THE CONTRIBUTION OF SPACE TECHNOLOGIES TO ARCTIC POLICY PRIORITIES

Polar View

2012

ABOUT POLAR VIEW

Polar View Earth Observation Limited offers integrated monitoring and forecasting services in the Polar Regions, as well as mid latitude areas affected by ice and snow.

Polar View services are designed to address environmental protection, maintenance of traditional ways of life, safety and efficiency of marine transportation, and sustainable economic development. Using satellite earth observation data, in combination with a number of sophisticated models and automatic tools, a wide variety of products are available to monitor sea ice cover, glacier runoff, snow cover, snow melt, icebergs, river ice and lake ice.

Polar View delivers services to stakeholder groups who are interested in issues related to economic development, safety, and the environment in the Polar Regions. These groups include policy makers, government departments, northern residents, and public agencies.

Our team consists of companies, government agencies and research institutes across Europe and Canada, and is the most experienced and comprehensive group in the world of polar earth observation experts. The consortium was originally funded by the European Space Agency under the Global Monitoring for the Environment and Security Service Element programme.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

This report compares the needs of Arctic stakeholders (as articulated in policies and strategies) with the contribution different types of satellite technologies (communications, weather, navigation, earth observation, surveillance, and science) can make to meet current and future requirements. It will help the European Space Agency (ESA) understand Arctic issues, increase the synergy between ESA activities and Arctic initiatives, and assist ESA in preparing relevant Arctic related programme proposals to meet future requirements.

The Arctic is changing. At the root of much of that change is global warming. The Arctic is warming much faster than the rest of the planet, and as a result, sea ice is receding. One impact of this is the opening of Northern sea routes and the prospect of dramatically increased levels of commercial shipping. A second impact is the easier access this provides to the resource wealth of the region - hydrocarbons, minerals, and fish. A third impact is the detrimental effect it is having on land and marine wildlife. These impacts have subsequent reverberations. The increase in economic activity is multiplied many times over as supporting infrastructure and systems are put in place. With the increased activity come pollution and the danger of environmental and humanitarian disasters. With the economic gain comes the desire to protect rights and investments, and the resulting potential for conflict. All of this is at odds with the traditional livelihoods of the Arctic's indigenous peoples.

The world has taken notice of the Arctic – of both the economic opportunities and the environmental threats. So far, there has been a remarkable spirit of cooperation among Arctic stakeholders as they recognize the common problems and needs that they all face.

Not surprisingly, there is considerable interest in the region on the part of the eight Arctic States: Canada, Norway, Iceland, Sweden, Finland, Denmark, Russia, and the United States. That interest has manifested in policies across all areas: safety, the environment, sustainable economic development, sovereignty, and indigenous and social development.

However, non-Arctic states have recently also turned their attention northward. Examples of such countries that have been examined in this report include France, Germany, India, and China. Of particular relevance here is the European Union that has had a northern policy since 1999 and will be issuing a revision in 2012. The interests of these states are focused on economic development, the environment, and safety.

In many cases, the joint interests of nations have been articulated in international agreements of various forms, often under the auspices of international organizations such as the United Nations and its groups. Such agreements tend to be in areas where there are aligned interests among nations, such as search and rescue or environmental protection.

Industry is also focusing on the potential opportunities that the Arctic presents. Industrial interests are obviously in economic development, but there is a realization that such activity must come with safety and environmental responsibility in mind.

The Arctic is a challenging region in which to live and work. Distances are vast, the weather is difficult, and for much of the year it is dark. Although increasing, Arctic populations are small. Space technologies have many attributes that make them ideal for application in the Arctic context. Satellites can see remote areas that could not be accessed in any other way. They can cover wide areas with relatively little infrastructure. And, they can provide types of information that are not available from any other source. Space technologies can contribute to Arctic policy priorities in many ways:

- **Communications** satellites can bring communities across the Arctic and around the world closer together, help bring education and health to isolated people, support the extraction and transportation of natural resources, and facilitate the provision of aid to people in distress.

- **Earth Observation** satellites can help vessels navigate through and around ice and icebergs, monitor pollution and environmental change, locate natural resources, and assist authorities in protecting national borders.

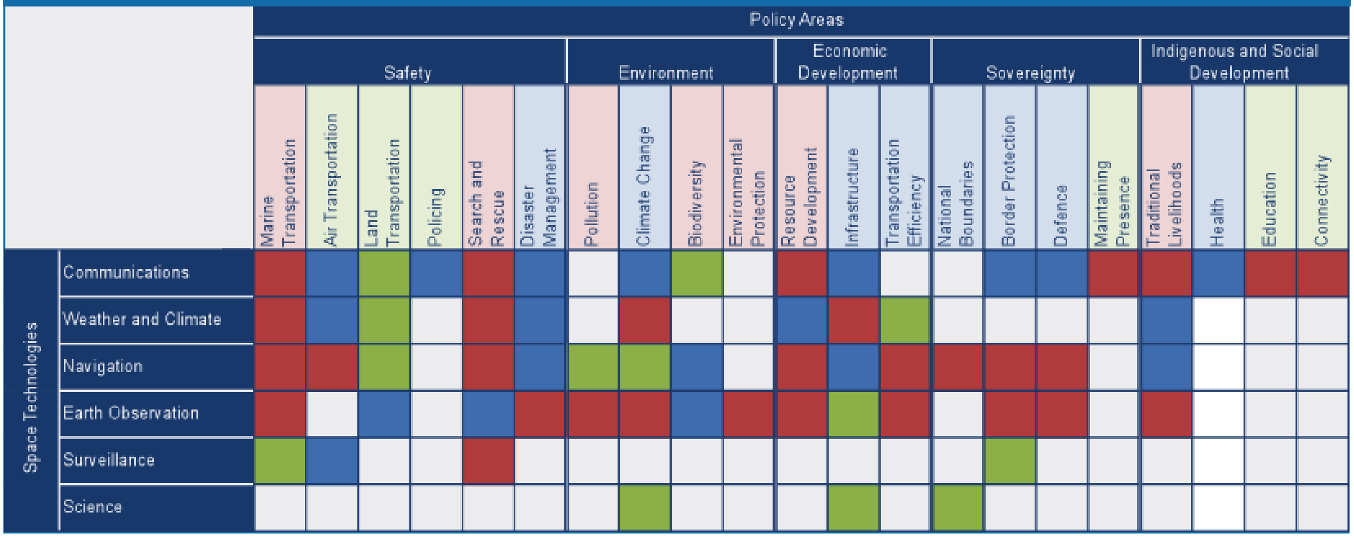
- **Navigation** satellites can help vessels, aircraft, and vehicles navigate more safely and efficiently, provide position information to assist in mapping and surveying in regions that frequently have poor charts available, and aid in locating and tracking vessels and people in distress.

- **Surveillance** satellites can help authorities locate vessels and people in distress, identify illegal activities that endanger ecosystems and resources, and help aircraft and ships avoid collisions.

- **Science** satellites can help protect electricity transmission lines and pipelines from harmful solar storms, provide information that will assist in the delineation of national boundaries, and help to monitor the progress climate change.

The following table summarizes the contribution that six classes of space technologies (communications, weather and climate, navigation, earth observation, surveillance, and science) can make to five key policy areas (safety, environment, sustainable economic development, sovereignty, and indigenous and social development) and their related sub-issues.

The Applicability of Space Technologies to Arctic Policy Areas



The report shows convergence of policies among states, as well as with capabilities of satellites systems. Space technologies have been contributing to Arctic policy priorities for quite some time. However, these assets will need to be renewed and enhanced if the increasing future challenges of the Arctic are to be met. The recent failure of Envisat provides a reminder of the limited life of space assets. And the delays in the launch of the European Sentinel Missions and in the funding of the Canadian Radarsat Constellation Mission are examples of how plans to replace space assets can become undone.

1. INTRODUCTION

In recent years, the uniqueness of northern regions and their importance to the world, including EU member countries, have been recognized and efforts have been made to develop policies in a cooperative manner across regions and nations. These police are aimed at resolving the specific environmental, economic development and social challenges faced by northern communities. The major areas of interest to both international and national northern policy groups can be categorised under five broad policy areas (i) safety (ii) environment, (iii) sustainable economic development, (iv) sovereignty, and (v) indigenous/ social development.

Space satellite systems can be a powerful tool to meet rapidly evolving stakeholder requirements in the northern context. Construction and maintenance of ground infrastructure is difficult due to extreme climatic conditions, low population density and the inaccessibly of the areas of interest. Under these conditions, satellite technology is ideally suited to provide cost-effective and unique opportunities to meet the communication, weather, navigation, observation, surveillance, and scientific needs of those living and working in northern communities in both Europe and North America.

1.1 Objectives

This report is the result of a study conducted for the European Space Agency (ESA) by the following partners in the Polar View network: UNEP/GRID-Arendal; Hickling Arthurs Low Corporation (HAL); Tromsø Centre for Remote Technology; and C-CORE. The project team received input and advice from a wide range of stakeholders through a document and web review, interviews, and in particular from the participants of workshop held in conjunction with the GMES Space and the Arctic 2012 Conference in Copenhagen.

The objective of the study is to provide a comprehensive, coherent perspective on how space-based technologies can support Arctic policies at national, regional, and international levels. The results will help ESA understand Arctic issues, to increase the synergy between ESA activities and Arctic initiatives, and to assist ESA in preparing relevant Arctic related programme proposals to meet future requirementThe study compares the needs of Arctic stakeholders (as presented in the Inventory of Arctic Policies and Industry Interests – Appendix B) with the capabilities of the satellite systems (as present in the Inventory of Space Systems – Appendix C) to meet these requirements and subsequently identify potential linkages. The analysis identifies the contribution each type of satellite technology (namely communications, weather, navigation, earth observation, surveillance, and science) can make to meet current and future arctic policy requirements.

1.2 Report Structure

This report is structured in nine chapters. The second chapter provides a summary of the chapters that follow. The third chapter provides an overview of the contributions and status of space systems. Chapters 4 to 8 present a discussion of each of the key policy areas and the role satellites can play in meeting operational needs related to national, regional, and international policies. Chapter contains the study conclusions. Appendix A provides study references, and Appendices B and C contain inventories of Arctic policies and space systems, respectively.

1.3 Defining Arctic Regions

Historically, the Arctic regions have been viewed as distinctly different from other geographic areas. Northern areas share a unique set of characteristics, including:

- low population densities with wide disparities in living standards;
- sensitive ecosystem of global importance combined with a limited but expanding scientific understating of northern systems;
- prevalence of large remote areas of limited accessibility;
- occurrence of rapidly expanding yet unchecked industrial activities; and
- presence of rich non-renewable and renewable resources.

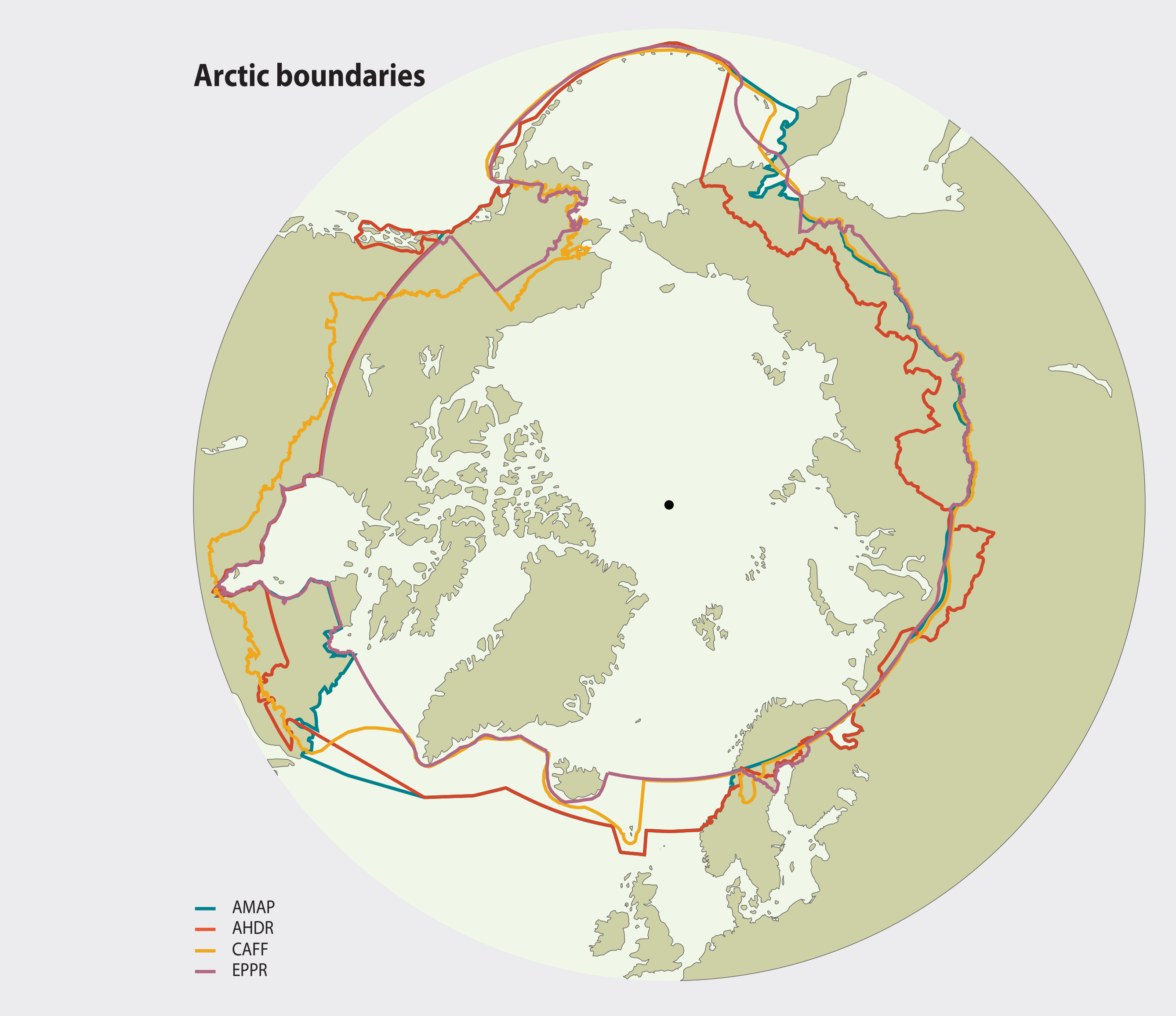
When defining Arctic regions, it is understood that no single, clear cut boundary exists to delineate their extent. Rather, this boundary will change with its application: environmental, biological, economic, jurisdictional, or social. For example the Arctic Council working groups have different definitions that reflect each of their interests.

The Arctic Monitoring Assessment Program (AMAP), which predates the Arctic Council, created its 'AMAP area' as the territory where it would carry out environmental monitoring under the Environmental Protection Strategy. AMAP has defined a regional extent based on a compromise among various definitions. The 'AMAP area' essentially includes the terrestrial and marine areas north of the Arctic Circle (66°32'N), and north of 62°N in Asia and 60°N in North America, modified to include the marine areas north of the Aleutian chain, Hudson Bay, and parts of the North Atlantic Ocean including the Labrador Sea, excluding the Baltic Sea. (University of the Arctic, http://www.uarctic.org/atlasmaplayer.aspx?m=642&amid=5955).

Other Arctic Council working groups such as Conservation of Arctic Flora and Fauna (CAFF) and Emergency, Prevention, Preparedness and Response (EPPR), and the Arctic Human Development Report (AHDR) developed their own boundaries or adapted the AMAP boundary. The CAFF boundary largely follows the treeline in order to include the ecosystems that are the focus of its activities. Similarly, the Arctic Human Development Report needed to be based largely on northern political units, as that is how the majority of socio-economic data and information on northern societies is organized.

The following map presents the Arctic region boundaries as defined by the various Arctic Working groups noted above (UArctic Atlas: Arctic Boundaries).

Figure 1: Boundaries of the Arctic Council Working Groups



For the purposes of this study, a precise definition is not important. Rather, our work has been guided by the definitions of the Arctic policies of the national, regional, international, and private organizations interested in the Arctic.

2. SUMMARY

The following sections summarize the contribution that the six classes of space technologies (communications, weather and climate, navigation, earth observation, surveillance, and science) can make to the five key policy areas (safety, environment, sustainable economic development, sovereignty, and indigenous and social development) and their related sub-issues.

First, Figure 2 maps the different Arctic policies that were reviewed in this study against the policy areas that they address. The relative interest in each policy area, as indicated by the frequency with which it is mentioned in a policy, is indicated by the colour coding of the policy area (low, medium, or high). Then, Figure 3 maps the contribution that each type of space system can make to each policy area (low, medium, or high).

The colour coding of the policy areas and space systems is carried through the subsequent sections:

- High priority policy or relevance of space system
- Medium priority policy or relevance of space system
- Low priority policy or relevance of space system

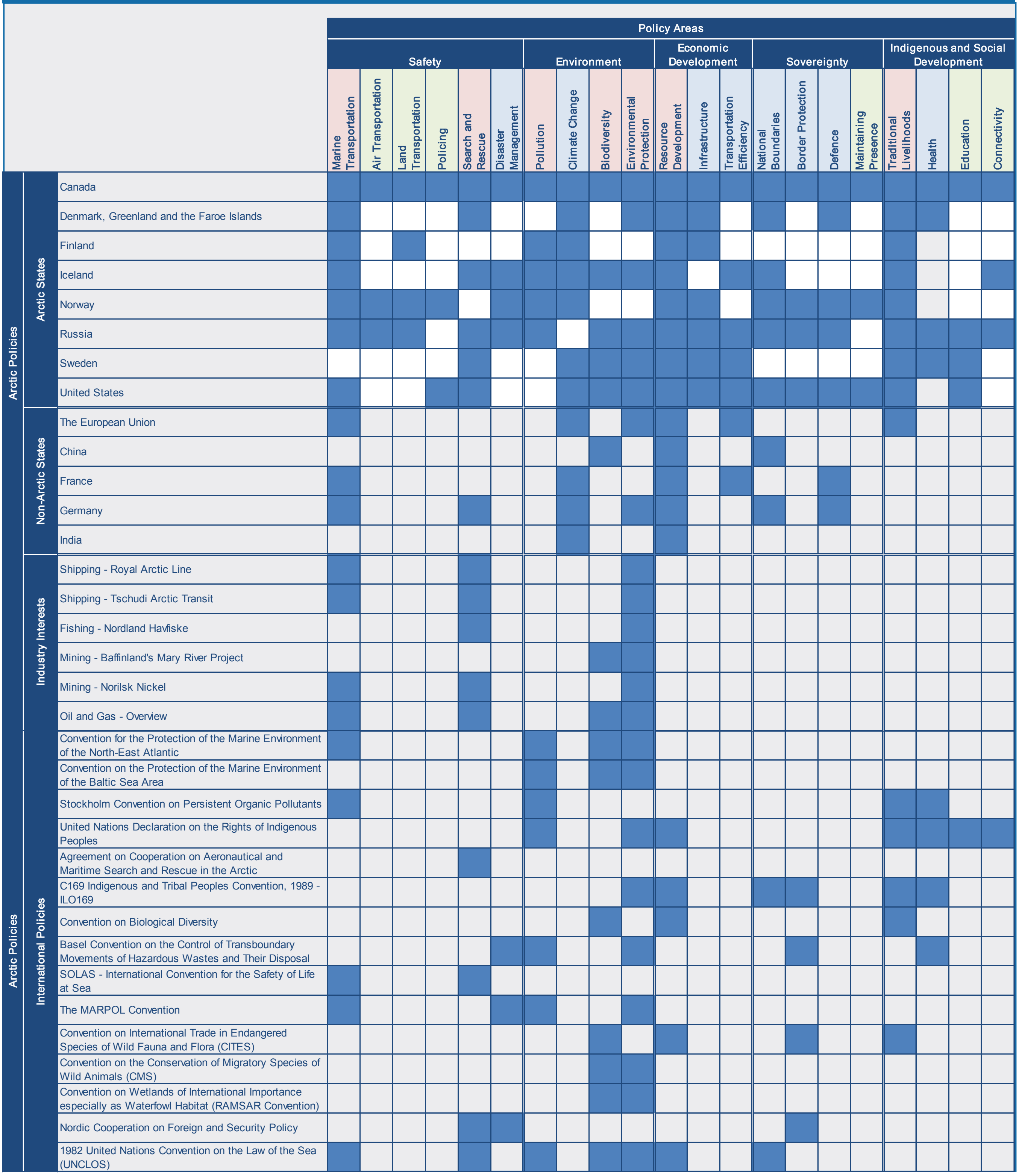
The final section of the chapter reviews the status of the space system classes.

2.1 Safety

2.1.1 Marine Transportation

The primary safety risks for marine transportation in the Arctic are from sea ice, icebergs and ice islands. Not surprisingly, given the

Figure 2: The Policy Areas Addressed by Different Arctic Policies

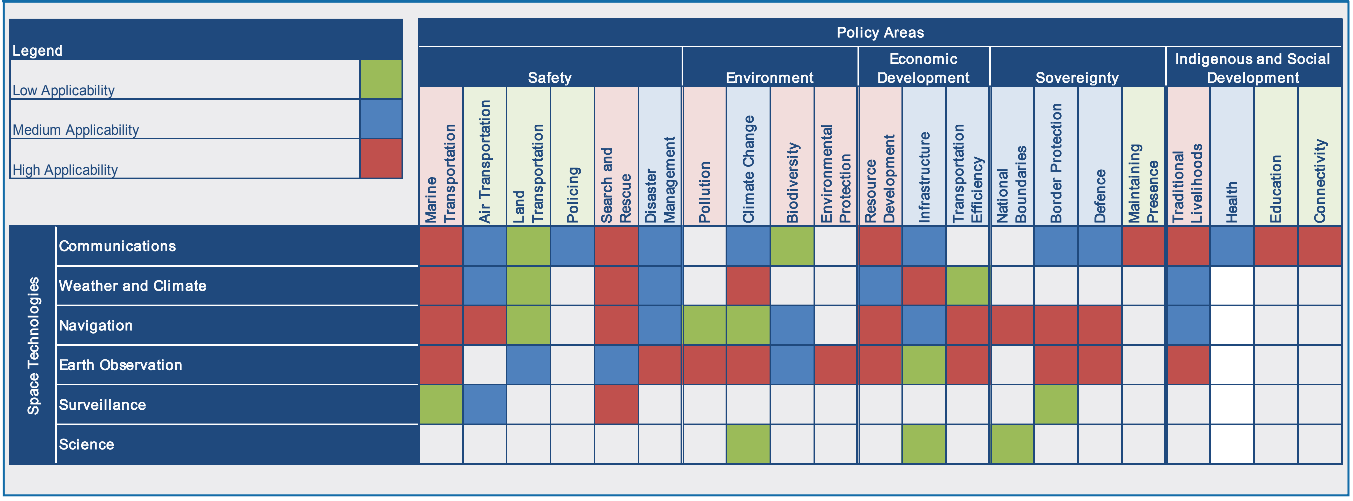


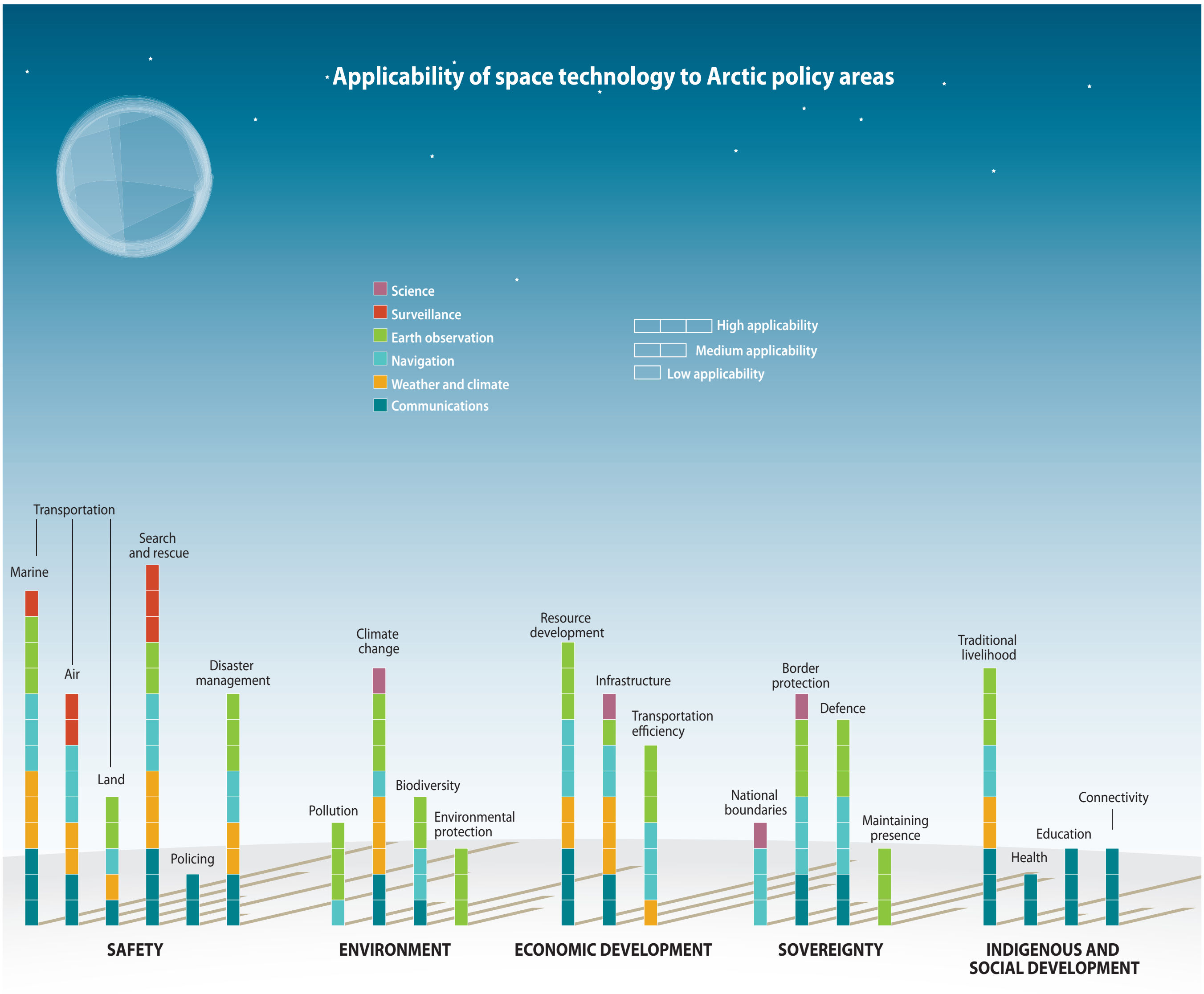
prospects of significantly increased shipping through the Arctic due to reduced ice, marine transportation in the Arctic is a policy objective that is given some prominence by the majority of Arctic nations and the European Union.

Communications – Crew welfare has been the main driver for installation of broadband satellite communication systems on vessels during the recent years. Current required data rates can easily be satisfied by GEO systems below 75°N, but this requirement cannot be met about 75°N. New applications will require higher bandwidths.

Weather – Marine safety is greatly affected by the ability to predict and understand weather patterns. Specialized weather forecasts may also be necessary for off-shore drilling activities to ensure necessary safety precautions are implemented.

Figure 3: The Applicability of Space Technologies to Arctic Policy Areas





Navigation – Marine navigation with GNSS is commonly used along with digital hydrographic charts, integrated into Electronic Chart Display and Information System (ECDIS) technology on the vessel bridge. In the ice infested waters of the Arctic, GNSS is even more critical to ensure the safety of vessels and their crews.

Earth Observation – Critical information on sea ice and iceberg location and characteristics derived from satellite imagery is used routinely for helping to protect vessels in the Arctic from collisions with ice. However, much of the Arctic basin is not covered by operational ice services providing high-resolution products.

Surveillance – Space-based AIS is necessary in the Arctic because of the unacceptably high costs of installing terrestrial AIS infrastructure to cover the long shipping routes in and through the region.

2.1.2 Air Transportation

The primary safety risks arise from loss of communications and navigation capabilities. There is an increased risk in the Arctic due to bad weather and landing surface conditions because of the much more limited number of alternate destinations to which an aircraft can reroute. Air transportation is referenced in only a few of the national Arctic policies.

Communications – The main requirements for satellite communications originate from air traffic services, aeronautical operation control, aeronautical administration communications, diagnostics and in-flight entertainment; the latter having the highest bandwidth requirements, including phone, e-mail and web services for passengers. Aircraft tracking, remote monitoring, and satellite communication as a backup to terrestrial systems (HF and VHF) can be satisfied by current systems, but entertainment service to passengers will require more capacity above 75°N.

