MarSafe North
Maritime Safety Management in the High North

The main objective of MarSafe North is to identify the user requirements and technological possibilities to be able to perform safe and efficient operations in the High North.

The study areas covered by the project are:

- Nautical Operations and Transport
- Dynamic Risk Assessment and Emergency Response
- Territorial Security Control and Resource Supervision
- Infrastructure and Integrated Coastal Zone Management

by utilizing novel underpinning technologies for:

- Environmental Surveillance and Sensing Technologies
- Arctic Communications
- Radio Navigation and Tracking

The following issues will be addressed in MarSafe North:

- Nautical operations and transport needs to be accomplished at identical or higher quality standards than they are accomplished in other Norwegian sea areas
- There are still significant technological gaps before safe and environmental-friendly operations can be guaranteed in the High North
- Norway's large territory and economic zone makes radio technology crucial to the endurance of our environment, industry and business
- The Barents Sea and the Arctic continental shelves is one of the world's most fertile ecosystems
- North of 76° North there are very poor or no available communication infrastructure

The project has a total budget of 23 million NOK, where 9 million is funded by the Norwegian Research Council, the MarOff program. MarSafe North will run until 2011.

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MarSafe North
Maritime Safety Management in the High North

ENVIRONMENT & GEOGRAPHY

The MarSafe High North project has studied the environmental challenges within maritime operations in the High North and have especially focused on the impact of harsh weather, low temperatures, reduced visibility, ice and icing, as well as use of on-board equipment within maritime operations in the Arctic environment. The large geographical distances in combination with poor access to qualified information, limited SAR/emergency preparedness resources, and poorly developed communication and surveillance infrastructures represent specific challenges

MarSafe North main findings:

- There is a need to improve the local meteorological- and ocean information forecasts, including ice forecasts, and the information should be made available to ships in near real time
- Detection of ice thickness, ice bergs and smaller bergy bits is important to maintain safe navigation
- Icing on ship equipment leads to hazardous work operations on deck
- Qualification, certification and training of ice navigators is crucial for maritime safety
- Escape, Evacuation and Rescue equipment is unfit to handle harsh Arctic environmental conditions
- Long distances combined with few SAR and emergency preparedness resources and poorly developed surveillance system infrastructures leads to long response time in critical situations
- Six ice trackers on ice floes drifting from the northern parts of the Barents Sea along the eastern side of Svalbard have shown that ice drifts with an average speed of 0.18 m/s and contributes to ice pollution in Isfjorden and Adventsfjorden.

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EER – Evacuation, Escape and Rescue **IMO – International Maritime Organisation** **IMO STCW Convention and Code (adopted 1978), contains Standards for Training, Certification and Watchkeeping** **ISO – International Standardisation Organisation** **VTS – Vessel Traffic System**	**Meteorological-, hydrological and ocean data** The weather in the Arctic is known for its sudden changes. The polar lows and the combination of wind, waves, fog, rain, darkness in winter period, snow and low temperatures often leads to hazardous working operations. When these factors are combined with poor visibility due to snowstorms or fog, and sea ice, it is also obvious that navigation in the area is challenging. There are several examples from the area around Svalbard where ships have been captured in ice and finally ended in a distress situation where assistance from helicopters or rescue vessels has been the result. **Ice detection** There are no good onboard ship systems available today that can measure ice thickness, predict and detect ice bergs and smaller bergy bits. Detection is based on visual inspection and experience of the navigators. A few systems based on radars exist on land, for example on the VTS in Prince William Sound (Alaska). Also, some of the Norwegian coast guard vessels have ice radars on board. However, these technologies need to be improved in order to make ice navigation safer. **Icing on equipment** Icing on structures and equipment is another challenge. It is a result from fog, freezing rain, green water trapped on decks, or wind and wave driven seawater spray. Icing modifies the aerodynamic and hydrodynamic properties and stability of ships and structures and can be dangerous if the ice is not removed in time. The crew need to get on deck to remove ice, and this is often a hazardous work operation due to the weather and sea conditions. **Qualification, certification and training** Since the maritime traffic in the Arctic so far has been limited, there are very few navigators that can be classified as experienced ice navigators (exceptions are fishermen, coast guard navigators and others frequently sailing in the area). Future crew need to be trained on how to navigate in ice and work in harsh weather conditions surrounded by ice. New technologies, training, experience and visual observations will have to be present to obtain safety in ice navigation. The Manila amendments to the STCW (Standards for Training, Certification and Watchkeeping – IMO) Convention and Code were adopted on 25th of June 2010. The amendment includes new training guidance for personnel serving onboard ships operating in polar waters and measures to ensure the competency of masters and officers of ships operating in polar waters. **Escape, Evacuation and Rescue** According to the emerging ISO 19906 standard for Arctic offshore structures the EER equipment shall be designed to achieve a consistent level of safety and effective operation throughout the complete range of physical environmental conditions expected for a given location. These environmental conditions are coldness, light, wind, sea spray and atmospheric icing, visibility, cold open water, ice-wave combinations, currents, ice and snow conditions. Also for ship equipment the environmental conditions matters. There are not much of life boats in ice covered areas. **Geography – Long distances** Long distances combined with few SAR and emergency preparedness resources and poorly developed surveillance system infrastructures leads to long response time in critical situations. It also makes it difficult to develop terrestrial infrastructures for surveillance, monitoring and communication.

