) Named policy
c) Fleet policy
d) Floating policy
e) Blanket policy
f) Policy Proof of Interest (PPI)
g) Block policy

(The definition of the policies is given in italics as defined by the aforementioned authors).

Time policy

The policy which is designed for a specific period of time is known as time policy. A marine insurance policy is valid for a specified time period generally valid for a year. All the marine perils during that period are insured. This type of policy is suitable for full insurance. The policy is generally taken for one year although it may be for less than one year. But there is no restriction to make this type of policy for less than one year. This policy is more commonly used for hull insurance than for the cargo insurance. The ship is insured for a fixed period irrespective of voyages.

Voyage policy

This policy gives more importance to the voyage. A voyage policy is the type of marine insurance policy, which is valid for a particular voyage. It covers the risk from the port of departure up to the port of destination. This type of policy is considered more useful for cargo. The insurance company should give indemnity for loss/ damage of any property of the insured during the period of the voyage. The liability of the insurer continues during landing and re-shipping of the goods. The policy ends when the ship reaches the port of arrival.

Mixed policy

The joint form of voyage policy and time policy is called mixed policy. In this policy, the elements of voyage policy and of time policy are combined. The reference is made certain period after completion of the voyage. The meaning of the mixed policy is that a new policy *combines the fundamental things of time and the place policy. Generally, this policy is used for ship insurance. This policy expires whichever is met first, time or place.*

Unvalued or open policy

In this type of marine insurance policy, the value of the cargo and consignment is not put down in the policy beforehand. The value thus left to be decided later on is called the unvalued or open policy. The insurable value of the policy includes the price of the insured's property, investment price, incidental expenditure and all the other expenditure as well .The unvalued policy is not used in practice so much. This policy is used only P&I insurance.

Valued policy

The opposite of an open marine insurance policy is a valued policy. In this type of policy, the value of the cargo and consignment is decided and mentioned in the policy document beforehand, thus, making clear about the value of the reimbursements in case of any loss to the cargo and consignment. Generally, the insured amount in this type of policy includes the price of cargo, ship, freight and approximate profit. Thus, the value which is mentioned in the policy is the insured amount.

Unnamed policy

The marine policy in which the name of the ship, the name of the voyage and the name of the route are not mentioned beforehand.

Named policy

The policy, which is issued by mentioning the name of the ship, the name of the voyage, the name off the route and the price of the cargo, is called named policy. This type of policy has been receiving popularity in marine insurance.

Fleet policy

When a single policy is taken for a group of vessels, the policy is known as fleet policy. This policy is popular for ship-owners that own a big amount of vessels with similar characteristics.

Floating policy

The floating policy is also called declaration policy. This policy is useful for the merchant who delivers cargo regularly. When a person ships goods regularly in a particular geographical area, he will have to purchase a marine policy every time. It involves a lot of time and formalities. He purchases a policy for a lump sum amount without mentioning the value of goods and name of the ship etc. It is the agreement between the insurer and insured that the insured declares a number of goods on the basis of shipment documents.

Blanket policy

In such a policy the type of the goods and the geographical boundaries have been decided. Under this policy the amount is indemnified for a fixed time period to the insured. The policy is *taken to cover losses within the particular time and place. The policy is taken for a certain amount and premium is paid on the whole of it in the beginning of the policy and is re-adjusted at the end of the policy according to the actual amount at risk. If the actual coverage of risk is less than the total amount of insurance, the premium related to the excess amount is returned to the insured. On the other hand, if the amounts of shipments are greater than the insured sum, additional premium is charged over the excess protection.*

Policy proof of Interest (PPI)

The policy is issued to avoid the complication of the principle of insurable interest. These are called Policy Proof of Interest and are honored by the insurer even in absence of insurable interest. This policy is based on mutual understanding, so, it is called honored policies. This is also called wagering policies because insurable interest is not required and consequently it cannot be legally enforceable.

Block policy:

It is the policy, which takes the risk in the block that is from sea route and land route. It does not only protect from the risk of the marine route but also covers the risk occurred on the land too. It takes the risk of transportation from the place of the seller to the place of the buyer. It is considered very useful policy to the landlocked countries.

The procedure for a ship owner to obtain a marine policy can be categorized in six steps:

1. *Selection of the marine insurance company*, where the ship owner has to select the marine insurance company that he wants to be insured with.
2. *Submission of marine declaration form*, where the ship owner has to submit all the information regarding his/ her vessel, the information of the voyage (e.g. place, time, ports that the vessel will visit, etc.).
3. *Risk assessment from the insurance company*, where the insurance company is assessing and weighting all the risks relevant to the trip and the vessel involved before defining the rate of the insurance premium that has to be paid by the insured, i.e. the ship owner.
4. *Payment of the premium*, where the insurer has to pay the fee set by the insurance company.
5. *Issue of the cover note*, where after the acceptance of the proposal and payment of premium, the insurance company issues a receipt, which is called cover note until the policy is issued.
6. *Issue of policy*, where the official policy is obtained from the ship owner and the vessel is insured for the voyage.

The aforementioned marine insurance types and marine insurance policies are presented to give an overall picture of the different alternatives that a ship-owner has, when it comes to insuring his vessels. Respectively, the cruise ship-owners are obliged, according to the international law and the national regulations of each country, to have specific type of insurance and insurance policy depending on the specifications and the details of the upcoming voyage of their vessel.

6.1.2. Travel Insurance

As we have already mentioned in the subchapter 6.1.1 the cruise insurance cannot be considered as solely marine insurance. It is better described as the "sum" of the marine insurance and the travel insurance. The marine insurance as part of the cruise industry will cover any losses and/or damages relevant to the vessel and the goods transported by that, whereas the travel insurance is till this day personal for each passenger of the ship and many times not mandatory, i.e. someone is not obliged to have a travel insurance to participate in a cruise as travel insurance is rather an option of the traveler.

With the term "travel insurance" we refer to an insurance product designed to cover the costs and losses, and reduce the risk associated with unexpected events that someone might incur while traveling. Many online companies selling airplane tickets or travel packages allow consumers to purchase travel insurance as an added service. Some travel insurance policies cover damage to personal property, rented equipment or even the cost of paying a ransom in the case of a kidnapping (Centers for Disease Control (U.S.), 2013) (Leggat et al., 1999).

According to the Insurance Information Institute (Insurance Information Institute, 2017) (Investopedia, 2016) the main categories of travel insurance include:

- Trip cancelation/interruption
- Baggage/personal effects coverage
- Major medical expenses
- Accidental death/flight accident

The part describing different components of the travel insurance is given in italics as these were defined by other authors (Centers for Disease Control (U.S.), 2013), (Investopedia, 2016):

Trip cancelation/Interruption

As its name implies, trip cancelation insurance (sometimes known as trip interruption insurance or trip delay insurance) reimburses someone for prepaid, nonrefundable travel expenses if a trip has to be canceled due to an illness, a death of a family member or another mishap listed in the policy. This type of policy also kicks in if the vendor (airline, cruise line or tour operator) goes bankrupt. The insurance pays the difference between the refund someone get from the vendor and the amount that originally someone paid for the trip.

Policies differ in terms of which reasons are acceptable, but it is fairly typical for this insurance to cover cancelation or interruption for the following reasons:

- *Sudden business conflicts*
- *Change of mind*
- *Delay in processing visa or passport*
- *Illness or injury*
- *Weather-related issues*

Some policies may include additional coverage, which would insure a client against one or more of the following events:

- *An act of terrorism*
- *An accident on the way to the airport*
- *Jury duty*

And some policies offer "cancel for any reason" coverage for an additional cost.

Baggage Insurance/Personal Effects Coverage

This type of insurance provides coverage if an insured person's belongings are lost, stolen or damaged during your trip, including while traveling to and from his destination.

Major Medical expenses

This insurance can help the insured cover medical expenses and locate doctors, healthcare facilities and foreign-language services. It covers airlift to a medical facility because of an accident or sudden illness, if the insured is sick or injured and have to spend an extended time in a foreign hospital, or if there is a need of repatriation receive proper care – something known as a medical evacuation. There are two basic types:

- *Travel medical insurance provides only short-term medical coverage; the duration can be anywhere from five days to up to one year, depending on the policy.*
- *Major medical insurance is for travelers who are planning to take longer trips of six months to one year or longer.*

Accidental Death and Flight Accident

Similar to life insurance, in the event of an accident resulting in death, disability or serious injury to the traveler or a family member traveling with him or her, this type of policy pays benefits to surviving beneficiaries.

6.2. Cost drivers of the cruise ship insurance industry in the Arctic region

In this subchapter, the specifications and the limitations that the Arctic waters pose to the cruise ship insurance industry are presented and how these influence the cost of an insurance premium. We follow the same rule with the subchapter 6.1 to define the cruise insurance, namely we divide that in i) Marine insurance and ii) Travel (personal) insurance. First, we discuss the Arctic region's influence on the marine insurance (i.e. the insurance that refers to the vessel, the equipment, etc.) and then we discuss the alternations, which raise the costs of a (personal) travel insurance in the Arctic.

6.2.1. Arctic region cost drivers of the marine insurance

The risks associated with the shipping are well known and understood by the insurance companies and the underwriters. However, the risks related to the Arctic shipping are not fully assessed. Thus, the question that arises is how do insurance companies react regarding the challenge of evolving Arctic shipping? The lack of data and standardized methods regarding the assessment and the modeling of the risks, as well as the poor background knowledge create a big challenge for the insurance companies. This leads the underwriters to work on a case-by-case basis that vastly increases the cost of the insurance premium. Thus, the sustainability of the Arctic expeditions is strictly dependent on the cost of the marine insurance and the industry calls for more standardized procedures.

The most important criterion that influences the cost of the insurance premium is the ice class of the vessel. It is definite that insurance companies will be extremely reluctant to insure ships not designed for navigation in potentially iced waters. Companies will ensure that the hull and machinery will not be extremely prone to cold weather conditions and possible sea ice. (Sarrabezoles et al., 2014) (Lasserre and Pelletier, 2011). In August 2006, the International Association of Classification Societies (IACS) released a document, titled the Unified Requirements for Polar Ships, which standardized global ice classification specifications for vessels as follows in Table 3.

Table 3: Polar Class descriptions (International Association of Classification Societies, 2016)

Polar Class	Ice descriptions (based on WMO Sea Ice Nomenclature)
PC 1	Year-round operation in all polar waters
PC 2	Year-round operation in moderate multi-year ice conditions
PC 3	Year-round operation in second-year ice which may include multiyear ice inclusions
PC 4	Year-round operation in thick first-year ice which may include old ice inclusions
PC 5	Year-round operation in medium first-year ice which may include old ice inclusions
PC 6	Summer/autumn operation in medium first-year ice which may include old ice inclusions
PC 7	Summer/autumn operation in thin first-year ice which may include old ice inclusions

Expect from the aforementioned polar classes the insurance companies can ask for specific ice classes (Sarrabezoles et al., 2014). The Table 4 presents the correspondence between the ice classes, as described by the different classification societies.

Table 4: Approximate correspondence between Ice Classes of the Finnish-Swedish Ice Class Rules (Baltic Ice Classes) and the Ice Classes of other Classification Societies (Baltic Sea Ice Services, 2016)

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

Another factor that could influence the cost of an insurance premium in the Arctic is the winterization of the vessels. Winterization is a process, which enables vessels to operate in extreme sub-zero temperatures without suffering loss of equipment operability, vessel stability and power, and personnel habitability, and permits crew operations to be performed safely (Ghosh and Rubly, 2015).

Class regulations require equipment and systems to be winterized. Some of those specific winterizations as presented by Hasholt (2011) are: the use of low-temperature non-brittle grade steel, ice removal equipment such as steam lances, under-deck heating, trace heating for walkways, stairs, and handrails, protective machinery covers, heating arrangements for drain piping and fluid systems, heated cargo and tank vent covers; heated ballast tanks; low temperature working fluids, heated mooring equipment; heated cargo manifolds; low temperature electrical cables and installations, low temperature emergency generators and essential safety systems, internal space heating, low temperature fire-fighting equipment, enclosed and heated lifeboats, and ice navigation radar and dedicated ice searchlights (Hasholt, 2011), (Ghosh and Rubly, 2015).

