EO4BAS
Earth Observation for Baltic and Arctic Shipping

European Space Agency

EARTH OBSERVATIONS FOR BALTIC AND ARCTIC SHIPPING
EO4BAS

Geoinformation requirements

23. October 2023

Prepared for:

European Space Agency (ESA)

ESA Contract No. 4000140121/22/I-DT with DNV AS BEST PRACTICE ARCTIC

DNV e-geos AN ASI / TELESPAZIO COMPANY CGI

DNV AS, Norway

EARTH OBSERVATIONS FOR ARCTIC AND BALTIC SHIPPING

Geoinformation Requirements

European Space Agency

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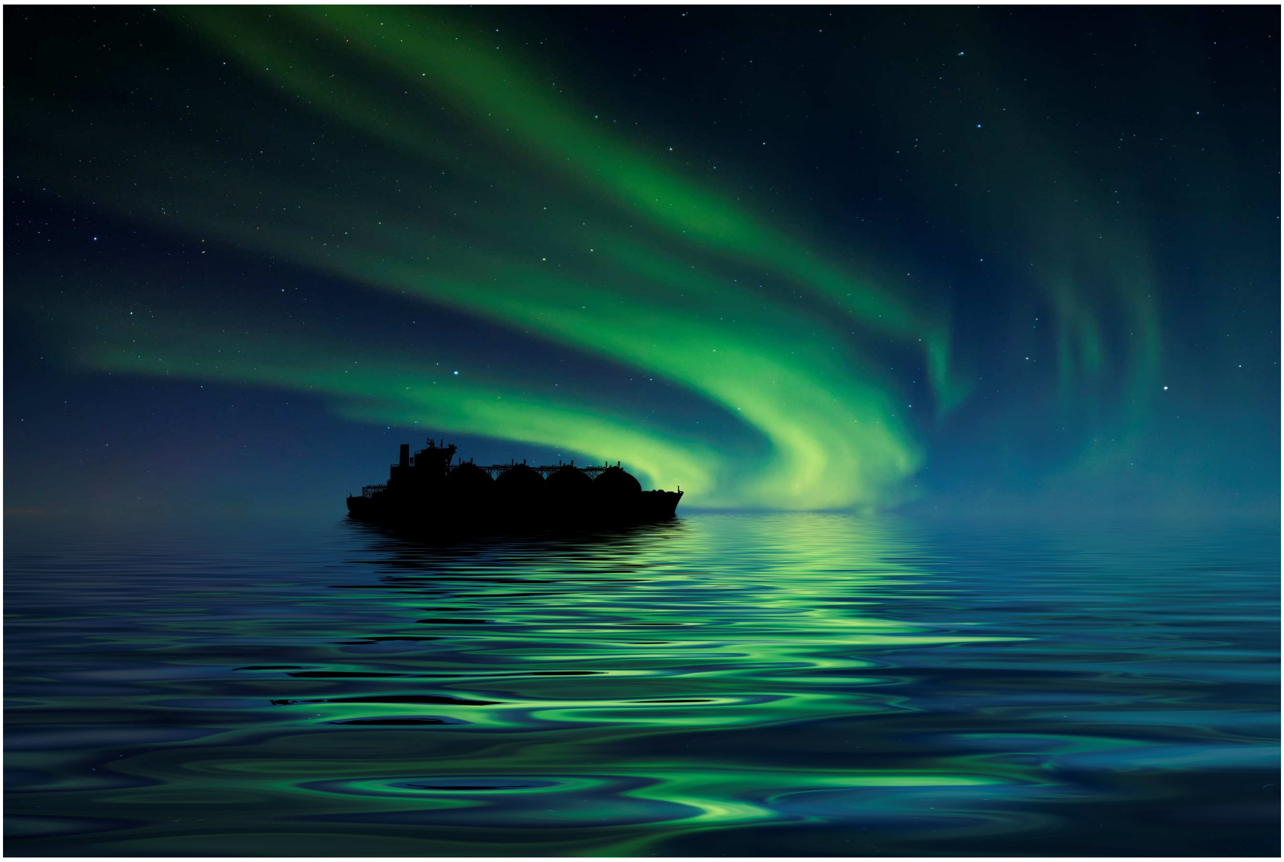

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Objective: The overarching goal of the EO4BAS project is to establish current information needs and a road map to a best practice for the use of Earth Observation information products and services by the shipping sectors operating in the Arctic and Baltic areas. This report provides the identification and consolidation of geoinformation needs and requirements.

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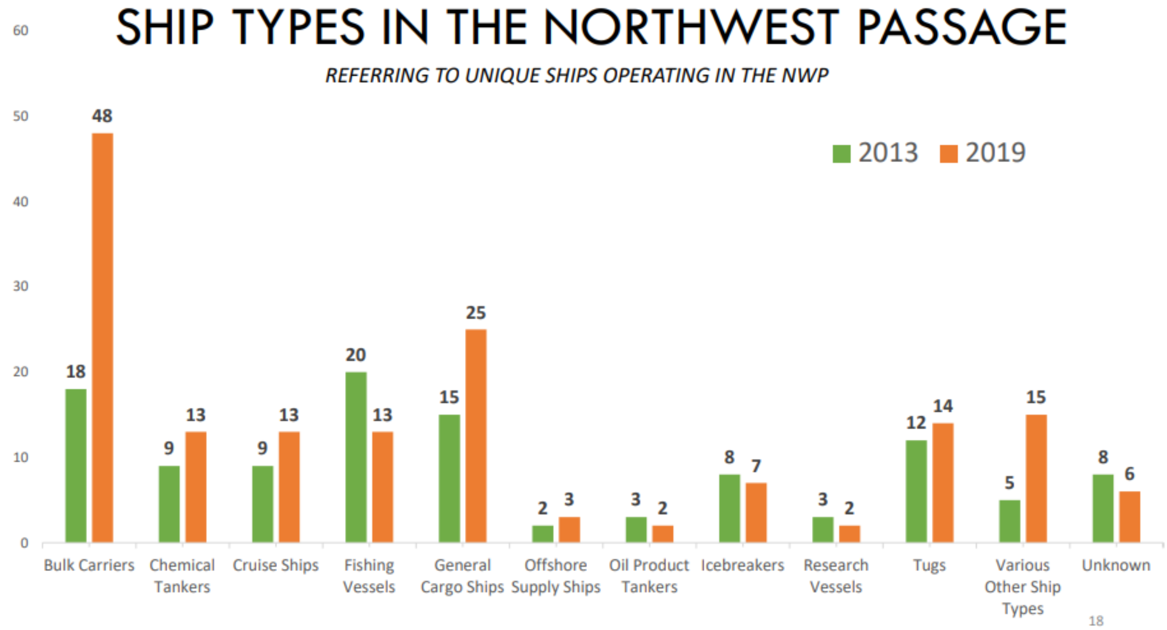
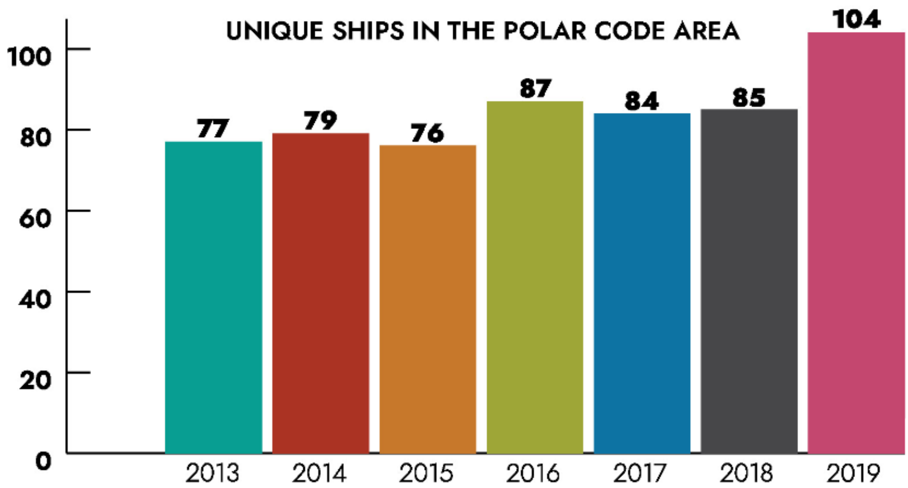
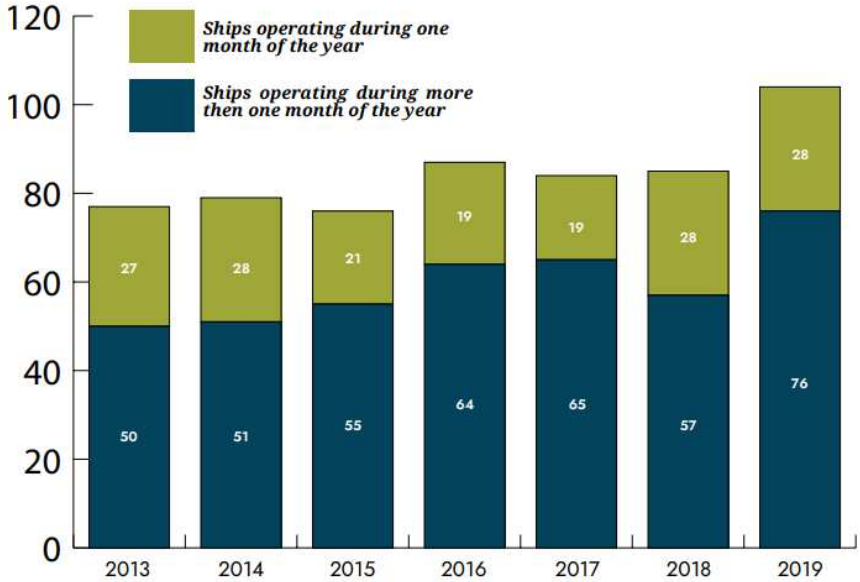
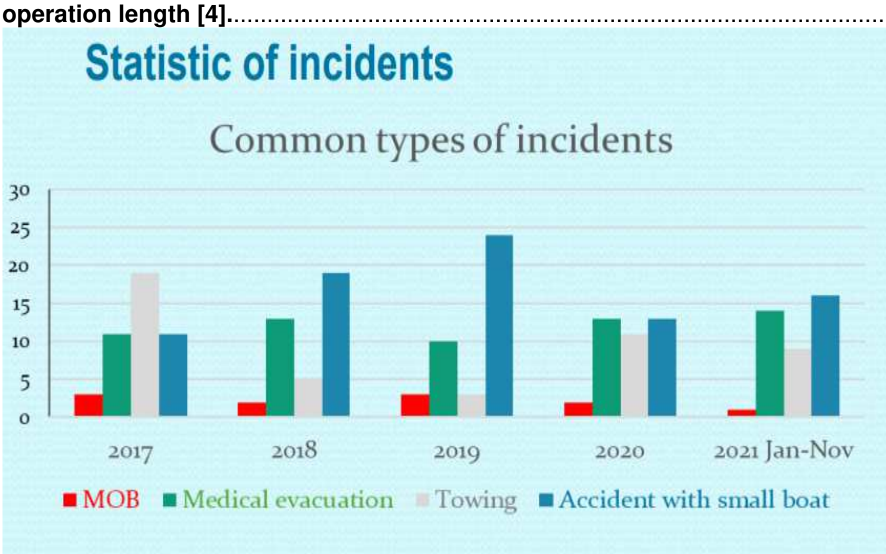

SHIP TYPES IN THE NORTHWEST PASSAGE
REFERRING TO UNIQUE SHIPS OPERATING IN THE NWP
2013
2019
60
50
40
30
20
10
0
48
18
13
9
13
9
20
13
15
25
2
3
3
2
8
7
3
2
12
14
5
15
8
6
Bulk Carriers
Chemical Tankers
Cruise Ships
Fishing Vessels
General Cargo Ships
Offshore Supply Ships
Oil Product Tankers
Icebreakers
Research Vessels
Tugs
Various Other Ship Types
Unknown
18

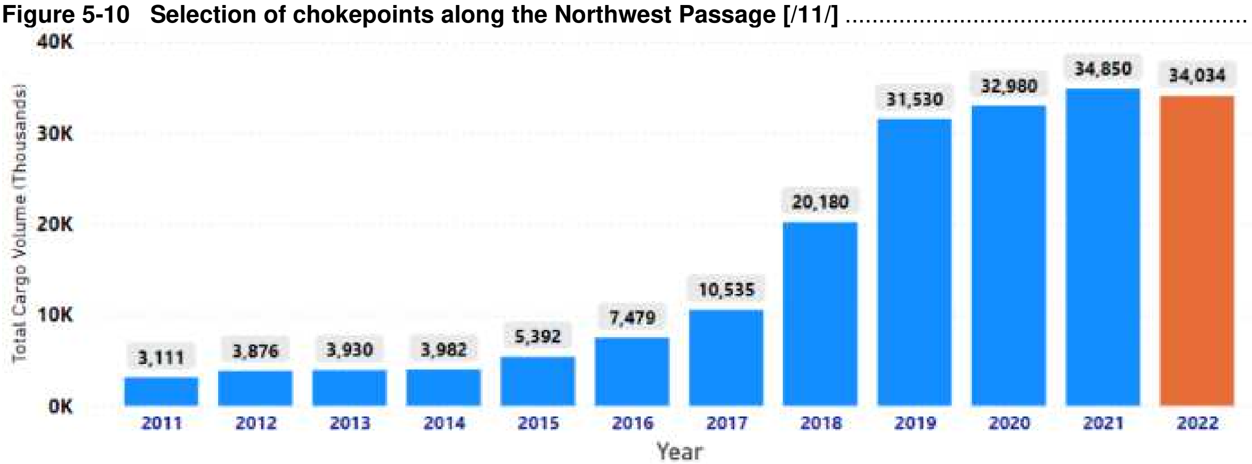

UNIQUE SHIPS IN THE POLAR CODE AREA
100
80
60
40
20
0
77
79
76
87
84
85
104
2013
2014
2015
2016
2017
2018
2019



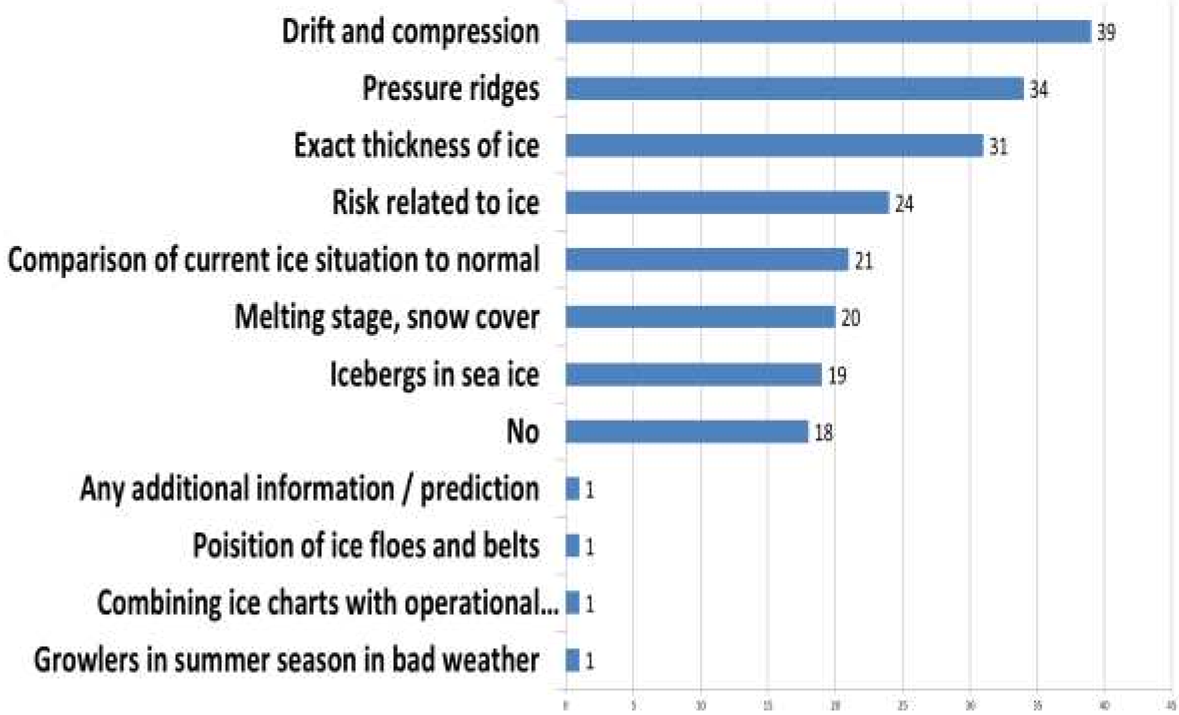
Ships operating during one month of the year
Ships operating during more then one month of the year
120
100
80
60
40
20
0
2013
2014
2015
2016
2017
2018
2019
27
28
21
19
19
28
28
50
51
55
64
65
57
76



Statistic of incidents
Common types of incidents
30
25
20
15
10
5
0
2017
2018
2019
2020
2021 Jan-Nov
MOB
Medical evacuation
Towing
Accident with small boat



40K
30K
20K
10K
0K
Total Cargo Volume (Thousands)
3,111
3,876
3,930
3,982
5,392
7,479
10,535
20,180
31,530
32,980
34,850
34,034
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Year



LIST OF ACRONYMS

AIS	Automatic Identification System
AMTP	Arctic Marine Tourism Project

ASTD	Arctic Ship Traffic Data
ASSR	Arctic Shipping Status Reports
CFD	Computational Fluid Dynamics
EO	Earth Observation
EO4BAS	Earth Observation for Baltic and Arctic Shipping
ESA	European Space Agency
GT	Gross Tonnage
HFO	Heavy Fuel Oil
LNG	Liquefied natural gas
MEPC	Marine Environment Protection Committee
MSC	Maritime Safety Committee
NRT	Near real time
NSR	Northern Sea Route
P&I	Protection and Indemnity
POLARIS	Polar Operation Limit Assessment Risk Indexing System
PAME	Protection of the Arctic Marine Environment
SAR	Synthetic-aperture radar
SCAT	Seafarer Crisis Action Team
WWF	World Wide Fund for Nature

1 EXECUTIVE SUMMARY

European Space Agency (ESA) project "Earth Observation for Arctic and Baltic Shipping (EO4BAS) focuses on the shipping sector operating in two geographical areas, including the Arctic and Baltic Sea. These two geographical areas, while having commonalities, present significant differences in the:

a) shipping business,

b) infrastructures.

c) geoinformation needs, and

d) challenges for the businesses in the various shipping processes.

This report describes the business process specific challenges and geoinformation requirements for shipping in the Arctic and the Baltic Sea. The six shipping business processes considered in this study were:

- Ship design,
- Ship construction,
- Ship certification,
- Insurance,
- Ship operations
- End of life vessel disposal.

Business process challenges and geoinformation requirements were mapped through literature survey, stakeholder workshop and stakeholder interviews that was enhanced with an online survey.

This report includes a project overview, as it is the first report published in EO4BAS project. Business processes and challenges are capture in using a user personas layout.

1.1 Conclusions

The project focused on the challenges and geoinformation requirements for 6 business processes in two geographical areas. User personas were used to detail the nuanced problems personnel working within these processes regularly face. A total of 29 unique business challenges were discovered to which 28 associated geoinformation variables were suggested to potentially remedy the problems. These variables form the geoinformation requirements for the industry sector in the two geographical areas. Many of these geoinformation requirements are associated with various of the challenges and have the challenge specific spatial and temporal resolution requirements. A total of 14 common constraints for using earth observations within the business processes were mapped during this project. The following observations can be concluded from the project findings:

- Maritime industry uses earth observations for different purposes. Thought, the use in many business processes is often limited for a few known EO products. Some of the business processes use very little or not at all geoinformation in their operations.
- There is significant potential for increasing the use of geoinformation in all business processes.
- There is an increased interest for using geospatial information for industry operations in the Artic and Baltic due increase in operations in the area.

- The rapid change of Artic and Baltic environmental conditions due to climate change affects the industry operations and the validity for using historical knowledge on operational conditions. Up-to-date earth observations can support effective and safe operation in these areas.
- The stakeholders have varied and sometimes limited knowledge on the available EO products and parameters.
- Satellite based EO is the only useful data source for areas in the in the remote areas of the Arctic where local observations are not available.
- Changing requirement landscape for operations in a remote area and environmentally vulnerable areas increases the need for up-to-date geoinformation that in many cases is only available from satellite earth observations.
- There is a need for geospatial information products at different time scales, including long term, NRT and forecast and predictions. The info is necessary to comply with requirements from IMO, EU for example on reduction of emissions. The requirements involve different business processes, including a better design and operation of a ship to minimize emissions in a selected area of operations.
- Costs and availability of suitable EO products together with lack of knowledge on available EO products are limitations for using EO.
- End users need often to use companies that process EO information for their use since products are not ready to be used or the companies lack ability to process raw information for their own use.
- The most used geoinformation among the stakeholders in the Arctic and Baltic Sea is information on sea ice. Sea ice thickness, ice concentration, ice edge and information on deformed ice are important for many stakeholders.

The collection of geospatial requirements and constrains are input for work package (WP) 2. In WP2 the sensors and information products fitting the requirements will be mapped for the technology available currently and in the next 5 years. The challenges for specific geoinformations can be used in performing the gap analysis in WP 2. The constrains for using geoinformation can be further used in the project in building the mock-up service concept and in building the road map for satellite EO use in shipping industry.

2 INTRODUCTION

The project Earth Observation for Arctic and Baltic Shipping (EO4BAS) focuses on the shipping sector operating in two geographical areas, the Arctic and Baltic Sea. The project covers several shipping business processes covering a wide range of activities from ship design to end-of-life disposal with many activities between those. This report describes the EO4BAS projects work package 1. The report gives a description of geoinformation requirements addressing challenges for key business processes of the industry sector, where geoinformation plays a role as an input for operations.

The project includes a review of literature, and stakeholders' insights on geospatial requirements in operation. A synthesis is presented with challenges for the business processes and consequent geoinformation needs. To highlight the differences between actors and business processes, the actors in the business process are represented by user persona.

3 PROJECT OVERVIEW

The project Earth Observation for Arctic and Baltic Shipping (EO4BAS) focuses on the shipping sector operating in two geographical areas, the Arctic and Baltic Sea waters. Climate change is opening access to the Arctic waters and marine traffic is increasing both due to a growth in long existing activities, such as fishing and cruise tourism, and due to a development of new industrial activities, such as the natural gas production on the Yamal peninsula and the Mary River mine on Baffin Island.

Marine traffic in the Arctic waters is currently not as extensive compared to activities in other oceans. Sea ice is heavily limiting the operations in the wintertime and summer operation season has varying length and conditions depending on the geographical location. Operation conditions in the Arctic vary heavily depending geographical location and time of years. Getting information regarding operational conditions can be challenging and limited due to vast areas with limited observations in the Arctic. Limited information availability and poor communication coverages can make data acquisition a difficult and time-consuming process.

Shipping activities in the Baltic Sea are more intense compared to the Arctic. Vessels are operating year-round in the Baltic Sea and assisted by icebreakers during the winter ice season. Operational conditions are better known due to more dense observation network than in the Arctic.

Differences in the shipping business and infrastructure in the Arctic and Baltic areas highlight differences also in the:

- geoinformation needs, and
- constraints for different business processes

Tailored satellite-based earth observation services may effectively ease both long-term and daily challenges facing users in these areas.

3.1 Objective

The aim of EO4BAS is to establish current information needs and best practices for the use of Earth Observation based products and services within Arctic and Baltic shipping. The project is part of the European Space Agency's (ESA) Earth Observation Strategy 2040. The prime objectives of the European Space Agency's (ESA) Earth Observation Strategy 2040 are:

- Observe: develop and provide observations to better understand the complexity of our planet and monitor its health.
- Understand: enable improved predictions of the physical interaction of society with the earth system.

- Decide: inform decision makers and citizens on scenarios and consequences of political and economic decisions regarding our planet.

These objectives are facilitated by the Earth Observation Envelope Programme (EOEP) to meet ESA's vison of enabling the maximum benefit of Earth observation for science, society and economic growth in Europe.

The EOEP includes the *EO science for society* program. The program aims to support the implementation of Earth Observations (EO) in a variety of industry sectors, through the development of a roadmap to a best practice. Industry sectors so far covered include oil and gas (EO4OG), agro-insurance (EO4I) and the mining of raw materials (EO4RM).

Earth Observations of Arctic and Baltic Shipping (EO4BAS) under the EO science for society program consisting of three partners; DNV, CGI and e-Geos. The consortium strives to:

1. identify the key challenges in the development of Arctic business processes and examine how they can be effectively addressed by the integration of Earth Observation (EO) means,
2. create a basis for future collaboration among practitioners in the field by providing a best practice roadmap, once suitable satellite-derived products useful for the Arctic maritime business processes have been identified.

EO4BAS seeks to reach these objectives through four main tasks, with associated activities as seen in Figure 3-1 and expected outputs as seen in Table 3-1. Each task represents a corresponding work package (WP)

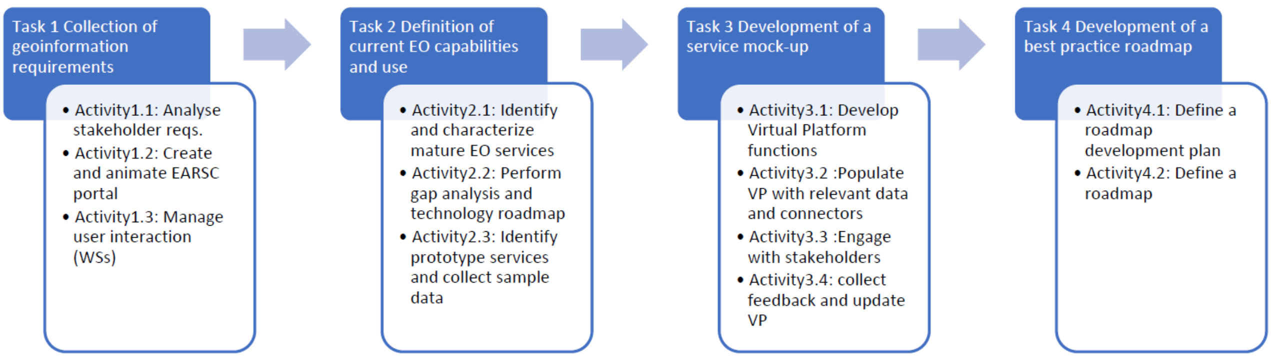


Figure 3-1 Task and activities in EO4BAS project

Table 3-1 Work packages, expected outputs.