Weather – Air transport is greatly impacted by weather patterns and access to reliable and accurate weather services is imperative for safe and effective operations.

Navigation – GNSS is the primary means of air navigation and has increased the safety of aviation by providing accurate, all weather navigation capability. Approaches with vertical guidance require augmentation of GNSS with an augmentation system.

Surveillance – Automatic Dependent Surveillance-Broadcast (ADS-B) is a surveillance technology for tracking aircraft. ADS-B helps to increase safety by pilots having the ability to see, on their in-cockpit flight display, other traffic operating in the airspace, receiving pertinent updates ranging from temporary flight restrictions to runway closings, and by air traffic controllers having the ability to more accurately and reliably monitor their positions.

2.1.3 Land Transportation

The primary safety risks are related to travel over fragile ice and the potential for vehicle submersion if the ice is too weak to support the vehicle. Improvements in land transportation are a priority for many of the Arctic nations.

Communications – Access to reliable satellite based mobile communications services improves the safety of travel in remote areas (e.g., along the ice-edge).

Weather – Access to reliable and timely weather forecasts allows effective route planning.

Navigation – GNSS is particularly important for land transportation off of established routes in the featureless Arctic landscape.

Earth Observation – Safety applications of EO in the Arctic include the surveillance of ice cover on rivers and lakes used as ice roads, and the monitoring of nearshore ice used as hunting gorunds for northern communities.

2.1.4 Policing

In the Arctic region, policing extends beyond law enforcement to include a variety of other sovereignty and security roles. The safety of policing in the Arctic is impacted by the isolation, extreme weather conditions, and dependency on reliable transportation and communications. Only a few of the Arctic nations' policies mention the importance of policing in the region.

Communications – Reliable communications is important for some policing roles, such as search and rescue.

2.1.5 Search and Rescue

Search and rescue (S&R) requirements are expected to grow as economic development and the population of the Arctic increases. S&R response times may be protracted because of the severe climate, great distances involved, and the relative shortage of personnel and equipment. S&R is mentioned in most nations' Arctic policy documents, either as an area where action is intended to be taken, or as an interest in terms of contribution to a multilateral solution for the region.

Communications – Access to reliable satellite based mobile communications services is a necessity for S&R in remote areas for both the parties in distress and the responders.

Weather – S&R situations during inclement weather require accurate weather information to assess which assets may be employed and determine optimal windows for response, while ensuring the safety of search personnel.

Navigation – Some distress alerting devices incorporate their GNSS position in their signals. GNSS is used by responders in planning S&R operations to lay out search patterns and subsequently to systematically navigate over those patterns with GNSS.

Earth Observation – Within an S&R context, EO is used for rapid, synoptic views of the emergency surroundings and the derivation of environmental parameters used to predict search zones. Emergency planning and delivery mechanisms exist that can be invoked to gain priority over all other uses of most EO systems.

Surveillance – The Cospas-Sarsat satellite system provides accurate, timely, and reliable distress alert and location information and is an important means by which S&R authorities are alerted to persons in distress in the Arctic.

2.1.6 Disaster Management

There are four phases of disaster management – mitigation, preparedness, response and recovery, and the latter two are of most significance in the Arctic because of the harsh conditions. The potential for disasters will increase as the accessibility of the region improves and the level of activity grows. This topic is identified in the policies of many of the Arctic nations.

Communications – Access to reliable satellite based communications services is important for disaster response in the Arctic.

Weather – Emergency situations during inclement weather require accurate weather information to assess which assets may be employed and determine optimal windows for response, while ensuring the safety of first responders.

Navigation – GNSS is used during response and recovery efforts for navigation and for the production of real-time mapping of the affected areas in support of the response work.

Earth Observation – EO imagery is used during the planning and response phases of the disaster management cycle. EO can provide detailed information about the extent of the disaster, the type of damage that has occurred, and the areas most severely impacted.

2.2 Environment

2.2.1 Pollution

Air and water pollution and soil contamination are expected to become much more significant problems as the Arctic region becomes more industrialized and marine transportation through Arctic waters becomes commonplace. Dealing with pollution in the Arctic is referenced in most of the Arctic nations' policies.

Navigation – GNSS has a role to play in the reduction of pollution since navigation with the use of GNSS is much more accurate, routing is more efficient and aircraft and vessels consume less fuel and release fewer pollutants into the atmosphere.

Earth Observation – Radar EO is particularly suitable for oil spill detection and monitoring. Multispectral EO is useful for monitoring vegetation stress, algal blooms and variations in water sediment loads that may result from pollution of land and water from mineral extraction, industrial activities and increased human habitation close to water bodies. EO is also useful for regulatory compliance monitoring (e.g., mine rehabilitation and discharge of pollutants).

2.2.2. Climate Change

Climate change is credited as the reasons for the most dramatic changes taking place in the Arctic, including melting of ice sheets, sea ice, glaciers and permafrost, changes in vegetation, and biodiversity impacts. The effect of these changes on the Arctic region and its people are widespread. Climate change is mentioned in the policies of almost all Arctic nations and the European Union.

Communications – Satellite communications have a key role to play in the remote access and delivery of data from automated in-situ monitoring stations in the Arctic.

Weather – Satellite-based time series of surface temperature, tropospheric and stratospheric measurements are used in the calibration and validation of climate models. Meteorological satellites are also monitoring the atmospheric Essential Climate Variables (ECVs), particularly the surface and upper-air elements.

Navigation – The application of GNSS in the climate change context is limited to its use for positioning of in situ sensors that are collecting weather and climate data.

Earth Observation – Satellite imaging is the primary means for monitoring and measuring the major changes on land and water that are attributed to climate change.

Science – Gravity science satellite missions are applicable to climate change due to their contribution to the definition of the geoid as a reference for measurements of sea level change and ice dynamics.

2.2.3 Biodiversity

Signs are evident that climate change is impacting Arctic species, with polar bear, reindeer and caribou, and shorebirds in decline in the High Arctic. Complex interactions between climate change and other factors (e.g., contaminants, habitat fragmentation, industrial development, and unsustainable harvest levels) have the potential to magnify impacts on biodiversity. The importance of biodiversity conservation is explicitly mentioned by most Arctic nations in their policies.

Communications – By tagging animals, such as polar bears and reindeer, with tiny location transmitters, researchers can monitor their movements and study the impacts of the changes taking place in the Arctic.

Navigation – GNSS, in conjunction with satellite-based communications, help in the monitoring of wildlife populations using animal tags. Positioning information is also used in mapping wildlife habitats.

Earth Observation – Combining information about the known habitat requirements of species with land cover derived from satellite imagery, scientists can estimate potential species ranges and patterns of species richness.

2.2.4 Environmental Protection

Environmental protection is particularly critical in the Arctic because the region is highly sensitive to pollution and its human population and culture is heavily dependent on the health of the region's ecosystems. In 1991, the Arctic nations approved the *Arctic Environmental Protection Strategy*, and protection of the environment and conservation of vulnerable species is a policy priority for the majority of Arctic nations and the European Union.

Earth Observation – EO is used to help monitor regulatory compliance, such as fishing quotas, and environmental remediation, such as at mine sites. EO is also used for monitoring and tracking atmospheric pollution and trace gases. This is of particular relevance to the Arctic, which receives contaminant deposits via the long range transport of pollutants from southern latitudes.

2.3 Sustainable Economic Development

2.3.1 Resource Development

Economic development is among the main policy priorities of all the Arctic states in question, as well as the European Union. Generally this refers to exploitation of natural resources; both renewable resources such as fisheries and forestry, and non-renewable ones, particularly hydrocarbon energy and mineral resources. There are also growing economic activities such as tourism and shipping. Throughout these policies and national strategies, there is a consistent focus on the sustainable use of natural resources in what is clearly recognized as a fragile environment.

Communications – In the resource development context, high bandwidth is particularly critical for the transmission of large volumes of digital satellite imagery data connected with the exploration, planning and operational phases of resource extraction.

Weather – Operational activities, such as off-shore drilling and fishing, need reliable and timely information about the weather.

Navigation – GNSS provide the critical positioning, navigation and timing services that are essential for Arctic operations, including mapping, positioning of resources, and movement of people and goods under extreme conditions.

Earth Observation – The use of EO technologies has value in many stages of resource development projects including resource exploration and identification, infrastructure construction and operation, site monitoring (such as tailings size calculations), and safety of operations. It is also connected with the monitoring and mitigation of environmental impacts from resource extraction.

2.3.2 Infrastructure

Policies related to economic development, in most cases, also recognize the critical need for improvements to regional infrastructure related to transportation (ports, terminals, and airports), communications, networks, and border crossings.

Communications – The applications of communications systems for infrastructure are similar to the requirements for resource development. Effective communications systems are necessary for the construction and ongoing maintenance of both the ICT and transportation and energy infrastructures in the Arctic.

Weather – Of particular concern in the Arctic region is permafrost and its impact on physical infrastructure. The warming climate is thawing permafrost, posing several risks including loss of mechanical strength of structures (foundations, pilings) due to freeze and thaw cycles. Improper design and construction methods have led to structural failure, expensive fixes and/or abandoned facilities. Global warming also accelerates the erosion of shorelines and riverbanks, threatening the infrastructure located in these areas.

Navigation - GNSS applications that are necessary to infrastructure development include: position determination for planning and design; positioning of infrastructure right of ways and easements; precise positioning of infrastructure components; and navigation to infrastructure sites for repair and maintenance work. The precise timing capability of GNSS is also used by power generation companies to synchronize frequencies and to analyze problems.

Earth Observation – EO has only limited applications in infrastructure development in the Arctic, primarily in the preliminary planning for location of assets, where high resolution optical imagery is a useful tool for investigating location and routing alternatives.

Science – An improved understanding of space weather will assist in the mitigation of potential impacts on technology systems and infrastructure (i.e., communication cables, power systems, pipelines and radio communication and navigation systems).

2.3.3 Transportation Efficiency

Transportation efficiency is mentioned in the policies of most Arctic nations and the European Union. Much of the focus is on cross polar air routes and the northern sea routes for international trade.

Weather - Access to reliable and timely satellite weather forecasts is important for effective and cost-efficient route planning for marine, land and air transportation.

Navigation – GNSS permits more precise and direct routes to destinations and around obstacles such as ice and weather.

Earth Observation – EO is necessary for the production of ice the charts used for marine navigation. For land navigation, real-time information on the ice edge, ice ridges and open water leads to better planning, which subsequently enables navigation via the shortest and safest route, important in reducing travel time, fuel costs, equipment wear and greenhouse gas emissions.

2.4 Sovereignty

2.4.1 National Boundaries

National boundaries feature in most of the Arctic nation policies. Countries need to determine the shape of the seabed, depth of seafloor and thickness of the underlying sedimentary layer in order to justify the limits of their territory under the UN Convention on the Law of the Sea (UNCLOS).

Navigation – GNSS is used to determine the position of the equipment that measures the parameters necessary for the UNCLOS calculations.

Science – Gravity science satellite missions are applicable to boundary measurements due to their contribution to the definition of the geoid.

2.4.2 Border Protection

Protection of extensive national borders in the remote areas of the Arctic is of growing interest to most Arctic nations. Border protection usually includes the dual mandate of managing access to borders by people and goods moving over land, by sea and by air, while maintaining the integrity of the border and providing protection from threats to its security and prosperity.

Communications – Robust and reliable communications systems (high speed internet and mobile phones) support both the security and operational needs of border protection activities.

Navigation – Border control officers employ GNSS in their vehicles, vessels, or aircraft for navigation purposes and in some cases for determining in which jurisdiction or restricted area the incident occurs.

Earth Observation – High resolution imaging systems help to ensure positive identification of illegal activities.

Surveillance – S-AIS, correlated with other sensors and information sources, such as EO can be used to help ensure compliance with areas of operation and help to identify vessels engaged in illegal activities.

2.4.3 Defence

In addition to the military responsibilities of protecting national territory, airspace and maritime areas of jurisdiction, defence organizations often support civil organizations in a variety of roles, such as emergency preparedness and disaster response. Most Arctic nations identify defence in their policies.

Communications – Robust and reliable communications systems support military operations.

Navigation – GNSS is important for military applications, and defence organizations typically have access to better navigation and positioning capabilities than do civilian users. Current use in the Arctic is primarily for military training exercises and disaster response.

Earth Observation – Defence organizations use the full range of commercial EO imaging services and have access to classified EO technologies that are not accessible to civilian users. In the Arctic context, the primary EO applications are in support of wide-area surveillance efforts, military training exercises, emergency response to environmental disasters and search-and-rescue missions.

2.4.4 Maintaining Presence

A strong presence in the Arctic enhances an Arctic nation's ability to protect and monitor the land, sea, and air of their region, and demonstrate their sovereignty over the region. This policy objective is of a few of the Arctic nations' policies.

Communications – Affordable and modern communication technology helps to improve the lives of isolated northern communities.

2.5 Indigenous and Social Development

2.5.1 Traditional Livelihoods

Preservation and respect for traditional ways of life are key priority areas in all of the Arctic nation's policies and the European Union. Areas related to culture and traditional ways of life include the impacts of climate change on indigenous cultures, and the preservation of indigenous languages and traditional knowledge. Health and self-sufficiency are also areas of concern.

Communications – Affordable and modern communication technology in isolated northern communities can play a role in improving the lives of northern communities. Satellite communication can be used to contact emergency services, increase contact among indigenous groups, strengthen feelings of identity, increase economic prospects, and increase indigenous peoples' political participation. Satellite systems can also help ensure safe hunting and fishing expeditions.

Weather – The need for accurate, timely weather forecasts to ensure safe travel (in particular on hunting and fishing expeditions) and to plan daily activities is important for inhabitants of northern communities.

Navigation – GNSS has a positive impact on the safety of travel and enables navigation via the most efficient route, which is important in reducing travel time, fuel costs, equipment wear, and greenhouse gas emissions.

Earth Observation – EO can be used to produce maps and other real-time information products that allow hunters and fishers to safely bypass dangerous areas including ice ridges, moving ice or stretches of open water. With this additional information hunters/fishers are better able to plan the shortest and safest route to the ice-edge. The information is vital to augmenting traditional knowledge that previously guided travel routes, but which is now impacted by climate change, thus making it less reliable.

2.5.2 Health

Health Care services and facilities are generally limited in the Arctic, and may be inaccessible or difficult to access by a significant proportion of the population, making the use of air transportation particularly critical. New services such as telemedicine are promising but require robust and reliable high bandwidth communications. A few Arctic nations reference health care as part of their policies.

Communications – Requirements in support of health care include high-band width video and file transfer for telehealth, and reliable voice communications for the emergency transport of patients.

2.5.3 Education

A few Arctic nations' policies consider the education of northern residents.

Communications – Access to broadband internet can facilitate distance learning, on-line courses, file sharing, video uploads and other on-line educational support tools.

2.5.4 Connectivity

A few Arctic nations' policies noted that modern communication technologies can support economic development, improve quality of life and strengthen cultural identity.

Communications – The need for modern communication technology in isolated northern communities is considerable, and access to affordable, reliable, high-speed digital connectivity systems can play a decisive role in improving the lives of northern people and linking them to other communities.

2.6 Satellite Systems

2.6.1 Communications

Space-based systems are among the best methods for providing communications across the vast, but sparsely populated, Arctic. Current demand below 75°N (in most cases) is being met by existing GEO systems. Above 75°N, there is a gap in coverage, with existing systems providing unreliable, limited capacity and low data rates. Most of the demand above 75°N will be from vessels and aircraft.

Several systems are currently being explored to bridge this service gap that involve multiple satellites in highly-elliptical polar orbits. Many of these projects are scheduled for launch in 2015 to 2016 and beyond (e.g. Iridium NEXT, CASSIPE, KosmoNet, Inmarsat Global Xpress, PCW). Services may still require trade-offs between data speed and number of users (capacity). Technical verification of future systems is under review.

Policy Relevance:

- Sovereignty (Border Protection, Defence, Maintaining Presence)
- Safety (Marine, Land and Air Transportation, Policing, Health, S&R, Disaster Management)
- Environment (Climate Change, Biodiversity)
- Economic Development (Infrastructure, Resource Development)
- Indigenous and Social Development (Traditional Livelihoods, Education, Connectivity)

2.6.2 Weather and Climate

Current systems are geostationary in near-equatorial orbits and are unable to provide data on high-latitude atmospheric conditions; the more northerly remote areas of Europe are on the periphery of such system's field of view. Since 1998, the councils of EUMETSAT, ESA and NOAA have worked to jointly develop satellite systems that will monitor weather and climate change over the poles. Current weather satellite systems that look to the Polar Regions employ Low-Earth Orbits that provide high-quality spatial resolution information over high latitudes but on a narrow flight path – sometimes taking 6 hours before the same area is imaged again (e.g. Metop, NOAA-19).

Several missions are proposed to be implemented over the next 10 years to address the deficiencies of current systems (e.g., Arktika, CARVE, CASSIOE, Meteosat Third Gen). In addition to improved imagery at more frequent repeat cycles, the provision of data from the infrared and ultraviolet/visible sounding missions will help derive improved forecasts.

Policy Relevance:

- Safety (Marine, Land and Air Transportation, S&R, Disaster Management)
- Environment (Climate Change)
- Economic Development (Resource Development, Infrastructure, Transportation Efficiency)
- Indigenous and Social Development (Traditional Livelihoods)

2.6.3 Navigation

Global navigation satellite systems (GNSS) are used in the Arctic as the preferred method of navigation for transportation and a variety of other positioning and timing applications. GNSS have some limitations in higher latitudes. For example, the declination of current GNSS satellite orbits leads to low elevation angles in polar areas and the geosynchronous satellites used for augmentation of GNSS signals do not reach to the high Arctic. Also, heightened ionospheric activity at the poles can result in signal delays and variability in location response.

The existing GPS system (USA) is undergoing modernization to 2025 and beyond, which involves the addition of: a second civilian GPS signal (L2C) for improved performance in commercial applications; a third civilian GPS signal (L5) for transportation safety; and a fourth civilian GPS signal (L1C) for international interoperability. It also involves improvements to the GPS control segment.

Compass /Beidou-2 (China) is implementing a regional system to provide service for areas in China and its surrounding areas in 2012, with global service being provided by 2020.

Galileo (EU) is expected to be fully operational by 2020. By placing satellites in orbits at a greater inclination to the equatorial plane than GPS, Galileo will achieve better coverage at high latitudes.

Policy Relevance:

- Sovereignty (National Boundaries, Border Protection, Defence)
- Safety (Marine, Land and Air Transportation, S&R, Disaster Management)
- Environment (Climate Change, Biodiversity, Pollution)
- Economic Development (Infrastructure, Resource Development, Transportation Efficiency)
- Indigenous and Social Development (Traditional Livelihoods)

2.6.4 Earth Observation

Given the Arctic region's spatial extent, remoteness and isolation, earth observation is frequently the only cost effective and technically feasible means of obtaining reliable information in a timely fashion. EO applications of particular relevance to the Arctic include: the mapping and characterization of snow and ice cover (land and sea ice); the systematic monitoring of shipping routes to detect vessels and icebergs; the assessment of land stability within permafrost regimes; and the description of land cover and land cover changes, often within the context of climate change. Limitations of current EO systems are largely due to limited spatial coverage and revisit frequency, which particularly affects the generation of high-resolution products over large areas, and frequent cloud cover and shortage of daylight in the winter, which limits the use of optical sensors.

The recent loss of Envisat and its synthetic aperture radar (SAR) sensor was a significant loss for Arctic monitoring. The future EO sensors of most importance for Arctic applications are the proposed Sentinel 1 (EU) and Radarsat Constellation (Canada) SAR satellites. These satellites will offer increased frequency of coverage and higher resolutions, important for such applications as S&R, ice products for transportation, biodiversity studies, and disaster response.

Policy Relevance:

- Sovereignty (Border Protection, Defence)
- Safety (Marine, Land and Air Transportation, S&R, Disaster Management)
- Environment (Pollution, Climate Change, Biodiversity, Environmental Protection)
- Economic Development (Infrastructure, Resource Development, Transportation Efficiency)
- Indigenous and Social Development (Traditional Livelihoods)

2.6.5 Surveillance

Space-based surveillance systems are useful sources of information for sovereignty and safety applications in the Arctic. The expansion of movement through the Arctic enabled by climate change is increasing the need for effective Search and

Rescue (S&R) capabilities and the protection of borders from movement of illegal goods.

Satellite-based Automatic Identification Systems (S-AIS) signal reception is the only cost-effective means of monitoring shipping in the region.

The next generation of the international distress alert detection and location system, COSPAS-SARSAT, will have S&R beacon signal repeaters hosted on GNSS satellites. Funds have been committed for development of a proof-of-concept (POC) system for the Distress Alerting Satellite System (DASS) (Canada-USA), which is intended to enhance the COSPAS-SARSAT system by installing transponders on the GPS satellites and introducing new ground segment tracking stations and processing algorithms.

Policy Relevance:

- Sovereignty (Border Protection)
- Safety (Marine and Air Transportation, S&R)

2.6.6 Science

There are a number of dedicated satellite missions that have been launched to address specific scientific objections; particularly relevant to understanding gravity fields and space weather (GOCE, GRACE, ACE, Cluster II) space weather systems can provide advanced warning of geomagnetic storms that can overload power grids and disrupt communications and pipeline systems in the Arctic regions, which are particularly vulnerable to these disturbances. Gravity satellite missions are crucial for deriving accurate and detailed measurements of ocean circulation and sea-level change, both of which are affected by climate change and subsequently impact Arctic interests.

Future systems (RBSP, ERR, MMS) will focus on research that will improve the understanding and eventually prediction of, hazardous events in the Earth's radiation belts and magnetic fields. These disturbances can subsequently impact both space-born and ground–based technologies, which are critical for providing communication services to the Arctic as well as supporting monitoring and surveillance activities. Gravity missions will also assist scientists to map, with precision, the uniformity of Earth's gravitational fields which are of particular interest in the Arctic, giving scientists a better understanding of the structure of the Earth.

- Sovereignty (National Boundaries)
- Environment (Climate Change)
- Economic Development (Infrastructure)

3 THE STATUS OF SPACE SYSTEMS

Space systems provide unique opportunities to meet the needs of northern stakeholders concerned with safety, the environment,

Figure 4: Space Technologies and Policy Drivers

sustainable economic development, sovereignty, and indigenous rights and social development.

The following sections provide an overview of the application of the different categories of satellite systems in the Arctic and their current status. Although the use of space-based technologies is frequently limited to a single type of application, or even a single mission, it should be noted that new opportunities for applications will arise from the simultaneous use of two or more types of these technologies. It should also be noted that some satellite systems are multipurpose and can fall into more than one of the categories (e.g., many earth observations systems could also be categorized as surveillance or weather and climate systems, and many science missions primarily serve weather and climate change applications).

3.1 Communications

Space-based systems are among the best methods for providing communications across the vast, but sparsely populated, Arctic. Where satellite-based communications are available, the technology is critical for environmental, economic, security and social concerns in the Arctic. Applications to support both the local community, civilian government (coast guard and local authorities), as well as the military, require a range of connection speeds, which can mostly be satisfied below 75^{0}N with the existing geostationary communications satellites (Inmarsat, Eutelsat, Iridium, Globalstar). Capacity is currently sufficient above 75^{0}N, mostly because there are few settlements in this area and they require only voice or LDR communications.

However, this will change as new businesses and commercial activities push further north and demand increases for high band width applications (such as health/wellness, marine and air transportation, entertainment). Current systems will be unable to provide adequate service (speed or capacity) above 75° latitude north, thus creating a gap in capabilities. Several systems are currently being explored to bridge this service gap that involves multiple satellites in highly-elliptical polar orbits. Some of these projects are scheduled for launch in the next few years and beyond (e.g., Iridium NEXT, CASSIPE, KosmoNet, Inmarsat Global Xpress, PCW/Canada, Polar Milsatcom/USA, Meridian/Russia).

3.2 Weather and Climate

Operational and science-oriented activities related to the monitoring of weather and climate rely heavily on global networks of dedicated meteorological satellites. As with communications satellites, many of the space-based weather observation platforms are geostationary in near-equatorial orbits and are also unable to provide data on high-latitude atmospheric conditions. The more northerly remote areas of Europe and Canada are on the periphery of such system's 'field of view'. EUMETSAT, ESA, and NOAA have been working since the late 1990s to jointly develop satellite systems that monitor weather and climate change over the poles. Current weather satellite systems that collect data over the polar regions employ Low-Earth Orbits that provide high-quality spatial resolution information over high latitudes but on a narrow flight path – sometimes taking 6 hours before the same area is imaged again. (e.g., Metop). Several missions are proposed to be implemented over the next 10 years to address the deficiencies of these systems. (e.g. Arktika, CARVE, CASSIOE).

3.3 Navigation

The impacts of climate change in the Arctic are making the region increasingly accessible. As a result, the northern sea routes are expected to attract growing levels of ship traffic through the Northeast and Northwest Passages. Low ice conditions also exposes new areas for resource exploitation, contributing to increased Arctic traffic and higher demand for navigation services in the region. Global Navigation Satellite Systems (GNSS) are the navigation technology of choice by the majority of vessel operators. In addition to supporting vessel traffic and industrial operations, GNSS also provide individuals travelling on ice and on land with accurate and reliable location information. GNSS have some limitations in higher latitudes as the geosynchronous satellites used for augmentation of GNSS signals do not reach to the high Arctic. Also, the declination of current GNSS satellite orbits leads to low elevation angles in polar areas. Furthermore, heightened ionospheric activity at the poles can result in signal delays and variability in location response.

Currently, the system that is in most common use is the US Global Positioning System (GPS), but other GNSS, such as Russia's GLObal NAvigation Satellite System (GLONASS) and the emerging EU Galileo system, are also applicable for this task. GPS and GLONASS are mature systems, having been operational since the mid-1990s. Galileo is not scheduled to be fully operational before 2019, but the addition of the planned full constellation of Galileo navigation satellites will provide more position fixes that will improve the accuracy of navigation and positioning in the Arctic.

GNSS have some limitations in higher latitudes. For example: geosynchronous satellites used for augmentation of GNSS signals do not reach to the Arctic region; the declination of current GNSS satellite orbits leads to low elevation angles in polar areas; and heightened ionospheric activity at the poles can lead to lower positioning and navigation accuracies. The addition of the planned full constellation of Galileo navigation satellites will provide more position fixes that will improve the accuracy of positioning required to achieve more efficient transportation in the Arctic.

3.4 Earth Observation

Earth Observation (EO) is a powerful tool in the Arctic context. Given the Arctic region's spatial extent, remoteness and isolation, remote sensing is frequently the only cost effective and technically feasible means of obtaining reliable information in a timely fashion. While modern space-borne sensors satisfy a wide range of monitoring and mapping applications, capabilities of particular relevance to the Arctic include the mapping and characterization of snow and ice cover (land and sea ice), the systematic monitoring of shipping routes to detect vessels and icebergs, the assessment of land stability within permafrost regimes, and the description of land cover and land cover changes, often within the context of climate change. EO is used to address both operational as well as science objectives.

There are a large number of current and proposed EO satellites operating across the range of the electromagnetic spectrum. Due to prevalent cloud cover combined with the absence of solar illumination for much of the year in the Arctic, synthetic aperture radar (SAR) sensors are particularly relevant, such as Radarsat 1&2 (Canada), TerraSAR-X (Germany), and COSMO-SkyMed (Italy). Specialized satellites such as Cryosat (ESA) measure the extent and thickness of Arctic sea ice. High resolution optical imaging satellites include SPOT and Pleiades (France), and GeoEye and QuickBird (US).

Limitations of current systems in the Arctic are largely due to limited spatial coverage and revisit frequency which particularly affects the generation of high-resolution products over large areas. In addition, the availability of image data in near-real-time is dependent on ground station coverage and satellite onboard resources.

Europe is building the next generation of EO satellites designed to continue and build on current capabilities in SAR (Sentinel-1), high resolution optical (Sentien-2), ocean sensors (Sentinel-3) and atmosphere (Sentinel-4). In Canada, the RADARSAT Constellation mission will provide continuity and improved coverage for SAR. The recent loss of ENVISAT increases the urgency for these new missions.

3.5 Surveillance

Satellite-based surveillance technologies provide vital information to stakeholders concerned with both sovereignty and safety. There are three satellite-based systems that help authorities keep track of the increasing marine and aviation activity in the Arctic.