Lack of intact stability enhancements, improved communications systems and adequate survival equipment are all reasons that the price of an insurance premium would increase. Communication systems and stability play an important role in the Arctic region. The remoteness of the area highlights the need for survival equipment able to help the passengers to survive for a period of five days (IMO, 2016). Inability of the ship-owner to prove that there is adequate survival equipment for all the travelers can for instance lead to cancelation of an insurance contract.

Furthermore, the planned route, the time of the year and the probable ice concentration/movement at that time can drive upwards the cost of the insurance premium. For example, an insurance company will probably give a more expensive insurance premium to a ship-owner when the voyage is planned during May rather than September, when the ice concentration and movement is at the lowest point of the year (Lasserre, 2014).

One of the most important criteria for an area like the Arctic, where we lack sufficient knowledge, is the captain's and crew's experience (Sarrabezoles et al., 2014). According to Sarrabezoles et al., after interviewing several companies that offer marine insurance for the Arctic, most firms said trust in the shipping company is important, and therefore they might be reluctant to insure firms that do not have experience in Arctic shipping. Some of them said they will examine every submission but evaluate the preparedness of the shipping firm, the crew experience, charts accuracy and contingency planning in case of problems. However, for the majority of the firms it is clear there is a strict inspection of the shipping firm's past behavior and safety-related policy. This means that the insurance company expects to see the proof that the shipping firm is able to perform well in Arctic waters (Sarrabezoles et al., 2014) (Lasserre and Pelletier, 2011).

Finally some additional cost drivers of an insurance premium in the Arctic region are identified by Marsh (MARSH RISK MANAGEMENT RESEARCH, 2014) and presented in the Figure 36 below, such as restricted visibility due to fog and other weather conditions, ice buildup on the deck and hatch covers can de-stabilize the vessel, etc.

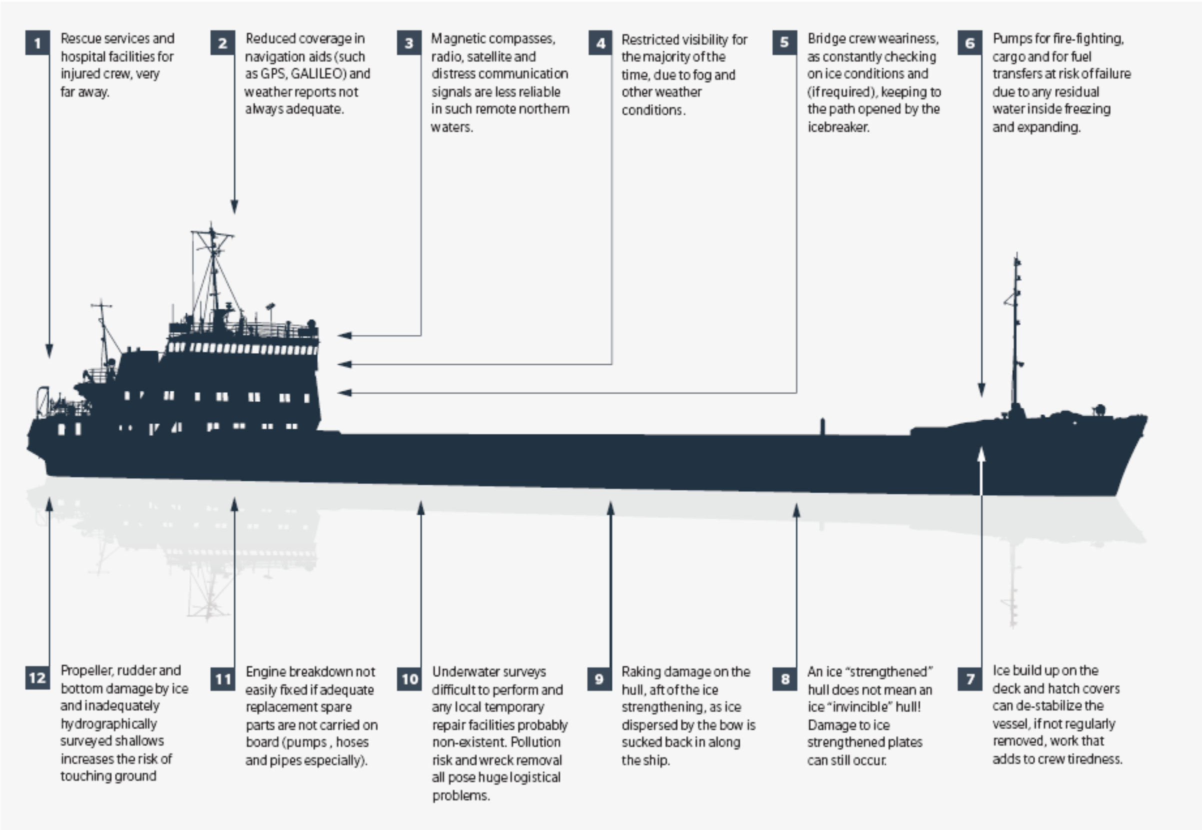

Figure 36: Polar ship risk (MARSH RISK MANAGEMENT RESEARCH, 2014)

6.2.2. <u>Arctic region cost drivers of the travel insurance</u>

In the previous subchapter, we have seen how the Arctic region particularities can dramatically raise the cost of an insurance premium for a ship-owner. As it is easily understandable, in the cruise industry this cost is divided down to passengers via the high amount of money that an Arctic voyage costs.

Though, there is a more direct way that travelers have to spend extra money due to a polar voyage. This comes through the travel insurance. Travel insurances, as mentioned in the subchapter 6.1.2, cover medical expenses of the travelers when they are travelling that usually are not covered by the health insurance (medical expenses when abroad).

However, most of the insurance companies, so as to give travel insurance to a person travelling in the Arctic, usually will insist the traveler to have a separate Search and Rescue coverage. That coverage is usually offered by third party search and rescue companies that provide evacuation services and the cost of acquiring this kind of special insurance is most of the times extensive. Even some of those third party evacuation companies put extra limitations to travelers, such as age limitation (usually below 70), that do not allow passengers to travel to areas like the Arctic, Antarctica, Himalaya, etc.

Safety is always the most important aspect of an operation, trip, etc. and should by no means be sacrificed for lowering the costs. Thus, Search and Rescue insurance should be mandatory when someone is traveling to remote areas like the Arctic. It is also understandable that the cost for an individual to purchase this kind of insurance is vast. However, the remoteness of the region and the extreme weather conditions call for better Search and Rescue operations, provided either by the Arctic states, or by private companies that will have an agreement with the ship-owners.

7. <u>DISCUSSION</u>

In this chapter, the overall discussion of this thesis report takes place. We elaborate initially, on the status of the cruise traffic in the Arctic before referring to the challenges that this environment poses. The importance of the real-life experience of the Search and Rescue exercise (SARex 2) in the hazard identification process is pointed out. Finally, we discuss regarding the insurance for the cruise ship industry in the Arctic region.

7.1. Arctic cruise challenges and evacuation hazards

As we have mentioned and documented before in Chapter 2.3.2., Arctic cruises are becoming more and more popular between travelers. Due to the special characteristics and the hostile environment of Arctic, the cruise season is normally open from the middle of May to the middle of September. Even though conditions are considerably better during this period of the year than during the winter months, cruise vessels should always expect to encounter some unexpected challenges regarding the weather conditions. It is not an unusual phenomenon during those expeditions to encounter sea ice or even icebergs, which, combined with poor visibility, because of thick fog conditions, waves and strong winds could constitute a real threat for the cruise ships. Thus, expedition and cruise vessels operating in the Arctic waters must be able to withstand such weather conditions with a proper ice or polar class design (see Chapter 6.2.1).

However, even if a ship is certified as having a proper class to operate in the Arctic environment, there is always the danger of an unexpected event. We have several examples from the past when a cruise ship had to perform an evacuation due to an accidental event – either a collision or a grounding or even a mechanical failure that could create stability problems of the vessel – even in areas that are not as hostile as the Arctic.

A case of an emergency where an evacuation needs to be conducted in the Arctic differs a lot compared to an evacuation in any other place on the planet. The remoteness of the area, high wind speeds, large waves, low temperatures and fog, all create challenging situations, which call for increased attention on both the evacuation procedure and the survival equipment that a cruise vessel carries on board. The Polar Code asks for a survival rate of five days, as the remoteness of the area combined with the harsh weather conditions that may occur could increase the time of a search and rescue operation.

The risks related to a vessel operating in the Arctic waters are sufficiently known (e.g. sea ice, icebergs, communication problems, grounding, etc.). However, there is poor knowledge regarding hazards of the evacuation procedure and the survival. The SARex 2 research trip was a first rated experience of a real case scenario that helped the author understand in detail the challenges and the risks that exist throughout this procedure. Risk mitigation measures that could decrease the probability of occurrence or the severity of the consequences, given that an unexpected event occurs, were identified during the research exercise.

During the Preliminary Hazard Analysis (PHA), described in Chapter 4 and fully presented in Appendix A, we have divided the operation of the evacuation and the survival in five phases according to the time of the exercise. The first phase refers to the time from the alarm until the passengers gather to the muster station. During this phase, the passengers will have to move from the different areas of the ship to the muster stations to be evacuated. Finding and getting to the correct muster station are two of the main challenges of this phase. Thus, proper training of all the passengers should be conducted before the trip, in order for everyone to know the escape routes on board. However, the fact that most of the cruise passengers are elderly people that could possibly need assistance to move, highlights the importance of proper training of the crew of the vessel. The condition of the passageways (slippery) can create additional problems to the passengers moving to the muster stations. The Polar Code requires the exposed escape routes to be accessible and safe when taking into consideration the potential icing of structures and the snow accumulation. This can be achieved with walkways being sheltered or heated or covered with friction material.

Figure 37: Snow accumulation on heli-deck of KV Svalbard during 2016 exercise @Trond Spande

The requirement to a survival period of five days highlights the importance of the equipment carried on board. The cruise ship owners must equip their vessels with sufficient number of lifeboats and liferafts that could accommodate all the passengers on board. Except from the survival crafts, special attention must be given to the personal survival equipment. In a case a wet evacuation the survival suits the Personal Survival Kit (PSK) and the General Survival Kit (GSK) are of vital importance. Ship owners must make sure not only to provide sufficient number of insulated survival suits, PSKs and GSKs, but also survival suits in different sizes that could cover all the body-types of the passengers. One important observation that was made during the author's stay in a liferaft in the Arctic waters for approximately 30 hours was the influence of the appropriate clothing under the survival suit. The high humidity after several hours could penetrate the insulated survival suits and the presence of woolen underwear kept the passengers dry. However, in a case of emergency it would be difficult for all the passengers to attend their cabins to wear woolen clothes. Thus, one important recommendation that is not stated in the existing regulatory framework is the presence of integrated woolen underwear in the survival suit.

The second phase describes the boarding of the passengers to the lifeboats and the liferafts. In an evacuation scenario, some injuries or some panicked passengers due to the emergency should be expected. This, combined with the high probability of the presence of elderly people, underlines once again the emphasis that must be given to the proper crew training for emergency situations. Crew members should be able to control the crowd and help people board on the lifeboat. They should also make sure that every passenger brings his/ her PSK along in the survival craft.

The launching of the lifeboats and liferafts is the subject of phase three. The failures that can occur on the survival equipment during the launching (i.e. mechanical failures, failure of inflating system of the liferaft, power shutdown of the launching, etc.) highlights the importance of proper maintenance of the equipment. Ship owners are responsible to conduct maintenance and tests on the survival equipment at regular intervals. In addition, they should verify that there is a proper vessel design with side dumping systems that could protect the passengers from a possible crush between the vessel and the lifeboat, while the latter being launched.

Phase four includes the operation and the survival in the lifeboats and liferafts and is divided in three sub phases – the lifeboat operation and survival, the liferaft operation and survival and the survival logistics. Regarding the operation and survival in the lifeboat and the liferaft, there have been several observations, identified through the author's stay in both types of the survival crafts during SARex 2 and presented in detail in Appendix A. Almost, all of the hazards identified highlight the value of the proper design of the survival crafts and the proper leadership on board during the survival.