Work Package	**Expected output**
WP1: Collection of geoinformation requirements and associated constraints	D1.1: Workshop Report D1.2: Geoinformation Requirements Report
WP2: Definition of current EO capabilities and use	D2.1: Current EO Capabilities Report D2.2: Gap Analysis Report D3.1 : Prototype Service Description (Draft)
WP3: Development of a service mock-up	D3.1: Prototype Service Description D3.2: User Feedback/Lessons Learned Report
WP4: Development of a best practice roadmap	D4: Best Practice Report

3.2 Scope

The project scope includes six business processes within the shipping in the Arctic and Baltic Sea. The project collects challenges related to business process and geoinformation requirements for all business processes by engaging with critical key stakeholders to build consensus on:

1. the operational and managerial situations in which EO derived information products and services can be used, and

2. the key elements to be addressed to ensure that EO data products and services fit the purpose specified.

3.2.1 Business processes addressed in the EO4BAS project

The study concentrates on business processes within the shipping industry. The shipping business processes of interest are:

- Ship design,
- Ship construction,
- Ship certification,
- Insurance,
- Ship operations
- End of life vessel disposal.

Description of each business process is given below.

The consortium has rephrased the business process originally referred to as ‘Voyage Planning’ to ‘Ship operations’, as this term better captures how ships operate in the Arctic and the Baltic Sea and is more easily understood by people working in the shipping industry. Voyage planning is essential part of the ship operations and is reflected in the mapping of the geoinformation requirements.

Ship Design

The business process includes the whole ship design value chain, including concept design and development of the final design of vessels, In the EO4BAS project only vessels operating in the Arctic and Baltic Sea are considered.

Designing ships for operation in the Arctic and the Baltic Sea requires detailed information of the anticipated environmental conditions, in which the vessel will operate, to optimize the vessel design parameters (e. g. length, width, hull form and propulsion power) and the vessel performance. Further, an analysis of the long-term time series of environmental indicators, in the intended areas of navigation, is necessary for:

1. the selection of correct ice vessel class,
2. selecting the correct level of winterization, and
3. fulfilling the requirements from certification.

For ship design, relevant geoinformation are long term time series of parameters like ice thickness, ice type, ice concentration, deformed ice, air temperature, wave height and direction, wind speed and direction.

Ship Construction

The business process includes activities in the shipyard including ship/vessel testing and validation. Once the ship construction process is terminated, the sea trials take place. The vessels with ice strengthening are tested in ice to ensure the vessel compliance with ice performance requirements, defined in the vessel specification.

Ship Certification

Ship certification includes the Polar Code compliance and vessel Polar Ship Certificate, by the flag administration or recognized organization on behalf of the vessel's flag. Further, ship classification is considered as a part of certification business process as it is a part of ship classification system and regulated through classification rules.

Insurance

Insurance is an important component of shipping costs, albeit minor when compared to capital, crew or fuel. The marine insurance industry relies on incident statistics when setting premiums. Hull and machinery (H&M) insurance has a leading role in estimating the risk of operation in the Arctic, with the Protection and Indemnity (P&I) insurance relying on their risk assessment when setting premiums. Outside of its traditional insurance role the marine insurance industry is increasingly getting involved in the shipping industry decarbonization process. All the above is considered part of the insurance business process.

Insurance premiums are likely to be higher for Arctic shipping, though little information is currently available assessing the cost of Arctic shipping insurance premiums, nor what specific demands insurance firms might formulate before agreeing to give coverage to a shipping company, thus presenting obstacles to entry in the Arctic shipping market. The process of identifying relevant Arctic shipping insurance policies and costs driving factors are considered, including how the risk-assessment process is being influenced by the IMO (International Maritime Organization) and classification societies.

Ship operations

Ship operations is a business process that covers a wide range of different activities in the Arctic and the Baltic Sea. These range from icebreaker and research vessel operations in ice to expedition cruise and fishing operating at or along the ice edge to cargo vessels operating in ice free waters. Thus, the need of geoinformation varies widely for different operators depending on their vessel capabilities and limitations as well as geographical area and time of operation. The consortium has rephrased the business process originally referred to as 'Voyage Planning' to 'Ship operations', as this term better captures how ships operate in the Arctic and the Baltic Sea and is more easily understood by people working in the shipping industry. Voyage planning is essential part of the ship operations and is reflected in the mapping of the geoinformation requirements.

Ship operation includes voyage planning, navigation, and the execution of both general and vessel specific operations from start to finish. Voyage planning covers both short-term tactical voyage planning and long-term strategic planning. This business process also covers activities that are beyond normal ship operations. They are rather supporting activities or special operations performed with specific vessels. These include icebreaker support, sea lane management, search and rescue among other alike operations supporting normal ship operations.

End of Life Vessel Disposal

The end-of-life vessel disposal includes vessel scrapping and recycling, disregarding salvage operation after shipwrecks and disposal of small recreational crafts.

3.2.2 Region Overview

The project concerns shipping industry in two geographical areas: the Arctic and Baltic Sea. These two geographical areas differ significantly from each other in both operational conditions, shipping traffic intensity and traffic pattern. There are also many similarities such as presence of sea ice, freezing temperatures and different seasons. The following sections describe their special characteristics, differences, and similarities.

3.2.2.1 Baltic Sea

The Baltic Sea has seasonal ice cover that appear during winter months in the northern parts of the Baltic Sea. In severe ice winters ice can also appear in the Baltic Proper and further south [/30/]. Most years Finnish and Estonian ports are frozen and ship traffic is limited by sea ice, especially at the Bay of Bothnia, where icebreaker assistance and traffic restrictions are needed to ensure traffic flow in the challenging ice conditions. Annual maximum sea ice extent in the Baltic

Sea is declining, but it is subject to large annual variations as seen in Figure 3-2 [/29/]. In the future, potentially thinner ice and more turbulent weather due to the climate change will potentially lead to more deformed ice and a more mobile ice field that can cause further challenges for shipping. Despite the general decrease of sea ice in the Bothnian Sea, Gulf of Finland and Baltic Proper there remains a probability of sea ice forming in large parts of the Baltic Sea causing a challenge for shipping [/21]. In summertime ice is gone and disappears typically in May or in early June allowing many months of ice-free operations for shipping. The new ice season starts to from late October to November at the Bay of Bothnia.

Ice information is provided to ships on ice charts prepared by national meteorological institutes, e.g., the Finnish Meteorological Institute, Swedish Meteorological and Hydrographic Institute. Satellite images and ice charts are sent from ice services to icebreakers via IBnet system for tactical navigation, and development is ongoing to provide better service for the users of icebreaking service [/22]. Mostly, SAR images are used in the tactical navigation by the icebreakers [/23], given the capability to provide a situational awareness in presence of cloud cover and no solar illumination. The icebreakers define the routes in ice for commercial vessels, and the information products provided by the national meteorological institutes are currently fitting their purpose for commercial vessels in the northern Baltic Sea. Local observations on ice conditions from icebreakers, research vessels and other infrastructure support the interpretation of satellite ice observations in production of ice charts and provide input for ice modelling. In the Baltic Sea, sea ice modelling is used to predict ice growth, movement, and areas of compression in ice that are important for navigation [/21]. Thus, knowledge of ice conditions at any time is high compared to Arctic.

Shipping in the Baltic Sea is transport of all kinds of goods, products, and materials in and out of and between the countries surrounding the Baltic Sea. The Baltic Sea is an enclosed sea with only access to the world oceans via the Danish straits. Thus, there is no transit traffic through the Baltic Sea like in the Arctic via Northern Sea Route and Northwest Passage.

Satellite EO is used extensively to monitor sea ice in the Baltic Sea, but other EO observations are as important to monitor the vulnerable and shallow Baltic Sea. The infrastructure for local observations is well developed at the Baltic Sea compared to the Arctic. Parameters that can be monitored from satellites, such as algae blooming, oil spill detection and vessel traffic support the land based and aeronautical observations. Geoinformation needs can be quite similar for different business processes in the Baltic Sea and the Arctic, but at the Baltic Sea better local observation network can provide information fast and accurately which is not the case in most of the Arctic. Further, needs for geoinformation and use of satellite EO data are different for shipping business processes in the Baltic Sea than in the Arctic due to more established trade routes, more intensive shipping and developed infrastructure.

The maximum sea ice extent in the Baltic Sea shows a decreasing trend since about 1800 and reached its lowest value ever in winter 2019/20 (see **Figure 3-2**). This decreasing trend is projected to continue. [/32/].

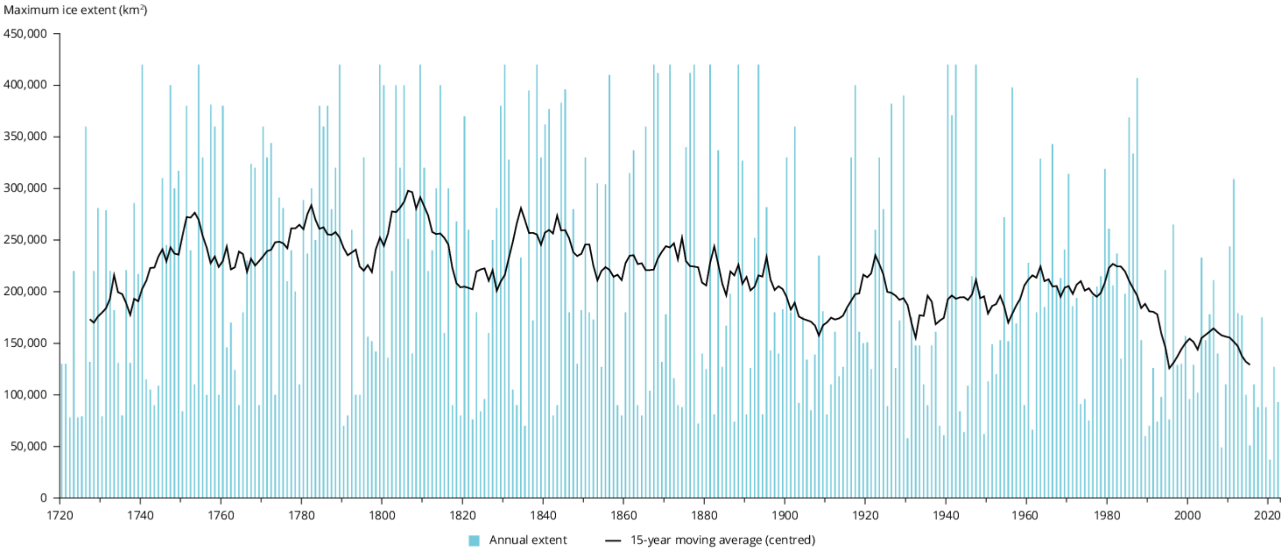


Figure 3-2 Maximum ice extent in the Baltic Sea [/29/]

3.2.2.2 Arctic

The Arctic Ocean is a large ocean surrounded by continents. Large part of the ocean is covered by sea ice all year around. In wintertime, sea ice cover most of the Arctic Ocean. Shipping in the Arctic is affected heavily by sea ice and cold weather. It needs to be recognized that conditions vary heavily depending on the season and location in the Arctic. Thus, there is no single conditions that describe the Arctic, but one needs to always consider local conditions. In context of the project, we consider Arctic to cover areas north of the Arctic Circle recognizing that there are other definitions for this northern area covering the high latitudes of the world. The Arctic is particularly affected by global warming with the increase in surface temperature leading to a thinning and decrease of the sea ice cover as seen in Figure 3-3. This further leads to the Arctic Ocean becoming increasingly accessible and enables longer seasons of ship navigation and access to previously difficult to reach regions. Therefore, the Arctic marine environment is undergoing both environmental and developmental changes.

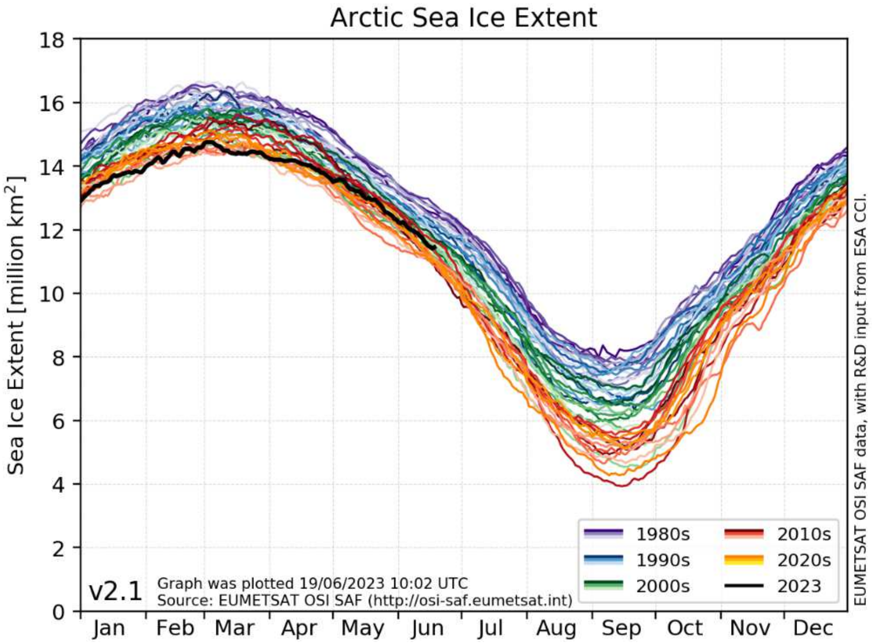


Figure 3-3 Arctic Sea ice extent [/**31s**]

The Arctic is home to significant natural resources with high commodity prices and a growing world-wide demand. An increasing amount of goods is transported by ships through the Arctic and to supply settlements in the Arctic. The majority of the shipping is for transporting raw materials from the Arctic. As the sea ice declines due to climate change, the Arctic routes represent immense potential savings in time and costs compared to traditional east-west shipping routes.

Ship traffic in the Arctic has been increasing for the last 20 years. Although Arctic routes will not be open year-round, companies are already investing billions of dollars in tankers capable of going through ice, see WWF (World Wide Fund for Nature) best practice report [/24/].

Most of the traffic, measured by vessels and distance sailed, is connected to fishing activates, followed by transportation of commodities and then other activities represented by research vessels, icebreakers, and cruise ships. The oil and gas export from Russian Arctic is increasing at higher rate compared to other sectors due to the Russian large investment projects in the Yamal Peninsula aimed to increase Russia's power and capabilities as they develop the Russian Arctic region. The exporting of mining products from the Arctic is increasing in Russian Arctic, in North American Arctic and Greenland. The transit traffic through Arctic has smaller volume and is concentrated on summer sailing season due to presence of less sea ice concentration. Other increasing sectors are activities for offshore oil and gas exploration and fishing. Traffic is not evenly distributed in the Arctic, as seen in Figure 3-4.

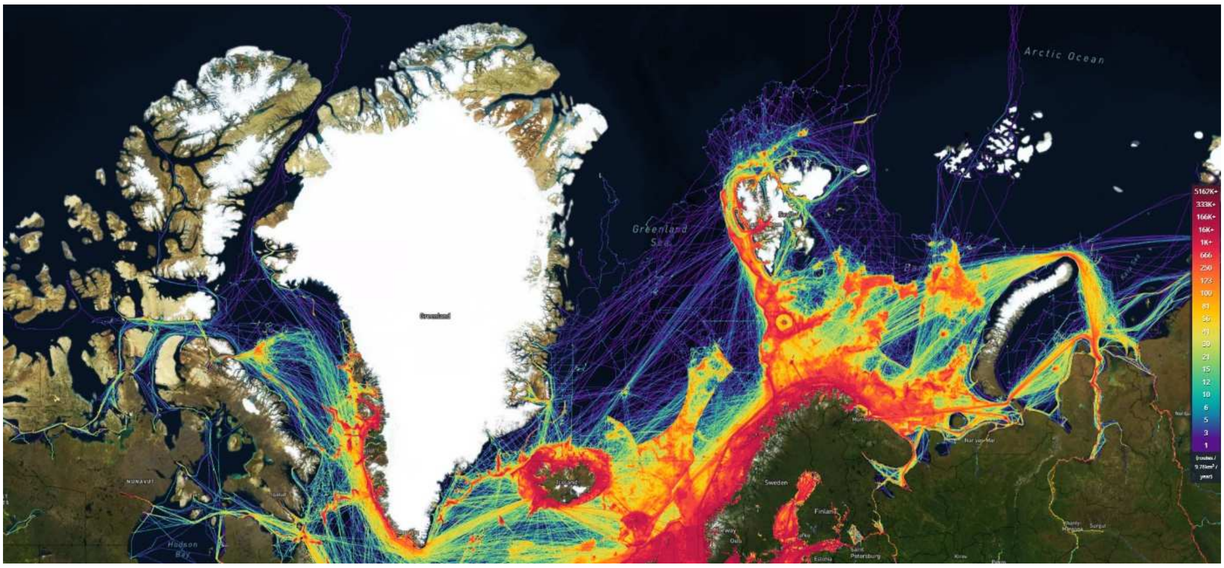


Figure 3-4 Arctic AIS density map for 2022 (MarineTraffic, 2022)

Cruise activities are mainly increasing in traditional areas, such as Svalbard, Greenland, and Canadian Arctic in the pre-Covid phase. The continued growth of the cruise market is likely once the international tourism market fully picks up after the Covid pandemic and if the geopolitical tensions start to decrease. Especially, we are likely to see significant growth in the expedition cruise market in the Arctic.

Fishing is pushing north at the Barents Sea and Bering Sea due to the increasing influence of Atlantic water in the Arctic Ocean. The Arctic Ocean is becoming warmer, and sea-ice is disappearing as a result.

Various Arctic shipping routes linking the Pacific and Atlantic oceans are being established or further developed, including the Northwest Passage, the Northern Sea Route, and the Transpolar Sea Route, and the Arctic Bridge Route (see Figure 3-5). These routes provide a more direct and potentially faster shipping of goods between ports in Europe, North America, and Asia, despite imposing higher risks for the navigation and the environment.

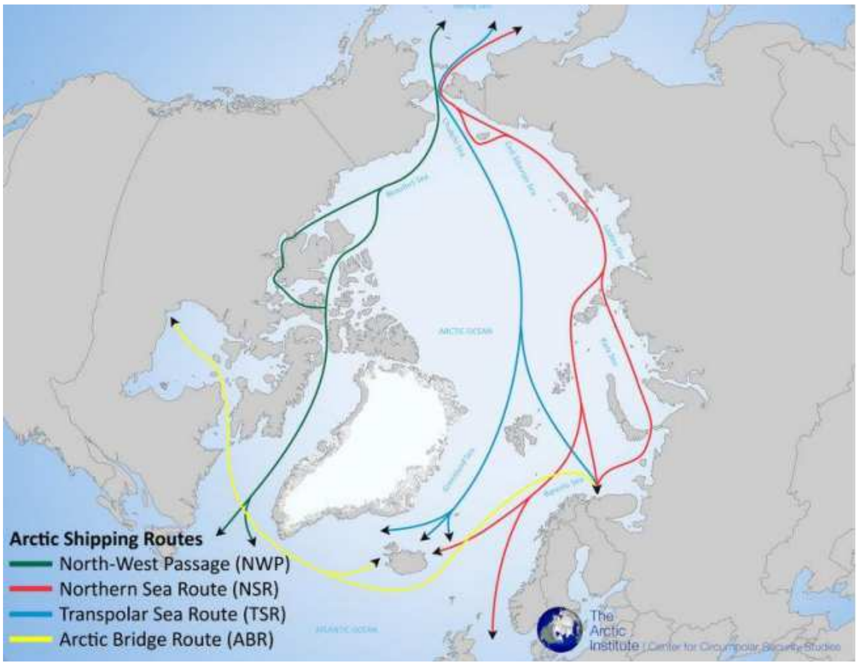


Figure 3-5 Arctic Shipping Routes [/33/]

3.3 Stakeholders

Close cooperation with the industry actors in Arctic and Baltic shipping is a key factor to ensure relevant input for a successful project. The project includes several stakeholders from most of Arctic and Baltic shipping business areas. The key stakeholders joined the project to provide their valuable support for the mapping the geoinformation challenges and requirements in the workshop and in the interviews. List of key stakeholders is presented in Table 3-2.

Table 3-2 List of key stakeholders.

Company name	Company business/R&D area	Business process
Aker Arctic Ltd.	Ship design, ice model test	Ship design
Arctia	Icebreaker operator, Baltic Sea and Arctic	Voyage planning
AON S.p.A	Insurance & Reinsurance Brokers	Insurance
Blue Water Shipping A/S	Shipping Company	Ship operations
Fednav Ice Services	Shipping in Arctic and Baltic Sea	Ship operations
Harnvig Arctic and Maritime	Service provider for Arctic operations	Ship operations
Italian Hydrographic Institute	High North Scientific campaigns	Ship operations
Italian Ship Owners Association ASSARMATORI	Ship owner’s association	Ship operations
The Norwegian Meteorological Institute	Weather and ice data provider	EO and weather forecast provider

The University Centre in Svalbard, UNIS	Arctic research and education institute	EO provider
British Antarctic Survey	Polar research institute.	EO provider, ship operations

DNV experts on cold climate operations, ship classification and ship scrapping have been used to cover the Ship Certification and End-of-Life disposal business processes.

The project engages stakeholders in close cooperation from early stages of the project with:

1. kick-off meeting to inform them on the project plans, stakeholder contribution and stakeholder involvement into the project.
2. a stakeholder workshop to map stakeholder geospatial requirements, and their perspective on the use of EO data
3. Stakeholder interviews to get more details on their geoinformation challenges and requirements.

4 METHODOLOGY

Geospatial requirements were collected to ensure holistic view on the industry challenges and geoinformation requirements following a variety of approaches or sources.

4.1 Literature review

A literature review was performed to map the industry challenges and geoinformation needs presented in recent scientific and industry publications.

The literature reviewed included a variety of documents including:

1. Deliverables from the EU funded project "Key Environmental monitoring for Polar Latitudes and European Readiness (KEPLER)", as it provides a state of art review of the shipping operations needs in the Arctic regions,
2. publications after the year 2020.

The literature review outcome is presented in the section5.1.4 to map common challenges and geoinformation needs. .

4.2 Stakeholder interviews

Stakeholders were invited to participate in a one-hour interview to gather comprehensive information about industry challenges and the geoinformation needs for the different business processes.

The interviews were hold with a hybrid approach, depending on the stakeholder's preference (face-to-face or online). A total of 11 stakeholders were interviewed including:

1. BAS,
2. Blue Water Shipping,
3. Harnvig Arctic & Maritime,
4. AON,
5. DNV, 2 experts interviewed
6. The Norwegian Meteorological Institute,
7. FedNav,
8. Arctia,
9. Aker Arctic, and
10. Italian Hydrographic Institute.

Together, these stakeholders represent all business processes, except Ship Construction. This business process was covered by the project team existing information on ship construction business together with support from stakeholders in other business processes.

The results and a summary of each of the interviews can be found in Chapter 6.

A set of standard questions were used during the interviews to guide and structure the conversation:

- What is your business?

- What are the general challenges in your industry/sector with regards to Arctic / Baltic shipping? (Seasonal differences?)
- Do you see any way how these challenges may be supported by EO data?
- What is your current use of EO data?
- What is the reason/criteria of selection for your current use of EO data? (Ease of access, cheap, improving safety, reducing cost through planning, legislative requirements?)
- If none; why/why not?
- Do you feel EO data is used to its full extent within your industry/sector? (why/why not)
- How easy and understandable is the current EO data being for decision making?
- How do you need to have the EO data delivered to make an action?
- Is the information available when it is needed?
- Do you envision EO data being used more, or less within your industry/ sector in the future?

4.2.1 Online questionnaire

An online questionnaire was distributed to stakeholder, in order to detail the gathered information on EO parameters currently utilized by the industry, as well as those required in the future, and who are currently using satellite data, as such ice information. The questionnaire focuses on ice information as the most used by the stakeholders. The questionnaire included a total of 22 questions, regarding the usage of geoinformation. The questions were organized in a manner, such that the following questions were chosen based on the response to previous ones. This was done to obtain a more detailed comprehension of the stakeholder's usage patterns and eliminate questions not relevant to certain stakeholders. The results of the questionnaire were used in forming summary of geoinformation needs by combining them with other results. The combined information for geoinformation requirements is presented in Chapter 9.

4.3 Stakeholder workshop

A workshop was conducted on the 22 March 2023 from 10 -15 UTC+1 in a hybrid mode at DNV headquarter in Høvik, Norway. The workshop was organized by DNV and lead by the WP1 leader, Janne Valkonen. The workshop was attended by 16 representatives from stakeholders and 13 representatives from the consortium partners.

The workshop provided an excellent opportunity for industry representatives to share valuable insights, and participants engaged in productive discussions across the different business processes and geo-requirement needs. Furthermore, the workshop facilitated networking among stakeholders, fostering greater collaboration and knowledge-sharing.

The workshop agenda was structured as follows: The day began with a welcome and introduction, during which all participants had the opportunity to introduce themselves. This was followed by a presentation from DNV summarizing the preliminary results from the interviews that had been conducted thus far. To facilitate fruitful discussions, stakeholders were asked various questions through live polls. The next item on the agenda was the breakout sessions, where stakeholders were grouped into two categories based on their business areas. Using Microsoft Teams Whiteboard, they answered three questions regarding their use and thoughts around EO data. Each question was given approximately 5 minutes for stakeholders to write their responses on sticky notes. This approach ensured that all viewpoints were considered, not just those who were the most vocal. Finally, the group examined and discussed the answers together before the results were brought back to the whole workshop group.

A workshop report was made by DNV after the workshop [25]. More details regarding participants, agenda, discussions, results, and outcome can be found there.

4.4 User personas

A user persona is a portrayal of an ideal customer or stakeholder that is somewhat fictionalized. The primary purpose of creating user personas is to establish a shared understanding among the project team about the needs, wants, and challenges of the different users being targeted by the project's product/service.

In each business process, at least one user persona is made, with each process being assigned a specific colour. The user personas are made based on information gathered through various activities in WP 1 such as the interviews, the workshop, online polls, and other interactions with stakeholders, in addition to the project team's overall understanding of the different roles.

All user personas are presented in Chapter 8.

5 LITERATURE REVIEW OUTCOME

- A literature survey was conducted for the latest academic and industry publications to gather the status of shipping in the Arctic, shipping industry challenges, geoinformation needs and the current use of satellite EO products. The following literature survey is presented the ASSR reports (**5.1**) and AMTP 2021 report (**5.2**) provides up-to-date information regarding the quantity and type of ships operating in the Arctic.
- Selected presentations from the fifth meeting of Arctic Shipping Best Practice Information Forum (**5.3**) provides insight into both the status of shipping in the Arctic as well as industry challenges.
- A recent report from the Centre for High North Logistics (**5.4**) supplemented by a scientific article (**5.4.1**) provides up-to-date information regarding shipping in the Northern Sea Route.
- Data from the NGO Shipbreaking Platform's Annual List of Ships Scrapped (2022) (**5.5**) is analysed to determine the extent of end-of-life activities occurring for ships in the Arctic and Baltic areas.
- The KEPLER(**5.6**),IICWG Mariner Ice Information Requirement Survey 2019 (**5.7**), and Salienseas' Mapping Weather, Water, Ice and Climate Knowledge & Information Needs for Maritime Activities in the Arctic (**5.8**) reports provide insight into industry current use and needs.

