Russian – Norwegian Oil & Gas industry cooperation in the High North

Logistics and Transport - Report
31st of October 2014

The Core Team:
Introduction by INTSOK

To develop the High North as a new energy province, we must have the necessary technology to operate in vulnerable Arctic areas. The Russian – Norwegian oil and gas industry cooperation in the High North project (RU-NO Barents Project) is the largest project INTSOK has ever undertaken in any market worldwide. The scope of the RU-NO Barents project, as a strategic project for both countries, is illustrated by the participation of both government and industry from both countries, thus being a part of the official Norwegian – Russian Energy Dialogue. The main objective of the RU-NO Barents Project is, through industry cooperation and knowledge of Arctic technology needs, to contribute to the growth of the Russian and Norwegian industry participation in future petroleum endeavors in the High North. Acting on this objective, INTSOK has mobilized the industry to:

- Assess common technology challenges Russia and Norway face in the development of the High North
- Analyze existing technologies, methods and best practice Russian and Norwegian industry can offer for the High North today
- Based on the above: Visualize the need for innovation and technology development the industry in our two countries needs to overcome
- Promote stronger industrial links between our two countries

It is envisaged that the RU-NO Barents project will benefit the industry, supporting their strategic decisions/direction for increased participation in field developments in the High North. The RU-NO Barents Project will also be an important arena to promote and ascertain their level of commitment given to innovation and technology development, forging stronger industry links and partnerships across the border to face our common oil and gas technology challenges of the High North and preparing the industry to meet and overcome these challenges.

The RU-NO Barents Project focuses on five major areas, which are all crucial to the development of an offshore oil and gas field.

1) Logistics and Transport (this report)
2) Drilling, Well Operations and Equipment
3) Environmental Protection, Monitoring Systems and Oil Spill Contingency
4) Pipelines and Subsea Installations
5) Floating and Fixed Installations

The RU-NO Barents Project could never have been undertaken without the guidance, support and financing from the Norwegian Ministry of Foreign Affairs, the Norwegian Ministry of Petroleum and Energy, Innovation Norway, Finnmark, Troms, Nordland, Rogaland and Akershus County Municipalities, the Barents Secretariat, Rosneft, ConocoPhillips Scandinavia AS, A/S Norske Shell, GDF Suez E&P Norge, Chevron Norge AS, Statoil ASA, Total E&P Norway, Eni Norge AS, ExxonMobil Production & Exploration Norway A/S, Det Norske Oljeselskap ASA, North Energy, FMC Technologies, GE Oil & Gas, the Norwegian Oil & Gas Association, Federation of Norwegian Industries, the Norwegian Confederation of Trade Unions, Petroarctic, Gazprom, Lukoil Overseas North Shelf AS, Krylov State Research Centre, Rubin Design Bureau for Marine Engineering, Union of oil & gas industrialists of Russia, Sozvezdye, Murmanshelf, as well as the University of Nordland/High North Center of Business and Governance, the Gubkin Russian State University of Oil & Gas, OG21 (Norwegian Oil & Gas Technology Strategy), Marintek/Sintef, Greater Stavanger Economic Development and Det Norske Veritas (DNV GL).

The RU-NO Barents Project adds industrial weight to Norwegian – Russian energy cooperation in the wake of the maritime delimitation treaty. In addition it facilitates increased petroleum activity in the High North and focus is placed on carrying out the activity in a sustainable and responsible manner, with the petroleum industry taking the lead.
I specifically would like to extend my sincere appreciation for the work undertaken by Johan Petter Barlindhaug and the Task Force Core Team for developing this report within the logistics and transport focus area.

Stavanger, 15. November 2013
Updated report, 31. October 2014
Thor Christian Andvik
Project Director Barents Region
INTSOK/RU-NO Barents Project
Foreword

The purpose of this report is to examine logistics and transport challenges related to oil and gas activities in the High North. More specifically, the report aims to highlight technology challenges and available technology applicable to logistics to and from an operating area and in-field, land based infrastructure, and emergency response and communication. The report also addresses challenges associated with the regulatory framework and prospects of Russian-Norwegian industrial cooperation. Furthermore, the report makes an assessment of technology/service providers working with, or already delivering, solutions to the identified logistics and transport challenges. Being the first of a total of five reports to be published as part of the RU-NO Barents Project a key objective of this report is to support an environmental and safe development of petroleum resources in the High North through increased Russian – Norwegian energy cooperation.

During the process of writing this report, two workshops were held. The intention of these workshops was to discuss various challenges when operating in the High North and to discuss industry capabilities, practice, readiness and technology gaps. The workshops have been characterized by openness and willingness to share views, knowledge, also on weak parts and properties. In random order, the core team would like to thank the following participants for their contribution during the workshops: Petroleum Geo-Services AS, Akvaplan-Niva, Russian Consulate General Kirkenes, The Mining Institute KCS (Kola Science Center), Rederi AB TransAtlantic, Shtokman Development AG, Krylov State Research Institute, Chevron Norge AS, Statoil ASA, Chapman Freeborn Aircharterering Ltd., The Norwegian Barents Secretariat, A/S Shell, Storvik Consult, North Energy, The Norwegian Coastal Administration, Askoi1, GECON Consultation, University of Nordland, Innovation Norway, StormGeo, Sør-Varanger Municipality, GE Oil & Gas, Tschudi Kirkenes AS, JSC "International Customs Terminal", Norconsult AS, Multiconsult AS, JSC Belomortrans, Central Marine Research & Design Institute (CNIIMF), Morspb, Korabel.ru, Nansen International Environmental & Remote Sensing Centre (NIERSC), Arctic And Antarctic Research Institute (AARI), JSC Baltiysky Zavod, Reinertsen AS, Jotun Paints, Murmanshelf - Association of Suppliers O&G Industry, INTSOK, Tschudi Shipping Company AS, DOF Subsea Arctic Ltd. and Det Norske Veritas (DNV).

In addition to the workshops, a number of informal industry meetings have been arranged to obtain knowledge of the industry’s thoughts and priorities regarding Arctic activities. In random order, the core team would like to acknowledge the contributions of the following companies and organizations: Northern Norway Regional Health Authority, Avinor, Dockwise, General Electric, Gassco, Rystad Energy, Norut Alta, Norwegian Ministry of Petroleum and Energy, Norwegian Ministry of Foreign Affairs, Norwegian Ministry of Trade and Industry, Siemens Subsea, Marintek, Telenor, Subsea 7, ABB Oil and Gas, PGS, Norwegian Coast Guard, The Norwegian Confederation of Trade Unions (LO) - Oil and Gas, The Industrial Development Corporation of Norway (SIVA), C-Card, Multiconsult, Kværner, Aker Solutions, Seadrill, Sovcomflot, SINTEF, Framo Subsea, Statnett and Norwegian Academy of Polar Research, Plenipotentiary Representative of the President of the Russian Federation in the Northwestern Federal District, AgustaWestland, Scandinavian Institute of Maritime Law at the University of Oslo and Geophysical Observatory at the University of Tromsø.

As with vessels trying to navigate their way through the unforgiving Arctic waters, this report would not have reached its final destination without the steady piloting of the core team. The core team includes the following companies represented by: A/S Norske Shell (Rolf Ole Eriksen), Tschudi Shipping Company (Henrik Falck), Gazprom JSC (Alexey Novikov), Murmansk Shipping Company (Antonov Dmitnevski), Norwegian Coastal Administration (John Evensen), Marintek (Peter Chr. Sandvik and Morten Henry Westvik), ExxonMobil Upstream Research (Ted Kokkinis), Barents Secretariat (Claus Bergersen), Statoil ASA (Aud Tveito Ekse), Krylov Shipbuilding Research Institute (R.J. Romanov), CJSC Belomortrans (Mikhail Sisin), GECON Consultation Centre (Mikhail Grigoryev) and North Energy ASA (Knut Aaneland and Johan Petter Barlindhaug).
It is the hope of INTSOK that this report could spur increased efforts on both sides of the border, to continue to develop technologies allowing safe and sustainable development of oil and gas activities in the High North. This report will be updated when the other RU-NO Focus Areas have completed their reports, respectively.

Updated report, 31.October 2014
Johan Petter Barlindhaug
Task Force Manager
RU-NO Barents Project, Logistics and Transport
Executive summary

The oil and gas industry has, through an extensive record of onerous offshore operations, demonstrated the industry’s capability to develop and to apply large and complex new innovative technologies. This experience will be important when moving into the High North. However, moving into the High North introduces new challenges.

The overall objective of this report is to assess logistics and transport challenges related to oil and gas activities in the Norwegian and the Russian High North. To fulfil this objective the report is focusing on best operation practice and existing technology solutions. Key challenges and operational and technological gaps are assessed in order to address the need for future innovation and technology development. The geographical scope includes six regions spanning from the coast of Finnmark to the waters east of Franz Josef Land. The six areas represent different physical and operational challenges making logistics and transport operations a true challenge. This report illustrates that there are still considerable measures to be taken by authorities, oil and gas companies and the manufacturing industry before exploration and extraction of oil and gas can be executed in a safe and environmental sustainable manner, as operations are expanded even further north from today’s areas of activity.

The key challenges identified in this report could be solved mainly in four ways:

1. Focus on strategies and plans for infrastructure development of national and common interest
2. Closer cooperation between national and local authorities in Russia and Norway
3. Focus on cooperation between Norwegian and Russian R&D institutions and companies
4. Carry out research projects focusing on infrastructure, technology and innovation

While the last two recommendations are closely connected and focused on technology development, the first two recommendations are concentrated on how the two countries can improve the framework and infrastructure to facilitate oil and gas development in the High North. They are all related to an international agenda regarding the overall increased activity in the Barents and the Arctic seas. In this respect, by taking the lead in identifying the key challenges and also indicating ways to solve them, Russia and Norway should maintain the leading position in the High North, also in areas that are important to other nations. In this context it is essential to discuss and develop a regional approach rather than single-field developments. A regional High North Forum may be considered. An interesting model is the ongoing Gassco Barents Sea Gas Infrastructure (BSGI) that examines the gas transport and infrastructure options on the Norwegian side.

In identifying key challenges and providing recommendations on how to solve these challenges, this report examines seven aspects of oil and gas operations in the High North.

1. Physical characteristics of operating in the High North

In the waters of Barents Sea South ice bergs/drifting ice normally do not represent a risk for maritime operations. However, in the northern parts of the Barents Sea South, challenges and operational risks include: icing on vessels or installations due to low air temperatures, drifting ice objects, heavy snowfall, fog, darkness, Arctic storms and lack of infrastructure especially related to search and rescue infrastructure capabilities.

Seasonal ice covered waters include the ice covered waters of the northern Barents Sea, the Pechora Sea and the Kara Sea. The same risks that apply for maritime operations in the Barents Sea South are also representative for activity in ice covered waters, but in addition, sea ice constitute an explicit risk for vessels and personnel and represent major cost and schedule challenges for normal seagoing transports.

Oil and gas activities in the northern parts of the Barents Sea and the Kara Sea will be significantly more challenging compared to activities in the Barents Sea South and the Pechora Sea. Therefore, a
very careful step-by-step development has to be implemented, where operational quality and control must be demonstrated before moving into even more physically challenging areas.

Confronted by physical operating challenges, this report recommends measures such as improved winterization of vessels and installations and Russian-Norwegian cooperation on development of improved weather forecasting models. This will be crucial in order to perform safe and sustainable development of oil and gas resources in the High North. To strengthen the overall safety of operational activities in the High North, it is recommended that the exchange of data and information and cooperation to develop improved prediction models for ice and weather conditions are given priority.

Common accepted design criteria for a “100 year event” due to a combination of wind/waves/ice/icing/dark time should to be established for floating installations operating in the High North. This is to a greater extent reflected in the ISO 19900 series including 19906.

2. Logistics to and from an operating area
To secure operational efficiency and safety, transport and logistics operations need to incorporate safety features, redundancies and operational systems, which may differ significantly from those in the North Sea. Among the special features of logistics and transport in the High North are the needs for ice breakers in ice covered waters and installations designed to withstand heavy icing conditions. Module transports and offshore loading will be the most exposed transport operations. Furthermore, the long distances and the demanding Arctic waters may impose restrictions on regular personnel transport.

Regular personnel transport is an important issue in the High North. Today, helicopters are preferred, but long distances require new thinking involving innovative maritime vessels and multitask vessels for direct and intermediate transport (to shore and to adjacent land areas). This may be addressed mainly to the oil companies, but such installations may preferably cover larger regional areas, not only one specific field development. It is recommended that forward supply bases, for instance multipurpose floaters functioning as storage facilities and helicopter landing sites, are established close to field operations in order to secure operational efficiency and security.

Considering the possible long travel distance to remote work locations, alternative rotation schedules may be suggested. With all the risks inherent in either a) extended helicopter flights over water or b) slow journeys by boat, the current Norwegian practice of two weeks/four weeks rotations may be added to the risk profile, whereas in the Russian sector they will have extended rotations which will reduce the risk. If there are a few days travel to either ends, waiting on weather, etc., the current schedule may be inefficient and extended working schedules should be considered.

3. In-field logistics
Since operations are challenging in waters with drifting ice, exploration drilling as well as construction and development will have to take place in the summer season. However, major delays and unplanned tasks, such as maintenance and repairs will occur, meaning that operations also must be considered during the winter season. Ice Management systems are dependent on a reliable surveillance system (detection, tracking, and forecasting) for continuous monitoring of ice movements. This involves different sources of data (e.g. satellite images and ice radars) and requires adequate satellite coverage not only for ice bergs, but also for minor ice objects.

In addition, Ice Management involves physical management such as ice breaking and iceberg towing. By giving attention to challenges relevant to in-field logistics, this report recommends that multitask vessels are developed to sustain Arctic operations. Harsh operational conditions offshore and long distances to onshore infrastructure may stimulate the industry to develop innovative designs for multitask vessels dedicated to serve the in-field needs. Multitask vessels may serve several important in-field functions, such as ice breaking capability to carry out operations such as towing of ice bergs and vessels out of ice covered areas. In addition, multitask vessels will have an important contingency function of rapid mobilization in case any unpredicted situation should occur in-field, while also being
The human factor and people trained to cope with Arctic challenges is crucial in order to be well prepared for operations in Arctic climate and to be trained when unpredicted situations occur. At present, there are no mandatory requirements in terms of training and certification of personnel working on board vessels operating in ice covered waters. Norway and Russia see the need for a set of mandatory requirements to ensure future safe maritime operations in the High North. Training centres, where crew members can develop relevant skills and be assessed on how to operate in Arctic conditions, should be established. Certification of personnel operating in the High North should be mandatory.

4. Land based infrastructure
The present level of land based infrastructure within the region is reflecting the level of industrial activities. Increased oil and gas activity will generate a certain need for more transport and land based infrastructure to support the level of oil and gas operations. This report addresses several solutions to these challenges related to inadequate port facilities and industrial backup (especially in the remote parts of Russia), the insufficient access to roads, railway and airports, and the shortage of onshore power supply. These solutions encompass such measures as; increased infrastructure investments towards the Russian-Norwegian border to strengthen bilateral cooperation, and upgrading the power grid in Finnmark and Russia. In Russia, the low offshore activity has resulted in that no tailor made port infrastructure to serve the oil and gas industry has been established. This is a bottleneck that has to be solved in order to create oil and gas related industrial development in Northern Oblasts of Russia.

5. Emergency response and communications
UN bodies, such as the International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO), provide international regulations on safety of maritime and aeronautical operations. These regulations are applicable for oil and gas operations in the Russian and the Norwegian High North. In this report, challenges related to emergency response capabilities, hereunder the lack of adequate communication infrastructure and satellite coverage, are addressed. Furthermore, the impairment of search and rescue (SAR) operations induced by the vast distances in the High North, is discussed. To meet these challenges, this report suggests that bilateral emergency cooperation between Russia and Norway must be strengthened and extended to also include joint R&D programs.

The harsh environment reduces survival time for persons in the sea and also in life rafts or lifeboats. To secure safety of personnel working in an Arctic environment it is important to implement adequate safety procedures assuring rapid mobilization of search and rescue units, high transit speed of SAR resources and installations of adequate equipment. On board SAR units may include advanced technologies for search in darkness and low visibility. Emergency/survival equipment for air drop should also be available at strategic locations onshore and offshore. Based on experience from operations in other remote areas it is, furthermore, important to establish a high quality telemedicine system supporting oil and gas operations in the Norwegian and the Russian High North. Telemedical presence will require a high bandwidth communication link and a geostationary satellite to cover the High North.

The report underlines the importance of further improvements in communication systems. At present, the systems are inadequate to support the needs of the oil and gas industry in the Norwegian and the Russian High North. However, there are ongoing projects trying to identify the main users and their system requirements. According to Telenor Satellite Broadcasting, a full covering Arctic real time
satellite based communication system may be operative in 2020, provided that funding is agreed. This will improve support of navigation in the northern part of the Barents Sea. Barents Watch is also assumed to be an important tool as a monitoring and information system covering the sea and coastal areas in the High North. However, it must be ensured that the available information is continuously updated.