Search and Rescue

Satellite S&R systems can provide a cost-effective means of ensuring lifesaving capabilities for polar accidents. COSPAS-SARSAT (COSPAS is an acronym for the Russian words "Cosmicheskaya Sistema Poiska Avariynyh Sudov", or Space System for the Search of Vessels in Distress, and SARSAT is Search and Rescue Satellite-Aided Tracking system) provides accurate, timely, and reliable distress alert and location information to help search and rescue authorities assist persons in distress. The system was established in 1979 by Canada, France, the United States, and the former Soviet Union, and today the system has 43 participating countries and has been instrumental in saving more than 28,000 lives worldwide.[1]

Marine Traffic Control

Commercial S-AIS services are provided by exactView (Canada) and ORBCOMM (US). Both suppliers have plans to expand their satellite constellations. Norway is operating an S-AIS nanosatellite and is expected to launch a second satellite in 2012 to provide increased coverage. While these services have been available for some time, there are still issues with signal collisions, interference, time latency and update frequency. Expansion of the satellite constellations that service the Arctic is necessary to ensure that AIS will fully meet the safety standards required for marine transportation.

Air Traffic Control

Automatic Dependent Surveillance – Broadcast (ADS-B), a significantly lower cost and higher performance technology for tracking aircraft than radar. The system relies on two avionics components – a high-integrity GNSS navigation source and a satellite data link (ADS-B unit). ADS-B uses GPS-supplied target information from aircraft as the basis for air traffic controllers to determine aircraft locations. ADS-B is currently being used for the high level airspace over Alaska, Hudson Bay, the high Arctic over Baffin Island, and along the coast of Newfoundland. It will be extended out over the ocean by 2012, with receiving sites that have been put in place on the southern tip of Greenland to cover a portion of their North Atlantic airspace, and will probably cover all of the Arctic in five years[2].

3.6 Science

While the majority of EO systems are also used by scientists and researchers around the globe, a number of dedicated satellite missions have been launched to address specific scientific objectives (e.g., ESA Earth Explorers). The gravity field of the Arctic Ocean region is of importance for global gravity field models, for geology and tectonics, as well as for navigation and orbit determination. For gravity satellite missions (e.g. GOCE/EU, GRACE/USA), the determination of gravity field models is affected by the lack of satellite coverage around the poles, resulting in relatively large errors in the coefficients for the region.

Space weather has a variety of impacts on technology, both in space (satellites and manned missions) and on the ground (pipelines, power systems, communication cables). Space weather phenomena occur when energetic particles thrown out from the Sun interact with the earth's magnetic field producing magnetic disturbances and increased ionization in the ionosphere, between 100 and 1,000 km above the earth. While the Sun is the main driver of space weather impacts, other factors (e.g., radiation belt dynamics) also play an important role. Since the earth's magnetic field is concentrated at the poles, high latitudes are particularly impacted by these disturbances. Planned satellite missions proposed to monitor the radiation belts include ERG/Japan, MMS/USA and RBSP/USA.

4. SAFETY

4.1 Marine Transportation

4.1.1 Overview

Marine transportation involves the movement on water of passengers and freight in the deep sea, and in coastal, harbour and inland water areas using a variety of vessels (e.g., passenger ships, tankers, freighters, barges and ferries). In the Arctic context, marine transportation can be considered to consist of the following modes or types of voyages (Arctic Council, 2009):

- *Destinational transport*, where a ship sails to the Arctic, performs some activity in the Arctic and sails south

- *Intra-Arctic transport*, a voyage or marine activity that stays within the general Arctic region and links two or more Arctic states

[1] David Affens, et al, 2011. Innovation: The Distress Alerting Satellite System, GPS World, January 1, 2011, (see http://www.gpsworld.com/gnss-system/innovation-the-distress-alerting-satellite-system-10883)
[2] Information provided by interviewee

- *Trans-Arctic transport* or navigation, voyages which are taken across the Arctic Ocean from Pacific to Atlantic oceans or vice versa

- *Cabotage*, To carry cargo between two points within a country by a vessel or vehicle registered in another country

The primary safety risks for marine transportation in the Arctic are from various forms of ice, including: sea ice (ice of various ages that results from the freezing of the sea surface); icebergs (large masses of ice originating from glaciers); and ice islands (vast tabular icebergs originating from floating ice shelves).

4.1.2 Policy

Not surprisingly, given the prospects of significantly increased shipping through the Arctic due to the reduction in sea ice as a result of global warming, marine transportation in the Arctic is a policy objective that is given some prominence by the majority of Arctic nations.

- *Canada's Northern Strategy: Our North, Our Heritage, Our Future* identifies the strengthening of its land, sea and air capability and capacity as an implementation activity to strengthen its presence in the Arctic.

- The *Kingdom of Denmark Strategy for the Arctic 2011–2020* places high importance on safety of marine transportation in the Arctic and Denmark has introduced improved control of cruise ships planning to sail to Greenland. New electronic nautical charts are being prepared for the busiest Greenland waters to ensure that they meet the demands of navigation based on GNSS. Another priority is adaptation of the existing Ice Services to the increased requirements for observation, forecasting and dissemination of ice conditions in Greenland waters due to changing climatic conditions and altered distribution of sea ice. In addition, enhanced surveillance of maritime traffic in the Arctic (e.g., with satellite based Automatic Identification System signal detection or S-AIS) will contribute to improved prevention of accidents and coordination of rescue efforts.

- Norway's Government White Paper, *The High North – vision and means* notes that government policy will lead to increased navigation and drilling in the Barents Sea, which will create challenges connected to monitoring, oil spill response and evacuation. Monitoring ice extent and ice drift as an important navigational hazard will be critical, and voice communications and broadband connections in the high north will become important, both for day to day use and in emergencies.

- The *Iceland in the High North* report notes concern about the growing number of inadequately equipped cruise ships in ice-infested areas and states as a priority the encouragement of the International Maritime Organisation (IMO) to update and make mandatory application of relevant parts of the Guidelines for Ships Operating in Arctic Ice-Covered Waters. Furthermore, Iceland believes that cooperation with other countries on preparedness and response measures for accidents and environmental emergencies must be strengthened. The feasibility of establishing international monitoring and response centers in Iceland, in connection with resource development in the Arctic and increased shipping traffic in the North-Atlantic, should also be explored (Heininen, 2011).

- *Finland's Strategy for the Arctic Region* notes that the increase in sea transportation is the biggest threat to Arctic marine ecosystems, and safety systems are inadequate

- Russia's *Fundamentals of State Policy of the Russian Federation in the Arctic in the Period up to 2020 and Beyond* policy document includes the policy objective of expanding their polar fleet to facilitate and monitor increased shipping, and constructing maritime check-points to improve navigation monitoring.

- The US *National Security Presidential Directive/NSPD – 66 concerning an Arctic Region Policy* includes the aim to facilitate safe, secure and reliable navigation, including developing safe navigation standards, and to protect maritime commerce and the environment, including the establishment of a risk-based capacity for addressing hazards in the Arctic.

- As a major exporting economy, maritime trade routes are of critical importance to Germany. Accordingly, the safety of marine transportation in Arctic waters is a major objective of German Arctic policy.

- As a result of articulated environmental, economic and security interests, the safety of transportation and operations is implicit in Frances's perspectives on the Arctic.

- The EU policy on the Arctic, *Communication from the Commission to the European Parliament and the Council – The European Union and the Arctic Region*, includes a policy objective of promoting stricter safety and environmental standards, and defending the principle of freedom of navigation throughout the Arctic (Heininen, 2011). The policies promote the full implementation of existing obligations concerning navigation rules, maritime safety, routes system and environmental standards in the Arctic, in particular those under the International Maritime Organization. Support is being provided to increase the safety of cruise ships and restrict their access to highly vulnerable areas.

- The *Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR)* impacts maritime safety through the regulation of the dumping of waste.

- The *Convention for the Protection of the Marine Environment of the Baltic Sea Area* aims at improved hydrographic services and promotion of the use of Electronic Navigational Charts and Automatic Identification Systems with positive implications on maritime safety.

- The *Stockholm Convention on Persistent Organic Pollutants* policy will contribute to increased safety measures for transporting and handling POPs.

- The *International Convention for the Safety of Life at Sea (SOLAS)* (particularly Chapter V) requires every mariner to take account of all potential dangers to navigation, weather forecasts, tidal predictions, the competence of the crew, and all other relevant factors. The primary safety risks in the Arctic are from sea ice, icebergs and ice islands. It also adds an obligation for all vessels' masters to offer assistance to those in distress and controls the use of lifesaving signals with specific requirements regarding danger and distress messages.

- The *United Nations Convention on the Law of the Sea (UNCLOS)* provides some general provisions with respect to safety of maritime operations and rescue, and for the prevention of harm to human health.

- *The MARPOL Convention* notes that as climate and sea ice conditions continue to change, the timing and movements of the animals' activity will also be modified, making predictions of the potential interactions between shipping and animals increasingly complex.

- The report, *Nordic Cooperation on Foreign and Security Policy*, proposes the development between the Nordic countries of cooperation on Arctic issues focusing on more practical matters, such as maritime safety.

4.1.3 Role of Satellite Systems

COMMUNICATIONS SYSTEMS

(Impact High)

Maritime rely to a great extent on satellite communication when vessels are moving into areas outside of coverage of terrestrial systems. Since communications costs are high, usage is limited to the most important applications, which includes reporting to shipping companies and crew welfare. Crew welfare has been the main driver for installation of broadband satellite communication systems on vessels during the recent years. Typically, required data rates are in the order of 500kbps, which can easily be satisfied by GEO systems below 75^{0}N; however there is a current gap in requirements about 75^{0}N (demand is currently low in this region but will increase as maritime transport and fisheries move further north). (ArticCOM Consortium, 2011)

Future demand for communication systems is expected to increase for numerous reasons, including increased maritime transport between Asia and USA/Europe, increased fishing activities, increased tourism, and increased maritime traffic associate with energy production. The availability of new applications will also contribute to the demand for higher bandwidth. These applications will be developed to meet on-going efficiency demands, crew safety and welfare, as well as expanded emergency situation applications that include more extensive use of real-time video being shared with on-shore operations. Other applications demanding high bandwidth will be for mandatory regulations (such as e-reporting of daily fish catch) and increased requirements for environmental monitoring from ships (emission of pollutants, ballast water etc.) (ArticCOM Consortium, 2011)

WEATHER SYSTEMS

(Impact High)

Marine safety and efficient route planning are greatly affected by the ability to predict and understand weather patterns. Specialized weather forecasts may also be necessary for off-shore drilling activities to ensure necessary operational/safety precautions are implemented.

NAVIGATION SYSTEMS

(Impact High)

GNSS is the primary means of marine navigation and has increased the safety of marine transportation by providing accurate, all weather navigation capability.

EARTH OBSERVATION SYSTEMS

(Impact High)

The primary safety application of EO in the Arctic concerns safe marine transportation and offshore operations in the presence of sea ice and icebergs. To this end, critical information on sea ice and iceberg location and characteristics derived from satellite imagery is used routinely by vessels and operations in ice infested waters to make tactical decisions. While satellite radar imagery is the primary data source for operational sea ice information world-wide due to its independence from solar illumination and most weather conditions, the use of optical data frequently supplements radar imagery to cover gaps in spatial/temporal coverage and/or provide higher spatial resolution over specific areas, particularly in support of search-and-rescue missions.

Ice charting and surveillance is typically provided by national ice services to ensure adequate coverage of high-resolution sea ice information (i.e. derived from wide-swath SAR data) for areas under their jurisdiction. However, much of the Arctic basin is not covered by operational ice services providing high-resolution products, although coarse-resolution, global-scale products derived from passive microwave sensors are available. As a result, the full potential for supporting safe shipping and offshore operations is only realized in areas covered by national ice services. For the remainder of the Arctic basin, an appropriate governance of ice services is yet to be established. This is particularly pressing in light of significantly increased ship traffic in the Arctic resulting from a steady decrease in summer ice cover.

Ice detection and monitoring is a mature application of radar EO. While national ice services provide reliable data, there remain some deficiencies that need to be overcome to optimize these services. Repeat coverage of the existing satellites like Radarsat-2 and COSMO-SkyMed is not frequent enough and the data resolution needs to be improved, so the launch of additional satellites, such as Sentinel 1 and 3 and Radarsat Constellation, is required to improve ice monitoring to ensure marine transportation safety as vessel traffic in the Arctic continues to increase.

SURVEILLANCE SYSTEMS

(Impact Low)

S-AIS is particularly applicable to the Arctic because of the high costs of installing terrestrial AIS infrastructure to cover the shipping routes in and through the region. The primary purpose of AIS is for safety of life in marine transportation and international regulation mandates use of this technology by all SOLAS class vessels operating in the Arctic. Initially conceived as a collision avoidance measure for vessel masters, the system has been readily adopted by many national coast guard agencies and port authorities around the world as an integral part of their vessel management and traffic services systems.

The utility of S-AIS for safety applications in remote areas such as the Arctic is being recognized and initiatives are underway to advance development. One of the key developments envisaged by S-AIS providers is more complicated receivers handling at least dual polarization extended to multiple antennas using Space-Time Adaptive Processing (STAP) to null out interferers automatically. S-AIS system performance is expected to greatly improve with the introduction of new AIS message types, particularly AIS message type 27, designed specifically for satellite detection, and the introduction of two new protected frequencies to facilitate more effective satellite detection of AIS. Advances in hardware and software are also being exploited to improve the performance of S-AIS through faster and more efficient data processing (HAL, 2011).

4.2 Air Transportation

4.2.1 Overview

Air transportation involves the movement of passengers and/or goods by aircraft over regular routes and on regular schedules (i.e., airlines and air courier services), and non-scheduled service (i.e., chartered aircraft). Also included is non-scheduled specialty flying services (e.g., flight training, aerial photography, air ambulance, etc.). While air transportation services in the Arctic are much more limited than in the south, they are more critical because of the absence of viable alternatives in many instances. Similar to other geographical regions, the primary safety risks arise from loss of communications and navigation capabilities. Unlike more highly populated areas, there is an increased risk due to bad weather and landing surface conditions because of the much more limited number of alternate destinations to which an aircraft can reroute.

4.2.2 Policy

While air transportation appears to be of less significance than marine transportation, from an Arctic policy perspective, it is mentioned in a couple of the Arctic nations' policy documents.

- Canada's *Northern Strategy: Our North, Our Heritage, Our Future* identifies the strengthening of its land, sea and air capability and capacity as an implementation activity to strengthen its presence in the Arctic.

- Norway's *New Building Blocks in the North* report cites developing the air transportation infrastructure in the North as a policy priority, since reliable air connections are necessary to meet their other policy objectives.

4.2.3 Role of Satellite Systems

COMMUNICATIONS SYSTEMS

(Impact Medium)

Overflight activities have increased significantly since Arctic routes are more time, cost and energy efficient for flight connections between eastern and western parts of the world. The main requirements for satellite communications originates from air traffic services, aeronautical operation control, aeronautical administration communications, diagnostics and in-flight entertainment, the latter having the highest bandwidth requirements, including phone, e-mail and web services for passengers. (ArticCOM Consortium, 2011)

WEATHER SYSTEMS

(Impact Medium)

Air transport is greatly impacted by weather patterns and access to reliable and accurate weather services is imperative for safe and effective operations. Weather forecasts can also significantly impact cost effectiveness as route planning and scheduling is dependent on a clear understanding of current and future weather systems.

NAVIGATION SYSTEMS

(Impact High)

Similar to marine transportation, GNSS is the primary means of air navigation and has increased the safety of aviation by providing accurate, all weather navigation capability. Navigation performance requirements are dictated by the phase of flight, the aircraft proximity to terrain and other aircraft, and the air traffic control process. Navigation avionics are frequently used in visual flight rules (VFR)[3] and flight below Flight Level (FL) 180, and are required when operating under instrument flight rules (IFR)[4]. The introduction of air navigation using GNSS has brought area navigation (RNAV)[5] within reach of all operators, making a full transition to RNAV-based en route and terminal operations possible in many countries. GNSS by itself does not support approaches with vertical guidance, which require augmentation of GNSS with either an augmentation system, such as WAAS in North America or EGNOS in Europe.

SURVEILLANCE SYSTEMS

(Impact Medium)

Automatic Dependent Surveillance-Broadcast (ADS-B) is a surveillance technology for tracking aircraft. The system relies on two avionics components – a high-integrity GNSS navigation source and a communications data link (ADS-B unit). In some areas of the Arctic (e.g., northern airspace around Hudson Bay in Canada, being extended to some oceanic areas off the east coast of Canada and Greenland) radar surveillance coverage does not exist, so ADS-B is a critical safety system for air transportation. Pilots benefit from ADS-B by having the ability to see, on their in-cockpit flight display, other traffic operating in the airspace, receiving pertinent updates ranging from temporary flight restrictions to runway closings, and by air traffic controllers having the ability to more accurately and reliably monitor their positions.

While ADS-B currently covers only a fraction of the Arctic, the US first implemented ADS-B in Alaska, Russia has a number of operational ADS-B stations (ICAO, 2003), Sweden has implemented nationwide ADS-B coverage (airport-technology.com, 2006) and at least Canada (Transport Canada, 2007) and Iceland (CANSO, 2011) plan to extend coverage over the

3 Rules and regulations which allow a pilot to operate an aircraft in weather conditions where visual reference outside of the aircraft is possible.
4 Rules and regulations to govern flight under conditions in which flight by outside visual reference is not safe.
5 RNAV – area navigation is an IFR method that allows an aircraft to choose any course within a network of navigation beacons, rather than navigating directly to and from the beacons, which can decrease flight distance, reduce congestion, and allow flights into airports without beacons

remainder of their Arctic regions. It is likely that other Arctic nations will follow and that this technology will only increase in relevance for air transportation safety.

4.3 Land Transportation

4.3.1 Overview

Land transportation involves the movement of people and goods by means of vehicles operating on a network of roads, railways and trails. Such transport in the Arctic is much more limited than in the south and principally includes local freight trucking, long distance freight trucking, often over ice roads in the winter, and movement of people primarily by automobiles in built up areas and snowmobiles in more remote areas. The primary safety risks are related to travel over fragile ice and the potential for vehicle submersion if the ice is too weak to support the vehicle. The warming of the global climate has reduced the timeframe for safe use of ice roads in the Arctic. In addition, the increase in snow accumulation in the region (caused by the greater amount of precipitation and moisture in the air that warmer temperatures bring) will increase the difficulties and costs of keeping roads open and accessible.

4.3.2 Policy

Improvements in land transportation are a priority for a number of Arctic nations, as reflected in their policy documents.

- *Canada's Northern Strategy: Our North, Our Heritage, Our Future* identifies the strengthening of its land, sea and air capability and capacity as an implementation activity to strengthen its presence in the Arctic.

- Norway's *New Building Blocks in the North* report proposes carrying out an analysis of the existing transport infrastructure and future needs of, and commercial basis for, new transportation solutions, such as improving the road system and expanding railway capacity (e.g., a railway from Nikel to Kirkenes).

- One of the objectives of *Finland's Strategy for the Arctic Region* is to develop transport routes in Northern Finland and the Barents Region (i.e., to the Barents Sea and its hubs, Murmansk and Troms) in partnership with neighbouring countries.

- Russia's *Fundamentals of State Policy of the Russian Federation in the Arctic in the Period up to 2020 and Beyond* policy identifies modernizing and developing the infrastructure of the Arctic transport system as one policy priority.

4.3.3 Role of Satellite Systems

COMMUNICATIONS SYSTEMS

(Impact Low)

Northern communities often utilize ice roads and travel in remote areas (e.g., along the ice-edge) during hunting and fishing expeditions or between isolated communities. Access to reliable satellite based mobile communications services, although expensive and not widely used, can be important for safety.

WEATHER SYSTEMS

(Impact Low)

Access to reliable and timely weather forecasts is important for effective route planning and to ensure safe access to remote communities.

NAVIGATION SYSTEMS

(Impact Low)

While GNSS is used for transportation on land, its application in the safety context is much more limited than for marine and air transportation, where the technology is critical for collision avoidance. As the availability of high quality digital map data increases, the use of GNSS for navigation over land by snowmobile may also grow.

EARTH OBSERVATION SYSTEMS

(Impact Medium)

Applications pertaining to safety in the Arctic include: the surveillance of ice cover on rivers and lakes used as ice roads; the monitoring of near-shore ice used as transportation corridors for northern communities; and the support for search-and-rescue missions on land and sea.

The coverage of critical ice road infrastructure is primarily an issue in Canada, the US and Russia. Many northern communities can only be reached by road/ice road during winter and are only accessible by boat or air during the ice-free seasons. In the case of ice roads, surveillance is required at a high resolution, with the key parameters being the completed freeze-up and melt-onset, defining the start and end dates for operating ice roads. The floe edge (i.e., the boundary between immobile near-shore ice and moving sea ice), is useful for many northern communities for hunting and fishing. Maps of near-shore ice conditions derived from satellite radar imagery are increasingly used by northern residents as important navigation aids.

4.4 Policing

4.4.1 Overview

Policing organizations operate within a legal framework that empowers them to enforce the law, protect property and limit civil disorder. In the Arctic region, policing can extend beyond law enforcement to include a variety of other sovereignty and security roles. For example, the main role of Canada's Royal Canadian Mounted Police (RCMP) in the North is to deter activities that threaten border integrity or national security, and to ensure the legitimate use of inland waterways. But out of necessity the RCMP often acts as a first responder for incidents that fall under other federal jurisdictions (e.g., customs issues, immigration issues, potential terrorist threats, rescues, etc.) (RCMP, 2009). Policing in the Arctic is made more difficult by the isolation, extreme weather conditions and strong dependency on reliable transportation and communications.

4.4.2 Policy

Only two of the policies published by the Arctic nations mentions the importance of policing in the region.

- Norway's *New Building Blocks in the North* report states that the presence of police in the Arctic is imperative to meet its policy objective of exercising Norwegian authority in a credible, consistent and predictable way.

- *Canada's Northern Strategy: Our North, Our Heritage, Our Future* has an objective of increased law enforcement presence and capabilities in the north (including satellite monitoring).

- The US *National Security Presidential Directive/NSPD – 66 concerning an Arctic Region Policy* references improving maritime and law enforcement by building capacity and capabilities.

- The report, *Nordic Cooperation on Foreign and Security Policy*, proposes the establishment of a Nordic resource network to defend the Nordic countries against cyber attacks. It also proposes a joint investigation unit should be established to coordinate the Nordic countries' investigation of genocide, crimes against humanity and war crimes committed by persons residing in the Nordic countries.

4.4.3 Role of Satellite Systems

COMMUNICATIONS SYSTEMS

(Impact Medium)

Reliable communications (e-mail and voice) are necessary between police headquarters and remote staff or travelers. The ability to monitor activities in remote sites and to disseminate notification of a safety or security incident or deterioration of security condition at any time is important. Also effective, mobile communications are required to coordinate emergency response, especially medical response and evacuation.

4.5 Search and Rescue

4.5.1 Overview

Search and rescue (S&R) involves the search for and provision of aid to people, ships or other craft that are, or are feared to be, in distress or imminent danger. S&R operations involve the response to distress signals by air-, water- or land-based equipment and personnel. There are many ways that distress can be signalled. Among these, signals from ELT (Emergency Locator Transmitter), EPIRB (Emergency Position Indicating Radio Beacon) and PLB (Personal Location Beacon) devices can be relayed to authorities through the COSPASS-SARSAT system of satellites.

In the Arctic, the length of time for S&R response may be protracted because of the severe climate, great distances involved, and the relative shortage of personnel and equipment.

4.5.2 Policy

S&R is mentioned in most nations' Arctic policy documents, either as an area where action is intended to be taken, or as an interest in terms of contribution to a multilateral solution for the region.

- Canada's *Northern Strategy: Our North, Our Heritage, Our Future* includes improving search and rescue capabilities for communities.

- The *Kingdom of Denmark Strategy for the Arctic 2011–2020* references the objective of seeking opportunities for closer operational cooperation with other Arctic nations in the Arctic Ocean, including rescue at sea.

- The *US National Security Presidential Directive/NSPD – 66 concerning an Arctic Region Policy* proposes the development of an effective search and rescue regime in the region requiring multi-level cooperation by all relevant actors.

- The *Iceland in the High North* report states that contributing to the establishment of a collaborative Search and Rescue agreement for the Arctic is one of the policy objectives.

- *Sweden's Strategy for the Arctic Region* cites sea and air rescue as one of the priorities.

- Russia's *Fundamentals of State Policy of the Russian Federation in the Arctic in the Period up to 2020 and Beyond* policy also mentions creating a uniform Arctic search and rescue regime and prevention of manmade accidents as a policy priority.

- Since maritime trade routes are of critical importance to Germany, coordinated search and rescue activities in Arctic waters is a major objective of German Arctic policy.

- The report, *Nordic Cooperation on Foreign and Security Policy*, proposes the establishment of a Nordic maritime response force to patrol regularly in the Nordic seas, and have search and rescue as one of its main responsibilities (Stoltenberg, 2009).

- The aim of the *Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic* is overall improved search and rescue response through cooperation and coordination of appropriate assistance to those in distress due to small or large incidents.

4.5.3 Role of Satellite Systems

COMMUNICATIONS SYSTEMS

(Impact High)

Ship distress and safety communications (mostly low bandwidth) involve the use of the Global Maritime Distress and Safety System (GMDSS) - an integrated communications system using satellite and terrestrial radio communications to ensure that no matter where a ship is in distress, aid can be dispatched.

The GMDSS was developed by the International Maritime Organization (IMO), the specialized agency of the United Nations with responsibility for ship safety and the prevention of marine pollution. Under the GMDSS, all passenger ships and all cargo ships over 300 gross tonnage on international voyages have to carry specified satellite and radio communications equipment, for sending and receiving distress alerts and maritime safety information, and for general communications. The regulations governing the GMDSS are contained in the International Convention for the Safety of Life at Sea (SOLAS), 1974, which has been ratified by 138 countries, covering 98.36 percent of the world merchant shipping fleet by tonnage.

WEATHER SYSTEMS

(Impact High)

Weather forecasts are integral components of S&R during both planning and execution stages. S&R situations frequently arise during inclement weather, and as a consequence accurate weather information is required to assess which assets may be employed and determine optimal windows of opportunity for rapid response, while ensuring the safety of search personnel. Weather and associated information (e.g., sea surface temperature) also feed into models predicting search areas and life expectancy.

NAVIGATION SYSTEMS

(Impact High)

Given the severe climatic conditions prevailing in the Arctic, and the potentially great distances between those in distress and

S&R personnel, timeliness of locating victims is of the essence. If a distress alerting device is equipped with GNSS, it can be employed by S&Rs team to identify the location of the person, vehicle, vessel or aircraft in distress and to quickly navigate to that location. GNSS is also used in planning S&R operations to lay out search patterns and subsequently to systematically navigate over those patterns with GNSS.

EARTH OBSERVATION SYSTEMS

(Impact Medium)

As a general rule, S&R response considers data from any observing system valuable that was acquired near (spatially and temporally) confirmed emergency situations. The major contributions of EO within a S&R context include: the provision of critical locations (e.g., initial locations of vessels or aircraft in distress if other options are not available); the delivery of a rapid, synoptic view of the surroundings of an emergency (e.g., ice conditions, land cover, access routes); and the derivation of environmental parameters used to predict search zones (e.g., wind fields, sea surface temperature, used to assess life expectancy during emergencies at sea).

Satellite SAR imagery can provide surface wind information at a high spatial resolution, which can subsequently be used in dedicated models to predict an optimal search radius for offshore S&R operations (e.g., the CANSAR model). For most missions, emergency planning and delivery agreements exist that can be invoked to gain priority over all other uses of the satellite system.

Satellite SAR imagery is largely unaffected by atmospheric conditions and solar illumination. However, the interpretation of SAR data may require specific expertise and processing capabilities (e.g., derivation of wind fields, target detection and classification) not typically resident within the community of first responders to emergencies.

The use of optical imagery may be limited by its dependency on clear atmospheric conditions and the fact that emergencies often arise as a result of inclement weather. Likewise, optical imagery cannot be acquired in the dark, which exists upt to 24 hours a day during the Arctic winter. On the other hand, optical imagery lends itself easily to visual interpretation by non-EO specialists and is easily integrated into S&R efforts composed of multi-disciplinary teams.

Timely access to EO data requires data downlink via a suitable network of ground stations, and delays ensue if no ground station is visible at the time of image acquisition. However, emergency operations usually rely on data streams from a multitude of available and potentially relevant observations, including EO and non-EO data. The unavailability of data from a single system is therefore somewhat mitigated.