MarSafe North
Maritime Safety Management in the High North

EMERGENCY PREPAREDNESS, SAR & EER

The MarSafe High North project has done detailed studies on Emergency preparedness, Search and Rescue (SAR) and Escape, Evacuation and Rescue equipment (EER) operations in the High North

MarSafe North main findings:

- Limited SAR resources versus large distances and areas of responsibility reduce safety at sea in the High North.
- Escape, evacuation and rescue (EER) equipment are often unfit for operations in Arctic areas
- There are no or very limited traditions for information sharing across organisations, companies and nations in SAR operations. Shared situational awareness is important, but today completely absent, in such operations.
- Places of refugee and stranding zones are so far not developed at Svalbard
- Today's towing capacity in the High North is limited and does not meet the future requirements on bollard pull
- The ships operating in arctic waters must have strong focus on autonomous solutions both regarding operational conditions as well as in a distress situation. If emergencies they can not relay on others then themselves. One possibility is to have collaborator operations where several ships are working in the same area at the same time.

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SAR – Search and Rescue **IMO – International Maritime Organisation**	**Limited SAR resources versus large distances** Some cruise ship operators have mutual agreements on coordinated sailings, making it possible to get assistance in emergency situations, if needed. However, this conflict with the commercial interests, where the cruise ships want to sell and demonstrate the remoteness of the Arctic. Fishing vessels and regular ship traffic in the areas are also prepared to give assistance to each other and operate as a rescue vessel. The large distances will also in many cases result in problems for helicopters and other SAR means to do efficient operations in a distress situation. Harsh weather and low visibility makes it hard to operate helicopters 365 days a year. Helicopters have only a few hours operation time and refuelling might be needed before the helicopter enter to a rescue area. **Unfit EER equipment** EER equipment for operations in the Arctic is also important. Such equipment will be different from warmer areas since one need to create "safe heavens" that can keep evacuated persons warm for a long time in harsh and cold weather. The safety equipment onboard ships visiting the Artic is normally not constructed for operations in this environment. As an example it will be meaningless to drop a free fall life boat directly to ice. There will also be a stronger need for warm clothing and personnel equipment as for example available food for a shorter or longer period. Such equipment will be different from warmer areas since one need to create "safe heavens" that can keep evacuated persons warm for a long time in harsh and cold weather. **Harmonisation of information sources and shared situational awareness** The situation today is that information is created for one purpose within one system and is hard to exchange with another system. A study on available information to be used for SAR operations should be done where sources, integrity, and historical statistic data is part of the study. It is also a good idea to have a look at concepts and procedures used within other sectors, for example the Integrated Operation (IO) concept from the oil and gas sector. IO will most likely give the SAR and Emergency preparedness operations added value in terms of shared situational awareness. This concept should also be used to focus upon human behaviour, organisational responsibilities, and technological potentials. Regarding the operations in the High North this must be also studied in a cross national perspective. MarSafe will recommend a detailed study on responsibilities, information availability and availability on SAR services. **Places of refuge and stranding zones at Svalbard** The Norwegian laws for “port and fairways” say that places of refuge shall be available in Norwegian waters. In 2009 this law also was deployed at Svalbard. MarSafe participates in the work on identifying, inspect and deploy such places of refuge at Svalbard. The main objective of these places is to minimize environmental effects from oil spill. **Bollard pull on special purpose vessels** Today’s vessels are often designed and built as multipurpose vessels, being able to run different types of operations. Open deck, too low towing capacity and constructions that accumulating icing is a problem. It is also important to notice that today’s towing capacity, e.g. on the coast guard vessels, is too low for emergency operations in the future, where the increased traffic and activity will increase the size of the vessels used.