5.1 Arctic Shipping Status Reports (ASSR)

The Arctic Shipping Status Reports (ASSR) are published by the Protection of the Arctic Marine Environment (PAME). The ASSR reports include:

- ASSR #1 – The increase in Arctic Shipping: 2013 – 2019 (2020) [/1/]
- ASSR #2 – Heavy Fuel Oil (HFO) Use by Ships in the Arctic 2019 (2020) [/2/]
- ASSR #3 – Shipping in the Northwest Passage: Comparing 2013 – 2019 (2021) [/3/]

The above- mentioned reports provide information on the status of shipping activities in the Arctic region, including trends, traffic volume, and types of vessels used, environmental risks and impact associated with shipping activities in the region and efforts to mitigate the risks. The protection of the Arctic Marine Environment (PAME) is a working group of the Arctic Council that focuses on the protection and conservation of the Arctic marine environment. The group is composed of representatives from all eight Arctic states and various observer countries and organizations. PAME's main objective is to promote sustainable development and protection of the Arctic marine environment, including addressing the impacts of climate change, oil and gas development, shipping, and other human activities in the Arctic Ocean.

PAME develops and coordinates scientific research, risk assessments, and policy recommendations to support effective governance and **decision-making for the protection of the Arctic marine environment.**

The ASSR reports highlight that:

- The Arctic region is experiencing an increase in shipping traffic, because of the melting sea ice caused by climate change, which has opened up new shipping routes. While the overall volume of Arctic shipping traffic is still relatively low compared to other regions of the world, it has been steadily increasing in recent years.
- The total number of vessels operating in the Arctic increased by 25% from 2013 to 2019 in the region.

  The Northwest Passage, which runs through the Canadian Arctic Archipelago, also saw an increase in traffic, with a 44% increase in the number of vessels from 2013 to 2019.
- The increasing size of vessels operating in the Arctic has been increasing, with larger vessels able to navigate the region due to improvements in technology and infrastructure. This trend raises concerns about the potential

environmental risks associated with larger vessels, as well as the need for increased safety and emergency response measures in the region.

More detailed information from the ASSR reports is given in the following 3 subsections.

5.1.1 The Arctic Shipping Status Report 1: The Increase in Arctic Shipping 2013-2019 (2020)

The Arctic Shipping Report 1 [/1/] provides an overview of the trends and developments in Arctic shipping from 2013 to 2019.

The report notes that:

- Arctic shipping has increased significantly by 25% from 1298 ships in 2013 to 1628 ships in 2019. Figure 5-1 shows the variety of vessel types in year 2013 and 2019, with fishing vessel as the dominating vessel type. In 2019 fishing vessels accounted for 45% of the combined distance sailed by all vessels in the Polar Code area. Figure 5-1 shows the uptake of different activities carried by fishing and general cargo vessels, along with ice breakers and research vessels. An even more significant increase was the increase in total accumulated distance sailed by all vessels in the Polar Code area. In 2013 the total distance sailed by all vessels was approximately 6.51 million nautical miles. In 2019 this had increased by 75% to 10.7 million nautical miles.

- The increase in Arctic shipping coincides with the decline of sea ice leading to the opening of new shipping routes and development of Arctic natural resources, such as natural mineral extraction. The distance sailed by bulk carriers in the Arctic Polar Code area increased by 160% between 2013 and 2019, see Figure 5-2.

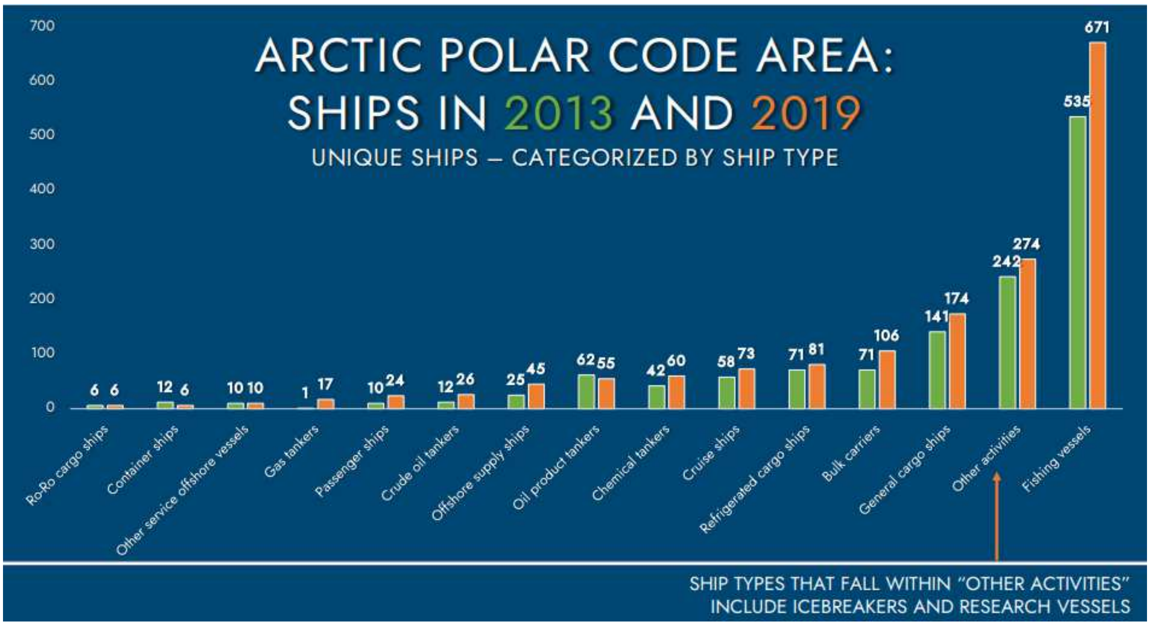


Figure 5-1 Unique ships in the Polar Code area in year2013 (green) compared to year 2019 (orange). [1]

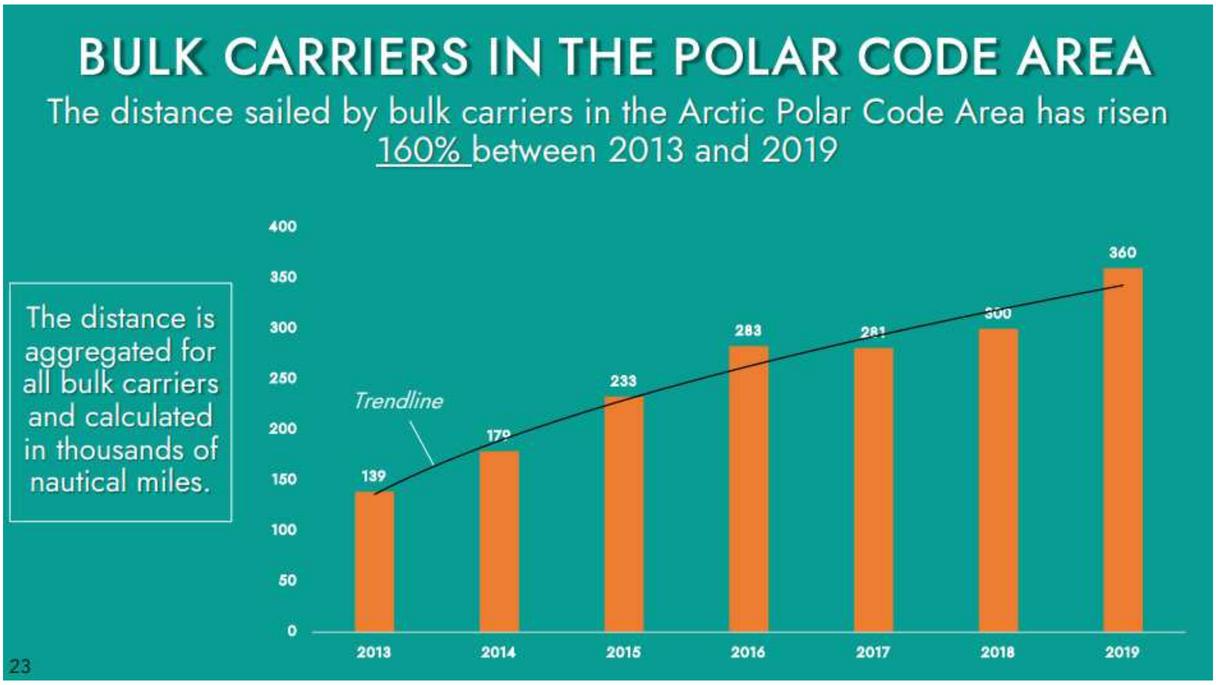


Figure 5-2 Distance sailed by Bulk Carriers in the Polar Code Area 2013 – 2019 [1]

Overall, ASSR# 1 states that the Article marine environment is undergoing environmental and developmental changes at a rapid pace. Shipping traffic increases across most vessel types; however fishing vessels remains the dominant one.

5.1.2 The Arctic Shipping Status Report 2: – Heavy Fuel Oil (HFO) Use by Ships in the Arctic (2020)

The Arctic Shipping Status Report 2 [/2/] provides an overview of the use of heavy fuel oil (HFO) in Arctic shipping and the potential impacts of HFO on the Arctic environment. The term HFO, according to the characteristics of paragraph 1.2 of regulation 43 of the MARPOL convention, referring to ***"Oils, other than crude oils, having a density at 15°C higher than 900 kg/m^3 or a kinematic viscosity at 50°C higher than 180 mm^2/s."***

The report notes that HFO is a widely used fuel in the shipping industry due to its low cost, availability, and properties, as a lubricant for ship engines, while at the same time providing more energy per volume then some other fuel types. However, it is also a highly polluting fuel that can have serious environmental consequences including the potential for oil spills and the release of harmful pollutants, such as Sulphur Oxides (SOx), Nitrogen Oxides (NOx), and particulate matter (PM). These pollutants can have significant impacts on air quality, human health, and the Arctic ecosystem, including marine mammals, fish, and birds.

According to the report ships operating in the Arctic waters use several types of fuel oils, as seen in **Figure 5-3**. The selection of fuel oils is based on several factors, such as vessel size, operation, logistics, chartering and legal requirements. However, *distillate marine fuel oil* was the most used fuel type in 2019 accounting for 61% of the vessels, compared to HFO which accounted for 10%. Distillate marine fuel oil is a lighter oil and as such is not considered a HFO.

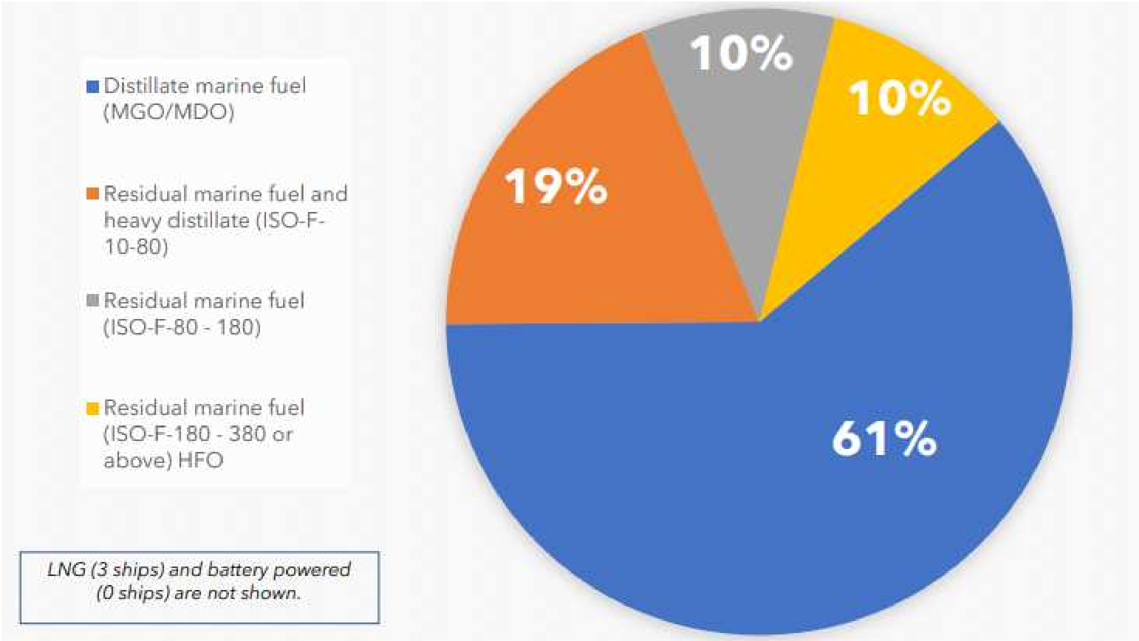


Figure 5-3 Distribution of fuel types in the Polar Code area in 2019 [2].

The report points at recent regulatory changes such as stricter IMO regulations with regards to allowable amount of sulphur contents in fuel, a future HFO ban in 2029 and IMOs goal of cutting greenhouse gas emissions in (at least) half by 2050 as reasons for the low HFO usage.

However, the report also reveals that the total fuel consumption in the Polar Code area grew by 82% between 2016 and 2019. A big contributor to this growth is the introduction of LNG tankers servicing Russia's Yamal project. In 2016 there were no LNG tankers in the Polar Code Area. This had increased to 29 in 2019 when these 29 LNG tankers consumed 28% of all combusted fuel in the entire Arctic Polar Code area.

5.1.3 The Arctic Shipping Status Report 3: Shipping in the Northwest Passage: Comparing 2013 to 2019 (2021

The Arctic Shipping Status Report 3 [3] compares shipping activities in the Northwest Passage between 2013 and 2019. Lacking any common official definition of the Northwest Passage, the report uses the definition set out under Canada's Arctic Waters Pollution Prevention Act as "Arctic waters", to establish geographic scope as shown in Figure 5-4.

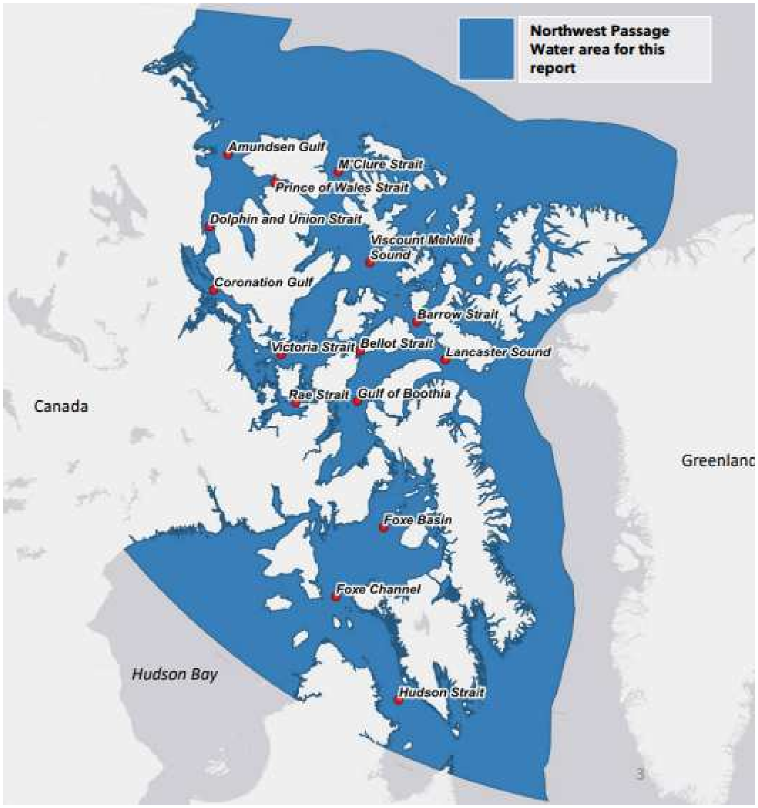


Figure 5-4 The area defined as Norwest Passage Water in ASSR #3.

Shipping activity in the Northwest Passage saw a large increase between 2013 and 2019, with the number of unique vessels entering the area increasing by 44% from 112 in 2013 to 160 in 2019. The total distance sailed by all vessels increased by 107% from 2,980,000 nautical miles to 6,170,000 nautical miles. A large contributor to this increase is the significant increase of bulk carriers, increasing from 18 vessels to 48, as shown in **Figure 5-5**. While the report doesn't directly explain the reason for this increase, likely it can be attributed to the opening of the Mary River mine on Baffin Island in 2014, as the report illustrate the activity increase in the Northwest Passage in year 2013 and 2019, see Figure 5-6.

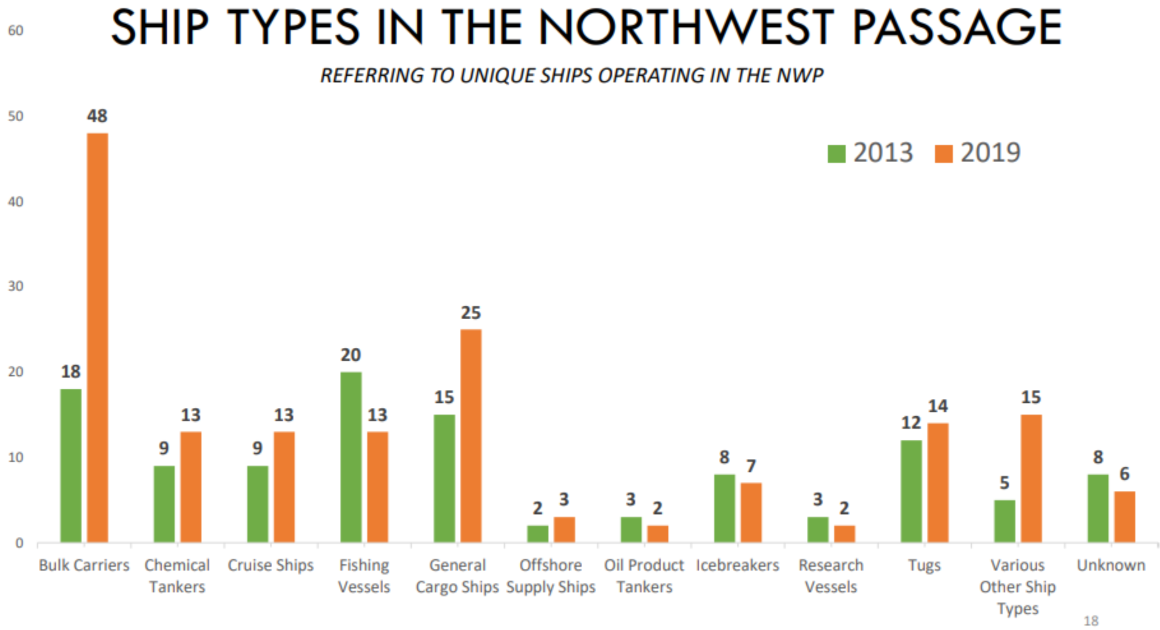


Figure 5-5 Unique ship in the Northwest passage, 2013 compared to 2019.

The increase of activity to the Mary River Mine on the east side of Baffin Island can be seen . Additionally, all ships traversing the Northwest passage in utilize a route, passing between mainland Canada and Victoria Island. This limits the possible draught of the vessels traversing along this route, as the ocean depth is as shallow as 10.3 meters.

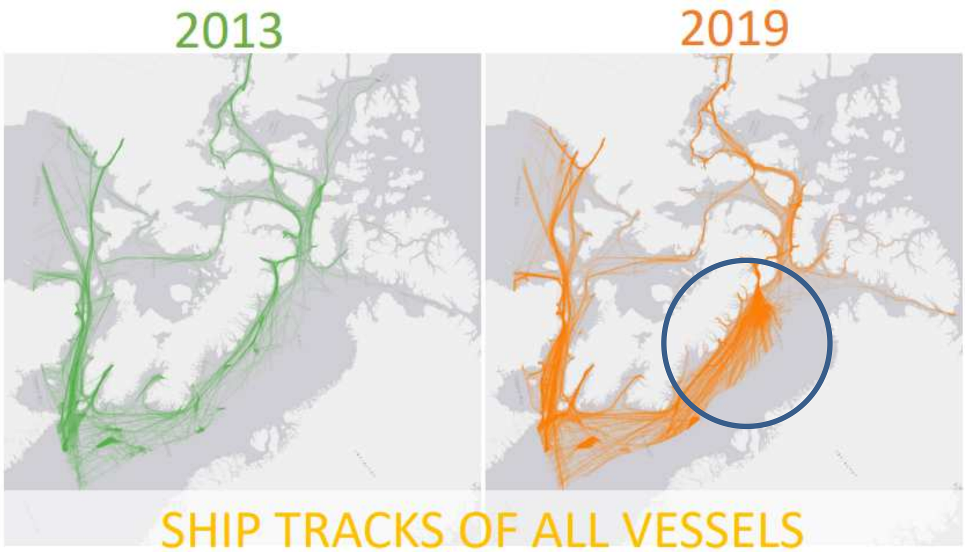


Figure 5-6 Aggregated ship tracks of all vessels in the Northwest passage, 2013 and 2019.

5.1.4 Comments on the ASSR reports

There are some discrepancies when it comes to the reported number of ships in Arctic Polar Code waters in 2019 between the 3 reports, as well as small errors in the calculated percentages. The difference in number of ships is according to PAME explained by update to data and a difference in analytical methodologies. Despite, this we consider the ASSR reports to be very strong and valid sources for understanding the recent development of the Arctic Shipping industry.

5.2 Arctic Marine Tourism Project: Passenger vessel trends in the Arctic (2013 – 2019) (AMTP 2021)

AMTP 2021 [4] project expands upon the previous PAME Arctic Marine Tourism Project – Best Practice Guidelines (AMTP 2015). The AMTP 2021 consists of two work packages (WP1 and WP2):

- WP1 contains data from the Arctic Ship Traffic Database (ASTD) on tourism vessels in the Arctic. The information on passenger vessels throughout the Arctic region is analysed to:
    - better understand recent developments,
    - identify gaps in the data, and
    - explore the options of obtaining vessel information on small recreational vessels without AIS transponders.
- WP2 summarises existing site-specific guidelines for near-shore and coastal areas of the Arctic, visited by passengers on passenger vessels and pleasure craft. A standardized template aimed at tourist/vessel operators is provided to help the development of site-specific guidelines encouraging sustainable use and educating visitors on ecological, cultural, and historical features unique to that area. TheWP2 is here not summarized, as not relevant for the EO4BAS project.

WP1 reveals the amount of passenger vessels in the Arctic, defined as the Polar Code area, increased by 35% from year 2013 to 2019 (from 77 to 104 passenger vessels), as shown in **Figure 5-7**. Concurrently, the total passenger capacity of all the vessels combined increased from 74,177 to 91,166, due to both the increase of passenger vessels and the overall increase in average size and capacity of the vessels.

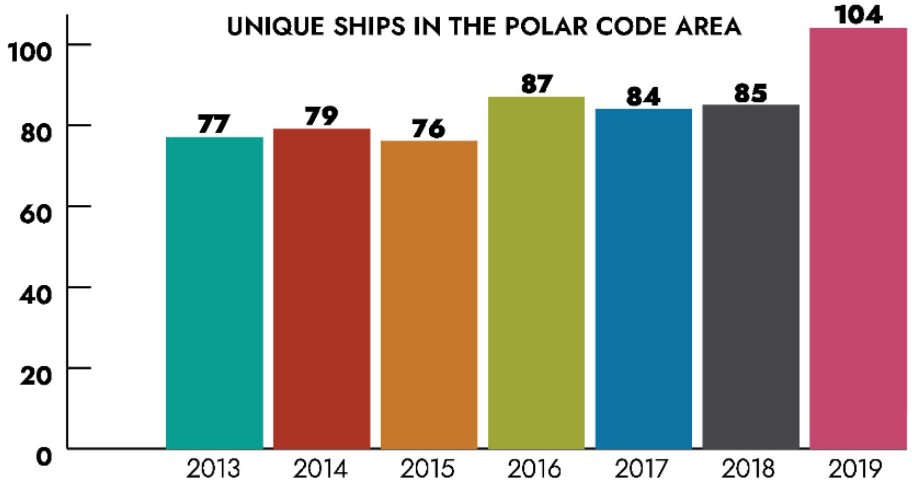


Figure 5-7 Unique passenger vessels in the Polar Code area from 2013 to 2019 [4].

WP1 also revealed an increase in passenger vessels operating for more than one month of the year, as seen in **Figure 5-8**, raising the average season length. 10% of these vessels operated for six months or longer**.**

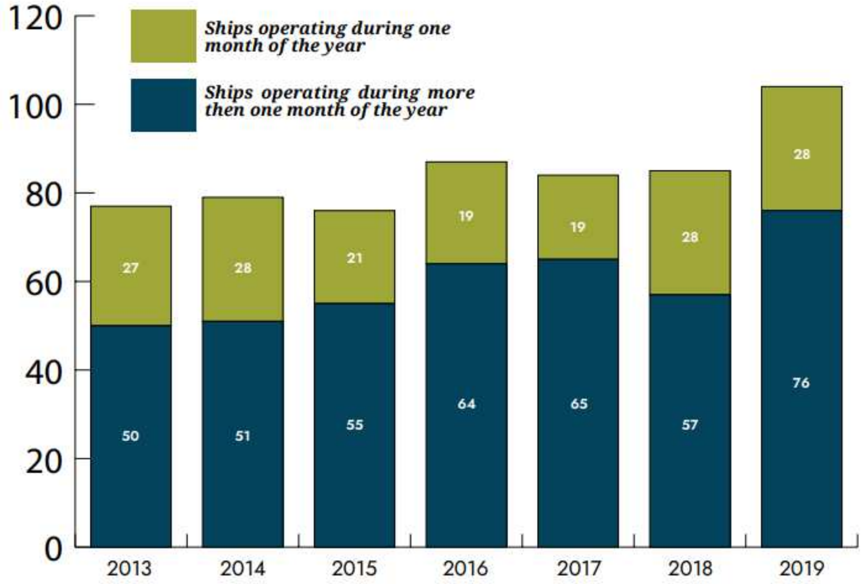


Figure 5-8 Passenger vessel operation length [4].

5.3 Arctic Shipping Best Practice Information Forum, Fifth Meeting

The Arctic Shipping Best Practice Information Forum is a collaborative platform establish in 2017 by the Arctic Council's PAME working group to raise awareness of the Polar Code amongst those involved or affected by Arctic marine operations. The forum facilitates exchange of information and promotes safe, environmentally sound, and efficient shipping practices in the Arctic region. The forum consists of representatives from governments, the shipping industry, indigenous organization, non-governmental environmental organization, and other stakeholders with an interest in Arctic shipping.

The fifth and latest meeting of the Arctic Shipping Best Practice Information Forum was held virtually from the 16th to the 18th of November 2021. No forum was held in 2022 as work of the forum was paused, alongside official Arctic Council meetings and its subsidiary bodies, after Russia's invasion of Ukraine in February 2022.