6. Regulatory framework
The main activity within IMO, associated with maritime safety in the Arctic, is the work on the Polar Code. Safety and competence requirements for personnel and vessels operating in Arctic ice covered waters are presently regulated by the IMO Guidelines. Specific requirements for standardized training of personnel, which include mandatory education, knowledge of navigation in ice covered waters and emergency procedures in Arctic environments are, however, absent. Furthermore, there is a lack of detailed requirements for survival equipment and guidelines about the use of lifeboats, rescue vessels and rescue suits. Norway is a driving force to make the guidelines mandatory and the aim is that the Polar Code should be implemented into Norwegian legislation from 2015 or 2016.

In general, risks associated with shipping are well known and understood by insurers. There are, however, still risks related to Arctic operations that need to be identified. Underwriters normally base their underwriting premiums on a historical loss record such as statistics. The frequency of accidents is a key element in the evaluation of risk when navigating in Arctic waters. However, lack of Arctic empirical maritime traffic data, in particular in the northern parts of the Barents Sea and the Kara Sea, and the lack of available statistics makes it difficult for insurers to compose an overall risk assessment related to the risks of the various Arctic sea routes. A more systematic knowledge of accident rates should be obtained in order to help the underwriters determine insurance rates.

7. Industrial cooperation
On short and medium term, the oil and gas activity level on the Norwegian and Russian side will differ significantly. The Russian interest of exploiting the gas resources in the Barents Sea seems to be decreasing to the benefit of their resources in the Asian part of the country. The Russian focus in the Barents Sea is to discover oil, but a specific exploitation strategy has not yet been launched.

At present, Russia has a primary focus on developing Yamal LNG and to explore the resources in the Kara Sea, both exposed to ice covered waters most of the year. Due to this, possible areas of cooperation might be concrete structures to withstand ice loads and use of Norwegian ports during construction, module transportation and operation (transshipment) of Yamal LNG. However, on the Russian side, plans are being developed for a large industrial area to serve these needs.

The activity on the Norwegian side of the Barents Sea is assumed to be higher than on the Russian side for the next decade. The current trends indicate that the Norwegian Shelf represents the driving force in the High North. Therefore, the Norwegian shelf could be a basis area for industrial cooperation and development between Norway and Russia in terms of meeting the challenges of the Barents Sea.

Finally, it is important to address and emphasize the need to continue the investments in Research and Development, seek new innovative ideas and technology improvements to ensure that operations satisfy even stricter requirements related to HSE, being more cost effective and reliable with minimum impact to the environment.
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1. Introduction
The Arctic continental shelf is expected to be an area with high potential of oil and gas. The Norwegian-Russian maritime delimitation treaty of the Barents Sea will spur a new round of active cooperation between Norway and Russia on the development of Arctic resources. New agreement opens new opportunities for active cooperation developing this strategically important area.

One major challenge to fully explore this region’s potential as a future energy supply base is the industry’s capability to provide efficient technology meeting the severe climate conditions affecting field development and operations, environmental demands, presence of ice and long transport distances. Not least, the issue of the associated high costs of offshore field developments is important as they may represent a significant barrier for development.

With the support of the Norwegian Government and Norwegian and Russian oil and gas industry, INTSOK has launched the RU-NO Barents project to address these challenges, to identify best available industry capabilities and to emphasize the need for common innovation and technology development between Norway and Russia. Norwegian industry has world class offshore technology, but meets new challenges demanding new and improved technology when moving towards the High North. Russian industry equally has long and valuable experience with severe climate conditions in the High North, but still an emerging offshore oil and gas field development.

1.1 A framework for industrial development
The focus area “Logistics & Transport” deals with issues, which to a great extent, have to be addressed to public authorities as challenges that have to be met in close cooperation with the oil and gas industry. By targeting recommendations both to the industry and to the authorities, the aim should be to establish a common understanding of the challenges of the High North, which in turn might result in:
- An overall conceptual strategy for oil and gas development in the High North focusing on the major and specific challenges of the area supported by the Governments and the Industry
- An approved list of actions that should be implemented
- A more comprehensive and fundamental understanding of the challenges and how these should be met by use of technology as well as by human skills

The end result will identify current industry capabilities and technology gaps, promote stronger industry links and indicate the need for future innovation and technology development through, e.g. design of new/improved technology, need for research projects, need for Arctic technology standard update and strengthening competitive industry links.

1.2 Maneuvering through the report
The overall objective of this report is to assess logistics and transport challenges related to oil and gas activities in the Norwegian and the Russian High North. To fulfil this objective the report is highlighting the best operation practice and existing technology solutions today. Furthermore, key challenges and operational and technological gaps are assessed in order to visualize the need for innovation and technology development within the industry of Russia and Norway.

Technology gaps are defined as the difference/distance between the best available technology solutions today and the technology needed for future oil and gas operations in the High North. At the end of each chapter, a summary of the key challenges is provided. The summary also contains a matrix that displays relevant technology/solution providers.

Logistics is dependent upon existing infrastructure. This is an essential component of all oil and gas operations. The geographical scope of this report, spanning from the coast of Finnmark to the waters
east of Franz Josef Land, are characterized by its different physical and operational challenges, remote settings and lack of established infrastructure. For the purpose of this assessment, logistics and transport is defined broadly to address the unique aspects of oil and gas activities in the Norwegian and Russian High North. This includes vessels and personnel, the systems needed to gather and supply accurate and timely information for safe operations, the resources needed to respond to a variety of potential emergencies, and the onshore and offshore facilities needed to provide supplies and logistics in support of oil and gas activities.

The report is structured as following:

Chapter 2 describes activities in, and physical characteristics of, the High North. The chapter focuses on challenges related to meteorological and oceanographic conditions, ice exposure and icing in the Barents, the Pechora and the Kara seas.

Chapter 3 provides an overview of challenges associated with logistics to and from an operating field focusing on the ice class notation system, icebreaker capacity, regular personnel transport, special needs for maritime facilities and technology innovation when operating in the High North.

Chapter 4 focuses on in-field logistics. The chapter predominately concentrates on challenges concerning Ice Management, human factors and Arctic maritime training.

Chapter 5 addresses challenges related to land based infrastructure offering an assessment of ports and port facilities, access to roads and railway infrastructure, location of airport and heliport facilities and onshore power supply.

Chapter 6 presents an overall imagery of the emergency response and communication capabilities in the regions. The chapter highlights challenges related to emergency response infrastructure, communication systems and the execution of SAR-operations.

Chapter 7 provides an overview of the regulatory framework which represents the legal foundation for activities in the High North.

Chapter 8 discusses current and prospective industrial cooperation between Russia and Norway.

Chapter 9 summarizes the most important findings and provides recommendations on how to address the challenges related to oil and gas operations in the High North.

Chapter 10 presents a comprehensive matrix of technology/solution providers relevant for logistics and transport in the High North.

In addition to the main report there is an Appendix that contains additional information and figures and tables.
2. Physical characteristics and activities of operating in the High North

This report aims to target logistics and transport challenges associated with oil and gas activities in the Barents Sea (including the Pechora Sea) and the Kara Sea (including the Ob and Yenisey river mouth) (Figure 1). In this chapter, the key physical characteristics and challenges, encountered by companies operating in these regions, are presented. Compared to the North Sea, operations in the High North are characterized by harsher operating conditions. Potential risk elements include low air temperatures, icing, remoteness, darkness, sea ice, polar lows and fog.

![Figure 1: Geographical areas of the Barents, Pechora and Kara seas.](Source: Graphic Maps)

In general, there is a lack of long term met ocean and ice data to develop a firm design base for ships and offshore units. A report issued by the Research Council of Norway in 2011 concluded that met ocean design criteria are missing in order to be able to design for worst case scenarios, i.e. wind, current, temperature, icing etc.

2.1 Present and planned activities in Norway and Russia

2.1.1 Norway

After the 22nd Norwegian licensing round for the Barents Sea there are 80 blocks awarded in the Norwegian part of the Barents Sea, including 17 operating companies and additional 23 partner companies (Figure 2). Lukoil and Rosneft were awarded three licenses. It is of significant importance that two blocks were awarded towards the border of the Barents Sea North.
2.1.2 Russia

As of October 2014, the development of oil and gas in the Russian Arctic covers 117 license sites. Of these, 63 are located offshore on the continental shelf, the territorial sea and internal waters of Russia. The other 54 license sites are located onshore. For this development, Arctic transportation schemes for the equipment and materials for construction of field infrastructure are being used.

The license sites are organized in 41 projects, which are the operating or potential source of cargo base of oil, condensate and LNG.

The Russian Arctic can be subdivided into 10 randomly ordered activity zones (see Figure 3). The development of these zones, which will be involved in the economic development of the hydrocarbon resources in Russia, will follow a random step-by-step process. Uncertainty still remains about when these zones will be developed.

In Russia, Rosneft and Eni have a joint venture for developing two blocks in the Barents Sea (see Figure 3). According to Eni Energhia, the companies began seismic mapping in 2014 and are planning to start drilling in 2016.

According to Statoil, the partnership of Rosneft and Statoil in the Perseyevsky field in the northern part of the Barents Sea has plans to perform seismic activities in 2016-2018 and with possibilities for exploration drilling in 2020.
Production and export of oil from the Prirazlomnaya platform in the Pechora Sea started in 2013 (see Figure 3). Norwegian technology and engineering companies have contributed with a large number of deliveries to the installation.¹

Figure 3: Oil and gas activity map in the Russian High North
Source: Gecon

Rosneft and ExxonMobil started seismic mapping in the Kara Sea in 2012. In September 2014, the companies completed drilling in the well Universitetskaya-1 (see Figure 3), which resulted in the discovery of oil.

For activities on the shelf in the Pechora Sea, Rosneft does not provide concrete terms on the initiation of drilling. It does, however, seem likely that drilling will commence shortly.

Thus, taking into account additional exploration of the open fields, the decision on their development will be made in 2020-2025. Rosneft will then formulate requirements to development of ports infrastructure.

Furthermore, The Yamal LNG project is being further developed by a joint venture of Novatek, Total and the Chinese company CNPC. The project includes the grand development of the Sabetta port in the Ob Bay. First train of the Yamal LNG plant is planned to be operational by year 2016.²

2.2 Key characteristics of High North operations

What makes the Arctic a true operational challenge is its distinct characteristics. The main natural, physical challenges encountered by the oil and gas industry, when operations are expanded towards the High North, could be described as follows:

Low temperatures
Low temperatures are frequent throughout the Arctic during the winter season. Low temperatures may seriously hamper SAR operations. Furthermore, low temperatures could cause cancellations or

¹ Ramsdal (2013).
delayed operations, as installations and equipment need to be protected and personnel are being prohibited from operating outdoor for longer periods.

**Icing**  
In cold temperatures, sea spray is freezing immediately on contact with a vessel or installations providing significant challenges for marine operation and operational safety for personnel. The combination of wind or wave induced icing with air temperature can lead to reduced operability, freezing mechanisms, slippery deck and ladders and also, in some cases, shutting down communication and evacuation systems.

**Remoteness**  
Large parts of the Arctic region are located a vast distance from existing infrastructure increasing time of travel for ships and helicopters. Combined with unreliable weather forecasts this represents a source of uncertainty, which in many instances may delay operations.

**Darkness**  
North of the polar circle, for extended periods of the year the sun will not rise above the horizon. Through reduced visibility, darkness can cause prolonged operation times for certain activities, while also representing a challenge to SAR operations.

**Sea ice**  
The sea ice varies in shapes, thicknesses, ages and hardness. The ice conditions in the Barents, Pechora, and the Kara seas are dynamic, leading to large annual, seasonal and regional variations presenting different challenges to vessels and installations operating in these areas.

**Polar lows**  
Polar lows occur when cold winds blow from the ice covered regions in the north over areas with relatively warm sea. Typically, polar lows endure for a couple of hours to a couple of weeks with strong winds and subsequent rain fall posing a major safety risk and challenge to operations in the Arctic. Despite this, polar lows may not be captured by today’s weather forecast models.

**Fog**  
Operations in ice covered waters will potentially include visual contact with ice, other maritime vessels or offshore installation. Fog also represents a challenge in terms of helicopter operations. In the Marginal Ice Zone fog is a phenomenon that occurs frequently. This may cause delays and limitations when considering operations.

### 2.3 A step-by-step approach to operations in the High North

Present oil and gas offshore activities in the High North take place in the Barents Sea South on the Norwegian side and in the Pechora Sea on the Russian continental Shelf. When Russian operations expands into the northern parts of the Barents Sea and the Kara Sea and with the Norwegian intention to further expand operations northward and eastward, oil and gas activities become more challenging. This calls for a step-by-step approach, where operational quality and control must be demonstrated before moving into even more physically challenging areas.

In this respect, the development has to be linked to a timeline that covers the present situation as well as the long term perspectives. Consequently, a timeline is described for the short term, medium term and long term (Table 1).

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See Appendix 2.3 for description of various types of sea ice.
Activity prospects and time perspective | Geographical regions (areas)
--- | ---
**Short term (until 2025):**  
4 | Barents Sea South (Area 1) and Pechora Sea (Area 2)
**Medium term (2025-2050):** | Barents Sea North (Area 3) and Kara Sea South (Area 4)
**Long term (after 2050):** | Barents Sea North (Area 5) and Kara Sea North (Area 6)

Table 1: Time perspectives

The three perspectives represent three scenarios described by a high degree of uncertainty. Thus, a careful step by step approach must be applied when preparing for more concrete activities on short and medium term and on long term only for very long lead infrastructure investments, e.g. satellite coverage to improve communication in the High North.

As a tool to describe the inter-dependencies between the time line and the expansion into more ice covered waters (and larger distance from infrastructure and SAR response), the project area is divided into six geographical areas, as illustrated in Figure 4. The six areas represent different challenges regarding, for instance, ice, infrastructure, communications, emergency preparedness and SAR response. The figure has been developed jointly by Russian and Norwegian parties to maintain the views of both parties.

1. No significant sea ice (mostly within SAR response)
2. Sea ice only part of the year (mostly within SAR response)
3. Limited sea ice part of the year (outside present SAR response)
4. Sea ice most of the year (outside present SAR response)
5. Sea ice part of the year (far outside present SAR response)
6. Sea ice most of the year (far outside present SAR response)

Figure 4: Geographical areas

The oil and gas industry meets different physical challenges in the six areas listed in Figure 4. A main distinction can be made between the concepts Arctic waters and Arctic ice covered waters.

Arctic waters include the ice free waters of the Barents Sea South (Area 1). In these waters ice bergs/drifting ice normally do not represent a risk for maritime operations. However, challenges and operational risks include: icing on vessels or installations due to low air temperatures, visibility, polar lows and lack of infrastructure especially related to insufficient search and rescue capabilities.

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4 Development projects that are overviewed today, i.e. discoveries resulting from application rounds 22 and 23.
Seasonal ice covered waters include the ice covered waters in the Barents, the Pechora and the Kara seas (Area 2,3,4,5 and 6). The same risks that applies for maritime operations in “Arctic waters”, are also representative for vessels operating in ice covered waters, but in addition, sea ice constitute an explicit risk for vessels and personnel.

The following sections will present the six development areas, also describing the distinct regional challengers.

2.4 Shipping in the Norwegian and the Russian High North

A minimum definition of the North East Passage (NEP) is that it is made up of all the marginal seas of the Eurasian Arctic, i.e. the Chukchi, the East Siberian, the Laptev, the Kara and the Barents seas. Russia has made a definition of the Northern Sea Route (NSR) being under full Russian national control and jurisdiction operating with fixed geographical endpoints in the east-west direction – the Bering Strait in the east and the Novaya Zemlya in the west. The NSR makes up approximately 90 percent of the North East Passage.

The NSR never got the intended significance as a transit route between the two world oceans after opening of international shipping in 1991. However, transit traffic through the NSR has had an upsurge in cargo volume in the recent years. The NSR has, nevertheless, mostly served regional developmental purposes. Shipping in the Kara Sea, for instance, has mainly been used for shipments of goods serving the local communities, as well as being a military sea area under strict Russian control. The Russian Icebreaker fleet has succeeded in keeping the stretch from Murmansk to Dudinka on the banks of the Yenisei River open for sailings 12 months a year.

Currently, most ship traffic is transported through the ice free part of the Barents Sea. Shipping of petroleum to the western markets is mainly transported through the southern part of the Barents Sea. These waters are ice free and less demanding for ships and personnel, compared to ice covered waters in the northern part of the Barents Sea. Murmansk and Kirkenes, for example, offers ice free ports on year-around basis. Currently, cargo are transported by railway to Vitino and Murmansk where it is transshipped to sea tankers in Kirkenes or Murmansk.

When considering shipping in Arctic waters, three types of sailing routes have been addressed: Intra-Arctic routes, i.e. sailing lanes between locations within the Arctic, destination-Arctic routes, i.e. sailing lanes between harbors inside and outside of the Arctic region and transit routes, i.e. sailing lanes between harbors in the Pacific and the Atlantic via the Arctic Ocean. Reference studies conclude that the most significant increase of future marine traffic most likely will be related to destination Arctic routes. This is even more relevant after the treaty of maritime delimitation between Norway and Russia, and the future possibilities for petroleum activities in the Barents, the Pechora and the Kara seas.

2.5 The Barents Sea

2.5.1 Meteorological and oceanographic conditions

Data on environmental parameters in the Barents Sea are scarce and difficult to obtain. Most of the reliable statistics are from land based meteorological stations located along the coast of Finnmark and the Bear Island. There are also three Wavescan met ocean data collecting buoys offshore in the Barents Sea. On the Russian side, considerable data is collected, with the Arctic and Antarctic Research Institute (AARI) serving as gathering and analysis center.

