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ACCESS

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Executive Summary

The Arctic Council's Arctic Marine Shipping Assessment (AMSA), reviewed in this report, revealed that basic marine infrastructure is significantly lacking in most of the Arctic. Except for the northern Norwegian coast, northwest Russia, and the Icelandic coast, extensive areas of the remaining regions of the maritime Arctic have insufficient or non-existent infrastructure to support safe marine operations and to allow an adequate, timely response to Arctic marine incidents. Marine infrastructure (defines as ports, navigation charts, places of refuge, salvage, communications, aids to navigation, icebreakers, emergency response, ship routing, ice navigator training, and more) is critical and integral to providing a baseline level of Arctic marine environmental protection and marine safety. Such infrastructure is also essential for the normal facilitation of marine commerce. The AMSA recommendations focus on three inter-related themes: (A) Enhancing Arctic Marine Safety; (B) Protecting Arctic People and the Environment; and (C) Building the Arctic Marine Infrastructure. Reducing the infrastructure deficit is an urgent task for the Arctic states and the global maritime industry. New public-private partnerships should be explored to close this gap as noted in AMSA, the Arctic Council's Arctic Marine and Aviation Transportation Infrastructure Initiative (AMATII), and other international reports. The results of a key AMSA workshop that focused on five plausible Arctic marine accidents are reviewed in this report. All of the Arctic accident scenarios indicated large gaps in a range of critical infrastructure including: communications coverage; environmental response capacity; lack of shore side capacity; no identified places of refuge; unavailability of large towing and salvage vessels; weather data; and, aviation response assets located far from the incident. These results are consistent with other studies reviewed for observing systems, port developments, and the AMATII project.

This report identifies eight strategic challenges for ACCESS that focus on addressing the large infrastructure gap in the maritime Arctic:

- #1 ~ Lack of Navigation Charts & Hydrography.
- #2 ~ Climate Change Impacts in the Arctic Coastal Zone.
- #3 ~ Lack of an Integrated Arctic Observing System.
- #4 ~ Training of Polar Operators and Ice Navigators.
- #5 ~ Development of an Arctic Marine Traffic Awareness System,
- #6 ~ Implementation of the Arctic Search & Rescue and Oil Pollution Agreements.
- #7 ~ Evaluation of Risk with Minimal Marine Infrastructure.
- #8 ~ Arctic Marine Infrastructure Investments.

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1. Introduction

Climate change, globalization, and geopolitics are influencing the maritime Arctic early in the 21st century in ways unforeseen. Arctic sea ice retreat is providing greater marine access and potentially longer seasons of navigation. The Arctic is becoming linked to global commodity markets by natural resource developments (Brigham 2011). The geopolitics of delimitation of the outer continental shelf and emergence of new rules and regulations (in particular at the International Maritime Organization) are influencing the future governance of the region. These new economic connections and increasing marine access are driving new challenges and opportunities for Arctic marine transport. Perhaps the most compelling challenge is the lack of adequate marine infrastructure throughout the region.

This report is an overview and synthesis of the Arctic Council's Arctic Marine Shipping Assessment (AMSA) and several, complementary international efforts including the Arctic Council's Arctic Marine and Aviation Transportation Infrastructure Initiative (AMATII), the Sustaining Arctic Observing initiative, and key Arctic port developments. All of these studies indicate a huge deficit in marine infrastructure, a critical missing element in providing the Arctic with a robust marine safety and environmental protection net. The goal of the report is to identify for ACCESS the key challenges regarding the significant gaps in Arctic marine infrastructure. These challenges will be useful and important factors in the ACCESS scenarios development and synthesis efforts involving the major ACCESS sectors and governance issues.

2. Arctic Marine Shipping Assessment

2.1. Introduction

At the 2004 Arctic Council Ministerial Meeting in Reykjavik, Iceland, the eight Arctic ministers called for an 'Arctic shipping assessment' (The Reykjavik Declaration 2004). During 2004-2009 nearly 200 experts led by Canada, Finland and the United States under the Council's working group PAME (Protection of the Arctic Marine Environment) analyzed current and future marine activity, created a list of critical findings and proposed a set of recommendations in the Arctic Marine Shipping Assessment (AMSA). AMSA focused on marine safety and environmental protection measures, consistent with the Arctic Council's dual mandates of environmental protection and sustainable development. The resulting comprehensive study in the *Arctic Marine Shipping Assessment 2009 Report* can be viewed as:

(A) A strategic guide to a host of Arctic actors and stakeholders,

(B) A baseline assessment and snapshot of Arctic marine activity early in the 21st century,

(C) A policy framework document for the Arctic Council, since the Report was negotiated and consensus was reached for its approval by the eight Arctic states in April 2009.

Ninety-six findings are presented in the report under a broad range of key themes, including: marine geography; climate and sea ice; a history of Arctic marine transport; governance and law of the sea; current marine use (from the AMSA database); scenarios and future uses; human dimensions and indigenous issues; environmental considerations and impacts; and, the Arctic marine infrastructure deficit. To support the AMSA effort, thirteen major workshops were held on scenarios of the future, marine insurance, Arctic indigenous use, environmental impacts, infrastructure, and integration of the AMSA research. Fourteen AMSA town hall meetings were held in Arctic communities to directly link the concerns and shared interests of indigenous residents.

A baseline database of Arctic marine activity (for the calendar year 2004) was essential to the credibility of AMSA. The Arctic Council and AMSA research team required a first-order understanding of the numbers of ships operating in the Arctic Ocean, by ship type, marine use, season, and region of operation. 'Arctic shipping' in AMSA is broadly defined to include such ship types as tankers, container ships, general cargo vessels, icebreakers, cruise ships, fishing vessels, ferries, tug-barge combinations, and survey/exploration vessels supporting offshore hydrocarbon development. An AMSA survey was sent to the Arctic states for their completion to ensure that the information provided would be the official national Arctic shipping data. Each of the Arctic states would also use its own definition of what constitutes their nation's 'Arctic region.' The AMSA database lists an estimated 6000 individual vessels operating in the Arctic region during 2004, with nearly voyages being destinational and regional (not trans-Arctic voyages). Four primary types of Arctic vessel activity were noted in the AMSA database: community resupply, fishing, bulk carriers, and marine tourism. Fishing vessels made up slightly less than half of the total and bulk carriers 20 per cent of the total (AMSA 2009). The regions with the highest concentrations of marine use were: coastal Norway and northwest Russia (in the Norwegian, Barents and Pechora seas); the North Pacific Great Circle Route near the Aleutian Islands; summer resupply into the Canadian Arctic; and, summer cruise ships off Greenland's west coast.

In the AMSA ocean governance review, it is clear that Arctic marine navigation and overall marine uses are to be conducted within the fundamental framework provided by the Convention on the Law of the Sea (UNCLOS). The Arctic region holds one of earth's oceans, the Arctic Ocean, and UNCLOS sets out the legal framework for the regulation of shipping and activity according to maritime zones of jurisdiction. This finding is consistent with the May 2008 Illulissat Declaration of the five Arctic Ocean coastal states, who stated to the world that the Arctic does not require a new treaty or agreement, since UNCLOS is the primary and appropriate basis for marine governance in the region (Illulissat Declaration 2008). Also important to the use of the Arctic Ocean is that UNCLOS gives coastal states the right to adopt and enforce non-discriminatory laws and regulations for the prevention, reduction, and control of marine pollution in ice-covered waters (UNCLOS Article 234). AMSA also reaffirms that it is the International Maritime Organization (IMO) to which the Arctic states should turn concerning issues related to Arctic marine safety, security, and environmental protection. All eight Arctic states are active members of the IMO, and they will need to work together to achieve Arctic-specific rules and regulations compatible with existing IMO conventions and standards.

2.2. AMSA Scenarios

One of the major challenges for the AMSA team was to identify the main uncertainties that will shape the future of Arctic marine activity and use to 2050. A scenario-based approach was used to create a set of plausible futures in which the set of different stories of future Arctic marine activity can illuminate where crucial uncertainties may play out. AMSA scenario workshop participants identified nearly 120 driving forces or factors that may influence future levels of marine activity. Included among the factors deemed most influential by AMSA are:

- World trade patterns and radical changes in global trade dynamics.
- Global oil and gas prices.
- Hard minerals and other global commodities pricing (Such as zinc, copper, nickel, and iron ore).
- Safety of other global maritime routes.
- New natural resource discoveries.
- Legal stability and overall governance of Arctic marine use.
- Occurrence of a major Arctic marine disaster.
- Transit fees for Arctic coastal routes.
- Engagement of the marine insurance industry.
- Climate change severity (more disruptive, sooner than anticipated).
- Limited windows of navigation and seasonality for Arctic marine operations (considering the economics of seasonal verses year-round Arctic marine operations).
- Global (IMO) agreements for Arctic ship construction rules and standards.
- Escalation of Arctic maritime disputes.
- Conflicts between indigenous and commercial users of Arctic waterways.
- Socio-economic responses to global climate change (e.g. emission controls for ships).
- Emergence of China, Korea, and Japan as Arctic maritime nations (AMSA 2009).

These select factors or driving forces illustrate the complexity and broad, global connections that can influence future uses of the Arctic Ocean. Two primary factors were selected to anchor, as axes of uncertainly, the scenarios matrix used for the development of plausible futures:

(A) ***Resources and trade:*** the level of demand for Arctic natural resources and trade. This driver relates to the uncertainties of global prices for commodities such as oil and gas, and hard minerals; potential global market developments (in Asia); and regional political instabilities.

(B) ***Governance:*** the degree of relative stability of rules and standards for marine use both within the Arctic and internationally. Less stability may imply a shortfall in transparency and a rule-based structure, and create an atmosphere where actors and stakeholders, such as the Arctic states and the global maritime industry, tend to work on a unilateral basis. More stability implies a stable, efficiently operating system of legal and regulatory structures and an atmosphere of international collaboration.

The two selected factors for the AMSA scenarios matrix met three key criteria: degree of plausibility, relevance to the Arctic and maritime affairs, and being at the right level or threshold of the many external factors. Thus, for the AMSA scenarios effort, the globalization of the Arctic and the development of Arctic natural resources , as well as governance of Arctic marine activity, were deemed most influential among the many drivers in determining the future of the Arctic navigation, Full consideration was given to climate change. The continued retreat of Arctic sea ice is assumed to provide opportunities for improved marine access and potentially longer seasons of navigation, Greater access facilitates Arctic marine uses, but critically important are global economic factors such as demand for natural resources.