5.3.1 Shipping in the Polar Code Area, recent trends

Mr. Hjalti Hreinsson of the PAME Secretariat [/5/], used data from PAME's Arctic Shipping Database (ASTD) to show changes in shipping activities from 2019 to the 2020:

1. the number of unique ships operating in the Polar Code Area decreased by 1.8% from 1725 to 1694.
2. fishing vessel was the largest vessel type, making up 42% and 41% of all ships in the Polar Code area in 2019 and 2020,
3. the amount of passenger ships decreased 89% (from 98 to 11) from year 2019 to 2020,
4. bulk carriers decreased 49% from 149 to 100.

It should be kept in mind that as 2020 saw the outbreak of the Covid-19 pandemic, and it is not expected to be indicative for future trends.

5.3.2 Update from the IMO

Dr. Heike Deggim, director of IMO's Maritime Safety Division, summarized IMO's regulatory developments for the protection of the Arctic marine environment during the year 2020-2021 [6] including:

- IMO's Marine Environment Protection Committee (MEPC) adopted amendments to MARPOL Annex I in order to prohibit the use and carriage of HFO by ships in Arctic waters on and after 1. July 2024.
- Further measures to reduce the impact of black carbon emissions from international shipping in the Arctic will be considered based on the work by the Sub-Committee Pollution Prevention and Response (PPR).
- PPR is expected to commence work on amendments to MARPOL Annexes I, II, IV, V and VI. These amendments would allow Arctic port states to establish regional arrangements for port reception facilities.
- IMO's Maritime Safety Committee (MSC) has approved two sets of Guidelines for safety measures for fishing vessels and pleasure yachts operating in polar waters (MSC.1/Circ.1641 and MSC.1/Circ.1642).
- MSC has tasked the Ship Design end Equipment sub-committee (SDC) to establish similar guidelines for commercial yachts between 300 GT and 500 GT as well as review the 2014 *Guidelines for the reduction of underwater noise from commercial shipping.*
- The work of reviewing IMO's 2016 *Guidance on methodologies for assessing operational capabilities and limitations in ice* shall commence.

The listed changes provide a view on coming updates on the regulatory environment for shipping in the Arctic. Regulatory changes often require better information on the operation environment. EO can be a potential provider for up-to-date geoinformation to answer requirements in new regulations.

5.3.3 Insurers and the Arctic

The head of Marine and Aviation at Lloyd's Market Association, Neil Roberts, states [/8/]:

"As we know, the Arctic is a challenging environment. So much so that insurers consider it to be at the frontier of risk. Arctic risks are only written on a special acceptance basis as quite literally, they are off the insurance coverage map."

Regarding protection and indemnity insurance (P&I), the P&I clubs do not generally impose navigational limits, however if a voyage does not fall withing a vessel's normal trading pattern the P&I clubs require the operators to consult them. This will be the case for most vessels, which are not purpose built for operation in the Arctic or areas with significant sea ice, such as the northern and eastern parts of the Baltic Sea.

As for Hull and Machinery insurance, insurance policies require the operator to inform the underwriter if the vessel is going above 70°N, Otherwise, the operator will lose coverage due to several concerns including:

- Sea ice,
- Harsh working conditions for the crew,
- Technical issues with machinery and equipment due to cold,
- Reduced coverage for navigational aids (such as GPS),
- Inaccurate charts and magnetic compasses (less than 10% of the Arctic Ocean is charted),
- Increased manpower to assure safety during navigation, as the duration of lookout shifts (for ice and icebergs) need to be reduced to ensure appropriate concentration levels,
- Restricted visibility with fog and/or darkness up to 90% of the time,
- Uncertainty in weather reports and the risk of storms to quickly form (polar lows).

- Salvage facilities are few and far between, increasing the possibility to have large claims escalating (e.g., when Northguider ran aground in 2018).
- Little incident data to serve as a basis for statistical analyses.

To grant coverage insurers needs that:

1. the clients conduct their operation in a professional manner,
2. the voyage is carefully planned,
3. the ship and the crew are properly equipped, and
4. all reasonable risks reducing measures have been taken. Roughly 90% of enquiries do not translate into written risks due to clients often not answering or answering questions poorly.

Underwriters support the Polar Code and make compliance to the Polar Code a condition for insurance coverage, thus adding another layer of protection and risk management. However, underwriters still need to ensure that shipowners have done their due diligence, as there are some clients that only do the minimum to fulfil the requirements. The insurance market relies on the work conducted in shipping regulation to improve the risk environment.

According to Roberts, ensuring compliance with the Polar Code is in many cases a more valuable tool then increasing premiums, as for the underwriter the occurrence of claims has a greater influence on an underwriter's result then the premium they charge. The insurance market has also adopted the POLARIS approach to establish a standard approach for evaluating the risk to a ship in ice condition.

Despite these recent developments, Roberts states that Arctic insurance remains a specialist area for the few and that price competition may lead clients to seek the path of least resistance with less scrutinising insurance providers.

Roberts also brought up that the insurance sector is increasingly being asked to justify the coverages they write from a moral perspective. That the insurance industry is being positioned as a driver of the carbon transition through the Poseidon Principles for Marine Insurance.

In short, the Poseidon Principles for Marine Insurance is a global framework and initiative where signatories will assess and disclose the climate alignment of their hull and machinery portfolios. The carbon intensity of each vessel in the portfolio will be assessed on an annual basis and how it is aligned with different decarbonization trajectories such as IMO's GHG reduction goal of 50% by 2050. The four titular principles it is built upon is assessment, accountability, enforcement, and transparency [/9/].

5.3.4 Providing Search and Rescue Services in the Arctic Region

Mr. Yury Malyshev, Deputy head of Main Maritime Rescue Coordination Centre of the Russian Marine Rescue Service, gave an overview of the Russian search and rescue system in the Arctic and the oil spill equipment and emergency supplies located in the four forward operating bases [/10/]. He provided statistics for the type of incident that occur as seen in Figure 5-9.

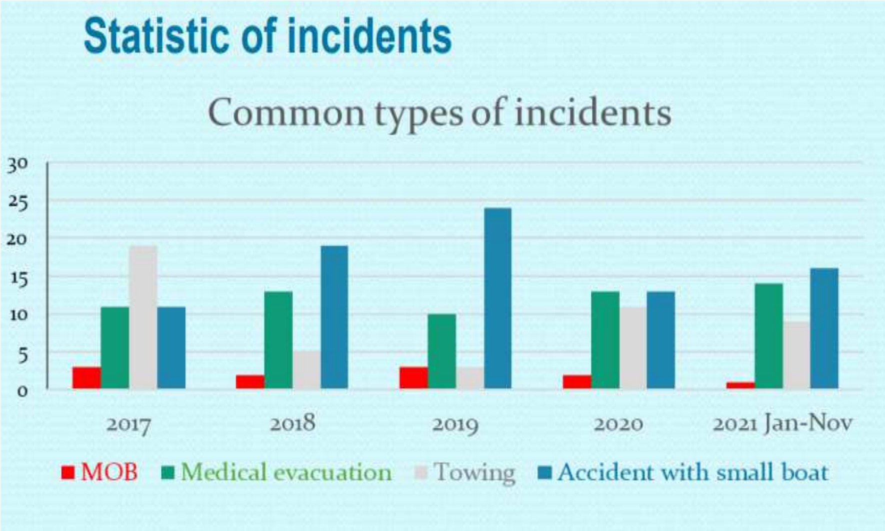


Figure 5-9 Incident statistics [/10/]

5.3.5 Ice Navigation and Pilotage in the Arctic

The CEO of Martech Polar [/11/], Captain David (Duke) Snider, highlighted the danger for shipowners and operators of underestimating the challenges, complexity and risk related to polar navigation and presence of ice.

The underestimation comes from operators complying only to lowest level of requirements expected, leaving operators off guard when conditions do not meet these expectations. Specifically, he underlines the need for mariners to consider the variability in ice extent and concentration that may occur, as the "good ice years" do not imply ice free conditions. Furthermore, various chokepoints along the Northwest passage may surprise unprepared mariners given unexpected or rapidly changing ice conditions, see **Figure 5-10**.

Figure 5-10 Selection of chokepoints along the Northwest Passage [/11/]

The CEO of Martech Polar brought to attention the challenge of:

- the lack of a standardized Polar Code Training and the apparent lack of oversight, leading to a wide variety in course length, quality, and variability in crew training.
- the underestimation of the severity of the ice conditions presently found in the area.

- the thinning ice leads to a change in ice characteristics, making it more prone to faster drifting and heavier deformation.
- only 15.8% of Canadian Arctic waters have been adequately surveyed, and only 44.7% of the key navigational routes [/26/]. Some bottom survey data in use dates to the 1800s due to lack of newer data. This is a sentiment also expressed by Dr. Geneviève Béchard, Director General of the Canadian Hydrographic Service and Chair of the Arctic Regional Hydrographic Commission, in his presentation [12].
- the lack of infrastructure and the absence of port, fuel, resupply or repair facilities between Nuuk and Dutch Harbour is a factor limiting shipping activity to "usual players" or expeditionary voyages.
- reduced satellite bandwidth capabilities due to the high latitude.
- higher insurance premiums increase the operating costs for vessels.

5.4 NSR Shipping Activities in 2022

The Centre for High North Logistics (CHNL) is an academic center for information and research on Arctic transportation and logistics at the Nord University Business School, Norway. According to their most recent report *NSR Shipping activities in 2022* [/28/] the number of voyages along the route decreased by 7% from 3227 voyages made by 414 ships in 2021 to 2994 voyages made by 314 ships in 2022. Of these 314 ships, 88% (278 ships) sailed under Russian flag. Despite this reduction in ships, total cargo volume transported along the route in 2022 remained stable as seen in **Figure 5-11**.

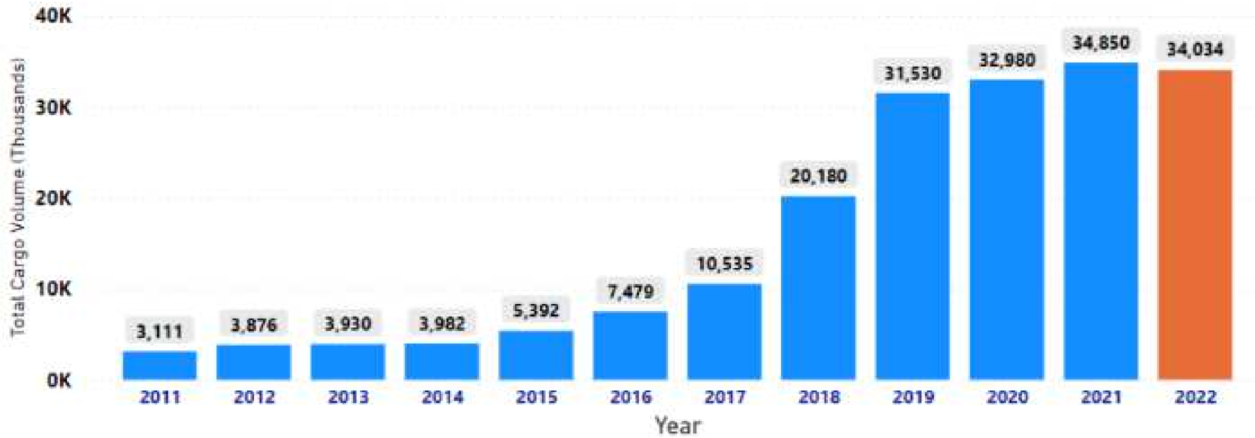


Figure 5-11 Total cargo volume along the Northern Sea Route by year. [/28/]

Number of transits along the route decreased by 50% from 86 in 2021, to 43 in 2022, 24 of which sailed with no cargo. Of the 43 transits, 35 were between Russian ports and the remaining 8 were between Russian and foreign ports. Not a single transit was made from a non-Russian port to a non-Russian port in 2022. This absence of international transit is reflected in volume of transit cargo along the route as seen in Figure 5-12.

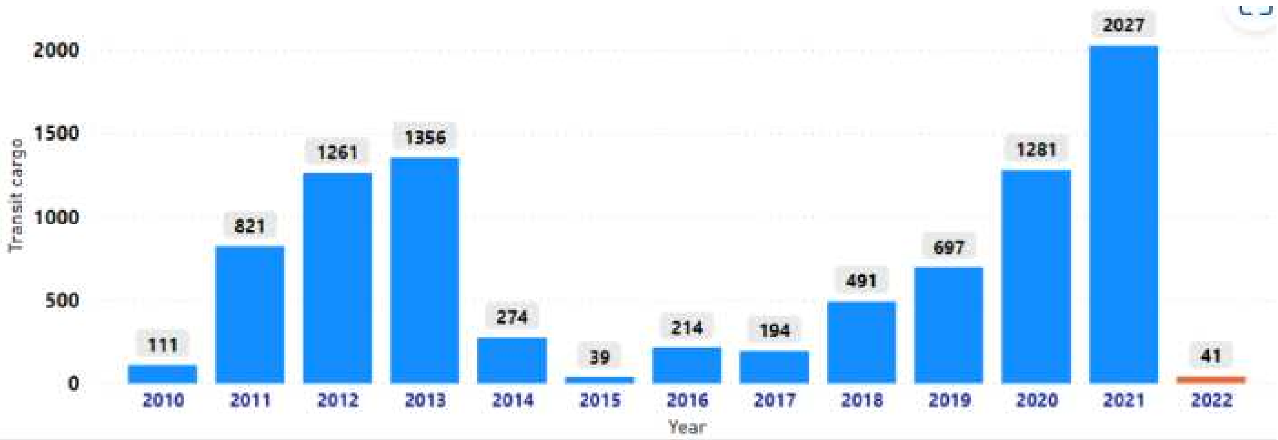


Figure 5-12 Transit cargo by year along the Northern Sea Route [/28/]

5.4.1 Recent ship traffic and developing shipping trends on the Northern Sea Route

The 2021 study "*Recent ship traffic and developing shipping trends on the Northern Sea Route"* by Björn Gunnarsson [/27/] from Nord University was used to supplement the information from 5.4 and provide insight into the activity along the Northern Sea Route preceding the Covid-19 outbreak and the 2022 Russian invasion of Ukraine. The study showed that from 2016 to 2019:

- The number of voyages along the Northern Sea Route increased by 58%, from 1705 to 2943, with majority of the voyages taking place between July and October.
- The rise in voyages was attributed to the growing domestic shipping on the NSR due to service/supply vessels and icebreakers servicing the hydrocarbon production around the Yamal Peninsula, and an increase in shipping to European ports by LNG carriers and gas condensate tankers.
- 84% of all voyages were domestic shipping in 2018, and the ports of Murmansk and Arkhangelsk were either the departure or arrival destination of 50% of these voyages. This is indicated in the aggregation of AIS tracks which is seen in Figure 5-15.
- International transit shipping made up 0.4%-0.8% of all voyages each year (8 – 19 voyages a year), with the Chinese company COSCO Shipping Specialised Carriers carrying out 45% of these voyages.

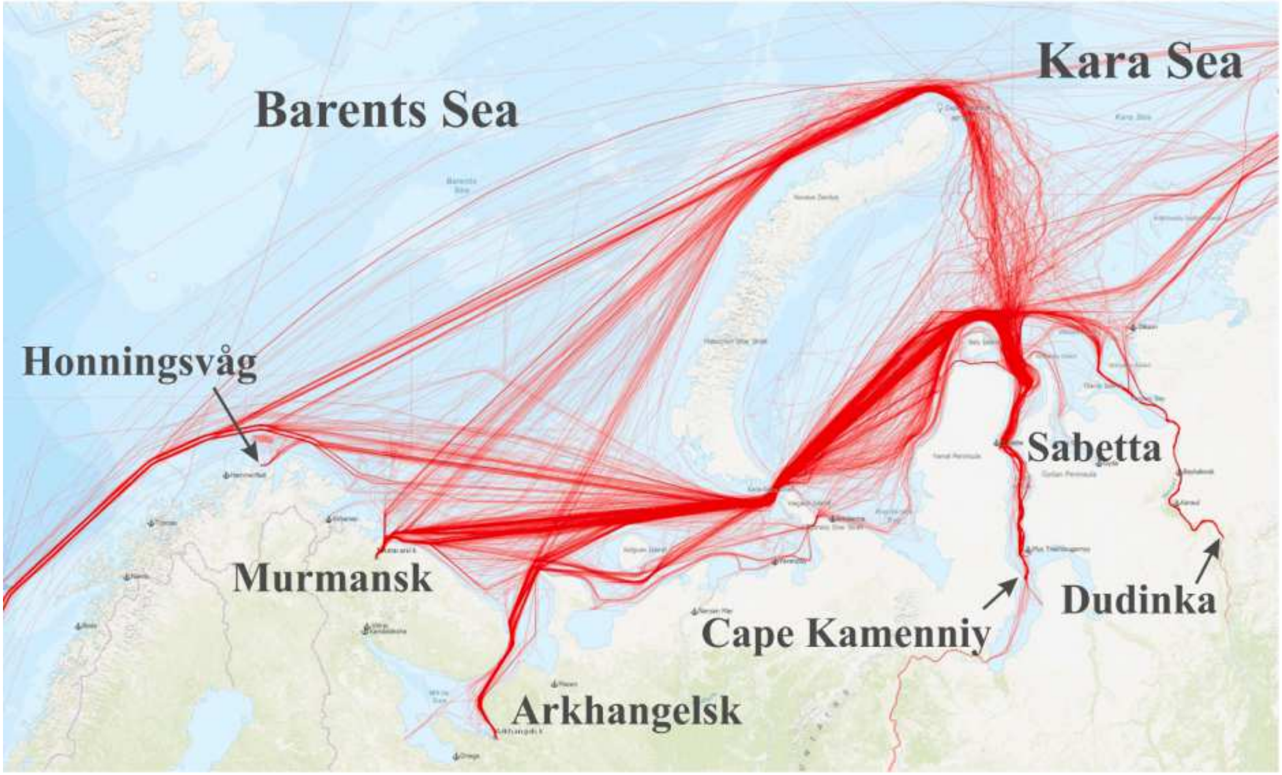


Figure 5-13 Aggregation of all AIS tracks from 2018. [/27/]

5.5 NGO Shipbreaking Platform's Annual List of Ships Scrapped 2022

According to the 9th edition of the European list of ship recycling facilities [/13/], the northernmost European ship recycling facility is Fosen Gjenvinning located on the Norwegian coast at 64°N. According to the NGO Shipbreaking Platform's Annual List of Ships Scrapped 2022 dataset [/14/], there are no such facilities located in the Arctic territories of Canada, USA, Denmark or Russia. As a result, end-of-life activities such as scrapping, or ship recycling does not occur in the Arctic.

There are a total of 11 approved ship recycling facilities mentioned within the Baltic Sea in the European list of ship recycling facilities. four located on the eastern shore of Denmark, four in Lithuania, and one in Latvia, Estonia and Finland. The Danish yards are in the Danish straits and Kattegat, which is occasionally counted as separate from the Baltic Sea. The location of ship recycling facilities in northern Europe and the Baltic Sea is shown in Figure 5-14. Note that 2 of the Danish facilities and all the Lithuanian facilities are in the same port and therefore don't show as separate locations markers on the map.

Figure 5-14 Ship recycling facilities in northern Europe [13]

According to the NGO Shipbreaking Platform's Annual List of Ships Scrapped 2022 dataset [/14/] 8 ships were scrapped/recycled within the Baltic Sea in 2022. 7 ships on the on the eastern shore of Denmark with a combined GT of 33 884 and one ship with a GT of 1 881 in Lithuania. No ships were scrapped in Latvia, Estonia, or Finland in 2022. This represents 0.43% of the total GT of all ships scrapped in 2022. Of the 7 ships scrapped on the eastern shore of Denmark, 3 of them were anchor handling tug supply ships and 1 was a jack-up oil rig. These vessels had a combined GT of 29 231. While extensive service records of these vessels were not found it is likely, based on the vessel types and owners, they've seen limited operation in the Baltic Sea.

The majority of ships scrapped (92% of world GP) took place in Bangladesh, India, Pakistan, and Turkey. If only considering the Baltic Sea proper (disregarding the Danish yards) than by GT approximately 0% (the single ship of GT 1 881 from Lithuania) of ships scrapped in 2022 were scraped in the Baltic Sea. Datasets from 2021 and 2020 shows a similar result.

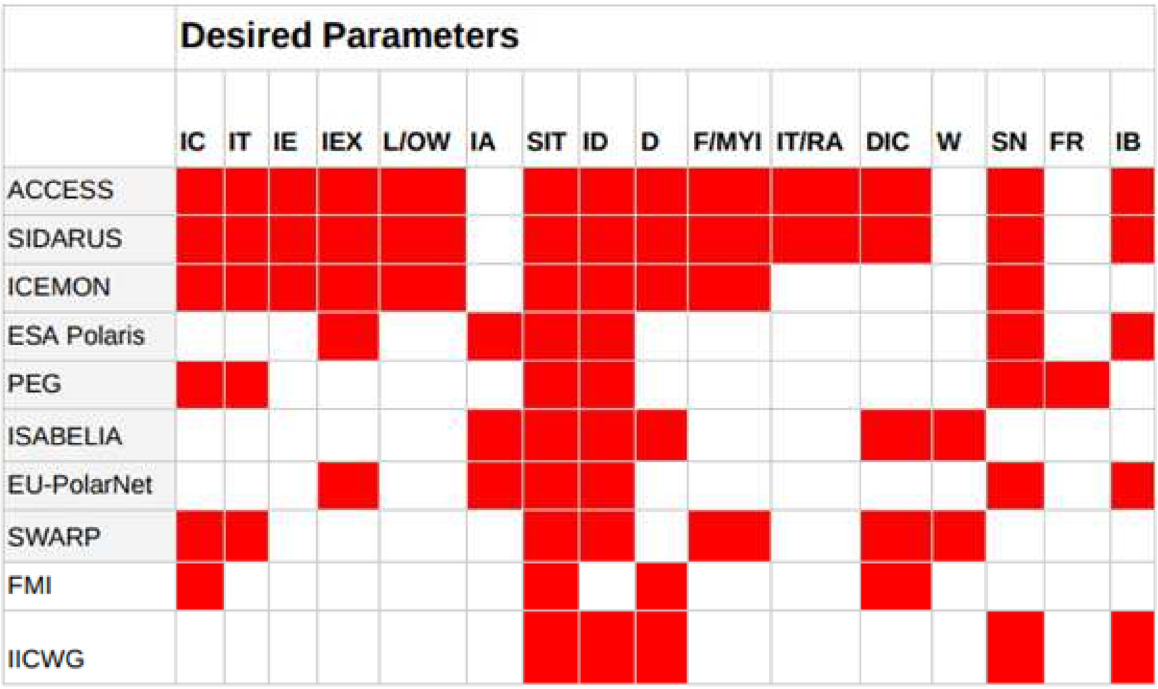
5.6 Key Environmental monitoring for Polar Latitudes and European Readiness (KEPLER)

Key Environmental monitoring for Polar Latitudes and European Readiness (KEPLER) was an EU funded initiative built around the European Ice Service and Copernicus information providers aiming to produce a clear road map for the Copernicus programme to develop value adding products, technologies, and other services. It ran from 1st of January 2019 to 30th of June 2021. During the project the needs of, the maritime sectors, among others, were mapped. These findings are contained within Report D1.1 Stakeholder Needs: Maritime Sector Needs [/15/] and Report D1.4 Overall Assessment of Stakeholder Needs [/16/].

Deliverable Report D1.1 contains a comprehensive summary of the marine sectors needs in the Arctic, Baltic and Antarctic regions and was compiled from several European Commission and European Space Agency projects. It represents a compilation of 15 years' worth of often parallel efforts into understanding the maritime communities Earth observational needs. The results of this study, which were summarized in Report D1.4 Overall Assessment of Stakeholder Needs [/16/], were that the requirements from the maritime community have largely remained unchanged for this 15-year period. With mariners asking for frequent (several times a day) data about the marine environment with high resolutions at the sub-km and meter scale for use in tactical navigation. This can be seen in Table 5-1, which is a summary of the user requirements from previous reports and studies. Lower resolution is of interest at the planning stage and for the research community but were deemed too coarse by end-users to be useful for navigation due to the inability to detect ice concentrations, features, leads and polynyas at these resolutions. Common parameters desired by mariners from the reports can be seen in table 7-2. Sea ice thickness, ice drift and snow on sea ice were the most desired parameter.

Table 5-1 - Summary of spatial resolution requirements from reports [16].

Table 5-2 Common desired parameters from EC and ESA project reports (grey) and Surveys (white) [16]. Legend IC = Ice Concentration, IT = Ice Type, IE = Ice Edge, IEX = Ice Extent, L/OW = Lead and Polynyas, IA = Ice Age, SIT = Ice Thickness, ID = Ice Drift, D = Deformation, F/MYI = Discrimination between FYI and MYI, IT/RA = Ice Thickness with Radar Altimetry, DIC = Detailed Ice Charts, W= Waves at ice edge, SN = Snow on Sea ice, FR = Sea Ice Freeboard, and IB = Icebergs.



5.7 Mariner Ice Information Requirement Selected results from the 2019 survey

The IICWG Mariner Ice Information Requirement Survey from 2019 [/17/] was a survey by IICWG Task Team 8. It contained 28 questions and gathered 95 responses. The survey was aimed at marine operators with most of the responders being ship captain or ship crew. The respondents had:

- 51,6% more than 10 years of experience,
- 33.7% had between 2 – 10 years of experience,
- 78% had experience operating ships in ice, and
- 58.9% also had experience operating in multi-year ice.

Regional ice charts were the most used source of ice information for navigation with 77 respondents selecting this option, followed by, local ice information (69 respondents), visible/IR satellite images (68 respondents) and SAR images (52 respondents). 25 respondents used radio bulletins and 24 used passive microwave data and climatology data.

Questions regarding spatial resolution for sea ice information showed high resolution data of less than 50 meters to be acceptable for more than half of the users asked, as seen in Figure 5-15. However, as seen in Figure 5-16 the optimal minimum resolution for about half of the respondents would be under 10 meters.