For the Barents Sea, there is a lack of empirical meteorological data on temperatures, darkness, snow, fog, icing, rapid weather changed caused by the large temperature gradients between the ice covered and open water, surface winds and polar lows (Figure 5). Such conditions are currently difficult to

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5 Østreng et. al. (2013) and AMSA (2009).
forecast due to their local formation and relatively small size. In light of current climate change trends we can expect a decrease of polar lows in the Barents Sea if the ice edge moves further north and east.

Figure 5: Formation areas of polar lows 2000-2012
Source: met.no

Considering visibility, for up to six months a year visibility can be below two km. This is partially because of snowfall and partially because of fog, which may reduce visibility below one km. The lack of daylight during polar nights has profound impact on the safety of vessel transport and operations, thereby interrupting the service of the platforms as well as hindering emergency response operations. Visibility measurements at different locations are provided by met.no.

The frequency of polar lows has increased in recent years, with significant numbers occurring in the period between November and April. However, according to recent research the projection is that warmer climate will result in reduced frequency of polar lows.

NORSOK N-003 provides design of relevant data concerning the maximum significant wave for different regions. Observations indicate a total average significant wave height of 2.35 m in the ice free southern part of the Barents Sea. Seabed bathymetry is typically available for areas within current traffic lanes and required to a large extent for the adjacent regions.

2.5.2 Ice exposure and icing

Since 1979, satellite observations monitoring sea ice extent has been available, thus providing data on the extent of sea ice. These observations are also reflected in the maximum sea ice extent seen in the past decade (Figure 6). However, design relevant knowledge concerning ice thickness, type of ice, presence and size of ridges, pressure zones, short-term drift velocities and general physical

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6 See appendix 2.4
7 Johannessen (2007).
8 See Appendix 2.5
and mechanical ice properties is still strictly limited and unreliable. The presence of icebergs in the southern Barents Sea is relatively rare, with the probability increasing toward the Barents Sea North and the Kara Sea respectively. In addition, iceberg encounters are increasing towards the southern part of the Barents Sea.  

Temperatures can fall significantly below zero in the Barents Sea, causing additional challenges for the design of vessels (i.e. material compliance) as well as equipment and systems and the operational environment for humans. Furthermore, the effect of wind chill must be considered for humans working in such cold climate as well as icing of the equipment. Thus, winterization of vessels and technical infrastructure, especially heating and isolation, must be adequately addressed.

Since the turn of the twenty-first century, Arctic sea ice has declined relative to its 1979–2000 mean extent. According to the National Snow and Ice Data Center (NSIDC), sea ice extent at the most recent summer minimum (September 2009) and winter maximum (March 2010) was greater than it had been in most recent years. This short-term gain does not, however, indicate a reversal of the long-term decline.

2.6 The Pechora Sea

Maritime traffic is limited in the wintertime and somewhat higher during summer. Traffic is mainly related to the ongoing activities at the Varandey oil terminal serving land based oil fields and Prirazlomnaya offshore installation. Pechora Sea is periodically used for the summer navigation for NSR transit, when ships are crossing the Vaygach straits. To a limited degree there are crude oil transports from the Kolguyev Island and from the Ob river mouth, but these are expected to increase in the future.

All-year-round traffic from Dudinka is related to ore concentrate and gas condensate deliveries. Currently there is some minor summer traffic due to the seismic and drilling activities on the Dolginskoye oil field and seismic activities in the Kara Sea (Rosneft/ExxonMobil). The maritime activities along this corridor may increase when drilling begins.

The Pechora Sea is quite shallow (mostly in the range of 20-60 m). This favors all types of sea bed based structures (ref. section 4.2), like e.g. at Prirazlomnaya. Concrete platforms with offshore storage

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9 See Appendix 2.7
10 NORSOK-N003 provides annual probabilities of accidence for iceberg collisions for this region.
are relevant and have been designed to resist all sea ice and ice bergs that may enter into the Pechora Sea.

The Pechora Sea is a region with proven resources of hydrocarbons, mainly consisting of oil. The seasonal ice development in the Pechora requires tankers with ice class and defines expediency of application of shuttle schemes of transport. It is expected that when the production starts at the Trebsa and Titov fields in 2014 there will be a gradual growth in shipment of oil to the Varandey terminal.

Now that production has started from the Prirazlomnaya field it is anticipated that the capacities of FSO Belokamenka will be insufficient and will require construction of one more transshipment complex of large capacity. In this context, Liinakhamari is frequently mentioned as a possible road-to-ship transshipment plant. The port economy and facilities are, however, currently in a poor state. The nearest railway station is located in 15 km away (Pechenga). However, Gazprom is planning a large refinery near Murmansk for full processing of heavy oil from Prirazlomnaya and condensate from Yamal. If this project is realized, an increase of maritime transport, as mentioned above, may not occur.

2.6.1 Meteorological and oceanographic conditions
In the Pechora Sea, temperatures are decreasing when moving eastwards and northwards compared to the Barents Sea South. The main sea currents are entering from the Barents Sea South, along the Norwegian coast, and encounter colder water from north along the coast of Novaja Zemlja. The difference in water temperature from west and worth is not substantial in the Pechora Sea. Thus, few occurrences of polar lows have been observed. Low temperatures and wind during winter time will, however, complicate working environment conditions for all types of operations.

2.6.2 Ice exposure and icing
Eastern and southern heading winds and currents will provide ice covered waters during the winter season. During summer, the ice will disappear. To operate during wintertime, ice classed vessels and support vessels will be needed. Ice bergs are hardly expected in the Pechora Sea, however, according to Krylov State Research Center, the risk of ice bergs must be taken into account in planning and construction. Icing due to lower temperatures and winds constitutes a major challenge to all kinds of operations during winter time. Additional sea spray freezing in open waters will create a major threat to vessels with respect to stability.

2.7 The Kara Sea
Maritime traffic today is very limited in the wintertime (mainly vessels to and from Dudinka) and somewhat higher during summer. The traffic is mainly linked to the ongoing activities at Yamal/Bovanenkovo, Sabetta and at Tambey. Transport between ports in the Atlantic and the Pacific oceans, using the Northeast Passage has been tested several times over the last couple of years and represents an interesting industrial opportunity in terms of future transport. Present activities in the Kara Sea South are mainly seismic operations, but drilling and development are expected to follow in short time.

To be able to operate safely, civil infrastructure has to be established both on Novaja Zemlja and at Yamal. Military restrictions at Novaja Zemlja and other adjacent land are assumed to be loosened or cancelled by the Russian authorities. The maximum distance to shore is approximately 200 km, which is within SAR/helicopter range from land, provided civil land bases and ports can be established (military restrictions). As the open water season is short (3–4 months), logistics operations (drilling/construction/operations) will be a huge challenge requiring a significantly improved port and transport infrastructure. In both southern and northern part of the Kara Sea the highest attention has to be paid to ice-resistant vessels and Ice Management.
2.7.1 Meteorological and oceanographic conditions

When moving into the Kara Sea the overall picture is growing more challenging. Cold winds and currents are entering from north along the eastern coast of Novaja Zemlja into the Kara Sea South basin more or less enclosed by Novaja Zemlja and the Yamal peninsula. Low temperatures and wind during winter time will challenge working environment conditions for all types of operations. Significant occurrences of polar lows are not expected.

2.7.2 Ice exposure and icing

Compared to the Pechora Sea, ice conditions in the Kara Sea are even more challenging. In the Kara Sea South, the sea ice is present most of the year (normally 7-8 months), resulting in a narrow maritime operational window. Due to northern currents and wind, the ice will pack up and multiyear ice is present most of the year. In the Kara Sea North, there will be frequent occurrences of ice bergs drifting in with the currents mainly from the Western part of Franz Josephs Land. As water depths in the ice berg origin areas are deep (more than 400 m) the ice bergs from Franz Josephs Land may be similarly large with a deep draught. However, looking at the bathymetry towards Novaja Zemlja the maximum possible ice berg draught is around 250 m both in the Kara Sea North and South. Such large ice bergs may only enter the Kara Sea South along the Eastern coast of Novaja Zemlja, as the central part of the Kara Sea is much shallower. In general, ice bergs are highly likely in the Kara Sea North, while less so in the Kara Sea South. Low temperatures and wind in the Kara Sea will imply heavy icing and challenging working environmental conditions in open or partly open waters during winter time.

2.8 Summary

2.8.1 Key challenges

Based on the presentation of physical features of operating in the High North, the following challenges can be highlighted when it comes to the Areas of development.

Arctic waters include the ice free waters of the Barents Sea South (Area 1). In these waters ice bergs/drift ice normally do not represent a risk for maritime operations. However, in the northern parts of the Barents Sea South, challenges and operational risks include: icing on vessels or installations due to low air temperatures, fog, darkness, polar lows and lack of infrastructure especially related to search and rescue infrastructure capabilities.

Seasonal ice covered waters include the ice covered waters of the Northern Barents Sea, the Pechora Sea and the Kara Sea (Area 2,3,4,5 and 6). The same risks that apply for maritime operations in the Barents Sea South are also representative for activity in ice covered waters, but, in addition, sea ice constitutes an explicit risk for vessels and personnel and represents major cost and regularity challenges for normal seagoing transports.

2.8.2 Technology/Solution providers

Weather predictions and surveillance

The operational network of meteorological and oceanographic observations in the Arctic is essential for accurate weather and wave forecasting for safe operations. Solution providers of services relevant for meteorological and oceanographic data (met ocean data) in the Arctic are listed in the matrix below (Table 2).

Currently, a cooperation program is being carried out between the Norwegian Meteorological Institute and the Roshydromet. The purposes of this program are, among others, development of meteorological observational systems, development of ice mapping and methods for presentation of

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11 See Appendix 2.8
12 See also a comprehensive overview of Technology/Solution providers in Chapter 10.
ice information in the High North. Furthermore, the program encompasses Norwegian/Russian exchange of weather data and experiences and methods such as operational forecasting methodology and climatology of polar lows. Expected results of the program include improvements of data collection systems, reporting on meteorological and ice conditions in the Barents Sea and a combined database for ice mapping and systems of hydrometeorological support to marine and coastal activities in the Barents Sea.¹³

<table>
<thead>
<tr>
<th>Nationality</th>
<th>Technology/solution providers</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>Arctic and Antarctic Research Institute (AARI)</td>
</tr>
<tr>
<td>C</td>
<td>The Canadian Ice Service</td>
</tr>
<tr>
<td>D</td>
<td>Danish Meteorological Institute</td>
</tr>
<tr>
<td>C</td>
<td>Fednav Group ENFOTEC</td>
</tr>
<tr>
<td>R</td>
<td>Hydrometeorological Centre of Russia</td>
</tr>
<tr>
<td>N</td>
<td>Jeppesen</td>
</tr>
<tr>
<td>N</td>
<td>Kongsberg Maritime</td>
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<tr>
<td>N</td>
<td>Kongsberg Norcontrol IT</td>
</tr>
<tr>
<td>N</td>
<td>Kongsberg Satellite Services</td>
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<tr>
<td>N</td>
<td>Miros</td>
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<tr>
<td>N</td>
<td>Multiconsult</td>
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<tr>
<td>N</td>
<td>Nansen Environmental Remote Sensing Centre (NERSC)</td>
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<tr>
<td>US</td>
<td>National Snow and Ice Data Center (NSIDC)</td>
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<td>N</td>
<td>Norut</td>
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<tr>
<td>N</td>
<td>Norwegian Meteorological Institute</td>
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<tr>
<td>R</td>
<td>Roshydromet</td>
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<td>N</td>
<td>SINTEF Group</td>
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<td>N</td>
<td>StormGeo</td>
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<td>N</td>
<td>Telenor</td>
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<tr>
<td>N</td>
<td>University Centre in Svalbard (UNIS)</td>
</tr>
</tbody>
</table>

Table 2: Technology/Solution providers – Weather predictions and surveillance

3. Logistics to and from an operating area

To secure operational efficiency, security and safety in Arctic waters, transport and logistics operations need to incorporate safety features, redundancies and operational systems (both offshore and onshore) which differ significantly from operations in the North Sea. The operational models will also depend on regional differences within the High North, being the Barents or Pechora or Kara Seas, and the stage of field operation, where needs and requirements vary significantly from seismic, exploration, development and construction, and production phase.

3.1 Maritime operations

3.1.1 Ice class notations

Maritime transport operations through the Barents, Pechora and the Kara seas include various challenges in terms of ice conditions. All vessels are subject to various rules and standards depending on type of vessel and operation. Compliance with these standards has to be certified and documented, normally by issuance of a certificate. Vessels intended for operation in ice covered waters will normally be built with an additional ice class notation.¹⁴ The different ice classes include requirements to strengthening of hulls, rudders and propulsion systems. Specification of an ice class notation is, however, not mandatory and the actual ice class, decided by the owner, will depend on type and area of operation.

¹³ Information based on meeting with the Norwegian Meteorological Institute.
¹⁴ See also the RU-NO Floating and Fixed Installations-report.
For areas with more heavy ice conditions (Areas 2, 3, 4, 5 and 6) the Polar Class notations will normally be applied. The current regulations include no direct technical requirements to hull and propulsion, but it refers to the additional requirements in the Polar Ice Classes. The additional requirements are divided into different levels depending on actual ice condition in area of operation. The Polar Classes are divided into seven levels, where PC7 is the least capable, limited to vessels operating in summer/autumn in thin first year ice (with old ice inclusions), whereas ships of PC1 are capable of operating year-round in all ice covered waters (Table 3).

<table>
<thead>
<tr>
<th>Polar Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC 1</td>
<td>Year-round operation in all Polar waters</td>
</tr>
<tr>
<td>PC 2</td>
<td>Year-round operation in all Polar waters</td>
</tr>
<tr>
<td>PC 3</td>
<td>Year-round operation in second-year ice which may include multiyear ice inclusions.</td>
</tr>
<tr>
<td>PC 4</td>
<td>Year-round operation in thick first-year ice which may include old ice inclusions</td>
</tr>
<tr>
<td>PC 5</td>
<td>Year-round operation in medium first-year ice which may include old ice inclusions</td>
</tr>
<tr>
<td>PC 6</td>
<td>Summer/autumn operation in medium first-year ice which may include old ice inclusions</td>
</tr>
<tr>
<td>PC 7</td>
<td>Summer/autumn operation in thin first-year ice which may include old ice inclusions</td>
</tr>
</tbody>
</table>

PC 1 to PC 6 may be assigned additional notation icebreaker

Table 3: Polar Class Notations
Source: IMO Guidelines

Currently, it is voluntary to be assigned to an ice class, but national and port authorities can require an ice class before accepting entrance into territorial waters, a port or request for ice breaker assistance. In that respect, Russia has national requirements regulating navigation on the Northern Sea Route applicable for all vessels of all nationalities. Meaning, these regulations are applicable for all vessels entering the Kara Sea (Area 4 and 6).

3.1.2 Ice breakers
An icebreaker is a vessel where icebreaking is the main purpose. Hence, ramming is part of the normal operation. Currently, Norway lacks the capacity of icebreakers to support oil and gas operations in the northern part of the Barents Sea (Area 1 and 3).

There are some 50 icebreakers in the world fleet. The Russian icebreaker fleet is by far the largest and most powerful, in terms of both icebreaking capability and number of ships. This includes the Russian state owned fleet, counting icebreakers powered by nuclear power plants, and several diesel powered icebreakers owned by private companies. Currently, Russia operates with five nuclear powered icebreakers capable for year round operations on the NSR. In addition, two nuclear powered icebreakers are operational on rivers. Nonetheless, the Russian fleet is aging and requires investments and replacements during the coming years to maintain its effectiveness and to support oil and gas operations in the Kara Sea (Area 4 and 6). Russia will have a large demand for new nuclear-powered icebreakers as activities increases. Of the existing six vessels that are operating in Arctic waters today only two will be operational by 2020. Currently, Russia has started construction of the first LK-60 nuclear-powered icebreaker at the Baltic shipyard outside St. Petersburg being the largest and most

15 See Chapter 7 for more information about Polar Code and the IMO Guidelines.
16 Developed and issued by the main Classification Societies members of the International Association for Classification Societies (IACS).
17 Rules of navigation on the water area of the Northern Sea Route (Approved by the order of the Ministry of Transport of Russia dated January 17, 2013).
18 The operative service of the Russian icebreaker fleet is administered by Atomflot.
powerful icebreaker ever built. The vessel is expected to be ready for traffic on the Northern Sea Route by 2018.

Commercial companies are also preparing for Arctic operations. For example, the multitask Ice breaking supply vessel, Vitus Bering, was delivered to Sovcomflot in late December 2012, by the shipbuilder Arctech Helsinki Shipyard. The yard was established by STX Finland and Russia’s state-owned United Shipbuilding Corporation in 2010. The overall purpose is to build specialized polar ships to complement Russian yards' capacity shortage.

3.2 Special needs for maritime facilities when operating in the High North

To ensure safe operations through the value chain of an offshore oil and gas field there are special needs of maritime facilities to support Arctic operations. The long distances to established onshore port infrastructure will require specific needs for the offshore operations. The following section underlines some of these needs.

To support offshore oil and gas operations there may be a need for forward based supply hub facilities close to field operations. In addition, special barges known as ware barges and/or dedicated offshore supply vessel design with ice class will be required. Vessels can serve as storage facilities for field operation/supplies, as a helicopter landing site for refuelling and emergency rescue operation and basic medical services. In addition, such hubs can serve as first line services/support facilities in case of an oil spill recovery.