Four scenarios, or stories of the future, were created by crossing the two primary drivers. A ***Polar Lows*** scenario (low demand and unstable governance) indicates a future of low demand for natural resources and minimal marine traffic. In this scenario less attention is given to marine regulations and standards, which remain weak and undeveloped. The ***Arctic Race*** scenario (high demand and unstable governance) is a future of generally high global prices for resources and a high demand for Arctic natural resources. This plausible future implies an ‘economic rush’ for Arctic development (not a geopolitical race), based in part on global markets where key elements of the global maritime industry moves to the Arctic Ocean to support resource development. Marine tourism is also an increasing sector. However, in this scenario there is lack of an integrated set of maritime rules and regulations and inadequate marine infrastructure to support such high level levels of Arctic marine activity. A ***Polar Preserve*** scenario (low demand and stable governance) is a future of low demand for Arctic resources, since global economic and geopolitical interests are focused elsewhere. This is a situation where environmental concerns drive a movement toward a systematic preservation of the Arctic; many Arctic marine regions are closed to navigation and development. The fourth AMSA scenario, ***Arctic Saga*** (high demand and stable governance), is a future of high global demand for Arctic natural resources, significant increases in Arctic marine traffic, and a stable, fully-developed governance system for multiple marine uses. This Arctic world leads to a healthy rate of Arctic development that includes broad concern for the preservation of Arctic cultures and ecosystems, as well as shared economic and political interests of the Arctic states. Regional and international cooperation among the Arctic states and many non-Arctic states will be required at historic levels of engagement to move the Arctic to this balanced state.

***Importance of the AMSA Scenarios Creation Effort* ~** The AMSA scenarios proved to be a powerful way to communicate to a wide audience the complexities influencing the future of Arctic marine navigation. The effort, facilitated by unconstrained thinking, identified the many plausible linkages of the Arctic to the global system and served to highlight the global economic forces that are shaping the North. While global economic drivers are considered in AMSA to be paramount (driving Arctic natural resource development), continued climate change and Arctic sea ice retreat are understood to provide greater marine access throughout the Arctic basin. The will require increased international cooperation, especially the future levels of Arctic marine traffic. Since the future is unpredictable, the AMSA scenarios are useful in that they provide alternative (and plausible) images of the future and can assist in the development of resilient strategies to deal with emerging uses of the Arctic Ocean. The AMSA scenarios effort was an integral and successful component of the assessment and highly useful to entire Arctic Council community.

2.3. AMSA Findings

Table 1 is a list of key AMSA findings including four that are directly relevant to the issue of marine infrastructure: the overall marine infrastructure deficit in the Arctic; the lack of charts and marine observations; the lack of an integrated Arctic traffic awareness system; and, the need for international training standards for mariners sailing in polar waters. AMSA findings also focused on the many uncertainties of Arctic navigation that will influence the future, and the central role of Arctic natural resource developments in driving increased Arctic marine activity. One of the most important findings was that the vast majority of Arctic shipping today is destinational, where ships carry natural resources out of the Arctic to global markets.

One key component of AMSA was a scientific review of the environmental impacts of current and future Arctic marine activity. The scientific group deemed the most significant threat from ships to the Arctic marine environment to be the release of oil from accidental or illegal discharge. This places an appropriate pressure on prevention programs and regulatory systems (including enforcement) to minimize the possibilities of discharges of oil and toxic chemicals into Arctic waters. The AMSA Team also compiled findings on a range of key impacts including:

- The introduction of alien species from ballast water, cargo, and hull fouling.
- The transfer of organisms from northern ecosystems to similar latitudes and conditions (for example, from the North Pole to the North Atlantic across the Arctic Ocean.
- Ship strikes on whales and other marine mammals.

- The regional impacts of black carbon emissions on sea ice melt.
- Potential impacts of anthropogenic noise from ships and other marine activities on marine mammals.
- Negative impacts on the migration corridors and natural chokepoints for marine mammals and birds which correspond broadly to current and future shipping routes.
- A lengthening of the Arctic navigation season (later in the autumn and earlier in the spring) and the potential consequences for Arctic ecosystems and migration patterns.
- The unintended, potential negative, consequences of Arctic ship emissions including greenhouse gases, nitrogen oxides, sulfur oxides, and particulate matter.

Two of the environmental findings emphasized were geographic in focus. The team highlighted that two of the world's richest fisheries, in the Bering and Barents seas, are also the location for heavy marine traffic in Arctic waters. Any spill in these waters would have major economic, cultural, and environmental impacts. Also noted in the AMSA findings were Arctic waters with considerable marine traffic that have a heightened ecological significance and are also geographically restricted, such as: Kara Gate in the Russian Arctic; Bering Strait; Hudson Strait and Lancaster Sound in the Canadian Arctic; and, the Pechora Sea in the southeastern corner of the Barents Sea.

The *AMSA 2009 Report* also provides findings and an overview related to the issues and challenges of trans-Arctic navigation. The AMSA team was careful to focus the assessment on issues related to marine safety and environmental protection, not on the economic viability of various Arctic trade routes, whether access across the Northwest Passage, the Northern Sea Route, or even the central Arctic Ocean. The global marine industry will judge the efficiency, reliability, seasonality, and economic viability of potential trans-Arctic trade routes. Marine insurers and ship classification organizations will add to the evaluation of any future trans-Arctic routes. Furthermore, AMS was clear that a mandatory polar code of navigation and other measures implemented by the IMO in accordance with international law should be considered applicable to all modes of Arctic navigation, whether they be destinational, intra-Arctic (such as between Churchill, Manitoba and Murmansk), or perhaps trans-Arctic in the future. The AMSA scenarios-creation effort indicted that the primary mode of marine transport in a future Arctic Ocean is likely to be destinational , with regional traffic related to the offshore development and carriage of natural resources out of the Arctic (AMSA 2009). The global demand for natural resources creates the need for new marine transport systems (such as the marine shuttle systems in northwest Russia) and results in increasing regional commercial traffic in Arctic coastal seas.

Key issues to be addressed (in other projects such as ACCESS) in viewing the potential of trans-Arctic shipping routes include:

- ***The continuing presence of sea ice.*** The central Arctic Ocean and coastal; seas will remain fully or partially ice-covered for9-10 months each year. It is likely that polar class ships will be the norm rather than an exception, incurring added costs to Arctic commercial shippers.

- ***The seasonality and reliability of Arctic navigation routes*.** If the Arctic Ocean were to be used for regular trans-Arctic navigation, could the new routes be economically viable if operated seasonally? How can the new Arctic ships be integrated into a shipping company's global marine operation? There are also questions of reliability of any new Arctic routes, given the regional variability of Arctic sea ice and the unpredictability of the weather in these remote regions.

- ***The need for icebreaker convoy or escort*.** Many of the new icebreaking carriers are designed to be independently operated, voyaging in ice without the need for icebreaker escort. There are a host of significant economic and safety issues relevant to such future shipping operations. One key economic question is the funding of escorting icebreakers and any fee system applied in Arctic waterways.

- ***The risks of trans-Arctic navigation*.** Long voyages in ice (for example, a voyage for 2000 nautical miles) can potentially increase the risks of ship cargo damages. Possible schedule disruptions and the lack of marine infrastructure (as a safety net) will be key factors influencing future marine insurance rates.

The integration of trans-Arctic navigation with global shipping routes in other oceans of the world will be attended by much uncertainty and potentially high operating costs, especially for the container industry. While crossing the Arctic Ocean may be theoretically possible today with advanced icebreaking ships, the economic and operational aspects of these routes have not yet been fully explored (ACCESS is exploring the opportunities of using the Northern Sea Route for such Arctic navigation). Modest volumes of cargo may be shipped trans-Arctic during future summer seasons of navigation, but AMSA indicates it is likely that most of the operations will be destinational voyages driven by natural resource development and global demands for key commodities (Brigham 2010).

***Lack of Marine Infrastructure* ~** One of the greatest concerns and significant risks identified as a finding in AMSA is the lack of maritime infrastructure in all regions of the maritime Arctic except for the Norwegian coast and the coastal regions of northwest Russia. Marine infrastructure was defined broadly in AMSA to include: marine charts (and hydrographic/bathymetric information); communications; salvage; aids to navigation; icebreaker capacity; environmental monitoring if weather, sea ice and icebergs; environmental response capacity (for example, oil spill response); search and rescue capability; deepwater ports and port reception facilities; ship monitoring and tracking; and other key needs such as places of refuge. This huge deficit in marine infrastructure makes it very difficult to evaluate the full risks associated with Arctic marine operations, and exposes most new Arctic marine projects to a non-existent safety net.

AMSA emphasized that the remoteness, vastness and harshness of the Arctic environment make emergency response in the Arctic difficult, even in the best of operating conditions. AMSA also further noted that the Arctic Ocean's hydrographic database is extremely sparse, and an observing network of meteorological and oceanographic observations critical to safe navigation is not adequate for current and future marine operations. Of all the challenges to increasing use of the Arctic Ocean, reducing this infrastructure deficit may be the most difficult to deal with because of the large investments required. The Arctic states and maritime industry must recognize that new public-private funding ventures and partnerships will be needed and new schemes for cost recovery of selected infrastructure should be designed. Prioritizing hydrographic surveys in response to advancing traffic, addressing icebreaker fleet renewal, defining satellite requirements for enhanced polar communications, and developing an integrated system for monitoring and tracking Arctic ships ~ these are key examples of the tasks ahead for the Arctic states regarding critical marine infrastructure.

2.4. AMSA Recommendations

AMSA's seventeen recommendations listed in **Table 2** were negotiated and approved by the Arctic Ministers and they represent a new level of Arctic state cooperation. They are collectively a 'policy statement' and an integrated framework that the Arctic Council can use to address future developments in Arctic marine use. The recommendations focus on three inter-related themes:

(A) Enhancing Arctic Marine Safety.

(B) Protecting Arctic People and the Environment.

(C) Building the Arctic Marine Infrastructure.