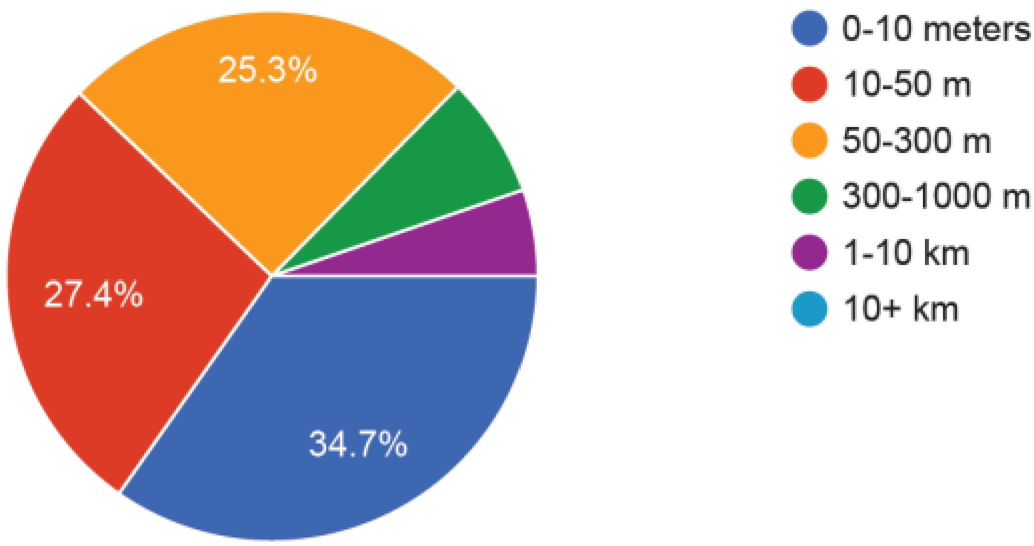


Figure 5-15 Pie chart representing the answers distribution to the question "What is the acceptable minimum size of any ice (iceberg, ridge, floe, lead...) you need information about? [17]

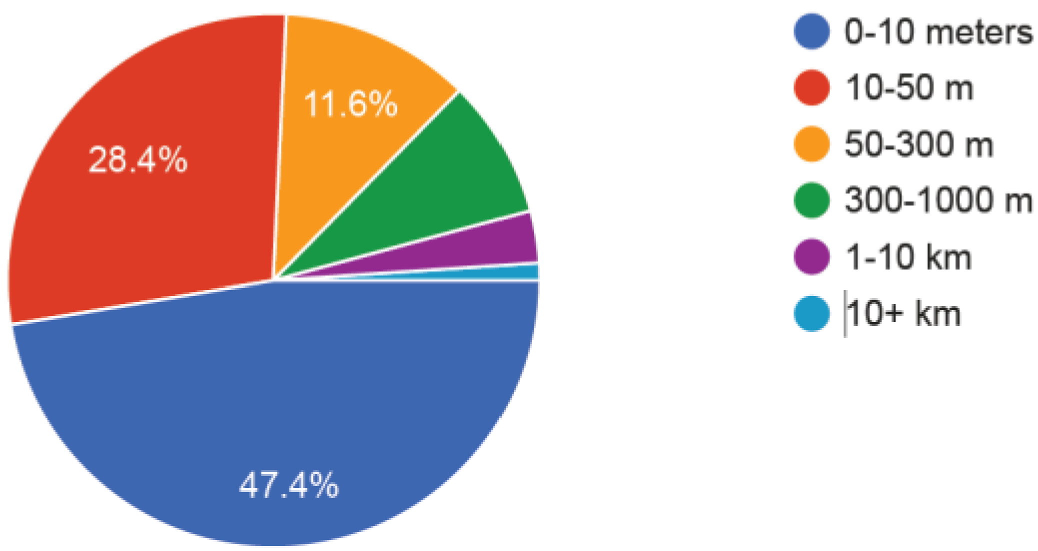


Figure 5-16 Pie chart representing the answers distribution to the question "What is the optimal minimum size of any ice (iceberg, ridge, floe, lead...) you need information about? [/17]

For the **temporal resolution** (update frequency) of the ice information, a daily frequency would be acceptable for about 75% of the users. However, many (47.4%) reported that twice a day would be optimal. The great majority of respondents reported that they considered an ice information product to be valid for less than 24 hours.

The preferred **delivery method** of information was through the internet, closely followed by email briefings, this overlapped significantly with how the users currently received their information. Users receiving information through the internet mostly reported receiving this in the form of digital graphics.

When asked what ice parameters the users missed in ice products the dominant answers were, drift and compression (39 responses), pressure ridges (34 responses) and the exact thickness of the ice (31 responses), as seen in **Figure 5-17**

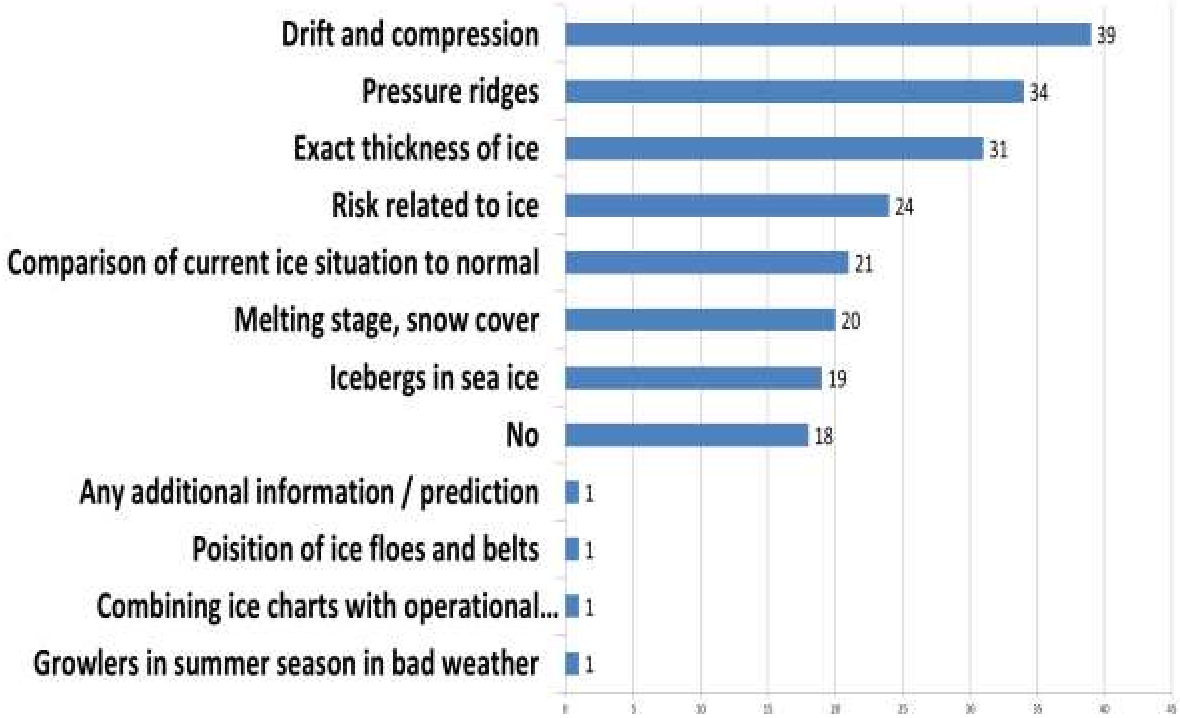


Figure 5-17 Horizontal bar graph representing the answers to the question "Are there ice parameters you are missing in ice products?"

5.8 Mapping Weather, Water, Ice and Climate Knowledge & Information Needs for Maritime Activities in the Arctic

In 2019 the SALIENSEAS conducted a survey [/18/] with 22 end-users operating around Greenland and Svalbard responding to their usage of weather, water, ice and climate information (WWIC). The end-users were mostly from the tourism industry, with some representation from other industries. The survey was based on the Maptionnaire platform, allowing respondent to tie their answers to specific geographic regions leading to the identification of particularly difficult to navigate straits and sounds.

According to the respondents their tasks and activities are very sensitive to ice and wind conditions with unfavourable conditions leading to change or cancelation of plans. These tasks and activities were calling certain ports, navigating certain chokepoints, fishing, sight-seeing, and excursions. About 90% responded that their activities were extremely or very sensitive to the variability of sea-ice concentration as seen in **Figure 5-18**. These parameters had a large degree of overlap with the parameters the respondents had experience information insufficiencies with as seen in **Figure 5-19**.

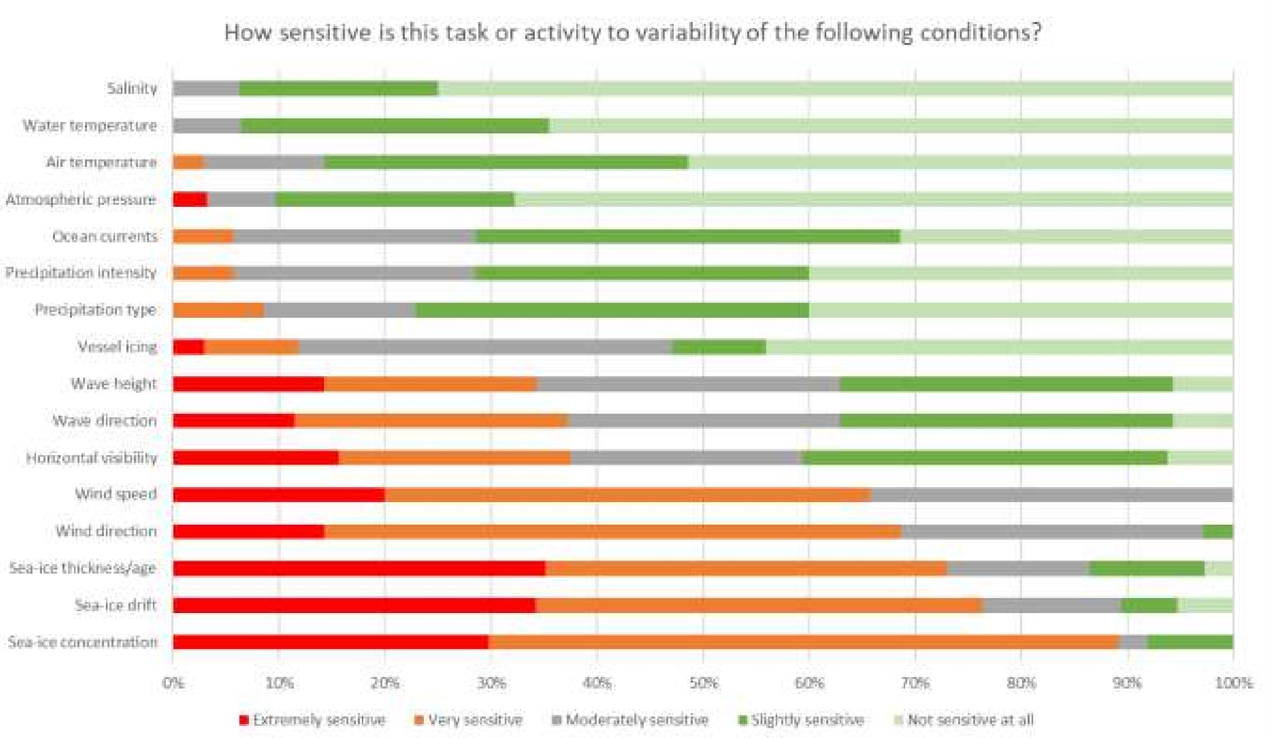


Figure 5-18 Sensitivity of activities to variability of met-ocean parameters.

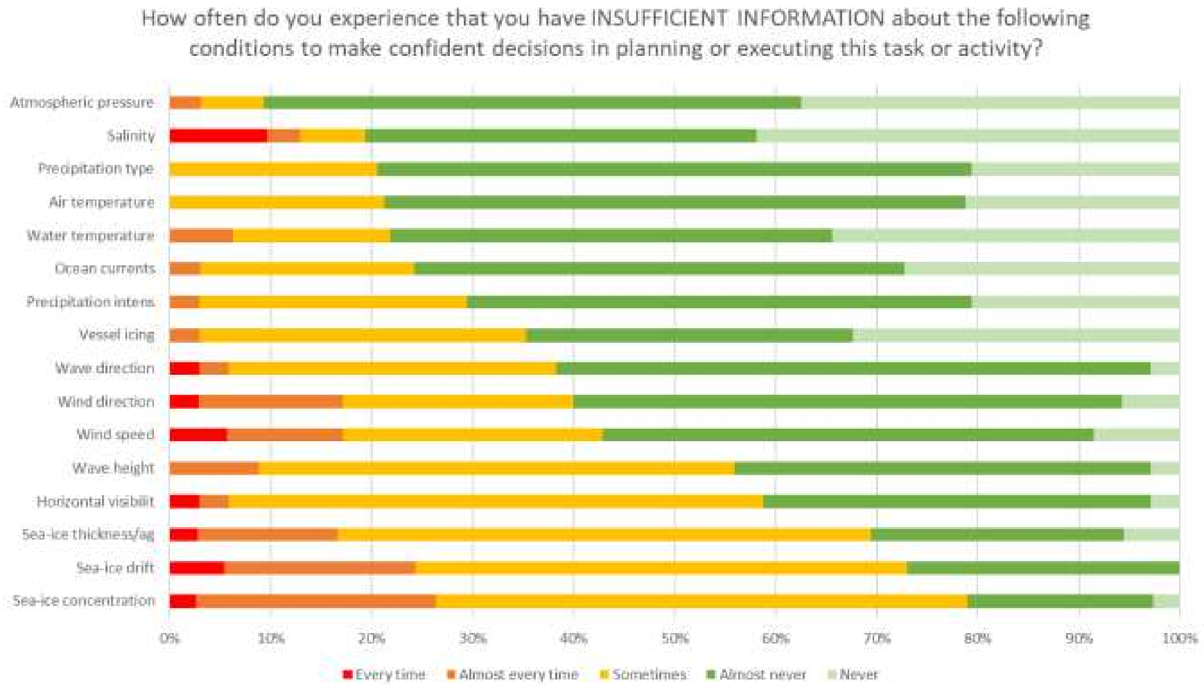


Figure 5-19 Frequency of perceived information sufficiency [18]

Characteristics which contributed to the insufficiency of the information included:

- a low frequency of ice-chart updates, particularly outside of the main operation season
- ice charts based on outdated data, leading to inaccurate charts.
- challenging internet coverage

- certain geographical location has rapidly changing conditions
- some areas are well covered by WWIC information services, such as around South Greenland and Isfjorden, while others are lacking. Lacking information is experienced more frequently outside of geographical centres such as the aforementioned.

Despite this, the respondents reported being generally satisfied with the accuracy of the information they require.

5.9 Ongoing research

Arctic PASSION

Arctic Pan-Arctic observing System of Systems: Implementing Observations for societal Needs an EU-funded Horizon 2020 project that seeks to co-create and implement a sustained and accessible observing system, which is tuned to the diverse needs of users ranging from locals to industry and decision-makers.

Part of this work is the development of pilot services. Pilot service 6 is called *Improving safety for shipping in the Polar Seas* and aims to develop an operational service that quantifies the risk of a vessel navigation ice-covered waters by an improved POLARS risk assessment methodology.

6 INTERVIEW RESULTS

One of the important data collection activities in WP1 was to conduct a series of stakeholder interviews to understand better the market needs, challenges, and gaps regarding geo information.

In addition to the listed stakeholders, DNV experts with deep knowledge on ship certification, ship construction and end of life disposal were interviewed to cover the entire business process portfolio. A summary of the stakeholder interviews is provided in the following. The results from the interviews were used among other collected information to form description of business process operations, current geoinformation use, struggles for utilizing geoinformation and future needs and wishes summarized in Section 8.

Table 6-1 Summary of interview for ship design business process.

Business Process: Ship Design
In ship design historical ice information is used in concept selection, where ice data is used as an input for ice transit simulations. Different ship size and hull form combinations are used in the simulator to find best suited combination for intended trade. Ice parameters of interest are ice thickness, ice concentration, and ice ridges. Currently used ice data has 25 km x 25 km resolution. Ice ridge information is based on own analysis of ice information, since parameter is not easily available in any dataset freely available. Data used is monthly data with time series 10 years back in time. Longer time series would be of interest, but not easily available in data sources currently used. Processed ice information is downloaded case by case from free open-source data. To get representative ice conditions, they try to capture heavy, normal and light ice winters in the data. This would be not necessary if a longer data series would be available since that would potentially cover different ice winters. Higher temporal resolution e.g., weekly ice data is of interest for the business. Combined statistics of ice conditions for the whole Arctic together with easier access to processed data including ice ridges would be useful improvement in the future to enhance ship design for ice conditions.

Table 6-2 Summary of interview for ship construction business process.

Business Process: Ship Construction
No interviews within the business process “ship construction” were conducted since the shipyards we invited for interview were not available in the time frame for WP 1. The information gathered for this business process is summarized in Section 8.2, and is based on the other interviews conducted with DNV Class, Aker Arctic and BAS, as well as the project team’s own knowledge on ship construction activities at different shipyards.

Table 6-3 Summary of interview for ship certification business process.

Business Process: Ship Certification (class/flag)
In ship certification business process the geo information is indirectly used through development of rules based on operational parameters. Long-term statistics of various parameters are used in the rule development. Air temperature, wind speed, wave height, sea ice information and other parameters are used in the development of rules and regulations. Direct use of geoinformation is only used on few occasions. Statutory certification sets requirements through IMO Polar Code for use of ice information in operational risk assessment, as wells as together with air temperature information for defining vessel operational capabilities.

Table 6-4 Summary of interview for insurance business process.

Business Process: Insurance
The insurance companies do not directly use EO data in the shipping sector. They would be interested to use geoinformation data if it was readily available and analysed product, which was easily understandable for the underwriters. They are specifically interested in how quick the wave, ice thickness and weather forecasts are changing and their variability to determine the uncertainty in predictability in the future. A temporal data range of 10-15 years would be useful.

Table 6-5 Summary of interview for ship operations business process.

Business Process: Ship Operations
Ship operations cover a large range of different ship types and operations which have common and the various types of challenges and geoinformation needs. Sea ice related challenges and geoinformation needs are special for the Arctic and Baltic Sea that makes the areas different from most of the worldwide shipping. Some shipping companies collect and even process geoinformation themselves. Others use external providers to gather required information for voyage planning and tactical navigation. Typical is that vessels receive processed information from the office and do not acquire information themselves directly from the data sources. The reason for this is that available information is not directly suited for use on board. It is either challenging to download, too big or not suited for shipboard systems without processing. Thus, preprocessing of geoinformation most often need to be done by a third party. The geoinformation needs for the ship operations varies from the strategic planning even years before the voyage to information needed for voyage planning and support for tactical navigation during the voyage. Sea ice information is especially of interest for ship operations in the Arctic. Data providers can assist vessels with voyage planning a year or two ahead of time, for which they require historical data regarding previous ice conditions (coverage, type, and thickness). Data from the last 3-5 years are used for studying the variability in the conditions, while longer time series are used for observing long term trends. This is typically 5-10 years past in time. For supporting vessels with tactical navigation near-real time (NRT) data is used, but not older than 24-48 hours. SAR data (at 100m) is used in combination (ideally) with low resolution optical images (MODIS/Sentinel 3). The optical images (MODIS) may also be merged with passive microwave measurements made by JAXA's AMSR2 (a product by the University of Bremen). Often free open-source data is preferred since it is more easily accessible than commercial data. For many operators also the cost of data is a limiting factor for using commercial data. This is used in combination with commercial data when possible. NRT EO data can be received even within 1-3 hours after it is generated, which is normal and sufficient for most needs. Generally, a daily overpass at a spatial resolution of 250 meter can cover many uses while higher resolution is needed for seeing details of ice formations. For observing ice movements a higher spatial resolution of 20 m needed. In detecting ice features by overlapping different image samplings is a useful tool. This requires overlap of satellite passes and different observations (e.g. SAR and visible wavelength, different resolutions etc.) of the same feature. Information of ice edge is of interest for fishing, cruise industry and sea bottom surveys. This information can be delivered to the vessel as an image or SMS that describes the ice edge as a line of coordinate points. Communication is still a challenge above 80°N where only Iridium is available. Thus, in many areas of the Arctic geoinformation provided to the vessel needs to be packaged and sometimes limited in coverage to allow the transfer via low band width. The way different actors have their EO data delivered differ depending on their communication link, activity, and preference. No one way suits all. Similarly, the preferred timescale of data differs, from climatological scale down to

tactical navigation (10-300m). For wind, wave and temperature data weather forecast models are currently used rather than EO directly. These models have certain limitations, particularly when local conditions are challenging to model. Mariners want sea ice SAR images with higher resolution, but there is not yet full SAR coverage in the Arctic or NSR due to time between overpasses in the same areas can be days.

Table 6-6 Summary of interview for end-of-life disposal.

Business Process: End of life vessel disposal
Results from interview indicate that there is little to no interest within the ship recycling industry to utilize EO data due to the perceived lack of practical applications for utilizing geoinformation. Possible applications could be ensuring compliance with ESG goals through environmental monitoring such as oil spill and pollution detection, algae blooming and changes to flora and fauna. However, the prevailing opinion is that this is more efficiently done through existing in-situ measurements and monitoring. Weather is not reported to be a limiting factor within the industry and as such readily available weather forecasts are considered sufficiently to not necessitate using EO data for this purpose. A possible application for EO data was identified as being used by local authorities for quick inspection and monitoring of scrapping yards.

7 WORKSHOP RESULTS

During the workshop, the stakeholders got accounted to the EO4BAS project goals and partners. The stakeholders identified geoinformation requirements and associated constrains for shipping within the Arctic and Baltic regions. The stakeholders identified geoinformation requirements and associated constrains for shipping within the Arctic and Baltic region. The workshop results are reported in EO4BAS D1.2 Stakeholder workshop report.

Key highlights include:

1. Despite the existence of a large amount of EO data, the stakeholders perceive a sense of disorientation in navigating the number of platforms to find the most relevant data for their needs.

2. The stakeholders often lack knowledge of the available EO data, where to access fit to purpose products, and the products and services that the market offers.

3. This gap is partially closed by specific shipping service providers, which gather available satellite data to generate suitable products for the end users. But on satellite service providers' side there were often less readily processed products available suited for shipping industry.

Among the stakeholders there is the consensus that it is easier to access to open source EO data than to get hold of commercial satellite products. Open source EO data platforms provide an overview of available satellite products, meta data, calibrations, and standards.

4. Most stakeholders rely mainly on open source EO information products given the data transparency and the higher cost attributed to commercial data and services. The most used geoinformation product is ice information, delivered in the form of ice charts.

    1. Ice information is used for both strategic and operations planning of vessels that operate outside of ice or close to ice edge.
    2. Most vessels do not perform tactical navigation in ice that would typically require more detailed ice information often derived from SAR satellite products. For tactical navigation higher temporal resolution and fast delivery to ship after satellite passing is a commonly recognized requirement. Level of spatial resolution depends on combination of temporal resolution and needed swath for satellite image. Of which the latter might be more important for vessels navigating through ice.

8 CHALLENGES FOR EACH BUSINESS PROCESS

The project strives to understand the challenges for the shipping business processes in the Arctic and the Baltic Sea and to map the geoinformation needs associated to these challenges. To achieve a holistic understanding for the shipping industry challenges and needs the findings from the literature review, the workshop and interview were combined with the project team's knowhow to design user personas. The user personas give an overview on the challenges, needs and frustrations concerning geoinformation for various representative stakeholders, providing a summary of business process challenges and current use and future needs for geoinformation.

Geoinformation requirements for shipping in the Arctic and Baltic Sea are summarized in the Section 9.

8.1 Ship Design

Ship design includes concept design and the development of the final design of ships. Detailed information of the environmental conditions is required to design ships operating in the Arctic and the Baltic Sea, to ensure the ships can cope with the expected environmental conditions. The optimization of design parameters depends on environmental parameters, including long term time series of ice thickness, ice type, ice concentration, deformed ice and ice ridges, air temperature, wave height and direction, wind speed and direction at medium / high spatial resolution. Good data quality of long-term time series is needed to ensure good statistics for these parameters for the planned operation area.

For ship design typically, the ice information such as ice thickness, ice concentration and ridges are derived from EO, while the other information are from design codes and rules and reanalysis weather models.

Long term time series of various parameters characterizing ice are used in the ship concept selection. Ice data is used as an input for ice transit simulations that is used to test various ship size and hull forms combinations in the ice conditions to find best suited combination for the intended trade.

Air temperature is available from weather observations and weather models with varying spatial resolution. An essential variable retrievable from air temperature is the mean daily low temperature (MDLT), which is not provided as a standard output from weather models. The MDLT is needed for design purposes in the Arctic, as the Polar Code requires operations to be planned within vessels capabilities. Designers and operators can calculate the MDLT from weather statistics or use external service providers, depending on the operator's knowhow.

Typically, within the ship design process, open-source satellite observations of ice are used as an input and to estimate ice ridges. Another important data source are historical ice charts that provide information on ice conditions in the area for long period of time.

Figure 8-1 shows the user persona for the ship design business process who represent a generic stakeholder with her needs and frustrations for utilizing geoinformation. Here the stakeholder is a ship designer with her challenges and needs for information for the ship design. Table 8-2 shows the current use and future need of geoinformation for ship design business process. Together these form a summary of business process current use and future needs for geoinformation. Business process geoinformation challenges and associated geoinformation requirements are listed in Table 8-2.

Figure 8-1 User persona for ship design representing background information, wants, needs and frustrations for the business process.

Table 8-1 Geoinformation use, constrains and future needs for ship design.

Currently used geoinformation	Parameters	Resolution	Constrains	Future wishes
Ice charts Ice parameters from SAR satellites	Ice thickness, Ice concentration, Deformed ice (ice ridges)	Monthly averages 25 km x 25 km spatial resolution	No data available in archives for certain time No easy access to data Limited processed products Ice ridge information not available	Higher spatial resolution than today Weekly ice information Processed long term statistics of ice conditions Ice ridges included in processed satellite data
	Air temperature	Temporal resolution from 10 minutes to hourly to several hours Spatial resolution can vary from below three kilometres to tens of kilometres		

Table 8-2 Business process challenges and geoinformation needs. Geoinformation needs refer to numbers in Table 9-1.

ID	Challenge	Geoinformation requirements
SD-1	Environmental conditions in vessels intended operation area	1, 2, 3, 4, 8, 9, 21, 22
SD-2	Defining ice class for vessel intended to operate in ice	1, 2, 3, 4
SD-3	Vessel concept, main dimensions, and hull form selection in early design	1, 2, 3, 4, 10

SD-4	Material selection in ship design phase for fulfilling design requirement for operation in cold climate	13
SD-5	Defining the design temperature for the vessel	13

SD-1 Environmental conditions in vessels intended operation area

Ship needs to be designed to cope with the environmental conditions in the operational areas, as ice class needs to match ice conditions, materials need to be suited for lowest operation temperature, and components and systems need to tolerate possible snow and ice accretion.

SD-2 Defining ice class for vessel intended to operate in ice

Ships ice class needs to be suited for ice conditions in intended operational periods and areas.

SD-3 Vessel concept, main dimensions, and hull form selection in early design

Ice transit simulations are used in ship concept selection phase, and ice conditions are an input. Different ship main dimension, propulsion and hull concepts are tested in the simulations to find suited combination for further design.

SD-4 Material selection in ship design phase for fulfilling design requirement for operation in cold climate

Polar Code requires that ship materials need to be suited for lowest operation temperatures. Class rules require steel material selection based on the intended operation temperatures.