SURVEILLANCE SYSTEMS

(Impact High)

COSPAS-SARSAT has been operational since 1979, and is a primary resource for S&R operations. Operating world-wide, it is highly relevant for search and rescue operations in the Arctic. COSPAS-SARSAT provides accurate, timely, and reliable distress alert and location information to help search and rescue authorities assist persons in distress. The next generation of the system will have S&R beacon signal repeaters hosted on GNSS satellites, but the GNSS signal may not be used as the primary location factor. The GNSS satellites are providing a platform to carry the S&R transponder into space, providing more available transponders to receive distress signals, which will allow for quicker notification, geo-location and response times. Although SARSAT beacons are equipped with an independent means of calculating their position, commercial products like the SPOT Personal Tracker (SPOT LLC, 2012) rely exclusively on their ability to receive and transmit accurate GNSS signals.

4.6 Disaster Management

4.6.1 Overview

The process of disaster management involves four phases:

- *Mitigation* – attempts to prevent hazards from developing into disasters altogether or to reduce the effects of disasters
- *Preparedness* – development of plans of action to manage and counter the risks and take action to build the necessary capabilities needed to implement such plans
- *Response* – mobilization of the necessary emergency services and first responders in the disaster area
- *Recovery* – restoration of the affected area to its previous state (e.g., rebuilding destroyed property, re-employment, and repair of essential infrastructure)

In the Arctic, the response and recovery phases are of particular significance, given the circumstances previously discussed (e.g., remoteness, extreme weather, scarcity of resources and equipment, critical dependence on communications and transportation infrastructure, etc.). There are concerns that the potential for disasters will grow in the Arctic region as the accessibility of the region improves and the level of commercial activity grows.

4.6.2 Policy

A number of Arctic policy documents reference disaster (or emergency) management initiatives.

- The *Iceland in the High North* report references the importance of a collaborative focus on emergency response and environmental protection due to increasing sea traffic in the Arctic.
- Norway's *New Building Blocks in the North* report lists improving monitoring, emergency (and oil spill) response and maritime safety systems in northern waters as a second strategic priority. Norway will establish an integrated monitoring and notification system, further develop the Coastal Administration's maritime safety expertise, and strengthen oil spill response.
- Canada's *Northern Strategy: Our North, Our Heritage, Our Future* includes assessment of capacity to respond to Arctic pollution events and ability to respond to environmental emergencies.

- Russia's *Fundamentals of State Policy of the Russian Federation in the Arctic in the Period up to 2020 and Beyond* policy document includes construction of ten permanent stations of the Russian Ministry for Emergency Situations along the Northern Sea Route, in cooperation with the Hydro-Meteorological Service.

- The report, *Nordic Cooperation on Foreign and Security Policy*, proposes that a Nordic disaster response unit be established for dealing with large-scale disasters and accidents in the Nordic region and in other countries (Stoltenberg, 2009).

4.6.3 Role of Satellite Systems

COMMUNICATIONS SYSTEMS

(Impact Medium)

Effective communication is imperative in times of disaster. Thus an efficient communication system which will work in adverse conditions is required. This can draw on satellite technologies for mobile phone applications or two-way satellite radio.

WEATHER SYSTEMS

(Impact Medium)

Weather forecasts are integral components of disaster response operations during both planning and execution stages. Disasters frequently arise during inclement weather, and as a consequence accurate weather information is required to assess which assets may be employed and determine optimal windows of opportunity for rapid response, while ensuring the safety of emergency response personnel. Weather and associated information (e.g. sea surface temperature) also feed into models predicting search areas and life expectancy.

NAVIGATION SYSTEMS

(Impact Medium)

GNSS are commonly employed in the disaster response phase by first responders attempting to navigate quickly to affected areas. The technology may also be employed for data collection and mapping during response, to help monitor changes in real time, and post-disaster, to assist with planning and implementing disaster recovery work. Research is ongoing on the use of GNSS for very precise geodynamics measurements, which may be used in the future for disaster mitigation by producing early warnings of impending disasters such as earthquakes, volcanoes and tsunamis.

EARTH OBSERVATION SYSTEMS

(Impact High)

Potential disasters with significant impact on communities and municipalities throughout the Arctic include flooding and accidental contaminant spills. Flooding may occur due to ice jams in rivers, substantial rainfall or snow melt over frozen ground, and as a result of storm surges. In the latter case, flooding conditions may be exacerbated by significant coastal erosion. Some locations may also be sensitive to inundation caused by outburst floods from glacial lakes. Contaminant spills, largely oil, are likely to occur as a result of increased resource extraction and trans-Arctic vessel traffic as receding summer ice cover makes the Arctic more accessible. In addition, the impact of changing ice and permafrost conditions on critical infrastructures and transportation links is of concern. Finally, certain areas may be affected by earthquakes and volcanoes.

EO imagery can be invaluable during the planning and response phases of the disaster management cycle. If weather conditions are conducive, optical EO can provide detailed information about the extent of the disaster, the type of destruction that has occurred, and the areas most severely impacted. EO data is also used to guide response and mitigation efforts. Satellite SAR data delivers valuable information during bad weather conditions and at night. SAR imagery is also the primary means of observing ice over large areas as well as the detection and monitoring of marine oil spills.

5. ENVIRONMENT

5.1 Pollution

5.1.1 Overview

Pollution occurs when contaminants are introduced into a natural environment (i.e., the air, water or soil) that causes instability, disorder, harm or discomfort to the ecosystem. In the Arctic, the major sources of pollution are from the following sources:

- Air pollution – smoke and particulates from extraction of minerals, oil and gas; volcanic eruptions; pollution from natural or manmade disasters

- Water pollution – wastewater discharges from extraction of minerals and oil; oil spills from illegal bilge pumping and accidental tanker ruptures; pollution from natural or manmade disasters. The accidental release of oil or toxic chemicals as a result of increased shipping is considered one of the most serious threats to Arctic ecosystems.

- Soil contamination – leaching from mining tailings; pollution from natural or manmade disasters

There are also significant stockpiles of nuclear waste in northern Russia.

Pollution is expected to become a much more significant problem as the Arctic region becomes more industrialized and marine transportation through Arctic waters becomes commonplace. In addition, the Arctic is being significantly impacted by transboundary pollution (i.e., pollution form one jurisdiction that is transported and deposited in another jurisdiction). For example, wind currents are bringing pollution from the South into the Arctic, as do rivers that flow into the Arctic Ocean. Many of the major ocean currents also flow through the Arctic, which transport pollution to the region (Safe Drinking Water Foundation, 2007).

5.1.2 Policy

Dealing with pollution in the Arctic is referenced in several of the Arctic nations' policy documents.

- *Canada's Northern Strategy: Our North, Our Heritage, Our Future* proposes taking concrete measures to protect Arctic waters by introducing new ballast water control regulations, and assessing the capacity to respond to Arctic pollution events and environmental emergencies.

- The *Canadian Arctic Foreign Policy* identifies enhancing its efforts, including pursuing and strengthening international standards, related to persistent organic pollutants as a policy objective.

- Norway's *New Building Blocks in the North* report cites as a priority plans to prepare for the melting of sea ice and the consequent increase in maritime traffic and fossil fuel extraction by establishing an integrated monitoring and notification system, further developing the Coastal Administration's maritime safety expertise, and strengthening oil spill response. The white paper *The High North – vision and means* has a focus on climate change, endangered species (connected to climate change), pollution and the transport of pollution from other parts of the world into the Arctic. Cooperation with Russia on monitoring and increasing safety concerning nuclear reactors and nuclear waste is also cited as being important.

- The *Iceland in the High North* report states that transportation of oil and gas through Icelandic waters must be closely monitored and provisions made to protect the marine environment and spawning grounds of fish stocks.

- One of the objectives of *Finland's Strategy for the Arctic Region* is to monitor long-range pollution since risk of pollution must be minimized.

- The *Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR)* policy is aimed at reducing harmful substances that are toxic or have other noxious properties affecting living organisms including humans. The policy is concerned with the prevention and elimination of pollution and the protection of the OSPAR maritime area against the adverse effects of human activities so as to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected. The policy also addresses the reduction of the impact on the environment of pollution from land-based sources, pollution by dumping from ships and incineration; pollution from offshore sources and pollution from other sources. Measures to cover non-polluting human activities that can adversely affect the marine environment are contained in the annex on biodiversity and ecosystems of 1998.

- The *Convention for the Protection of the Marine Environment of the Baltic Sea Area* aims at reducing harmful substances that are toxic or have other noxious properties affecting living organisms including humans. The policy is focussed on the reduction of the impact on the environment of: harmful substances; pollution from land-based sources; pollution from ships; pollution, noise, hydrodynamic effects and waste from pleasure crafts; incineration at sea; dumping from ships; and exploration and exploitation of the seabed and its subsoil. The policy also promotes the exchange of information on pollution incidents and co-operation in combating marine pollution.

- The *Stockholm Convention on Persistent Organic Pollutants* policy will lead to the increased protection of the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have adverse effects on the environment.

- The *MARPOL Convention* is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. All ships flagged under countries that are signatories to MARPOL are subject to its requirements, regardless of where they sail, and member nations are responsible for vessels registered under their respective nationalities.

- Article 234 of the *United Nations Convention on the Law of the Sea (UNCLOS)* allows Arctic states to adopt and enforce non-discriminatory laws and regulations for the prevention, reduction, and control of marine pollution from vessels operating in ice-covered waters within their EEZ.

- The *United Nations Declaration on the Rights of Indigenous Peoples* proposes that States take effective measures to ensure that no storage or disposal of hazardous materials takes place in the lands or territories of indigenous peoples without their free, prior and informed consent. It also proposes that States take effective measures to ensure that programs for monitoring, maintaining, and restoring the health of indigenous peoples are implemented.

- The *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal* calls for increased protection of the environment against the adverse effects of hazardous and other wastes which may result from the generation and management of these. It also identifies the need to be able to monitor effects and extent of hazardous and other wastes on the environment.

5.1.3 Role of Satellite Systems

NAVIGATION SYSTEMS

(Impact Low)

GNSS has a role to play in the reduction of pollution from marine and air transportation. Since navigation with the use of GNSS is much more accurate, routing is more efficient and aircraft and vessels consume less fuel and release fewer pollutants into the atmosphere.

EARTH OBSERVATION SYSTEMS

(Impact High)

There are a number of important applications of earth observation related to pollution in the Arctic region. For example, there is growing concern about the increased potential for oil spills in the shipping routes, as traffic increases and offshore oil reserves are eventually tapped. Radar EO is particularly suitable for oil spill detection and monitoring. Multispectral EO technologies are useful for monitoring vegetation stress, algal blooms and variations in water sediment loads that may result from pollution of land and water from mineral extraction, industrial activities and increased human habitation close to water bodies. EO is also applicable to monitoring specific sites of known impact (e.g., deposition of mine tailings), detecting changes over time (e.g., changes in vegetation cover as a result of industrial activities), studying transboundary pollution, and assessing compliance with regulatory requirements (e.g., discharge of pollutants from offshore structures).

The applications of EO in pollution detection are mature and for the most part are relevant for the Arctic. A limitation in Arctic waters is oil spill detection and monitoring, because satellite radar does not work well if the oil slick is under ice. If oil slicks are moving quickly due to strong currents or winds, the frequency of repeat satellite passes can create problems, reinforcing the importance of the availability of data from planned missions such as Sentinel 1 and 3 and Radarsat Constellation.

The use of optical satellite imagery for water quality monitoring, including chlorophyll, sediment concentration and concentration of dissolved organic matter in the Arctic is restricted to ice-free periods. The use of concurrent in-situ observations via dedicated, long-term measurement networks can significantly enhance the value of EO-derived water quality parameters through improved calibration and validations. Key data sources in the future will be Sentinel-2 for site-specific assessments and Sentinel-3 for large-area surveillance and monitoring operations.

5.2 Climate Change

5.2.1 Overview

Climate change can be defined as a change in the statistical properties of the climate system when considered over long periods of time, regardless of cause. In the environmental policy context, this normally means climate change caused by human activity, as opposed to changes in climate that may have resulted as part of Earth's natural processes. While the terms climate change and global warming are often used synonymously, scientists use *global warming* to refer to surface temperature increases and *climate change* to refer to global warming and everything else affected by increasing greenhouse gas levels. The primary effects of ongoing changes in the climate of the Arctic include loss of sea ice, and melting of permafrost and the Greenland ice sheet.

While there is no consensus on why the Arctic ice is melting so rapidly, it is generally agreed that the underlying cause is global warming brought about by greenhouse-gas emissions and that the Arctic air is warming twice as fast as the atmosphere as a whole (The Economist, 2011). There are a number of other climate change impacts as well, including: the melting of permafrost and changes in surface vegetation in the Arctic, and the impact on global climate of the changes taking place in the Arctic. As discussed elsewhere is this report, the impacts of climate change on the Arctic region and its people are widespread, including: creating the potential for significantly increased maritime transportation; opening up the region to increased industrial and commercial activity; endangering flora and fauna species; and creating new challenges and opportunities for Arctic residents.

5.2.2 Policy

Not surprisingly, the environmental topic that is of most concern to Arctic nations, and that is given priority in their policies for the region, is climate change and its impact on the ecosystem and people of the north.

- The *Kingdom of Denmark Strategy for the Arctic 2011–2020* states that "The Kingdom will pursue vigorous and ambitious knowledge building on climate change in the Arctic and its consequences in order to foster global and local adaptation to far-reaching change." (Governments of Denmark, Greenland and Faroe Islands, 2011). Denmark plans to strengthen efforts to quantify global and regional impacts of climate change in the Arctic, including knowledge about how Arctic ecosystems, sea ice and ice sheets are responding.

- Norway's *New Building Blocks in the North* report identifies as strategic priorities: the development of greater knowledge about climate change and the environment in the High North by allocating more funds for arctic research, strengthening educational institutions and establishing a Centre for Ice, Climate & Ecosystems; and positioning Norway as a base for international research activities through strategic investments (e.g., by developing a centre for climate and environmental research in Tromsö and establishing an Arctic earth observing system in Svalbard).

- One of the objectives of *Finland's Strategy for the Arctic Region* is to give support for research in the Arctic and the development of regional climate models as the basis for decision making (Heininen, 2011).

- The *Iceland in the High North* report notes that climate change has vast implications for its Arctic region.

- *Sweden's Strategy for the Arctic Region* identifies climate and the environment as a top priority, with substantial coverage being given to biodiversity. It discusses planned actions on reducing greenhouse gas emissions, and becoming a leading nation in research on climate and the environment, as well as the impacts of climate change on humans (Heininen, 2011).

- The *Canadian Arctic Foreign Policy* identifies contributing to and supporting international efforts to address climate change in the Arctic as a policy objective.

- The US *National Security Presidential Directive/NSPD – 66 concerning an Arctic Region Policy* notes that there is a high level of uncertainty concerning the impacts of climate change and that decisions must be based on sound scientific and socioeconomic information, environmental research, monitoring, and vulnerability assessments. The Policy supports collaborative research that advances fundamental understanding of the Arctic region in general and potential arctic change in particular, including portions expected to be ice-covered as well as seasonally ice-free regions. The document states that the US will "continue to play a leadership role in research throughout the Arctic region".

- As a global leader in environmental issues, Germany promotes environmental protection in the Arctic, including the mitigation of climate change on the Arctic environment, flora and fauna.

- France is carrying out major research initiatives designed to understand climate change in the Arctic, as well as adapting to the consequences of climate change, particularly with respect to economic activities. The Arctic is considered a major element in the climate system with direct consequences for France.

- India is not an Arctic nation, but investment in international scientific collaboration and research in Arctic/global climate change are evidence of its interest in the region.

- The EU policy on the Arctic, *Communication from the Commission to the European Parliament and the Council – The European Union and the Arctic Region*, identifies protecting and preserving the Arctic environment and its population as a top priority and preventing and mitigating the negative impacts of climate change and supporting adaptation to inevitable changes is a key goal. In addition, climate change research to close knowledge gaps and assess future anthropogenic impacts is a high priority for the EU.

- The report, *Nordic Cooperation on Foreign and Security Policy*, proposes the development between the Nordic countries of cooperation on Arctic issues focusing on more practical matters, such as climate change.

5.2.3 Role of Satellite Systems

COMMUNICATIONS SYSTEMS

(Impact Medium)

Successful strategies for assessing the impact of climate change and adapting to its consequences include continued monitoring and short-term prediction of key environmental parameters. In light of difficult, costly and potentially dangerous field-based data collection in the Arctic, automated stations for the collection of in-situ observations possess a significant potential for application throughout the Arctic. Accordingly, satellite communications have a key role to play in the remote access and delivery of data from automated in-situ monitoring stations.

WEATHER SYSTEMS

(Impact High)

Accurate and timely meteorological observations are critical ingredients to model-based climate change predictions. In particular, satellite-based time series of surface temperature, tropospheric and stratospheric measurements are used in the calibration and validation of climate models. Meteorological satellites are also tasked with the monitoring of the Global Climate Observing System's (GCOS) atmospheric Essential Climate Variables (ECVs), particularly the surface and upper-air elements (e.g., temperature, precipitation, water vapour, radiation budgets, etc.).

NAVIGATION SYSTEMS

(Impact Low)

The application of GNSS in the climate change context is limited to its use for positioning of in situ sensors that are collecting weather and climate data.

EARTH OBSERVATION SYSTEMS

(Impact High)

EO has a number of applications in climate change research. Satellite imaging is the primary means for monitoring and measuring the major changes on land and water that are attributed to climate change, such as: changes in vegetation; melting of polar ice and glaciers; reduced snow cover; earlier spring thaw and later fall freeze-up; coastal erosion linked with rising sea level; and major floods resulting from the increasing frequency of extreme weather events. In addition, EO can provide a range of oceanic and terrestrial ECVs required to support the UN Framework Convention on Climate Change (UNFCCC) and the Intergovernmental panel on Climate Change (IPCC).

EO is highly relevant over the Arctic, since the impacts of climate change are particularly severe and noticeable in this region. The applications of EO to climate change research are mature but challenges remain. For example, monitoring programs require both high temporal and high spatial resolution. However, there is a requirement for additional spatial resolution for radar imagery and improved temporal resolution (i.e., repeat coverage frequency) for optical imagery to meet the needs of the climate change research community. In terms of ECV mapping, some variables can be measured directly from satellite imagery (e.g., sea ice, sea surface temperature, sea surface salinity, ocean colour, glaciers, biomass, etc.), while others may be observed indirectly only and inferred via indicators (e.g., permafrost, groundwater, river discharge, etc.).

SCIENCE SYSTEMS

(Impact Low)

Gravity science satellite missions are applicable to climate change due to their contribution to the definition of the geoid (the surface of an ideal global ocean in the absence of tides and currents). The geoid is a crucial reference for measuring ocean circulation, sea-level change and ice dynamics, which are all affected by climate change (ESA, 2011). Recent gravity space science missions like CHAMP, GRACE and GOCE have helped to improve the definition of the geoid, increasing its usefulness and relevance for climate change research in the Arctic.

5.3 Biodiversity

5.3.1 Overview

Biodiversity is the degree of variation of life forms within a given species, ecosystem, or region and can be considered as a measure of ecosystem health. Among other things, biodiversity helps to purify our air and water, ensure the productivity of our agriculture and forestlands, and regulate our climate. Warmer climates sustain greater biodiversity whereas colder climates, such as in the Arctic, support fewer species. Signs are already evident that climate change is impacting Arctic species, with species such as polar bear, reindeer and caribou, and shorebirds in decline in the High Arctic. Complex interactions between climate change and other factors (e.g., contaminants, habitat fragmentation, industrial development, and unsustainable harvest levels) have the potential to magnify impacts on biodiversity. Changes in Arctic biodiversity create both challenges and opportunities for Arctic peoples. For example, declines in Arctic biodiversity may affect the availability of traditional foods, and decreasing access to freshwater and the unpredictability of winter ice will make sustaining traditional ways of life more difficult. On the other hand, such factors as movement of southern species into the Arctic, shifting habitats and changes in resource use may provide opportunities to harvest new species (CAFF, 2010).

5.3.2 Policy

The importance of biodiversity conservation is explicitly mentioned by a number of policy documents.

- The *Iceland in the High North* report states that the utmost caution must be practiced in resource development in the Arctic region to protect its fragile environment and ecosystems.

- Biodiversity receives considerable attention in *Sweden's strategy for the Arctic region*, under the first policy priority – climate and the environment. Sweden pledges to work for conservation and sustainable use of biodiversity in the Arctic.

- *Finland's Strategy for the Arctic Region* notes the need for preservation of fish stocks in northern rivers.

- Biodiversity objectives of Russia's *Fundamentals of State Policy of the Russian Federation in the Arctic in the Period up to 2020 and Beyond* include ensuring environmental preservation and biological diversity of Arctic flora and fauna, taking into account the potential of economic activity and global climate change. Ways of achieving these aims include introducing new wildlife management regimes, improving monitoring of pollution, and restoring natural environments.

- The *Canadian Arctic Foreign Policy* identifies enhancing its efforts, including pursuing and strengthening international standards, related to biodiversity and genetic resources as a policy objective.

- Implementation of Environmental Protection and Conservation of Natural Resources actions under the *US National Security Presidential Directive/NSPD – 66 concerning an Arctic Region Policy* include identifying "ways to conserve, protect, and sustainably manage Arctic species", and pursuing "marine ecosystem-based management in the Arctic" (Heininen, 2011).

- While not an Arctic nation, China's interests in the region include: investment in international scientific collaboration; research in oceanography, biology, atmospheric science, and glaciology; and membership in the International Arctic Science Committee (IASC).

- The *Convention on Biological Diversity* is aimed at the conservation and sustainable use of biological diversity and is the first agreement to address all aspects of biological diversity: species, ecosystems and genetic resources.

- The *Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR)* policy states that parties shall take the necessary measures to protect the maritime area against the adverse effects of human activities so as to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected.

- The *Convention for the Protection of the Marine Environment of the Baltic Sea Area* promotes conservation of natural habitats and biological diversity and the protection of ecological processes ensuring the sustainable use of the natural resources.

- The *Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)* is an international agreement between governments the aim of which is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. In the Arctic region, protecting habitat, avoiding heavy depletion of populations, and trying to protect species from extinction are priorities.

- The *Convention on the Conservation of Migratory Species of Wild Animals (CMS)* is also an intergovernmental treaty, the aim of which is to conserve terrestrial, aquatic and avian migratory species throughout their range. CMS Parties strive to strictly protect animals that are threatened with extinction, conserve or restore the places where they live, mitigate obstacles to migration and control other factors that might endanger them.

- The *United Nations Convention on the Law of the Sea (UNCLOS)*, states the need to take measures to prevent the introduction of alien species that may cause significant and harmful changes to the local environment.

5.3.3 Role of Satellite Systems

COMMUNICATIONS SYSTEMS

(Impact Low)

Satellite-based communications systems play a role in the monitoring of wildlife populations via animal tags. This applies equally to terrestrial (e.g., caribou) and marine species (e.g., whales).

NAVIGATION SYSTEMS

(Impact Medium)

The use of GNSS in biodiversity applications in the Arctic is limited to the tracking of endangered wildlife species. Tagging and GNSS tracking of animals is a routine method for scientific research of biodiversity and is relevant in the Arctic, where the impacts of climate change on animal populations seems to be particularly severe. By tagging animals such as polar bears and reindeer with tiny GPS receivers and location transmitters, researchers can monitor their movements and study the impacts of the changes taking place in the Arctic on the health and life expectancies of individual animals to infer overall impacts on the species.

EARTH OBSERVATION SYSTEMS

(Impact Medium)

There are two approaches to the use of EO for biodiversity studies (Turner, et al, 2003). The first involves the direct remote sensing of individual organisms, species, or ecological communities from satellites. This approach is now possible with the availability of high resolution EO data and new sources of hyperspectral EO data (i.e., data from across the electromagnetic spectrum that is divided into many bands beyond the visible spectrum), enabling the detection of spectral signatures that are characteristic of different plant species or communities. The second involves the indirect remote sensing of biodiversity through reliance on environmental parameters as proxies. This approach combines information about the known habitat requirements of species with land cover derived from satellite imagery to estimate potential species ranges and patterns of species richness. By monitoring the pace and distribution of habitat loss or conversion, biodiversity specialists can produce quantitative estimates of biodiversity losses.

While these approaches are mature, there have been limited applications in the Arctic. This may be primarily due to the increased difficulty of detecting land cover changes in a landscape of more limited species and the presence of snow and ice cover for extended periods, relative to the south. As the impacts of climate change produce more species diversity in the region and snow and ice cover is for shorter periods, the relevance of EO for biodiversity monitoring in the Arctic will increase.

5.4 Environmental Protection

5.4.1 Overview

Environmental protection can be defined as the work conducted by individuals, organizations or governments for the benefit of the natural environment and humans. Environmental protection is particularly critical in the Arctic because the region is highly sensitive and its human population and culture is heavily dependent on the health of the region's ecosystems. In 1991, the eight Arctic countries (USSR, USA, Sweden, Norway, Iceland, Finland, Denmark and Canada) approved the *Arctic Environmental Protection Strategy* (Government of Canada, 1991). The *Strategy* deals with four themes: monitoring and assessment of contaminants; protection of the marine environment; emergency preparedness and response; and conservation of flora and fauna. The first theme – contaminants in the Arctic – is a major focus of attention, which is being handled by the Arctic Monitoring and Assessment Programme (AMAP) that was established under the aegis of the *Strategy*.

5.4.2 Policy

Protection of the environment and conservation of vulnerable species is a policy priority for a number of Arctic nations.

- The *Iceland in the High North* report calls for the strengthening of international cooperation on research and monitoring in the Arctic in response to changing environmental and social conditions in the region. Mention is made of the Arctic Portal (www.arcticportal.org), an Icelandic initiative that is playing an increasing role as an internet-based venue for communication and information sharing on Arctic affairs, research and monitoring.

- The *Denmark, Greenland and the Faroe Islands: Strategy for the Arctic 2011-2020* policy document states that illegal, unreported and unregulated fishing are a serious threats to marine ecosystems and have considerable implications for conservation and rational management of marine resources.

- Norway's *New Building Blocks in the North* report identifies cooperation with Russia on monitoring and increasing safety concerning nuclear reactors and nuclear waste as important.

- One of the objectives of *Finland's Strategy for the Arctic Region* is to give support for research in the Arctic and long-term monitoring of the state of the environment as the basis for decision making (Heininen, 2011). Promotion of nuclear safety, especially on the Kola peninsula is an important objective.

- *Sweden's strategy for the Arctic region* has environment protection as a main objective

- *Canada's Northern Strategy: Our North, Our Heritage, Our Future* includes establishment of protected areas and improved environmental assessments for industrial activities as key environmental protection measures.

- The *Canadian Arctic Foreign Policy* includes the policy objective of promoting an ecosystem-based management approach with its Arctic neighbours and others.

- Russia's *Fundamentals of State Policy of the Russian Federation in the Arctic in the Period up to 2020 and Beyond* policy document includes expanding protected areas (land and sea), recycling of their aging nuclear fleet, and chemical safety from industrial sites and mitigating contaminated sites as policy objectives.

- The US *National Security Presidential Directive/NSPD – 66 concerning an Arctic Region Policy* recognises that the Arctic ecosystem is unique and in transition due to human activity, with potentially serious consequences for northern communities and the Arctic ecosystem. A policy deliverable is to protect the Arctic environment and conserve its biological resources. Implementation should include identifying "ways to conserve, protect, and sustainably manage Arctic species.

- As a global leader in environmental issues, Germany promotes the mitigation of pollution impacts on the Arctic environment, flora and fauna.

- India has proposed the declaration of the Arctic as a region free from nuclear weapons.

- The EU *Communication from the Commission to the European Parliament and the Council – The European Union and the Arctic Region* document identifies a policy objective of resource exploitation respecting strict environmental standards, taking into account the particular vulnerability of the Arctic, and in the case of fisheries, exploitation at sustainable levels, taking into account the rights of local communities.

- Policy objectives of the *C169 Indigenous and Tribal Peoples Convention, 1989 – ILO169* include protecting and preserving the environment of the territories inhabited by indigenous and tribal peoples and safeguarding areas for traditional use (fisheries, reindeer husbandry).

- A policy objective of the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal* is increased protection of the environment by minimizing the generation and regulating the management (collection, transport, and disposal) of hazardous and other wastes.

- The *Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention)* Contracting Parties, or Member States, commit themselves to implementing the "three pillars" of the Convention: to designate suitable wetlands for the List of Wetlands of International Importance ('Ramsar List') and ensure their effective management; to work towards the wise use of all their wetlands through national land-use planning, appropriate policies and legislation, management actions, and public education; and to cooperate internationally c oncerning transboundary wetlands, shared wetland systems, shared species, and development projects that may affect wetlands. Parties also endeavour through management to increase waterfowl populations on appropriate wetlands.