Innovative maritime technology to meet Arctic conditions

Technologies can be modified or developed to address specific needs and requirements when operations are carried out in the Arctic. Though equally important is it to adjust and modify operational business and value chain models to provide for specific regional conditions. The High North presents itself with challenges related to severe physical conditions. As a result, new solutions and technology innovations are required, some examples being:

- Module transport to land based construction sites and transhipment.
- Supply (general cargo) – from base to end user or having a floating logistics base in open water to reduce distance in open water for ice strengthened vessels
- Waste transport from end user to open water logistics hub and then to shore. An additional transfer operation which may increase the risk for accidents/failures
- Transport of hazardous materials – according to Code – special problems for fluids in cold waters – need for heating in tanks
- Reduce human exposure to open air as effective air temperature may be extremely low due to the wind chill effect
- Stand-by vessel operations, with integrated multi-functionalities
- Towing – transporting offshore units to new operation sites
- Emergency towing – handling disabled vessels or offshore units

3.3 Regular personnel transport

Today, helicopter transport is the dominating mean of transport when it comes to transport of personnel to and from offshore facilities, as well as rapid transport of personnel back to the mainland if an emergency situation should occur. Two types of helicopters are used for transport of offshore personnel at the Norwegian continental shelf, the Sikorsky S92 and the Eurocopter Super Puma. Helicopter operations in the geographical focus areas are demanding due to vast distances, complicated climatic conditions and darkness as well as limited infrastructure. To ensure compliance with safety regulations, all flights will require helicopters with twin engines and two pilots certificated

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See Chapter 2 and appendix 3.1
for such operations in the Norwegian sector.\textsuperscript{20} OGP safety guidelines call for twin engines and two pilots when flying over water. The latest proven helicopter technology with rotor deice capability will also be needed for operations in Arctic conditions. Nevertheless, it is envisaged that the current practice of personnel transport may not be the only alternative to be considered for Arctic operations, except for the southern parts of the Barents Sea (Area 1).

The amount of fuel a helicopter can carry is the deciding factor for the operational range.\textsuperscript{21} The fuel requirement is calculated based on the requirement to be able to fly to the destination, perform an approach and be able to return to the original or an alternate airport onshore and still have sufficient fuel for 30 minutes flying time.\textsuperscript{22} Transport helicopters, currently in use, carry fuel for approximately three and a half hours of flying. The required reserve of 30 minutes of fuel is included. The Norwegian Oil and Gas Association guideline 066 sets as an additional requirement that the alternate airport cannot be an offshore facility. This limits the possibilities for long-range flights.

It is possible to increase the range by installing additional fuel tanks on the helicopter. This will, however, increase the weight of the helicopter and reduce the payload. Offshore facilities with fuel depots can increase the useful range of helicopter operations by providing refueling. The helicopter will have to land on the helideck at the facility in order to refuel. Helicopter in-flight refueling equipment is available on some Norwegian coastguard vessels. This system does not involve landing on the vessel. A fuel hose is hoisted from the vessel to the helicopter while in flight, connected to the helicopter and refueling is performed.\textsuperscript{23}

When considering future oil and gas activities in the Barents Sea South East (the southern parts of Area 1) a solution would be to establish a helicopter base somewhere in the Finmark East, dedicated to transport of personnel in and out of the offshore fields. However, if oil activities are relocated further north in the Barents Sea (northern parts of Area 1 and Area 2), the distance from the mainland will be too long when considering the helicopter’s point of no return. In other words, to carry out regular helicopter transport of personnel and efficient SAR operations from the mainland of Finmark East would not be possible when considering support for oil and gas activities in the northern parts of the Barents Sea.

Considering the possible long travel distance to remote work locations, alternative rotation schedules may be suggested. With all the risks inherent in either a) extended helicopter flights over water or b) slow journeys by boat, the current Norwegian practice of two weeks/four weeks rotations may be added to the risk profile, whereas in the Russian sector they will have extended rotations which will reduce the risk. If there are a few days travel to either ends, waiting on weather, etc., the current schedule may be inefficient and extended working schedules should be considered.

\subsection*{3.4 Summary}

\subsubsection*{3.4.1 Key challenges}

Vast distances from Arctic offshore fields to established port infrastructure entails specific needs of maritime facilities to support offshore operations. This may require supply hub facilities closer to field operations, special barge and/or dedicated offshore standby vessel design with ice class, as well as multitask vessels serving both as storage facility for field operation/supplies, as a helicopter landing site for refuelling and emergency rescue operation and basic medical services. In addition, such hubs can serve as a first line service/support facility in case of an oil spill recovery.

\textsuperscript{20} I.e. meet the requirements reflected in the OGP Aviation Management Guideline.
\textsuperscript{21} Norwegian Oil and Gas Association (2011 and 2013).
\textsuperscript{22} Forskrift om erversmessig luftfart med helikopter.
\textsuperscript{23} Jacobsen (2012).
Norway currently lacks the capacity of icebreakers to support oil and gas operations in the northern part of the Barents Sea (Area1 and 3). The Russian icebreaker fleet is the world’s strongest, in terms of both icebreaking capability and number of ships. Nonetheless, the Russian fleet is aging and requires investments and replacements during the coming years to maintain its effectiveness and to support future oil and gas operations in the Barents, Pechora and Kara seas (Area 2, 4, 5 and 6).

Helicopters are the most efficient mean of transport when considering regular personnel transport in and out of offshore fields. However, long distances from the mainland and severe Arctic conditions are making these operations challenging. The distance from the mainland of Finnmark East to potential offshore fields in the Barents Sea North (Area 2) is too large, when considering regular personnel transport and efficient SAR operations with helicopter. Long distances from shore to potential oil and gas fields in the Barents, Pechora and the Kara seas require new thinking, involving ice strengthened maritime vessels and multitask vessels for direct and intermediate transport (to shore and to adjacent land areas).

3.4.2 Technology/Solution providers

*Design and construction for ships operating in Arctic ice covered waters*\(^{24}\)

Safe operation of ships in Arctic conditions with ice and very low temperatures set strict requirements to technical standards. Innovative technological solutions for building and design of ships (i.e. hull strength, cargo containment systems, winterization, equipment, propulsion systems etc.), customized for Arctic ice covered operations, are being provided by several class societies, institutions, companies and shipyards worldwide.

Norway and Russia have a long tradition of providing innovative technology of design of ships and equipment as well as shipyards constructing ships for operations in Arctic ice covered waters. The Russian nuclear icebreaker fleet is able to meet most of the requirements in The Barents Sea North and the Kara Sea. The shipbuilding industry has traditionally been one of the leading defense industries in Russia. The state enterprise United Shipbuilding Corporation are managing a large number of Russia’s main shipyards. Atomflot has announced the construction of a new generation of nuclear icebreaker. The vessel will be built by St. Petersburg Baltisky Zavod shipyard beginning in 2013, and will be ready for operations in 2017.

The ministry of Industry and Trade in Russia recently addressed a need for new vessels by 2030, counting 1200 units. Furthermore, Rosneft has identified that there is a need for up to 500 vessels for the development of oil and gas fields in the Kara Sea, counting eleven vessels per well. Finnish shipyards such as the Aker Arctic Aker Yards have long expertise in the technology needed for designing and building icebreakers and icebreaking special vessels. A total of 60 icebreakers have been built so far, ranging from super-class, nuclear-powered icebreakers, Arctic multitask vessels and tankers to shallow draught river-sea cargo vessels. Innovative vessel design for future oil and gas activities are currently being developed by several companies worldwide.

Another example of research and innovation projects being carried out to provide the knowledge necessary for the industry to develop knowledge and technology for design of ships vessels operating in the High North is the ColdTech program.\(^{25}\) The ColdTech initiative is an international partnership led by Norut in Narvik and uniting a consortium of 21 partners being R&D institutes and partners from industry and business.

The table below gives an overview of companies/institution currently being a provider of the technology/solution for design and construction of ships (i.e. hull strength, cargo containment systems, equipment as well as shipyards constructing ships for operations in Arctic ice covered waters).

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\(^{24}\) See Chapter 10 for matrix for Technology/Solution providers for design and construction for ships operating in Arctic waters.

\(^{25}\) The Sustainable Cold Climate Technology initiative.
equipment, propulsion systems etc.), customized for Arctic ice covered operations (Table 4). Designs and constructors of offshore rigs and platform are not considered in the list.

<table>
<thead>
<tr>
<th>Nationality</th>
<th>Technology/solution providers</th>
<th>Arctic ship design and construction</th>
</tr>
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<tbody>
<tr>
<td>US</td>
<td>ABS Harsh Environment Technology Centre</td>
<td></td>
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<tr>
<td>R</td>
<td>Admiraltyevskiy Verfi (The Admiralty Shipyard) JSC</td>
<td></td>
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<tr>
<td>F</td>
<td>Aker Arctic Technology Inc. (AARC)</td>
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<tr>
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<td>AKAC Inc.</td>
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<tr>
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<td>Arctech Helsinki Shipyard Inc.</td>
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<td>Arktica Shipping</td>
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<td>R</td>
<td>Baltiysky Zavod (The Baltic Shipyard) JSC</td>
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<tr>
<td>FR</td>
<td>Bureau Veritas Group</td>
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<tr>
<td>R</td>
<td>Central Marine Research and Design Institute (CNIIMF)</td>
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<td>J</td>
<td>ClassNK</td>
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<tr>
<td>N</td>
<td>Det Norske Veritas (DNV)</td>
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<td>Lazurit Central Design Bureau</td>
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<td>Murmansk Shipping Company (MSC)</td>
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<td>Murmanskaya Sudoverf (Murmansk Shipyard)</td>
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<td>Nordic Yards</td>
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<td>N</td>
<td>Rolls Royce Marine</td>
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<td>R</td>
<td>Rubin Central Design Bureau for Marine Engineering</td>
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<td>R</td>
<td>Russian Maritime Register of Shipping</td>
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<td>R</td>
<td>Sevarnaya Yard</td>
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<td>Shipyard Yantar JSC</td>
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<td>Sevmash Yard</td>
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<td>R</td>
<td>Sovcomflot</td>
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<td>N</td>
<td>Yard Group</td>
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<tr>
<td>D</td>
<td>Viking Supply Ships</td>
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<td>F</td>
<td>VTT Technical Research Centre of Finland</td>
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<tr>
<td>R</td>
<td>Vyborg Shipyard JSC</td>
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<td>F</td>
<td>Wärtsilä Corporation</td>
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<tr>
<td>R</td>
<td>Zvezdvaz Far Eastern Shipyard</td>
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<tr>
<td>R</td>
<td>Zvezdochka yards</td>
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</tbody>
</table>

Table 4: Technology/Solutions providers - Design and construction for ships operating in Arctic Waters
4. In-field logistics

4.1 Development of oil and gas fields

Various operations take place in different phases of the value chain of an offshore oil and gas field. First phase include seismic mapping and long streamer operations and exploration drilling. The second phase includes development and construction and the third phase include production and maintenance.

Operations are challenging in waters with drifting ice, especially 3D seismic operations. Exploration drilling as well as construction and development will have to take place in the summer season. However, unplanned tasks such as maintenance and repairs may occur, meaning that operations also may be carried out during the winter season. In addition, periods of operation may be restricted due to environmental conditions (such as breeding season, migration season etc.).

4.2 Ice Management/operations

According to the Barents 2020 program, Ice Management is the sum of all activities where the objective is to reduce or to avoid actions from any kind of ice features. Ice management includes, but is not limited to:

- Detection, tracking and forecasting
- Physical management, such as ice breaking and iceberg towing
- Threat evaluation and alerting

Ice detection, tracking and forecasting must be capable of identifying, tracking and predicting the drift of all kinds of potentially hazardous ice features or ice situations. The devices, data collection and data integration systems used for ice detection will include a suite of platforms that should provide adequate and demonstrable ice detection capability for the expected ranges of environmental conditions. Devices should also provide sufficient information to detect, characterize and track the potential threat of ice features or situations, and take into consideration the risks of the potential ice hazards, their probabilities of becoming a threat, and the appropriate operation specific reaction times.

Physical Ice Management includes resources in form of qualified personnel and appropriate vessels. The resources must provide a demonstrated and adequate level of effectiveness and they must operate at an efficiency level that is consistent with the reliability requirements of the overall Ice Management system. Furthermore, they must be available on a fit-for-service basis when required and be designed to operate under the anticipated range of physical environmental conditions. Threat evaluation means identifying potentially adverse ice scenarios that can lead to the exceedance of pre-defined design or operating parameters (see Figure 7).

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26 For more information about drilling operations in the High North see the RU-NO Drilling, Well Operations and Equipment-Report.
In the findings of the Barents 2020 program, it was identified that threat evaluation is challenging and highly complex, involving large amounts of communication, several data sources and monitoring a constantly changing environment. In addition, the whole Ice Management system is dependent on a reliable surveillance system (detection, tracking, and forecasting). The detection systems involve different sources of data, e.g., satellite images and ice radars. The reliability and update frequency of such systems vary, e.g., due to non-controllable events like atmospheric conditions.\(^{28}\) Unless there is some redundancy, small deficiencies in the data gathering system may have effects on the efficiency of the Ice Management system. While Ice Management has been successfully carried out during operations in other parts of the Arctic, further improvement of technologies and procedures is crucial to operations in the High North.

### 4.3 Multitask vessels

Development of oil and gas activities in the Norwegian and Russian High North will require development of innovative designs for new offshore multitask vessels having various multiple functions.\(^{29}\) Furthermore, new types of vessels are likely to be required for operation in ice covered waters during winter time. Harsh operational conditions offshore and long distances to established onshore infrastructure, should stimulate the industry to develop multitask vessel design dedicated to serve the in-field needs in ice covered waters. Furthermore, multitask vessels will have important contingency functions of rapid mobilization in case of any unpredicted situation should occur in-field. Multitask vessels may have various functions:\(^{30}\):

- Ice breaking capabilities and systems for towing operations
- Search and rescue functions
- Emergency preparedness for operations/coordination, including acting as a place of safety in the event of evacuation from a platform
- Medical treatment and facilities
- Firefighting equipment
- Oil spill recovery systems
- Helideck for intermediate refueling of SAR helicopters

### 4.4 Human factors

Arctic climate will have a significant higher impact on humans and equipment than experienced by the Norwegian oil and gas industry in southern parts of the shelf, partly also the Russian. The Barents 2020 program addresses the needs and the importance having standards for working environment.

#### 4.4.1 Working environment

The Barents 2020 program was carried out to identify and address the needs of having common standards for offshore operations in the Norwegian and Russian parts of the Barents Sea, including standards for people working on board vessels and installations in the severe conditions. According to the Barents 2020 Guidelines, the general design philosophy should be that technical safety and working environment quality on facilities in the Barents Sea shall be maintained at the same level as for other facilities not exposed to Arctic environmental conditions. The Barents 2020 program concluded that the current standard, NORSOK S-002, provides the best baseline for further joint work on working environment and human factors for offshore and maritime operations in the Barents Sea. It offers a reasonably comprehensive guidance on working environment issues, but it is weak on Arctic-

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\(^{28}\) See Chapter 6 for more information on communications in the Norwegian and Russian High North.

\(^{29}\) For more information about multitask vessels see the RU-NO Fixed and Floating Installations-report

\(^{30}\) Reference is also made to “Multipurpose hubs”. See Chapter 6.3.2
relevant aspects. Therefore, the Barents 2020 addresses the need for specific standards related to offshore operations in cold climate. The group that was analyzing working environment calls for:

- **Safety and health standards of work in cold climate** (e.g. standards for cold risk management, safety of outdoor work in cold climate, clothing and personal protection equipment (PPE), first aid and medical provision etc.).
- **Winterization: design and technical solutions related to Arctic climate** (e.g. standards for safety dangers from icy conditions and vessel/installation motion at sea, de-icing and preventing falling ice etc.)
- **Noise & vibration in Arctic climate and Arctic operations** (e.g. standards for noise and vibration etc.)
- **Stress management: work situations in extreme climate zones** (e.g. standards for stress management, medical requirements and support for working in the Arctic, work/rest/rehabilitation regimes)

### 4.4.2 Arctic maritime training centers and certification for cold climate operations

A significant body of international public maritime law has established safety standards for maritime personnel. The IMO addresses mandatory competence and training requirements. However, the contents of these conventions are not specific when it comes to requirements for navigators and crews operating in ice covered waters. On the other hand, personnel operating in ice covered waters face several challenges and risks that require specific training and experience. These are, for instance, highlighted through Norwegian-Russian bilateral cooperation such as the Barents 2020. Furthermore, the IMO Guidelines call for specialized training for maritime personnel operating in ice covered waters. These regulations are currently voluntary, serving merely recommendations. At present, there are no mandatory requirements in terms of training and certification of personnel working on deck or board vessels or installations operating in ice covered waters. However, for safety reasons, it is important that personnel working on deck have sufficient training for cold climate operations.