These themes are fundamental to a multi-faceted response to expanded Arctic marine use and to the investment requirements necessary to achieve enhanced marine safety and environmental protection throughout the Arctic marine environment. The AMSA team noted that implementation of these recommendations might require increased international cooperation at the IMO, and new public-private partnerships for investments. Most of the marine safety recommendations under ***Enhancing Arctic Marine Safety*** involved the IMO and underline the global nature of the marine industry. The most important is surely a call for development of uniform and mandatory standards and requirements for ships operating in the Arctic. Related is the move to support augmentation of global IMO ship-safety and pollution-prevention conventions with specific, mandatory requirements for Arctic ship construction, design, equipment, crewing, training, and operations. The Arctic states also decided to develop a Search and Rescue (SAR) agreement, and formed a task Force in April 2009 led by the United States and Russia. Key recommendations also focused on the Arctic states linking more closely with unified positions at international organizations, and strengthening passenger-ship safety in Arctic waters.

For the theme ***Protecting Arctic People and the Environment***, the Arctic states recognize the importance of effective communications and engagement with Arctic coastal communities early in all marine transport initiatives. The Arctic states also considered conducting surveys of Arctic indigenous marine use which will be necessary if integrated, multiple-use management schemes are applied to coastal marine areas. Critical issues such as invasive species, oil spills, marine mammal impacts (ship strikes, noise and disturbances), and stack emissions are addressed in the recommendations with a view to involving the IMO and other relevant international organizations. Further, the Arctic states acknowledged the potential for specially designated Arctic marine areas in need of unique environmental protection measures, such as IMO-designated 'special areas' and Particularly Sensitive Sea Areas (PSSAs) consistent with international law.

The Arctic states recognize the critical importance of the recommendations related to the third theme, ***Building the Arctic Marine Infrastructure***, and they focus on development of a comprehensive Arctic marine traffic awareness system to improve monitoring and tracking of marine activities. Such an effort will require real-time sharing of ship data (across national boundaries) and enhanced communication systems. Future response capabilities are critical to protecting the unique Arctic marine ecosystem, and the Arctic states are committed to developing a circumpolar response capacity through Arctic-wide and regional agreements. Key AMSA recommendations also note the need to bring Arctic navigation charts to a level acceptable for current and future safe navigation, and greatly enhanced systems for acquiring, analyzing and transferring meteorological, oceanographic, sea ice, and iceberg information to a host of new users. Each of these Arctic infrastructure initiatives will require significant and long-term funding. The Arctic marine infrastructure deficit as highlighted in AMSA Recommendation IIIA. is one of the most challenging task facing the Arctic states and the global maritime enterprise early in the 21st century.

2.5. Implementation Process

One of the clear successes of AMSA has been the recommendation follow-up and implementation process by PAME and the Arctic Council Ministers. With an agreed (by consensus) and approved list of AMSA recommendations, the Council has worked hard to use this assessment as a policy strategy for marine safety and environmental protection. Follow-up AMSA status reports have been requested by the Arctic Ministers in 2011, 2013 and 2015. The 2011 and 2013 reports issued by PAME and presented at ministerial meetings in Nuuk, Greenland (May 2011) and Kiruna, Sweden (May 2013) indicated significant progress in implementation related to:

- marine accident response issues;
- identifying Arctic marine areas of heightened ecological and cultural significance;
- the Arctic states engaging together in international organizations and focusing in unified approaches to Arctic issues;
- progress on an mandatory IMO Polar Code for ships in polar waters;
- an international SAR agreement;
- an international agreement on oil spill preparedness and response;

- the expansion of Arctic vessel monitoring and surveillance systems using AIS (Automatic Identification System) signals received by satellite and land-based receivers;
- the carriage of heavy fuel oil (HFO) in Arctic waters;
- the establishment of an Arctic Regional Hydrographic Commission within the International Hydrographic Organization (IHO) to promote common standards and new surveys for the Arctic;
- the establishment by IMO, IHO, and the World Meteorological Organization (WMO) of five new NAVAREAS/METAREAS into Arctic waters;
- the establishment of several projects related to accessing the impacts of black carbon emissions from international shipping in Arctic waters;
- the conduct of several key indigenous use surveys by several Arctic states and Permanent Participants of the Arctic Council;
- explore the need for internationally designated areas in the high seas of the Arctic Ocean that warrant protection from the risks posed by international shipping.

2.6. Arctic SAR Agreement

One of the key recommendations of the AMSA 2009 Report (see Table 2, I.E. Arctic Search and Rescue Instrument) was for the Arctic states to negotiate an agreement (treaty) on Arctic search and rescue (SAR). The *Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic* was signed by the Arctic Ministers of the eight Arctic states in Nuuk, Greenland on 12 may 2011. It is a binding agreement strengthening SAR cooperation and coordination in the Arctic and establishes areas of responsibility for each of the Arctic states. These areas of responsibility are indicated in **Figure 1** (the Arctic states noted that these new SAR boundaries do not prejudice any other boundaries between the states or their sovereignty). The agreement also fosters the conduct of joint SAR exercises and training, lists information on the Arctic states' rescue coordination centers, and addresses the critical issue of requests to enter the territory of a Party for SAR operations (Arctic SAR Agreement 2011). The Arctic SAR agreement entered into force on 19 January 2013 following ratification by each of the eight (Arctic) signatory states. While the SAR agreement does not deal directly with the infrastructure required to conduct Arctic SAR operations, it does place an onus on the Arctic states to have resources such as coordination centers and assets available for emergency operations.

2.7. Arctic Marine Oil Pollution Agreement

The second agreement responding to the AMSA recommendations and negotiated under the auspices of the Arctic Council is the *Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic* signed by the Arctic Ministers in Kiruna, Sweden on 15 May 2015. This agreement focuses on Arctic oil spills and addresses a range of practical issues such as: requiring a national 24-hour system for response; facilitation of cross-border transfer of resources; notification of the Parties; monitoring of spills; conduct of exercise and training; joint reviews of responses to Arctic spills; and, a set of operational guidelines in an appendix to the agreement. The language of this agreement presumes that each of the Arctic states has a command structure to deal with Arctic oil spill response and infrastructure available to respond to an emergency. The agreement is in its implementation phase with joint exercises to be held and issues to be raised to test the level of cooperation necessary to adhere to the elements of this treaty (Arctic Marine Oil Pollution 2013).

2.8. Arctic Marine Incidents Workshop

An important AMSA workshop titled *Opening the Arctic Seas: Envisioning Disasters and Framing Solutions* was held in March 2008 at the Coastal Response Research Center of the University of New Hampshire, USA. Experts from academia, government agencies, Arctic indigenous groups, marine industry and non-governmental organizations attended. The focus of the workshop participants (from Canada, Denmark, Finland, Norway, Russia, South Africa and the United States) was on identifying key strategies, action items and resource needs for preparedness and response to potential Arctic marine incidents (Coastal Response Research Center 2009). Five plausible Arctic marine incidents were studied: a cruise ship grounding in the west coast of Greenland; a bulk carrier beset in ice in the central Arctic Ocean; fire and collision in offshore operations in the Beaufort Sea (on the Canadian-United States border); an oil tanker and fishing vessel collision in the Barents Sea (on the border between Russia and Norway); and, a tug and barge grounding on St. Lawrence island in the Bering Sea. Each of the plausible scenarios was designed to study a range of issues: search and rescue; spill response; salvage and firefighting; communications; governance and jurisdiction; and legal challenges.

Table 3 provides a short synopsis of each of the Arctic incident scenarios and a summary of key infrastructure gaps indentified by the marine experts. Lack of critical infrastructure in the Arctic was a significant limitation to the conduct of response operations in each of incidents. Consistent missing or weak infrastructure included: communication gaps; lack of identification of places of refuge; little capacity to support responders; weather information gaps; lack of long range helicopters for rescue; and, lack of salvage and towing vessels (located long distances from the Arctic). Except for the Barents Sea scenario, remoteness of the incident proved to be a challenging aspect to overcome to achieve timely and effective response. In scenario A (Table 3) for a cruise ship grounding in Greenland's west coast, local and regional SAR and response assets were overwhelmed by the large number of passengers and crew who abandoned ship in Arctic waters. The exercises also indicated the Arctic states needed to enhance their cooperation in SAR and environmental response (contingency planning) in multilateral and bilateral agreements. It was also clear from these Arctic incident exercises that mandatory safety regulations must be developed at IMO for ships operating in polar waters. The workshop included recommendations in the following themes, each requiring the enhancement of marine infrastructure:

- Ports and waterways management (places of refuge identification; ship routing).
- Vessels and crew safety (mandatory IMO ship regulations and crew training).
- Response agreements and plans (circumpolar SAR agreement and contingency plans).
- Strategies to improve prevention and preparedness (risk and impact assessments; forward-operating response bases).
- Strategies to improve response (expanded communications; improve logistical support capacities for responders).
- Strategies to foster community involvement (planning, response and recovery; better communications with Arctic communities).
- Strategies to ensure availability of funds for response (new Arctic response funds; penalties and insurance requirements for Arctic marine operations).

2.9. Baltic Cooperation and Infrastructure ~ Case Study for Ice-Covered Seas

The Arctic Ocean is becoming more seasonally ice-covered, in some respects emerging to be similar to the Baltic Sea where three Arctic states (Finland, Russia and Sweden) have coastlines. In AMSA the Baltic Sea marine shipping regime and regional infrastructure were evaluated as a ‘model’ or case study for the Arctic including ship operations, information systems (with environmental and ship traffic data), incident response, and the standardization or harmonization of marine regulations (AMSA 2009).

More than 2,000 ships are sailing in the Baltic on an average day and of this total 200 are oil takers (with cargoes up to 150,000 tonnes); this number does not include ferries, fishing vessels (an estimated 2000), and pleasure craft (AMSA 2009). The Baltic countries have developed strategies to protect this marine environment under the Convention on the Protection of the Marine Environment of the Baltic Sea Area (known as the Helsinki Convention) and a governing body, the Baltic Marine Environment Protection Commission (known as HELLCOM). Baltic infrastructure and marine management systems that have relevance to the Arctic include:

- Protected areas (89 Baltic Sea protected Areas; the Baltic as a IMO Special Area under MARPOL Annexes I-oil, V-garbage, and VI-SOx Emission Control Area).
- Mandatory ship reporting and traffic surveillance (national reporting in approaches to oil terminals and all ports).

- Traffic routing schemes (15 traffic separation schemes in eight Baltic regions).
- Baltic Icebreaking Management organization (for coordinating icebreaker escort and response) and ice/weather information systems.
- Incident response and overall, integrated SAR coordination.
- Aerial surveillance (coordinated) and oil & hazardous spills response.
- Port state control systems among all Baltic countries and enforcing regulation compliance.