- The *United Nations Convention on the Law of the Sea (UNCLOS)* contains an entire section dedicated to the protection and preservation of the marine environment (Part XII), and the treaty also contains numerous references to environmental duties and obligations throughout its many articles. Coastal states are required to maintain the existing fish stock and protect it from over-exploitation in their exclusive economic zone, including special provisions for straddling stocks and migratory species, and all nations have a duty to take measures to ensure the conservation of living resources on the high seas.

- The *United Nations Declaration on the Rights of Indigenous Peoples* states that Indigenous peoples have the right to the conservation and protection of the environment and the productive capacity of their lands or territories and resources. It proposes that States establish and implement assistance programs for indigenous peoples for such conservation and protection, without discrimination.

5.4.3 Role of Satellite Systems

EARTH OBSERVATION SYSTEMS

(Impact Medium)

The applications of EO for environmental protection are primarily the detection and monitoring of environmental contaminants and the monitoring of regulatory compliance. In the Arctic context, the contaminants of most interest are oil and chemical spills, mining tailings, industrial, commercial, and residential refuse, etc. EO possesses significant potential for the monitoring and tracking of atmospheric pollution and trace gases. This is of particular relevance to the Arctic, which receives contaminant deposits via the long range transport of pollutants from southern latitudes. EO is also useful for investigating regulatory compliance such as, for example, the environmental remediation and reforestation of mining sites and the monitoring of fisheries for illegal fishing.

The full GMES space infrastructure (i.e., Sentinel-1 to Sentinel-4) will be critical in delivering a complete suite of services and applications related to environmental protection.

6. SUSTAINABLE ECONOMIC DEVELOPMENT

One of the key priorities in the Arctic has consistently been the balanced development of the area's rich natural resources with the protection of its fragile northern ecosystem and the values and beliefs of the native communities. Key areas for economic growth include oil and gas, fisheries, tourism, mining and forestry. Significant emphasis is also placed on infrastructure development including aviation, marine and surface transport, modern telecommunications and structures, bearing in the mind the significant impact climate change may have on infrastructure in the Arctic. Also of key importance is the effective management of energy supply and energy networks.

6.1 Resource Development

6.1.1 Overview

Having been assessed as one of the world's last frontiers for both renewable and non-renewable resource development, there is a growing global interest in the region's oil and gas and mineral wealth. Much of this potential has yet to be realized due to the environmental, technological and logistical challenges of operating in the north. Yet, resource development is a fundamental policy priority for each of the Arctic states, with significant investment on the part of state government and private companies in offshore development in both the Barents and Beaufort Seas. Non-Arctic states are also intending on profiting from the region's economic development. Arctic energy has already been identified as an important cornerstone for growing Asian markets, especially China and India.

Resource development potential in the US and Canadian Arctic has been a catalyst for increased public and private interest in the region. Within the US, the expansion of the North Slope project and emerging opportunities in the Beaufort Sea has put pressure on government agencies and regulatory bodies to approve development, and development in the Barents Sea is progressing rapidly. Within Canada, opportunity in the Beaufort is matched by other major development projects like Baffinland's Mary Rive Project (iron ore), the mining exploration boom in Nunavut and Yukon, and on-shore gas potential in both Yukon and Northwest Territories (GRID Arendal, February 2012).

In Europe, the oil and gas industry is the key area for resource development in terms of both activities underway and revenue. Companies currently involved in the Arctic energy business include Gazprom and Rosneft (Russia), BP and Shell (UK), Statoil (Norway), Exxon Mobile, Chevron and ConocoPhillips (US). Russia is known to have approximately 90% of the Arctic's proven oil reserves with the remaining found in Canada, Greenland, Alaska and Norway (ArticCOM Consortium, 2011). Mineral and metal extraction is also underway in Russia, Canada, Greenland and Svalbard (coal). There is also a large number of mineral deposits of significant interest on the Arctic Ocean and Barents Sea floor which have remained until now largely inaccessible. The economic and technical viability of exploration has been proven and extraction activities are now underway, particularly by Norway and Russia.

Agriculture and fisheries have also become priority areas with an increased focus on modernization, restructuring and privatization of the agriculture and agro-industrial sectors. In fisheries in particular, the EU is focusing on fisheries cooperation with all states around the Baltic Sea.

6.1.2 Policy

Economic development is among the main policy priorities of all the Arctic states as well as the EU. Generally this refers to exploitation of natural resources, both renewable resources such as fisheries, forestry and marine mammals, and non-renewable ones, particularly fossil energy resources, and different kinds of economic activities in and dealing with the Arctic (e.g., tourism, shipping). Throughout these policies and national strategies there is consist focus on the sustainable use of natural resources in what is clearly recognized as a fragile environment. The Danish Greenlandic strategy speaks of "protection and sustainable use of natural resources" and the US Policy of "environmentally sustainable development". Further, the *EU Communication from the Commission to the European parliament and the Council – the EU and the Arctic Region* speaks of "promoting sustainable use of resources with exploitation of Arctic offshore hydrocarbons provided in full respect of strict environmental standards taking into account the particular vulnerability of the Arctic" and suggests that Arctic fisheries should take place "at sustainable levels whilst respecting the rights of local coastal communities". As well, the *Northern Dimension of the European Union*, adopted in November 2006, has been developed to deliver a common policy for Northern Europe (Heininen, August 2011).

Some specific policies/strategies of interest include:

- *Canada's "Our North, Our Heritage, Our Future"*: Released in 2009, the strategy's second priority is the promotion of social and economic development with a vision to create the sustainable use of Arctic potential. Development includes the exploration and utilization of natural resources (e.g., Geo-Mapping for Energy and Minerals) and mega-projects such as the Mackenzie Gas Project. An interesting point in the strategy is the implementation of a free trade agreement with EFTA member countries, as an avenue to enhance trading relations with other Arctic states (Heininen, August 2011).

- *Norway's High North Initiative*: Launched in 2006, the *Initiative* puts the Arctic and the High North at the centre of Norwegian economic development. The *Initiative* has three principal pillars: resource extraction (oil and gas, fisheries; and new types of marine and biological resources); knowledge accretion; and Norway's relationship with Russia. Norway's achievements in the Arctic are marked, and include extension of the Arctic shelf, the recent border deal with Russia and more globally, a burgeoning oil and gas industry (Heininen, August 2011).

- *Russia's Arctic Policy to 2020* focuses on several key areas including expanding hydro-carbon production in the Arctic Sea; assessing resource potential across vast territory by improved geological-geophysical, hydrographic and cartographical mapping; and expansion of conventional (oil and gas) and non-conventional (renewable) energy resources.

- *Denmark, Greenland and the Faroe Islands: Strategy for the Arctic 2011-2020:* The recently released *Strategy* emphasises self-sustaining growth and development as one of its key objectives, with a focus on fishing, mining and a large expansion of oil and gas in both Faroe and Greenland waters. There is also expected growth in renewable energy, particularly hydro-electric. Tourism and cruise liners will create both challenges and opportunities. (GRID-Arendal, 2012).

- *Finland's Strategy for the Arctic Region:* Released in 2010, the *Strategy* is organized around four themes, with the second being "Economic activities and know-how". Finland's objectives are first to strengthen its role as an international expert on arctic issues; second, to make better use of Finnish technology-based expertise of winter shipping and transport and ship-building; and third, to expand opportunities for Finnish companies to benefit from their arctic expertise and know-how in the large mega-projects of the Barents Regions (Heininen, August 2011).

- *Iceland in the High North:* Released in 2009, this document indicates that a key priority is the environment and resources, emphasising both sustainable development and Iceland's interests; particularly those of Iceland's fishing industry. Resource development in the Arctic should not undermine sustainable development in the region. It must serve the interests of its inhabitants and communities contributing to long-term economic development. Key areas of development include access to previously inaccessible resources on the ocean floor and new fishing grounds that are emerging following the retreating ice.

- *Sweden's Strategy for the Arctic region:* Released in 2011, the *Strategy* lists economic development as one of its key priorities. Several business areas are highlighted including: (i) mining petroleum (oil and gas resources) and forestry; (ii) land transport and infrastructure; (iii) maritime security and shipping; (iv) sea and air rescue; (v) icebreaking; (vi) energy; (vii) tourism; (viii) reindeer herding; and (ix) ICT and space technology (Heininen, August 2011).

- *USA's National Security Presidential Directive/NSPD-66 concerning Arctic Region Policy*: Released in 2009, with the growing awareness that the Arctic is both fragile and rich in resources, the policy sets forth several priorities, with one being economic issues including energy. In subsequent sections of the document, six themes are highlighted, with one focused on ensuring that natural resource management and economic development in the region are environmentally sustainable (Heininen, August 2011).

- *China* has yet to release an official Arctic policy at the state level. Instead, its position on Arctic affairs has been limited to individual references from the state on specific issues, most notably on its growing commercial interest in resource development, more specifically investment in mining projects in Greenland (rare earth metals) and Northern Canada (iron). China is also in negotiations with Russia in regards to bilateral agreements for Siberian pipeline projects.

- *India* has not released a formal Arctic strategy. However, their interest in the Arctic can be identified as being three-fold- environmental protection, economy, and policy. The need to fuel India's emerging economy with hydro-carbons has prompted the government to look northward for resource development

- *Germany* does not have a cohesive Arctic strategy currently in place. Access to natural resources and safe and secure maritime trade routes constitute major Arctic objectives for Germany. Accordingly, Germany is working actively through international collaborative channels (EU, NATO, Arctic Council, etc.) to achieve these objectives.

- *Arctic Policy of France*, in response to the increased accessibility of the Arctic as a result of a decreasing ice cover, actively promotes regulating use of the Arctic Ocean by means of an international treaty. Focal points of special interest include French business interests in the Arctic (e.g. fishing, shipping, oil/gas).

- *The European Union Strategy for the Arctic Region's* key policy objective is promoting the sustainable development of resources, noting that the exploitation of resources should be done with full respect of environmental standards and the rights of local communities while respecting the vulnerability of the Arctic region. Particular emphasis is on the areas of hydrocarbons, fisheries and tourism.

- *The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)*, brought into force in 1975, notes that international wildlife trade is estimated to be worth billions of dollars and includes hundreds of millions of plant and animal specimens. CITES' objective is to subject international trade in specimens of selected species to certain controls and standards. In particular, all import, export, re-export and introduction from the sea of species covered by the Convention has to be authorized through a licensing system.

- *The United Nations Convention of the Law of the Sea (UNCLOS)* addresses a number of provisions with respect to economic rights. Article 193: States have the sovereign right to exploit their natural resources (living and non-living) pursuant to their environmental policies. It regulates payments and contributions with respect to the exploitation of the continental shelf beyond 200 M.

- *The United Nations Declaration of the Rights of the Indigenous People* promotes the right of indigenous people to pursue their own economic development. The Declaration also establishes the need to consult with indigenous peoples before exploration or exploitation of natural resources is undertaken, including water.

- *C169 Indigenous and Tribal Peoples Conventions 1989* indicates that handicrafts, rural and community-based industries, and subsistence economy and traditional activities of the peoples concerned are to be promoted and strengthened. The policy promotes effective protection with regard to recruitment and conditions of employment of these peoples. It also establishes the need to consult with indigenous peoples before exploration or exploitation of natural resources happens on their land and that they participate in the benefits of such activities or receive compensation for the damages resulting from them.

- *The Convention on Biological Diversity* notes that states have sovereignty over their own genetic resources and are entitled to the "fair and equitable sharing of the benefits" that these resources provide. The value of biodiversity should be quantified and internalized into market prices, and perverse government-financed incentives that accelerate the loss of biodiversity need to be addressed. It also recognizes that ecotourism is a very fast growing industry and needs to be wisely managed so it has the potential to reconcile economic and environmental concerns and give a practical meaning to sustainable development.

6.1.3 Role of Satellite Systems

COMMUNICATIONS SYSTEMS

(Impact High)

A prerequisite for the increase in economic development activity in the Arctic is the availability of a means of communication. Most of the Arctic is covered by ocean and ice, there are large distances and there is little ground infrastructure that allows coverage of shore-based communication systems. Moreover, geostationary communication systems have poor or no coverage over large parts of the Arctic. Hence, there is a concern that lack of communication will be an obstacle to future activities in the region (ArticCOM Consortium, 2011). However, it should be noted that most of the future communications demand is expected to come from regions below 75^0N and thus be addressable by GEO satellites. Demand for satellite capacity in the GEO- reachable part of the European Arctic regions is forecasted to grow at 26% from 110 Mbps in 2010 to 1 Gbps by 2020. (Page 45, ArticCOM Consortium, 2011).

WEATHER SYSTEMS

(Impact Medium)

Operational activities, such as off-shore drilling and fishing, need reliable and timely information about the weather patterns and they rely heavily on global networks of dedicated meteorological satellites (e.g., METEOSAT, NOAA, Meteor, TIROS, and Fengyun).

An ongoing understanding of weather patterns is important to effectively managing Arctic activities ranging from commercial shipping and fishing, to the exploitation of natural resources and energy, and the continuity of the traditional indigenous ways of life.

NAVIGATION SYSTEMS

(Impact High)

GNSS provide the critical positioning, navigation and timing services that are essential for Arctic operations, including development of resources, movement of people and goods under extreme conditions, and voice and data communications. Applications critical to resource development include: position determination for the collection of geological and geophysical data and the production of mineral exploration mapping; positioning of oil and gas and mining lease sites; navigation to development sites and between those sites and shipping terminals; measurement of ore extraction from open pit mines, etc.

EARTH OBSERVATION SYSTEMS

(Impact High)

Modern earth observation sensors satisfy a wide range of monitoring and mapping applications. Capabilities of particular relevance to resource development activities in the Arctic include the mapping and characterization of snow and ice cover (land and sea ice), the assessment of land stability within permafrost regimes and the description of land cover and land changes, often within the context of climate change.

6.2 Infrastructure

6.2.1 Overview

In order to realize economic development activities in the Arctic, major infrastructure developments are required. Energy network pipelines, road systems, railways and deep sea ports, and buildings of all kinds are required in order to access, process, store, and ship resource wealth.

Community infrastructure refers to facilities not specifically associated with transportation or energy networks and includes private and public buildings, landfills, sewer, water, and solid waste facilities.

Arctic activities must be supported by robust, accessible and cost-effective telecommunications and information technology systems which play a crucial role in the development of a prosperous and sustainable northern region.

Delivering on infrastructure projects in the Arctic has particular challenges that are not common in southern communities given the remote areas and extreme climates, including the risks associated with permafrost. Long lead times are required to plan for shipping and delivery of materials and to secure contractors from a competitive and limited pool of experts. The construction season is short in the North given that the ground freezes significantly earlier in the year compared with the South. Permafrost also poses challenges for traditional construction methods.

6.2.2 Policy

Policies related to economic development, in most cases, also include improvements to regional infrastructure.

- In *Canada's Northern Strategy* (released in 2009) there is a focus on "promoting social and economic development" and to do this means "addressing critical infrastructure needs as modern infrastructure will contribute to a stronger economy, cleaner environment and increasingly prosperous communities."

- *Finland's Strategy for the Arctic Region:* Launched in June 2010, the *Strategy* defines Finland's key objectives in transport and infrastructure, which are: to improve business opportunities in the Arctic by developing transport, communication, logistical networks and border crossings; and to develop transport routes in the Barents regions.

- *Norwegian Government's High North Strategy:* Launched in 2006, the *Strategy* describes one of Norway's key priority areas as providing a suitable framework for further development of petroleum activities in the Barents Sea, seeking to ensure that these activities boost competence in (North) Norway and foster local and regional business activity. In particular, one of the action points includes the analysis of the existing transport infrastructure and future needs of, and commercial basis for, new transportation solutions, such as a railway from Nikel to Kirkenes and new flights within the High North.

- *Russia's Arctic Policy to 2020* describes the specific requirement to improve infrastructure for sea mineral production and Arctic fishing. Russia intends "to modernize and develop the infrastructure of the Arctic transport system and fisheries in the Russian Arctic" (Heininen, 2011).

- *Sweden's Strategy for the Arctic Region* identifies the development of land transport and infrastructure as one component of their economic development policy priority.

- *US Arctic Region Policy* seeks to balance development with adequate research and assessment in the field of infrastructure, subsistence, community impact, living marine resources, alternative energy, etc.

See also Policy Section 7.1.2 above on resource development, which includes discussion on the need for infrastructure to facilitate resource extraction.

6.2.3 Role of Satellite Systems

COMMUNICATIONS SYSTEMS

(Impact Medium)

The applications of communications systems for infrastructure are similar to the requirements for resource development. Effective communications systems are necessary for the construction and ongoing maintenance of both the ICT and transportation and energy infrastructures in the Arctic.

Opportunities exist to double the satellite bandwidth available for broadband in the North and provide a more robust, stable and affordable communications network to meet the needs of the north communities over the next decade. From an infrastructure development perspective, these expanded services will have an important positive impact on the ability to transmit the high volumes of satellite imagery that will be involved in the planning, construction and ongoing maintenance of new infrastructure in the Arctic.

WEATHER SYSTEMS

(Impact High)

Of particular concern in the Arctic region is permafrost and its impact on structures. The warming climate is thawing permafrost, posing several risks including loss of mechanical strength of structures (foundations, pilings) due to freeze and thaw cycles. Improper siting, design and construction methods have led to structural failure, expensive fixes and/or abandoned facilities. Global warming also accelerates the erosion of shorelines and riverbanks, threatening the infrastructure located in these areas. Satellite weather systems, which are able to effectively monitor weather and climate change over the poles, can assist in predicting and understanding climate change trends and their impacts on physical infrastructure.

NAVIGATION SYSTEMS

(Impact Medium)

GNSS positioning and navigation applications that are critical to infrastructure development include: position determination for the collection of geographical data and the production of precise mapping required for infrastructure planning and design; positioning of infrastructure right of ways and easements; precise positioning of infrastructure components such as bridges, dams, and electricity distribution stations and towers; and navigation to infrastructure facilities for repair and maintenance work. The precise timing capability of GNSS is also used by power generation companies to synchronize frequencies and to analyze frequent power blackouts. The exact location of a power line break can be determined by the precise timing of an electrical anomaly as it travels through the grid (C-CORE and HAL, 2012). Energy transmission companies use GNSS for pipeline leak detection surveys by aircraft, and use GNSS-equipped pigging tools that travel through pipelines to collect precise positions of defects in the pipe.

Similar to resource development, GNSS have broad ranging impacts in infrastructure development in the Arctic. There is a need for effective GNSS services in both the development of this infrastructure and its ongoing management.

EARTH OBSERVATION SYSTEMS

(Impact Low)

EO has only limited applications in infrastructure development in the Arctic, primarily in the preliminary planning for location of assets, where high resolution optical imagery is a useful tool for investigating location and routing alternatives.

SCIENCE SYSTEMS

(Impact Low)

The immense clouds of material (called coronal mass ejections) that are periodically emitted during solar wind activities can cause large magnetic storms in the space environment around the planet. As the earth's magnetic field is concentrated at the poles, high latitudes are particularly impacted by these space weather disturbances. The impacts of space weather are perhaps best known and documented with respect to electric power grids (HAL, 2010). During major geomagnetic disturbances, geomagnetically induced currents (GIC) are produced by the magnetic field variations that occur. GIC flows to ground through substation transformers, which can lead to transformer burn-out and unwanted relay operations, suddenly tripping out power lines. As compensators switch out of service, entire system stability can be affected.

Variations of the Earth's magnetic field also induce electric currents in long conducting pipelines and the surrounding soil (currents as high as 1,000 amperes have been detected). During magnetic storms, these variations can be large enough to increase the corrosion rate of the pipeline. The lifetime of the Alaskan pipeline is now estimated to be many years shorter than originally planned due to the impacts of such storms (Solarstorms.org).

The type of research that is being undertaken with support from dedicated science space systems (e.g., proposed Radiation Belt Storm Probe (RBSP) mission) is a key to understanding and eventually predicting hazardous events in the Earth's radiation belts and magnetic fields.

An improved understanding of space weather will assist Arctic interests to better predict potential impacts on technology systems and infrastructure (i.e., communication cables, power systems, pipelines and radio communication and navigation systems) as well as better prepare systems to be more robust and resilient.

6.3 Transportation Efficiency

6.3.1 Overview

Improvement of the North's transport efficiency is important for the overall development and viability of the region. More time and cost-efficient intercontinental shipping is a key economic driver for Arctic development. Global recognition of the Northern Sea route and Northwest Passage as new alternative trade routes has spurred significant infrastructure investment on the part of Arctic states, as well as a global demand for ice-capable shipping vessels. The current focus is to develop a multi-modal transport system improving the connections within the region and with neighbouring countries. Specific areas of concern include:

- Improvement in safety and maintenance of road transport;
- Modernization and development of railways
- Improved efficiency of existing capacity in maritime ports;
- Promotion of multi-modal transport; and
- Safety during periods of ice break-up (river and sea ice are frequently used as efficient means of transport in the North).

When addressing these areas, factors unique to the Arctic region must be addressed, including use of ice-breakers, expensive road maintenance, and associated customs procedures as well as high logistics costs for industry to maintain the transportation systems.

6.3.2 Policy

Transportation, largely in terms of maritime shipping and transport, is among the priorities or objectives of the strategies and policies of Finland, Iceland, Russia, Canada and the USA; this is less so in the policies of Denmark/Greenland, Norway, Sweden and the EU.

- One of the priority areas of the US Arctic Policy is maritime transportation "to facilitate safe, secure and reliable navigation" and "to protect maritime commerce and the environment".
- Iceland has a particularly strong emphasis on shipping and northern sea routes, such as trans-Arctic routes, but also on aviation.
- Russia, similar to Iceland, emphasizes "management and effective use of cross-polar air routes and the Northern Sea route for international navigation." (Heininen, 2011).
- The *Canadian Arctic Foreign Policy* document notes that the improvement of sea and air transportation routes is a key priority.
- The *EU Strategy for the Arctic Region* notes that Member States have the world's largest merchant fleet and many of those ships use trans-oceanic routes. The melting of sea ice is progressively opening opportunities to navigate on routes through Arctic waters. This could considerably reduce the distance of trips from Europe to the Pacific. The policy also has an objective of gradually introducing arctic commercial navigation, while promoting stricter safety and environmental standards, and defending "the principle of freedom of navigation".

See sections 3.1 Marine Transportation, 3.2 Land Transporation and 3.3 Air Transporation above for further policy discussion.

6.3.2 Role of Satellite Systems

WEATHER SYSTEMS

(Impact Low)

Access to reliable and timely satellite weather forecasts is important for effective and cost-efficient route planning for marine, land and air transportation to remote communities. For land transportation, the global climate has reduced the timeframe for access to ice roads in the Arctic thus making alternative route planning a necessity. In addition, the increase in snow accumulation in the region (caused by the greater amount of precipitation and moisture in the air that warmer temperatures bring) will increase the difficulties and costs of keeping roads open and accessible. For air transportation, weather forecasts can significantly impact cost effectiveness as route planning and scheduling is dependent on a clear understanding of current and future weather. For marine operations, the ability to predict and understand weather patterns is important to ensure the most timely and cost-effective route is selected. Specialized weather forecasts may also be necessary for off-shore drilling activities to ensure necessary operational efficiencies are implemented.

NAVIGATION SYSTEMS

(Impact High)

Northern sea routes are expected to attract growing levels of ship traffic through the Northeast and Northwest Passage for numerous reasons (increasing accessibility due to reduced ice coverage, resource exploitation, tourism, etc.) thus resulting in a higher demand for GNSS for planning efficient transportation routes.

EARTH OBSERVATION SYSTEMS

(Impact High)

The primary contribution of EO to improving the efficiency of transportation in the Arctic includes the monitoring and charting of sea ice covers. In particular, areas of open water within ice fields, as well as areas of thin, first-year ice constitute transportation corridors of choice in ice-infested waters. In addition to vessel traffic, EO is also useful as a navigation aid for individuals travelling on near shore ice, as well as on river and lake ice covers used as ice roads during the winter months.

The systematic coverage of Arctic shipping routes with operational ice charts derived from wide swath imagery is currently limited to national territorial waters and exclusive economic zones. In the future, there is considerable potential to expand routine ice charting with full-resolution wide swath data to the entire Arctic basin. This will be particularly important considering the expected increase in Arctic vessel traffic over the coming years. In addition to operational ice charts, a need exists for localized ice products generated at higher spatial resolutions (e.g., access to specific ports or coastal installations). In this case, beam modes other than wide swath are available, down to resolutions between 1 and 3 meters provided by the most recent generation of SAR systems. For ice road applications, typically spatial resolutions used range from 10 to 30 m.

7. SOVEREIGNTY

7.1 National Boundaries

7.1.1 Overview

The national boundaries of most concern in the Arctic are the outer limits of national jurisdictions in the ocean. The United Nations Convention on the Law of the Sea (UNCLOS) provides the framework for the governance of the world's oceans. Once a nation ratifies UNCLOS, it has ten years to submit a claim to the Commission on the Limits of the Continental Shelf (CLCS) in order to establish the outer limits of the territory over which it claims jurisdiction (DFAIT, 2011). UNCLOS offers nations an opportunity to make a claim, or partial claims, for jurisdiction over areas that extend beyond the 200 nautical mile limit (i.e., the Exclusive Economic Zone or EEZ). A nation's objective, therefore, is to define the outer limit of this area, called the "extended continental shelf", using the rules for this purpose set out in Article 76 of UNCLOS. This is foremost a technical exercise involving a broad range of scientific disciplines and methodologies, depending on the article or articles within the Convention that will serve as the basis for a claim.

Despite overlapping claims to the Arctic seabed, regional cooperation on issues pertaining to sovereignty and security has never been higher. Increased cooperation among Arctic states and the passing of the Arctic Council's Search and Rescue Agreement demonstrate the concerted effort of countries relying on each other to prepare for increased interest and activity in the region. The adherence from each of the five Arctic coastal states to the peaceful resolution of overlapping claims through UNCLOS and the International Seabed Authority has curbed investment in military operations and strengthened cooperation on cross-border security areas like joint coast guard exercises.

7.1.2 Policy

All of the nations with Arctic territories (i.e., Canada, Denmark/Greenland, Finland, Iceland, Norway, Russia, Sweden, and the USA) have recently published strategies describing priority areas and policy objectives both locally and in the circumpolar Arctic region as a whole. Sovereignty features prominently in most of these documents.

- The *United Nations Convention on the Law of the Sea (UNCLOS)* creates a unified regime for governance of the rights and responsibilities of nations in their use of ocean space. It governs all aspects of ocean space including: delimitation; environmental control; marine scientific research; economic and commercial activities; transfer of technology; piracy, and the settlement of disputes relating to ocean matters. UNCLOS Parts II, V, VI, and VII establish the various regions of the oceans, who has sovereignty over each, and to what degree (e.g. for international navigation, submarine cables, exploitation of natural resources, installations and structures).

- *Canada's Northern Strategy: Our North, Our Heritage, Our Future* states that exercising sovereignty over Canada's North is "our number one Arctic Foreign policy priority" (Government of Canada, 2009). Implementing this strategy includes defining Canada´s domain and advancing knowledge of the Arctic through the continued use of UNCLOS in setting maximum outer seabed limits, and amending the Arctic Waters Pollution Act to extend its coverage to 200 nautical miles. Other priorities include extending Canada's national boundaries to the North Pole and increasing military/law enforcement presence and capabilities in the north (including satellite monitoring).

- The *Canadian Arctic Foreign Policy* includes policy objectives of resolving boundary issues in the Arctic region, in accordance with international law and securing international recognition for the full extent of our extended continental shelf wherein Canada can exercise its sovereign rights over the resources of the seabed and subsoil.

- The *Kingdom of Denmark Strategy for the Arctic 2011–2020* refers to the central role of the Danish Armed Forces in enforcement of sovereignty in Denmark, Greenland and the Faroe Islands, which is exercised through a visible presence in the Arctic region where surveillance is critical (Governments of Denmark, Greenland and Faroe Islands, 2011). It also references the ongoing dispute with Canada regarding the sovereignty of Hans Island.

- The *Iceland in the High North* report notes that sovereignty is an issue. Iceland disputes the Norwegian interpretation of Norway's sovereignty of Svalbard.

- Norway's *New Building Blocks in the North* report emphasizes the importance of cooperation with Russia, and it has numerous, ambitious and concrete objectives in this regard. These objectives have been furthered by agreement on where to draw an offshore boundary line in the Barents Sea, which was reached between the two countries in September 2010 (Heininen, 2011). The main sovereignty goals are to have enough information and knowledge about human, biological, and geological activities to be able to manage the oceans well.

- The Arctic policy of Russia, *Fundamentals of State Policy of the Russian Federation in the Arctic in the Period up to 2020 and Beyond*, includes the policy of maritime delimitation in accordance with international law.