Training of personnel operating in Arctic waters is usually subdivided into four categories:

- **Theoretical Training**: Creates a general understanding of ice navigation, icing, icebreaking operations and escorting in ice
- **Practical Training Course**: Navigator is considered as a student or trainee on board a ship, in addition to the regular crew, in order to observe and learn from experienced officers
- **On the Job Experience**: Inexperienced navigators are integrated as part of the regular crew and have to learn various ice operations from experienced colleagues
- **Simulator Training**: Enables navigators and crews to be trained properly for actions in different ice conditions including emergency situations. The main purpose of simulator training course is an increase of a professional level of the navigators appointed on large-capacity vessels or vessels with unusual maneuvering characteristics

Various maritime training institutions are developing, or have developed, ice navigation courses, employing full mission bridge simulators and associated software products. The IMO, for instance, has developed a program of model training to assist institutions developing ice navigation courses.

The most effective training is the so called “structured training”, which include simulation with an icebreaker maneuvering in different types of ice as well as simulation training with commercial ship ice maneuvering in combination with “Practical Training Course”. Currently, most training of personnel has been accomplished in an *ad hoc* approach, with the instruction of persons new to vessel

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32 See Chapter 7 for more information about the IMO-Guidelines.
33 With an emphasis on meeting STCW requirements.
operations in ice covered waters achieved by simple on the job experience and depending on knowledge transfer by experienced northern mariners. In other words, and in accordance with findings in an international research program, formal education requirements have been nonexistent, despite various classification societies working to develop such certified training programs.\(^{34}\)

Several countries have instituted courses, for instance in Russia, Norway and Canada.\(^{35}\) International harmonization is still necessary in order to provide the next generation of qualified personnel operating in the High North.

### 4.5 Summary

#### 4.5.1 Key Challenges

The various geographical focus areas have specific challenges through all the phases that restrict the operations. The exploration phase in the Barents Sea (south and particularly in the north), the Pechora Sea and the Kara Sea may experience challenges with regard to reduced progression of seismic surveying, GPS positioning and accuracy and ice interfering with riser/wires.\(^{36}\)

Various types of sea ice represent a challenge across all phases of an offshore oil and gas field development, in particular when operations are carried out in the Barents Sea North, the Pechora Sea and the Kara seas.\(^{37}\)

Human skills are critical when operating in cold climate. At present, there are no mandatory regulations in terms of training, assessment and certification of personnel working on deck on board vessels operating in ice covered waters. Several nations, among them Norway and Russia, focus on cold climate technology through research and education and see the need for a set of mandatory requirements to ensure future safe maritime operations in the High North.

In addition, there is a need for training and education of all personnel that will be, or are, involved in Ice Management. The training may include use of simulators and in-field exercises and would benefit from common guidelines. Today, the regulations and certifications for training of personnel operating in cold climate conditions in the north are not harmonized. Education and training of main functions may be needed prior to maritime activities in the High North.

#### 4.5.2 Technology/Solution providers

**Arctic maritime training of personnel**\(^{38}\)

The Russian Arctic maritime centers train prospective Arctic navigators using the “Preparation for Navigation in Ice Conditions” course developed by the Makarov Training Center. These courses are designed around three subdivisions: theoretical training, simulator training and practical training on board a vessel.\(^{39}\)

In Norway, the University of Tromsø offers practical and theoretical training related to navigation in ice covered waters through the Maritime Arctic Competence program (MAK). The training courses offered at the Tromsø University are similar to the training courses offered in Canada (St. Johns) and in Russia (Makarov). When conducting the practical training course, the students are training together with more experienced navigators onboard the Norwegian ice-breakers “KV Svalbard” and/or “KV Lance” in the ice covered waters around Svalbard. Furthermore, development of the simulator training

\(^{34}\) According to the research program Arctic Operational Platform (ARCOP).

\(^{35}\) See more about Technology/Solution providers in Chapter 10.

\(^{36}\) See also chapter 2.2

\(^{37}\) See Appendix 3.

\(^{38}\) See Chapter 10 for a comprehensive overview of the Technology/Solution providers.

\(^{39}\) AMSA (2009).
technology is in progress. For instance, the Ship Maneuvering Simulator Centre (SMSC) in Norway has, in cooperation with Det Norske Veritas (DNV GL), developed advanced mathematical models for the realistic visualization of ice for real-time simulation. The purpose of the ice maneuvering simulator includes Ice Management, different loading scenarios in drift ice and maneuvering in ice.

Many new icebreakers are equipped with azimuthal propulsion systems which require a different skill set to operating a linear propelled vessel. Training on driving an azimuthal vessel is required prior to entering an ice simulator as if the vessel cannot be handled effectively in open water, there is no chance in ice.

Opinions on simulator training are divided. Some studies argue that simulation training is the most effective way of preparing navigators for operations in ice covered waters. On the other hand, the simulator training is not always found to be effective because it is very difficult to create models for ships operating in ice. The functionality and the realism of the ice field movements and the dynamic interaction between ship hull and ice are restricted to very simple scenarios such as navigation in level ice, navigation in an opened lead and ship handling during convoy operations. The Norwegian company, Kongsberg Maritime, and the Marine Institute in St. John’s (Newfoundland) are collaborating on a five-year research project aims to improve the safety and efficiency of oil and gas operations in ice environments by improving dynamic positioning (DP) system technologies for operations in ice (Table 5).

<table>
<thead>
<tr>
<th>Nationality</th>
<th>Technology/solution providers</th>
<th>Arctic Maritime Training of Personnel</th>
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<tbody>
<tr>
<td>F</td>
<td>Aker Arctic Technology Inc. (AARC)</td>
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<tr>
<td>R</td>
<td>Admiral Makarov State Maritime Academy</td>
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<td>R</td>
<td>Admiral Nevelskoy Far East State Maritime Academy</td>
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<td>R</td>
<td>Captain Voronin Arkhangelsk Maritime College</td>
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<td>C-Core Research Institute</td>
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<td>Marine Institute of Memorial University of Newfoundland</td>
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<td>N</td>
<td>University of Tromsø</td>
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Table 5: Technology/Solution providers - Arctic maritime training of personnel

**Arctic Personnel Protection**

Protection and lifesaving equipment tailor made for operations in the Arctic is essential. Norwegian solution providers of services related to Arctic personnel protection in Arctic operations include design and development of cold climate clothing, survival suits, various innovative designs for life boats, rescue boats etc. The table below gives a description of some of the Norwegian solution providers of such equipment (Table 6).

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40 AMSA (2009).
41 According to the research program Arctic Operational Platform (ARCOP).
42 Kongsberg Maritime (2012).
Table 6: Technology/Solution providers - Arctic Personnel Protection

<table>
<thead>
<tr>
<th>Nationality</th>
<th>Technology/solution providers</th>
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<tbody>
<tr>
<td>N</td>
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<td>GB</td>
<td>Survitec Group</td>
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<tr>
<td>D</td>
<td>Viking Life Saving Equipment</td>
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</tbody>
</table>

Ice Management

The Barents 2020 program has identified that there has been a significant technological development within Ice Management over the last 30 years. This has had an impact on ice detection, surveillance, monitoring and forecasting. Furthermore, the Barents 2020 program highlights that the Ice Management system outlined for the Shtokman project illustrates that the endorsement of technology development, of building on other’s experience as well as the importance of doing own developments.

Several research centres and companies have experience in Ice Management, especially in Canada the C-Core Research Institute in St. Johns has experience in Ice Management in the sea areas surrounding Newfoundland and are one of the leading solution providers of such services. Also from Canada, AKAC Inc. were the providers of the active ice management services to Sakhalin Energy in support of an export operation in ice over a period of 10 years (Table 7). In Russia, research centres such as Arctic and Antarctic Research Institute (AARI), Central Marine Research and Design Institute (CNIIMF) as well as the Rosatomflot, has long experience from Ice Management in severe conditions in Russian Arctic waters.

Another example of a research and innovation project being carried out to provide the knowledge necessary for the industry to develop knowledge and technology of Ice Management is the SAMCoT program. The research activities in SAMCoT are carried out by the Norwegian University of Science and Technology (NTNU) together with sixteen other international research and industry partners.

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43 See Chapter 10 for an overview of Technology/Solution providers relevant for Ice Management.
44 Sustainable Arctic Marine and Coastal Technology (2013).
## 5. Land based infrastructure

The level of infrastructure within a region reflects the level of industrial activities. Increasing oil and gas activity generates a certain need for more transport and land based infrastructure to support the level of oil and gas operations. Today, the seaway transport system in Northern Norway is generally in good condition. On the other hand, the road system and, to some extent, the aviation system needs to be significantly improved. The latter two will be improved upon major resource discoveries and may not represent critical issues, if fully recognized as challenges and included in the planning.

### 5.1 Existing ports and port facilities related to oil and gas development in Norway and Russia

*The major ports supporting oil and gas development in Norway*

At present, the most important port in Northern Norway supporting petroleum activities is located in Hammerfest and include the supply base Polarbase and the LNG plant on Melkøya. Some supply services related to drilling and seismic activity have so far been performed from Kirkenes and some maintenance activities have been carried out in Tromsø. Both Hammerfest and Kirkenes have plans for expansion of their port facilities.

The port of Honningsvåg in the Sarnes Fjord serves today as the most important port for rescue operations and as a “waiting on weather window” port. The Sarnes Fjord is selected by Statoil as the most likely location for a possible shore based oil terminal for the oil fields in the Barents Sea (Johan Castberg).

In Tromsø, the construction work has started on a new industrial harbor at Tømsnes designed for the future oil and gas activity in the High North. This harbor is expected to be completed for operations in 2014. However, the industrial back-up facilities in Northern Norway are somewhat insufficient today, but many of the big manufacturers and oil companies are now establishing sub-departments.

Outside Kirkenes, the company Norterminal is planning to build a new oil terminal. The terminal is intended to serve the shipping and the oil and gas industry operating in the Barents Sea and adjacent waters. The facility is scheduled to be completed in 2018 with start of construction in 2015.
In 2011, The Norwegian Coastal Administration conducted a study of all ports and port facilities supporting large vessels in Northern Norway. The assessment also included an assessment of the maritime conditions for future maritime operations in the High North. The study was made on behalf of the Norwegian Government as a response to the rising strategic industrial focus on the High North, focusing on the needs of the oil and gas industry. The study has been an important contribution to the National Transport Plan (2014-2023) administered by the Norwegian Transport Authorities. The purpose of the study was to highlight the challenges of maritime and other supporting infrastructure in the northern part of Norway as well as requirements for further development of the Norwegian oil and gas industry. The conclusions provide a valuable basis for prioritizing future investments, both private and governmental. All major relevant ports and sailing routes in Northern Norway are discussed and characterized. Moreover, the assessment considers aspects for maritime surveillance, tugboat assistance, environmental emergency preparedness and emergency ports.

The major ports supporting oil and gas development in Russia

Currently, the ports of Murmansk and Archangelsk play an important role in the development of oil and gas activities on the Russian Arctic shelf. The ports are supporting drilling operations on the Kolguev Island, the Ob River mouth, the coast of the Pechora Sea and the peninsula of Yamal. Seismic vessels, supply bases of the Gazflot and Arktikmorneftegazrazvedka are located in the port of Murmansk.

Of all the western Russian ports, the port of Murmansk is the only ice free port that operates on a year round basis. Development of port facilities in Murmansk is connected with the western (opposite to the city) coast of Kola Bay as there are no free areas within the city zone. Further development would therefore depend on utilizing and updating existing facilities. The main naval base of the Russian Northern Fleet located in Severomorsk is likely to represent a major obstacle for the use of the port of Murmansk as a year-around port for the oil and gas industry. Liinakhamari Port in the Pechenga Fjord is favored by the Russian Marine Board as an industrial hub for the oil and gas industry and processes are ongoing to follow up this discussion.

The port of Archangelsk is located in the delta of the river Northern Dvina. One of the main drawbacks is that icebreaker escort is needed during large parts of the year, which is a disadvantage compared to Murmansk. Other handicaps include the shallow harbor (maximum draft 9 m compared to Murmansk’s 16 m). However, there are plans to build a deep water port (minimum 16 m) on the mouth of the river Northern Dvina making it possible to perform supply base services and to support the oil and gas industry.

The existing system of export of crude oil includes the transport project on shipment from Varandey terminal by shuttle tankers of an ice class and transshipment on Floating Storage and Offloading (FSO) Belokamenka on conventional non ice-classed linear tankers. Crude oil is carried out by small tankers (20-30 000 tons deadweight) from other shipping terminals (Kolguev Island and the Cape Kamenny) directly to the Western and northern European markets. See Appendix 5.4 for a comprehensive overview of Russian.

Previous plans for development of port infrastructure in the Murmansk region were connected with development of the Shtokman field. However, these plans are currently on hold and it remains to be seen whether the plans will become a reality in the future.

5.2 Ports and port requirements

The experience from Norway demonstrates the need for port facilities serving the oil and gas industry to be separated from the general cargo traffic. There are several reasons for why this is an adequate solution. Firstly, there are regulations and restrictions related to the operation of various types of cargo as well as requirements related to utilization of the port area. Secondly, there is a certain need for
flexibility in order to serve the oil and gas industry in a cost effective manner. Thirdly, there are various needs and requirements related to the security and the safety of operations.

Ports serving the oil and gas industry may have various purposes. Functions can be divided into the following categories:

- Supply bases
- Industrial sites
- Oil and gas processing plants and terminals
- Bad weather “waiting on weather” ports of refuge

The two first categories may be combined. However, if there is a lack of land and other infrastructure properties these two might be separated.

Taking into account the technological development and the challenges in the High North, requirements related to the following topics are important:

- The site, expansion and cost of land area
- Safe sailing route, from a maneuvering and environmental point of view
- Adequate harbor conditions related to maneuvering, space, anchoring areas, storage capacity and wave conditions

The High North is going through an early stage of oil and gas development and the distance to established industrial backup in the South involves long distances. Weather conditions may be severe and unpredictable for large parts of the year and the quality of the local industry backup service is currently inadequate. All this underlines the importance of creating industrial sites that have the possibility to grow and to be able to respond to the requirements of the oil and gas industry.

Furthermore, future logistics and industrial hubs will need access to land based infrastructure, such as roads, airports and railways.

Considering oil and gas terminals, there are two main issues of concern:

1. Environmental risk
2. High shipping regularity.

The costs and risks of operating in the harsh conditions in the North are of such a scale that only the best locations should be used, (i.e. those who have advantages of natural conditions).

5.3 Access to roads and railway network in Norway and Russia

The Norwegian railway network has its northern end at the port of Bodø, while the Swedish railway network ends in Narvik. Thus, the northernmost coast of Norway has no railway connection. It has, however, been suggested that the Finnish railway system might be expanded up to Kirkenes and that the Russian network should be lengthened from Nikel to Kirkenes. Notwithstanding, it remains to be seen whether these suggestions will become a reality in the future.

In Northern Norway, road connections to the ports are predominantly mainland connections and the most crucial requirements are related to:

- Width and bearing capacities of the roads
- High regularity during the winter season

In that respect the present road network in Finnmark represent a major bottleneck to obtain regional development and regularity during winter time to an expanding oil and gas development in the Barents Sea. The roads in Finnmark have to be significantly upgraded to achieve an acceptable standard. Otherwise, this is going to be a bottleneck for future oil and gas construction and may be a hindrance.
for project development. In the Eastern part of Finnmark, the road connections to Russia and Finland are the most important. Major upgrades towards Russia has started up while the connections to the future port facilities in Kirkenes are still on hold, as the port development structure has not yet been decided.

**The Russian Road and Railway network**

The road network in North West Russia is linked to several corridors connecting Norway, Sweden and Finland. The road conditions on the Russian side vary considerably and needs improvements. E105 between Murmansk and Kirkenes is undergoing improvement and will be completed during 2015.66

In Russia, the railway system is the “backbone” of the land based transport system. This means that all major ports related to oil and gas development should have a railway connection. Murmansk and Archangelsk have railway connections, but railways are not connected to adequate harbor areas for the oil and gas industry.

In Archangelsk, a new industrial harbor area with railway connection is likely to be built. This is, however, not the case in Murmansk, where there is lack of land and possible constraints on other maritime traffic in the Kola Fjord. Liinakhamari in the Pechenga Fjord is a possible location for a new port designated to oil and gas development. Pechenga is connected with railway to Murmansk and a former railway track goes out to Liinakhamari.

The perspectives of expanding the port of Murmansk include development of the west shore of Kola Bay. Current activities in the port include small-scale supply bases and areas designated for storage of drilling rigs. The transport of freight is provided by land based transport or by sea transport. The beginning of the construction of the coal terminal on the west shore of the gulf provides construction of a branch railway line which will accelerate development of the west shore area.

### 5.4 Airports and helicopter facilities in Norway and Russia

**Airports and helicopter facilities in Norway**

In Northern Norway, the airports in Finnmark County are most important and on the Russian side those in Murmansk Oblast. In Finnmark, there are landing restrictions in Hammerfest and Honningsvåg causing significant problems in terms of regularity. Alta is the main backup airport, but in winter time the road may be closed due to harsh weather conditions. The largest airport in Finnmark is located in Lakselv, which has the capacity to receive the biggest aircraft. Alta and Kirkenes are regularly used by domestic aircraft. The other airports have regular traffic only by smaller aircrafts.

In Northern Norway, rescue helicopters have their base of operation in Lakselv and Bodø, while the oil companies have established a base of operations in Hammerfest. In connection with the opening process of the Barents Sea Southwest, it is stressed that the helicopter range from Hammerfest is insufficient. In that perspective, it is reason to believe that a new base of operations further east has to be established.
Airports and helicopter facilities in Russia
In Murmansk Oblast, the main airport is close to Murmansk City. However, in the Pechenga valley there is a former military airport, which for a short period was used for civilian purposes that is now closed down. The latter might in the future be supplementary to the airport in Murmansk.