SD-5 Defining the design temperature for the vessel

Design temperatures for the vessel are based on air temperature statistics to comply with the class rules and Polar Code requirements based on intended operation area and season.

8.2 Ship Construction

Ship construction includes building of the ship in the shipyard, testing and validation before and during the sea and ice trials. The planning and execution of the of the sea ice trials is an essential part of construction of ships for ice operations that mostly happens only in the Arctic and the Baltic Sea.

The actual construction work at the shipyard is based on the ship design (including certifications and operational requirements). Weather forecast information is used for planning activities during the ship construction. Wind affects lift operations and air temperature and moisture as well as rain for installation works of different materials and systems. Also, weather forecasts are utilized in planning vessel tow out. For the shipyards in the Baltic Sea ice might be a challenge when non-ice strengthened vessels are leaving during the winter season. Information on the ice formation in the autumn can be used to plan when the ship needs to leave the yard at the latest. The weather parameters of interest for the ship construction are wind speed and direction (including gusts), wave height and direction, air temperature and sea currents.

Sea trials are important part of ship construction process. During the sea trials vessel's systems and performance are tested. Vessels with ice strengthening are tested in ice for compliance to performance requirements, defined by the vessel specification. Sea ice trials occur in the spring and summer in the Arctic and during winter months in the Baltic Sea. Sea ice trials are planned on suitable testing locations, based on historical ice information and ice charts from satellite data. During actual sea ice trials satellite EO based sea ice products are used to find suitable locations for testing of the vessels along with the ice charts for the area. Ice parameters, such as ice thickness, concentration, and deformed ice (ice ridges) are important parameters for testing the vessel performance in ice. The fit to purpose spatial resolution could include very high resolution NRT data with a daily temporal frequency. Optical satellite imageries are used when available, while SAR images are more widely utilized due to capability to provide information during cloud cover and absence of light.

Sea ice trials are scheduled activities, thus both freely available and commercial satellite EO products can be used to ensure sufficient data coverage. During sea ice trials, ice information is intentionally used to find the hardest ice conditions to test the vessel. In normal ship operations, vessels try to avoid the hardest condition when possible.

The vessels sea trials are testing of open water performance of vessels. During the sea trials historic ice data in form of ice charts and satellite ice observations is used to plan sea trials and to avoid ice.

Figure 8-1 and Figure 8-2 shows the user personas for the ship construction business process who present typical persons with their needs and frustrations within the business process. They represent a ship builder and a person who organizes sea trials for the ship, respectively. Both have unique challenges in their work and needs for different kind of geoinformation. Table 8-3 shows current use and future need of geoinformation for the business process Ship Construction. Together these form a summary of business process current use and future needs for geoinformation. Business process geoinformation challenges and associated geoinformation requirements are listed in Table 8-4.

Figure 8-2 User persona named Louis within the business process Ship Construction working with ship building at a shipyard.

ABOUT:

Age: 49 years
Location: Stavanger, Norway
Role: Responsible for sea ice trials
Business process: Ship construction

DO YOU CURRENTLY USE EO DATA IN YOUR BUSINESS?

☑ Yes
☐ No

WANTS AND NEEDS:

- Satellite-based sea ice products and ice charts for the area are utilized during sea ice trials to identify appropriate testing locations for the vessels.
- Ice parameters like ice thickness, ice concentration, deformed ice and ice movement, in addition to wave and wind speed and direction are relevant for the sea ice trial.
- Want the resolution to be as high as possible

FRUSTRATIONS:

- The cost of high resolution data
- The access to data products
- Bandwidth on board
- Timely data

"Since the sea ice trials are like normal ship operations the products used should be near real time and easily available for the operation area"

Figure 8-3 User persona named George within the business process Ship Construction being responsible for the ship sea ice trial.

Table 8-3 Geoinformation use and future needs for ship construction.

Use case	Currently used geoinformation	Parameters	Resolution	Constrains	Future wishes
Ship construction	Weather data from forecasts	Wind speed Wind direction Wave height Wave direction Temperature	Weather model spatial resolution Daily or more frequent updates	Do not know what geoinformation more is available and how to utilize it	To better understand how geo information could be used in the ship construction
Sea ice trials	Ice charts Satellite ice data	Ice thickness, Ice concentration, deformed ice (ice ridges) Ice edge	Monthly averages and weekly averages Daily ice charts Daily ice edge As high as available spatial resolution for operation area	No data available in archives for certain time No easy access to data Limited processed products Ice ridge information not readily available	Higher spatial resolution than today Processed long term statistics of ice conditions Ice ridges included in processed satellite

Table 8-4 Geoinformation challenges and geoinformation requirements for ship construction. Geoinformation needs refer to numbers in Table 9-1.

ID	Geoinformation challenge	Geoinformation requirements
SC-1	Planning and execution of lifting operations at the shipyard	11
SC-2	Planning and execution of vessels tow out at the shipyard	11, 12, 17

SC-3	Planning sea ice trials outside of ice season	1, 4, 8, 21
SC-4	Avoiding sea ice during sea trials	1, 8
SC-5	Planning of sea ice trials	1, 2, 3, 4, 8, 10, 21
SC-6	Finding suitable ice conditions for testing vessel's capabilities during sea ice trials	1, 2, 3, 7, 8, 10, 11, 13, 18
SC-7	Ship operation in ice during sea ice trials	1, 2, 3, 7, 8, 10, 11, 13, 18

SC-1 Planning and execution of lifting operations at the shipyard

Lifting operations may be limited by the weather conditions, in particularly wind conditions. Earth observational data could be used for planning suitable dates for the operation and reduce the risk of cancelation.

SC-2 Planning and execution of vessels tow out at the shipyard

The towing of a vessel may have certain associated limitations on meteorological and oceanographical parameters to conduct the operation. Earth observational data could be provided to support the planning and decision-making process and reduce the operational risk.

SC-3 Planning sea trials outside of ice season

Ships who do not have ice class need to avoid ice during sea trials. Time for the sea trials need to be planned outside of ice season in anticipated test area.

SC-4 Avoiding sea ice during sea trials

If sea ice is present closely to the test area keeping away from sea ice and monitoring sea ice movements are essential for ensuring safety of the sea trial.

SC-5 Planning of sea ice trials

Sea ice trials are arranged to test the ships performance in design ice conditions. Areas and times where suitable ice conditions are in present at suitable time for trials. Level ice, deformed ice and ridges of specified size are suitable for testing need to be found. Historical ice information is used to find suitable locations and time for testing ship's performance in ice.

SC-6 Finding suitable ice conditions for testing vessel's capabilities during sea ice trials

Ice trails are an important step in assuring and documenting that a vessel meet its design icebreaking, and navigational capabilities. Finding a suitable area with ice conditions of suitable concentration, thickness, and features is a challenging and crucial task which may be supported by earth observational data.

SC-7 Ship operation in ice during sea ice trials

When undergoing sea trails, earth observational data may support a vessel in tactical navigation or to find nearby ice conditions and features which may be of interest for the trail. In the event that ice conditions are not as planned, earth observational data could be used to identify alternative locations with more suitable conditions.

8.3 Ship Certification

Ship certification is considered to cover statutory certification and ship classification. The main statutory certification in the Arctic is Polar Code compliance and vessel Polar Ship Certificate.

Polar Code requires that ice conditions in the ship's intended operation area is considered as a hazard in operational analysis. IMO POLARIS is a suitable methodology to estimate ship's risk for operating in ice. This can be calculated based on the ice type and ice concentration either from ice charts, satellite observations of sea ice or during the vessel operations based on the visual observations of sea ice around the ship. POLARIS uses the sea ice concentration that is well established satellite EO product. The ice type is the ice stage of development which is similar to WMO ice type definitions representing pretty much the ice thickness. The ship capability is represented by the vessel's ice class that dictates which values for ice types are to be used in calculations.

For strategic planning and for certification historical data from ice charts and satellite ice observations can be used for areas and times when ship is planned to operate in ice. These products are often based on SAR images and resolution can be lower than in actual navigation.

To fulfil the Polar ship Certificate requirements the vessels must use the POLARIS in tactical ice navigation. So, the products used during operation should be near real time and easily available for the operation area. It is the master's responsibility to operate the vessel within its capabilities. Enforcing of this comes from authorities. Flag authority might follow up that vessels operate in suitable conditions. Sometimes, also the port state authorities might monitor that vessel's operations are within set limits. The authorities use typically ice charts and other available ice information to determine ice conditions and POLARIS Risk Index Outcome for the vessel whose position is captured via AIS land stations or AIS satellites.

Another parameter coming from statutory requirements and IMO Polar Code is the operation temperature for the vessel. This is defined based on the concept of mean daily low temperature as described in Section 8.1. The lowest mean daily low temperature (MDLT) is used to define vessels operational limit temperature or Polar Service Temperature (PST) that will set a practical sensible temperature limit for the vessel's operation.

Icing is also an environmental parameter Polar Code uses for setting requirements for the ship and its operations. Icing needs to be considered in the ship stability in case the vessel is intended to operate in areas and times where icing is likely to occur. Icing information can be acquired from weather forecast reports or icing potential can be calculated based on the wind, air temperature and sea water temperature.

Ship classification is not using geoinformation from satellite EO directly now. Some statics, like waves, used in the ship rules, as design parameters can include satellite EO data in combination of other observations and modelling results. Input for ship design is coming from the class rules and not based on current observations of conditions. In the future, class rule development might utilize satellite EO data in determining design parameters.

Flag states or port states might want to utilize the satellite monitoring of vessels more in the future. This is not necessarily geoinformation but observing ships and their emissions using similar instruments as is used for satellite EO like SAR and visible wavelength sensors. Other sensors can be the currently used AIS, ship radar detection from satellites and other novel satellite sensors /34/.

Figure 8-4 shows the user persona for the ship certification business process who represents typical actor in this business process describing needs and frustrations on utilizing geoinformation. This user persona is someone that works in the flag administration and executes statutory requirements for the ships including requirements from different IMO instruments. Table 3 current summarizes the current use and the future needs for geoinformation for the business process. Together these form a summary of business process current use and future needs for geoinformation. Business process geoinformation challenges and associated geoinformation requirements are listed in Table 8-6.

Figure 8-4 User persona named Daniel within the business process Ship Certification working for a flag authority.

Table 8-5 Geoinformation use and future needs for ship certification.

Currently used geoinformation	Parameters	Resolution	Constrains	Future wishes
Ice charts Satellite ice data	Ice stage of development, Ice concentration Icebergs	Monthly averages and weekly averages Daily ice charts As high as available spatial resolution for operation area	Ice charts are not providing consistent ice information. Information on small icebergs and bergy bits are not readily available	New sensors for monitoring ship movements in the Arctic

Table 8-6 Geoinformation challenges and geoinformation requirements for ship certification. Geoinformation needs refer to numbers in Table 9-1

ID	Geoinformation challenge	Geoinformation requirements
SCE-1	Defining operational limit temperature or polar ship temperature for a ship	13

SCE-2	Icing prediction for vessel certification	11, 13, 16, 25
SCE-3	Risk assessment for operations in ice	1, 2, 3
SCE-4	Determining areas where vessel can operate based on ice class in strategic planning using POLARIS	1, 2, 3, 4
SCE-5	Monitoring ship icing conditions during voyage in the polar waters to ensure vessel is operated within its limitations	11, 13, 16, 24, 25
SCE-6	Monitoring ice conditions during voyage in the polar waters to ensure vessel is operated within its limitations	1, 2, 3
SCE-7	Defining design parameters for ship class rules based on long term statistics of environmental conditions	12, 13
SCE-8	Ship emission monitoring	26
SCE-9	Authorities want to monitor ship location and operation	27
SCE-10	Monitoring environmental impact in case of incidents releasing oil and other substances into water	15, 20,

SCE-1 Defining operational limit temperature or polar ship temperature for a ship

Polar Ship Certification requires operational limit temperature to be defined for the ships and this is presented in the Polar Ship Certificate. This can be presented also presented as Polar Service Temperature. Polar Code requires that at least 10 years of observations of temperature is used in defining mean daily low temperature (MDLT) for ships operation area. Operational limit temperature needs to be selected at least 10°C below lowest MDLT for operation season. VE

SCE-2 Icing prediction for vessel certification

Polar Code requires that vessels operating in areas and times where icing is likely to occur have suitable stability under icing loading. Information on icing is needed for defining if icing is a relevant hazard for the vessels where and when it is planning to operate

SCE-3 Risk assessment for operations in ice

Polar Code requires that the ship operating in Other Waters, which is in ice concentrations 10 % or more, needs to use a risk assessment method for defining risk for ice operations. IMO has developed a method called POLARIS to perform the risk assessment. As input ice concentration and stage of development is needed. Alternatively, ice thickness information can be used to define stage of development if that is available. POLARIS can be used in planning of operations or when operating in ice.

SCE-4 Determining areas where vessel can operate based on ice class in strategic planning using POLARIS

POLARIS as described above can be used in the strategic planning to get indications when a vessel with a given ice class can enter certain areas. Input for the calculations can be obtained from ice conditions statistic or historical ice charts-

SCE-5 Monitoring ship icing conditions during voyage in the polar waters to ensure vessel is operated within its limitations

Icing is an important parameter that can affect in ship's stability and safety. Ships that are not intended to operate in icing conditions do not have sufficient stability and need to avoid icing conditions. They need to know when and where the icing is likely to occur to avoid icing. Ships prepared for operations in icing conditions need to be aware of icing and monitor that ice accumulation on the deck does not affect vessel stability negatively.

SCE-6 Monitoring ice conditions during voyage in the polar waters to ensure vessel is operated within its limitations

Ship ice class or lack of it defines in what kind of conditions the vessels is allowed to operate. POLARIS is once again a tool for defining if the risks for ice operations are acceptable. The crew on board need to monitor this but also authorities might be following the ships voyage and checking that the vessels it is operating as they are allowed in ice.

SCE-7 Defining design parameters for ship class rules based on long term statistics of environmental conditions

The class rule development need input for defining design points e.g. for wave conditions. This needs to be based on proper statistics and accurate measurements of wave conditions for different sea areas over long period time.

SCE-8 Ship emission monitoring

Emissions from ships contribute to climate change and local air pollution. In some areas limitation for emissions are set and this trend is likely to continue so authorities need to have tools to monitor emission levels from ships.

SCE-9 Authorities want to monitor ship location and operation

Port authorities might want to monitor vessels who operate in national waters or in countries exclusive economic to ensure they operate within their capabilities and limitations. Similarly, vessel's flag authority or even owner might want to monitor ships operation continuously. Normally, this can be done using satellite that monitor ships' AIS signals. In case of error or if the AIS is turned off intentionally other means to monitor the ship is needed. This can be based on monitoring ships with visual wavelength satellite products, SAR satellite data or using novel instruments on satellites like monitoring of ship's radar signal.

SCE-10 Monitoring environmental impact in case of incidents releasing oil and other substances into water

Sometimes accidents lead to oil spill or release of other substances into sea. In the vast geographical areas in the Arctic only reasonable way of monitoring the spill extend and long-term effects in using satellites to monitor changes.

8.4 Insurance

The Arctic among other areas with frequent sea ice, such as the north-eastern parts of the Baltic Sea are generally outside the coverage area for standard marine insurances. This can be seen in Figure 8-5 which is the coverage map from the Nordic Marine Insurance Plan of 2013, Version 2023.

Figure 8-5 Marine insurance coverage map [19]

The exclusion of such areas is due to the challenges posed by the environment and, in the case of the Arctic, the extra challenges due to the remoteness of the latitudes. While coverage is offered it entails special acceptance from the insurers and generally higher premiums. The Polar Code and POLARIS approach has support in the insurance industry and are being used as tools, despite this it remains a specialist and challenging area to insure.

Insurance industry relies on incidents statistics when setting premiums which provides a challenge for insurers as the dataset for the Arctic is lacking compared to other water areas. It is the hull and machinery insurance that has a leading role in estimating the risk for operation in the Arctic. Protection and Indemnity (P&I) Insurance and cargo insurance rely on their risk assessment when setting premiums. Collecting information on incidents is an important part of the building the statistics. Typical incidents in the Arctic and the Baltic Sea are ice damages in the vessel's hull and machinery leading into need for reparations. Mostly, damages are small but sometimes so extensive that the vessel is lost.

Incident investigation is important in collection data for statistics and in deciding if the consequences of the incident are covered by the insurer. This is an activity typically conducted by external actors hired by the insurance company. For incident investigation ice and weather conditions in the area of an incident are important parameters to map to understand the potential impacting factors. EO can provide information in the Arctic, where other observations are not available, while in the Baltic Sea other sources of information are available to complement EO data. SAR images, wave observations, optical images, AIS data and ship radar detection are relevant parameters for monitoring environmental conditions and the ship's movements. For environmental monitoring of accident consequence parameters related to oil spill detection,

detection of other potentially harmful substances in the water and for monitoring long term the environmental changes in vegetation, fauna and algae blooming can be relevant.

For incident investigation and consequence monitoring the geoinformation can be archived products. The resolution should be as high as possible and relevant parameters include ice thickness, ice concentration, deformed ice, ice edge, ice movement, wave height and direction, wind speed and direction.

With the insurance industry taking on a more active role in the decarbonization of the shipping industry through the Poseidon Principles for Marine Insurance, a hypothetical future EO usage could be spot checking of the carbon intensity of vessels in their portfolio through satellite-based measurements the vessels emissions.

Figure 8-6 shows the user persona for the Insurance business process who represents typical actor in this business process describing needs and frustrations on utilizing geoinformation. Table 8-7 summarizes the current use and the future needs for geoinformation for the business process. Together these form a summary of business process current use and future needs for geoinformation. Business process geoinformation challenges and associated geoinformation requirements are listed in Table 8-8.

Figure 8-6 User persona named Peter within the business process Ship Insurance working for a hull and machinery insurance.

Table 8-7 Geoinformation use and future needs for Ship Insurance

Use case	Currently used geoinformation	Parameters	Resolution	Constrains	Future wishes
Insurance	Not used			Do not know how to utilize EO data in their business.	Understanding how and how fast weather is changing.

Incident investigation	SAR images Visual wavelength images Wave and wind data AIS data	Ice thickness, Ice concentration, Deformed ice, Ice movement, Wave height and direction, Wind speed and direction. AIS Radar detection, oil spill detection.	As high as possible	Cannot know the area of interest ahead in time.	Easy access to available EO products.

Table 8-8 Geoinformation challenges and geoinformation requirements for Ship Insurance. Geoinformation needs refer to numbers in Table 9-1.

ID	Geoinformation challenge	Geoinformation requirements
IN-1	Incident investigation	1,2,3,4,8,9,10,11,12,13,14,15,16,17,18,22,23,26,27
IN-2	Understanding the current and future expected conditions	4,21
IN-3	Ensure compliance of portfolio with Poseidon Principles. (CO2 monitoring)	26
IN-4	Risk evaluating vessels according to POLARIS	1,2,3,4

IN-1 Incident investigation

In the aftermath of an incident the insurance provider may hire external resources to conduct an investigation into the causes of the incident. The use of earth observational data can provide critical insights into the causes by providing detailed information on the environmental conditions leading up to and following the incidents. Data regarding sea ice and weather patterns can be used to identify anomalies or hazards leading up to the event which may have impacted the vessel and crew's behaviour. When used in conjunction with other types of evidence such as AIS and communication logs earth observational data may help to build a more complete picture of the events preceding and following an incident and help resolving insurance claims.

IN-2 Understanding the current and future expected conditions

Understanding the current and future conditions in the Arctic is crucial for marine insurance companies. The region is experiencing significant changes due to climate change and increasing activity which impacts the risks and hazards associated with marine operations. With the lack of statistical incident data found in other waters, satellite data may provide insurance companies with information on the changing ice, sea and climate conditions, which can help to inform risk assessments and mitigation strategies. This information can help insurers to develop more accurate models for predicting risk and to adjust premiums accordingly. By utilizing satellite data, marine insurance companies can better assess the risks associated with operating vessels in the Arctic and provide more effective insurance coverage for their clients.

IN-3 Ensure compliance of portfolio with Poseidon Principles

While not currently identified as a data source in the technical guidance of the Poseidon Principles, earth observational data still has a hypothetical application for insurance companies in monitoring the environmental impact of vessels in their portfolio. Earth observation data such as space-based measurements of carbon dioxide, other greenhouse gases and aerosols could be used to spot-check and verify reported emission and fuel consumption data provided by certain high-risk vessels.

IN-4 Risk evaluating vessels according to POLARIS

With the Polar Operational Limit Assessment Risk Indexing System (POLARIS) gaining traction as a tool withing the insurance industry, earth observational data can support its usage by providing data regarding expected sea ice concentration, its varying thickness, and composition of ice in different stages of development.

8.5 Ship operations

Ship operations is considered to cover planning and execution of the vessel voyage from start to finish including voyage planning and other related support functions before and after the voyage.

Ship operations is a business process that covers wide range of different activities in the Arctic and the Baltic Sea. These range from icebreaker and research vessel operations in ice to expedition cruise and fishing operating at or along the ice edge to cargo vessels operating in ice free waters. Thus, the need of geoinformation varies widely for different operators. For ship operations ice information is the only satellite EO that is directly utilized currently. Other parameters, like weather information is coming from weather forecasts that are based on model heavily relying on satellite EO in the Arctic where other forms of weather observations are scarce.

In this study the ship operations are divided in four use cases depending on their operation in relation to sea ice. Group that is operating most in ice are vessels performing independent navigation ice like icebreakers and research vessels forms the first use case. The second use case includes vessels that operate along or just inside ice edge such as fishing vessels and expedition cruise vessels. Third use case are vessels trying to keep outside of ice or operating in ice under icebreaker assistance. Vessels in this group are typically cargo and tankers that transport cargo from the Arctic, through the Arctic or the Baltic Sea. The fourth use case is the strategic planning that is relevant activity for all shipping and covers the planning needs for all above use cases. Needs and frustrations of these groups are represented by user personas including a user persona for strategic planning which is common activity for all ship operations in the Arctic and the Baltic Sea.

Ice charts are most used ice information source for all parts of ship operations. National ice services provide daily ice charts for ice season but there are some variations on delivery between ice services. Historic ice charts can be used for planning purposes e.g., when operations are planned, and suitable time window is for entering certain location is defined by ice melting. The current ice charts are used typically to follow ice presence in the operation area and the location of the ice edge. They also give some understanding on the harshness of ice conditions for the ships planning operations in ice. Ice charts are based on satellite EO of sea ice supported by other ice observations where available. Typically, one gets ice concentration, some thickness information, potentially floe size and some information on deformed ice like ridges from ice charts. There are huge variations between ice charts on the type of information, level of detail and way of presenting information they provide. Thus, information available for different areas vary. Ice charts are either downloaded by the vessel from ice service websites or uploaded to the vessel by their office on land.

8.5.1 Ships performing independent navigation in ice

Icebreakers and research vessels along with a few cruise vessels are the few operators who navigate independently in ice and perform tactical navigation. Only some cargo vessels and expedition cruise ships operate independently in ice in the Arctic. Most often, they are in assisted by icebreakers who at least define their routes in the Baltic Sea and aid in convoys in the Arctic.

Icebreakers and research vessels along with a few cruise vessels are among the few operators who navigate independently in ice and perform tactical navigation. Only some cargo vessels operate independently in ice in the Arctic.

Most often, they are assisted by icebreakers who at least define their routes in the Baltic Sea and aid in convoys in the Arctic.

Vessels operating independently in ice utilize most up to date geoinformation from the satellite EO to navigate through sea ice. Their goal is to find easiest way through ice and for that they need fresh satellite images for typically from SAR satellites. Crew on board most often want to make their own interpretation of satellite images rather than using ice charts or other products giving interpretation of ice conditions. For their ice operations detailed ice information is a key navigational information. Ice concentration, open water leads, ice floes, ridges and ice thickness information are relevant input for these operations. Most often processed SAR satellite images are provided on board once or twice a day. Spatial resolution can vary from 50 m -250 m resolution depending on the needed areal coverage for the images.

The limitations in utilizing ice information for this group are related to ice data products and getting data on board in suitable format as described in the following. Getting SAR images on board after satellite pass takes time. Receiving data from satellites, processing of data and uploading to the vessel takes all some time and can cause that satellite images are rather old. For tactical navigation as new as possible to find the easiest route through ice. If the delivery chain is too slow ice might have changed or vessel sailed outside of the coverage of the satellite image. Another challenge is that product the operators need in their operations are not readily available and they need to have a service provider in house or externally to get the correct products on board. This is related to lack of actual products when the service provider needs to process products from satellite data either by adding different polarization from the same satellite and by adding information from another satellite to get better description of ice conditions. Service providers are also needed to gather satellite data from different sources due to lack of application programming interface (API) at data providers or to lack of standard APIs. This limit building of automated routines for providing satellite data to vessels. Another limiting factor is the bandwidth in high latitudes. Data products need to be packaged for sending, limited in areal coverage and resolution to allow transfer via limited data pipeline via satellites.

In the future, these vessels would like more accurate ice information in the form of SAR images utilizing more than one polarization from SAR satellites or combined products with information of various satellites utilizing different frequencies. Other wishes for the future are ice drift, compression and divergence products and forecasts that would provide essential information for navigation in ice. Also, improved satellite data coverage is in the wish list for operators in high latitudes.

Figure 8-7 show the user persona for the ship operation business process who represent operators who operate independently in sea ice. This person utilizes the most up to date satellite information on sea ice. Often interpreted products and when available satellite images from SAR and optical wavelength sensor.

Figure 8-7 User persona named Jan within the business process Ship Operations working onboard a research vessel.

8.5.2 Ships operating along or inside ice edge

Cruise ships and fishing vessels among other ships that operate along or just inside the ice edge form another kind of group that has different need for ice information. They are not navigating in ice but entering the marginal ice zone or keeping just outside of ice to observe ice and to fish. They need information on the location of the ice edge in good precision and frequently updated. Also, ice drift forecast can be useful for this user group to give indication when and where ice is going along the ice edge. Other operations utilize less detailed ice information typically from ice charts and ice edge information. This also includes vessels operating in the wintertime in the Baltic Sea who operate under supervision of icebreakers. E.g., fishing relies on ice edge information since they try to operate close to ice edge. Ice edge information and ice chart also sufficient for vessels that try to avoid operations in ice. Typically, these are cargo ships and tankers.

In the future, ice drift forecasts including information on changes for the ice edge will be useful for the vessels operating along the ice edge. Also, getting easier access to data products on board the vessel especially using automated data gathering from data providers could be useful for this use case.

Figure 8-8 show the user persona for the ship operations business process for use case operations along or just inside ice edge. For him information on the ice edge and ice edge movements are of interest when he tries to avoid getting in ice with fishing equipment out.

Figure 8-8 User persona named Oscar within the business process Ship Operations working onboard a fishing vessel who operates along the ice edge.