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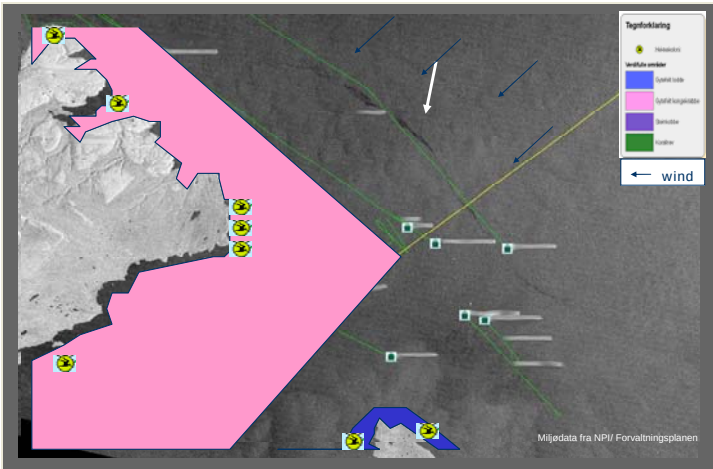
Maritime Safety Management in the High North

INFORMATION & DATA CAPTURE

The MarSafe High North project has studied the information availability and quality, within dynamic risk assessment, the electronic navigational charts and ice charts. Also information sharing between Arctic actors has been an important issue.

MarSafe North main findings:

- The quality on meteorological and oceanographic forecasts and data is rather low due to low resolutions
- There are no available techniques and methodologies for identifying and broadcasting information integrity.
- The availability of Dynamic Risk Assessment tools for use in vulnerability analyses for Arctic operations is limited
- Electronic Navigational Charts (ENC) is being used by most vessels today. However, the accuracy of these maps in Arctic areas is low due to few hydrological measurements.
- Information exchange between Arctic actors only exists on a very low level today



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DRA – Dynamic Risk Assessment **VTS – Vessel Traffic System**	**Quality on meteorological and oceanographic forecasts and data** Trustable weather information is very important to the navigators in the High North. For example if the wind directions changes, a vessel can have limited time to navigate out of the area before the ice is blocking the escape routes. Therefore it is also important to be able to communicate with the ship and send pre-warnings from observation centres such as traffic stations or operation centres a shore. A lot of research is ongoing to obtain improved models and forecasts of the dangerous polar lows, this information is extremely important to broadcast to navigators in time. The ice information available today is mostly based on satellite images and some observations from inspections, as well as collection from buoys sensors. The satellite images have a certain resolution, and the challenge is the ice floes and bergy bits not discovered by these images. Due to the limited capacity and coverage on communication links it takes time to present the ice data to navigators' onboard ships. So far there is no system that can offer ice detection or forecasts in near real time. **Information integrity** MarSafe has also pointed out the need for trustable information sources. The end users, either on vessels or on shore based centres, should know that the data they are using is of sufficient quality for their type of operation. One example is sea maps. The official source is the Norwegian Mapping Authority. However there are other sources, both Norwegian and Russian. If the user new the level of accuracy/integrity of the different sources, they could use the one with sufficient quality for their type of operation. **Dynamic Risk Assessment** The availability of Information to use in Dynamic Risk Assessment tools is limited and not integrity checked. Such tools are important for planning and execution of emergency operations, for situation analyses at the Vessel Traffic Service centres (VTS) and in integrated coastal planning. MarSafe recommends that Dynamic Risk Assessment tools for maritime operations in the Arctic are further developed. **Electronic Navigational Charts** The electronic navigational charts are of low quality in many of the areas in the High North. This is mainly because of the low update frequency on bathymetric measurements. The sea bottom changes rapidly in many areas due to the ice. Therefore, the maps should be updated more frequently, and good distribution network should be established to ensure that the vessels have the latest possible versions, in time. A combination of dynamic sea maps with the official sea maps could also give added value to the navigators. For example use of the echo sounder in combination with observations from vessel. The sea maps could also be combined with satellite images and more dynamic weather information to be downloaded in real time. This will challenge the technological infrastructure, as from the MarSafe point of view should be more prioritised by those responsible for it. **Information exchange** Exchange and sharing of information between actors only exists on a very low level today. A simple demonstration on information sharing in an emergency operation in Arctic waters was run by MarSafe and showed how this can lead to improved shared situational awareness.