Along the coast of North West Russia, there are a number of airports (Figure 8), but from other airports in the northern regions of the western part of Russia only the airport of Murmansk and the airport of Archangelsk have the international status giving permission to receive international flights for Arkhangelsk-Murmansk-Tromsø.

5.5 Onshore power supply
Both in Murmansk Oblast and in Finnmark County energy supply is limited. In Finnmark County, the challenge is mainly related to the capacity of the distribution grid, while in Murmansk Oblast it is related to lifetime of the nuclear power stations and the grid.

The current power supply system in Northern Norway is insufficient to support the oil and gas industry. A likely requirement from Norwegian authorities is power supply from shore (if possible), e.g. from Finnmark. Statnett/North Energy has made attempts to estimate the future needs for
electrical power, and on this basis developed a possible grid scenario for supply. However, the concession time for new el-power infrastructure (420 kV) is almost the same as for an oil field from exploration to production (15 years). Norway has already experienced constraints when it comes to power supply of a possible expansion of the Snøhvit LNG plant and the supply to the Goliat platform.

In Murmansk, very high energy cost is experienced. Consequently, the onshore energy supply either in Russia or Norway must be able to serve an expanding oil and gas industry with energy without major investments. The solution being discussed in Norway requires significant investment in grid infrastructure, while in Russia possible gas power plants are on the agenda.

Floating offshore installations and processing plants can produce their own energy, while subsea installations have to be served by electrical cables from land and/or from platforms. From an oil and gas point of view, energy supply from the shore in Finnmark is a major bottleneck in order to exploit oil and gas resources in the High North.\footnote{Statnett (2011).} More energy is needed and can possibly be supplied by power lines from the south and gas power plants or nuclear plants, including the floating nuclear thermal power plants, which construction is begun on Baltiysky shipbuilding plant in St. Petersburg. For use of the electric power for the Kola nuclear power plant expansion of capacity of distributive networks is necessary.

Finnmark is today importing some electrical power from Russia. However, the Russian oil fueled power plant in Murmansk is not sufficient and is to be modernized. One alternative is to build a new plant based on natural gas. In that case Norwegian authorities may open for a significant increase of el-power from Russia securing the supplies in Northern Norway. Russian authorities are also evaluating import of LNG gas from Norway for the same purpose.

When considering possible cooperation between Norway and Russia, this is an interesting alternative that opens for a variety of common efforts.

5.5.1 Power supply to the Barents Sea South and North

ABB and Siemens has received the request from the RU-NO Barents Project, (Focus Area Logistics and Transport), to describe a power transmission and distribution concept that could support development of fields far from shore and in difficult climatic conditions in the Barents Sea.\footnote{Based on feasibility studies from Siemens (2013) and ABB (2013).}

The figure below gives two examples on how such a grid solutions could be solved (Figure 9). The feasibility study made by ABB is based on high-voltage direct current (HVDC) power transmission system. The Siemens feasibility study is based on alternating current (AC) power transmission system.
5.6 Summary

5.6.1 Key challenges

Considering the current level of port infrastructure, some of the challenges related to the northern cities are the quality and the capacity of the industrial backup. However, as oil and gas activities increase, as well as the level of improved port infrastructure, it is assumed that the high level of activity combined with more focus from the industry on the locations with the best opportunities and advantages will result in a significantly stronger industrial development in Northern Norway.

In the North West Russia, the situation is even more challenging. The existing port infrastructure is not adapted to the specific needs and requirements of the oil and gas industry. This is both related to the physical infrastructure and the legal and bureaucratic framework. The quality and capacity of the industrial backup services are currently far from what is required from the oil and gas industry. These challenges are closely connected to the lack of predictability related to future oil- and gas activity on the Russian Shelf in the North.

Improved energy supply is an important issue to both Norway and Russia in the North. Norway is planning to extend high power lines from south to north in order to increase the capacity while Russia are considering to replace the present (and old) nuclear power plants with gas power plants. In that respect the question has been raised whether a possible increase of energy export to Finnmark would be of interest.

In order to improve the ports of Archangelsk and the port of Murmansk there are several challenges. Currently, Murmansk lacks railroad connections to important terminal areas. There will be a need for development of supply bases and industrial zones in order to service future oil and gas activities. However, the region lacks qualified construction companies as well as qualified personnel necessary for oil and gas technology production.

The shipping lanes to the port of Arkhangelsk are characterized by its narrow channel with insufficient depths, which does not allow large vessels to enter the port. In addition, it will be necessary to have icebreaker support in order to enter the port during certain period of the year.
6. Emergency response and communications

The purpose of this chapter is to examine the emergency response systems (capability) in Norway and Russia, respectively, including available search and rescue (SAR) capabilities.

6.1 Emergency response in Norway and Russia

UN bodies such as the International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO) provide international regulations concerning safety of maritime and aeronautical operations. These regulations are applicable for oil and gas operations in the Russian and the Norwegian High North.

Emergency response in Norway

In Norway, the northern Joint Rescue Coordination Centre (JRCC), located in Bodø, has the overall operational responsibility to coordinate rescue operations in the Norwegian sector of the Arctic SAR area. The JRCC has two important purposes, the Air Traffic Service units, which carry out notification and communication tasks when aircraft are in distress, and the coast radio stations, which monitor the maritime activities and effect communication when emergencies occur at sea. JRCC has available resources if any emergency situation should occur. This includes the Norwegian Coast Guard, maritime radio, local emergency capacities, the 330 Squadron of the Norwegian Air Force, Vessel Traffic Services, the Norwegian Coastal Administration, the Norwegian armed forces and the emergency capacities of oil and gas companies (ships and helicopters).

BarentsWatch is a comprehensive monitoring and information system covering the sea and coastal areas from Denmark in the south, to Greenland in the west, the North Pole in the north and Novaya Zemlya in the east. The main purpose of this system is to secure a civilian monitoring of Norwegian waters, as part of an operational activity, contributing to responsible management of environment and resources. The Barents Watch system is administrated by the Norwegian Coastal Administration.

Emergency response in Russia

In Russia, search and rescue operations and oil spill responsibility are shared by the Marine Rescue Coordination Centre (MRCC) Murmansk and MRCC Dikson in their respective search and rescue areas. Murmansk (MRCC) and (JRCC) in Bodø can coordinate Norwegian/Russian rescue operations in the Barents Sea.

The Russian ministry of Emergency (Emercom) is responsible for preparedness of major accidents on land and in coastal areas of Russia. Emercom is not responsible for incidents at sea, but may requisition civilian helicopters and fire helicopters - thus playing an important role in air-to-sea rescue operations at sea. Also, the State Maritime Rescue and Salvage Department (Federal Basu) vessels participate in rescue operations in the Barents Sea.

The cooperation between Russia and Norway is practiced through joint projects and joint exercises. One example is the joint exercise between the rescue centers in Norway, Russia, Sweden and Finland called Barents Rescue, where the military is also involved among many others. The purpose of this exercise is to drill collaboration and information exchange between the two nations, where saving lives at sea and protection of the environment is the common goal.

6.2 Communications

Currently, communication services are far from adequate in order to support the needs of the oil and gas industry within the geographical focus areas. The level of communication is severely limited due to lack of ground infrastructure and insufficient or non-existent geostationary satellite (GEO)

49 See more about this theme in chapter 7.
50 See more about the Norwegian Arctic search and rescue area (SAR-agreement) in chapter 7.
Today’s satellite coverage is reduced when passing 72° N latitude and is, for all practical purposes, non-existing from 75° N and northwards.\textsuperscript{51}

Table 8 summarizes the main communication systems and roughly depicts their characteristics in different parts of the Arctic. The green and red areas represent available and unavailable systems respectively. The yellow areas represent a combination that is not fully investigated and where more research and development are required. The yellow/green areas are mostly well understood, but where more research may be needed for special use cases, such as the oil and gas industry.

<table>
<thead>
<tr>
<th>Systems</th>
<th>Characteristics</th>
<th>(&gt; 80° N)</th>
<th>(70° N - 80° N)</th>
<th>(&lt; 70° N)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Terrestrial systems</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HF, MF</td>
<td>Safety related messages and voice communication</td>
<td>Low reliability and unsuitable for digital communications</td>
<td>Low reliability</td>
<td>OK, but unsuitable for digital communications</td>
</tr>
<tr>
<td>VHF,</td>
<td>Line-of-sight (30 nautical miles), voice and low data rate communications</td>
<td>Ship-to-ship communication is OK. No connection to land based stations</td>
<td>Connection to a small number of land based stations. Ship-to-ship OK</td>
<td>OK close to the coast.</td>
</tr>
<tr>
<td>GSM, 3G</td>
<td>Line-of-sight (30 nautical miles), voice and data rate communications</td>
<td>No connection to land based stations</td>
<td>Connection to very few land based stations</td>
<td>Limited coastal coverage. Connection to land based stations making the system suitable near the coast.</td>
</tr>
<tr>
<td><strong>Satellite systems</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GEO satellites, including Inmarsat</td>
<td>Medium capacity. Low to medium latency</td>
<td>Not available</td>
<td>Potential problems with quality and availability</td>
<td>OK (except in fjords and similar special areas)</td>
</tr>
<tr>
<td>LEO satellites; Iridium, OpenPort</td>
<td>Currently max. 128 kbps. High and variable latency</td>
<td>Potential problems with quality</td>
<td>Potential problems with quality</td>
<td>OK</td>
</tr>
<tr>
<td>HEO Satellites</td>
<td>Properties comparable to GEO. Currently unavailable</td>
<td>Expected to provide coverage, capacity and quality in the Polar and Sub-Polar areas. Spare capacity can be used in other sea areas. Not yet implemented.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8: Communication systems in the High North
Source: Marintek and DNV

Currently, Very High Frequency radio (VHF) is mainly used for connection to land based stations (voice) during maritime operations related to offshore oil and gas activities. As illustrated in the table above, communications during operations between 70-75° N latitude, corresponding with the geographical areas of the Barents Sea South (Area 1), the Pechora Sea (Area 2) and the Kara Sea South (Area 4), have low reliability when it comes to connection to land based stations. GSM is also limited when it comes to connection to land based stations.

When operating in latitudes above 75° N, approximately corresponding to the geographical areas of the Barents Sea North (Area 3 and 5) and the Kara Sea North (Area 6), are most communication systems unavailable. This also includes VHF connections to land based stations, which are essential for efficient SAR operations.

Experiences from seismic operations in the High North indicate that communication is satisfactory on board and between vessels. A significant challenge, however, occurs in emergency situations where

\textsuperscript{51} Lunde (2013).
numerous instructions and large amounts of information have to be provided, understood and coordinated in the field and between fields and rescue centers/communication centers. This is the case in all areas, except for parts of the Barents Sea South (Area 1). \textsuperscript{52}

Even though the satellite communication capacity is expected to be sufficient in areas below 72°N, there are other issues that might still make the systems inadequate, especially for complex offshore and marine operations. Some of these operations require very high Quality of service (QoS), such as high system reliability and low latency (for real time transfer of data/information). Due to the Arctic impact of the Arctic environment on communication signals (icing of outdoor equipment, salinity, wave height, humidity, high ionosphere activity and magnetic influence) the QoS can be degraded. Figure 10 displays (GEO) satellite coverage, illustrating non-existent coverage in the High North. The blue circle represents Telenor’s coverage and the red, yellow and green circled Inmarsat’s coverage.

To keep control of the trajectory of the wellbore during directional drilling, drilling companies apply compasses and satellite geomagnetic referencing models to calculate the position and direction of the wellbore. In the Barents Sea, auroras occur regularly during night time causing disturbances to the earth’s geomagnetic field. As compasses and satellite based geometrical models rely on the earth’s geomagnetic field, frequent outbursts of auroras may hamper the development of oil and gas fields in the Barents Sea and other areas characterized by recurring auroras. \textsuperscript{53}

6.3 Search and Rescue

\textit{Vessel Traffic Services}

The vessel traffic services (VTS) of the Norwegian Coastal Administration (NCA) is established in areas where shipping represents a particular risk to maritime safety and to the environment. Within these areas the VTS monitor tankers and other risk traffic using vast networks of monitoring sensors. On behalf of the Norwegian authorities the traffic control center provides Vessel Traffic Services based on domestic and international regulations. A VTS has three main tasks:

1. Monitor all ship movements - record, identify and detect irregularities
2. Be in continuous dialogue with the vessel traffic
3. Take action when an incident occurs

\textsuperscript{52} See Chapter 2.
\textsuperscript{53} Based on meetings with the Geophysical Observatory at the University of Tromsø.
Vardø Vessel Traffic Service (NOR VTS) has as scope of operations in the Norwegian economic zone from the Swedish border in the south to the border between the Norwegian and Russian economic zones in the north, in addition to Svalbard and Jan Mayen. The Northern Maritime Corridor is regarded as an important linkage to North West Russia, connecting the Northern Norway to the North West Russia. This is also a main route for oil tankers from Murmansk to the markets in Europe.

A VTS has different tools for use, these are:
- Radar that gives operators a real-time picture of the traffic situation
- Automatic Identification System (AIS).
- Ship Reporting System / other sources.
- Video surveillance in narrow shipping lanes.
- Meteorological stations.
- Maritime VHF communications with vessels.
- Integrated computer systems where most of the available information is displayed and store

Another important task is the management of the state emergency tow response service in Norway. During incidents at sea, the traffic centre in Vardø and the emergency tow response service will be included as a part of the NCA’s total resources in cooperation with the NCA’s emergency department.

Norway is now establishing a joint ship reporting system with Russia for surveillance of traffic from Lofoten to Murmansk. All vessels passing through, or proceeding to and from ports and anchorages within the Barents area, will have to report to the vessel traffic management information system, named Barents VT/s. The vessel traffic centers in Vardø and Murmansk (Kola Bay VTS) are to function as key information nodes for ship traffic in the north. Of particular importance are tankers and ships carrying hazardous cargoes. In northwest Russia, both the ports of Murmansk and Kandalaksha will be integrated to the system as well as voyages in the Russian sector of the Barents Sea.

**The Norwegian Coast Guard**
The Norwegian Coast Guard’s main tasks are fishery inspection, environmental protection, customs surveillance, as well as representing an important emergency capacity ambitioned to be staffed with a doctor on one or more vessels operating in the Barents Sea at any time. The helicopter carrying units are equipped with medical devices for provision of first aid and minor surgical treatment. Collaborating with other emergency capacities, such as the JCRR, the Norwegian Coastal Administration, the Norwegian Maritime Authorities and other important rescue capacities (including the Norwegian Sea Rescue), the Coast guard is usually the first emergency response organization in place when accidents occur at sea. Today, the Coast Guard fleet of type Lynx helicopters are old and must be replaced.

**6.3.1 SAR helicopters**
Helicopter evacuation is considered as the preferred method of dry evacuation from a facility in an emergency situation in the High North. However, SAR operations are hindered by wind speed, poor visibility, fog or snow and the pilot’s ability to operate under prevailing conditions.

The Governor of Svalbard deploys ambulance helicopter services on the Svalbard archipelago and in adjacent sea areas. The Governor has signed a contract with Airlift AS to serve two rescue helicopters (Super Puma AS 332 L1 AW SAR and AS 365 Dauphin N2 Helicopter).

The Norwegian rescue service, the 330 Squadron, is the operator of the rescue helicopter services in Norway. The squadron is located in Banak, nearby Lakselv in Finnmark and operates one Sea King helicopter (Figure 11). When considering rescue operations in the Barents Sea, and the distance from the helicopter base at Banak, the coverage will be limited to only small parts of the Barents Sea East.
(Area 1). This means that SAR helicopters served from the mainland will not have the capacity to support oil and gas activities in the Barents Sea North (Area 3).

![Figure 11: Current helicopter range from Hammerfest, Banak and Vardø](source: Proactima, 2012)

A limiting factor with regard to helicopter transport is related to the ability to rescue personnel in the event of a helicopter incident leading to persons in the sea. Where rescue is based on the use of SAR helicopters, the general rule is that helicopter transport of personnel shall not be carried out if the wind on the helicopter deck where the SAR helicopter is stationed exceeds 55 knots. This is due to the fact that the SAR helicopter rotor cannot be started when the wind is above 55 knots. The platform manager, together with the SAR captain, can deviate from this guideline if the local conditions allow a deviation.

The Norwegian Search and Rescue Service are in a process of acquiring 16 new helicopters. The contract award was signed on 19th of December 2013 with the total acquisition being made within 2020. The selected supplier, Agusta Westland, has offered their AW101 helicopter solution. The AW101 has sufficient cabin volume with the capacity to carry 29 survivors and a crew of 6. The SAR-reach (from shore and return) of this type of helicopter is approximately 480 km (approximately 300 miles), including recovery of 20 people from the sea. Installation of an auxiliary fuel tank may further extend the total reach from the starting point, but will reduce the payload. 16 of the helicopters will be based on one of the six main Norwegian rescue bases, of which two are in the Northern Norway (Banak and Bodø). The optional six helicopters are intended to serve the helicopter rescue base at

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54 Norwegian Oil and Gas Association (2013).
55 In addition, an option on six more helicopters.
Svalbard/Longyearbyen. The alert time for the latter is one hour whilst the alert time for the helicopters at the six base stations are 15 minutes.