8.5.3 Ships that operate outside of sea ice or in ice with icebreaker assistance

Third use case is the vessels that try to operate outside of sea ice or operate in ice with icebreaker assistance. These vessels are typically cargo ships and tankers who operate in the Arctic in the summer season as well as ships who operate in the Baltic Sea in the winter season. These vessels need to know where ice is present and how ice conditions change. When operating in ice in both Arctic and the Baltic Sea these vessels typically do not perform independent navigation and are steered by icebreakers to find their way through ice. Icebreakers in the Baltic Sea provide ships a route in a form of way points to follow so that they keep collected in the area for assistance and operate in easier ice conditions. Close assistance is more common in the Baltic Sea and convoy operations in the Arctic. Ice charts and ice edge data provide detailed enough ice information for this use case for most operations. Especially, for those who keep away from sea ice and operate in ice free conditions.

Sea bottom surveys, fairway maintenance and other similar operations who spend longer periods in the limited area might want utilized weather information from satellites including wind and wave data, snow showers and local storms. This might provide more accurate information in areas where weather models have their challenges.

Search and rescue activities are heavily dependent on accurate and timely information on environmental conditions when in case of incident. Most search and rescue assets are only capable for operation in ice free waters or in light ice conditions. They need information on ice conditions in the operation area to avoid getting in too rough conditions. Thus, their operations like with respect to ice than other vessels described in this section. Only icebreakers and other similar vessels with high capability for operations in ice can perform search and rescue activities in ice. They operate like vessel described in section 8.5.1 and need similar geoinformation for their operations. Other geoinformation important for search and rescue operations are temperature, waves and wind together with icing information. Air assets are important part of search and rescue operations and rely on accurate meteorological information. For search and rescue and monitoring of operations AIS data and radar detection are relevant parameters to form a view on vessels in the area of incident.

In the future, ice drift forecasts including information on compressive, and divergence of ice field can help navigation in ice by providing information for the vessel to avoid challenging compressive ice field conditions are useful also for winter operations in the Baltic Sea. This will make directing of the traffic for icebreakers easier.

Figure 8-9 shows the user persona Paul for the ship operations business process who represent cargo ship operations in ice. His interest is to avoid sea is when possible and eventually find a route through easiest ice conditions.

Paul

"Non-free products are often underutilized due to both their purchase costs and the fact that free products are frequently of comparable quality."

ABOUT:

Age: 62 years
Location: Riga, Latvia
Role: Navigator cargo vessel
Business process: Ship operations

DO YOU CURRENTLY USE EO DATA IN YOUR BUSINESS?

☑ Yes
☐ No

WANTS AND NEEDS:

- Information on ice conditions are in form of ice charts and ice edge
- Daily ice information is useful for the operations
- Ice information at conning station

FRUSTRATIONS:

- Not straight forward to get ice information in format suited for the conning station
- Ice charts are not available daily and have varying level of detail on ice conditions

Figure 8-9 User persona named Paul within the business process Ship Operations working onboard a cargo vessel who operates in the Baltic Sea in the wintertime and in the Arctic during summer season.

8.5.4 Strategic planning

The fourth use case strategic planning of ship operations is essential part for all operations in the Arctic and the Baltic Sea since ice limits operation times. In the Arctic summer operations times when ice starts to melt from the operation area to allow vessels to enter intended locations is important information. For example, cruise industry and other shipping operating outside of sea ice needs to plan itineraries using historical ice information to find as long operating season length. Especially, shoulder seasons and their variability important periods that define when it is safe to plan operations with limited capacity to operate in ice. Earliest departures are of interest for cruise vessels since they want to operate in times and areas where day light, sea mammals and birds are present in the Arctic. Other operators want to utilize the summer season length to its full extend. Ice typically has largest extend in April and the least ice is present in September in the Arctic and operations need to be planned to allow access to destinations. Similarly, in the Baltic Sea operations need to be planned for different cargo vessels such that vessels have suitable ice class for intended operation season.

For the planning purposes good quality geoinformation is essential. Long term statistics on various parameters in vessel's intended operations area is needed to get correct view on season length and expected conditions. For strategic planning the geoinformation can be archived products covering 5 to 10 years history for the vessels intended operational area. Often also a shorter set of historical ice conditions for 3-4 years for the shoulder season are used to see the latest variability of conditions. The spatial resolution can vary from medium to high depending of available information and relevant parameters include ice concentration and stage of development or alternatively ice thickness and ice type and air temperature. The need for air temperature data is similar to the ship design since the Polar Code requires that the vessels is operated within its capabilities. To get hold of the MDLT the operator either need to calculate it from weather statistics which requires special skills typically not available in a shipping company or use external service provider to the calculations.

Typical information sources are ice charts and processed SAR data for wanted period and location. Typically need for information can be for a whole Arctic and temporal resolution can vary from monthly, weekly or daily depending on availability. In the Baltic Sea, ice charts that provide detailed information over longer period are mostly used for planning.

Industry wants to use freely available satellite EO since that is easier to get access to and provides good enough data for planning purposes.

Challenges for using geoinformation from EO related to data availability in archives for certain time and areas. Data is not easily accessible and various data sources need to be used to get the needed information. Also, level of detail on information varies and combining information from various sources can be challenging. For some areas ice information is not available for long periods in a single dataset and combining several data sets to form a longer history can be challenging and beyond capabilities of the available at the shipping company. Also, spatial statistics of ice conditions over longer period are not readily or at least not easily available. Difficulties for accessing suitable data leads the shipping companies to use service providers that are not that many in the market. Using external provider adds on cost. Similarly as the commercial data products that seem to be too costly for the most operations.

In the future the strategic planning would like to see more readily available ice information product and spatial statistics products, with higher spatial resolution than is available today. Also, as for the ship design the chartering departments in shipping companies need more information on available geo information products since they struggle to find available information themselves. More readily free satellite products are in the wish list for the industry.

Figure 8-10 shows the user persona Olivia for the ship operations business process who represent strategic planning needs for the industry. For her looking at historic conditions in the operation area and drawing conclusions when and where each vessel can operate are essential part of daily work.

Figure 8-10 User persona named Olivia within the business process Ship Operations working in chartering department of a cruise line company.

Table 8-9 summarizes the current use and the future needs for geoinformation for ship operations. Business process geoinformation challenges and associated geoinformation requirements are listed in Table 8-10

Table 8-9 Geoinformation use and future needs for ship operations.

Use case	Currently used geoinformation	Parameters	Resolution	Constrains	Future wishes
Independent navigation in ice	Ice chart SAR images	Ice concentration Leads Ice thickness Deformed ice / ridges	Once or twice-a-day 50-200 m resolution Swath of tens or hundreds of nautical miles	Getting SAR images on board after satellite pass takes time Need to have a service provider to get the correct products on board Bandwidth in high latitudes	SAR images utilizing more than one polarization Ice drift, compression and divergence products and forecasts
Operations along or just inside the ice edge	Ice charts Ice edge charts SAR images	Ice concentration Ice thickness	Once or twice-a-day Ice charts similar to SAR images 50-200 m Ice edge 1 km or more	Ice charts not always updated daily Challenges for getting ice data in format suited for navigation system.	Ice drift forecast Higher resolution on ice edge data
Operations outside of ice or convoy operations	Ice charts Ice edge charts	Ice concentration Ice stage of development Ice edge location	Once or twice-a-day Ice charts similar to SAR images 50-200 m Ice edge 1 km or more	Ice charts not available for all locations in the Arctic Ice charts have varying level of detail	Ice drift forecast Higher resolution on ice edge data
Strategic planning	Ice charts Processed SAR images	Ice concentration Ice stage of development	Weekly or daily ice charts Resolution of available ice charts Whole Arctic	No data available in archives for certain time and areas No easy access to data Limited processed products readily available	Higher spatial resolution than today Processed long term statistics of ice conditions

Table 8-10 Geoinformation challenges and associated geoinformation requirements for ship operations. Geoinformation needs refer to numbers in Table 9-1

ID	Geoinformation challenge	Geoinformation requirement
SO-1	Navigating through ice	1, 2, 3, 5, 6, 7, 8, 9, 18, 22,23,24,
SO-2	Avoiding ice edge	8
SO-3	Navigating along (or just inside) the ice edge	1,7,8,11,12,14,17,18,
SO-4	Avoiding ship icing conditions	11,12,13,16,24
SO-5	Avoiding sea ice	7,8,14,18
SO-6	Oil spill monitoring	11,12,15,17
SO-7	Avoiding snow cover on ice	24
SO-8	Strategic planning	1, 4,8,14,
SO-9	Risk analysis according to POLARIS	1, 2, 3, 4
SO-10	Search and rescue operations	1, 2, 3, 5, 6, 8, 11, 12, 13, 14, 18, 24
SO-11	Monitoring vessels without AIS transponder	27
SO-12	Navigating waters with poor charting	28

SO-1 Navigating through ice

Independent tactical navigation through ice requires a wide range of near-real time information regarding the current ice and sea conditions to assist crew. The ability to identify ice features which may either hamper (ice ridges, ice rafting, snow on ice) or assist (leads, polynyas) the vessels ability to traverse the sea ice is of great importance both from a safety and efficiency point of view. Weather and ice drift forecasts are necessary to avoid entrapment within the ice due to unforeseen ice movements.

SO-2 Avoiding ice edge

The location of the ice edge is of great importance for ships which are not designed for ice operations or are limited to predominantly open waters. Daily ice chart updates in conjugation with accurate ice-drift forecasts would aid such vessels from exceeding their operational design conditions and ensure safe operation.

SO-3 Navigating along (or just inside) the ice edge

For vessels such as cruise ships or fishing vessels that may seek to operate in proximity or just inside the ice edge, may require data of higher spatial resolution then that provided by daily ice charts as limited tactical navigation may be required. Likewise, an accurate ice drift forecast may aid the vessel's crew for avoiding entrapment in ice.

SO-4 Avoiding icing conditions

Marine icing is the accumulation of ice on a vessel's hull, superstructure, and equipment either due to sea spray, atmospheric conditions, or a combination of the two. This ice build-up adds additional weight to a vessel and can affects a vessel's stability, fuel efficiency and manoeuvrability. For vessels vulnerable to marine icing, avoidance may be necessary and may be facilitated using earth observational data.

SO-5 Avoiding Sea ice

For vessels limited to operation in open waters, satellite data can be used to detect the presence of sea ice, ice bergs and bergy bits.

SO-6 Oil spill monitoring

Earth observational data, especially satellite imagery, can be used for monitoring ships to detect potential oil spills as well as tracking oil slicks after a spill has occurred. Both cases may reduce the consequences of a spill by identifying an ongoing oil spill early and by tracking and predicting its movements.

SO-7 Avoiding snow cover on ice

The presence of snow on sea ice may adversely increase the resistance of a vessel moving through sea ice as well as reducing manoeuvrability and decreasing its icebreaking capability. Additionally, the presence of snow on sea ice can affect the accuracy of certain other earth observational sea ice parameters. By avoiding areas with snow cover vessels may reduce the uncertainty in the expected conditions and improve the vessels efficiency.

SO-8 Strategic planning

As discussed in chapter 8.5.4, by utilizing historical earth observational data and long-term statistics covering meteorological, oceanographical and sea ice parameters Arctic and Baltic operators may better plan their operation ahead of time both to reduce their operational risk and maximize their operational period with within their risk acceptance criteria.

SO-9 Risk analysis according to POLARIS

Operators may use the Polar Operational Limit Assessment Risk Indexing System (POLARIS) to help in their operational decision making, both on the tactical and strategical level. Earth observational data can support this action by either providing data regarding expected sea ice concentration, its varying thickness, and composition of ice in different stages of development or by products which automatically calculating a vessels Risk Index Outcome, based on the vessel type and observed conditions.

SO-10 Search and rescue operations

Earth observational data may provide valuable data in the event of search and rescue operations in the Arctic outside of tactical navigation which was covered in SO-1. Earth observational data may be used in tracking the location and movements of ships in need of assistance as well as the locations and movements of ice floes potentially containing evacuated people.

SO-11 Monitoring vessels without AIS transponder

Certain vessels for various reasons either lacks or turns of their AIS transponders for prolonged periods of time. Earth observational data could be used for tracking such vessels.

SO-12 Navigating waters with poor charting

Large areas of the Arctic are not mapped to modern standards and represents a navigational risk to mariners. Earth observational data could be used to detect recent changes caused by shore erosion and sediment transportation (expansion of shallows).

8.6 End of life vessel disposal

We consider end of life vessel disposal to include vessel scrapping and recycling, disregarding salvage operation after shipwrecks and disposal of small recreational crafts. According to 9th edition of the European list of ship recycling facilities [13] there are currently no ship recycling facilities in the Arctic. While some ship recycling facilities exists in the Baltic Sea, the analysis done in chapter 7.4 based on the NGO Shipbreaking Platform's Annual List of Ship Scrapped [14] shows that there are very few vessels being recycled there. Making up only 0.43% of the total gross tonnage (GT) scrapped in 2022 if including facilities on the eastern parts of Denmark and approximately 0% if the Danish straits are not considered. Based on our interview and internal discussions with DNV experts, there is little interest from the ship recycling industry to utilize EO data, due to their perceived lack of application areas. Weather forecasts are sufficient to plan their activities, and in-situ measurements and inspections are used to document the environmental impact of the facility.

Potential EO application pertaining to monitoring of facilities and vessel in transit to these facilities using EO were identified through brainstorming. EO images could be utilized by governmental or regulatory bodies to monitor or inspect for environmental consequences related to the activities. Such as oil spills, release of other harmful substances in the water, change in vegetation or algae blooming, either during the vessels final voyage or of the recycling facility. This could be done through high resolution optical images or SAR images.

Figure 8-11 shows the used persona for the end-of-life vessel disposal business process. Stakeholder Yuliya has very little experience in using geoinformation in her daily work. Thought, she is interested to find out how geoinformation and satellite EO could benefit her line of business. Table 8-11 summarizes the current use and the future needs for geoinformation and Table 8-12 lists the business process geoinformation challenges and associated geoinformation requirements.

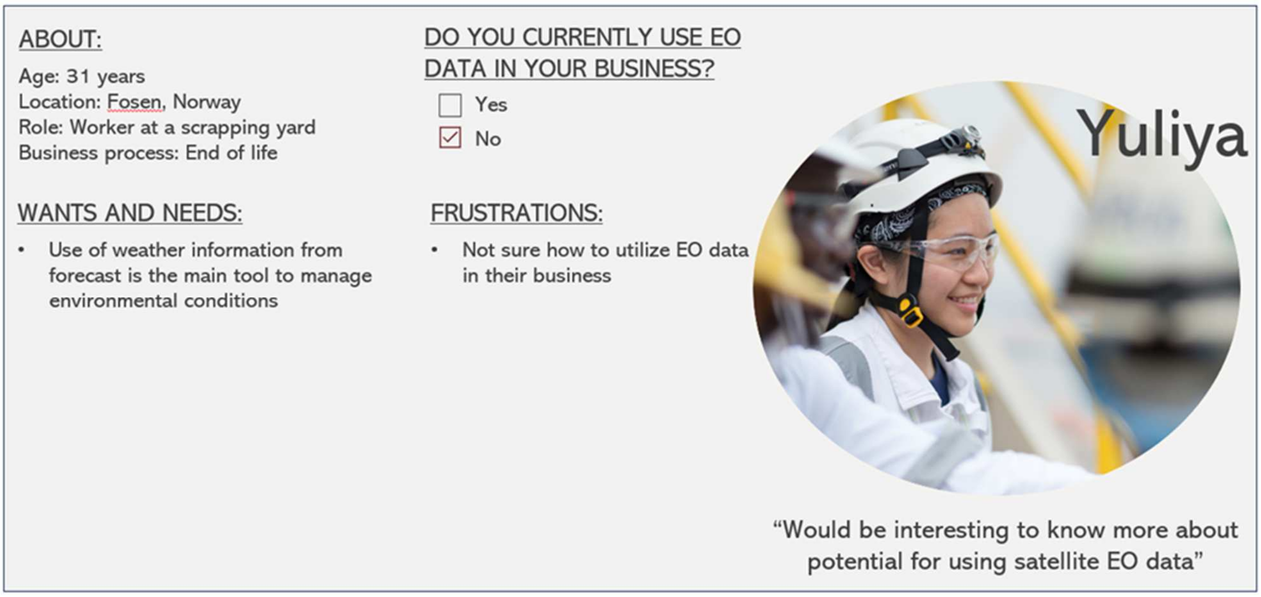


Figure 8-11 User persona named Yuliya within the business process end-of-life disposal working for a scrapping yard in Norway.

Table 8-11 Geoinformation use and future needs for End-of-life vessel disposal

Currently used geoinformation	Parameters	Resolution	Constrains	Future wishes
Weather forecasts	Wind Rain	Daily forecasts	Do not know how to utilize EO data in their business	To better understand possibilities for utilizing satellite EO data

Table 8-12 Geoinformation challenges and geoinformation requirements for End-of-life vessel disposal. Geoinformation needs refer to numbers in Table 9-1

ID	Geoinformation challenge	Geoinformation requirements
ELD-1	Weather condition monitoring	10, 11, 12
ELD-2	Environmental impact monitoring of operations impact to local nature	15, 19, 20, 26
ELD-3	Authorities want to monitor ships on their way for scrapping	28

ELD-1 Weather condition monitoring

Transportation of the vessel, as well as a few activities at the ship recycling facility require favourable weather conditions.

ELD-2 Environmental impact monitoring of operations impact to local nature

Ship recycling facility operators are required to monitor their impact on the local environment. By using earth observational data oil spills, algae blooming, and air emissions could be monitored. Using historical images over the facility and its surrounding area long term changes to the environment could be documented.

ELD-3 Authorities want to monitor ships on their way for scrapping

EU and other parts of the world have strict regulations on how and where ships end of life disposal can be performed. Sometimes vessels try to escape the established end of life disposal schemes. Authorities might want to monitor vessels who they know are on the way for scrapping to ensure safe and sustainable end of life disposal. Normally, this can be done using satellite that monitor ships' AIS signals. In case of error or if the AIS is turned off intentionally other means to monitor the ship is needed. This can be based on monitoring ships with optical sensors and , SAR sensors or using novel instruments on satellites like monitoring of ship's radar signal.

9 GEOINFORMATION REQUIREMENTS

Geoinformation challenges described in Chapter 8 for the business processes are associated with geo-information requirements that provide necessary information for responding to the challenges. A summary of geoinformation requirements for shipping in the Arctic and the Baltic Sea is presented in this chapter. Recognized geoinformation needs are collected from findings in the literature survey, stakeholder workshop and stakeholder interviews. Table 9-1 list the geoinformation requirements that are relevant for providing information to tackle business process challenges. Description of the geoinformation requirements is given under the table.

Business process challenge listed in Chapter 8 are linked geoinformation requirements presented as reference in tables describing the challenges e.g. in Table 8-4. The geoinformation requirements' ID numbers refer to the IDs as presented in Table 9-1

Table 9-1 Geoinformation requirements

ID	Geoinformation requirement
1	Ice concentration information
2	Ice thickness information
3	Ice stage of development information
4	Long term ice condition statistic
5	Find leads in ice
6	Find polynyas in ice
7	Forecast ice drift
8	Ice edge information
9	Information on ice field compression and divergence
10	Identify ice ridges and deformed ice
11	Wind speed and direction monitoring
12	Wave height and direction monitoring
13	Air temperature
14	Iceberg and bergy bit information
15	Oil spill detection
16	Icing conditions detection
17	Sea current monitoring
18	Ice drift monitoring
19	Change in vegetation

20	Algae blooming monitoring
21	Ice season length
22	Fast ice information
23	Snow on ice information
24	Icing forecasting
25	Sea surface temperature
26	Emissions to air
27	AIS, radar signal and other instruments suited for ship detection and monitoring
28	Monitoring of shore changes, shore erosion and sediment deposits

1 Ice concentration information

The ice concentration is here understood to mean the fraction of ice coverage over a certain area of ocean. Ice information may be acquired by satellites through various ways such as visual wavelength imagery, SAR imagery, measurement of thermal microwave radiation and satellite altimetry. Required temporal and spatial resolution will change depending on the challenge the information is addressing.

2 Ice thickness information

The sea ice thickness refers to the combined draft and freeboard of the sea ice. Draft being the depth of sea ice below the ocean surface and freeboard being the depth of ice above the waterline. The exact fraction between drat and freeboard of ice depends on the buoyancy of the waters the ice is located but on average $1/9^{th}$ of the sea ice is above the waterline and $8/9^{th}$ below. Combined with the sea ice concentration the total ice volume in an area may be estimated.

3 Ice stage of development information

Sea ice goes through several stages of development from it is initially formed until it melts, these stages have different physical properties which can be of interest for operators in Arctic waters. For example, the salinity of sea ice decreases over time which again increases its hardness. Meaning that multi-year ice of a certain thickness is expected to pose a larger navigational obstacle then first year ice of the equivalent thickness.

4 Long term ice condition statistic

A historical archive over previous sea ice parameters and statistics has uses for a wide range of operators in the Arctic. The temporal length of the archive and details change with user.

5 Find leads in ice

Ice leads are fractures, or fissures in a sea ice cover forming channels of open water between sea ice floes. They may form due to movements in the ice caused by wind and ocean currents which can push and break apart the ice coverage. The channels and openings can range in size from a few meters to kilometres and may connect two bodies of open water, connect to the shore, or be a blind lead which is closed off

6 Find polynyas in ice

Polynyas are large semipermanent areas if open water surrounded by ice in areas where open water of such size is not climatologically expected to occur. They are yet not completely understood but are believed to be of two types. Coastal polynyas which are located near land fast ice and caused by local wind patterns or open-ocean polynyas which are larger and believed to be caused by upwelling of warm water from the water column. Polynyas range in size from 10s to 100s of kilometres [20].

7 Forecast ice drift

The ability to predict the drift of sea ice has uses both for vessels trying to avoid encountering sea ice as vessels operating inside the ice edge seeking to avoid getting trapped inside the ice by closing leads, bottlenecks, or an adverse change of ice conditions.

8 Ice edge information

The ice edge is the boundary between open water and sea ice, be it land fast or not. It is an ecosystem with increased activity compared to other parts of the Arctic and is of interest for a wide range of operators seeking to avoid it, operate along it, or enter it.

9 Information on ice field compression and divergence

Compression and divergence in the ice field can lead to increased and decreased ice pressure along the hull of a vessel operating inside an ice field. Sufficiently high pressures may reduce the navigational ability of a vessel or entirely halt it.

10 Identify ice ridges and deformed ice

Ice ridges and areas of deformed ice such as ice rafting are caused by colliding ice floes. The resulting features can have a significantly increased thickness compared to the surrounding ice and serve as a navigational hazard to vessels traversing the area.

11 Wind speed and direction monitoring

Wind and weather models may not always be accurate particularly at capturing effects from local geography. Monitoring of wind conditions using earth observational services can supplement wind and weather models and give vessels increased confidence in current conditions at critical areas.

12 Wave height and direction monitoring

Wave and weather models may not always be accurate particularly at capturing effects from local geography or ice conditions. Monitoring of wave conditions using earth observational services can supplement wave and weather models and give vessels increased confidence in the current conditions at critical areas.

13 Air temperature

Earth observational data can be used in conjunction with weather models to reduce the risk of inaccurate temperature data.

14 Iceberg and bergy bit information

Icebergs and bergy bits are pieces of glacial ice that forms when glaciers calve into the ocean or by the breakup of already existing icebergs. Bergy bits together with growlers are smaller pieces of glacial ice and are usually classified to be in the size of less than 5 meters. Glacial ice consists of fresh water and is very dense and as such can damage vessels encountering them. Icebergs and bergy bits can be transported long distances from the originating glacier. Locational information of iceberg and bergy bits, both in open waters and as inclusions in sea ice, can be used by mariners to avoid them.

15 Oil spill detection and monitoring

Earth observational data can be used both to detect an occurring oil spill as well as monitor and track the movement of the oil slick, aiding response teams in minimizing the environmental damage caused by the incident.

16 Icing conditions detection

Marine icing can be divided into two main categories based on the origin of the ice. Sea spray icing and atmospheric icing. As the ice forms on the hull, superstructure, and equipment of a vessel it can add significant weight and may reduce the vessels stability, safety, and navigational properties. Early detection of icing conditions by earth observational data can assist vessels, especially those poorly suited to deal with icing, to take appropriate risk reducing measures.

17 Sea current monitoring

Monitoring of sea currents can provide operators and scientist data over large areas of the ocean and enable the study of changes and variability in the currents. Accurate and updated information of sea currents may have applications for operational marine activities, navigational safety and as input for climate models and scientific research.

18 Ice drift monitoring

Similar to ice drift forecast, continuous ice drift monitoring may aid vessels seeking to avoid sea ice as well as aid vessels operating inside the ice edge to avoid getting trapped by drifting ice. Monitoring of ice drift may provide warning to vessels when real-life drifting conditions deviates from the drift forecasts.

19 Change in vegetation

Long term satellite imagery may reveal changes to an areas vegetation and can be used as a tool for environmental monitoring.

20 Algae blooming monitoring

Algae blooming can be, among other factors, be caused by the introduction of nutritional pollution. Monitoring for algae blooms could be beneficial to identify developing environmental hazards.

21 Ice season length

The length of the ice season provides opportunities and restrictions for operators in the cold climates. Accurate historical data, and forecasts of further seasons may assist operators in strategic, long-term planning and researchers studying the climatology of the region.

22 Fast ice information

In comparison to sea ice, fast ice is anchored to the shoreline making it stationary, more stable, and generally thicker than sea ice. Information regarding the location and properties of fast ice may be useful to vessels, allowing them to plan for the changing ice condition and take appropriate risk reducing measures.

23 Snow on ice information

Snow on sea ice adversely increase the resistance of a vessel moving through sea ice as well as reducing manoeuvrability and decreasing its icebreaking capability. Additionally, the presence of snow on sea ice affects the measurement accuracy of certain earth observational services. Information regarding the presence and extent of snow in sea ice may be valuable to vessels operating in ice be reducing the uncertainty in the expected conditions and improve the vessels efficiency.

24 Icing forecasting

Forecast of marine icing condition could assist vessels in route planning, avoidance or give the crew time to plan appropriate risk reducing measures and prepare for the icing conditions.

25 Sea surface temperature

Information regarding the temperature of the sea surface may be indicative of sea ice formation, biological activity and future weather patterns.

26 Emissions to air

Environmental monitoring of air emissions from vessels such as CO_2, greenhouse gases, aerosols and particulates could be of interest for ship owners, insurance companies, flag and port states, and other stakeholders such as non-governmental organizations.

27 AIS, radar signal and other instruments suited for ship detection and monitoring

The ability to detect, monitor and track ships has several benefits such as improved maritime safety, security, optimization of operations, and environmental management. AIS data is a major source for such data, however some vessels either lack or disables their AIS transceivers for prolonged periods of time due to the nature of their activities. Detection and monitoring of such vessels could be done by earth observational either through radar signals or other means.