HELLCOM is a regional coordinating body that is an environmental policy maker developing common environmental objectives and strategies, much like the Arctic Council's Protection of the Arctic Marine Environment (PAME) working group. But it is also a supervisory body (ensuring standards implementation by all the parties), a development body (new rules and also measures from other bodies such as the IMO), and a coordinating body, if a major maritime incident requires a multilateral response. Overall, the international cooperation and close coordination of the Baltic Area states in sharing information, infrastructure (such as icebreakers and surveillance), and response assets is an excellent model for the future of Arctic marine operations.

3. Arctic Marine and Aviation Transportation Infrastructure Initiative

3.1. Introduction

The Arctic Marine and Aviation Transportation Infrastructure Initiative (AMATII) was a project of the Arctic Council's Sustainable Development Working Group (2011-2013). One objective was to develop a platform to inventory the Arctic's aviation and maritime infrastructure, principally Arctic marine ports and airports. Both function as gateways to: Arctic natural resource development; SAR and environmental response to emergencies; community resupply; and, regional security. The AMATII project recognizes the intermodal nature of transportation and the linkages of ports and airports to response capabilities in the Arctic. Three elements of AMATII include:

(A) An Arctic Maritime and Aviation Infrastructure Database (web-based, searchable inventory of ports and airports….[arcticinfrastructure.org]); 349entires are listed for large and small ports; 601 airports are listed in the inventory;

(B) An Arctic Maritime and Aviation Infrastructure Map (port and airport asset location shown graphically…..[arcticinfrastructure.org]);

(C) A Guidance Document (includes the Proceedings of the Port and Airport Infrastructure Workshop held 3-6 December 2012 in Rekjavik, Iceland).

The following are policy-related conclusions from the AMATII project workshop and are relevant to ACCESS:

- The need continues for meaningful evaluation of response capacity; a tiered approach would be useful where Arctic states identify primary, secondary and tertiary response assets.
- Differences in systems, geography, and scale of challenge make evaluation of response capacity difficult.
- Infrastructure development must be responsive to social, environmental and cultural impacts (both positive and negative) as a core element of sustainable development. This is consistent with the AMSA findings and recommendations.
- Creative funding strategies, such as public-private partnerships must be pursued. Critical Arctic infrastructure is under the same influences of time, regional climate change, and decreasing resources from governments.
- Investments in infrastructure should be leveraged using intermodal approaches and a layering of resources providing a 'multiplier effect' on transportation infrastructure development.
- Increasing attention should be paid to key elements of infrastructure: communications; workforce development; mapping and bathymetry; and aids to navigation.
- Innovation can begin in the North where ingenuity can sometimes mean survivability. The Arctic can become the test bed for new technology and approaches (such as the use of UAVs).
- Sometimes there are simple solutions to problems that shared information can address. This requires greater sharing and cooperation among the Arctic states.
- Additional review of available/loose infrastructure outside the Arctic and mobile assets (vessels moving in and out of the Arctic) is warranted.

3.2. AMATII and Infrastructure Response Issues

The AMATII project discussions revealed a number of issues related to fully assessing Arctic response operations. The AMATII databases for marine and aviation assets indicated gaps in information and different definitions for capacity and risk. The value of the AMATII database assembled by the Arctic Council is that it can be publically available to a host of actors and stakeholders. It is also an ongoing effort and a valuable an access point to view current infrastructure patterns of development. The following issues are highlighted by assessing the database which will be useful to evaluating an adequate Arctic safety net:

- There are multiple ways to evaluate response including: time to respond and/or launch an asset; cost to respond; communication and coordination capabilities; and, agility and execution.
- Response capacity is both weather and distance dependent. Distance to respond depends on the scale of the response area, which varies widely among the Arctic states (for example the size of both the Russian and Canadian Arctic areas).
- With regard to SAR operations, there is a clear need to know where and what kind of fuel exists. The current Arctic system reflects a reluctance to share this kind of detailed information, which may be a result of competitive environment or security concerns.
- Some Arctic states have a risk calculation for oil spill response which evaluates activity/usage. This is a possible tool or future measure.
- A majority of the Arctic states have fuel caches for emergency response in the Arctic. However, these assets are owned by different entities (for example, the private sector or Coast Guard) and each may include different and sometimes inappropriate fuel types.
- A crucial step to ensuring effective response is training and equipping first responders. Human resources are part of critical infrastructure (advanced also in AMSA).

3.3. AMATII Marine Infrastructure Drivers and Aviation Funding

Table 4 includes a synthesis of the key drivers of marine infrastructure for each of the Arctic states. Many of these drivers are consistent with the AMSA scenarios creation effort and confirm the AMSA database of marine uses. **Table 5** is useful in that it indicates the funding for Arctic aviation infrastructure. There are elements of the private sector in Arctic aviation funding for several of the largest airports, but most infrastructure in the North is supported by the national governments. There are also examples of state-owned companies that manage Arctic aviation. Various models of public-private partnerships will be required for future investment in marine and aviation infrastructure.

4. Arctic Ports and Development

4.1. Importance as Service Hubs

Ports are the essential service hubs for global shipping corridors, marine tourism, national security, and offshore development (fisheries and hydrocarbons). Readily available in most major ports are deep water berths, marine salvage (and towing), port reception facilities, repair facilities, medical support, and a range of human services. Also, SAR and environmental response organizations are usually co-located in ports for logistic support. However, in the Arctic there are few ports that can provide the full range of maritime services. Also Arctic service ports are generally located quite far apart, if they even exist. AMSA makes the case that port infrastructure and support are directly relevant to maritime risk for a waterway and risk relates to the level of marine insurance (AMSA 2009). One of the challenges for the marine insurance industry and the ship classification societies is evaluating Arctic risk without the availability of port infrastructure (such as places of refuge, salvage, and maritime response). For each of the below examples of Arctic port developments, one of the key findings is that public-private partnerships are required to plan, provide funding, and oversee construction of a major Arctic maritime service hub.

4.2. Current and Key Arctic Port Developments

4.2.1. Sabetta, Russia

The ongoing construction of a major port in Sabetta on the western shore of the Ob Bay and on the Yamal Peninsula is perhaps the most important infrastructure development in today's Arctic. Of importance to the ACCESS synthesis effort, this port could add significant LNG tanker traffic along the NSR. This project has support from the highest levels of the Russian government (Meeting on the Yamal LNG Project 2013). The new LNG port is a public-private partnership between Novatek (Russia's largest independent gas producer, and 80% private partner), other private investors (France's Total as a private partner at 20%), and the federal government, which is responsible for dredging a navigable channel to the port in the shallow estuary of the Ob Bay. A major LNG plant near Sabetta will be supplied with gas from fields in the Yamal Peninsula and will be built to handle annually more than thirty million tons of cargo (Petterson 2013). The strategic location of Sabetta will facilitate the shipping of LNG eastward along the NSR during extended summer navigation seasons, and to Asian Pacific ports. More LNG carriers will be using Bering Strait on regular summer voyages. The Yamal port can also operate year-round with LNG ice-capable carriers sailing westward to European ports and potentially North and South American ports.

The Port of Sabetta will provide a service hub and critical marine infrastructure not only for many of the hydrocarbon fields throughout the Yamal Peninsula, but also for the NSR as a whole. The operation of the new port year-round is entirely feasible given the experience of the portt of Dudinka on the Yenisey River which services the mining complex at Norilsk using year-round Arctic carriers. . It has been reported that the total investment for the Sabetta port project is 75 billion rubles (1.82 billion Euros), with 49 billion rubles (1.19

billion Euros) from the Russian government and the remaining from private investors (Petterson 2013).

4.2.2. Murmansk, Russia

Murmansk is the historic and central service port for the Russian maritime Arctic. Ice-free year-round and a deep-water port, Murmansk is strategically located with access to Western Europe, the Barents Sea (and offshore hydrocarbon developments), and the western end of the Northern Sea Route at Kara Gate. It also has rail, road, and air links within Russia, is a service port for industrial fishing in the Barents Sea, and is an important naval port. Murmansk is clearly important to servicing the Northern Sea Route and future traffic and key to developing the entire Russian North as 'Russia's' northern gateway (Murmansk Regional Government 2014). The port is the base for Rosatomflot's nuclear icebreaker fleet and homeport to Murmansk Shipping Company.

The development of the 'Murmansk Transport Hub' is one of the largest ongoing port infrastructure projects in Russia and has strong support and investment from the federal government (Russian Federation 2008). Public-private partnerships are at the heart of this costly modernization of Murmansk and a number of private companies are involved in this long-term project. While the eastern shore of the Kola Bay has extensive port infrastructure, the western shore of the Bay is undeveloped and ideal for new port terminals. The goal is to develop Murmansk into a modern, international transport hub for processing containers and oil cargoes, and facilitating the transshipment of coal and fertilizers. Plans call for the following infrastructure:

- Coal terminal on the western shore of Kola Bay (20 million tonnes annual capacity).
- Railway linkages to the new coal terminal on the western shore.
- Oil terminal on the western shore of Kola Bay (35 million tonnes annual capacity).
- Container terminal on the eastern shore of Kola Bay (1 million TEU annual capacity).
- Modernization of the coal terminal on the eastern shore of Kola Bay.
- Construction of facilities for the operation of transshipment terminals.
- Construction of support facilities for border guards, customs, and security systems.

One of Russia's new SAR centers is to be established in Murmansk by November 2014. The first of the ten SAR centers to support the Northern Sea Route opened in Naryan-Mar in August 2013 and all should be completed by the end of 2015. They are located from Murmansk in the west to Provideniya in the east. The Murmansk SARE center will respond to a wide range of emergency incidents in the Arctic including marine accidents, nuclear (power plants and icebreakers) and chemical emergencies, and response to oil spills. (Barents Observer 2014). Plans call for the following infrastructure:

4.2.3. Kirkenes, Norway

The port of Kirkenes is strategically located in the northeast corner of Norway on the Russian-Norwegian border. It is a gateway to the Barents Sea and the Northern Sea Route and a logistics center in northern Norway. It has been a service port for the Russian Barents Sea fishing fleet and a support/service base for oil and gas exploration in the Barents Sea. Kirkenes is well positioned to be a service port for Arctic shipping sailing along routes across the north of Eurasia (the Northeast Passage and Northern Sea Route). An example of the new connections came in September 2010 when the M/V *Nordic Barents* carried 40,000 tonnes of concentrated iron ore from Kirkenes east across the Barents Sea and along the length of the NSR to Bering Strait and then to China. The average speed was reported by the Tschudi Group as 12 knots and this is first foreign-flag voyage across the entire NSR without stopping in a Russian Arctic port. Barents Sea oil and gas should drive regional port development in northern Norway. Kirkenes is developing a new oil terminal and service port to capitalize on new offshore oil and gas developments in the Norwegian and Russian sides of the Barents Sea border. (Staalesen 2014). Kirkenes and Hammerfest in Finnmark are positioning themselves to send bulk carriers and LNG carriers in summer along the Russian Arctic to Asian markers.