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MarSafe North

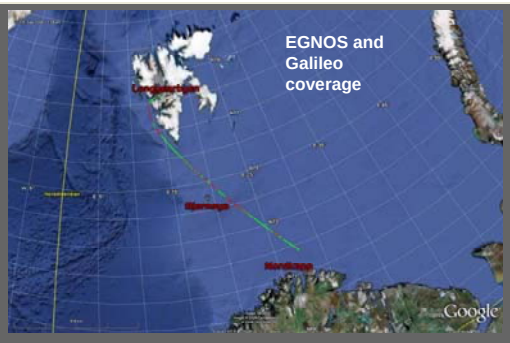
Maritime Safety Management in the High North

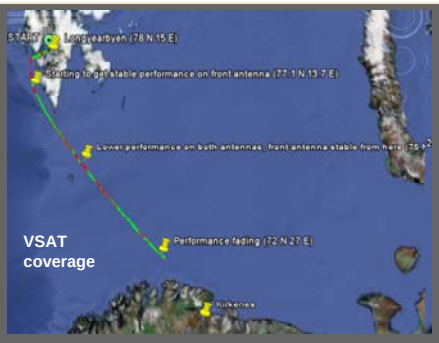
COMMUNICATION, SURVEILLANCE & TRACKING

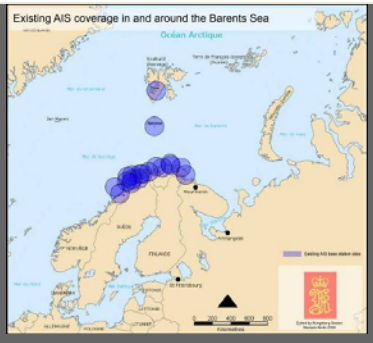
The MarSafe North project has identified the current status on available communication-, surveillance- and tracking technologies in the High North. These are technologies that typically support nautical operations, SAR, territorial and environmental surveillance and integrated coastal zone management.

MarSafe North main findings:

- AIS coverage in the High North is limited and should be improved, both on ground and by satellite. Increased maritime traffic needs to be monitored to obtain safety at sea.
- There is limited dGPS coverage in the High North, too limited to meet future demands from increased maritime traffic and more advanced maritime operations such as for example DP operations.
- Services based on geostationary satellites can not be considered reliable in areas above 75° North
- There is poor coverage from terrestrial communication systems such as VHF
- The only communication system offering truly global services is Iridium. However, Iridium has a limited bandwidth capacity and is for many operations not sufficient.
- Digital HF has a very large coverage area, however it has very limited bandwidth capacity







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AIS – Automatic Identification System **GPS – Global Positioning System** **DP – Dynamic Positioning** **GNSS – Global Navigation Satellite System** **HF – High Frequency** **MF – Medium Frequency** **VHF – Very High Frequency** **VSAT – Very Small Aperture Terminal**	**Limited AIS coverage** Increased traffic leads to increased demands for traffic monitoring. The AIS is used both in public and private sectors. The most critical situation is when AIS is used in emergency operations to identify surrounding ships that can assist the ship in distress. This is not possible today with the very limited AIS infrastructure (except the Norwegian coast line) **Limited dGPS coverage** dGPS is of high importance in Ship-to-ship operations, e.g. DP operations. E.g. in the oil and gas sector, there are requirements on the level of accuracy of positions. Not having access to differential corrections on GNSS data can lead to situations where operations are not allowed, due to low accuracy on position. In the Arctic, the dGPS infrastructure is very limited, and SBAS is not reliable because it is based geostationary satellites. Hence operations might not be allowed in the area. **Poor coverage from geostationary satellites** Services based on geostationary satellites can not be considered reliable in areas above 75° North. Inmarsat-C (low data rate/kbps, omni directional antenna and L-band frequency) provides more reliable communication links than VSAT based services (higher data rate/Mbps, directional antenna, Ku-band frequency). As new maritime operations starts, other type of bandwidth requirements occurs. Today's communication infrastructure is not sufficient to meet these demands. **Poor coverage from terrestrial communication systems** The challenge today with regards to terrestrial communication systems is that it is missing in many areas. VHF is restricted to coastal areas, however large parts of e.g. Svalbard is uncovered. HF and MF can be used; however, these systems will not be able to meet the increasing capacity demands. Renewed interests and more frequent sailings in the Northeast and Northwest transport corridors will also require improved communication infrastructure, both for safety and for operational reasons. **Limited bandwidth capacity on Iridium** Iridium provides true global coverage and is today probably the most reliable communication system in the Arctic. However, future capacity requirements and also timing requirements will make Iridium not sufficient for many operations (e.g. transmitting real time images and video from emergency operations) **Limited bandwidth capacity on digital HF** Even though digital HF is sufficient for transmission of small messages, future operations and cooperation between different land based organisations will require higher capacity than can be offered by digital HF.