**Medical resources**

The University Hospital of Tromsø is the largest hospital in the region and provides remote medical diagnostics, telemedicine. There is a national centre for this type of medical care and support in Tromsø, the Norwegian Centre for Integrated Care and Telemedicine. An extensive air ambulance service is operated from Tromsø. If it should become necessary to treat a large number of injured persons the combined resources of Hammerfest, Kirkenes and Tromsø hospitals could be used with Tromsø dealing with the more serious injuries.

### 6.3.2 Multipurpose hubs

As part of a license to operate, oil companies have to develop their own emergency response systems covering probable incidents and accidents. A multipurpose hub could be a floating or land based unit focusing on supporting offshore oil and gas operations and ensuring support functions such as:

- Emergency operations/coordination
- Weather surveillance
- Hospitals/medical facilities
- Firefighting equipment
- Oil spill recovery equipment
- Additional systems and equipment for SAR
- Communications
- Helicopter base
- Telemedicine

The Agusta Westland AW101 is one example of the current state-of-the-art helicopters. This type of helicopters can reach out approximately 480 km from the base in a search and rescue configuration to recover 20 people from the sea. The map below shows the geographical focus area, with the red circles indicating possible multipurpose hubs with helicopter facilities in order to cover the Barents Sea in a large scale SAR scenario (Figure 12). Upon discoveries on the Russian side in the Kara Sea and Northwards more hubs may be considered.

![Map showing possible multipurpose hubs with helicopter facilities](image)

**Figure 12: Multipurpose hubs with helicopter facilities**

Source: North Energy
6.3.3 Emergency response covered by the industry

To specify resources and develop operational procedures for the High North there is a need to develop a set of defined scenarios. Guidance on how to use defined danger and accident scenarios (Definerte fare- og ulykkeshendelser, DFU) are provided by the Norwegian Oil and Gas Association in their guidance documents. This is a good starting point when developing an emergency response system. The SARiNOR pilot project has identified the following resources available, when operating oil and gas fields in the Arctic waters there is a need for:

- Drilling/production unit
- Stand-by vessel
- Vessels supporting the drilling/production rig
- Floating / forward based supply base
- Extended on-board medical competence and equipment due to long transport distances to shore based medical expertise and hospitals
- Extended use of telemedicine – need for communication equipment and tools for minor surgeries.

In addition the SARiNOR project identified the following critical issues for SAR operations in Arctic waters:

- Early notice without loss of time
- Effective systems and equipment for search e.g. helicopters. This requires a high broadband communication link. The harsh environment reduces survival time for persons in the sea and also in life-rafts or lifeboats. Alarms should be sent early, mobilization of search and rescue units should be short, transit speed of SAR resources high and localization equipment on board SAR units should include advanced technologies for search in darkness and low visibility. Emergency/survival equipment for air drop should be available at strategic locations on shore.
- Fast mobilization and presence of rescue vessels and equipment.
- Emergency response equipment and local storage
- Efficient ways of getting people on board rescue vessels
- Effective coordination and execution of SAR operations
- Communications in real time; common understanding of the situation. Overall management organization
- Hospitals/medical treatment facilities/temporary evacuation, remote located equipment/depots. High quality telemedicine system (access to competence on cold climate injuries.)
- Personal emergency equipment, such as survival suits, reducing loss of temperature and increasing survival time.

6.4 Summary

6.4.1 Key challenges

Currently, communication services are insufficient in order to support the needs of the oil and gas industry when operating in the High North. Communication is limited due to lack of ground infrastructure and insufficient geostationary satellite coverage. Today’s satellite coverage is reduced when passing 72° N latitude and is, for all practical purposes, non-existing from 75° N and northwards.

Experiences from seismic operations in the High North indicate that communication is satisfactory on board and between vessels. A significant challenge, however, occurs in emergency situations where numerous instructions and large amounts of information have to be provided, understood and coordinated in the field and between fields and rescue centers/communication centers. This is the case in all areas, except from the southern parts of the Barents Sea South (Area 1).  

56 See Chapter 2.
In an emergency situation in the High North, offshore SAR operations are challenging due to wind speed, visibility, fog or snow as well as distances from the mainland. When considering helicopter rescue operations in the Barents Sea, and the distance from the helicopter base at the current base station located at Banak, the coverage will be limited to only small parts of the Barents Sea East (Area 1). When considering rescue operations in the Barents Sea North (Area 3), and the distance from the mainland, SAR operations with helicopters will not be possible without an intermediate fuelling platform, such as a heli ware ship.

6.4.2 Technology/Solution providers

Communications
Currently, research is carried out by several industrial players in order to meet the future challenge of oil and gas operations. Marintek started up a project with Telenor in May 2013 called Arctic Satellite Communication (ASK). The first phase of the project is to identify who potential users are and what are their needs. The next phase is to make a system proposal for continuous satellite coverage in the Arctic. The SARiNOR report emphasizes the need for a high capacity broad band in emergency situations, which will also be covered by the ASK-project. If everything goes according to intentions, Norway will be able to launch two satellites into high elliptical polar orbits covering the needs of the oil and gas industry by 2020.

In October 2013, the Ministry of Foreign Affairs approved an application of funding in order to stimulate more innovation on the efficiency and capacity of the search and rescue operations in the Arctic. The funds will be allocated to create a collaborative arena for the industry and public actors in search and rescue to contribute to a common understanding of the situation. It will also prepare a roadmap with concrete proposals for technical improvements in the various phases of a search and rescue at sea. This is a continuation of the SARiNOR project.

Arctic SAR and Helicopters
Helicopters are vital to transport of personnel to and from facilities operating the Arctic. Some research has been carried out focusing on safety improvement of helicopter operations. The safety status of helicopter operations has been documented and studied in three helicopter safety studies performed by SINTEF on behalf of the stakeholders in the industry. The overall objective of the studies has been to contribute to improved safety in helicopter transport of personnel.

The solution providers within SAR are a combination of several institutions and companies. These are the national authorities such as the Arctic coastal authorities, the research institutions and the industry working with development of new design for various Arctic SAR purposes, as well as military resources. The scope of Arctic SAR capabilities is the sum of all these capabilities. Some of these solution providers are listed in Table 9.

57 Such as Telenor, Avinor, Kongsberg Satellite Systems and various R&D institutions.
58 SINTEF (2010).
7. Regulatory framework

This chapter gives a brief overview of the regulatory framework and regulations of particular relevance for logistics operations related to oil and gas activities in the High North.

7.1 International regulatory framework

7.1.1 UNCLOS

The Arctic Ocean is, like all other oceans, subject to international ocean law laid down in United Nations Convention on the Law of the Sea (UNCLOS III). Of particular relevance are the coastal state regimes, such as internal waters, territorial sea, contiguous zones and Exclusive Economic Zone (EEZ), all of which can be found in the waters of the states bordering the Arctic Ocean. UNCLOS provides a fundamental framework for the governance of Arctic marine operations and entitles coastal states to adopt and enforce laws and regulations to prevent, to reduce and to control marine pollution from vessels in ice covered waters.

7.1.2 The IMO-Guidelines and the Polar Code

The International Maritime Organization (IMO) is the UN agency responsible for issues related to the international maritime industry. The purpose of the IMO is to facilitate cooperation among governments on regulations and practices related to technical matters affecting shipping engaged in international trade. Furthermore, the IMO shall encourage and facilitate the general adoption of the highest practicable standards in matters concerning maritime safety, efficiency of navigation and prevention and control of marine pollution from ships. The main activity within IMO, associated with maritime safety in the Arctic, is the work on the Polar Code.

The main purpose of developing a Polar Code is to supplement relevant regulations and to address risks that are specific for operations in polar waters, taking into account the extreme environmental
conditions and the remoteness of operation. The IMO is currently developing a draft International code of safety for ships operating in polar waters (Polar Code), which would cover the full range of design, construction, equipment, operational, training, search and rescue and environmental protection matters relevant to ships operating in the inhospitable waters surrounding the two poles.

The current regulations applicable for ships operating in polar waters are known as the IMO-Guidelines - Guidelines for ships operating in Polar Waters. The IMO-guidelines are non-mandatory, serving merely as recommendations. For the IMO-guidelines to become legally binding depends on the individual states implementing the regulations in their national legislation. According to the Norwegian Coastal Administration there is a process, which should see the Polar Code being implemented into Norwegian legislation from 2015 or 2016. It remains, however, to see whether this milestone will be achieved in time.

7.1.3 The SAR-Agreement

The first international agreement made exclusively for the Arctic region was signed in 2011. The SAR-Agreement is the first legally binding agreement established under the auspices of the Arctic Council and covers search and rescue of aeronautical and maritime vessels and passengers. The objective of the SAR-agreement is to strengthen the search and rescue cooperation and coordination in the Arctic. In order for that to be clear, each member state was given a particular search and rescue area, for which it is responsible (Figure 13). The necessity of such an agreement and cooperation is important, as accidents in the region rely on immediate responses and efficient operations, as much as fully qualified rescue personnel and equipment.

Figure 13: SAR responsibilities between the Arctic nations
Source: Arctic Council

59 Such as the Convention on Safety of Life at Sea (SOLAS) and the International Convention for the Prevention of Pollution from Ships (MARPOL).
60 (A 26/Res.1024).
61 Arctic Council (2011).
7.1.4 The Oil Spill Response Agreement

A legally binding agreement on: *Cooperation on Marine Oil Pollution Preparedness and Response* was signed by all the Arctic member states under the auspices of the Arctic Council in May 2013. The purpose of the agreement is to strengthen cooperation, coordination and mutual assistance among the Parties on oil pollution preparedness and response in the Arctic in order to protect the marine environment from oil pollution. The agreement also emphasizes regularly conducting joint training and exercises, as well as joint research and development.

7.2 National regulatory framework

When entering the Kara Sea, Russia has a set of national regulations applied for navigation on the Northern Sea Route (NSR). Russia regulates shipping along the Northern Sea Route on the basis of UNCLOS III and domestic legislation. Regulations adopted in 2013 allow navigation on the NSR basis for ships of all nationalities based on *Rules of navigation on the water area of the Northern Sea Route*. This basic legal framework is applicable to foreign shipping navigating on the NSR. When applying for permission to enter the NSR, entrance must be approved by the Northern Sea Route Administration, established as a federal government institution. The application must be sent to the NSR Administration not earlier than 120 calendar days and not later than 15 working days before the intended date of the entering of ship into the water area of the Northern Sea Route. The NSR Administration will consider the application within 10 working days.

If the ship-owner gets permission of entering the NSR, there is a set of fees that the ship-owner must comply with. For instance, ship may be required icebreaker assistance. Icebreaker assistance is provided by icebreakers authorized to navigate under the State flag of the Russian Federation. Icebreaker assistance involves ensuring safety of navigation of ship in the water area of the Northern Sea Route. Information on the necessity to use icebreaker assistance under heavy, medium and light ice conditions, while sailing in the water area of the Northern Sea Route, is provided by the NSR Administration. Fee rate of the icebreaker assistance of ship in the water area of the Northern Sea Route is determined according to Russian legislation about natural monopolies, taking into account the capacity of ship, ice class of ship, distance of the escorting and period of navigation.

Furthermore, an ice pilot and ice helmsman may be required in order to guide a ship through the NSR. Pilot ice assistance of ships is carried out with the purpose of ensuring safety of the navigation of ships and prevention of accidents as well as protection of the marine environment in the water area of the Northern Sea Route. According to the Russian regulations, persons carrying out the pilot ice assistance of ships must be authorized for carrying out pilot ice assistance on the NSR. It is required that the ice pilot shall have experience for at least three years as a ship master and at least six months of navigation of ships in ice conditions on the NSR.

7.3 Marine insurance in the High North

Marine insurance is an essential service to international maritime transport. Unlike most aspects of marine transport, there is no international convention on marine insurance. There are, however, International Navigation Limits (INL), which exclude Arctic Areas for vessels insured for normal worldwide trading. Moreover, insurance practices are driven by insurance markets. Marine insurance generally allows ship owners and carriers to take on the risk of navigating in Arctic waters. Underwriters normally base their underwriting premiums on a historical loss record such as statistics and the frequency of accidents. These are key elements in the evaluation of risk when navigating in Arctic waters. Nevertheless, lack of Arctic empirical maritime transport data and statistics, in particular for the northern parts of the Barents Sea and the Kara Sea, makes it difficult for insurers to

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62 Arctic Council (2013).
63 Rules of navigation on the water area of the Northern Sea Route (Approved by the order of the Ministry of Transport of Russia dated January 17, 2013).
64 Article 15 of the Federal Law No 81-3 (1999).
compose an overall risk assessment related to the risks of the various Arctic transport routes. As a result, the provision of insurance for Arctic maritime transport tends to be on a per-voyage basis.

Of particular importance to Arctic maritime transport are three main types of marine insurance; Protection and Indemnity (P&I), Cargo, and Hull and Machinery (H&M). For the purpose of this report, the focus is primarily on H&M insurance, which is to protect the ship-owner’s investment in the ship. It is basically a property insurance covering the ship itself, the machinery and the equipment. This type of insurance cover will include a “Trading warranty”, a clause stipulating where the vessel may trade.

“Trading warranties” for most sets of conditions exclude roughly the same geographical areas. These areas represent some kind of hazard or an increased exposure to the vessel, hence the exclusion. There are mainly two different types of excluded areas, those that are subject to seasonal exclusions and those that are excluded all year round. The latter areas are close to the Arctic region, whilst the seasonal exclusions are typically ice-related areas such as the St Lawrence Seaway and the Baltic. The permanent excluded areas also include areas where information on the charts is poor and inadequate for safe navigation. In addition, weather conditions may be extremely severe in certain seasons and the risk of various types of ice may be imminent.

Ice is known to be a risk to ships. Too many ships are not fitted for navigation in ice and even if they are, the risk of damage is high. To navigate in such areas the ship owners have to contact their hull underwriters to get permission to enter such an area, or, as it is often expressed, they breach the International Navigating Limits (INL). This is a set of clauses that regulates where the ship may trade under the English Hull Conditions (ITC Hull Clauses).

The hull underwriters may allow vessels to trade outside the INL depending on conditions and the time of the season. If vessels are allowed to breach the warranties, that is, to trade in the excluded areas, the underwriter will charge an additional premium for such a voyage. Unless otherwise agreed, the premium is set for a voyage in and out of the excluded area. Should the vessel stay in the area and add ports or cross trade the cover may be cancelled unless the underwriters have agreed to such an extension. Vessels trading permanently in an excluded area can often choose to pay a season cancellation, which is a premium for the period instead of paying on a per-voyage basis.

Past experience has shown that ice damage is directly related to the severity of the winter sea ice and the condition of the ship, including the skill of the officers. Winters may be different in severity and some hull conditions will have additional premiums depending on the current ice situation.

Today, even if lots of the risks associated with shipping are well known and understood by insurers, there are still risks related to Arctic navigation that needs to be identified. Statistics and knowledge of accident rates can help determine insurance rates. However, lack of Arctic empirical maritime traffic data and statistics, in particular in the northern parts of the Barents Sea and the Kara Sea, makes it difficult for insurers to compose an overall risk assessment related to the risks of the various Arctic transport routes.

7.4 Summary

7.4.1 Key challenges
The present international conventions regulating the safety of ships and personnel at sea are predominately developed for offshore operations in open blue waters. However, the IMO Guidelines provide a set of regulations covering maritime operations in ice covered waters. These guidelines are, however, non-binding and should thus be considered as norms.

Safety and competence requirements for personnel operating in Arctic ice covered waters are presently regulated by the IMO Guidelines. Specific requirements for standardized training of crew members,
including mandatory education, knowledge of navigation in ice covered waters and emergency procedures in Arctic environments, are, however, absent. Furthermore, there is a lack of detailed requirements for survival equipment and guidelines about the use of lifeboats, rescue vessels and rescue suits.

For the IMO-guidelines to become legally binding depends on the individual states implementing the regulations in their national legislation. According to the Norwegian Maritime Authority there is a process, which should see the Polar Code being implemented into Norwegian legislation from 2015 or 2016. It remains, however, to see whether this milestone will be achieved in time.

In general, risks associated with shipping are well known and understood by insurers. There are still risks related to Arctic operations that need to be identified. Underwriters normally base their underwriting premiums on a historical loss record, such as statistics and the frequency of accidents is a key element in the evaluation of risk when navigating in Arctic waters. However, lack of Arctic empirical maritime traffic data, in particular in the northern parts of the Barents Sea and the Kara Sea, and significant statistics makes it difficult for insurers to compose an overall risk assessment related to the risks of the various Arctic sea routes. A more systematic knowledge of accident rates may be obtained in order to help the underwriters determine insurance rates.

8. Industrial cooperation

The most fruitful cooperation between Russia and Norway in the Barents Sea will be achieved if activities on both sides are executed simultaneously. After the Parliament decision on the opening of the South-east Barents Sea Norway intends to issue licenses in this area in 2015. Drilling activity is likely to begin in 2016/17. A number of licenses with different operators and partners are likely to be awarded also in this area.