4.2.4. Finna Fjord, Northeast Iceland

Iceland has for several decades looked to build suitable port infrastructure to link with potential future Arctic shipping. The region that has been studied is located in the far northeast of the country in an ice-free coast with deep-water, the Finna Fjord. The Icelandic company EFLA Consulting Engineers has been working with the German firm Bremenports (who has experience with worldwide port construction projects) to conduct key feasibility studies for a major port facility (The Arctic Journal 2013). The planners believe such a port would be strategically located to take advantage of transshipment of Arctic cargoes (from the Northern Sea Route and Northwest Passage) and also act as a service hub for offshore hydrocarbon developments on Iceland’s continental shelf. The port could also service the cruise ship industry and link with natural resource developments in Greenland. The Finna Fjord project is a novel port infrastructure development designed to strategically position Iceland as a significant player in future Arctic marine operations.

4.2.5. Alaska Deep-draft Arctic Port

One of the challenges in the U.S. maritime Arctic is that in western and northern Alaska, a distance of more than 3,000 nautical miles of coastline, there is no port capable of handling deep-draft vessels. Since 2012 the U.S. Army Corps of Engineers and the State of Alaska (Department of Transportation and Public Facilities) have partnered to evaluate potential deepwater port locations in the region. The study effort included several key elements: defining the Arctic study area; establishing siting criteria; conducting scenario analysis; identifying potential sites; engaging stakeholders and communities; identifying other agency efforts and requirements; evaluating public-private partnerships; and, examining problems and opportunities (Alaska District Army Corps of Engineers 2012). The Arctic Council’s Arctic Marine Shipping Assessment and its scenarios creation effort for the future of Arctic navigation was one key guide in the Alaska study process. Key recommendations from the Alaska Arctic ports study include:

- Invest strategically to enhance the Arctic Ports System.
- Assign lead federal agency responsibility to the U.S. Army Corps of Engineers for permitting, design, and construction.
- Encourage private entities/banks and authorize other public agencies to collaborate in funding and constructing marine infrastructure.
- Increase funding to NOAA and other (federal) agencies to provide hydrographic and bathymetric mapping and needed data to support marine infrastructure development.
- Explore and develop navigational aids, such as ship routing, vessel tracking, traffic separation, and identification of areas of concern.
- Conduct feasibility analysis of shortlisted sites (Nome and Port Clearance) using physical criteria and alignment with potential investors; public-private-partnership developments; and, port management authority.

One of the key long-term drivers for a U.S. Arctic port is to facilitate the export of Alaska's natural resources in a new era of demand for Arctic resources by global markets. This driver is consistent with Alaska's long-term strategy of increased development of Arctic oil and gas, and hard minerals. Such a port would also place emergency response capacities within the U.S. maritime Arctic and provide a forward site to a host of federal agencies.

4.2.6. Nuuk, Greenland

Nuuk is the capital of Greenland and its port is critical to Greenland's entire economy. Today's port does not have the space nor water depth to handle larger container ships and cruise ships that frequent in the summer. Terminal logistics require that containers and other materials are stored outside the harbor in Nuuk forcing transfers by truck and increasing costs (The Arctic Journal 2014). The new port expansion will be able to better support four sectors: container shipping; the mining industry; offshore oil and gas exploration; and, the marine tourism industry. For most visits today large cruise ships must anchor off Nuuk and bring their passengers ashore in the ship's passenger boats. Being able to berth alongside will allow bunkering, filling water tanks and handling passengers more efficiently and safely. Nuuk's airport also remains limited as large jet aircraft cannot land on the short runway. Proposals have been submitted to combine a new, international airport with a shipping port, a realistic and future intermodal transportation hub that would greatly enhance Greenland's direct connections to Europe and North America.

5. Observing Systems, Monitoring and Tracking

5.1. Sustaining Arctic Observing Networks

The Sustaining Arctic Observing Networks (SAON) initiative is focused on developing a comprehensive, sustained, and interdisciplinary system of Arctic observations and data management (SAON 2008). The SAON international team has been focusing since 2006 on several key activities: enhancing geospatial tools; maintaining national inventories of Arctic observing and data activities; providing support for a community-based monitoring program; engaging with funding officials and implementing agencies; supporting the data management community; and developing partnerships with other regional, national, Arctic, and global observing programs. SAON is an integral element of Arctic marine infrastructure and any investment in SAON, wherever in the circumpolar world, must also be considered an investment in enhancing Arctic marine safety and marine environmental protection. The scientific and marine operational agencies of the Arctic and non-Arctic states contributing to SAON initiative must work closely together to ensure that the development of SAON includes pathways to provide advanced and timely Arctic information for strengthening safety and environmental protection measures. Such international cooperation will also provide an improved capability for protecting Arctic coastal communities. A coordinated network, designed for monitoring regional climate change and local environmental conditions, will have certain synergies and direct value to a myriad of operational requirements that will be responding to increased Arctic marine operations. Enhancing the interoperability of the various observing systems and improving the accessibility of environmental information can result in a more robust Arctic safety shield for marine operations.

The SAON initiative can be linked to the implementation of the AMSA recommendations in many ways. Select linkages include:

- ***Specially Designated Arctic Marine Areas*** ~ Internationally-designated areas for regional environmental protection (IMO Special Areas and Particularly Sensitive Sea Areas) require substantial environmental information under a rapidly changing Arctic climate.

- ***Areas of Heightened Ecological and Cultural Significance*** ~ In view of changing climate conditions and increasing multiple uses, measures to protect these areas require robust environmental data and sustained monitoring.

- ***Circumpolar Environmental Response Capacity*** ~ Baseline information on regional Arctic environments and real-time operational information, both possible from SAON, are required to adequately respond to circumpolar environmental pollution incidents. The new Arctic oil spill agreement signed in May 2013 has strengthened Arctic state cooperation and coordination in this arena. SOAN should be tied directly to providing future support to Arctic environmental response.

- ***Investing in Hydrographic, Meteorological and Oceanographic Data*** ~ Improved systems are required, as with SAON, to support the real-time acquisition, analysis, and transfer of meteorological, oceanographic, sea ice, and iceberg information.

- ***Arctic Marine Traffic Systems ~*** A comprehensive Arctic marine traffic awareness system called for in AMSA will require near, real-time environmental information, improved monitoring, and enhanced data sharing among the Arctic states.

- ***Arctic Search and Rescue ~*** The 2011 Arctic SAR agreement promotes establishment of adequate and effective SAR capability by each of the Arctic states with defined areas. Collaborative efforts by the Arctic states include: the sharing of real-time meteorological and oceanographic observations, analyses, forecast, and warnings; sharing information systems; and, using ship reporting systems for SAR operations (Arctic SAR Agreement 2011). A robust SAON can directly support many aspects of this agreement.

- ***Survey of Arctic Indigenous marine Use*** ~ On-going surveys are creating baseline data to access the impacts of Arctic marine operations on costal indigenous life. SAON will be a key tool to adequately monitor the environment and provide timely information to indigenous marine users.

- ***IMO Measures for Arctic Shipping ~*** The implementation of an IMO mandatory Polar Code will require an augmented Arctic sea ice monitoring and prediction system so that polar class ships of varying capability can be effectively regulated.

A second key example for support to a fully functioning SAON involves integration of the operational work of the national ice centers and their collaboration within the International Ice Charting Working Group (IICWG). The IICWG is the leading international forum for cooperation among the operational ice services for coordination of ice matters, including icebergs (IICWG 2007). The IICWG members are involved in: data and product exchange; standardization of terms; data and mapping; operations and unique customer support; shared training initiatives; sharing technology for analysis and forecasting; and, applied research in such areas as ice prediction models, remote sensing, and digital image processing. All of these activities have key linkages o the SAON initiative. And, the work of the ice centers is central to advancing Arctic marine safety and environmental protection in ice-covered seas that are experiencing increasing marine use.

A strong case can be made that the SAON initiative is directly relevant to efforts that will greatly enhance Arctic marine safety and environmental protection. More dialogue between the scientific and marine operational communities is required, and more engagement necessary with abroad array of stakeholders. In the context of the ACCESS project, SAON is an integral and essential element of Arctic marine infrastructure.

5.2. Monitoring and Tracking

Developing an effective Arctic maritime surveillance system for ship traffic is one of the important infrastructure recommendations of AMSA. Strengthening the regional ‘picture’ of marine operations, or what is termed Marine Domain Awareness (MDA), will require the integration of information from many categories including: vessels; cargo; infrastructure; maritime personnel and organizations/companies; and, the regional environment. The harsh operating environment, expanse, and remoteness of the Arctic add considerably to the MDA requirements to attain effective monitoring and surveillance. Infrastructure investment is required for several MDA elements: improved communication networks (a critical need in the Arctic); effective maritime tracking technologies; improved information-processing tools; enhanced Automatic Identification System (AIS) - satellite monitoring in northern latitudes; and additional AIS land-based receiving sites. As of 31 December 2004 IMO has required AIS transponders be aboard the following categories of ships: all ships 300 gross tons (and greater) on international voyages; cargo ships 500 gross tons (and greater) not on international voyages, and, all passenger vessels regardless of size. For nearly a decade most large ships have been required to have AIS transponders, but development of the regional tracking systems and networks of receivers has not kept pace in all areas of the Arctic. The northern coast of Norway and the coast of Alaska are two regions that have robust AIS-base tracking systems providing real-time Arctic traffic information. **Figure 2** is an example of the AIS traffic data (land-based receivers) for the U.S. maritime Arctic for the period 1 June through 30 November 2013.