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MarSafe North
Maritime Safety Management in the High North

NATIONAL & INTERNATIONAL GOVERNANCE

The MarSafe High North project has identified the international and national organisations, rules and regulations, mandatory and not mandatory, which regulates the maritime activities in the High North.

MarSafe North main findings:

- The UNCLOSIII, SOLAS, MARPOL, STCW and SAR conventions relates to the Arctic waters in the same way as other international waters. As of today, none of these includes specific requirements for the Arctic.
- A few guidelines on how to operate in the Arctic exists, such as the IMO 'Guidelines for Ships Operating in Arctic Ice covered Waters'. Shipping companies and others decides if they want to follow the guidelines.
- Important emerging standards for Arctic maritime operations are the IMO Polar Code, ISO 19906 and IMO e-Navigation.

IMO

ISO International Organization for Standardization

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UNCLOS – UN Law of Sea Convention SOLAS – Safety of Life at Sea Convention STCW - Standards of Training, Certification and Watchkeeping MARPOL - International Convention for the Prevention of Pollution from Ships SAR - International Convention on Standards of Training, Certification and Watchkeeping for Seafarers E-Navigation is *'the collection, integration and display of maritime information aboard and ashore by electronic means to enhance berth-to-berth navigation and related services, safety and security at sea, and the protection of the marine environment'*	As for other sea areas in the world, the seafearers and shipping companies need to follow the UNCLOSIII, SOLAS, STCW, MARPOL and SAR conventions. However, non of these IMO conventions includes specific requirements for navigation in Arctic waters. Other organizations such as ILO (International Labour Organisation) and ISO (International Organisation for Standardisation) offers guidelines for Arctic activities. The discussions should be; Should any one of the be made mandatory? **IMO – Polar Code** IMO has developed guidelines in the form of a Code for ships operating in Polar waters, which could, eventually, be made mandatory. It is difficult to draw conclusions on how this could affect the maritime activity in the High North, but it is clear the shipping companies would need to ensure that their ships are designed and equipped according to the polar codes if they want to operate in the area. It is unclear if the costs related to modification of existing ships or designing new ice classed ships following the polar codes will exceed the benefits of operating in the area. **IMO – STCW** The STCW Convention was revised at Manila in June 2010. Norway proposed at the session of the Sub-Committee (STW 40 in February 2009) the introduction of mandatory minimum requirements for the training and qualification of navigators serving on board ships operating in ice-inflated areas and this was adopted in the STCW convention in Manila. **ISO-19906** This standard was developed in response to the offshore industry's demand for a coherent and consistent definition of methodologies to design, analyze and assess arctic and cold regions offshore structures. MarSafe North has identified the challenges of communication at high latitudes, and points out that ice management in electronic means, distribution of data to all relevant actors is difficult with today's available infrastructure. **COMSAR – World Wide Navigational Warning Service (WWNWS)** It is being discussed to expand the WWNWS into Arctic waters. This includes the Arctic Maritime Safety Information (MSI) services and has agreed that a common MSI broadcast system is required for the Arctic region. Nations responsible for NAVAREAS are responsible for the broadcast of Arctic MSI for the area. Norway is responsible for NAVAREA 19 and 20. **COMSAR – e-Navigation** COMSAR is developing the concept of e-Navigation. MarSafe North has identified challenges for Arctic areas that should be considered within the e-Navigation concept. **Other- Increased requirements on new roles for Vessel Traffic Services (VTS)** New functions and alarms to meet Polar Class requirements, extended support to navigators such as route proposals based on gathered data from different sources (ice images/models, traffic image, weather forecasts etc). Emergency support, such as route planning, includes dynamic risk assessment tools. Another challenge is to clarify the role of the VTS, its interface towards other authorities and organisations such as the joint rescue coordination centres and local authorities. Also in the interface towards other nations the VTS is important. Norway and Russia have started on this work.