On the Russian side, the whole area has been licensed to Rosneft, which has entered into agreements with ENI and Statoil. At present, there is no detailed knowledge regarding the actual level of activity in this area. However, with only a few companies to share the cost and risk, it is assumed that the activity will be lower on the Russian side compared to the Norwegian, also with regard to development of Russian competitive suppliers and manufacturers. If this would be the case, it will difficult to develop the regional infrastructure and related industry on a normal competitive base. Necessary measures should be implemented to secure that the Russian industry in the North can participate both on short, medium and long term.

8.1 Possible cooperation with the Plenipotentiary to the President of the Russian Federation

The Plenipotentiary of the President of the Russian Federation is the official representative of the President in the respective federal district. The Plenipotentiary reports directly to the President and is accountable to him. The Russian Federation is divided in seven Plenipotentiaries. The Plenipotentiary in St. Petersburg is responsible for the entire North West Russia. During meetings with the Plenipotentiary it was suggested that “The Strategic Partnership on economic and social development of the North West of the Russian Federation” could represent a driving force. 65

The objective of the partnership is to realize the “Strategy of social and economic development of the Northwest federal district until 2020”, as approved by the Russian Government. The Strategic Partnership is corresponding with the councils at the Plenipotentiary, including the coordination council for the cross-border and interregional cooperation. These structures include expert groups concerning development of mineral resources and development of transport system in the Arctic.

65 Two meetings have been carried out, with the Plenipotentiary in St. Petersburg (December 3, 2012) and with the “Strategic Partnership” in St. Petersburg (January 31, 2013).
Oil and gas activity is the main driving force in northern parts of Russia as well as in the Northern Norway. Therefore, the development of this sector has the highest priority from both an industrial and political point of view.

From the Russian side a clear understanding was expressed that the Russian offshore industry and related land based infrastructure have a long way to go in order to meet the requirements of the oil and gas industry, expanding into the Barents Sea. The Partnership has expressed strong interest in looking to Norway to gain more knowledge through increased cooperation. This creates a good foundation for a closer cooperation. This is in line both with the RU-NO project and the objectives of INTSOK.

At present, the matter of cooperation is still being discussed in Russia.

8.2 Possible areas of cooperation

In the North West Russia the most adequate port for industrial activities related to oil and gas terminals is Liinakhamari in the Pechenga Fjord. Both in the government, among the investors and within Russian shipping companies, evaluations and processes are in progress in order to decide the future use of this port. The final decision on the use of Pechenga will have great impact on the development strategy for the port of Kirkenes, which also is a possible oil terminal for Russian crude oil. According to the Russian strategy, Russia is also considering an oil refinery with a capacity of 6 million tonnes.

As a result of the long time and expansion of oil and gas activities in the Norwegian part of the Barents Sea, the land based infrastructure in Norway has a standard and capacity to also serve parts of the activity on the Russian side. Nevertheless, it is important that the infrastructure on the Russian side is being improved as soon as possible. In Murmansk Oblast, the port of Murmansk has its constraints, not only regarding land areas and infrastructure, but also with respect to free access – 24 hours – the year around, due to military restrictions.

The Russian focus in the Barents Sea is to discover oil, but a specific exploitation strategy has not yet been launched.

At present Russia has a primary focus on developing Yamal LNG and to explore the resources in the Kara Sea, both exposed to ice covered waters most of the year. Due to this, possible areas of cooperation might be concrete structures to withstand ice pressure and use of Norwegian ports during construction, module transport and operation (transshipment) of Yamal LNG. However, on the Russian side plans are being developed for a large industrial area to serve these needs.

Today, Norway imports electric power from Russia, with Russia having expressed interest to increase exports. According to the Norwegian Ministry of Petroleum and Energy, there are strong limitations on import as long as the supply of electricity is based on nuclear power. If Russia decides to proceed with their plans on gas power plants, this might be an issue of interest also to Norway. Upon more energy being exported to Finnmark from Russia, it might be possible for Norway to reduce investments in new and expensive power lines in Finnmark.

Export facilities for oil and gas may potentially represent an area of cooperation. While the investment costs are substantial and oil and gas from the Barents Sea is expensive to extract, to be competitive on the world market, both countries will benefit from investment cost for export infrastructure being kept at a minimum. Thus, when investing in gas pipelines and land based oil terminals, possibilities of common use may be considered.
9. Findings and Recommendations

The oil and gas industry has, through an extensive record of onerous offshore operations, demonstrated the industry’s capability to develop and to apply large and complex new innovative technologies. This experience will be important when moving into the High North. However, moving into the High North introduces new challenges.

The key challenges identified in this report may be solved mainly in four ways:

1. Focus on strategies and plans for infrastructure development of national and common interest
2. Closer cooperation between national and local authorities in Russia and Norway
3. Focused cooperation between Norwegian and Russian R&D institutions and companies
4. Carry out research projects focusing on infrastructure, technology and innovation

While the last two recommendations are closely connected and focus on technology development, the first two recommendations are concentrated on how the two countries can improve the framework and infrastructure to facilitate oil and gas development in the High North. They are all related to an international agenda regarding the overall increased activity in the Barents and the Arctic seas. In this respect, by taking the lead in identifying the key challenges and also showing the way to solve them, Russia and Norway should maintain the leading position in the High North, also in areas that are important to other nations. In this context, it is essential to discuss and develop a regional effort rather than single field developments.

A regional High North Forum may be considered. An interesting model is the ongoing Gassco Barents Sea Gas Infrastructure (BSGI) Forum that examines the gas transport and infrastructure options on the Norwegian side.

The following sections express findings and recommendations.

9.1 Physical characteristics of operating in the high North

Development of the High North

Oil and gas activities in the northern parts of the Barents Sea and the Kara Sea will be significantly more challenging than the present activities in the Barents Sea South and the Pechora Sea. Therefore a very careful step-by-step development has to be implemented. In that respect the report addresses short-, medium- and long term scenarios.

Common accepted design criteria for a “100 year event” due to a combination of wind/waves/ice/icing/dark time should to be established for floating installations operating in the High North. These design criteria have to be determined by research institutes in close cooperation with the oil companies, manufacturing industry and maritime authorities.

Maritime operations and icing exposure

The combination of arctic storms, sea ice, icing, heavy snow fall and complete darkness has been identified as the most challenging situation for the maritime operations in the High North. As a consequence of the ice cap apparently withdrawing towards north, the polar lows follow longer into the Barents Sea and the areas of major interest for increased oil - and gas activities. The main areas of concern that have been identified are:

- A challenge related to crude oil export is offshore loading in areas where polar lows and icing may occur. This will most certainly challenge the regularity compared to what has been experienced along the Norwegian coast, but may also represent a possible environmental risk. This is an area of concern that has to be examined as part of the “icing issue” related to maritime operations.

- In order to strengthen the overall safety for operational activities in the High North, it is recommended that the cooperation between Norway and Russia is reinforced and given priority to enhance exchange of data and information in order to develop better prediction models for ice and weather conditions.

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66 Bente Nyland, the Director of the Norwegian Petroleum Directorate (NPD), recently expressed an overall need for “a coordinated area development”.

9.2 Logistics to and from an operating area

*Module transportation, maintenance, subsea installation*

Future sea bed factories will, according to Statoil and the industry, be qualified within 2020. For this purpose larger and more robust heavy lift vessels may be required. Topside production plants, land-based and subsea process modules are likely to be produced in the southern part of Norway, Europe and Asia. Industry, service, transshipment and maintenance areas may be established in the northern part of both Russia and Norway.

Intermediate module storage and preservation (mostly to be undertaken by the equipment vendors) takes extensive planning and competence. In Norway the industry mostly seems to be well prepared while the North West Russia needs to establish industry areas with appropriate supporting infrastructure.

Currently, Norway lacks the capacity of icebreakers to support oil and gas operations in the northern part of the Barents Sea. The Russian icebreaker fleet is the world’s strongest, in terms of both icebreaking capability and number of ships. However, the Russian fleet is aging and requires investments and replacements during the coming years to maintain its effectiveness and to support future oil and gas operations.

*Regular personnel transportation*

Regular personnel transportation is an important issue in the High North. Today helicopters are preferred, but long distances in the High North require new thinking involving enforced maritime vessels and multitask vessels for direct and intermediate transportation (to shore and to adjacent land areas). This may be addressed mainly to the oil companies but such installations should preferably cover larger regional areas, not only one specific field development. Furthermore, manufacturers of helicopters may be encouraged to develop helicopters covering longer distances.

9.3 In-field logistics

*Ice management*

This is an area that primarily should be examined by Russian and Norwegian shipping companies having operational experience from similar activities, mainly in Russia, Canada and Greenland. The operational experience has to be combined with the knowledge and new research being performed by research institutes in Russia and Norway. The outcome of such studies may be:\n
- New multitask vessels with improved properties
- Common regulatory framework in Russia and Norway
- Common standards for Russian and Norwegian training centers

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67 Strongly supported by participants on the two workshops (see Appendix).
**Multitask Vessels**

Vast Arctic areas and long distances should stimulate innovation. Multitask vessels may have various functions:

- Ice breaking capabilities and systems for towing operations
- Search and rescue functions
- Emergency preparedness for operations/coordination, including acting as a place of safety in the event of evacuation from a platform
- Medical treatment and facilities
- Firefighting equipment
- Oil spill recovery systems
- Helideck for intermediate refueling of SAR helicopters

Russia and Norway should gain views and information from all nations that have expressed their interest in operating in the High North. An initiative is taken in the Arctic Council to gain industrial experience and knowledge. It is recommended that new innovative solutions are identified and developed in close cooperation between companies and rescue institutions.

**Working environment**

Arctic climate will have a significantly higher impact on humans and equipment than so far have been experienced by the Norwegian oil and gas industry in southern areas, partly also the Russian. Cold climate exposure can be reduced by various means. The R&D institutions and the industry seem to be working on the most important issues. Despite the working environment being challenging it does not seem to represent a critical issue. Reference is made to the Barents 2020 program.

Personnel operating in the Arctic are facing challenging conditions and accidents may occur during maritime operations. In this respect, one is facing challenges that will require highly skilled operating personnel.

It is recommended to establish common training requirements in Russia and Norway and to require training of all crew involved in Arctic operations. Common Norwegian-Russian training requirements will improve skills of operating personnel in both countries and enhance cooperation and understanding between Russia and Norway with respect to SAR, emergency response and other maritime functions such as Ice Management.

Both Norway and Russia see the need for a set of mandatory requirements to ensure future safe maritime operations in the High North, and they support the work being carried out by IMO.

**9.4 Land based infrastructure**

The Russian concerns for the quality of the land based infrastructure in North West Russia are expressed by the Plenipotentiary to the President of the Russian Federation for North West Russia. It is necessary to establish high quality and relevant logistics and industrial infrastructure to secure the Russian interests in the High North. In that respect the Norwegian experience on how to combine national interests in oil and gas development with a strong focus on regional development has gained interest by the Russian Authorities.

The land based infrastructure on the Norwegian side is likely to be strengthened in accordance with the needs of the industry. In Norway, the land based infrastructure has been continuously developed in line with increasing oil- and gas activities in the North. The ongoing port developments in Sandnessjøen, Tromsø, Hammerfest, Honningsvåg and Kirkenes are established to meet the requirements from the oil and gas industry. A stronger attention may be paid to infrastructure investments towards the Russian–Norwegian border and in the Kirkenes area to support new discoveries and to strengthen Russian–Norwegian cooperation.
9.5 Emergency response and communications

Search and Rescue and multipurpose hubs

A bilateral cooperation agreement between Norway and Russia within SAR has been established for a while. However, the mandatory agreement made by the Arctic Council in 2012 further clarifies the responsibilities for each nation and underlines the need for closer cooperation. The level of SAR cooperation should be further strengthened when oil and gas activities increase in the High North.

Furthermore, this will require more than just increased bilateral cooperation between public bodies. It may also be necessary to establish multipurpose hubs. The SAR helicopters, served from the mainland of Norway, do not cover large parts of the Barents Sea. To extend their distance range, multipurpose hubs may be developed. A multipurpose hub could be a floating or land based unit focusing on supporting offshore oil and gas operations and ensuring support functions such as:

- Emergency operations/coordination
- Weather surveillance
- Hospitals/medical facilities
- Firefighting equipment
- Oil spill recovery equipment
- Additional systems and equipment for SAR
- Communications
- Helicopter base
- Telemedicine

Such hubs may be located on the Arctic islands in both Russia and Norway. In a short term perspective, one opportunity could be the Bear Island and probably also in Longyearbyen, to meet the SAR requirements on the Norwegian shelf. This may also be the situation on the Kolguev Island, Southern and on the Northern islands of the Novaya Zemlya archipelago in order to serve the Russian shelf. In addition it may also be necessary to establish floating multipurpose hubs with helicopter facilities.

Functional requirements for multipurpose hubs are at present not established. A regional approach involving both Russia and Norway may be initiated. It is recommended that these issues have a strong focus on a governmental level e.g. through the R&D programs governed by the Norwegian Research Council and by Russian parallels. Cooperation in a wide regional Norwegian-Russian perspective will constitute an excellent area of cooperation as both countries have the same interests.

The harsh environment reduces survival time for persons in the sea and also in life rafts or lifeboats. To secure safety of personnel working in Arctic environment it is important that operating personnel have sufficient clothing such as survival suits, reducing loss of temperature and thus increasing survival time. Furthermore, it is important to implement adequate procedures of safety including rapid mobilization of SAR units and high transit speed of SAR resources. Required equipment on board SAR units should include advanced technologies for search in darkness and low visibility. In addition emergency/survival equipment for air drop should be available at strategic locations onshore.

Communications

Communication systems are currently inadequate for supporting the needs of the oil and gas industry in the High North. Telenor Satellite Broadcasting, Norwegian Space Centre, Avinor, Kongsberg Satellite Systems and R&D institutions are addressing this challenge. The issue clearly needs both governmental and industrial support. A prerequisite for communications, accurate navigation, effective SAR, and emergency management operations is real time high broadband capacity.

Communication is a critical issue, which has to be in place before the oil and gas industry can move into Arctic areas (except for parts of Area 1). Lack of communication systems will slow down industry

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68 See Figure 12.
development in the High North. However, there are ingoing projects with purpose of identifying the main users and their system requirements. According to Telenor Satellite Broadcasting, a full-covering arctic real time satellite based communication system may be operative in 2020, provided that the funding (joint venture authorities and industry) is agreed. This will improve support of navigation in the northern part of the Barents Sea.

Based on experience from operations in other remote areas it is important to establish a high quality telemedicine system. Telemedical presence requires a high bandwidth communication link.

In order to provide relevant information when planning and executing operations, Norway has established the Barents Watch program as a portal with open access. The content of this is to be continuously expanded and both Norwegian and Russian shipping companies and authorities may provide views and input to the further development of the program. It must be ensured that the available information is continuously updated.

9.6 Regulatory framework

The Polar Code
For the IMO-guidelines to become legally binding it is required that the individual states implement the regulations in their national legislation. Norway is a driving force to make the IMO-guidelines mandatory. The aim is that the Polar Code should be implemented into Norwegian legislation from 2015 or 2016. It remains, however, to be seen whether this milestone will be achieved in time.

Marine Insurance
In general, risks associated with shipping are well known and understood by insurers. There are still risks related to Arctic operations that need to be identified. Underwriters normally base their underwriting premiums on a historical loss record such as statistics and the frequency of accidents. However, lack of Arctic empirical maritime traffic data and statistics, in particular in the Northern parts of the Barents Sea and the Kara Sea, makes it difficult for insurers to compose an overall risk assessment related to the risks of the various Arctic sea routes. A more systematic knowledge of accident rates should be obtained in order to help the underwriters determine insurance rates.

9.7 Industrial cooperation

Activity level and cooperation
On short and medium term, oil and gas activity levels on the Norwegian and Russian side will be significantly different. The Russian interest of exploiting the gas resources in the Barents Sea seems to be decreasing to the benefit of their resources in the Asian part of the country. The Russian focus in the Barents Sea is to discover oil, but a specific exploitation strategy has not yet been launched.

At present Russia has a primary focus on developing Yamal LNG and to explore the resources in the Kara Sea, both exposed to ice covered waters most of the year. Due to this, possible areas of cooperation might be concrete structures to withstand ice loads and use of Norwegian ports during construction, module transport and operation (transshipment) of Yamal LNG. However, on the Russian side, plans are being developed for a large industrial area to serve these needs.

The activity on the Norwegian side of the Barents Sea is assumed to be higher than on the Russian side for the next decade. The current trends indicate that the Norwegian Shelf represents the driving force in the High North. Therefore, the Norwegian shelf might be a basis area for industrial cooperation and development between Norway and Russia in terms of meeting the challenges of the Barents Sea.

Russian preparedness for further offshore development (projects)
It is a major concern on various regional authority levels in Russia that neither the infrastructure nor the industry in the north are prepared to meet the requirements from the offshore oil and gas industry. A possible consequence is that lack of back-up services and technological competence in the northern regions, combined with the low offshore activity level, will result in a low gear development of land based activities. From Russia interest has been expressed for a closer cooperation with Norway in order to strengthen the industrial development on the Russian side e.g. the Kirkenes Declaration on cooperation in the Barents region.

**Strong focus on R&D and technology**

Finally, it is important to address and emphasize the need to continue the investments in Research and Development, seek new innovative ideas and technology improvements to ensure that operations satisfy even stricter requirements related to HSE, being more cost effective and reliable with minimum impact to the environment.
## 10. Matrix of Technology/Solution providers

### Table 10: List of Technology/Solution providers

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11. References


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