One of the most important findings of the SARex 1 exercise was the need for a better design of the survival crafts that could reduce the influence of the low temperature and the humidity on the survivability rate of the passengers. In this year's exercise (SARex 2) improved models of the lifeboat and the liferaft were used during the exercise. The lifeboat had an integrated heating system that could help increase the temperature levels when needed, while the liferaft was designed with a double-layer bottom inflated with air between the two layers and a double-layer roof. These improvements made a huge impact in this year's results. In the 2016 exercise only two participants (out of 20) stayed in the lifeboat after 24 hours, whereas in the 2017 exercise most of the participants stayed on board for 27 hours with a potential of considerable further extension in the time that they could survive. In the liferaft, during the 2016 exercise the last passengers aborted the exercise after 18 hours and only one person was fit to stay longer than 24 hours, while during the 2017 exercise the first participant aborted the exercise after 24 hours and several participants were fit to stay beyond the 29 hours limit that the exercise was aborted due to the risk of weather conditions (See Chapter 3). The comparison between the body temperatures of the participants for the two years are shown in Figure 38.

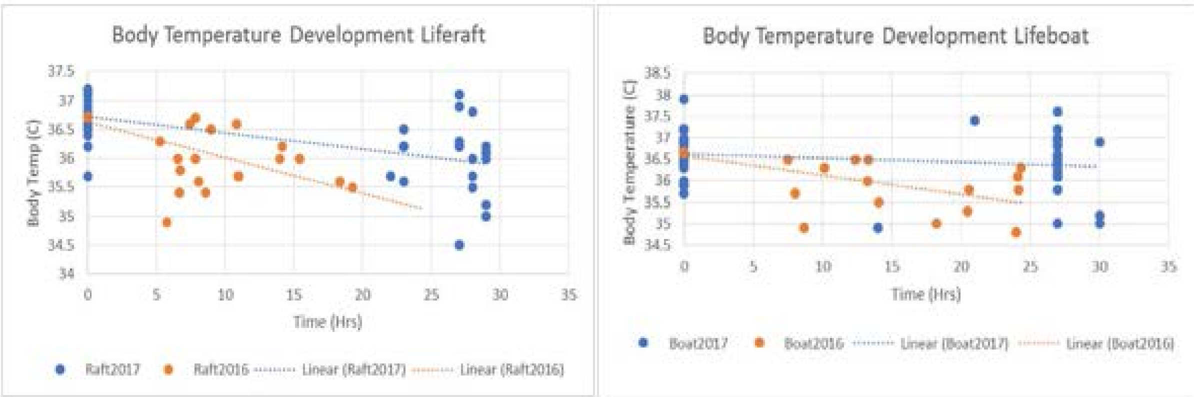

Figure 38: Body temperature measurements for life raft and lifeboat in 2016/2017 (Gudmestad et al., 2017)

Vessel owners together with the survival equipment manufacturers must confirm that the crafts are properly designed, maintained and equipped for operating in Arctic waters. It has been noted during the SARex 2 exercise that there was an overestimate of the capacity of the crafts from the manufacturers, as there was not enough space for the people to sit or move around with the survival suits, which created back pains, discomfort and lack of sleep. The lifeboat was designed to accommodate 50 people and the liferaft 25. During the survival test the lifeboat was filled with 40 people and the liferaft with 19. However, even though the number of people in both survival crafts was below the utilized capacity stated by the manufacturers there was clearly not enough space to move around the craft, which is vital to reduce the probability of blood clots and fatigue. The capacity calculations are based on the standard IMO definition of a standard maximum linear width of 430 mm and a body weight of 75 kg. Yet, these calculations are clearly not representative and are not taking into consideration the existence of the extra space needed when passengers are wearing survival suits. Taking also into account that a big percentage of cruise passengers are usually elderly people, reducing the number of passengers in the survival crafts by at least 20% is of great importance to increase the probability of survival. In addition, the food and water rations provided were not sufficient to meet the five days survival rate stated by the Polar Code and almost all the passengers lost two to three kilograms in less than 30 hours mainly due to the lack of sufficient water.

Figure 39: Raft designed for 25 passengers crowded with 19 persons on board. Limited space for activities to maintain good circulation and heat @Andreas Kjøl

The presence of at least one well trained officer in each liferaft and lifeboat must be mandatory. Strong leadership is needed throughout all the three sub phases of phase four. The captain of the survival craft should be in charge of not only operating the craft and communicating with the other lifeboats and liferafts, but also should encourage passengers and help them build relations that could prove vital for their survival. In addition, the presence of more than one medical doctor is suggested for the arctic cruise expeditions. The number proposed is proportionate to the number of the survival crafts, in order to divide them in the crafts in case of emergency.

The final phase describes the rescue of the passengers either by helicopter or by a rescue vessel. During SARex 2 an additional test was conducted with a helicopter evacuation. During this evacuation, the hatches of the lifeboat did not allow transferring of injured people by stretchers. Improved lifeboat and liferaft design must be implemented in order to allow the survival of injured or older people with stretchers. Finally, the proper training and the competence of the rescuers for harsh weather situations should be verified.

After discussing the findings of the risk analysis conducted in Chapter 4, we feel there is a need to make a special reference to a risk mitigation measure that could vastly increase the overall probability of passengers' survival. Most of the aforementioned identified challenges are linked with the extension of the survival time of the passengers due to the harsh weather conditions and the remoteness of the Arctic region. Thus, the estimated time of rescue in Arctic waters could last several days (up to five according to The Polar Code). In order to solve this problem, in our opinion, a "buddy" system should be implemented for cruise vessels in the Arctic. With this system, two vessels will travel at small distance with each other, so as in case of an emergency in one of the vessels, its passengers could be almost instantly transferred to the other vessel. In this way, the challenges related to the long time survival rate could be avoided and the passengers could safely be transferred to the closest harbor.

However, this system could have some potential drawbacks. For example, the buddy system could be implemented on small to average sized expedition ships (up to 1000 people), but it would be problematic in cases of large cruise ships of more than 3000 passengers, as there would not be enough space in the other ship to accommodate all the passengers. Another potential disadvantage of this system is that it 'creates risk' for two vessels at the same time. Cruise ships in the Arctic could face harsh weather conditions, as we have already mentioned, such as drifting ice. With this system, there is a simultaneous risk of crushing into sea ice for both vessels, as they would be operating in the same area at the same time. Thus, the author's opinion is that the buddy system would be a very beneficial solution for small to average sized vessels, but probably should be more carefully implemented in larger cruise ships. Hence, adequate and proper survival equipment including lifeboats, liferafts, survival suits, etc. should in no case be decreased but buddy system should rather work as an additional safety barrier in case on an emergency.

7.2. Arctic cruise insurance policies

In this subchapter, we discuss the policies of the arctic cruise insurance. The limitations that the insurance companies should put to the ship owners in order to offer insurance for their vessels are presented. Finally, we debate on which are the cost drivers and how could they affect the price of an insurance premium.

As we have already mentioned in Chapter 6, the cruise insurance constitutes of two elements: the marine insurance and the travel insurance. With the term 'marine insurance' we mean the contract offered by an insurance company to the ship owner. With this contract, the insurer undertakes to indemnify the assured, in manner and to the extent thereby agreed, against marine losses, that is to say, the losses incident to marine adventure (Marine Insurance Act, 1906). There are specific marine insurance types and policies presented in Chapter 6.1.1, which the cruise ship-owners are obliged to have, according to the international law and the national regulations of each country, depending on the specifications and the details of the upcoming voyage of their vessel.

On the other hand, travel insurance is considered as the insurance product designed to cover the costs and losses of the passengers, and reduce the risk associated with unexpected events that someone might incur while traveling. There are again here different types that cover the specific needs of the travelers.

The insurance companies decide on whether they should offer insurance to a ship owner according to their policies. It depends on the risk appetite if they are going to offer an insurance premium to a cruise vessel owner, meaning that it depends on the 'amount' and type of risk that a company is willing to take in order to meet their strategic objectives. An insurance company can be defined as: a) risk-averse when the company dislikes risk and will stay away from adding high risk investments to their portfolio, b) risk-seeking when the company prefers to take some high risk investments and c) risk-neutral when the company is seeking for high risk investments but at an average level.

As we have shown in Chapter 5, insurance is an alternative of investing in safety measures offered in order transfer risk to a third party (insurance company). However, Arctic is a very hostile environment that we lack sufficient knowledge. Even though, there are no specific limitations stated by the regulatory framework in the Arctic, in order for a ship owner to obtain insurance, we strongly believe that there should be some minimum requirements that should be covered prior to an Arctic expedition.

It is quite often, that the ship owners are trying to save money from safety measures investments by buying insurance. In order to make Arctic expeditions safer, there should be some limitations for them to obtain insurance. The main requirement that they must cover is to have a sufficient polar or ice class certified vessel for traveling in the Arctic. A vessel should not be allowed to operate in the Arctic area unless, it is certified that it is eligible for the area. Another limitation should be the shipping's firm competence in Arctic shipping. There should be a strict investigation of the firm's past behavior related to the safety policies. For example, if a shipping firm have neglected safety issues in previous trips and put at risk passengers lives, then they should not be offered an insurance contract. Furthermore, before given the right to a ship owner to insure his vessel for an Arctic voyage there should be a thorough inspection of the vessel and at what extent the ship owner has covered the requirements for the survival equipment. An insurance company must deny insuring a ship that does not have sufficient lifeboats and liferafts for all the passengers; modified to suit the Arctic needs (i.e. winterized). Another example could be the lack of adequate insulated survival suits, as well as Personal Survival Kits (PSKs) and General Survival Kits (GSKs). An insurance company could protect themselves against wrongdoing or neglect on safety issues by the shipping firm by stating specific terms in the insurance premium that put the blame on the ship owner in case of an accidental event which occurred due to negligence from the ship owner.

But then there is an important question arising: Should those limitations regarding the shipping firm depend only on the insurance company's interpretation? As we have already stated there are insurance companies that are considered risk seeking, meaning that they are willing to take high risks in order to have profits. Thus, it is of great importance these limitations to be included in a legally binding agreement. There must be a regulatory framework between the Arctic countries and the ship owners interested to operate in Arctic waters that state specific limitations for the vessels not only in terms of operating in the Arctic but also in terms of obtaining insurance coverage. This way, the ship owner can be made responsible in case of an accidental event that involves neglect or wrongdoing from the shipping firms side.

After presenting the limitations that should apply for the Arctic voyages, we will now discuss the influence of specific factors identified in Chapter 6.2.1 on the insurance premium. Arctic waters pose a great threat for the ships and the poor knowledge regarding the hazards related to this hostile environment leads to increased insurance premiums. However, there are specific factors that could dramatically lower the price of the agreement.

We have already stressed the importance of a vessel being polar or ice class certified before an Arctic voyage. Thus, the higher the polar and / or ice class of a vessel is the lower the price of the insurance premium offered by the insurance company. This is reasonable, as the higher the ice class of a vessel the higher the capacity of the vessel to withstand harsh weather conditions and avoid any accidental events. Furthermore, winterization could play a crucial role in lowering the price. Sheltered pathways, under-deck heating, heated mooring equipment, low temperature emergency generators, ice navigation radar, ice searchlights, etc. are all elements that could drive the cost of an insurance premium down. The more from the aforementioned elements a cruise ship has the more 'winterized' it is and the less is the price of the premium. Each element has specific importance for operating in the Arctic and all together constitute the winterization of the vessel. For example, if a vessel is considered 40% winterized then there could be an agreement with the insurance company to lower the insurance premium price by 5%-10%.

The presence of enhanced communication systems and adequate survival equipment could also dramatically lower the overall price of an insurance premium. Improved communication systems could prevent loss of communication during harsh weather that could be vital for the cruise ship. Being equipped with sufficient number of lifeboats, liferafts, survival suits, PSKs and GSKs is one of the limitations stated above. However, improving ever more the survival suits by adding integrated woolen underwear and providing sized for all the passengers could lead to an insurance company's decision to lower their offer, as the severity of the consequences in case of an unexpected event are reduced.