Northeast passage transits by Beluga shipping

By the completion of the Northeast-Passage transit and previously the safe discharging of the cargo in a rather remote area in Siberia, we have opened the gate to a seaway which will further gain in importance in the future. The savings of voyage costs to a total amount of about 300,000 Euro for each multipurpose heavy lift project carrier of the F-class, later about 600,000 Euro for each travelling vessel of our new Beluga P-class, are a major achievement particularly in times that have become economically more difficult. With regard to the global CO2 balance we are able to reduce the bunker consumption and cut down the environmentally harmful emissions by using the Northern Sea Route", Niels Stolberg, President and CEO of Beluga Shipping GmbH, draws a very positive preliminary conclusion before the pioneer-project will be evaluated in more details later.

Beluga shipping, www.beluga-group.com

The role of the Norwegian Coastal Administration in the High North

The maritime activity in the northern parts of the Norwegian seas will increase within the fields of transport, resource exploitation and tourism. New areas will become available and increased demands to safety, environmental considerations and administration will arise. The location and the climate are challenging. The Norwegian Coastal Administration will be an active contributor and actor within our sectors of responsibility in order to secure transport, environment and business. This demands new solutions for civil traffic monitoring, emergency preparedness and administration because today's solutions were developed for more central parts of sea transport. E.g. VTS services, communication, climate risk models, and we need to develop these solutions ourselves. This will give us opportunities for increased competence and technology.

Jon Leon Ervik
Manager for Pilotage and VTS
The Norwegian Coastal Administration

e-Navigation

The purpose of the e-Navigation development is to enhance safety at sea, enhancing the environmental safety in coastal zones and in the oceans, adjust for higher efficiency and reduce costs in sea transport and logistics, simplify the work on bridge and adjust for improved preparedness and search and rescue services.

The Norwegian Coastal Administration has engaged to this work through IMO as leader of the three work groups and the accompanying "Correspondence Group". One works with instruments like improved surveillance and monitoring of sea traffic, improved communication between ship-shore/ship-ship/shore-shore, by concretizing critical thresholds in security systems, further development and simplification of human-machine interfaces, making training a part of the development process, ensuring interoperability between systems, achieving a global coverage and building on sustainable standards and organisational structures.

John Erik Hagen
Chairman of IMO e-Navigation Working Group and Correspondence Group

Operations depend on good communication links

To be able to enhance the safety and environmental and emergency preparedness, the AIS network needs to be further developed at Svalbard. This is important for both traffic monitoring and coastal management in general.

Experience shows that in all operations, independent of type, area and/or surroundings, where two or more partners are communicating, the success is highly dependent on the quality of communication. In almost all operations where things have been out of control, the poor communication has been the main reason. It is hard enough to achieve good communications in near coastal areas. When we move the operations farther north to the Arctic, one can assume that the number of challenges will be higher and more difficult. In the future, with the challenges existing in the Arctic, it will from an emergency preparedness perspective be crucial to establish a robust and flexible communication infrastructure which will support operations from surveillance and control to reporting and direct communication between the different actors.

Tore Strøm
Orlogskaptein/Nestkommanderende
KV Svalbard

Communication challenges in the Svalbard zone

Communication in the high Arctic is currently limited due to limited systems for communication between ships and ship to shore. Radio communications are developed to a limited extent around the settlements and the most frequently trafficked areas near settlements on Spitsbergen.

Satellite-based solutions in the high Arctic has limited data capacity which makes it difficult to have a reliable and effective communication with ships that are operating north of 76°N. With the traffic trends we have seen in recent years on Svalbard, and with the prospect of increased activity due to warmer climate and increased focus on resources in northern areas, the need for a robust communications platform is essential for safe communications in some of this planets most inaccessible and remote waters.