One of the foundations of integrated maritime surveillance is the critical importance of exchanging information and data. AMSA recommended that a comprehensive marine traffic awareness system be developed and such a system requires an integrated approach to maritime awareness in a circumpolar domain (AMSA 2009). The Arctic states should negotiate an agreement to share Arctic marine traffic information among its maritime agencies in a real-time manner. This is particularly important for cross-border ship traffic information. An assessment of the current status of information exchange in the Arctic would be a first step, followed by a gap analysis of where the required marine information is not being shared. Such a comprehensive study could be conducted by a collaborative effort of the maritime authorities and ministries of the eight Arctic states. To gain an appreciation of the added value (both qualitative and quantitative) of sharing Arctic marine traffic information, a regional demonstration or test case should be conducted during a period of maximum Arctic marine use. The practical and technical details of harmonizing the reporting requirements and establishing common data definitions can be part of an Arctic state agreement.

6. Linking Infrastructure with Climate Change

Much of the Arctic marine infrastructure (such as port, places of refuge, aids to navigation, response assets, and salvage equipment) in the future will be located in the coastal zone. This is the same region that is undergoing rapid change with retreating sea ice, melting permafrost, and sea level rise. Several key findings in the *State of the Arctic Coast 2010* report (Forbes 2010) that will directly impact infrastructure include:

- The evolution of Arctic coasts over the coming decades will be strongly influenced by changes in the natural environment caused by the effects of climate warming.
- The past decade has seen successive new record minima in Arctic sea ice extent. At the same time, the mean ice thickness has been decreasing, driven by the export of perennial ice.
- Less extensive sea ice creates more open water, allowing stronger wave generation by the wind. This, combined with warmer sea surface and ground temperatures, has the potential to increase erosion along Arctic coasts. Record warm temperatures in 2007 contributed to rapid coastal erosion in Alaska.
- Sea level rise in the Arctic is very responsive to freshening and warming of the coastal ocean (leading to increased sea level at the coast) and is highly susceptible to changing large-scale air pressure patterns.
- Despite increasing annual freshwater discharges, some Arctic deltas are being progressively flooded, with most of the Mackenzie Delta front (the second largest Arctic delta) retreating at 1-10 meters/year or more.
- Storm-surge inundation of low coastal areas and deltas affects coastal communities and can have profound impacts on delta ecology through salinization of freshwater environments.
- Decadal-scale mean rates of coastal erosion retreat are typically in the 1-2 meter/year range, but vary up to 10-30 meters/year in some locations. The highest mean erosion rates are in the Beaufort Sea, the East Siberian Sea, and the Laptev Sea.
- The distribution and stability of gas hydrates in the Arctic coastal zone is poorly documented, but there is concern that climate change and other effects such as coastal erosion may destabilize some hydrate deposits.

The coastal zone is a key interface in the Arctic environment where the land, sea and atmosphere link making it a highly dynamic region. It is an Arctic zone where climate warming is expected to influence instability for the landscape and cause longer seasons of vast stretches of open water (with resulting coastal erosion). Monitoring of this dynamic coastal zone will require new strategies and approaches, and a robust SAON to detect and track changes as they unfold. The coastal zone is right at the nexus between infrastructure development and social-ecological systems that will require integrated approaches to coastal change and risk-based management.

7. Conclusions and Strategic Challenges

7.1. Conclusions

Marine infrastructure is significantly lacking in most of the Arctic as reported by AMSA and other reports focusing on current and future Arctic marine operations (AMSA 2009, AOR 2013). Only three regions are deemed to have adequate, modern marine infrastructure to support current levels of traffic and offer some measure of a safety net: the Norwegian northern (Arctic) coast; northwest Russia; and the Icelandic coast. Extensive areas of the remaining regions of the maritime Arctic have insufficient or non-existent infrastructure to support safe marine operations and respond to marine incidents in the Arctic marine environment. This is the overall theme and key conclusion to this report within the context of the ACCESS objectives.

A second clear conclusion is that infrastructure is critical and integral to providing a baseline level of Arctic marine environmental protection and marine safety. AMSA emphasizes this perspective in its recommendations in building the Arctic marine infrastructure (AMSA 2009). Infrastructure initiatives must also be linked to Arctic sustainable development strategies in a circumpolar context.

7.2. Infrastructure Strategic Challenges for ACCESS

Eight strategic challenges related to infrastructure have been identified as critical to the future of Arctic marine development. All are key factors in the creation of a safer operating environment throughout the maritime Arctic. All will be important to consider in the ACCESS scenarios and synthesis effort to integrate the overall findings of the ACCESS project.

7.2.1. *Strategic Challenge 1:* Lack of Navigation Charts & Hydrography

The Arctic Ocean is estimated to be 8-11% charted to international navigation standards. This of course includes the vast expanse of the Central Arctic Ocean which has been traversed by submarines and more infrequently by surface ships since the early 1990s. Some progress has been made in charting select routes along the Northern Sea Route and Northwest Passage. However, significant regions of the coastal Arctic marine environment remain uncharted to standards required by modern navigational charts. In areas without adequate charting it is difficult to evaluate risk for all marine operations. The International Hydrographic Organization has established an Arctic Regional Hydrographic Commission to deal with these gaps and also create an Arctic spatial data infrastructure (IHO 2010). One area of focus is on quality assured data from remote reaches of the Arctic marine environment.

7.2.2. *Strategic Challenge 2:* Climate Change Impacts in the Arctic Coastal Zone

Climate change is impacting the Arctic coastal zone where much of the marine infrastructure is today and will be located in the future. Large regions of the circumpolar Arctic coast are undergoing rapid change due to melting permafrost, sea level rise, and retreating sea ice (leaving greater fetch for winds to operate across the open ocean surface for longer seasons) (Forbes 2010). The result is high coastal rates of erosion in the Alaskan Arctic, Canada Arctic (Beaufort Sea) and the Russian Arctic (East Siberian and Laptev seas) (Forbes 2010). Coastal erosion and sea level rise can also impact sediment transport in coastal areas where ports and other physical infrastructure are located. Integrated approaches to Arctic coastal change (such as ecosystem-based management and coastal zone management) and enhanced monitoring of the Arctic coastal zone are required to improve understanding of the vulnerability, resilience and adaptive capacity of coastal communities and social-ecological systems. The construction of new and critical marine infrastructure in this highly dynamic coastal environment will require national and regional governance featuring: commitment to effective management and management flexibility; integrated decision-making that is science based; stakeholder and Arctic community participation; and, an understanding of trans-boundary perspectives and area-based approaches (Forbes 2010).

7.2.3. *Strategic Challenge 3:* Lack of an Integrated Arctic Observing System

There is a lack of a robust and integrated Arctic environmental observing system to provide timely oceanographic, atmospheric and sea ice information required for safe and efficient marine operations. An international effort, Sustaining Arctic Observing Networks (SAON), is underway to create such a system. The scientific and marine operational agencies of the Arctic and non-Arctic states contributing to this initiative must work closely together to ensure that the development of SAON includes pathways to provide advanced and timely Arctic information for strengthening safety and environmental protection measures. Such cooperation will also provide an improved capability to protect Arctic coastal communities. A coordinated network designed for monitoring regional climate change and local environmental conditions will have certain synergies and direct value to a myriad of operational requirements that will be responding to increased Arctic marine use. Enhancing the interoperability of the various observing systems and improving the accessibility of environmental information will result in a more robust Arctic safety shield for marine operations.

7.2.4. *Strategic Challenge 4:* Training of Polar Operators and Ice Navigators

The lack of Arctic marine infrastructure and the challenges of operating in the Arctic environment require high skill levels and broad experience in ice/polar waters of the mariners in the pilothouse. There are few mariners with this experience today and they can be found in only a handful of northern nations. The education and training programs for mariners required to enhance safe navigation in polar waters are a critical part of marine infrastructure. AMSA notes that there are maritime institutes that have developed ice navigation courses which employ bridge simulators for training on vessels operating in ice-covered waters (AMSA 2009). Also, the maritime administrations are tasked with maritime certification and licensing programs. Special training for mariners operating in ice-covered and polar waters must be developed by national programs and one of the challenges will be to harmonize the standards and requirements at the IMO. Mandatory IMO standards must be agreed on as annexes to the International Convention on Standards of Training, Certification and Watchkeeping of Seafarers (STCW 1978 and 1995). The Arctic states and leading maritime countries at IMO should strongly promote the development of mandatory training and standards for polar operators to prepare for the next generation of northern mariners.

7.2.5. *Strategic Challenge 5:* Development of an Arctic Marine Traffic Awareness System

The Arctic states should work together on the development of an enhanced marine traffic awareness system to improve monitoring and tracking of Arctic marine activity. ***To enhance data sharing in near real-time, the Arctic states should negotiate an agreement among their respective maritime administrations that will facilitate the transfer of ship traffic and movements across borders.*** Such an agreement will reduce the risk of incidents, provide awareness of potential user conflicts (especially between indigenous hunters and large ships), and facilitate emergency response. The negotiation process could use the Arctic Council as a facilitator as was done with the SAR and oil spill agreements, or could be conducted solely among the maritime authorities and diplomats. Passing ship traffic across all the Arctic state marine borders is a much needed requirement to implement effective, circumpolar ship awareness. An Arctic marine traffic system is one of the recommendations in AMSA (AMSA 2009) and is an integral component of an integrated strategy to improve marine safety and environmental protection.

7.2.6. *Strategic Challenge 6:* Implementation of the Arctic State Search & Rescue and Oil Pollution Agreements

Two AMSA recommendations have resulted in the negotiation of two Arctic state agreements (or binding treaties). The *Agreement on Cooperation on Aeronautical and Maritime Search and Rescue (SAR)* was signed by the Arctic Ministers in Nuuk, Greenland on 12 May 2011 (entered into force on 19 January 2013 following ratification by the eight Arctic states). The *Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic* was signed by the Arctic Ministers in Kiruna, Sweden on 15 May 2013. Each agreement fosters the conduct of joint exercises and training. The SAR agreement addresses the issues related to entering the territory of Party for SAR operations; the oil pollution agreement addresses facilitation of cross-border transfer of resources. Both agreements require implementation and exercising all of the elements related to Arctic response operations in summer and winter scenarios. Cooperation by the Arctic states in development of a system Arctic *Places of Refuge* for ships needing assistance is urgently needed. Use should be made of risk-based planning and IMO guidelines (IMO 2003). Although establishing *Places of Refuge* is a coastal state responsibility, international cooperation will enhance cross-border safety and security concerns.