Another important cost driver of the insurance premium is the crew members' experience and training. The higher the training and the experience of the crew the lower the price offered by the insurance company. We have identified how crucial the proper leadership is, in extreme environments and emergency situations during our participation in the SARex 2. Thus, the insurance premium offered to a vessel with a captain with strong experience in Arctic voyages and crew that have received proper training prior to the voyage, would be much lower than a vessel whose captain has no relevant experience.

The time of the year and the route that the cruise ship is planning to take can also influence the insurance premium. For instance, a trip planned during August would have lower insurance premium than a trip planned during the beginning of the Arctic cruise season in May. This because the probable ice concentration and ice movement during August would be lower than the corresponding ice concentration and ice movement during May.

Finally, each traveler should have a private travel insurance when traveling. However, as we have seen in Chapter 6.2.2. most of the private travel insurance companies require travelers to have separate Search and Rescue coverage. This coverage can raise the price for the traveler up to double or sometimes triple compared to the initial travel insurance cost. Furthermore, it is not unusual for those third party companies that offer search and rescue coverage, to put extra limitations to travelers, such as the age or the area that they provide coverage. Thus, it is of significance importance that the ship owners would acquire such a search and rescue coverage for all their passengers. This way, the insurance premium provided by the insurance company would decrease, as there would be higher chances of survival in case of an accidental event and thus lowest severity of the consequences. The private travel insurance premium of the travelers would also decrease. However, the ship owners will have to undertake extra cost for the search and rescue coverage.

After discussing the limitations that must be covered before a ship owner is eligible for insurance and the cost drivers that could influence the cost of an insurance premium we will elaborate on the procedure that should be followed, in our opinion, in determining an insurance premium. As we have already mentioned in Chapter 6.1.1.2. in order a cruise ship owner to obtain an insurance policy, six steps need to be followed. The insurance company determines the insurance premium during the third step and after the ship owner has submitted all the relevant information for the vessel and trip to be insured. The insurance premium cost can fluctuate between different insurance companies as it depends on the company's strategy (i.e. risk-averse, risk-seeking, risk-neutral) and the profit that the company seeks out of this insurance contract.

However, there should be a standardized procedure that all the insurance companies should follow before putting a value on the insurance contract, regardless of the final price. Initially, and after receiving all the relevant information by the ship owner through the marine declaration form, an insurance company should check if the shipping firm covers the limitations of obtaining insurance (polar/ ice class, life equipment, etc.). If those limitations are covered, then a qualitative risk analysis should follow, where the hazard identification and the weighting of the risks take place. After identifying the possible hazards and its related consequences, a quantitative risk analysis should follow, where according to the data for the region of the trip concerned and the background knowledge of previous incidents, a probability number must be assigned to each risk. Then, by using the information obtained by the shipping firm (e.g. ship design information, winterization of the ship, quality and quantity of survival equipment, etc.), adjustments should be made to the probabilities linked with the specifications of the shipping firm. For example, a vessel that does not have lifeboats with integrated heating system will be assigned a higher probability for the risk of people getting cold due to low temperatures than a vessel equipped with lifeboats with heating system. Thus, the insurance premium will be lower for the second vessel as the passengers have higher probability of surviving and the insurance company takes lower risk. After, having adjusted the probabilities according to the specifications provided by the ship owner, different accidental scenarios should be evaluated using different methods (Event Tree Analysis, Bayesian Networks, etc.) and a cumulative level of risk should be extracted from each scenario. Finally, the percentage of profit that the company wants to have should be added to the price of the premium decided by the insurance company, according to the overall risk picture of the ship. It is finally of great importance for the insurance company to execute a self-assessment of the vessel sending its own surveyors to check the design and the equipment of the cruise ship.

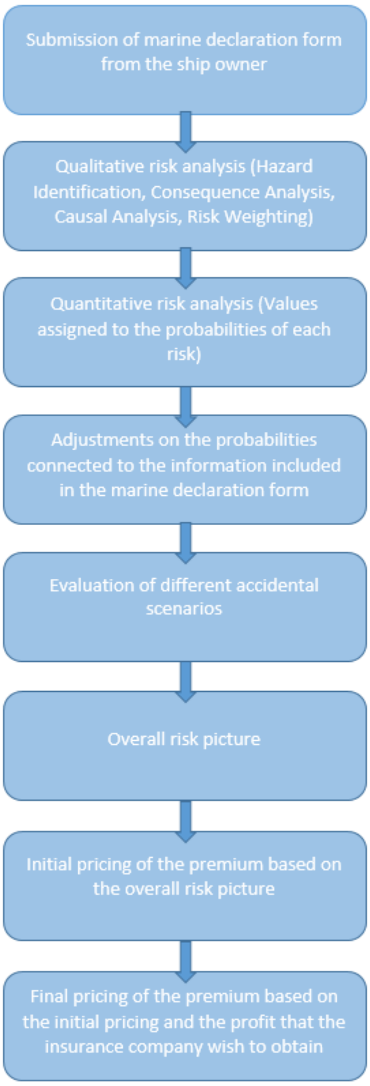

Figure 40: Flow chart of suggested insurance premium procedure

A cruise ship operator is thinking about lowering the costs and will, most likely, only want to fulfill the minimum requirements stated by the legal framework. However, if the requirements are very strict and conservative, it might make the vessel owners stop their arctic cruise business. Having first-class survival equipment that could fit every passenger on a cruise ship of more than 2000-3000 passengers could be quite expensive. The level of safety regarding the cruise trips in the Arctic waters should be obtained and secured by all means, and should not be sacrificed for lowering the costs. Thus, there must be a conscious effort by the legislators to secure top levels of safety in the Arctic cruise traffic while at the same time they do not act conservatively and overestimate the presence of extra safety measures.

8. CONCLUSION

In this chapter, we present the conclusions of this master's thesis report. The findings derive from the literature review, the Search and Rescue exercise conducted of north of Svalbard in May 2017, the risk analysis and the discussions on the cruise insurance policies of the Arctic waters.

Even though Arctic cruises are gaining in popularity, the Arctic region remains a hostile environment, where we lack sufficient background knowledge and data for determining insurance premium. There are many hazards related to the cruise traffic in the Arctic, and even more challenges arise in case of an accidental event during the voyage. Strong winds, high waves, low temperatures, navigational problems and human related mistakes can all lead to disastrous events.

Thus, special attention should be given to the life-saving appliances and the evacuation procedure. The remoteness of the area and the Polar Code highlight the importance of prolonged survival periods (up to five days) in a harsh environment like Arctic. A proper evacuation plan and adequate training of the crew members for Arctic conditions must be prioritized before the trip. Sufficient survival equipment, including winterized lifeboats and liferafts, insulated suits modified for the Arctic conditions, personal survival kits and general survival kits should be in place on board. The cruise vessel should be winterized polar class, with sheltered walkways and heated surfaces that could prevent icing, low temperature emergency power generator and systems to prevent icing and low temperatures, in order to allow passengers to be evacuated. A proper maintenance at regular time intervals of all the exposed equipment is also needed.

The lifeboats and the liferafts must be properly equipped with sufficient food and water for five days and comfort requirements that would allow the evacuated passengers to move, so as to keep higher heart rate and temperature. The insulated survival suits should be accompanied by integrated woolen underwear for avoiding low core temperature in case of the survival suit is penetrated by humidity. Better design of the lifeboats and the liferafts with bigger hatches and openings that would allow rescue of the injured people or the people unable to move with stretchers. Finally yet importantly, special attention should be given in informing and training all the passengers for the hazards the Arctic poses, prior to their trip.

The second objective of this thesis was to present the insurance policies that should be followed in the Arctic region. Specific limitations must be implemented through a legislation framework that unless they are covered by the ship owners, forbid the signing of an insurance coverage. Ice and/ or polar class certification, thorough background check and inspection of the vessel and adequacy on survival equipment must all be included as mandatory limitations before insuring a cruise vessel for an Arctic voyage.

Different factors can influence the cost of an insurance premium between a shipping firm and an insurance company, with the most important being the level of winterization of the cruise vessel, the level of training of the shipmaster and the crew members and the coverage of the search and rescue procedure of the passengers in case of emergency.

8.1. Suggestions for further research

After presenting the conclusions of this thesis, in this subchapter we suggest ideas for future work related to our topic:

- Perform new qualitative risk analyses with different methods.
- Create a platform, where Arctic data would be easily gathered and accessible.
- Perform quantitative risk analyses that would give a more detailed picture on the probability of occurrence of a risk and its related consequences.
- Possible innovations on the lifeboat and the liferaft design, and the overall survival equipment.
- Detailed work on a new regulatory framework of the insurance policies regarding the Arctic region.
- A standardized procedure to execute the pricing of an insurance premium for a cruise ship in the Arctic waters.

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APPENDIX A

Preliminary Hazard Analysis

Phase one: Alarm to muster station						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
1.1	Passengers attend wrong muster station or cannot find the muster station	- Lack of information before starting the cruise - Poor information regarding evacuation routes onboard - Lack of clear thinking from the passengers due to dangerous/ stressful situation	- Delay on evacuation - Passengers do not reach the correct muster station	**Probab.: 3 Conseq.: B**	- Proper passengers' training programs (e.g. via e-learning) - Better crew training - Posters showing the evacuation routes	**Probab.: 2 Conseq.: B**
1.2	Slippery/ crowded/ blocked passageways, stairs and other routes used on evacuation	- Wet or iced surfaces caused by atmospheric or sea spray - Nonfunctional areas due to smoke, accidents, etc. - Overcrowded areas	- Passengers get trapped and do not reach the muster station - Injuries from falling	**Probab.: 3 Conseq.: C**	- Sheltered and heated outside areas (passageways, muster stations, etc.) - Friction materials used on the floor of outside areas - Wider passageways that can serve more passengers at the same time	**Probab.: 1 Conseq.: C**
1.3	Unavailability of a muster station	- Blocked route to the muster station - Muster station damaged and nonfunctional	- Not enough space in the other muster stations -Not enough evacuation means and equipment in the other muster stations (lifeboats/ liferafts, personal equipment, etc.)	**Probab.: 2 Conseq.: C**	- Alternative plan to organize passengers in the other muster stations - Extra evacuation means and equipment in each muster station	**Probab.: 2 Conseq.: B**

Phase one: Alarm to muster station						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
1.4	Inadequate passenger evacuation equipment (e.g. survival suits, inappropriate/ not woolen clothing, PSK, GSK, etc.)	- Lack of clear thinking from the passengers due to dangerous/ stressful situation - Captain/ crew error of not checking PSK and GSK availability - Polar Code risk assessment does not require PSK/ GSK	- Reduced survival period of the evacuated passengers	**Probab.: 4 Conseq.: D**	- Better crew training - Polar Code requirements - Woolen underwear fit with the survival suits - Survival suits, PSK/ GSK adequate and easy accessible	**Probab.: 3 Conseq.: B**
1.5	Insufficient number of lifeboats/ liferafts or lack of capacity	- Poor planning - Shipowner/ Captain did not follow the regulations for the proposed number and capacity of lifeboats and liferafts - PSK, GSK and the survival suits need extra space	- Some passengers are not evacuated - Chaotic situation (all the passengers will try to get on the lifeboats/ liferafts) - Possible loss of human lives - Overcrowding existing lifeboats and liferafts which would eventually be dangerous for all the passengers	**Probab.: 3 Conseq.: D**	- Follow regulations regarding the proposed number and capacity of the lifeboats/ liferafts - Proper planning of the capacity needed including PSK, GSK and survival suit	**Probab.: 1 Conseq.: D**

Phase two: Boarding (Lifeboats and Liferafts)						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
2.1	Passengers not capable of evacuating without assistance	- Minor or major injuries - Elderly or people with movement problems that need assistance for evacuating to lifeboat or liferaft - Complicated boarding procedure	- Delay on evacuation - Some passengers are not evacuated - Chaotic situation	**Probab.: 5 Conseq.: B**	- Proper passengers' training programs (e.g. via e-learning) with special information for elderly or people with movement problems - Better crew training - Easy accessible evacuation routes and procedures for all the passengers	**Probab.: 3 Conseq.: B**
2.2	Panicked passengers	- The evacuation situation is considered stressful for the passengers	- Minor or major injuries - Overcrowded lifeboats and liferafts	**Probab.: 5 Conseq.: A**	- Proper crew training for crowd control situations - Clear and easy evacuation procedures that will reduce passengers' panic	**Probab.: 3 Conseq.: A**
2.3	Lifeboats/ liferafts not usable	- Lifeboats/ liferafts damaged (due to collision, fire, etc.)	- Some passengers are not evacuated - Chaotic situation (all passengers try to get on the lifeboats/ liferafts) - Possible loss of human lives - Overcrowding existing lifeboats and liferafts which would eventually be dangerous for all the passengers	**Probab.: 2 Conseq.: C**	- Alternative means of evacuation (e.g. extra liferafts)	**Probab.: 2 Conseq.: B**