Kjetil Bråten
Harbour Master
Port of Longyearbyen

APPENDIX A – INTRODUCTION TO MarSafe North THEMES

Management of safety related issues is crucial for the nautical operators in Arctic waters, as well as for maritime operators and organisations on shore. The purpose of this report is to provide an overview of maritime user needs and existing technologies to support maritime users in the High North. It focuses on the following issues:

- Nautical operations and transport
- Dynamic risk assessment and emergency response
- Territorial security control and resource supervision
- Infrastructure and Integrated coastal zone management

And it also gives an overview of existing technologies for:

- Environmental surveillance and sensing
- Arctic communication
- Radio navigation and tracking

Nautical operations can be divided into four classes: Transport, fishery, passenger vessel and cruise traffic and other nautical operations. Other nautical operations include oil & gas exploration related support (supply, stand-by, etc.) and research vessels. The common denominator for all these types of operations is that they do not happen very often in the Arctic. However, fishing and cruise traffic is the operations most present in the High North today. The requirements are distinguished by existing rules and regulations already implemented for other more central and congested sea areas.

Dynamic risk assessment is used for trying to get an overview of the risks of performing certain operations. Even though some analyses have been done on this issue, dynamic risk assessment is not a widely used tool within shipping. However, it has been used to study groundings, collisions and especially oil spills. Dynamic risk levels will depend on a number of parameters such as vessel type and condition, crew qualification, geographic location, vulnerability of the environment, weather conditions etc. It will be important to consider that operations in the High North introduce specific challenges in form of sea ice and icing in combination with lower quality of meteorological forecasts and reduced communication ability.

Emergency preparedness in the High North in Norway includes today the Joint Rescue Coordination Centre (JRCC) in Bodø, several Rescue Sub Centres (RSC) manned by the Norwegian police, the RSC at Svalbard is organised directly under the Governor of Svalbard, emergency towing capacity (3 during winter, 2 during summer), acute oil spill preparedness (private, regional and national) and there are depots distributed along the Norwegian coast line, including Longyearbyen in Svalbard. For the expected future activity level in the High North, this will not be sufficient, and efforts need to be put into training of personnel, since experience is viewed upon as the most important success factor in emergencies. Another important task to follow up is further development of emergency preparedness equipment. The Norwegian Coastal Administration has prepared a new tender document for future emergency response vessels. One major change is the increased requirement on bollard pull (150 tonnes).

Territorial security control and resource supervision of coastal/maritime areas is an increasingly challenging task. Accidents, oil spill, illegal fisheries, as well as possible terror threats and smuggling must be averted while important legal activities such as maritime transportation and recreational traffic must be safely secured.

Within this scope, it is easy to point out a number of related main domains/responsibilities like Traffic Control (Vessel Traffic Services (VTS)/Vessel Traffic Monitoring Information Systems (VTMIS)), Coastal Surveillance, Search and Rescue, Coast Guard; Customs, Fishery, Environmental protection etc.

The systems existing today to support these domains/responsibilities are AIS (Automatic Identification System), SafeSeaNet, Paris MoU, radars, surveillance satellites, military systems and the VTS. In the future however, the tasks covered by the VTS need to be further developed. Examples are e.g. functions and alarms which should include e.g. alarms for vessels with wrong Polar Code, alarms for vessels entering areas with risks for ice encounter and alarm for vessels carrying thick/heavy oil in sensitive/dangerous areas. *Also, the* VTS should act as an information source, and provide mariners with sailing route proposal with respect to current situation, considering various risks and sensitive zones in the High North. Also support tools for 'emergency' route planning, that is, tools for supporting the VTS operators, SAR leaders or pilots to assist vessels. Good dynamic risk assessment tools should be a part of the VTS. Agreements between the VTS and other central partners such as e.g. the JRCC and the navy should be developed in order to ensure that information can be shared and used in critical situations to raise the situational awareness.

Integrity on information will be an important issue and is a requirement being brought forward by many actors in the High North. Efforts need to be put into the classification of information sources and finding methods and tools for deciding the integrity levels on information sources.
Integrated Coastal Zone Management is about how to protect our coastline and get prepared for the critical situations in the High North. The issues in focus in the first phase of MarSafe is the poor Electronic Navigation Chart (ENC) coverage, aids to ships in degraded situations, which also relates to the poor resource situation for emergency preparedness, and places of refuge and stranding zones.