- The US *National Security Presidential Directive/NSPD – 66 concerning an Arctic Region Policy* encourages the Senate to act favorably on US accession to UNCLOS to secure US sovereign rights over extensive marine areas, including the valuable natural resources they contain. The policy claims that the US and Canada have an unresolved boundary dispute in the Beaufort Sea. These policies are intended to be implemented through legal actions for extending the US continental shelf, consideration of the natural environment and fragile marine ecosystem in the process of extension, and encouragement of Russia to ratify its maritime boundary agreement. It also reaffirms the US recognition of the Northwest Passage as an international strait and defends the importance of the Northwest Passage being recognized by international law as an international strait. (Heininen, 2011).

- Although Germany has no national borders in the Arctic it encourages the settlement of territorial disputes through UNCLOS and other relevant processes to further the objectives of safe transportation, access to resources and environmental protection.

- Although it has no territorial claims in the Arctic, China has shown support for the legal process of Arctic states extending their continental shelf through UNCLOS. Their Arctic interests include making sure the Northwest Passage and the Northern Sea Route remain open for international navigation and increased international collaboration, which is currently most pronounced with Norway, Denmark, and Russia.

- The *C169 Indigenous and Tribal Peoples Convention, 1989 – ILO169* has national border implications. Since many indigenous peoples have been involuntarily divided or separated by state borders that run across their territories, contact between members of their people divided by the border (e.g. the Sami people) has been hampered. Governments are obligated under the *Convention* to take appropriate measures, such as by means of international agreements, to facilitate contacts and co-operation between indigenous and tribal peoples across borders, including activities in the economic, social, cultural, spiritual and environmental fields.

7.1.3 Role of Satellite Systems

NAVIGATION SYSTEMS

(High Impact)

Article 76 of UNCLOS requires nations to determine the shape of the seabed, depth of seafloor and thickness of the underlying sedimentary layer (DFAIT, 2011). These measurements result in two limits: the *formula line*, obtained by the application of distance formulae outlined in Article 76, and the *constraining line*, defining the maximum extent of the outer limit. The starting point for the formula line is the 'foot of the continental slope (FOS)', defined as the point of maximum change in the gradient at its base. The location of this line can be found from two formulae: a) a distance of 60 nautical miles from the FOS, or b) the distance to a point where the thickness of the sedimentary layer is at least 1% of the distance to the FOS. In constructing the combined formula line, a coastal state may apply that formula which is most advantageous to its case. The constraining line is defined as the most seaward of a line 350 nautical miles from the baselines of the coastal state, or a line 100 nautical miles seaward of the 2,500 m depth contour. To construct the final outer limit, a coastal state must choose at each point the most landward of the constraining and the formula lines. The determination of these parameters is only possible with the aid of Global Navigation Satellite Systems (GNSS), which are used to determine the positions of the equipment used in the measurement of the shape of the seabed, depth of seafloor and thickness of the underlying sedimentary layer.

SCIENCE SYSTEMS

(Low Impact)

Gravity science satellite missions are applicable to boundary measurements due to their contribution to the definition of the geoid. The geoid is an approximate mathematical figure of the earth determined from precise gravity measurements. The accuracy of the geoid affects the accuracy of GNSS positioning, and particularly the vertical component, used for offshore boundary determination work.

The scarcity of ground- or airborne-based gravity measurements in the Arctic has meant that the geoid determination in the region is relatively poor. Gravity space science missions like CHAMP (Challenging Minisatellite Payload – launched in 2000 and expired in 2010), GRACE (Gravity Recovery and Climate Experiment – launched in 2002) and GOCE (Gravity field and steady-state Ocean Circulation Explorer – launched in 2009) helped to address this problem. The most recent geoid model was unveiled at the Fourth International GOCE User Workshop in March 2011 (ESA, 2011).

7.2 Border Protection

7.2.1 Overview

Border protection involves supporting national security priorities and facilitating the flow of people and goods across a country's borders. Typical activities include (Canada Border Services Agency, 2011):

- Administering legislation that governs the admissibility of people, goods and plants and animals into and out of the country;
- Detaining those people who are inadmissible or may pose a threat to the country;
- Identifying and removing people who are inadmissible to the country;
- Interdicting illegal goods entering or leaving the country;
- Protecting food safety, plant and animal health, and the country's resource base;
- Promoting business and economic benefits to the country by administering trade legislation and trade agreements to meet international obligations, including the enforcement of trade remedies that help protect industry from the injurious effects of dumped and subsidized imported goods;
- Administering a fair and impartial redress mechanism; and
- Collecting applicable duties and taxes on imported goods.

Border protection usually includes the dual mandate of managing access to borders by large numbers of people and goods moving over land, by sea and by air, while maintaining the integrity of the border and providing protection from threats to the country's security and prosperity. Security in the Arctic is not so much about militarization of the region as it is about governments effectively controlling their jurisdiction.

7.2.2 Policy

Border protection is an area of special interest that is reflected in a number of the Arctic nations' policy documents.

- *Canada's Northern Strategy: Our North, Our Heritage, Our Future* includes the building of eight state-of-the-art Arctic offshore patrol ships and establishment of new regulations under the Canadian Shipping Act 2001 to require reporting to the Coast Guard prior to entering Canadian waterways.
- According to Norway's *New Building Blocks in the North* report, firm exercise of sovereignty and strengthening of cross-border cooperation in the North is a policy priority, and the Government intends to increase activities of the Coast Guard, further develop border control, and improve civilian border surveillance and control along the Norwegian-Russian border. In addition, a strategic focus on knowledge will include further developing the capacity to safeguard Norway's foreign policy interests in the High North. As part of its High North strategy, the Norwegian Government has given the Ministry of Fisheries and Coastal Affairs the responsibility for setting up a full-spectrum monitoring and information system for the Northern Sea and coastal areas called 'BarentsWatch'.
- The Arctic policy of Russia, *Fundamentals of State Policy of the Russian Federation in the Arctic in the Period up to 2020 and Beyond*, includes the policy of optimizing levels of control over the Arctic through advanced boundary control, improvements to surveillance techniques of its maritime areas and greater patrolling of trade (Heininen, 2011). Improving military security and protection of state border in relation to increased terrorist threats is a priority.
- Steps in the US *National Security Presidential Directive/ NSPD – 66 concerning an Arctic Region Policy* to protect US sovereignty include: development of capabilities and capacity for protecting the country's air, land, and sea borders in the Arctic; an increase in Arctic maritime domain awareness to protect US commerce and key resources; projection of a sovereign US maritime presence in the region; and preservation of the global mobility of American military and civilian vessels throughout the Arctic. The US is prepared to act unilaterally or multilaterally to safeguard its Arctic interests, including in areas of missile defence, early warning systems, and maritime presence.
- The *Indigenous and Tribal Peoples Convention, 1989 – ILO169* notes that many indigenous peoples have been involuntarily divided or separated by state borders that run across their territories and hamper contact for members of their people divided by the border. It requires Governments to take appropriate measures, including by means of international agreements, to facilitate contacts and co-operation between indigenous and tribal peoples across borders, including activities in the economic, social, cultural, spiritual and environmental fields.
- The report, *Nordic Cooperation on Foreign and Security Policy*, proposed that the Nordic countries explore cooperation in the development and operation of a Nordic system for monitoring and early warning in the Nordic sea areas (Stoltenberg, 2009). The proposal was for a maritime monitoring system with two pillars, one for the Baltic Sea ('BalticWatch') and one for the North Atlantic, parts of the Arctic Ocean and the Barents Sea ('BarentsWatch'), under a common overall system. BarentsWatch is presently underway (Norway Ministry of Foreign Affairs, 2011). The

report also proposed the establishment by 2020 of a Nordic polar orbit satellite system that could provide frequently updated real-time images of the situation at sea for effective maritime monitoring and crisis management, as well as communications capabilities.

7.2.3 Role of Satellite Systems

COMMUNICATIONS SYSTEMS

(Impact Medium)

Robust, reliable, and efficient communications systems (high speed internet, digital network infrastructure, mobile phones) to support both the security and operational needs of border protection activities are essential. The presence of governments in the Arctic is forecasted to increase over the years in terms of personnel, vehicles, and budgets for the main purpose of sovereignty and border protection. Applications to support both the civilian government sector (coastal guard and local authorities), as well as military systems, require a range of connection speeds, which can mostly be satisfied below 75°N. However, above 75°N there is a lack of communication available to satisfy all current needs (especially monitoring type applications). As such, governments are looking to fund higher speed systems with coverage above 75°N. (ArticCOM Consortium, 2011)

NAVIGATION SYSTEMS

(Impact High)

The use of GNSS is applicable to border protection for the roles of intercepting illegal goods that may be coming across borders and for tracking people that are inadmissible or may pose a threat to a country. Border control officers employ GNSS in their vehicles, vessels, or aircraft for navigation purposes when in pursuit of such goods or persons. In addition to navigation, in some circumstances they are important in determining in which jurisdiction or restricted area the incident occurs.

EARTH OBSERVATION SYSTEMS

(Impact High)

Earth observation (EO) satellite systems provide valuable imagery that can be of benefit in identifying and tracking the movement of illegal goods such as drugs and nuclear materials. The most applicable systems for border protection purposes are the high resolution imaging systems, which are required to ensure positive identification of illegal activities.

Significant challenges for identification and tracking applications in border protection include the differing repeat coverage cycles of the various systems, as well as trade-offs between spatial resolution and areal coverage. As a result, the integration of multiple EO data streams (e.g., optical, radar, infrared, etc.) may be necessary to meet application needs.

SURVEILLANCE SYSTEMS

(Impact Low)

The primary space-based surveillance technology is the reception by satellite of Automatic Identification Systems (AIS) signals emitted by marine vessels (S-AIS). S-AIS can contribute to surveillance by providing marine domain awareness in areas beyond the reach of terrestrial AIS systems, which do not exist in the Arctic. This application requires that S-AIS be correlated with other sensors and information sources, such as EO. S-AIS can be used to ensure compliance with areas of operation and help to track vessels engaged in illegal activities.

The time from reception of the AIS message on the satellite to the time the data is available to the user on the ground (time latency) and time between satellite passes (update frequency) can present problems in the border protection context, where vessels will be moving as fast as possible in order to avoid apprehension. In addition, although illegal, vessel captains may turn off their AIS transmissions in order to help avoid detection.

7.3 Defence

7.3.1 Overview

The primary roles of defence organizations are to protect their country's security, deter war with other nations, and contribute to international peace and security. In addition to the military responsibilities of protecting national territory, airspace and maritime areas of the jurisdiction, defence organizations often support civil organizations in a variety of roles, such as:

- Maintaining an adequate, reasonably uniform level of emergency preparedness; and
- Responding to major emergencies and disasters.
- And participate internationally in such areas as:
- Multilateral operations through international organizations like the United Nations (UN) and the North Atlantic Treaty Organization (NATO);
- Humanitarian-relief efforts and restoration of conflict-devastated areas; and
- Arms-control programs.

7.3.2 Policy

Closely linked with border protection as a means of protecting Arctic nations' sovereignty is defence, and a number of policy documents explicitly reference the importance of the defence role in the region.

- The *Kingdom of Denmark Strategy for the Arctic 2011–2020* places emphasis on the tasks of the Danish Armed Forces in the Arctic. Measures being taken to strengthen the ability of the armed forces to conduct operations in the Arctic environment include: the establishment of an Arctic Command and an Arctic Response Force to strengthen the enforcement of sovereignty and surveillance, for instance through military exercises; and involvement of Greenland's citizens in handling key tasks of the armed forces in the Arctic.
- According to Norway's *New Building Blocks in the North* report, the Barents Sea will continue to have an important military strategic position, especially for Russia, but also for the USA concerning their nuclear weapons policy.
- Russia's *Fundamentals of State Policy of the Russian Federation in the Arctic in the Period up to 2020 and*

Beyond policy document discusses the necessity of the Armed Forces, being capable of defending the Arctic region, depending on various political and military situations.

- *Canada's Northern Strategy: Our North, Our Heritage, Our Future* has an objective of increased military presence and capabilities in the north (including satellite monitoring).

- The US *National Security Presidential Directive/NSPD – 66 concerning an Arctic Region Policy* stresses the importance of national defence by stating that the US is willing to cooperate, or act unilaterally, to safeguard its interests in the region (e.g., missile defence and early warning; deployment of sea and air systems for strategic sealift, strategic deterrence, maritime presence and security operations; and ensuring freedom of navigation and overflight).

- Germany is also supporting the development of military strategies (within appropriate frameworks of international collaboration, such as NATO) to secure trade routes and access to resources.

- Although also without Arctic territories, France is concerned with questions of military security in the Arctic via its engagement with NATO and the European Union. In this context, special concerns arise from France's status as a nuclear-weapon state. A major goal is the preservation of stability and the guaranteed access to critical transportation routes and natural resources.

- The *Nordic Cooperation on Foreign and Security Policy* report proposes that:

    - a Nordic stabilisation task force be established that can be deployed to states affected by major internal unrest or other critical situations where international assistance is desirable;

    - the Nordic countries strengthen their defence cooperation on medical services, education, materiel and exercise ranges;

    - a Nordic amphibious unit be established based on existing units and the current cooperation between Sweden and Finland and, in the longer term, the unit should develop its own Arctic expertise; and

    - the Nordic governments issue a mutual declaration of solidarity in which they commit themselves to clarifying how they would respond if a Nordic country were subject to external attack or undue pressure.

7.3.3 Role of Satellite Systems

COMMUNICATIONS SYSTEMS

(Impact Medium)

Robust, reliable, and efficient communications systems (high speed internet, digital network infrastructure, mobile phones) to support both security and operational needs of defence personnel are essential. The defence presence in the Arctic is forecasted to increase over the years in terms of personnel, vehicles, and budgets for the main purpose of sovereignty and border protection. Applications to support both the civilian government sector (coastal guard and local authorities) as well as military systems require a range of connection speeds.

NAVIGATION SYSTEMS

(Impact High)

GNSS is critical for military applications, and defence organizations typically have access to better navigation and positioning capabilities than do civilian users. The EU decided that it needed to have a sovereign GNSS capability, primarily because the US or Russia could deny access to GPS or GLONASS during military conflicts. While the Arctic has not been a theatre of war in the past, this could conceivably change as the region becomes more industrialized and populated. At present, the primary uses of GNSS in the Arctic are for military training exercises and for participation of the military in responses to emergencies and disasters.

EARTH OBSERVATION SYSTEMS

(Impact High)

There are a broad range of defence applications of satellite EO, including intelligence gathering, detection and monitoring the movement of opposing troops and equipment, military operations planning and assessment, and planning and executing assistance to civilian agencies in response to major emergencies or disasters. In the Arctic context, the primary applications support wide-area surveillance efforts, military training exercises, emergency response to environmental disasters and search-and-rescue missions.

Defence organizations can access and use the full range of commercial EO imaging services and also have access to classified EO technologies that are not accessible to civilian users. All types of imagery are typically used, including radar, optical and thermal EO data. Thematically, target detection and classification constitute central elements in defence EO applications. Accordingly, emphasis is placed on EO data acquired at very high spatial resolutions. Multi-spectral and thermal imagery are further used to differentiate camouflaged military equipment or installations from their surrounding environments. Military applications also emphasize monitoring for changes and/or of traffic at specific locations (e.g. suspected/actual military installations, critical transportation links). The information required is typically extracted from imagery by means of visual interpretation by trained operators and supplemented by automated algorithms. In many cases, data collected for defence applications is shared with other national law enforcement and/or border protection agencies.

7.4 Maintaining Presence

7.4.1 Overview

A country's ability to effectively maintain jurisdiction over and administer remote regions is tied to the presence of their people and economic activity in those regions. It also depends to a large extent on how well a region is known and understood and the kind of stewardship of the region's land and resources that is undertaken. A strong presence in the Arctic enhances an Arctic nation's ability to protect and monitor the land, sea and air of their region and therefore demonstrate their sovereignty over that region.

7.4.2 Policy

While a presence in the Arctic is an important means of demonstrating sovereignty over the region, this policy objective is explicit in only a few of the Arctic policy documents.

- *Canada's Northern Strategy: Our North, Our Heritage, Our Future* emphasizes the importance of strengthening Canada's presence in the Arctic by, for example: exerting rights based on the historical presence of the Inuit; strengthening military presence and control in the Arctic through the establishment of an Army Training Centre and the construction of an icebreaker; and construction of a new world-class Arctic research centre.

- The US *National Security Presidential Directive/NSPD – 66 concerning an Arctic Region Policy* refers to heightened human activity in the Arctic, and the necessity of asserting a more active and influential presence in the region to protect US interests.

- Norway's *New Building Blocks in the North* discusses the importance of the presence in the High North of Norwegian Air and Sea forces. It underlines that this presence must be permanent, consequent and predictable.

7.4.3 Role of Satellite Systems

COMMUNICATIONS SYSTEMS

(Impact High)

As of 2010, almost four million people live in the Arctic and they include indigenous people, immigrants, hunters, herders and urban dwellers (ArticCOM Consortium, 2011). Arctic communities are similar to the south, whereby a significant population tends to be concentrated in core areas with good terrestrial systems; however, the Arctic has proportionately more remote villages that have poor communication systems. The key application utilized in the northern communities are backhaul systems, broadband services, broadcasting (TV), voice and low data rate communications and tracking and monitoring. Satellite systems currently provide sufficient supply below 75°N to meet basic connectivity needs; however they are not fully sufficient for Internet access. Supply is also currently sufficient above 75°N, mostly because there are few settlements in this area and they require only voice or LDR communications for security reasons. However, this will change as new businesses and commercial activities push further north and demand increases for education and health/wellness applications. (ArticCOM Consortium, 2011)

8. INDIGENOUS AND SOCIAL DEVELOPMENT

The values, beliefs and social development of the indigenous population have always been a primary concern for Arctic nations. As noted by the Arctic Council's *Arctic Human Development Report (2004)*, "Arctic societies have a well-deserved reputation for resilience in the face of change. But today they are facing an unprecedented combination of rapid and stressful changes involving both environmental forces like climate change and socioeconomic pressures associated with globalization." Under the circumstances, it is particularly noteworthy that the "… Arctic has become a leader in the development of innovative political and legal arrangements, including co-management regimes governing the use of natural resources, collaborative arrangements designed to facilitate cooperation between public governments and indigenous peoples organizations, and transnational arrangements like the Northern Forum and the Arctic Council itself."

8.1 Traditional Livelihoods, Culture and Rights

8.1.1 Overview

Recognition through international law of indigenous rights has provided the foundation for Arctic indigenous groups to lobby for greater political autonomy and economic recognition, while at the same time allowing them to protect their traditional livelihoods (including fishing, hunting and reindeer herding). As the Arctic frontier moves further north and economic development gains momentum, large expanses of land may be converted to uses for transportation, forestry, mining and oil production, and could be destroyed by irresponsible environmental management. In this capacity, the International Labour Organizations' *Convention 169* and the UN's *Declaration on the Rights of Indigenous Peoples* have been critical in strengthening indigenous peoples self-determination, political autonomy, and voice in economic activity decisions.

A number of regional organizations have played an important role in promoting indigenous rights, including the Arctic Council and its Sustainable Development Working Group, as well as its Indigenous Peoples Secretariat. The role of the Council's Permanent Participants and the development of their own strategies cannot be understated. Furthermore, scientific organizations like the International Arctic Science committee and International Arctic Social Science committee have added significant contributions to the understanding of environmental and social impacts on northern communities.

8.1.2 Policy

The majority of the Arctic states have policies in place that focus on maintaining traditional livelihoods, protecting cultural heritage and ensuring healthy and safe northern communities. Below is a summary of some the key themes:

- *Finland's Strategy for the Arctic Region:* Launched in June 2010, the *Strategy* states that "Finland continues to work for the rights of the indigenous people." The strategy has the following objectives: to ensure indigenous peoples participation when dealing with their affairs; to safeguard the funding needed for their efficient participation; and to strengthen the status of the Barents Region's indigenous peoples within the work of the Arctic Council (AC) and Barents Euro-Arctic Council (BEAC) (Heininen, 2011).

- *Iceland in the High North:* Published in 2009, this report presents six key goals, with the fifth focused on people and cultures with unique cultural heritages. Arctic communities possess unique cultural heritages which should be preserved. Their cultural identity can be strengthened through increased cooperation, making use of modern technology. Close cooperation with Iceland's neighbours in Greenland and the Faroe islands is also of particular importance for Iceland in view of their proximity and similar interests (Heininen, 2011).

- *Denmark, Greenland and the Faroe Islands: Strategy for the Arctic 2011-2020:* The *Strategy* notes that some Arctic communities are facing difficult social issues. To deal with adverse social trends, the emphasis on social coherence and integration is central to development in the Arctic (GRID-Arenda, 2012).

- *Canada's "Our North, Our Heritage, Our Future":* Released in 2009, the strategy notes that one of its key priorities is geared towards improving both self-sufficiency and the health of northern communities. It notes that to achieve this requires supporting healthy and vibrant communities and human well-being in the north (Heininen, 2011).

- *Sweden's Strategy for the Arctic Region:* A key priority of the *Strategy* is the human dimension which includes people of the region and their living conditions. Areas related to culture and traditional ways of life include the impacts of climate change on indigenous cultures and industries, and preservation of Saami languages and traditional knowledge.

- *Norway's Arctic Policy – the High North Vision and Means* puts a key focus on safeguarding the language and culture of indigenous peoples. It recognizes that development, internationalization, new industries, and resource exploitation create both challenges and opportunities. Indigenous peoples must be able to participate in the planning processes so traditional use of fisheries and reindeer herding is safeguarded.

- *United States Arctic Region Policy* seeks to improve the degree to which indigenous communities are consulted and involved in relevant decision-making forums.

- *Russia's Arctic Policy to 2020 and Beyond* focuses on improvements to the quality of life and social conditions for indigenous peoples.

- *Arctic Policy of France* does not include Arctic indigenous and social development as a primary policy objective, although issues affecting northern communities are implicitly addressed in France's stance on Arctic environment and science.

- *The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITIES 1975),* controls and licences the international trade of wildlife species ensuring the protection of natural habitat which indigenous people are dependant on for their livelihood.

- *The Stockholm Convention of Persistent Organic Pollutants,* entered into force in May 2004, contributes to increased public awareness on the impact and presence of harmful POPs on indigenous communities and their subsequent health and welfare.

- *The United Nations Declaration on the Rights of Indigenous People* addresses issues such as identity, language, health, traditional livelihoods, connectivity and education, and provides guidance on harmonious, cooperative relationships with Indigenous peoples. It also states that the right to self-determination of indigenous peoples implies the right to autonomy or self-government and rights to lands, territories and resources.

- *The Indigenous and Tribal Peoples Conventions 1989* recognizes peoples' aspiration to exercise control over their own institutions, ways of life and economic development and to maintain and develop their identities, languages and religions, within the framework of the States in which they live. Social security schemes shall be extended progressively to cover the peoples concerned, and applied without discrimination against them.

- *The Convention on Biological Diversity* recognizes that many indigenous and local communities interact closely with biological diversity. They contribute to the conservation and sustainable use of biological diversity through their role as natural resource managers. Traditional knowledge should be respected and maintained and benefits arisen from their utilization should be equitable shared.

- *The EU Strategy on the Arctic Region* gives a clear indication of EU support to indigenous peoples and local populations with the statement that "Arctic indigenous peoples in the EU are protected by special provisions under European Community Law".

8.1.3 Role of Satellite Systems

COMMUNICATION SYSTEMS

(Impact High)

The need for efficient and modern communication technology in isolated northern communities is considerable, and access to affordable, reliable communication infrastructure can play a role in improving the lives of northern communities. Space based satellite communication facilities can be used to contact emergency services, increase contact among indigenous groups and tie them together, strengthen feelings of identity, increase economic prospects thru e-commerce, and increase indigenous peoples' political participation.

WEATHER SYSTEMS

(Impact Medium)

The need for accurate, timely weather forecasts to ensure safe travel and plan daily activities is essential for inhabitants of northern communities.

Northern residents rely heavily on traditional modes of life (e.g. hunting, fishing), and the knowledge of expected and actual weather along travel routes is essential component of northern life. While indigenous communities have a wealth of traditional knowledge concerning expected and experienced states of the environment, that knowledge cannot always be relied upon because of the uncertain impacts of climate change. As a result, conventional weather forecasts are used by all individuals engaged in travel over larger distances.

NAVIGATION SYSTEMS

(Impact Medium)

Indigenous peoples in the Arctic have adapted to modern technologies very quickly and apply GNSS technology to navigate through a very hostile and unforgiving terrain to visit other communities, travel to hunting and fishing destinations, etc.

The ability to use GNSS for navigation has a significant positive impact on the safety of travel for indigenous peoples and enables navigation via the shortest and safest route, important in reducing travel time, fuel costs, equipment wear and greenhouse gas emissions.

EARTH OBSERVATION SYSTEMS

(Impact Medium)

EO can be used to produce maps and other real-time information products that allow hunters and fishers to safely navigate around dangerous areas, including ice ridges, moving ice or stretches of open water. With this additional information hunters/fishers are better able to plan the shortest and safest route to their destination. The information is vital to augmenting traditional knowledge that previously guided travel routes, but which is now impacted by climate change, thus making it less reliable. This is important in reducing travel time, fuel costs, equipment wear and greenhouse gas emissions.

Travel by northerners is largely restricted to ice roads and nearshore, land-fast ice. Accordingly, the use of EO in support of traditional livelihoods is primarily based on all-year, 24h capabilities of satellite SAR imagery, and its proficiency for ice mapping. Optical data is considered useful in general, but is generally of limited availability due to prevalent cloud cover. The context in which EO data is beneficial is similar to applications in transportation efficiency and safety described earlier.

8.2 Education

8.2.1 Overview

The EU and other Arctic nations have allocated significant resources to foster the development of education systems that are not only sensitive to Arctic conditions but that are designed to provide students with the skills required to thrive in the northern communities. Key issues include:

- Development and restructuring of the higher education system;
- Management training for entrepreneurs;
- Incorporation of new technologies to deliver distance education of high quality
- Provision of instruction in native languages;
- Development of networks between universities
- Student teacher exchange programs and specialized training in social work, health care and physical education.

8.2.2 Policy

The policy review indicated a limited amount of discussion related specifically to educational activities in the Arctic.

- *Sweden's Strategy for the Arctic Region:* This policy notes that education and research are also included as important activities to support economic development, particularly education in the field of mining and the mineral industry.
- *The United Nations Declaration on the Rights of Indigenous People* specifically addresses issues such as connectivity and education, and provides guidance on harmonious, cooperative relationships with Indigenous peoples.
- *Russia's Arctic Policy to 2020* includes an investment in social infrastructure including education.
- *Canada's Northern Strategy* puts on emphasis on increasing investment in education and employability programs.

8.2.3 Role of Satellite Systems

COMMUNICATIONS SYSTEMS

(Impact High)

Efficient, affordable, reliable communications technology is a necessary modern technology in isolated northern communities to support effective education systems. Access to broadband internet can facilitate distance learning, on-line courses, file sharing, video uploads and other on-line educational support tools.

8.3 Health

8.3.1 Overview

Health (or medical) care includes goods and services that provide patients with curative, preventive, rehabilitative, and palliative care. The health care sector includes: hospitals, medical and dental practices, and other human health facilities (e.g., scientific or diagnostic laboratories, pathology clinics, residential health facilities, ambulance services, etc.). These services and facilities are often very limited in the Arctic, and may be inaccessible or very difficult to access by a significant proportion of the population, making the use of air transportation particularly critical. Given the remoteness of communities and the scattering of the population over very large geographical areas, new approaches to health care such as telemedicine (i.e., the use of telecommunication and information technologies to provide clinical health care at a distance) has promise for the Arctic. However, the use of such new approaches is highly dependent upon the availability of robust and reliable high bandwidth communications.

8.3.2 Policy

There is limited reference to health care in the Arctic nations' policy documents, with only three countries specifically referencing this as part of their policy priorities. However, numerous international conventions highlight the need for health services for northern communities and the need to monitor environmental conditions that can adversely impact human health.

- *Canada's Northern Strategy* makes a commitment to improving the health and wellbeing of Arctic residents. This will be implemented through Territorial Formula Financing for schools, hospitals and social services; making health care more responsive to northern needs, including reduced reliance on external medical assistance and travel for patients; improvements in promoting awareness of general health and diseases; and cost-effective provision of food for isolated communities.

- Under the social and economic development priority in Russia's *Fundamentals of State Policy of the Russian Federation in the Arctic in the Period up to 2020 and Beyond* policy, modernization of education, housing and health facilities is mentioned. Under the information, science and technology priority, increased support for scientific research in health is also mentioned.