Phase two: Boarding (Lifeboats and Liferafts)						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
2.4	Not enough officers for boarding in each lifeboat/ liferaft (at least one is recommended to lead each evacuation mean)	- Poor crew training - Many officers are unable of evacuating	- Lack of experience and leadership during all the stages of survival - Reduced survival period of the evacuated passengers - Possible loss of human lives	**Probab.: 5 Conseq.: B**	- Proper passengers' training programs informing them how to get organized in the lifeboat/ liferaft (e.g. via e-learning) - Better crew training	**Probab.: 4 Conseq.: A**
2.5	Injuries of passengers while boarding	- The boarding procedure is complicated and need physical competences - Lack of clear thinking from the passengers due to dangerous/ stressful situation	- Reduced survival period of the injured passengers	**Probab.: 4 Conseq.: B**	- Easy accessible evacuation routes and procedures for all the passengers	**Probab.: 3 Conseq.: B**
2.6	PSK/ GSK not brought along in lifeboat/ liferaft by the evacuated passengers	- Lack of information before starting the cruise - Lack of clear thinking from the passengers due to dangerous/ stressful situation		**Probab.: 3 Conseq.: C**	- Proper passengers' training programs (e.g. via e-learning) - Proper crew training in order to make sure that the passengers have their survival equipment	**Probab.: 2 Conseq.: C**

Phase three: Launching of Lifeboat or Liferaft						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
3.1	Mechanical failure (Lifeboat)	- Icing on mechanical components of the ship or lifeboat (e.g. crane) - Poor maintenance -Material fatigue/ corrosion	- Lifeboat launching cannot be conducted -Cables break - Uncontrollable fall into the sea - Injuries and/ or loss of human lives	**Probab.: 3 Conseq.: D**	- Proper maintenance - Sheltered/ heated mechanisms and components related to launching	**Probab.: 1 Conseq.: D**
3.2	Failure of inflating system (Liferaft)	- Icing on mechanical components of the ship (e.g. inflating system) - Poor maintenance -Material fatigue/ corrosion	- Liferaft launching cannot be conducted - Uncontrollable fall into the sea - Injuries and/ or loss of human lives	**Probab.: 3 Conseq.: D**	- Proper maintenance - Sheltered/ heated mechanisms and components related to launching	**Probab.: 1 Conseq.: D**
3.3	Impossible launching of the lifeboat/ liferaft	- Thick ice around the ship - Ship tilt to one side make launching from this side impossible	- Impossible launching of lifeboat/ liferaft	**Probab.: 2 Conseq.: C**	- Use alternative evacuation techniques to evacuate passengers on the ice - Use the equipment on the other side of the ship	**Probab.: 2 Conseq.: B**
3.4	Uncontrollable movements of lifeboat during lowering	- Ship motions - Harsh weather conditions - Unbalanced spreading of the passengers in the lifeboat	- Smashing of the lifeboat with the ship or other lifeboats/ liferafts - Injuries and/ or loss of human lives	**Probab.: 3 Conseq.: C**	- Proper spreading of the passengers in the lifeboat - Dumping systems on the side of the lifeboat that can reduce the consequences of a possible crush - Passengers using seatbelts when onboard	**Probab.: 3 Conseq.: B**

Phase three: Launching of Lifeboat or Liferaft						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
3.5	Power shutdown for the launching procedure	- Power/ Electricity of the ship is out because of the accident	- Lifeboat/ liferaft launching not possible	**Probab.: 2 Conseq.: D**	- Emergency power system - Alternative system for launching (e.g. gravity systems)	**Probab.: 1 Conseq.: D**
3.6	Passengers jumping into the sea to board in the liferafts	- Lack of inflatable slide to safely transfer passengers into the sea - Lack of clear thinking from the passengers due to dangerous/ stressful situation	- Injuries and/ or loss of lives	**Probab.: 4 Conseq.: C**	- Ensure inflatable slides to safely transfer passengers from the ship to the sea	**Probab.: 4 Conseq.: B**

Phase four(a): Operation and survival (Lifeboat)						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
4a.1	Engine failure	- Poor maintenance - Icing on mechanical components of the lifeboat - No fuel	- Lifeboat unable to maneuver away from the ship - Lifeboats unable to tow liferafts away from the ship - Lifeboat stuck in sea ice - Lifeboat drifts uncontrollably in the sea (danger of getting crashed from sea ice) - Heating system cannot function without the engine - Reduced survival period of the passengers	**Probab.: 3 Conseq.: C**	- Proper maintenance of the lifeboat - Back-up engine -Ensure that lifeboats are equipped with fuel	**Probab.: 2 Conseq.: B**
4a.2	Fire	- Engine fire - Electrical fire	-Loss of propulsion, heater - Smoke in vessel - Need to abandon lifeboat	**Probab.: 2 Conseq.: E**	- Install fire extinguisher connected directly to engine compartment - Install extinguishing hole to the engine department to extinguish fire without opening the door of the compartment	**Probab.: 2 Conseq.: C**

Phase four(a): Operation and survival (Lifeboat)						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
4a.3	Discomfort due to sitting position	- Poor seating design - Extended period in same sitting position	- Health problems and injuries such as: Pain (back, bottom) reduced blood circulation, headache, irritability, cold extremities	**Probab.: 4** **Conseq.: A**	- Handles to hold onto above seating area giving the possibility to stretch, move and change seating position with other passengers at certain intervals - More ergonomic design for seats (inclination angle for back rest)	**Probab.: 3** **Conseq.: A**
4a.4	Condensation	- No insulation between cold outside air and warm inside air - Lack of condensation management system (collection etc.) - Warm temperature created from the heater and the survival suits leading to increased sweating	- Poor visibility through windows (navigational issues) - Discomfort	**Probab.: 3** **Conseq.: A**	- Possibility to utilize heat from heat-exchanger to defrost window (valves from heated fan onto window) - Insulate windows and top of boat - Improved condensation management and possibility to collect condensation (can be used for drinking water) - Hatch on roof of vessel for improved ventilation and navigational purposes	**Probab.: 2** **Conseq.: A**
4a.5	High temperature inside the lifeboat	- Survival suits -Heater - insufficient ventilation	-Sweating and associated condensation - Discomfort	**Probab.: 4** **Conseq.: B**	- Temperature management	**Probab.: 3** **Conseq.: B**

Phase four(a): Operation and survival (Lifeboat)						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
4a.6	Low temperature inside the lifeboat	- Low outside temperature - Heating system not working - Few people	- Core body temperature decreases (hypothermia)	**Probab.: 3 Conseq.: C**	- Survival suits and PPE requirements of Polar Code -Insulated seats - Tarp or canopy to isolate empty areas of lifeboat and maintain heat	**Probab.: 2 Conseq.: B**
4a.7	Insufficient/ blocking of ventilation system	- Warm humid air condenses on cold surfaces	- Condensation from ceiling - Poor air circulation	**Probab.: 2 Conseq.: B**	- Improved ventilation design	**Probab.: 1 Conseq.: B**
4a.8	Poor visibility	- Condensation inside - Icing on the outside of windows - Fog, snow	- Poor visibility leading to navigational issues	**Probab.: 4 Conseq.: B**	- Anti-icing, heated and angular windows - Improved ventilation system -Insulated windows and walls - Hatch in roof of cockpit - Searchlights	**Probab.: 3 Conseq.: B**
4a.9	Maneuvering and navigation difficulties	- Lack of navigational information - Harsh weather conditions - Insufficient maneuvering during towing of the liferafts due to the small distance between rudder axis and towing point	- Running aground - Collision with other lifeboats/ liferafts or icebergs - Difficulty in optimizing heading to minimize movement	**Probab.: 3 Conseq.: B**	- Hydrographic, weather and ice information - Optimized lifeboat design for arctic conditions	**Probab.: 2 Conseq.: B**

Phase four(a): Operation and survival (Lifeboat)						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
4a.10	Sea spray	- Open hatches (e.g. for extra ventilation, saving people from the sea, etc.)	- Passengers get wet and cold - Water inside the lifeboat	**Probab.: 4 Conseq.: A**	- Improved ventilation design - System for draining water from the lifeboat	**Probab.: 3 Conseq.: A**
4a.11	Icing	- Sea spray or rain combined with low temperatures	- Hatches, hinges and other components get stuck - Blocking of ventilation system	**Probab.: 3 Conseq.: B**	- Winterized lifeboat design	**Probab.: 3 Conseq.: A**
4a.12	Internal communication	- Noisy environment - Poor visibility from operating station/ cockpit	- Difficulty distributing information	**Probab.: 4 Conseq.: A**	- Speaker, whistle, megaphone depending on the size of the lifeboat	**Probab.: 1 Conseq.: A**
4a.13	External communication	- Communication device not available/ working - Poor visibility	- No detection during search	**Probab.: 2 Conseq.: C**	- AIS-transponder - Brackets for transponder on roof for increased range	**Probab.: 1 Conseq.: C**
4a.14	Lack of sleep	- Disorganized area - Uncomfortable seating - Stressful situation	- Fatigue	**Probab.: 4 Conseq.: B**	- Vessel capacity should adhere to ergonomic needs. Storage for personal belongings (food, water and survival suit). - More ergonomic design for seats (inclination angle for back rest) - Sleeping pills	**Probab.: 3 Conseq.: B**

Phase four(a): Operation and survival (Lifeboat)						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
4a.15	Seasickness	- Excessive vessel motions (especially roll) - Reduced visibility	-Dizziness, apathy, vomiting, cognitive impairment, reduced positivity	**Probab.: 4 Conseq.: C**	- Anti-seasickness medicine - Vessel design (bilge keels), possibility to see outside vessel	**Probab.: 2 Conseq.: C**
4a.16	Injuries while using the pyrotechnics	- Use of flares etc. for signaling purposes	- Major or minor injuries -Fire	**Probab.: 2 Conseq.: E**	- Need for PPE in the pyrotechnical container (gloves and glasses) - Additional first-aid equipment	**Probab.: 1 Conseq.: D**
4a.17	Insufficient/ obsolete and loose equipment	- Lack of basic equipment	- Unable to dry wet areas - Other function difficulties	**Probab.: 3 Conseq.: A**	- Include sponges, trash bags, sea-sickness bags, paper towels, sunglasses (polarized) for crew for watch-keeping purposes	**Probab.: 2 Conseq.: A**
4a.18	Insufficient/ obsolete medical equipment	- Injured passengers - Passengers that need special medication	- Unable to treat injured - Possible loss of human lives Unable to dry wet areas. House-keeping onboard. Snow blindness	**Probab.: 3 Conseq.: D**	-Supply lifeboat with basic medical equipment - Passengers that need special medicines should be advised during the training to carry their medicine with them Include sponges, trash bags, sea-sickness bags, paper towels. Review existing list of required loose equipment. Include sunglasses (polarized) for watch-keeping purposes	**Probab.: 2 Conseq.: C**