Upon input from MarSafe the Norwegian Hydrographical Service (NHS) will perform hydrographical measurements around Svalbard, providing the data needed to develop improved ENC's. Priority will be given to areas with high risk traffic, implying that dynamic risk assessment will be an important tool also for integrated coastal planning.

Ice data and ice charts are very important information for vessels operating in Arctic waters, and are of major importance for all sea traffic around Svalbard. This information is also of interest in VTS, and operation centres assisting a ship in distress. Information should be near real time, and include sea ice coverage, ice bergs, bergy bits, and ice thickness. Some information is available today, but requirements far exceed today's applications and information.

Except in limited areas of the Arctic, there is a lack of *emergency response* capacity for saving lives and for pollution mitigation. There are serious limitations to radio and satellite communications and few systems to monitor and control the movement of ships in ice covered waters. The current lack of marine infrastructure (operational centres, vessels, decision support systems etc.) in all but a limited number of areas, coupled with the vastness and harshness of the environment, makes emergency response significantly more difficult in the Arctic. Success factors in emergency response that needs to be followed up are: Improved means for communication, improved distribution and sharing of information (e.g. meteorological data, simulations of oil dispersion, images from site are of high relevance in leading the emergency response, live transfer of video and other live data), improved means for monitoring of sea traffic from the VTS and AIS also on smaller vessels.

Another important part of emergency response and preparedness is the places of refuge along the coast of Svalbard. A pre-selection of potential places have been done in the first phase of the MarSafe

project, and stranding of a vessel as such, in Arctic environment like Svalbard, should be discussed, and a mapping of possible stranding zones/places should be considered.

The availability of technology solutions to support the above described operations is sufficient in some areas and insufficient in others. For example, a large number of *surveillance satellites* orbit the Earth over the Poles and the application areas range from environmental sensing to traffic monitoring and spying. However, sensor technology on ground e.g. buoys in water and sub sea sensors are not that widely used in the High North, there is a potential for further development of terrestrial sensor networks.

The systems available for *communication in the Arctic* today are VHF, MF/HF, Inmarsat, VSAT and Iridium. VHF is mostly used for ship-shore voice communication in near coastal areas, communication between ships, distress alerting and navigational updates. Digital VHF is deployed along the Norwegian coast line, offering digital services making it possible to send reports, to send e-mails and communicate on a digital link. Since digital VHF could be considered a suitable link for future e-Navigation messages one should consider to extend the infrastructure, e.g. at Svalbard.
MF/HF is used as a backup voice communication system when nothing else is available. It is also used for navigational updates (NAVTEX) and distress alerting. Telenor Maritime Radio has developed the application WaveMail which is an e-mail system optimized for low capacity links such as e.g. HF. Compression/decompression techniques are used to make this possible. This service is suitable for very small data packages.

Inmarsat C, B and F77 are used for voice communication, navigational updates and distress calling. Due to the use of omni directional antennas (Inmarsat C), L-band frequencies and low data capacity they have slightly better coverage in the High North compared to other GEO systems which are using directional antennas, higher frequencies (e.g. Ku-band) and offering higher data rates (VSAT). A field test run by MarSafe showed that VSAT is available (except for Longyearbyen), but unstable on latitudes from Longyearbyen (78° N 15° E) to Kirkenes (69° N 30° E).

Iridium is the only communication system offering truly global coverage. Iridium is sufficient for a wide range of applications, as e.g. broadcasting of compressed satellite images. However, even this system will be inadequate for future applications due to capacity and latency.

Radio navigation and tracking technologies are important contributors to safe navigation, and in ice infested areas they do not become less important. The systems available in the High North today are GPS, GLONASS, Satellite Based Augmentation Systems (SBAS/EGNOS), dGPS, AIS and LRIT. The main challenge for these systems is that the coverage of the augmentation systems is not sufficient to meet the future requirements. New systems for distribution of differential corrections need to be discussed.

The next phase of the MarSafe project will focus on sharing of information (Integrated Operations), integrity issues on information, covering gaps in emergency preparedness, ice tracking and ice forecasts, new maritime operations in the Arctic and proposing technology solutions to meet the future demands.

The tables on the following pages summarises the main findings on challenges in the High North. The findings are divided into 5 main groups:
1. Environment and geography
2. Emergency preparedness, SAR services and EER (Escape, Evacuation and Rescue)
3. Information and data

4. Communication, surveillance and tracking
5. National and international governance

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