- *Kingdom of Denmark Strategy for the Arctic 2011-2020* emphasises that some Arctic communities are facing difficult social issues and a focus on coherence and integration will ensure the continuing positive development of Arctic communities. In particular, enhanced Arctic cooperation could include shared research and the exchange of "good / best practices" regarding infectious diseases, public health, telemedicine, as well as a culturally attuned health service and an environmental medicine focus.

- *Stockholm Convention on Persistent Organic Pollutants* contributes to increased safety measures for transporting and handling POPs. The policy will lead to the increased protection of human health from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have adverse effects to human health (e.g. cancer, birth defects, disrupting immune systems).

- *The United Nations Declaration on the Rights of Indigenous People* addresses issues such as, identity, language, health, traditional livelihoods and provides guidance on harmonious, cooperative relationships with Indigenous peoples to ensure the on-going development of health, strong communities.

- *The Indigenous and Tribal Peoples Convention 1989* has implications on the availability of health services to indigenous and tribal peoples.

8.3.3 Role of Satellite Systems

COMMUNICATIONS SYSTEMS

(Impact Medium)

Telemedicine systems aim to provide quality health care services to persons whose access is otherwise restricted by geography or environment and they are particularly relevant in northern communities. Telemedicine encompasses the diagnosis, treatment, monitoring, and education of patients and provides convenient, site-independent access to expert advice and patient information. Telemedicine requires high-band width for video and file transfer. Health care services also require effective communications to support emergency transport of patients.

8.4 Connectivity

8.4.1 Overview

Broadband or high-speed connectivity to a digital network infrastructure (including mobile communications) has become a fundamental necessity in society. The role of broadband connectivity in remote, sparsely populated northern communities can be viewed as even more important for their quality of life, growth, competitiveness, and perhaps even the long-term survival, than in the south. As noted in the recent 2011 report prepared for the Canadian Northern Economic Agency entitled *A Matter of Survival: Arctic Communities Infrastructure in the 21st Century*, access to reliable and affordable broadband is related to trade and commerce, education and health, government services, knowledge transfer, public safety, social network and entertainment, and it has become a foundation for a better way of life (Imaituk for Canadian Northern Economic Development Agency, April 30, 2011).

8.4.2 Policy

The policy review found several specific references to the importance of connectivity in the Arctic regions to strengthen communities and increase prosperity.

- *Iceland and the High North*: This report, released in 2009, notes that cultural identity can be strengthened through increased cooperation and making use of modern technologies in a globalised world community.

- Russia's *Fundamentals of State Policy of the Russian Federation in the Arctic in the Period up to 2020 and Beyond*: Released in 2009, the policy priorities include the improvement of the quality of life for indigenous peoples and their economic activities in the Arctic environment, and the development of the Arctic resource base through improved technological capabilities, with a particular focus on improved information technology and communications.

- *Canada's Northern Strategy* notes the importance of addressing critical infrastructure needs such as modern communications networks which will contribute to a strong economy and increasingly prosperous communities. More specifically, this will be implemented by investing in infrastructure programs like broadband internet connections.

- *The United Nations Declaration on the Rights of Indigenous People* addresses issues such as, connectivity and education and provides guidance on harmonious, cooperative relationships with Indigenous peoples to ensure communities have access to network infrastructure to improve quality of life.

8.4.3 Role of Satellite Systems

COMMUNICATIONS SYSTEMS

(Impact High)

The need for modern communication technology in isolated northern communities is considerable, and access to affordable, reliable, high-speed digital connectivity systems can play a decisive role in improving the lives of northern people and linking them to other communities.

9. CONCLUSIONS

The Arctic is Changing

The Arctic is changing. At the root of much of that change is global warming. The Arctic is warming much faster than the rest of the planet, and as a result, sea ice is receding. One impact of this is the opening of Northern sea routes and the prospect of dramatically increased levels of commercial shipping. A second impact is the easier access this provides to the resource wealth of the region - hydrocarbons, minerals, and fish. A third impact is the detrimental effect it is having on land and marine wildlife. These impacts have subsequent reverberations. The increase in economic activity is multiplied many times over as supporting infrastructure and systems are put in place. With the increased activity come pollution and the danger of environmental and humanitarian disasters. With the economic gain comes the desire to protect rights and investments, and the resulting potential for conflict. All of this is at odds with the traditional livelihoods of the Arctic's indigenous peoples.

The Arctic is Important

The world has taken notice of the Arctic. Part of that attention is focused on the opportunities; there is money to be made, and no one wants to be left out. The other part of that attention is focused on the threats; the Arctic environment is fragile and there is a growing recognition of the impact that all human activity is having on this pristine natural region. Perhaps of more influence is the realization that the Arctic is linked to the rest of the world, and what happens in the Arctic will eventually affect everyone.

Not surprisingly, there is considerable interest in the region on the part of the eight Arctic States: Canada, Norway, Iceland, Sweden, Finland, Denmark, Russia, and the United States. That interest has manifested in policies across all areas: safety, the environment, sustainable economic development, sovereignty, and indigenous and social development.

However, non-Arctic states have recently also turned their attention northward. Examples of such countries that have been examined in this report include France, Germany, India, and China. Of particular relevance here is the European Union that has had a northern policy since 1999 and will be issuing a revision in 2012. The interests of these states are focused on economic development, the environment, and safety.

In many cases, the joint interests of nations have been articulated in international agreements of various forms, often under the auspices of international organizations such as the United Nations and its groups. Such agreements tend to be in areas where there are aligned interests among nations, such as safety and environmental protection.

Industry is also focusing on the potential opportunities that the Arctic presents. Industrial interests are obviously in economic development, but there is a realization that such activity must come with safety and environmental responsibility in mind.

So far, there has been a remarkable spirit of cooperation among Arctic stakeholders as they recognize the common problems and needs that they all face. The Arctic Council is acting as the prominent model and forum for discussion. Its structure is noteworthy on two accounts: indigenous peoples participate as full members on par with the Arctic states, and non-Arctic states and organizations can participate as observers.

The Arctic is Challenging

The Arctic is a challenging region in which to live and work. Distances are vast, the weather is difficult, and for much of the year it is dark. Although increasing, Arctic populations are small, making the economic justification for some services challenging.

Space technologies have many attributes that make them ideal for application in the Arctic context. Satellites can see remote areas that could not be accessed in any other way. They can cover wide areas with relatively little infrastructure. They can provide types of information that are not available from any other source. And, the cost of satellite services can often be spread across applications in both the south and the Arctic, helping to justify the required investments.

Space Technologies can Contribute

Space technologies can contribute to Arctic policy priorities in many ways:

- **Communications** satellites can bring communities across the Arctic and around the world closer together, help bring education and health to isolated people, support the extraction and transportation of natural resources, and facilitate the provision of aid to people in distress.

- **Weather and Climate** satellites can make travelling in harsh Arctic conditions safer, monitor the impact of climate change on Arctic ecosystems, and help with the proper design of Arctic infrastructure, such as pipelines, buildings, and oil platforms.

- **Navigation** satellites can help vessels, aircraft, and vehicles navigate more safely and efficiently, provide position information to assist in mapping and surveying in regions that frequently have poor charts available, and aid in locating and tracking vessels and people in distress.

- **Earth Observation** satellites can help vessels navigate through and around ice and icebergs, monitor pollution and environmental change, locate natural resources, and assist authorities in protecting national borders.

- **Surveillance** satellites can help authorities locate vessels and people in distress, identify illegal activities that endanger ecosystems and resources, and help aircraft and ships avoid collisions.

- **Science** satellites can help protect electricity transmission lines and pipelines from harmful solar storms, provide information that will assist in the delineation of national boundaries, and help to monitor the progress climate change.

Space Technology Priorities

Space technologies have been contributing to Arctic policy priorities for quite some time. However, these assets will need to be renewed and enhanced if the increasing future challenges of the Arctic are to be met. The recent failure of Envisat provides a reminder of the limited life of space assets. And the delays in the launch of the European Sentinel Missions and in the funding of the Canadian Radarsat Constellation Mission are examples of how plans to replace space assets can become undone.

In the Arctic context, future satellite mission priorities should focus on two areas:

- Earth Observation – in particular, radar sensors that are the most useful for monitoring ice and snow.

- Communications – in particular, highly elliptical orbit satellites that can provide high bandwidth capabilities for latitudes above about 75 degrees that cannot be seen by geosynchronous orbit satellites.

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B. INVENTORY OF ARCTIC POLICIES AND INDUSTRY INTERESTS

This Appendix presents a summary of key national and EU policies/strategies relating to the Arctic. It also contains an overview of key industry interests and information needs in the North pertaining to shipping, fishing, and mining activities.

B.1 National Policies

B.1.1 Denmark, Greenland and the Faroe Islands

<table>
<tr><th colspan="3">Denmark, Greenland and the Faroe Islands: Kingdom of Denmark Strategy for the Arctic 2011-2020</th></tr>
<tr><td>Facts in Brief</td><td colspan="2">Jurisdiction: The Danish Realm (Denmark, Faeroes and Greenland)
Responsible Organizations: The governments of Denmark, Faeroe Islands and Greenland
Status: Issued by the Ministry of Foreign Affairs (2011)
Type: Government strategy
Coverage: Denmark, Faroes, Greenland (North-Atlantic)
Web link: http://um.dk/en/~/media/UM/English-site/Documents/Politics-and-diplomacy/Arktis_Rapport_UK_210x270_Final_Web.ashx</td></tr>
<tr><td>Policy Objectives</td><td colspan="2">• A peaceful, secure and safe Arctic
• With self-sustaining growth and development
• With respect for the Arctic's fragile climate, environment and nature
• In close cooperation with our international partners.
The purpose of this strategy is to focus attention on the Kingdom's strategic priorities for future development in the Arctic towards 2020. The aim is to strengthen the Kingdom's status as global player in the Arctic.</td></tr>
<tr><td rowspan="5">Policy Implications</td><td>Sovereignty</td><td>International law must be the basis for conflict resolution. UNCLOS is mentioned as the main instrument for this. The Danish armed forces are important for enforcing sovereignty. The Kingdom will submit further continental shelf claims before the 2014 deadline. There will be overlap with other claims.</td></tr>
<tr><td>Safety</td><td>Maritime safety is a fundamental priority. The extreme Arctic conditions require preventive measures including training and ship safety, as well as regional cooperation on search and rescue.
High international safety standards for ships navigating the Arctic must be set. The IMO should adopt a mandatory Polar Code to ensure high safety levels.
An agreement on search and rescue was adopted at the Arctic Council Foreign Ministers' Meeting in May 2011 in Nuuk.
Nautical maps must be updated. AIS will be important in the future in addition to LRIT.</td></tr>
<tr><td>Environment</td><td>Illegal, unreported and unregulated fishing is a serious threat to marine ecosystems which has considerable implications for conservation and rational management of marine resources. It is a huge task for small communities with large ecosystems to provide adequate expertise for the management and control of the fishery.</td></tr>
<tr><td>Economic Development</td><td>Fishing will continue to be a very important part of the Greenlandic and Faroes economy. Mining is set to have a large role, especially in Greenland. There are expectations of a large expansion of oil and gas extraction both In Faroe and Greenlandic waters.
Tourism and cruise liners create challenges and opportunities.
Infrastructure is a key element in the development of the Greenland society and to ensure long term sustainable development
Expectation of growth in renewable energy (primarily hydro-electric)</td></tr>
<tr><td>Indigenous and Social Development</td><td>Some Arctic communities are facing difficult social issues. To deal with adverse social trends, the emphasis on social coherence and integration is central to development in the Arctic.
Enhanced Arctic cooperation could include, research, evaluation and exchange of "good / best practices" regarding infectious diseases, public health, telemedicine, a culturally attuned health service and environmental medicine.</td></tr>
<tr><td>Capability Requirements</td><td colspan="2">The capability to:
• Monitor traffic, especially around Greenland
• Detect oil spills, on ocean and on ice
• Monitor ice drift, ice thickness and ice rim
• Communicate at sea
• Monitor snow, snow amount and snow intensity
• Ascertain the level of fish stocks and other biological activity
• Monitor long range transport of pollution
• Provide telemedicine for remote areas</td></tr>
<tr><td>Information Requirements</td><td colspan="2">Information on:
• Ice and snow
• Rate of climate change
• Navigation hazards
• Ships in the area
• Potential environmental hazards.</td></tr>
</table>

B.1.2 Sweden

<table>
<tr><th colspan="3">Sweden's Strategy for the Arctic Region</th></tr>
<tr><td>Facts in Brief</td><td colspan="2">Jurisdiction: Sweden
Responsible Organizations: The Swedish government
Status: Issued by the Ministry of Foreign Affairs May 12th 2011
Type: Government strategy
Coverage: Sweden/Arctic
Web link: http://www.sweden.gov.se/download/9168f21a.pdf?major=1&minor=186174&cn=attachmentPublDuplicator_0_attachment</td></tr>
<tr><td>Policy Objectives</td><td colspan="2">The main policy objectives of the strategy
• Climate and the environment
• Economic development
• The human dimension.
The strategy has a focus on international cooperation. The strategy is closely connected to the Swedish program for their chairmanship of the Arctic Council</td></tr>
<tr><td rowspan="5">Policy Implications</td><td>Sovereignty</td><td>There are few sovereignty implications for Sweden. Will work to support international law</td></tr>
<tr><td>Safety</td><td>There are few safety implications in the Swedish strategy. Wants to improve cross border cooperation in Search and Rescue. Fuels production in the Arctic will positively affect European fuel security</td></tr>
<tr><td>Environment</td><td>The strategy has environment protection as a main objective, climate change being paramount. By developing and disseminating knowledge on how the Arctic is affected by climate change, the Arctic Council can raise the bar with regards to international climate efforts. Important knowledge is fostered within the framework of forums such as the International Arctic Science Committee (IASC) and the Arctic Council's Sustaining Arctic Observing Networks (SAON). Transported pollutants, a wider use of environmental impact assessments, challenges to biodiversity connected to oil and gas and climate research are also important issues</td></tr>
<tr><td>Economic Development</td><td>• Improvement of transport infrastructure
• More free trade
• Promote Swedish technology
• Work for the adoption of IMOs Polar Code
• More research cooperation
Economic development is important in the Swedish strategy. Sweden has significant industrial policy interests in the Barents region, which contains major ore, mineral, forest and fish assets, i.e. sectors in which Swedish industry is strong and has extensive research expertise. Increased trade and cooperation in energy- and raw material-related sectors have been given high priority in Sweden and would help to achieve economic, energy and environmentally related objectives.

Swedish industry should seek opportunities in other Arctic countries especially related to resource extraction</td></tr>
<tr><td>Indigenous and Social Development</td><td>The economic development of the Sami population is important; reindeer herding, hunting and fishing.
Will combat negative health and social effects of climate change, hazardous substances, and resource extraction.
Sweden will promote and preserve the Sami language.</td></tr>
<tr><td>Capability Requirements</td><td colspan="2">The capability to:
• Monitor ice in the Baltic
• Communication at sea
• Monitor snow, snow amount and snow intensity
• Monitor long range transport of pollution
• Telemedicine for remote areas</td></tr>
<tr><td>Information Requirements</td><td colspan="2">Information on:
• Ice and snow
• Rate of climate change
• Navigation hazards
• Ships in the area
• Potential environmental hazards.</td></tr>
</table>

B.1.3 Finland

Finland's Strategy for the Arctic Region		
Facts in Brief	**Jurisdiction:** Finland **Responsible Organizations:** The Finish government **Status:** Issued by the Prime Minister's Office July 5th 2010 **Type:** Government strategy **Coverage:** Finland/Arctic **Web link:** http://vnk.fi/julkaisukansio/2010/j07-suomen-arktinen-08-finlands-strategy/pdf/en.pdf	
Policy Objectives	Finland's Strategy for the Arctic Region defines the goals of Finland's Arctic policy and means for their promotion. It discusses the region's security, environment, economy, infrastructure, indigenous peoples, international institutions and the European Union's Arctic policy. The fundamental observations of the Strategy deal with the utilization of Finland's Arctic know-how, research, strengthening of the Arctic Council and development of the EU's Arctic policy.	
Policy Implications	Sovereignty	Finland has few sovereignty issues. After the end of the cold war the strategic importance of the long border with Russia has diminished
	Safety	Promote Nuclear Safety, especially on the Kola peninsula The increase in sea transportation is the biggest threat to Arctic marine ecosystems. Safety systems are inadequate.
	Environment	Climate change is one of the most serious challenges to the Arctic Region. There needs to be development of regional climate models. Promote Nuclear Safety, especially on the Kola peninsula. Need long-term monitoring of the state of the environment. Risk of pollution must be minimized, long-range pollution must be monitored. Need preservation of fish stocks in northern rivers.
	Economic Development	• Strengthen the role as an expert on Arctic know how • Make use of Finish experience with winter shipping • Norwegian and Russian oil and gas offers opportunities • Tourism will increase • Export offices in Norway and Russia It is important to develop transport networks, communications and logistics. Broadband networks must be built along the Northern Sea Route.
	Indigenous and Social Development	Will ensure the participation of indigenous people. Safeguard the funding for this. The Sami are the only indigenous people in the EU.
Capability Requirements	The capability to: • Monitor ice in the Baltic and along the Northern Sea Routes • Communication at sea • Monitor snow, snow amount and snow intensity • Monitor long range transport of pollution • Long time monitoring of the environment	
Information Requirements	Information on: • Ice and snow • Rate of climate change • Navigation hazards • Ships in the area • Potential environmental hazards.	

B.1.4 Iceland

Iceland's position in the Arctic (draft translation of Ísland á norðurslóðum)	
Facts in Brief	**Jurisdiction:** Iceland **Responsible Organizations:** The Icelandic government **Status:** Issued by the Ministry of Foreign affairs 2009 **Type:** Government report **Coverage:** Iceland/Arctic **Web link:** http://www.utanrikisraduneyti.is/media/Skyrslur/Skyrslan_Island_a_nordurslodumm.pdf (Icelandic version)
Policy Objectives	The main policy objectives of the strategy • International cooperation • Security • Resource development and environmental protection • Transportation • People and culture • Science and monitoring. The report has a heavy focus on international cooperation especially through the Arctic Council.

Iceland's position in the Arctic (draft translation of Ísland á norðurslóðum)		
Policy Implications	Sovereignty	Sovereignty is an issue. Iceland disputes the Norwegian interpretation of Norway's sovereignty of Svalbard.
	Safety	The main safety issues are concerned with transportation and accidents with ships. Environmental safety is an important issue.
	Environment	The environmental threat from oil exploitation and transportation is highlighted. This demands heightened surveillance. Climate change has vast implications.
	Economic Development	The sovereign right to sustainable utilization of natural resources and protection of the fragile environment is the foundation of the Icelandic Arctic Policy. New shipping lanes open new opportunities for Iceland. Fishing is an important activity. Climate change affects the range of fish stocks. The right to resources is paramount. High speed Internet connections opens new possibilities in the region.
	Indigenous and Social Development	Tourism is important economically, but could be a challenge to small societies. The unique cultural heritage of Arctic societies must be preserved.
Capability Requirements	The capability to: • Monitor sea ice, make sea ice forecasts • Communication at sea • Survey shipping • Telecommunications • Monitoring fisheries and fish stocks • Monitor oil in ice	
Information Requirements	Information on: • Ice and ice drift • Rate of climate change • Navigation hazards • Ships in the area • Potential environmental hazards.	

B.1.5 Norway

Meld. St. 7 (2011-2012) Nordområdene - Visjon og virkemidler (The High North – vision and means)	
Facts in Brief	**Jurisdiction:** Norway **Responsible Organizations:** The Norwegian Government **Status:** Will be passed by parliament in April 2012, builds on earlier strategies and white papers **Type:** Government White Paper **Coverage:** Norway, including Spitsbergen and the surrounding waters **Web link:** http://www.regjeringen.no/pages/35878716/PDFS/STM201120120007000DDDPDFS.pdf (in Norwegian only)
Policy Objectives	The main focus is on foreign Policy and how this can contribute to welfare and value creation in the country through seven strategic areas/development lines: 1) A new energy region in Europe 2) A new industry era in the north 3) A pioneer area for integrated marine management 4) The polar ocean's growing attraction 5) A global knowledge bank for the environment, climate and society 6) Strong and innovative collaboration in the North 7) A new geopolitical center of the North There are four overriding objectives: • to secure peace, stability and predictability • to secure the entire eco-based management of the region • to strengthen international cooperation and the international legal order • to strengthen the basis for employment, value creation and welfare in the whole country through regional and national commitment, in cooperation with other countries and affected indigenous peoples.

Meld. St. 7 (2011-2012) Nordområdene - Visjon og virkemidler (The High North – vision and means)		
Policy Implications	Sovereignty	All the borders in the North are now resolved, except some continental shelf claims. The Barents Sea will continue to have an important military strategic position, especially for Russia, but also for the USA concerning their nuclear weapons policy.
	Safety	There will be increased navigation and drilling In the Barents Sea. This will create challenges connected to monitoring, oil spill response and evacuation and will necessitate monitoring ice as an important navigational hazard. Communications and broadband connections in the high north will become important, both for day to day use and in emergencies.
	Environment	The paper has a focus on climate change, but also on endangered species (connected to climate change), pollution and the transport of pollution from other parts of the world into the Arctic. Oil spill prevention and clean-up will become more important as navigation and drilling increases. SAON (http://www.arcticobserving.org) is mentioned as important. The main challenges are to have enough information and knowledge about human, biological, and geological activities to be able to manage the oceans well. The government will procure a new research vessel with icebreaking capabilities. Cooperation with Russia on monitoring and increasing safety concerning nuclear reactors and nuclear waste is important.
	Economic Development	The increase in off shore oil and gas drilling and production will probably be the biggest driver of economic change in the region. In addition, mining could be significant, while fisheries will continue to be an important part of the economy in northern Norway. The government wishes to develop a more knowledge intensive industry in the area. Marine bio-prospecting is an important part of this.
	Indigenous and Social Development	Safeguarding the language and culture of indigenous peoples is important. Development, internationalization, new industries and resource exploitation create both challenges and opportunities. Indigenous peoples must be able to participate in the planning processes. Areas for traditional use of fisheries and reindeer herding must be safeguarded.
Capability Requirements	The capability to: • monitor traffic in the Barents Sea • detect oil spills, on ocean and on ice • monitor ice drift, ice thickness and ice rim • communication at sea • monitor vegetation in reindeer areas • monitor snow, snow amount and snow intensity • ascertain the level of fish stocks and other biological activity • monitor long range transport of pollution • monitor nuclear incidents	
Information Requirements	Information on: • ice and snow • rate of climate change • navigation hazards • ships in the area • potential environmental hazards.	

B.1.6 Canada

Canadian Northern Strategy (August 2009)	
Facts in Brief	**Jurisdiction:** The Canadian Northern Strategy was published under the authority of the Minister of Indian Affairs and Northern Development and Federal Interlocutor for Métis and Non-Status Indians **Responsible Organizations:** Spearheaded by Aboriginal Affairs and Northern Development Canada, the implementation of the strategy involves the participation of the Departments of National Defence, Fisheries and Oceans, Environment, Natural Resources and Foreign Affairs and International Trade. Policy implementation also involves territorial and land claims governments. **Status:** Canada's Northern Strategy came into effect in August 2009. In has since been confirmed in Canada's Arctic Foreign Policy Statement in August 2012. Implementation is ongoing through legal instruments (e.g. Arctic Waters Pollution Prevention Act, Canada Shipping Act, land claims) as well as international programs (e.g. IPY, UNCLOS). **Type:** The Canadian Northern Strategy is strategic in emphasis. Accordingly, existing laws and legal frameworks are applied, and programs are supported that further the strategy's objectives. Within the stated priorities, focus is placed primarily on economic impacts and benefits. **Coverage:** The Canadian Northern Strategy covers northern Canadian territory (including the Yukon and Northwest Territories, Nunavut, as well as Labrador, Northern Quebec, Northern Ontario and Northern Manitoba) and extending to the North Pole. It recognizes 76 northern communities and municipalities distributed throughout the area of interest. **Web link:** http://www.northernstrategy.gc.ca/index-eng.asp
Policy Objectives	The principal objectives of Canada's Northern strategy include exercising Canada's Arctic sovereignty, promoting social and economic development, protecting the North's environmental heritage and improving and devolving northern governance to increase the participation on northern residents.

Canadian Northern Strategy (August 2009)		
Policy Implications	Sovereignty	Extension of Canada's national boundaries to the North Pole Increased military/law enforcement presence and capabilities in the north (including satellite monitoring) Redefining national boundaries according to UNCLOS process Increased international collaboration
	Safety	Increased search and rescue capabilities Amended regulations to demand registration of all vessels traversing Canadian Arctic waters with the Canadian Coast Guard
	Environment	Extension of Arctic Waters Pollution Prevention Act to 200 NM limit Investment in international scientific collaboration Establishment of protected areas Assessment of capacity to respond to Arctic pollution events and ability to respond to environmental emergencies Improved environmental assessments for industrial activities
	Economic Development	Establishment of an economic development agency for the north Upgrade of critical infrastructure Support for large-scale mining and oil/gas activities (on-shore and off-shore)
	Indigenous and Social Development	Increased investment in housing, schools, hospitals and social services Increased investment in health care Increased investment in education and employability programs Increased self-governance
Capability Requirements	Comprehensive ability to monitor air and vessel traffic, in air, on land/ice and off-shore Effective communications networks Effective navigation ability in air, on land/ice and off-shore Effective funding for relevant scientific research	
Information Requirements	Comprehensive information on weather and ice conditions Detection and monitoring of pollution events Real-time satellite imagery and navigation data streams Satellite/fibre optic-based communications technologies In-situ environmental observations Up-to-date infrastructure to support movement of goods and services	

Canadian Arctic Foreign Policy (August 2010)	
Facts in Brief	**Jurisdiction:** Canada's Arctic Foreign Policy has been developed by the Department of Foreign Affairs and International Trade (DFAIT). **Responsible Organizations:** The Canadian Arctic Foreign Policy is implemented by DFAIT. **Status:** The policy came into effect in 2010 in support of Canada's Northern Strategy. **Type:** The Canadian Arctic Foreign Policy governs international relations maintained by Canada pertinent to Canada's Northern Strategy. **Coverage:** The policy applies to northern Canadian territory (including the Yukon and Northwest Territories, Nunavut, as well as Labrador, Northern Quebec, Northern Ontario and Northern Manitoba) extending to the North Pole. It recognizes 76 northern communities and municipalities distributed throughout the area of interest. **Web link:** http://www.international.gc.ca/polar-polaire/canada_arctic_foreign_policy-la_politique_etrangere_du_canada_pour_arctique.aspx?lang=eng&view=d
Policy Objectives	• The primary objectives of the Canadian Arctic Foreign Policy include the following: • Engaging with neighbours to seek to resolve boundary issues; • Securing international recognition for the full extent of our extended continental shelf; • Addressing Arctic governance and related emerging issues, such as public safety; • Creating the appropriate international conditions for sustainable development; • Seeking trade and investment opportunities that benefit Northerners and all Canadians; • Encouraging a greater understanding of the human dimension of the Arctic; • Promoting an ecosystem-based management approach with Arctic neighbours and others; • Contributing to and supporting international efforts to address climate change in the Arctic; • Enhancing our efforts on other pressing environmental issues; • Strengthening Arctic science and the legacy of International Polar Year; • Engaging Northerners on Canada's Arctic foreign policy; • Supporting Indigenous Permanent Participant organizations; and • Providing Canadian youth with opportunities to participate in the circumpolar dialogue.