Phase four(a): Operation and survival (Lifeboat)						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
4a.19	Lack of diesel fuel or clogging of the filter	-Diesel fuel not made for cold climate - Not enough fuel for maximum expected days of survival	- Diesel engine stop working - Heater stop working	**Probab.: 4 Conseq.: C**	- Winterized fuel and/or heating of lifeboat at all times in storage position	**Probab.: 3 Conseq.: C**
4a.20	Potentially dangerous wildlife (e.g. polar bear, whale, etc.)	- Wild animals can attack from hunger, curiosity, injury, feeling threatened, etc.	- Damaging lifeboat - Injury and/ or loss of human lives	**Probab.: 1 Conseq.: C**	- Weapons - Lookout patrols - Bear sprays	**Probab.: 1 Conseq.: B**
4a.21	Lack of food/ water	- The LSA requirement not enough for 5 days survive - Poor distribution of the food/ water in rations	- Starvation - Dehydration	**Probab.: 5 Conseq.: D**	- Ensure lifeboat has enough food/ water for the maximum passenger capacity for a 5 days survive - Proper training of the crew	**Probab.: 2 Conseq.: D**
4a.22	Operational management	- Inadequate training and instructions - Inefficient communication	- Reduced positivity, physical health, house-keeping	**Probab.: 4 Conseq.: C**	- Increased training with emphasis on the importance of effective management in cold climate operations (Passengers may not be aware of relevant needs for survival)	**Probab.: 3 Conseq.: C**

Phase four(b): Operation and survival (Liferaft)						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
4b.1	Discomfort due to sitting position	- Difficulties in standing and moving around - Extended period in same sitting position - Overcrowded	- Health problems and injuries such as: Pain (back, bottom) reduced blood circulation, headache, irritability, cold extremities - Falling and stumbling	**Probab.: 4 Conseq.: A**	- Handles and grips on the tubes to hold onto above seating area giving the possibility to stretch, move and change seating position with other passengers at certain intervals - Limit the amount of passengers	**Probab.: 3 Conseq.: A**
4b.2	Condensation	- No insulation between cold outside air and warm inside air - Lack of condensation management system (collection etc.) - Warm temperature created from passengers wearing the survival suits	- Water comes into the raft - Discomfort	**Probab.: 3 Conseq.: A**	- Double layer fabric all around the liferaft - Improved condensation management and possibility to collect condensation (can be used for drinking water)	**Probab.: 2 Conseq.: A**
4b.3	Water leakage from the floor or the roof	- Leakage from valves in the floor - Floor of raft was in contact with the water	- Passengers getting cold - Food and equipment getting wet	**Probab.: 5 Conseq.: C**	-Double bottom floor - Improved valves and waterproof zippers - Centralized drainage system and manual drainage pumps - More and bigger sponges and buckets	**Probab.: 3 Conseq.: B**

Phase four(b): Operation and survival (Liferaft)						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
4b.4	High temperature inside the liferaft	- Survival suits - Insufficient ventilation	-Sweating and associated condensation - Discomfort	**Probab.: 3 Conseq.: B**	- Temperature management	**Probab.: 2 Conseq.: B**
4b.5	Low temperature inside the liferaft	- Low outside temperature - Few people	- Core body temperature decreases (hypothermia)	**Probab.: 4 Conseq.: C**	- Survival suits and PPE requirements of Polar Code -Insulated pads - More survival bags - Personal heating systems (e.g. heat-bags for the hands)	**Probab.: 3 Conseq.: B**
4b.6	Poor visibility	- Lack of windows - Condensation inside - Fog, snow	- Poor visibility leading to navigational issues	**Probab.: 4 Conseq.: B**	-More lookout windows - Transparent material on the side and the roof - Searchlights	**Probab.: 2 Conseq.: B**
4b.7	Maneuvering and navigation difficulties	- Lack of navigational information - Harsh weather conditions - Lack of oars	- Running aground - Collision with other lifeboats/ liferafts or icebergs	**Probab.: 4 Conseq.: A**	- Hydrographic, weather and ice information - Optimized lifeboat design for arctic conditions - Include oars - Include towing and lifting point considering the full capacity of the liferaft	**Probab.: 3 Conseq.: A**
4b.8	Sea spray	- Non waterproof zippers allow water inside the liferaft	- Passengers get wet and cold - Water inside liferaft	**Probab.: 5 Conseq.: B**	- System for draining water from the liferaft -Waterproof zippers	**Probab.: 4 Conseq.: B**

Phase four(b): Operation and survival (Liferaft)						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
4b.9	Icing	- Sea spray or rain combined with low temperatures	- Zippers get stuck	**Probab.: 3 Conseq.: B**	- Winterized liferaft design	**Probab.: 2 Conseq.: B**
4b.10	External communication	- Communication device not available/ working - Poor visibility	- No detection during search	**Probab.: 3 Conseq.: C**	- Include AIS-transponder - Brackets for transponder on roof for increased range	**Probab.: 2 Conseq.: C**
4b.11	Lack of sleep	- Disorganized area - Uncomfortable seating - Stressful situation	- Fatigue	**Probab.: 4 Conseq.: B**	- Vessel capacity should adhere to ergonomic needs. Storage for personal belongings (food, water and survival suit). - Sleeping pills	**Probab.: 3 Conseq.: B**
4b.12	Seasickness	- Excessive vessel motions (especially roll) - Reduced visibility	-Dizziness, apathy, vomiting, cognitive impairment, reduced positivity	**Probab.: 4 Conseq.: C**	- Anti-seasickness medicine - Vessel design (bilge keels), possibility to see outside vessel	**Probab.: 2 Conseq.: C**
4b.13	Injuries while using the pyrotechnics	- Use of flares etc. for signaling purposes	- Major or minor injuries -Fire	**Probab.: 2 Conseq.: E**	- Need for PPE in the pyrotechnical container (gloves and glasses) - Additional first-aid equipmen	**Probab.: 1 Conseq.: D**
4b.14	Potentially dangerous wildlife (e.g. polar bear, whale, etc.)	- Wild animals can attack from hunger, curiosity, injury, feeling threatened, etc.	- Damaging liferaft - Injury and/ or loss of human lives	**Probab.: 1 Conseq.: E**	- Weapons - Lookout patrols - Bear sprays - If possible use only lifeboats	**Probab.: 1 Conseq.: D**

Phase four(b): Operation and survival (Liferaft)						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
4b.15	Insufficient/ obsolete and loose equipment	- Lack of basic equipment - Lack of storage space	- Unable to dry wet areas - Missing and wet equipment - Breakage of equipment (passengers sitting on top of the equipment)	**Probab.: 3 Conseq.: A**	- Include sponges, trash bags, sea-sickness bags, paper towels, sunglasses (polarized) for crew for watch-keeping purposes, throwing rope, holding rope - Storage nets on the roof and walls	**Probab.: 2 Conseq.: A**
4b.16	Insufficient/ obsolete medical equipment	- Injured passengers - Passengers that need special medication	- Unable to treat injured - Possible loss of human lives	**Probab.: 3 Conseq.: D**	-Supply liferaft with basic medical equipment - Passengers that need special medicines should be advised during the training to carry their medicine with them Include sponges, trash bags, sea-sickness bags, paper towels. Review existing list of required loose equipment. Include sunglasses (polarized) for watch-keeping purposes	**Probab.: 2 Conseq.: C**
4b.17	Operational management	- Inadequate training and instructions - Inefficient communication	- Reduced positivity, physical health, house-keeping	**Probab.: 4 Conseq.: C**	- Increased training with emphasis on the importance of effective management in cold climate operations (Passengers may not be aware of relevant needs for survival)	**Probab.: 3 Conseq.: C**

Phase four(b): Operation and survival (Liferaft)						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
4b.18	Lack of food/ water	- The LSA requirement not enough for 5 days survive - Poor distribution of the food/ water in rations	- Starvation - Dehydration	**Probab.: 5 Conseq.: D**	- Ensure lifeboat has enough food/ water for the maximum passenger capacity for a 5 days survive -Improved water gathering systems inside the liferaft - Proper training of the crew	**Probab.: 2 Conseq.: D**

Phase four (c): Survival logistics						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
4c.1	Lifeboats and liferafts spread around uncontrollably	- No towing of the liferafts - Lack of communication	- Some lifeboats or liferafts move away from the rest creating problems in finding that during the rescue	**Probab.: 4** **Conseq.: C**	- Attach liferafts to lifeboats - Maintain a communication schedule between all the lifeboats and liferafts	**Probab.: 3** **Conseq.: C**
4c.2	Lack of communication	- No communication devices in the liferafts - Break down of communication device in lifeboat	-Lack of important information - Some lifeboats or liferafts move away from the rest creating problems in finding that during the rescue	**Probab.: 4** **Conseq.: C**	- Include communication devices in the liferafts - Improved communication device in lifeboat - personal communication devices (included in the PSK)	**Probab.: 3** **Conseq.: C**
4c.3	Lack of officers and / or doctors in a lifeboat or liferaft	- Not enough officers or doctors	- Passengers have no experienced or properly trained personnel to lead them - Lack of doctor in case of emergency	**Probab.: 4** **Conseq.: B**	- Reorganizing the people and the equipment (medicines, clothing, etc.) from one lifeboat/ liferaft to the other according to the needs - Try to maintain constant communication with a lifeboat that has an experienced officer if there are not enough to cover all lifeboats/ liferafts	**Probab.: 3** **Conseq.: B**

Phase five: Rescue						
Hazard code	**Hazard**	**Cause**	**Possible consequences**	**Pre risk reducing measures risk**	**Risk reducing measures**	**Post risk reducing measures risk**
5.1	Transfer of people from lifeboat/ liferaft to rescue vessel or helicopter	- Insufficient design of lifeboat to transfer people to another vessel or helicopter (e.g. small hatches – injured people need stretchers, older people need extra help) - Reaction of people (e.g. getting anxious or impatient to be rescued) - Harsh weather conditions	- Injuries and possible losses of human lives -Time consuming process - Falling into the sea (from boat or helicopter)	**Probab.: 4 Conseq.: D**	-Improved lifeboat/ liferaft design to accommodate rescuers - Improved lifeboat/ liferaft design for easy access with stretchers	**Probab.: 3 Conseq.: D**

APPENDIX B

Polar Code relevant parts

Introduction

3. Sources of hazards

3.1. The Polar Code considers hazards which may lead to elevated levels of risk due to increased probability of occurrence, more severe consequences, or both:

1. *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;*

2. *experiencing topside icing, with potential reduction of stability and equipment functionality;*

3. *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;*

4. *extended periods of darkness or daylight as it may affect navigation and human performance;*

5. *high latitude, as it affects navigation systems, communication systems and the quality of ice imagery information;*

6. *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 SAR facilities, delays in emergency response and limited communications capability, with the potential to affect incident response;*

7. *potential lack of ship crew experience in polar operations, with potential for human error;*

8. *potential lack of suitable emergency response equipment, with the potential for limiting the effectiveness of mitigation measures;*

9. *rapidly changing and severe weather conditions, with the potential for escalation of incidents; and*

10. *the environment with respect to sensitivity to harmful substances and other environmental impacts and its need for longer restoration.*

3.2. The risk level within polar waters may differ depending on the geographical location, time of the year with respect to daylight, ice-coverage, etc. Thus, the mitigating measures required to address the above specific hazards may vary within polar waters and may be different in Arctic and Antarctic waters.

Safety Measures

Chapter 1 – General

1.2. Definitions

1.2.7. Maximum expected time of rescue means the time adopted for the design of equipment and system that provide survival support. It shall never be less than five days.

1.5. Operational Assessment

In order to establish procedures or operational limitations, an assessment of the ship and its equipment shall be carried out, taking into consideration the following:

1. *the anticipated range of operating and environmental conditions, such as:*
    1. *operation in low air temperature;*
    2. *operation in ice;*
    3. *operation in high latitude; and*
    4. *potential for abandonment onto ice or land;*

2. *hazards, as listed in section 3 of the Introduction, as applicable; and*

3. *additional hazards, if identified.*

CHAPTER 8 – LIFE-SAVING APPLIANCES AND ARRANGEMENTS

8.1. Goal

The goal of this chapter is to provide for safe escape, evacuation and survival.

8.2. Functional requirements

In order to achieve the goal set out in paragraph 8.1 above, the following functional requirements are embodied in the regulations of this chapter:

8.2.1. Escape

8.2.1.1. Exposed escape routes shall remain accessible and safe, taking into consideration the potential icing of structures and snow accumulation.

8.2.1.2. Survival craft and muster and embarkation arrangements shall provide safe abandonment of ship, taking into consideration the possible adverse environmental conditions during an emergency.

8.2.2. Evacuation

All life-saving appliances and associated equipment shall provide safe evacuation and be functional under the possible adverse environmental conditions during the maximum expected time of rescue.