28 Monitoring of shore changes, shore erosion and sediment deposits

Large parts of the Arctic are still not mapped to modern standards, with certain areas using survey data dating back to the 1800s. Monitoring and mapping of areas experiencing rapid changes due to erosion and sediment deposits might improve navigational safety.

9.1 Challenge specific details for geoinformation

During the process of collecting geoinformation requirements for the business process challenges more detailed information was found on the current use and the future wishes for geoinformation quality. This information came from interviews, surveys, the workshop, and the literature survey. Since this information was available it was found that this detailed information is useful input for the following activities in other work packages of this project. This collection also highlights the fact that the requirements for the same geoinformation in spatial and temporal variation can differ significantly depending on what kind of business challenge the geoinformation is connected to. The Table 9-3 describes the details for geoinformation for different challenges defined in Section 8. Note that the information on resolutions is not complete for all geoinformation requirements since it was not available or not known for all. This table was filled in as well as practicable possible to highlight the details where they were available.

Table 9-2 Challenge specific details for geoinformation.

ID	Geoinformation requirement		Spatial resolution	Temporal resolution	Future spatial resolution	Future temporal resolution	Source of information
1	Ice concentration						
1.1	SD-1	Environmental conditions in vessels intended operation area		Weekly, monthly		Daily, Weekly	
1.2	SD-2	Defining ice class for vessel intended to operate in in ice	25 km x 25 km	Monthly	<25 km x 25 km	Weekly or Monthly	Ice observations from SAR satellite
1.3	SD-3	Vessel concept, main dimensions, and hull form selection in early design	25 km x 25 km	Monthly	<25 km x 25 km	Weekly or Monthly	Ice observations from SAR satellite
1.4	SC-3	Planning sea ice trials outside of ice season	50-100 m	Daily, Weekly	50-100 m	Daily or twice-a-day	Ice charts, ice data from e.g. USNIC
1.5	SC-4	Avoiding sea ice during sea trials	50-100 m	Daily (requirement)	50-100 m	Daily or twice-a-day	
1.6	SC-5	Planning of sea ice trials	50-100 m	Daily, Weekly	50-100 m	Daily or twice-a-day	Ice charts, ice observations from satellites

1.7	SC-6	Finding suitable ice conditions for testing vessel's capabilities during sea ice trials	50-100 m	Daily	50-100 m	Daily or twice-a-day	
1.8	SC-7	Ship operation in ice during sea ice trials	50-100 m	Daily	50-100 m	Daily or twice-a-day	
1.9	SCE-3	Risk assessment for operations in ice		Weekly			Ice charts, ice data from e.g. USNIC
1.10	SCE-4	Determining areas where vessel can operate based on ice class in strategic planning using POLARIS		Daily, weekly			Ice charts, ice data from e.g. USNIC
1.11	SCE-6	Monitoring ice conditions during voyage in the polar waters to ensure vessel is operated within its limitations		Daily, weekly			Ice charts, ice data from e.g. USNIC
1.12	IN-1	Incident investigation		Weekly		Daily or twice-a-day	All available ice observations from satellites
1.13	IN-4	Risk evaluating vessels according to POLARIS		Daily, weekly			Ice charts, ice data from e.g. USNIC
1.14	SO-1	Navigating through ice	less than 100m (requirement)	Daily (requirement)	50-100 m	Daily or twice-a-day	Ice charts, ice data from e.g. USNIC
1.15	SO-3	Navigating along (or just inside) the ice edge	less than 100m (requirement)	Daily (requirement)	50-100 m	Daily or twice-a-day	
1.16	SO-8	Strategic planning					
1.17	SO-9	Risk analysis according to POLARIS		Daily, weekly		Daily or twice-a-day	Ice charts, ice data from e.g. USNIC
1.18	SO-10	Search and rescue operations	50-100 m	Daily	50-100 m	Daily or twice-a-day	Ice observations from SAR satellite
2	Ice thickness						
	SD-1	Environmental conditions in vessels intended operation area		Weekly, monthly		Daily, Weekly	Ice charts, ice data from e.g. USNIC
	SD-2	Defining ice class for vessel intended to operate in in ice	25 km x 25 km	Monthly	<25 km x 25 km	Weekly or Monthly	Ice observations from SAR satellite
	SD-3	Vessel concept, main dimensions, and hull form selection in early design	25 km x 25 km	Monthly	<25 km x 25 km	Weekly or Monthly	Ice observations from SAR satellite
	SC-5	Planning of sea ice trials		Daily, weekly			Ice charts, ice data from e.g. USNIC
	SC-6	Finding suitable ice conditions for testing vessel's capabilities during sea ice trials	50-100 m	Daily	50-100 m	Daily or twice-a-day	
	SC-7	Ship operation in ice during sea ice trials	50-100 m	Daily	50-100 m	Daily or twice-a-day	
	SCE-3	Risk assessment for operations in ice		Weekly			
	SCE-4	Determining areas where vessel can operate based on ice class in strategic planning using POLARIS		Daily, weekly		Daily, weekly	Ice charts, ice data from e.g. USNIC

	SCE-6	Monitoring ice conditions during voyage in the polar waters to ensure vessel is operated within its limitations		Daily, weekly		Daily, weekly	Ice charts, ice data from e.g. USNIC, visual observations
	IN-1	Incident investigation		Weekly		Daily or twice-a-day	All available ice observations from satellites
	IN-4	Risk evaluating vessels according to POLARIS		Daily, weekly			Ice charts, ice data from e.g. USNIC
	SO-1	Navigating through ice	less than 100m (requirement)	Daily (requirement)	50-100 m	Daily or twice-a-day	Ice charts, ice data from e.g. USNIC
	SO-9	Risk analysis according to POLARIS		Daily, weekly		Daily or twice-a-day	Ice charts, ice data from e.g. USNIC
	SO-10	Search and rescue operations	50-100 m	Daily	50-100 m	Daily or twice-a-day	Ice observations from SAR satellite
3	Ice stage of development						
	SD-1	Environmental conditions in vessels intended operation area		Daily		Daily or twice-a-day	
	SD-2	Defining ice class for vessel intended to operate in in ice		Daily, weekly		Daily, weekly	
	SD-3	Vessel concept, main dimensions, and hull form selection in early design		Weekly, monthly		Weekly, monthly	
	SC-5	Planning of sea ice trials		Daily, weekly		Daily, weekly	
	SC-6	Finding suitable ice conditions for testing vessel's capabilities during sea ice trials	50-100 m	Daily	50-100 m	Daily or twice-a-day	SAR images, ice charts
	SC-7	Ship operation in ice during sea ice trials	50-100 m	Daily	50-100 m	Daily or twice-a-day	SAR images, ice charts
	SCE-3	Risk assessment for operations in ice		Daily, weekly		Daily, weekly	
	SCE-4	Determining areas where vessel can operate based on ice class in strategic planning using POLARIS		Daily, weekly		Daily, weekly	
	SCE-6	Monitoring ice conditions during voyage in the polar waters to ensure vessel is operated within its limitations		Daily, weekly		Daily or twice-a-day	
	IN-1	Incident investigation		Weekly		Daily or twice-a-day	All available ice observations from satellites
	IN-4	Risk evaluating vessels according to POLARIS		Weekly		Daily or twice-a-day	All available ice observations from satellites
	SO-1	Navigating through ice	less than 100m (requirement)	Daily	50-100 m	Daily or twice-a-day	Ice charts,
	SO-9	Risk analysis according to POLARIS		Daily, weekly		Daily or twice-a-day	Ice charts, ice data from e.g. USNIC
	SO-10	Search and rescue operations	50-100 m	Daily	50-100 m	Daily or twice-a-day	Ice observations from SAR satellite

4	Long term ice condition statistics						
	SD-1	Environmental conditions in vessels intended operation area		Daily		Daily or twice-a-day	
	SD-2	Defining ice class for vessel intended to operate in in ice		Daily, weekly		Daily, weekly	
	SD-3	Vessel concept, main dimensions, and hull form selection in early design		Weekly, monthly		Weekly, monthly	
	SC-3	Planning sea ice trials outside of ice season	50-100 m	Daily	50-100 m	Daily or twice-a-day	SAR images, ice charts
	SC-5	Planning of sea ice trials	50-100 m	Daily	50-100 m	Daily or twice-a-day	SAR images, ice charts
	SCE-4	Determining areas where vessel can operate based on ice class in strategic planning using POLARIS		Daily, weekly		Daily, weekly	
	IN-1	Incident investigation					
	IN-2	Understanding the current and future expected conditions					
	IN-4	Risk evaluating vessels according to POLARIS		Daily, weekly		Daily, weekly	
	SO-8	Strategic planning		Weekly		Weekly	
	SO-9	Risk analysis according to POLARIS		Daily, weekly		Daily or twice-a-day	
5	Find leads in ice						
	SO-1	Navigating through ice		Daily		Twice-a-day, near real time	
	SO-10	Search and rescue operations		Daily		Twice-a-day, near real time	
6	Find polynyas in ice						
	SO-1	Navigating through ice		Daily		Twice-a-day, near real time	
	SO-10	Search and rescue operations		Daily		Twice-a-day, near real time	
7	Forecast ice drift						
	SC-6	Finding suitable ice conditions for testing vessel's capabilities during sea ice trials		Daily		Twice-a-day, near real time	Daily
	SC-7	Ship operation in ice during sea ice trials		Daily		Twice-a-day, near real time	Daily
	SO-1	Navigating through ice		Daily		Twice-a-day, near real time	Daily
	SO-3	Navigating along (or just inside) the ice edge		Daily		Twice-a-day, near real time	Daily
	SO-5	Avoiding sea ice		Daily		Twice-a-day, near real time	Daily
8	Ice edge information						
	SD-1	Environmental conditions in vessels intended operation area		Daily		Daily or twice-a-day	
	SC-3	Planning sea ice trials outside of ice season	50-100 m	Daily	50-100 m	Daily or twice-a-day	SAR images, ice charts

	SC-4	Avoiding sea ice during sea trials	50-100 m	Daily	50-100 m	Daily or twice-a-day	SAR images, ice charts
	SC-5	Planning of sea ice trials	50-100 m	Daily	50-100 m	Daily or twice-a-day	SAR images, ice charts
	SC-6	Finding suitable ice conditions for testing vessel's capabilities during sea ice trials		Daily		Daily or twice-a-day	
	SC-7	Ship operation in ice during sea ice trials	50-100 m	Daily	50-100 m	Daily or twice-a-day	SAR images, ice charts
	IN-1	Incident investigation		Daily, weekly		Daily or twice-a-day or more often	SAR images, visible wavelength images, ice charts
	SO-1	Navigating through ice	less than 100m (requirement)	Daily	50-100 m	Daily or twice-a-day	Ice charts,
	SO-2	Avoiding ice edge	less than 100m (requirement)	Daily	50-100 m	Daily or twice-a-day	Ice charts,
	SO-3	Navigating along (or just inside) the ice edge	less than 100m (requirement)	Daily	50-100 m	Daily or twice-a-day	Ice charts,
	SO-5	Avoiding sea ice	less than 100m (requirement)	Daily	50-100 m	Daily or twice-a-day	Ice charts,
	SO-8	Strategic planning		Weekly, daily		Weekly, daily	
	SO-10	Search and rescue operations	less than 100m (requirement)	Daily	50-100 m	Daily or twice-a-day	Ice charts,
9	Information on ice field compression and divergence						
	SD-1	Environmental conditions in vessels intended operation area		Daily		Daily or twice-a-day	
	IN-1	Incident investigation		Daily, weekly		Daily or twice-a-day or more often	SAR images, visible wavelength images, ice charts
	SO-1	Navigating through ice	less than 100m (requirement)	Daily	50-100 m	Daily or twice-a-day	Ice charts,
10	Identify ice ridges and deformed ice						
	SD-3	Vessel concept, main dimensions, and hull form selection in early design		Weekly		Daily	
	SC-5	Planning of sea ice trials	50-100 m	Daily	50-100 m	Daily or twice-a-day	SAR images, ice charts
	SC-6	Finding suitable ice conditions for testing vessel's capabilities during sea ice trials	50-100 m	Daily	50-100 m	Daily or twice-a-day	Satellite ice data
	SC-7	Ship operation in ice during sea ice trials	50-100 m	Daily	50-100 m	Daily or twice-a-day	Satellite ice data
	IN-1	Incident investigation		Daily, weekly		Daily or twice-a-day	SAR images, visible wavelength

						or more often	images, ice charts
	ELD-1	Weather condition monitoring		Weekly		Daily	
11	Wind speed and direction monitoring						
	SC-1	Planning and execution of lifting operations at the shipyard		Several times a day		Several times a day	Weather forecast
	SC-2	Planning and execution of vessels tow out at the shipyard		Several times a day		Several times a day	Weather forecast
	SC-6	Finding suitable ice conditions for testing vessel's capabilities during sea ice trials		Several times a day		Several times a day	Weather forecast
	SC-7	Ship operation in ice during sea ice trials		Several times a day		Several times a day	Weather forecast
	SCE-2	Icing prediction for vessel certification		Several times a day		Several times a day	Weather observations Weather model reanalysis
	SCE-5	Monitoring ship icing conditions during voyage in the polar waters to ensure vessel is operated within its limitations		Several times a day		Several times a day	Weather forecast
	IN-1	Incident investigation		Several times a day		Several times a day	Weather forecast
	SO-3	Navigating along (or just inside) the ice edge		Several times a day		Several times a day	Weather forecast
	SO-4	Avoiding ship icing conditions		Several times a day		Several times a day	Weather forecast
	SO-6	Oil spill monitoring		Several times a day		Several times a day	Weather forecast
	SO-10	Search and rescue operations		Several times a day		Several times a day	Weather forecast
	ELD-1	Weather condition monitoring		Several times a day		Several times a day	Weather forecast
12	Wave height and direction monitoring						
	SC-2	Planning and execution of vessels tow out at the shipyard		Several times a day		Several times a day	Weather forecast Wave observations
	SCE-7	Defining design parameters for ship class rules based on long term statistics of environmental conditions		Monthly		Weekly	Wave statistics
	IN-1	Incident investigation		Several times a day		Several times a day	Weather observations Weather model reanalysis
	SO-3	Navigating along (or just inside) the ice edge		Several times a day		Several times a day	Weather forecast
	SO-4	Avoiding ship icing conditions		Several times a day		Several times a day	Weather forecast
	SO-6	Oil spill monitoring		Several times a day		Several times a day	Weather forecast
	SO-10	Search and rescue operations		Several times a day		Several times a day	Weather forecast
	ELD-1	Weather condition monitoring		Several times a day		Several times a day	Weather forecast
13	Air temperature						
	SD-4	Material selection in ship design phase for fulfilling design requirement for operation in cold climate		Several times a day		Several times a day	Weather observations Weather model reanalysis

	SD-4	Material selection in ship design phase for fulfilling design requirement for operation in cold climate		Several times a day		Several times a day	Weather observations Weather model reanalysis
	SC-6	Finding suitable ice conditions for testing vessel's capabilities during sea ice trials		Several times a day		Several times a day	Weather forecast
	SC-7	Ship operation in ice during sea ice trials		Several times a day		Several times a day	Weather forecast
	SCE-1	Defining operational limit temperature or polar ship temperature for a ship		Several times a day		Several times a day	Weather observations Weather model reanalysis
	SCE-2	Icing prediction for vessel certification		Several times a day		Several times a day	Weather observations Weather model reanalysis
	SCE-5	Monitoring ship icing conditions during voyage in the polar waters to ensure vessel is operated within its limitations		Several times a day		Several times a day	Weather forecast
	SCE-7	Defining design parameters for ship class rules based on long term statistics of environmental conditions		Several times a day		Several times a day	Weather observations Weather model reanalysis
	IN-1	Incident investigation		Several times a day		Several times a day	Weather forecast
	SO-4	Avoiding ship icing conditions		Several times a day		Several times a day	Weather forecast
	SO-10	Search and rescue operations		Several times a day		Several times a day	Weather forecast
14	Iceberg and bergy bit information						
	IN-1	Incident investigation		Daily		Daily or twice-a-day	Ice charts
	SO-3	Navigating along (or just inside) the ice edge	50-0 m (requirement)	Daily		Daily or twice-a-day	
	SO-5	Avoiding sea ice	50-0 m (requirement)	Daily		Daily or twice-a-day	
	SO-8	Strategic planning		Daily		Daily or twice-a-day	
	SO-10	Search and rescue operations		Daily		Daily or twice-a-day	
15	Oil spill detection and monitoring						
	SCE-10	Monitoring environmental impact in case of incidents releasing oil and other substances into water		Daily or weekly			
	IN-1	Incident investigation		Daily or weekly			
	SO-6	Oil spill monitoring		Daily or weekly			
	ELD-2	Environmental impact monitoring of operations impact to local nature		Weekly or monthly			
16	Icing condition detection						
	SCE-2	Icing prediction for vessel certification		Several times a day		Several times a day	Weather observations Weather model reanalysis
	SCE-5	Monitoring ship icing conditions during voyage in the polar waters to		Several times a day		Several times a day	Weather forecast

		ensure vessel is operated within its limitations					
	IN-1	Incident investigation		Several times a day		Several times a day	Weather forecast
	SO-4	Avoiding ship icing conditions		Several times a day		Several times a day	Weather forecast
17	Sea current monitoring						
	SC-2	Planning and execution of vessels tow out at the shipyard		Several times a day		Several times a day	Weather forecast
	IN-1	Incident investigation		Several times a day		Several times a day	Weather forecast
	SO-3	Navigating along (or just inside) the ice edge		Several times a day		Several times a day	Weather forecast
	SO-6	Oil spill monitoring		Several times a day		Several times a day	Weather forecast
18	Ice drift monitoring						
	SC-6	Finding suitable ice conditions for testing vessel's capabilities during sea ice trials		Daily		Daily or twice-a-day	
	SC-7	Ship operation in ice during sea ice trials		Daily		Daily or twice-a-day	
	IN-1	Incident investigation		Daily		Daily or twice-a-day	
	SO-1	Navigating through ice		Daily		Daily or twice-a-day	
	SO-3	Navigating along (or just inside) the ice edge		Daily		Daily or twice-a-day	
	SO-5	Avoiding sea ice		Daily		Daily or twice-a-day	
	SO-10	Search and rescue operations		Daily		Daily or twice-a-day	
19	Change in vegetation						
	ELD-2	Environmental impact monitoring of operations impact to local nature		Weekly or monthly		Weekly or monthly	
20	Algae blooming monitoring						
	SCE-10	Monitoring environmental impact in case of incidents releasing oil and other substances into water		Weekly or monthly		Weekly or monthly	
	ELD-2	Environmental impact monitoring of operations impact to local nature		Weekly or monthly		Weekly or monthly	
21	Ice season length						
	SD-1	Environmental conditions in vessels intended operation area		Daily or weekly		Daily or weekly	
	SC-3	Planning sea ice trials outside of ice season		Daily or weekly		Daily or weekly	
	SC-5	Planning of sea ice trials		Daily or weekly		Daily or weekly	
	IN-2	Understanding the current and future expected conditions		Daily or weekly		Daily or weekly	
22	Fast ice information						
	SD-1	Environmental conditions in vessels intended operation area		Daily or weekly		Daily or twice-a-day	
	IN-1	Incident investigation		Daily or weekly		Daily or twice-a-day	
	SO-1	Navigating through ice		Daily or weekly		Daily or twice-a-day	
23	Long term consistent data series of ice parameters						

	SD-1	Environmental conditions in vessels intended operation area		Daily or weekly		Daily or twice-a-day	
	IN-2	Understanding the current and future expected conditions		Daily or weekly		Daily or twice-a-day	
	SO-8	Strategic planning		Daily or weekly		Daily or twice-a-day	
24	Snow on ice information						
	IN-1	Incident investigation		Several times a day		Several times a day	Weather forecast
	SO-1	Navigating through ice		Several times a day		Several times a day	Weather forecast
	SO-7	Avoiding snow cover on ice		Several times a day		Several times a day	Weather forecast
25	Icing forecasting						
	SCE-5	Monitoring ship icing conditions during voyage in the polar waters to ensure vessel is operated within its limitations		Several times a day		Several times a day	Weather observations Weather model reanalysis
	SO-4	Avoiding ship icing conditions		Several times a day		Several times a day	Weather forecast
	SO-10	Search and rescue operations		Several times a day		Several times a day	Weather observations Weather model reanalysis
26	Sea surface temperature						
	SCE-2	Icing prediction for vessel certification		Several times a day		Several times a day	Weather observations Weather model reanalysis
	SCE-5	Monitoring ship icing conditions during voyage in the polar waters to ensure vessel is operated within its limitations		Several times a day		Several times a day	Weather forecast
27	Emissions to air						
	SCE-8	Ship emission monitoring	25m (available but not used)				25m (available but not used)
	IN-1	Incident investigation	25m				25m
	IN-3	Ensure compliance of portfolio with Poseidon Principles. (CO2 monitoring)	25m				25m
	ELD-2	Environmental impact monitoring of operations impact to local nature	25m	Weekly or monthly		Weekly or monthly	25m
28	AIS, radar signal and other instruments suited for ship detection and monitoring						
	SCE-9	Authorities want to monitor ship location and operation	100m	>30 seconds (terrestrial AIS) few minutes up to several hours (Satellite AIS)			Terrestrial or satellite AIS-receiving station
	IN-1	Incident investigation	100m	>30 seconds (terrestrial AIS) few minutes			Terrestrial or satellite AIS-receiving station

				up to several hours (Satellite AIS)			
	SO-11	Monitoring vessels without AIS transponder					
	ELD-3	Authorities want to monitor ships on their way for scrapping	100m	>30 seconds (terrestrial AIS) few minutes up to several hours (Satellite AIS)			Terrestrial or satellite AIS-receiving station
29	Monitoring of shore changes, shore erosion and sediment deposits						
	SO-12	Navigating waters with poor charting		Weekly or monthly		Weekly or monthly	

9.2 Constrains for using geoinformation

Some common constrains for using more geoinformation were collected during the work in WP 1 as listed in Table 9-3. These are hurdles that prevent or limit actors in different shipping business processes from using geoinformation in their daily business. Tackling the constrains can help EO industry to promote the use of geoinformation in shipping.

Table 9-3 Constrains for using geoinformation

ID	Geoinformation requirement
C-1	Cost of geoinformation
C-2	Do not know how geoinformation could be used
C-3	Do not know where to access geoinformation
C-4	Do not know what geoinformation products are available
C-5	Cannot follow development of the geoinformation products
C-6	Limited processed products readily available
C-7	APIs are not available or are non-standard and changing continuously
C-8	New products not available daily
C-9	Not easy to access geoinformation products
C-10	Long term archives of processed data products not available
C-11	Data products not covering all geolocations or times
C-12	Data product format not suited for using effectively in navigation system
C-13	Need to use experts to access geoinformation products

C-14	Limited band width in high latitudes

10 EARSC PORTAL

One of the key tasks in the project is to establish a net portal for the project. The portal for the EO4BAS will be as a working tool during the duration of the project and to later serve as a hub for the project results. During the project the portal will facilitate the exchange and review of requirements and information with relevant industry actors and stakeholders as well as providing news and updates related to the project. During the WP1 the portal structure was setup and the main findings in the WP1 made visible in the portal together with the locations to store the findings in other work packages. After the completion of the EO4BAS project it will provide a comprehensive list of all identified challenges, related geoinformation requirements and identified mature EO products and solutions to support potential EO customers locating relevant information. All deliverables from the project will be available through the portal.

The European Association of Remote Sensing Companies (EARSC) is a not for profit, membership-based organization consisting of full-member companies from Europe representing the entire EO value chain, and observer members which can be any organization interested in the sector. Currently EASRS consists of over 130 members from 25 countries.

The objective of EARSC is to coordinates and promotes the activities of European companies engaged in delivering Earth observation-derived geo-information services. EARSC represents this sector in a broad sense, creating a network between industry, decision makers and users and covering the full EO value chain from data acquisition through processing, fusion, analysis to final geo-information and services. As part of this work EARSC provide and facilitates information exchange on different EO products offered and their application between product suppliers and potential customers through various platforms. such platform is the EARSC EO Portals, which among others, hosts portals for the best practice guidelines developed from previous similar ESA projects, EO4OG, EO4I and EO4RM. One such portal was also developed for EO4BAS.

11 CONCLUSIONS

The project focused on the challenges and geoinformation requirements for 6 business processes in two geographical areas. User personas were used to detail the nuanced problems personnel working within these processes regularly face. A total of 29 unique business challenges were discovered to which 28 associated geoinformation variables were suggested to potentially remedy the problems. These variables form the geoinformation requirements for the industry sector in the two geographical areas. Many of these geoinformation requirements are associated with various of the challenges and have the challenge specific spatial and temporal resolution requirements. A total of 14 common constraints for using earth observations within the business processes were mapped during this project. The following observations can be concluded from the project findings:

- Maritime industry uses earth observations for different purposes. Thought, the use in many business processes is often limited for a few known EO products. Some of the business processes use very little or not at all geoinformation in their operations.
- There is significant potential for increasing the use of geoinformation in all business processes.
- There is an increased interest for using geospatial information for industry operations in the Artic and Baltic due increase in operations in the area.
- The rapid change of Artic and Baltic environmental conditions due to climate change affects the industry operations and the validity for using historical knowledge on operational conditions. Up-to-date earth observations can support effective and safe operation in these areas.
- The stakeholders have varied and sometimes limited knowledge on the available EO products and parameters.
- Satellite based EO is the only useful data source for areas in the in the remote areas of the Arctic where local observations are not available.
- Changing requirement landscape for operations in a remote area and environmentally vulnerable areas increases the need for up-to-date geoinformation that in many cases is only available from satellite earth observations.
- There is a need for geospatial information products at different time scales, including long term, NRT and forecast and predictions. The info is necessary to comply with requirements from IMO, EU for example on reduction of emissions. The requirements involve different business processes, including a better design and operation of a ship to minimize emissions in a selected area of operations.
- Costs and availability of suitable EO products together with lack of knowledge on available EO products are limitations for using EO.
- End users need often to use companies that process EO information for their use since products are not ready to be used or the companies lack capacity to process raw information for their own use.
- The most used geoinformation among the stakeholders in the Arctic and Baltic Sea is information on sea ice. Sea ice thickness, ice concentration, ice edge and information on deformed ice are important for many stakeholders.

The collection of geospatial requirements and constrains are input for work package (WP) 2. In WP2 the sensors and information products fitting the requirements will be mapped for the technology available currently and in the next 5 years. The challenges for specific geoinformations can be used in performing the gap analysis in WP 2. The constrains for using geoinformation can be further used in the project in building the mock-up service concept and in building the road map for satellite EO use in shipping industry.

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