7.2.7. *Strategic Challenge 7*: Evaluation of Risk with Minimal Marine Infrastructure

One of the difficult, practical challenges for the marine industry (and governments) is the evaluation of risk where there is little or no adequate infrastructure. The complexity and uncertainty of Arctic navigation demands that formal risk analysis be conducted particularly where unprecedented marine operations are undertaken. In the Arctic these types of new operations are usually accompanied by limited infrastructure and the missing elements of an adequate safety net for normal ship operations. Risk is about likelihood and severity, and the ship classification societies and marine insurers will be challenged to carry out sophisticated risk analyses of Arctic marine systems taking these factors into account. When developing scenarios, as will be done in the ACCESS synthesis effort, it will be important to keep in mind the large infrastructure deficit that exists in most regions of the maritime Arctic (AMSA 2009). The development of an IMO mandatory Polar Code, based in part on risk-based approaches, will begin a process that will integrate infrastructure requirements into Arctic marine systems development.

7.2.8. *Strategic Challenge 8:* Arctic Marine Infrastructure Investments

Most marine infrastructure is capital intensive and requires long-term planning and implementation. And importantly for the future, infrastructure is a prerequisite for sustainable development in the Arctic (World Economic Forum 2014). Arctic marine infrastructure investments require new public-private partnerships and perhaps a new, cross-border investment vehicle focused on financing Arctic projects. A newly established Circumpolar Economic Forum of the Arctic Council could foster Arctic international investments in systems that will enhance protection of Arctic people and the marine environment. National and regional governments must look to private investors as partners to foster Arctic development and coordinate large infrastructure investments. One of the key concluding issues is that it is unlikely that the Arctic state governments will fully fund Arctic marine infrastructure projects in the future. Private industry and private investors will be critical to supporting the maritime systems necessary to achieve an adequate safety net for marine operations in a 21st century Arctic.

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Tables

Table 1. Key Findings of the Arctic Council's Arctic Marine Shipping Assessment (AMSA 2009). Marine infrastructure findings are highlighted below.

***Governing Legal Regime ~** The law of the sea, as reflected in the 1982 United Nations Convention on the Law of the Sea (UNCLOS), set out the legal framework for the regulation of (Arctic) shipping according to maritime zones of jurisdiction.

***Key Drivers of Arctic Shipping ~** Natural resource development and regional trade are the key drivers of increased Arctic marine activity. Global commodities prices for oil, gas, hard minerals, coal, etc. are the driving the exploration of the Arctic's natural wealth.

***Retreat of Arctic Sea Ice ~** Global climate model simulations show a continuing retreat of Arctic sea ice through the 21st century; all simulations indicate an Arctic sea ice cover remaining in winter.

***Uncertainties of Arctic Navigation ~** A large number of uncertainties define the future of Arctic marine activity including: the legal and governance situation; degree of Arctic state cooperation; climate change variability; radical changes in global trade; insurance industry roles; an Arctic maritime disaster; new resource discoveries; oil prices and other commodity pricing; and, future marine technologies.

***Destinational Shipping ~** Most Arctic shipping today is destinational (vice trans-Arctic), moving goods in the Arctic for community resupply or moving natural resources out of the Arctic to world markets.

***Arctic Community Impacts ~** Marine shipping is one of many factors affecting Arctic communities, directly and indirectly. The variety of shipping activities and the range of social, cultural and economic conditions in Arctic communities mean shipping can have many effects, both positive and negative.

***Most Significant Environmental Threat ~** Release of oil in the Arctic marine environment, either through accidental release or illegal discharge, is the most significant threat from shipping activity.

***Special Areas ~** There are certain areas of the Arctic region that are of heightened ecological significance, many of which will be at risk from current and increased shipping.

***Central Arctic Ocean ~** Increased traffic for scientific exploration and tourism in the central Arctic Ocean during summer is a reality early in the 21st century.

***Marine Infrastructure Deficit ~** A lack of major ports and other critical marine infrastructure (for example, communications, places of refuge, aids to navigation, icebreakers, traffic monitoring systems, and more) are significant factors and limitations for future Arctic marine operations.

***Lack of Charts and Marine Observations ~** Significant sections of the primary shipping routes do not have adequate hydrographic data to support safe navigation. The operational network of meteorological and oceanographic observations in the Arctic, essential for accurate weather and wave forecasting for safe navigation, is extremely sparse.

***Arctic Traffic Awareness System ~** The maritime Arctic lacks an integrated system for monitoring and tracking of marine activity.

***Ice Navigator Experience ~** Safe navigation in ice-covered waters depends much on the experience and skills of the ice navigator. There are no uniform, international training standards for polar waters.

Table 2. The Arctic Marine Shipping Assessment Recommendations by Theme: A Policy Framework for the Arctic Council (AMSA 2009). Marine infrastructure recommendations are highlighted and expanded below.

I. Enhancing Arctic Marine Safety

A. Linking with International Organizations

B. IMO Measures for Arctic Shipping

C. Uniformity of Arctic Shipping Governance

D. Strengthening Passenger Ship Safety in Arctic Waters

E. Arctic Search and Rescue (SAR) Instrument

II. Protecting Arctic People and the Environment

A. Survey of Arctic Indigenous Marine Use

B. Engagement with Arctic Communities

C. Areas of Heightened Ecological and Cultural Significance

D. Specially Designated Arctic Marine Areas

E. Protection from Invasive Species

F. Oil Spill Prevention

G. Addressing Impacts on Marine Mammals

H. Reducing Air Emissions

III. Building the Arctic Marine Infrastructure (Expanded)

A. Addressing the Infrastructure Deficit

That the Arctic states should recognize that improvements in Arctic marine infrastructure are needed to enhance safety and environmental protection in support of sustainable development. Examples of infrastructure where critical improvements are needed include: ice navigation training; navigational charts; communications systems; port services, including reception facilities for ship-generated waste;

accurate and timely ice information (ice centers); places of refuge; and icebreakers to assist in response.

A. Arctic Marine Traffic Systems

That the Arctic states should support continued development of a comprehensive Arctic marine traffic awareness system to improve monitoring and tracking of marine activity, to enhance data sharing in near real-time, and to augment vessel management service in order to reduce the risk of incidents, facilitate response and provide awareness of potential user conflict. The Arctic states should encourage shipping companies to cooperate in the improvement and development of national monitoring systems.

B. Circumpolar Environmental Response Capacity

That the Arctic states decide to continue to develop circumpolar environmental pollution response capabilities that are critical to protecting the unique Arctic marine ecosystem. This can be accomplished, for example, through circumpolar cooperation and agreement(s), as well as regional bilateral capacity agreements.

C. Investing in Hydrographic, Meteorological and Oceanographic Data

That the Arctic states should significantly improve, where appropriate, the level of and access to data and information in support of safe navigation and voyage planning in Arctic waters. This would entail increased efforts for: hydrographic surveys to bring Arctic navigation charts up to a level acceptable to support current and future safe navigation; and systems to support real-time acquisition, analysis and transfer of meteorological, oceanographic, sea ice and iceberg information.

Table 3. AMSA UNH Workshop Plausible Scenarios on Arctic Marine Accidents and Critical Infrastructure Gaps (AMSA 2009).

Arctic Marine Accident Scenario A ~ <u>Cruise Ship Grounding on the Greenland West Coast</u>
Mid-September; progressive flooding and ship stability problems require abandoning ship; 1400 passengers and 400 crew in life boats and rafts; spill surrounds the ship.

****Critical Infrastructure Gaps: *Minimal charting; no places of refuge identified; salvage and towing more than 7-10 days away; 1800 persons overwhelm SAR forces; onshore, local facilities (housing/food/medical) quickly overwhelmed; late season and an additional cruise ship not in the region*.**

Arctic Marine Accident Scenario B ~ <u>Bulk Ore Carrier Beset in the Central Arctic Ocean:</u>
Attempting September/late season crossing of the Arctic Ocean from the Atlantic to Bering Strait; ice damage to rudder and propeller renders ship not maneuverable; remotest region of the Arctic Ocean; ship's non-ice strengthened hull makes wintering impossible.

****Critical Infrastructure Gaps: *Communications gaps; response ports/bases far from remote region; need for long rage helicopters for crew rescue; potential Russian nuclear icebreakers as only salvage support; no places of refuge identified.***

Arctic Marine Accident Scenario C ~ <u>Ice Management Vessel Fire and Collision with Drill Ship in the Beaufort Sea:</u> Late winter fire aboard an ice management vessel causes collision with drill ship; on boarder between U.S, and Canada 20 nautical miles offshore; spills from both ships; crew injuries.

****Critical Infrastructure Gaps:** ***No salvage capacity available; heavy lift helicopters not readily available; little capacity to support responders (Prudhoe Bay 200 nautical miles away and Tuktoyaktuk, Canada has few resources; no forward deployed (pre-staged) response caches; no places of refuge identified.***

Arctic Marine Accident Scenario D ~ Oil Tanker and Fishing Vessel Collision in the Barents Sea: March with heavy fog; 25,000 barrels of oil lost from the tanker; fishing vessel sank and crew missing; tanker requires towing/salvage; major SAR case and major oil spill response situation.

****Critical Infrastructure Gaps:** ***Large number of SAR and oil spill responders required; no places of refuge identified; weather data gaps; large towing vessels not readily available; lack of adequate transportation for equipment; lack of maps of environmental sensitivity.***

Arctic Marine Accident Scenario E ~ Tug and Barge Grounding on St. Lawrence Island in the Bering Sea: May in broken ice conditions; barge has containers and explosives for mining; incident located near key walrus haul out area; tug and barge separated by several miles; containers in the water and have drifted ashore' tug has ruptured fuel tank.

****Critical Infrastructure Gaps:** ***Communication gaps (no cell phone and satellite phone coverage on the island); explosive and hazardous materials experts must come long distances; good response aircraft & vessel response from Coast Guard & State of Alaska; no place of refuge for damaged vessels; limited resources for housing and feeding responders; remote location and lack of island roads; limited local weather observations; no response equipment stored on the island.***

Table 4. AMATII Project Marine Infrastructure Drivers for Each Arctic State (AMATII 2013).

Canada: *Drivers identified include:* exports leaving the Port of Churchill and Resurrection Bay; small cruise traffic; community resupply to northern communities; the MacKenzie River is a major waterway and connector.