8.2.3. Survival

8.2.3.1. Adequate thermal protection shall be provided for all persons on board, taking into account the intended voyage, the anticipated weather conditions (cold and wind), and the potential for immersion in polar water, where applicable.

8.2.3.2. Life-saving appliances and associated equipment shall take account of the potential of operation in long periods of darkness, taking into consideration the intended voyage.

8.2.3.3. 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. These resources shall provide:

1. *a habitable environment;*
2. *protection of persons from the effects of cold, wind and sun;*
3. *space to accommodate persons equipped with thermal protection adequate for the environment;*
4. *means to provide sustenance;*
5. *safe access and exit points; and*
6. *means to communicate with rescue assets.*

8.3. Regulations

8.3.1. Escape

In order to comply with the functional requirements of paragraphs 8.2.1.1 and 8.2.1.2 above, the following apply:

1. *for ships exposed to ice accretion, means shall be provided to remove or prevent ice and snow accretion from escape routes, muster stations, embarkation areas, survival craft, its launching appliances and access to survival craft;*
2. *in addition, for ships constructed on or after 1 January 2017, exposed escape routes shall be arranged so as not to hinder passage by persons wearing suitable polar clothing; and*
3. *in addition, for ships intended to operate in low air temperatures, adequacy of embarkation arrangements shall be assessed, having full regard to any effect of persons wearing additional polar clothing.*

8.3.2. Evacuation

In order to comply with the functional requirement of paragraph 8.2.2 above, the following apply:

1. *ships shall have means to ensure safe evacuation of persons, including safe deployment of survival equipment, when operating in ice-covered waters, or directly onto the ice, as applicable; and*
2. *where the regulations of this chapter are achieved by means of adding devices requiring a source of power, this source shall be able to operate independently of the ship's main source of power.*

8.3.3. Survival

8.3.3.1. In order to comply with the functional requirement of paragraph 8.2.3.1 above, the following apply:

1. *for passenger ships, a proper sized immersion suit or a thermal protective aid shall be provided for each person on board; and*
2. *where immersion suits are required, they shall be of the insulated type.*

8.3.3.2. In addition, for ships intended to operate in extended periods of darkness, in order to comply with the functional requirements of paragraph 8.2.3.2 above, searchlights suitable for continuous use to facilitate identification of ice shall be provided for each lifeboat.

8.3.3.3. In order to comply with the functional requirement of paragraph 8.2.3.3 above, the following apply:

1. *no lifeboat shall be of any type other than partially or totally enclosed type;*

2. *taking into account the assessment referred to in chapter 1, appropriate survival resources, which address both individual (personal survival equipment) and shared (group survival equipment) needs, shall be provided, as follows:*
    1. *life-saving appliances and group survival equipment that provide effective protection against direct wind chill for all persons on board;*
    2. *personal survival equipment in combination with life-saving appliances or group survival equipment that provide sufficient thermal insulation to maintain the core temperature of persons; and*
    3. *personal survival equipment that provide sufficient protection to prevent frostbite of all extremities; and*

3. *in addition, whenever the assessment required under paragraph 1.5 identifies a potential of abandonment onto ice or land, the following apply:*
    1. *group survival equipment shall be carried, unless an equivalent level of functionality for survival is provided by the ship's normal life-saving appliances;*
    2. *when required, personal and group survival equipment sufficient for 110% of the persons on board shall be stowed in easily accessible locations, as close as practical to the muster or embarkation stations;*
    3. *containers for group survival equipment shall be designed to be easily movable over the ice and be floatable;*
    4. *whenever the assessment identifies the need to carry personal and group survival equipment, means shall be identified of ensuring that this equipment is accessible following abandonment;*
    5. *if carried in addition to persons, in the survival craft, the survival craft and launching appliances shall have sufficient capacity to accommodate the additional equipment;*
    6. *passengers shall be instructed in the use of the personal survival equipment and the action to take in an emergency; and*
    7. *the crew shall be trained in the use of the personal survival equipment and group survival equipment.*

8.3.3.4. In order to comply with the functional requirement of paragraph 8.2.3.3.4 above, adequate emergency rations shall be provided, for the maximum expected time of rescue.

APPENDIX C

SARex 2 participants and personal contributions

	Contributor	Institution
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	Bjørn Carlsen	Rescue man, air ambulance
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Regulators:	Jan Erik Jensen	Petroleum Safety Authority
	Erik Johann Landa	Norwegian Maritime Authority
	Turid Stemre	Norwegian Maritime Authority
	Kristian Torkildsen	Norwegian Maritime Authority
	Rune Magne Nilsen	Norwegian Maritime Authority
	Jan Reinert Vestvik	Norwegian Maritime Authority
	Johan Iseskjær	DNV GL
Persons of interest:	Andreas Kjøl	Viking Ice Consultancy/Viking Supply Ships
	Marit Brandal	Innovasjon Norge
	Lars Vollen	SARiNOR/Maritimt Forum Nord
	Jahn Viggo Rønningen	Rederiforbundet (/SARiNOR)
	Jorodd Asphjell	Member of Parliament (AP)
	Lars Gunnar Dahle	Media/Journalist

The table below shows the contribution of the participants of SARex 2:

Theme/ Name of participant:	Contributing paper
Polar Code	
Turid Stemre	Background to and implementation of the Polar Code in relation to the SARex 2
Johan Iseskær	Classification society's implementation of the IMO Polar Code
Jahn Viggo Rønningen	Lifesaving and emergency equipment; present situation on ships operating in polar waters
Execution of the Exercise	
Konstantinos Trantzas	Risk analysis for evacuation of vessels in the Arctic waters
Johannes Jacobus Boot Lars Ove Seglem	SARex 2 lifeboat test
Jørgen Dyrholm and Andreas Tolstrup Laursen	SARex 2: Use of Viking life-saving equipment in polar regions
Simen Strand/ Anders Johan Christensen	- «Livbåtførers erfaringer og betraktninger» (In Norwegian) - «Kan man overleve 5 døgn i en redningsflåte i Arktis?» (In Norwegian)
Erik Johann Landa	Safe transfer and stay in the life raft
Jan Reinert Vestvik	Safe stay in and transfer from lifeboat
Robert Brown	Recommended ways to conduct research in exercises in Arctic waters
Results	
Medical	
Bjørn Carlsen and Eivinn Skjærseth	SARex 2: Human response of participants involved in evacuation to survival crafts in a cold climate environment
Milan Cermack	Some remarks to Arctic survival
Daniel Kristoffer Johnsen Swart.	Information from thermographic cameras, general experience on heat loss and use of these data
Search Robustness	
Rune Magne Nilsen	Emergency search in arctic waters
Brian Murray and Magne-Petter Sollid	Navigational Challenges in the Spitsbergen Area
Implementation of results	
Lars Singsaas Vollen	SARiNOR and SARex Spitzbergen
Jorodd Asphjell	Relevant parts of White Paper to the Norwegian

	Parliament. Innst. 326 S (2016 – 2017) Innstilling fra justiskomiteen om Risiko I et trygt samfunn – Samfunnssikkerhet (In Norwegian)
Jan Erik Jensen	Learnings for the oil and gas industry after SARex I and II
Fred Skancke-Hansen	Report from participation in SARex 2 on behalf of UNIS and the Arctic Safety Centre
Marit Karlsen Brandal	Innovation in arctic safety equipment
Andreas Kjøl	Experiences after SARex 2, by Viking Ice Consultancy
Bjørn Ivar Kruke	Training and crisis response in a cold climate condition – the SARex 2
Kristian Torkelsen	Learnings from SARex related to Norwegian fishing vessels
Conclusions	
Knut Espen Solberg	Implications caused by SARex on the implementation of the IMO Polar Code on Survival at Sea

APPENDIX D

ESREL 2018 paper draft

In this Appendix, the draft of the paper submitted and accepted in the ESREL 2018 conference that will take place in Trondheim between 17th and 21st of June 2018 is presented. The paper is currently under revision from the ESREL board and will be finalized on 15th of February.

Considerations related to Insurance of Cruise Traffic in the Arctic Waters

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ABSTRACT: The wish of humans to explore new areas, the environmental changes and growing worldwide demand have led to an increasing popularity of the Arctic region the last years. Cruise industry is continuously evolving in this area, creating an important need for more research on the risk of operating in the Arctic Ocean. However, most insurance firms do not yet have standard procedures to evaluate risk and policies to build the insurance premiums for the Arctic cruiseship industry. In this paper, we are evaluating how an insurance firm could approach the Arctic waters. We are discussing the insurance process that should be followed and the key factors that drive an insurance premium's cost for the cruiseship industry in the Arctic. The paper refers to our participation in a survival exercise in Arctic waters during May 2017, where the objectives were to assess the capability of rescue means in cold regions.

1 INTRODUCTION

The recent years, Arctic is gaining more and more popularity due to the extraordinary environmental and developmental changes that take place in this region. Meanwhile, climate change has led to extensive thinning of sea ice, making marine access in the Arctic Ocean much easier. It is obvious that this ice reduction extents to all seasons of the year, giving the maritime industry the opportunity for extended seasons of navigation and access to new areas that were previously difficult to reach. (Guy, 2006, Lasserre, 2011, Østreng et al., 2012, Sarrabezoles et al., 2014, Lasserre and Pelletier, 2011). At the same time, global marine tourism is rising and a place of extraordinary beauty like Arctic could not stay unaffected by this trend. The potential impacts of these new marine uses - social, environmental and economic - are unknown, but will be significant. Thus, there is a great interest from both cruise ship owners and insurance companies regarding these trips. Safety is the main challenge that should be addressed for the cruise ship owners in a remote and isolated area, with harsh weather conditions and poor infrastructure and communications. When a company needs to manage the negative consequences of an accident, it can: a) take all the consequences if/when an accidental event occurs, b) reduce the probability for an accident and/or its consequences by safety measures or c) transfer the consequences of the occurrence to parties better able to carry them (i.e. buying insurance) (Abrahamsen and Asche, 2011).. As during any other operation, when planning a cruise, especially in an unfriendly environment like the Arctic, both the ship owners and the passengers have to be insured. Thus, marine and travel insurance companies are keen to increase their involvement in the Arctic cruise and this paper aims to give some considerations related to the insurance policies that should be followed in the Arctic region. The limitations that the insurance companies should put to the ship owners in order to offer insurance for their vessels are discussed. In addition, this paper presents a standardized procedure that the insurance companies should follow before putting a value on the insurance contract. Finally, we debate on which are the cost drivers and how could they affect the price of an insurance premium.

2 CRUISE INSURANCE

The cruise insurance is not considered marine insurance (Burke, 2000) but is better described as the sum of two categories: the marine insurance and the travel insurance.

With the term 'marine insurance', we mean the contract offered by an insurance company to the ship owner. With this contract, the insurer undertakes to indemnify the assured, in manner and to the extent thereby agreed, against marine losses, that is to say, the losses incident to marine adventure (Marine Insurance Act, 1906). There are specific marine insurance types and policies, which the cruise shipowners are obliged to have, according to the international law and the national regulations of each country, depending on the specifications and the details of the upcoming voyage of their vessel.

On the other hand, travel insurance is considered as the insurance product designed to cover the costs and losses of the passengers, and reduce the risk associated with unexpected events that someone might incur while traveling. There are again here different types that cover the specific needs of the travelers.

In this subchapter, we discuss the policies of the arctic cruise insurance. The limitations that the insurance companies should put to the ship owners in order to offer insurance for their vessels are presented. Finally, we debate on which are the cost drivers and how could they affect the price of an insurance premium.

Figure 1: Cruise Insurance

3 LIMITATIONS

The insurance companies decide on whether they should offer insurance to a ship owner according to their policies. It depends on the risk appetite if they are going to offer an insurance premium to a cruise vessel owner, meaning that it depends on the 'amount' and type of risk that a company is willing to take in order to meet their strategic objectives. An insurance company can be defined as: a) risk-averse when the company dislikes risk and will stay away from adding high risk investments to their portfolio, b) risk-seeking when the company prefers to take some high risk investments and c) risk-neutral when the company is seeking for high risk investments but at an average level.

Insurance is considered an alternative of investing in safety measures offered in order transfer risk to a third party (insurance company) (Abrahamsen and Asche, 2011). However, Arctic is a very hostile environment that we lack sufficient knowledge. Even though, there are no specific limitations stated by the regulatory framework in the Arctic, in order for a ship owner to obtain insurance, we strongly believe that there should be some minimum requirements that should be covered by the cruise ship owners prior to an Arctic expedition.

It is quite often, that the ship owners are trying to save money from safety measures investments by buying insurance. In order to make Arctic expeditions safer, there should be some limitations for them to obtain insurance. The main requirement that they must cover is to have a sufficient polar or ice class certified vessel for traveling in the Arctic. A vessel should not be allowed to operate in the Arctic area unless, it is certified that it is eligible for the area. In August 2006, the International Association of Classification Societies (IACS) released a document, titled the Unified Requirements for Polar Ships, which standardized global ice classification specifications for vessels (Table 1).

Table 1: Polar Class descriptions (International Association of Classification Societies, 2016)

Polar Class	Ice descriptions (based on WMO Sea Ice Nomenclature)
PC 1	Year-round operation in all polar waters
PC 2	Year-round operation in moderate multi-year ice conditions
PC 3	Year-round operation in second-year ice which may include multiyear ice inclusions
PC 4	Year-round operation in thick first-year ice which may include old ice inclusions
PC 5	Year-round operation in medium first-year ice which may include old ice inclusions
PC 6	Summer/autumn operation in medium first-year ice which may include old ice inclusions
PC 7	Summer/autumn operation in thin first-year ice which may include old ice inclusions

Another limitation should be the shipping's firm competence in Arctic shipping. There should be a strict investigation of the firm's past behavior related to the safety policies. For example, if a shipping firm have neglected safety issues in previous trips and put at risk passengers' lives, then they should not qualify for an insurance contract.

Furthermore, before given the right to a ship owner to insure his vessel for an Arctic voyage there should be a thorough inspection of the vessel and at what extent the ship owner has covered the requirements for the survival equipment. An insurance company must deny insuring a ship that does not have sufficient lifeboats and liferafts for all the passengers; modified to suit the Arctic needs (i.e. winterized). Another example could be the lack of adequate insulated survival suits, as well as Personal Survival Kits (PSKs) and General Survival Kits (GSKs). An insurance company could protect themselves against wrongdoing or neglect on safety issues by the shipping firm by stating specific terms in the insurance premium that put the blame on the ship owner in case of an accidental event which occurred due to negligence from the ship owner.

But then there is an important question arising: Should those limitations regarding the shipping firm depend only on the insurance company's interpretation? As we have already stated there are insurance companies that are considered risk seeking, meaning that they are willing to take high risks in order to have profits. Thus, it is of great importance these limitations to be included in a legally binding agreement. There must be a regulatory framework between the Arctic countries and the ship owners interested to operate in Arctic waters that state specific limitations for the vessels not only in terms of operating in the Arctic but also in terms of obtaining insurance coverage. This way, the ship owner can be made responsible in case of an accidental event that involves neglect or wrongdoing from the shipping firms side.

4 INSURANCE PREMIUM IN THE ARCTIC

The lack of data and standardized methods regarding the assessment and the modeling of the risks, as well as the poor background knowledge create a big challenge for the insurance companies in the Arctic. This leads the underwriters to work on a case-by-case basis that vastly increases the cost of the insurance premium. Thus, the sustainability of the Arctic expeditions is strictly dependent on the cost of the marine insurance and the industry calls for more standardized procedures. Here, a standardized procedure that all the insurance companies should follow before putting a value on the insurance contract, regardless of the final price is suggested.

Initially, and after receiving all the relevant information regarding the vessel and the trip to be insured, by the ship owner through marine declaration form, an insurance company should check if the shipping firm covers the limitations of obtaining insurance (polar/ ice class, life equipment, etc.). If those limitations are covered, then a qualitative risk analysis should follow, where the hazard identification and the weighting of the risks take place. After identifying the possible hazards and its related consequences, a quantitative risk analysis should follow, where according to the data for the region of the trip concerned and the background knowledge of previous incidents, a probability number must be assigned to each risk. Then, by using the specific information obtained by the shipping firm regarding the vessel and the trip (e.g. ship design information, winterization of the ship, quality and quantity of survival equipment, etc.), adjustments should be made to the probabilities linked with the specifications of the shipping firm. For example, one important finding of our participation in the survival exercise in the Arctic was the influence of an integrated heating system in the lifeboats in the survivability rate of the passengers (Gudmestad et al., 2017). A vessel that does not have lifeboats with integrated heating system will be assigned a higher probability for the risk of people getting cold due to low temperatures than a vessel equipped with lifeboats with heating system. Thus, the insurance premium will be lower for the second vessel as the passengers have higher probability of surviving and the insurance company takes lower risk. After, having adjusted the probabilities according to the specifications provided by the ship owner, different accidental scenarios should be evaluated using different methods (Event Tree Analysis, Bayesian Networks, etc.) and a cumulative level of risk should be extracted from each scenario. Finally, the percentage of profit that the company wants to have should be added to the price of the premium decided by the insurance company, according to the overall risk picture of the ship. It is finally of great importance for the insurance company to execute a self-assessment of the vessel sending its own surveyors to check the design and the equipment of the cruise ship (Fig. 2).

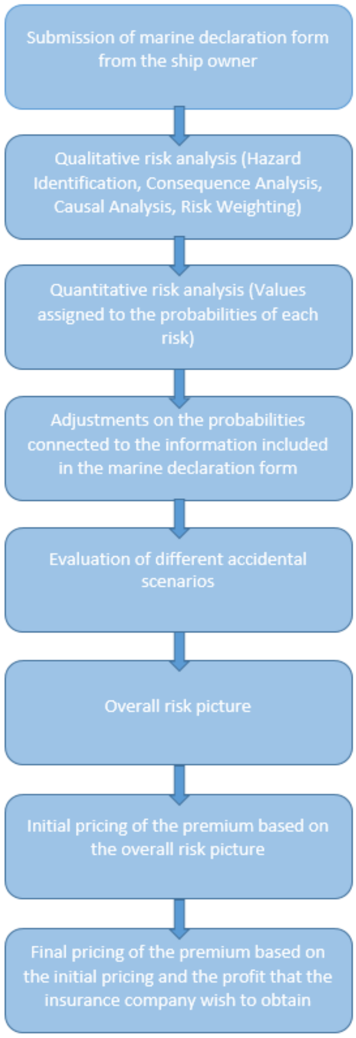

Figure 2: Flow chart of suggested insurance premium procedure

A cruise ship operator is thinking about lowering the costs and will, most likely, only want to fulfill the minimum requirements stated by the legal framework. However, if the requirements are very strict and conservative, it might make the vessel owners stop their arctic cruise business. Having first-class survival equipment that could fit every passenger on a cruise ship of more than 2000-3000 passengers could be quite expensive. The level of safety regarding the cruise trips in the Arctic waters should be obtained and secured by all means, and should not be sacrificed for lowering the costs. Thus, there must be a conscious effort by the legislators to secure top levels of safety in the Arctic cruise traffic while at the same time they do not act conservatively and overestimate the presence of extra safety measures.

5 ARTIC REGION COST DRIVERS OF THE MARINE INSURANCE

After presenting the limitations that should apply for the Arctic voyages, and our suggestion for a standardized procedure that should be implemented on determining an insurance premium in the Arctic, we will now discuss the influence of specific factors on the insurance premium.

The most important criterion that influences the cost of the insurance premium is the ice class of the vessel. It is already mentioned that insurance companies should not offer insurance contracts to shipping firms not designed for navigation in potentially iced waters. However, there are different polar and ice class categories and thus, the higher the polar and / or ice class of a vessel is the lower the price of the insurance premium offered by the insurance company. This is reasonable, as the higher the ice class of a vessel the higher the capacity of the vessel to withstand harsh weather conditions and avoid any accidental events.

Another factor that could influence the cost of an insurance premium in the Arctic is the winterization of the vessels. Winterization is a process, which enables vessels to operate in extreme sub-zero temperatures without suffering loss of equipment operability, vessel stability and power, and personnel habitability, and permits crew operations to be performed safely (Ghosh and Rubly, 2015). Class regulations require equipment and systems to be winterized. Some of those winterizations are presented by Hasholt (2011). Sheltered pathways, under-deck heating, heated mooring equipment, low temperature emergency generators, ice navigation radar, ice searchlights, etc. are all elements that could drive the cost of an insurance premium down. The more from the aforementioned elements a cruise ship has the more 'winterized' it is and the less is the price of the premium. Each element has specific importance for operating in the Arctic and all together constitute the winterization of the vessel. For example, if a vessel is considered 40% winterized then there could be an agreement with the insurance company to lower the insurance premium price by 5%-10%.

Communication systems and stability play an important role in the Arctic region. The remoteness of the area highlights the need for survival equipment able to help the passengers to survive for the period of five days stated in the regulatory framework for the ships operating in the Arctic, The Polar Code (IMO, 2016). The presence of enhanced communication systems and adequate survival equipment could dramatically lower the overall price of an insurance premium. Improved communication systems could prevent loss of communication during harsh weather that could be vital for the cruise ship. Being equipped with sufficient number of lifeboats, liferafts, survival suits, PSKs and GSKs is one of the limitations stated before. However, during our survival exercise in Arctic waters it was noted that improving even more the survival suits by adding integrated woolen underwear and providing sized for all the passengers could lead to an insurance company's decision to lower their offer, as the severity of the consequences in case of an unexpected event are reduced (Gudmestad et al., 2017, Solberg et al., 2016).

The time of the year and the route that the cruise ship is planning to take can also influence the insurance premium. For instance, a trip planned during August would have lower insurance premium than a trip planned during the beginning of the Arctic cruise season in May. This because the probable ice concentration and ice movement during August would be lower than the corresponding ice concentration and ice movement during May (Lasserre, 2014).

One of the most important criteria for an area like the Arctic, where we lack sufficient knowledge, is the captain and crew members' experience. According to Sarrabezoles et al. (2014), after interviewing several companies that offer marine insurance for the Arctic, most firms said trust in the shipping company is important, and therefore they might be reluctant to insure firms that do not have experience in Arctic shipping. Some of them said they would examine every submission but evaluate the preparedness of the shipping firm, the crew experience, charts accuracy and contingency planning in case of problems. However, for the majority of the firms it is clear there is a strict inspection of the shipping firm's past behavior and safety-related policy. This means that the insurance company expects to see the proof that the shipping firm is able to perform well in Arctic waters.

Finally, each traveler should have a private travel insurance when traveling. However, most of the private travel insurance companies require travelers to have separate Search and Rescue coverage. This coverage can raise the price for the traveler up to double or sometimes triple compared to the initial travel insurance cost. Furthermore, it is not unusual for those third party companies that offer search and rescue coverage, to put extra limitations to travelers, such as the age or the area that they provide coverage. Thus, it is of significance importance that the ship owners would acquire such a search and rescue coverage for all their passengers. This way, the insurance premium provided by the insurance company would decrease, as there would be higher chances of survival in case of an accidental event and thus lowest severity of the consequences. The private travel insurance premium of the travelers would also decrease. However, the ship owners will have to undertake extra cost for the search and rescue coverage.

6 CONCLUSIONS

Even though Arctic cruises are gaining in popularity, the Arctic region remains a hostile environment, where we lack sufficient background knowledge and data for determining insurance premium. There are many hazards related to the cruise traffic in the Arctic, and even more challenges arise in case of an accidental event during the voyage.

Specific limitations must be implemented through a legislation framework that unless they are covered by the ship owners, forbid the signing of an insurance coverage. Ice and/ or polar class certification, thorough background check and inspection of the vessel and adequacy on survival equipment must all be included as mandatory limitations before insuring a cruise vessel for an Arctic voyage.

A standardized procedure should be followed by underwriters to determine insurance premiums in the Arctic. Thus, the creation of a platform, where Arctic data would be gathered and easily accessed is of high importance.

Different factors can influence the cost of an insurance premium between a shipping firm and an insurance company, with the most important being the level of winterization of the cruise vessel, the level of training of the shipmaster and the crew members and the coverage of the search and rescue procedure of the passengers in case of emergency.

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