Denmark (Greenland): *Drivers indentified include:* increasing marine tourism; offshore oil and gas exploration; mining in the south; development of a new mine near Nuuq; all traffic is by ship yet there are few infrastructure assets along the eastern coast.

Finland: *Drivers identified include:* exports of wood, metal, iron ore and two refineries (in the Baltic Sea) which is seasonally ice-covered; increasing oil tanker traffic to/from the Russian Federation in the Gulf of Finland; potential exists to build rail connections from northern Finland to Arctic ports in Norway.

Iceland: *Drivers identified include:* year-round (ice-free) maritime travel; energy intensive industry imports raw materials and exports manufactured goods; ferries operate year-round (to Denmark and the Faroe Islands).

Norway**:** Drivers indentified include: cruise ship transits north to south; LNG export out of Hammerfest; Barents Sea fisheries; Port of Narvik export of hard minerals (iron ore from Kiruna, Sweden); offshore oil and gas exploration/production.

Russia: *Drivers indentified include:* recent 50% growth in Northern Sea Route traffic and domestic cargo traffic (food, fuel and minerals); offshore exploration ad productions.

Sweden: *Drivers identified include:* export traffic and cruise ship traffic (in the Baltic Sea); Baltic winter ice cover (January to May).

United States (Alaska): *Drivers identified include:* offshore oil and gas leasing and development; northern mineral deposits (for example zinc ore from the Red Dog mine in northwest Alaska); coastal community resupply by summer barge service.

Table 5. AMATII Project Arctic Aviation Infrastructure Funding by Arctic State (AMATII 2013).

Canada: NAV CANADA is a private, self supporting company with leases for airline agreements negotiated with Transport Canada. Regulation of the industry is federal, but overflights still pay fees to NAV CANADA for air flight services. Operating expenses must match user fees or there will be a reduction in fees for the following years. Contingency funds exist to cover emergency expenditures. NAV CANAD must negotiate with territorial governments for northern airports which are not eligible for matching grants (Transport Canada is responsible for filling gaps).

Denmark (Greenland): As there are no roads, Greenland is solely dependent on air and sea travel. Only two airports are self-sufficiently funded. The Greenland Airport Authority (GAA) is home-rule owned and backed the Government of Denmark. Ownership has been shifting in recent years pushing the economic burden on GAA, including responsibility for a number of remote airports.

Finland: Helsinki is the main revenue airport; others are subsidized by the national government.

Iceland: Iceland follows a European system regarding airport infrastructure and flight operations of airlines. In remote areas, certification is necessary for both infrastructure and operations. Public Service Obligation purpose is to: provide air transportation to remote areas and to ensure the socio-economic benefits. Every three years new contracts to remote locations go to the lowest bidder. Infrastructure is handled separately, with public funding for each project. Airports are funded partially with user fees, supplemented by the government.

Norway: Avinor AS (a state-owned, limited company) owns nearly all airports in the country, with nearly half funded by user fees; all others receive funding from commercial ventures, such as parking and duty free shopping at airports. Only 5 of 46 airports have positive revenue, and they pay for all the rest. Avinor has a contract with each airport until 2015 when there will be a performance review of the largest to determine risk-sharing. Norway has a social contract like Iceland, a duty to keep airports running despite unprofitability. Any expansion must be financed wholly by Avinor.

Russia: The government is reviewing airport infrastructure and support. Most general aviation airports for fixed wing aircraft became helipads without government subsidization (the airports were purchased by private enterprise for helicopters). The federal government subsidizes state-owned companies and works to find economical ways to manage airports.

Sweden: The important airports are owned by a state-owned company. Similar to Norway, the aviation systems are owned by a different entity. There are no government subsidies. In fact, airports must pay returns to the government.

United States (Alaska): The Federal Aviation Administration (FAA) administers the Airport Improvement program (AIP) funding ~ federal dollars from a trust fund acquired from surcharges on every U.S. airline passenger. Alaska receives $200 million per year (for 10 years) but the grant program reflects federal priorities: rural airports; safety projects for certified airports (jet services); rehabilitation programs (pavement); and to large international airports for recapitalization. Future trends indicate that federal funding is shrinking, a major concern for remote aviation infrastructure.

Figures

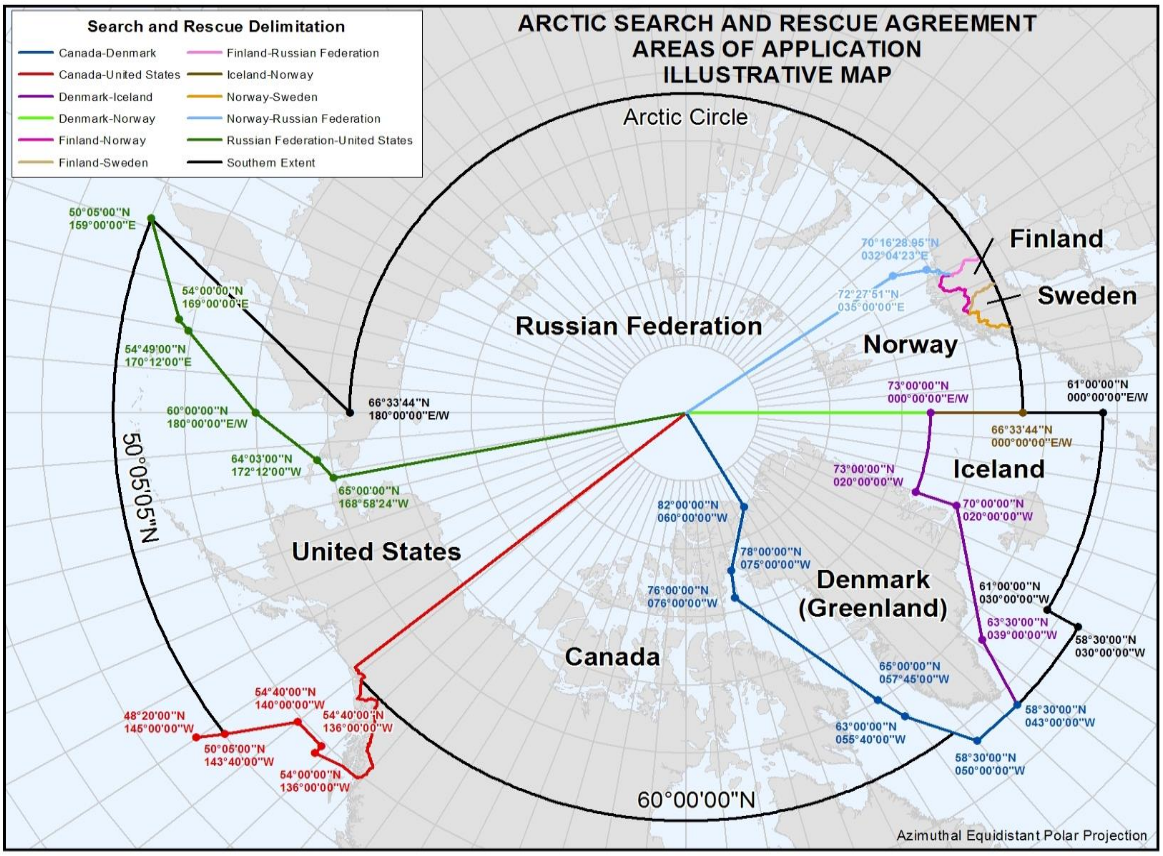

Figure 1. Arctic Search and Rescue (SAR) Agreement Areas of Responsibility for Each Arctic State (Arctic SAR Agreement 2011).

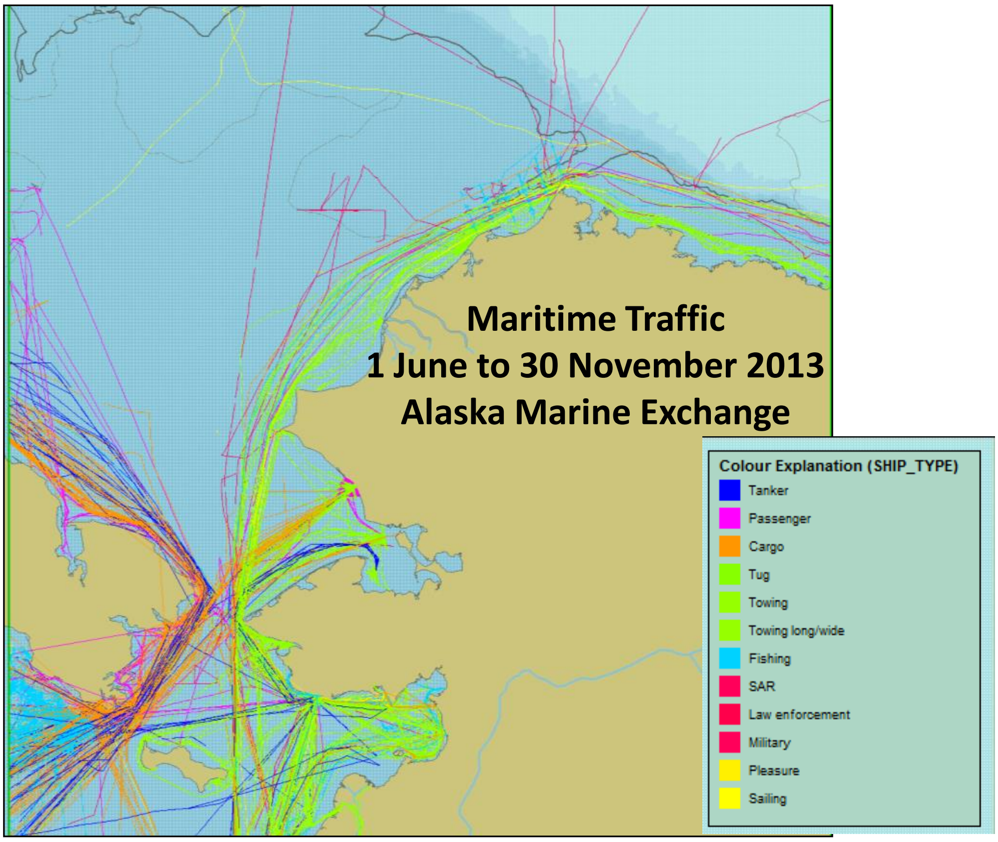

Figure 2. Example of AIS Traffic Data for the U.S. Maritime Arctic, 1 June to 30 November 2013).