Canadian Arctic Foreign Policy (August 2010)		
Policy Implications	Sovereignty	Resolution of boundary issues in the Arctic region, in accordance with international law. Secure international recognition for the full extent of our extended continental shelf wherein Canada can exercise its sovereign rights over the resources of the seabed and subsoil.
	Safety	Ensure public safety across Canada's north Promote safe shipping and offshore operations Address human health issues in northern communities.
	Environment	Promote an ecosystem-based management approach with its Arctic neighbours and others. Actively contribute to and support international efforts to address climate change in the Arctic, including both mitigation and adaptation. Canada will enhance its efforts, including pursuing and strengthening international standards, related to biodiversity, genetic resources, and persistent organic pollutants. Contribute to strengthening Arctic science and the legacy of International Polar Year.
	Economic Development	Create the appropriate international conditions for sustainable development in the Arctic, complementing domestic measures to support economic development. Understanding the opportunities and challenges of Arctic energy and resource development and developing regulations, guidelines and standards that are informed by Arctic science and research, including traditional knowledge, with special emphasis on oil and gas development. Seek and promote trade and investment opportunities that benefit Northerners and all Canadians. Improve sea and air transportation routes
	Indigenous and Social Development	Encourage a greater understanding of the human dimension of the Arctic to improve the lives of Northerners, particularly through the Arctic Council. Engage with Northerners on Canada's Arctic foreign policy Continue to support Indigenous Permanent Participant organizations in Canada, including financially, to contribute to strengthening their capacity to fully participate in the activities of the Arctic Council. Provide Canadian youth with opportunities to participate in the circumpolar dialogue.
Capability Requirements	• Effective representation in relevant international, inter-governmental forums • Effective participation relevant international programs and initiatives • Comprehensive ability to monitor air and vessel traffic, in air, on land/ice and off-shore • Effective communications • Effective navigation ability in air, on land/ice and off-shore • Effective resource mapping and inventory • Enforce applicable legislation • Effective support for science	
Information Requirements	• Comprehensive information on weather and ice conditions • Detection and monitoring of pollution events • Real-time satellite imagery • Satellite/fiber-optic-based communications technologies • In-situ environmental observations • Up-to-date infrastructure to support movement of goods and services	

B.1.7 United States

US Arctic Region Policy- NSPD-66/ HSPD-25 (January 2009)	
Facts in Brief	**Jurisdiction:** The Policy was signed by President Bush, in one of his final acts in office. Despite being developed by a different administration, the policy is considered to be non-partisan and remains the primary policy related to the Arctic for the Obama Administration. The Obama Administration has struck an Arctic Policy Group that oversees policy development related to the Arctic. **Responsible Organizations:** The Policy is a statement from the executive, and thus includes overall implementation objectives for relevant state departments. Responsibilities for the implementation of the document reference: the Secretaries of State; Departments of Defense, Transportation, Commerce, the Interior, Energy, and Homeland Security; and the Environmental Protection Agency. The document also urges that the Senate consider immediately signing and ratifying the U.N Convention on the Law of the Sea. **Status:** Since its release in 2009, the policy remains the overarching state directive related to the Arctic. Subsequent internal strategies that take into consideration the objectives of the policy have been developed by Executive Office, Departments of Defense, State, Commerce, Energy, Interior, Homeland Security, Agriculture, Health and Human Services, and Environmental Protection Agency. There are no current plans to update or replace the policy, and internal strategies are continuing to evolve based on the policy's framework. **Type:** The US Arctic Region Policy is a strategic document that seeks to re-position the US as an Arctic power. Although it does not contain individual pieces of legislation, it recommends the implementation of a number of measures identified to improve the US ambitions in the region and clarify and update its stance on a number of broad issues. The policy is consistent with the laws and Constitution of the U.S., and affirms that the Law of the Sea is deemed to be international customary law, despite it not being party to the agreement. **Coverage:** The policy does not define the Arctic region by a stated geographic boundary. The policy includes priorities and recommendations that have national, regional, and international implications. Nationally, these include measures related to security, research, continental shelf, environmental protection, and energy. Regionally, there are provisions that seek to improve regional governance and shared environmental stewardship. Internationally, maintaining the freedom of the seas is solidified as an overarching priority. **Web link:** http://www.fas.org/irp/offdocs/nspd/nspd-66.htm

US Arctic Region Policy- NSPD-66/ HSPD-25 (January 2009)		
Policy Objectives	The principal objective of the US Arctic Region Policy is to re-position the U.S. as an Arctic power and to establish priority areas and recommendations for relevant state departments and agencies. Subsidiary objectives are defined as: • To meet national security and homeland security needs; • Protect and preserve the Arctic environment; • Sustainable resource management and economic development of Arctic resources; • Strengthening international cooperation; • Improving indigenous representation in decision-making; • Enhancing scientific and research in local, regional and global issues.	
Policy Implications	Sovereignty	Prepared to act unilaterally or multilaterally to safeguard its Arctic interests, including in areas of missile defence, early warning systems, and maritime presence. Ensure the freedom of navigation and overflight, with specific reference to the Northwest Passage status as an international strait. Become a member of the UN Convention of the Law of the Sea. Improve maritime and law enforcement by building capacity and capabilities. Encourage peaceful resolution of Arctic territorial disputes.
	Safety	Prepare for increased human activity in the region. Marine transportation for secure and reliable navigation. Developing safe navigation standards. Enhanced local, national and international search and rescue capabilities.
	Environment	Pursue marine ecosystem-based management in the Arctic. Investment in international scientific collaboration. Gain a better understanding of global changes and potential environmental and socio-economic effects. Address information gaps in expanding commercially fishing industry. Lead establishment of Arctic observation network.
	Economic Development	Seek to balance development with adequate research and assessment in the field of infrastructure, subsistence, community impact, living marine resources, alternative energy, etc. Work with Arctic countries to establish Arctic hydro-carbon best practices. Protect offshore resources to mitigate environmental and economic impacts.
	Indigenous and Social Development	Improve the degree to which indigenous communities are consulted and involved in relevant decision-making forums. Develop scientific information on the adverse effects of pollutants on human health and the environment in order to reduce the introduction of key pollutants.
Capability Requirements	• Ability to develop technical expertise to address challenges of off-shore drilling in the Arctic. • Effective communications networks. • Effective navigation ability in air, on land/ice and off-shore. • Effective management regime to support vessel traffic-monitoring, navigation, standardized charting and timely environmental/navigational information. • Adequate funding for relevant scientific research in multi-areas	
Information Requirements	• Detection and monitoring of pollution events and human impact • Socio-economic impact assessment of resource development • Real-time satellite imagery and navigation data streams • In-situ environmental observations • Response mechanisms for offshore oil and gas leaks specific to the Arctic environment	

B.1.8 Russia

Russia's Arctic Policy to 2020 and Beyond (September, 2008)	
Facts in Brief	**Jurisdiction:** The policy was adopted by President Medvedev but has implications for all levels of government. **Status:** Russia's Arctic Policy to 2020 was the first in a series of national policies that places the Arctic at the centre of Russia's political and economic future. Elements of the policy can be found in the National Security Strategy to 2020 and Russia's Energy Strategy to 2030, both released in 2009. The policy remains the overarching directive **Coverage:** The Arctic region of the Russian Federation is defined as being the territories of the Sakha Republic (Yakutia), Murmansk and Arkhangelsk oblast, Krasnoyarsk Kray, the Nenets, Yamalo-Nenets and Chukotka Autonomous Okrugs, as well as the islands located in the Arctic Ocean and the adjacent waterways, territorial waters, exclusive economic zone and the continental shelf. Interestingly, it limits the regional geography to the littoral Arctic states, as opposed to the more common Arctic eight states. **Web link:** http://www.scrf.gov.ru/documents/98.html
Policy Objectives	The policy defines the national interests of Russia in the Arctic as being: • Using the Arctic resource base to improve the economic and social development of the country. • Maintaining the region as a zone of peace and cooperation. • Preserving the ecological diversity of the region. • Expanding the opportunities of the Northern Sea Route.

Russia's Arctic Policy to 2020 and Beyond (September, 2008)		
Policy Implications	Sovereignty	Improving military security and protection of state border in relation to increased terrorist threats Maritime delimitation in accordance with international law Continued interest with Russia's role in Spitsbergen
	Safety	Regional agreement on search and rescue for the Arctic Expanding polar fleet to facilitate and monitor increased shipping Construction of maritime check-points to improve navigation monitoring Assistance with cross pole air-born navigation Chemical safety from industrial sites and mitigating contaminated sites
	Environment	Mitigating environmental impacts from industrial activity Strengthening regional governance institutions for effective resource management and environmental protection Expansion of protected areas (land and sea) Recycling of aging nuclear fleet Monitoring environmental conditions in the Arctic Meteorological stations Develop modern customs infrastructure
	Economic Development	Expanding hydro-carbon production in the Arctic Sea Assessing resource potential across vast territory by improved geological-geophysical, hydrographic and cartographical mapping Improved infrastructure for sea mineral production and Arctic fishing Expansion of conventional (oil and gas) and non-conventional (renewable) energy resources
	Indigenous and Social Development	Improved information technology and communications Improved quality of life and social conditions for indigenous peoples Social infrastructure investments in education, housing and health-care
Capability Requirements	• Comprehensive ability to monitor air and vessel traffic, in air, on land/ice and off-shore • Expanding existing communications networks • Effective navigation ability in air, on land/ice and off-shore • Effective funding for relevant scientific research	
Information Requirements	• Assessment of known and estimated resource base • Comprehensive information on weather and ice conditions • Detection and monitoring of pollution events • Real-time satellite imagery and navigation data streams • Satellite/fibre optic-based communications technologies • In-situ environmental observations • Up-to-date infrastructure to support movement of goods and services • Communications and broadband connections	

B.1.10 China

China and the Arctic	
Facts in Brief	**Background:** China has yet to release an official Arctic policy at the state level. Instead, its position on Arctic affairs has been limited to individual references from the state on specific issues, most notably on its Arctic/Antarctic science program, its growing commercial interest in resource development, and its diplomatic ambition of joining the Arctic Council as an Observer. **Areas of interest:** Research, commercial shipping, mining, oil and gas. **Responsible Organizations:** The only formal agency dealing with the Arctic is the Chinese Arctic and Antarctic Administration (CAA), a division of the State Oceanic Administration. The CAA is responsible for coordinating its research programs; as of April 2012, it had organized four Arctic missions (1999, 2003, 2008, and 2010) and 23 Antarctic science missions since 1985 on its research icebreaker Xuelong. In 2003 it opened its only permanent Arctic science station in Ny-Alesund, Svalbard. It will conduct a mission to the Arctic in the summer of 2012, through the Northern Sea Route. The mission will be the first time a Chinese vessel will sail the pass. **Status:** China is In the process of drafting an official policy, however the timeline of when it will be released is unknown. **Coverage:** To date, China has had a larger and longer research interest in Antarctica. Being a new player in the region's politics with no geographic connection, China is approaching the Arctic from the standpoint of cooperation, not intimidation, and is starting with research as its basis. **Web link:** http://www.chinare.gov.cn/en/index.html
Principle Objectives	Until now, China's Arctic research agenda has identified four primary research objectives: oceanography, biology, atmospheric science, and glaciology. Although the Chinese government has linked its research objectives with localized impacts of climate change in China, there are ulterior motives for these research areas, particularly in the potential for Arctic continental shipping lanes and energy production. China's interests in the region are slowly growing beyond research, however. The growing demand for rare earth metals and iron has taken Chinese companies to Greenland and Northern Canada (Nunavik). PetroChina's purchasing of 20% of the Royal Dutch Shell's Groundbirch shale-gas assets in February 2012 will likely open up access to Canadian Arctic fossil fuels.

China and the Arctic		
Policy Implications	Sovereignty	No territorial claims in the Arctic, but have shown support for the legal process of Arctic states extending their continental shelf through UNCLOS. Making sure the Northwest Passage and the Northern Sea Route remain open for international navigation. Increased international collaboration, most pronounced with Norway, Denmark, and Russia. Pursuing Arctic Council Observer status.
	Safety	N/A
	Environment	Investment in international scientific collaboration. Arctic research in oceanography, biology, atmospheric science, and glaciology. Member of the International Arctic Science Committee (IASC).
	Economic Development	Investment in mining projects in Greenland (rare earth metals) and Northern Canada (iron). Negotiating bilateral agreements with Russia on Siberian pipeline projects. China must partner with foreign companies on offshore projects; it lacks the technological expertise to develop this independently.
	Indigenous and Social Development	N/A
Capability Requirements	• Effective funding for scientific research in the fields of oceanography, biology, atmospheric science, and glaciology.	
Information Requirements	• Developing technological expertise for offshore oil and gas production • Ice conditions • Navigation hazards	

B.1.11 India

India and the Arctic		
Facts in Brief	**Background:** Similar to China, India has not released a formal Arctic strategy. Instead, its primary activity in the Arctic has been largely limited to research. However, their interest in the Arctic can be identified as being three-fold: environmental protection, economy and policy. The need to fuel India's emerging economy with hydro-carbons has prompted the government to look northward. **Areas of interest:** Research, hydro-carbons **Status:** India is discussing whether to release a strategy, as well as whether to join the Arctic Council.	
Principle Objectives	Indian scientific missions date back to 1981. Research is largely related to global warming, impacts of sea-level rise, and the potential climatic effects of Arctic change on India's monsoons. Prior to 2008, India led three to four research projects annually. In 2008, a permanent research station was built in Ny-Alesund on Svalbard. India is expected to get a research vessel in 2012. It is clear that economic interests will also drive India's interests in the Arctic; however outside of specific projects in Siberia, it is not clear the extent to which they will pursue Arctic development.	
Policy Implications	Sovereignty	N/A
	Safety	Proposed the declaration of the Arctic as a region free from nuclear weapons.
	Environment	Investment in international scientific collaboration. Arctic research in Arctic/global climate change.
	Economic Development	Bilateral relationship with Russia in Salekhard for hydrocarbon resources. An agreement in 2011 with India's largest oil company.
	Indigenous and Social Development	N/A

B.1.11 Germany

Germany's Interests in Arctic Region	
Facts in Brief	**Jurisdiction:** Germany **Responsible Organizations:** Foreign Office, Ministry of Defence, Ministry of Environment **Status:** No cohesive Arctic strategy is currently in place; as a non-Arctic country Germany exerts influence via international networks (e.g. NATO, EU). Germany is a permanent observer on the Arctic Council **Type:** Uncoordinated approach to Arctic policy shared by multiple departments **Coverage:** Arctic **Web link:** http://www1.carleton.ca/ces/ccms/wp-content/ccms-files/Kaim.pdf http://geopoliticsnorth.org/images/stories/attachments/Steinicke%20Major_2011.pdf http://www.cducsu.de/Titel__rede_eine_deutsche_position_hinichtlich_der_eu_arktis_politik_erforderlich/TabID__1/SubTabID__2/InhaltTypID__2/InhaltID__19738/Inhalte.aspx
Policy Objectives	Germany's interests in the Arctic include open and secure maritime transportation (includiing search and rescue), access to critical hydrocarbon resources, and environmental protection. In addition, Germany has a long-standing, leading role in Arctic science and supports the settlement of territorial disputes.

Germany's Interests in Arctic Region		
Policy Implications	Sovereignty	Germany has no national borders in the Arctic; the protection of national territory is therefore not an issue. However, Germany encourages the settlement of territorial disputes through UNCLOS and other relevant processes to further the objectives of safe transportation, access to resources and environmental protection. Germany is also supporting the development of military strategies (within appropriate frameworks of international collaboration, such as NATO) to secure trade routes and access to resources.
	Safety	As a major exporting economy, maritime trade routes are of critical importance to Germany. Accordingly, the safety of marine transportation in Arctic waters, including coordinated search and rescue activities, are a major objective of German Arctic policy.
	Environment	As a global leader in environmental issues, Germany promotes environmental protection in the Arctic, including the mitigation of climate change and pollution impacts on the Arctic environment, flora and fauna. The development of a national Arctic strategy and an international Arctic treaty are currently being debated in the German parliament. Germany is investing heavily in polar research programs covering scientific, governance and socio-economic issues in the Arctic.
	Economic Development	Access to natural resources and safe and secure maritime trade routes constitute major Arctic objectives for Germany. Accordingly, Germany is working actively through international collaborative channels (EU, NATO, Arctic Council, etc.) to achieve these objectives
	Indigenous and Social Development	Arctic indigenous and social development is not a primary policy objective for Germany.
Capability Requirements	The capability to: • Evaluate effects of climate change on the Arctic • Monitor long range transport of pollution • Long time monitoring of the environment • Apply instruments of international law and multilateral governance • Establish military policy and regional security • Implement environmental standards • Provide safe and secure transportation across maritime trade routes • Provide effective search and rescue capabilities throughout the Arctic • Provide access to critical natural resources (primarily oil and gas) • Effective response to environmental emergencies	
Information Requirements	Information on: • Environmental conditions • Comprehensive situational awareness • Rate and impacts of climate change • Navigation and environmental hazards	

B.1.12 France

Arctic Policy of France	
Facts in Brief	**Jurisdiction:** France **Responsible Organizations:** Foreign Office, Ministry of Defence, Ministry of Environment **Status:** France is increasingly articulating its interests in the Arctic, which include climate change, maritime security, natural resources, as well as geopolitical issues. A permanent observer on the Arctic Council and the Barents Euro-Arctic Council, France is the only non-arctic country with a dedicated Arctic (and Antarctic) ambassador (i.e. Michel Rocard). **Type:** Diplomatic outreach and negotiations via Arctic ambassador. **Coverage:** Arctic **Web links:** http://www.defense.gouv.fr/irsem/publications/laboratoire/laboratoire http://www.senat.fr/rap/r06-230/r06-230.html http://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000020949548&dateTexte=&categorieLien=id http://questions.assembleenationale.fr/q13/13-43770QE.htm
Policy Objectives	Centered on the principal issues of climate change, maritime security and the exploitation of natural resources, French Arctic policy emphasizes that governance of the Arctic should be globally designed to reflect not only the interests of Arctic states, but the concerns of global Arctic stakeholders.

Policy Implications	Sovereignty	Although without Arctic territories, France is concerned with questions of military security in the Arctic via its engagement with NATO and the European Union. In this context, special concerns arise from France's status as a nuclear-weapon state. A major goal is the preservation of stability and the guaranteed access to critical transportation routes and natural resources.
	Safety	As a result of articulated environmental, economic and security interests, the safety of transportation and operations is implicit in Frances's perspectives on the Arctic.
	Environment	A leader in international polar research, France is carrying out major research initiatives designed to understand climate change in the Arctic, as well as adapting to the consequences of climate change, particularly with respect to economic activities. The Arctic is considered a major element in the climate system with direct consequences for France.
	Economic Development	In response to the increased accessibility of the Arctic as a result of a decreasing ice cover, France actively promotes regulating use of the Arctic ocean by means of an international treaty. Focal points of special interest include French business interests in the Arctic (e.g. fishing, shipping, oil/gas).
	Indigenous and Social Development	Arctic indigenous and social development is not a primary policy objective for French Arctic policy, although issues affecting northern communities are implicitly addressed in France's stance on Arctic environment and science.
Capability Requirements	The capability to: • evaluate effects of climate change on the Arctic • monitor long range transport of pollution • long time monitoring of the environment • Apply instruments of international law and multilateral governance • Establish military policy and regional security • Implement environmental standards • provide safe and secure transportation across maritime trade routes • provide effective search and rescue capabilities throughout the Arctic • provide access to critical natural resources • effective response to environmental emergencies	
Information Requirements	Information on: • knowledge of environmental conditions • comprehensive situational awareness • rate and impacts of climate change • knowledge of navigation and environmental hazards	

B.1.13 The European Union Strategy for the Arctic Region

The European Union Strategy for the Arctic Region	
Facts in Brief	**Jurisdiction: Europe (EU).** **Background:** Finland, Sweden, and Denmark are the only EU member states within the Arctic, and thus have seats on the Arctic Council. The EU has sought Observer status on the Council for several years, but the application has been stalled due to disagreement from within the Council. Greenland holds special status within the EU and is recognized as one of the Overseas Countries and Territories (OCT), thus promoting special trade agreements and fishing rights. The Northern Dimension (1999, renewed in 2006) has been an important policy in shifting the EU's focus northward, establishing regional security, and improving ties with Russia, as well as building its relationship with Iceland and Norway. The EU has also been involved in regional Arctic governance, and was one of the original signatories of the Kirkenes Declaration, which founded the Barents-Euro Arctic Council. Depending on the outcome of Iceland's accession to the EU, formally applied in 2009, the EU may eventually have a legitimate territorial claim to the Arctic Ocean. Finally, an official EU Arctic Strategy is expected to be released in 2012, and will provide a clearer framework for assessing EUs interest and impact in the Arctic, as follow-up to the direction taken from the policies and reports analyzed below. **Responsible Organizations:** The European Union. **Status:** The European Union and the Arctic Region (Commission of the European Communities 2008); European Council's Conclusions on Arctic issues in March 2009. European Council 2009a and 2009b. A Sustainable EU Policy for the High North, 2011. Joint Report to the European Parliament and the Council: Progress in developing a European Union policy toward the Arctic Region (anticipated 2012). **Type:** Government policy. First step towards a strategy. **Coverage:** Europe (EU) **Web link:** http://eeas.europa.eu/arctic_region/docs/com_08_763_en.pdf
Policy Objectives	The main policy objectives of the EU Commission's Communication (supported by the Council's Conclusions) are first, protecting and preserving the Arctic environment and its population; second, promoting sustainable use of resources; and third, contributing to enhanced Arctic multilateral governance.

The European Union Strategy for the Arctic Region		
Policy Implications	Sovereignty	There are few direct sovereignty implications for the EU mentioned in the policies. However, support for UNCLOS in resolving potential disputes between Arctic states is seen as key for maintaining peace and cooperation in the region, as promoting the sustainable resource development and joint management/response regimes.
	Safety	The policies promote the full implementation of existing obligations concerning navigation rules, maritime safety, routes system and environmental standards in the Arctic, in particular those under the International Maritime Organisation. Support to increasing the safety of cruise ships, better navigation, and restriction of access to highly vulnerable areas. The GNSS Galileo positioning system is an example of the EU's commitment to navigation safety. Policy initiatives have also focussed on adopting common guidelines and best practices to improve safety.
	Environment	The environment and climate change is a major priority where the main goal is "to prevent and mitigate the negative impacts of climate change as well as to support adaptation to inevitable changes". This is consistent with the EU's commitment towards progressive global climate targets in climate policy negotiations. Particular support for Global Monitoring of Essential Climate Variables, the Global Monitoring for Environment and Security (GMES) and contribution to the Sustainable Arctic Observatory Network (SAON) are examples of the EU acting in this regard. There is also strong interest in addressing issues such as monitoring of ice, permafrost, biodiversity and related environmental issues.
	Economic Development	**Hydrocarbons** – the policies focus on how the significant and known Arctic offshore hydrocarbon resources "are located inside the Exclusive Economic Zone of Arctic states" and a policy objective saying that the exploitation of these resources "should be provided in full respect of strict environmental standards taking into account the particular vulnerability of the Arctic". EU member states have a vested interest in securing reliable hydrocarbon resources, particularly as reliance on foreign sources become increasingly more unreliable, including energy relations with Russia. **Fisheries** – the policies focus on "significant Arctic fisheries that are present in the Barents Sea and to the east and south of the Norwegian Sea", and that "The EU is among the most important consumers of Arctic fish, of which only a small part is caught by Community vessels". Also included is the policy objective of ensuring exploitation of Arctic fisheries to be "at sustainable levels whilst respecting the rights of local coastal communities". As well as securing access to the Arctic Ocean, and the potential for hydro-carbon resources, the EU also has a definitive interest in Iceland's application for accession because of its fishing resources, as well as expanding its already large market with Norway. **Transport** - EU Member States have the world's largest merchant fleet and many of those ships use trans-oceanic routes. The melting of sea ice is progressively opening opportunities to navigate on routes through Arctic waters. This could considerably shorten trips from Europe to the Pacific." The policy also has an objective of gradually introducing Arctic commercial navigation, while promoting stricter safety and environmental standards, and defending "the principle of freedom of navigation". **Tourism** – there is reference to a policy objective of continuing "to support sustainable Arctic tourism" but to try to minimize "its environmental footprint".
	Indigenous and Social Development	There is clear indication of EU support to indigenous peoples and local populations with the statement that "Arctic indigenous peoples in the EU are protected by special provisions under European Community Law". The EU has also embraced research as a form of better understanding Arctic environment and social change. Its ongoing commitment to an EU Arctic Information Centre is a pillar of its overall strategy of being a key player in Arctic science development. Similarly, the EU sponsored IPY project, IPY-CARE (Climate of the Arctic and its Role for Europe), included partners from over 60 countries to assess Arctic change on Europe.
Capability Requirements	The capability to: • conduct research, monitoring and assessments - with the statement that "EU Member States and the European Community are major contributors to Arctic research", and a policy objective to "maintain the Arctic as a priority area for research to close knowledge gaps and assess future anthropogenic impacts, especially in the area of climate change". • monitor traffic in the Barents Sea and to the east and south of the Norwegian Sea – linked to fisheries • communications networks related to shipping and marine traffic • navigation ability in air, on land/ice and off-shore (particularly sea-ice conditions). • monitoring for relevant scientific research	

The European Union Strategy for the Arctic Region	
Information Requirements	Information on: • near-real time sea-ice information to ships in all Arctic waters • socio-economic impact assessment of resource development • near-real-time satellite imagery and navigation data streams • vessel traffic and monitoring (particularly north of 85°N) • in-situ environmental observations (sea ice, icebergs, snow, glaciers, ice sheets and permafrost), in particular to support GMES, including biodiversity monitoring and support to international initiatives such as SAON. • rate of climate change; continuous observations ensuring long term data records to support climate monitoring • data communications across a broad spectrum of needs (oil and gas surveying and exploration, maritime activities, arctic shipping, search and rescue, air traffic management, environmental management, tourism, surveillance, security and safety as well as applications for navigation and positioning, and scientific purposes.) • navigation hazards • information about potential environmental hazards (particularly early warning and decision support facilities). • support fully open and "obstacle" free data access policy and infrastructure.

B.2 International Policies

B.2.2 Convention for the Protection of the Marine Environment of the North-East Atlantic

Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR)

Facts in Brief

Jurisdiction: The Contracting Parties to the OSPAR Convention are Coastal States of the North-East Atlantic: Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, the Netherlands, Norway, Portugal, Spain, Sweden and the United Kingdom of Great Britain and Northern Ireland plus the European Commission and Luxembourg and Switzerland (as part of the Northeast Atlantic watershed).

Responsible Organizations: Respective Governments and the European Commission/ The OSPAR Commission is the governing body, working through intergovernmental co-operation.

Status: The text of the convention was adopted in 1992 and entered into force on 25 March 1998.

Type: Legally-binding multilateral treaty

Coverage: The Convention applies to the internal waters and the territorial seas of the Contracting Parties, the sea beyond and adjacent to the territorial sea under the jurisdiction of the coastal state including the bed of all those waters and its sub-soil situated within the Atlantic and Arctic Oceans and their dependent seas which lie north of 36° north latitude and between 42° west longitude and 51° east longitude excluding the Baltic Sea and the Belts and the Mediterranean Sea.

The North East Atlantic

Web link:
http://www.ospar.org/content/content.asp?menu=01481200000000_000000_000000 (Home); http://www.ospar.org/html_documents/ospar/html/OSPAR_Convention_e_updated_text_2007.pdf (PDF)

Policy Objectives

Contracting Parties shall take all possible steps to prevent and eliminate pollution and shall take the necessary measures to protect the maritime area against the adverse effects of human activities so as to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected. General obligation of signatories is to follow:

- The precautionary principle;
- The polluter pays principle;
- Best available techniques (BAT) and best environmental practice (BEP), including clean technology.

A mechanism for cooperation to protect the marine environment of the North-East Atlantic, guided by the ecosystem approach to an integrated management of human activities in the marine environment.

Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR)		
Policy Implications	Sovereignty	N/A
	Safety	The policy is also aimed at reducing harmful substances that are toxic or have other noxious properties affecting living organisms including humans.
	Environment	The policy is directly aimed at the prevention and elimination of pollution and the protection of the OSPAR maritime area. The policy is focussed on the reduction of the impact on the environment of pollution from land-based sources, pollution by dumping from ships and incineration; pollution from offshore sources and pollution from other sources. There are measures to cover non-polluting human activities that can adversely affect the marine environment (annex on biodiversity and ecosystems of 1998).
	Economic Development	N/A
	Indigenous and Social Development	N/A
Capability Requirements	Capability to: • Monitor pollution from land-based sources, dumping and incineration, offshore sources, other sources • Assess the quality of the marine environment • Assess the impact of human activities on human health • Develop best practices	
Information Requirements	Information on: • Distribution of harmful substances (including oil slicks and marine debris). • Distribution of pollution (source, qualitative, quantitative) leading to adverse effects in the marine environment including eutrophication (monitoring of chlorophyll concentration in surface waters) • Maritime traffic and other coastal and offshore human activities • Distribution of biodiversity including marine and coastal habitats and ecosystems. • Water properties • Physical properties: Sea surface temperature, salinity, turbidity • Chemical properties: pH, dissolved oxygen, nutrients • Biological properties: surface chlorophyll concentration for primary productivity estimates, dissolved organic matter, suspended particulate organic matter.	

B.2.2 Convention on the Protection of the Marine Environment of the Baltic Sea Area

Convention on the Protection of the Marine Environment of the Baltic Sea Area	
Facts in Brief	**Jurisdiction:** The Parties to the Convention are all the States surrounding the Baltic Sea. (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden) plus the European Community. **Responsible Organizations:** Respective Governments and the European Commission/ The Helsinki Commission - Baltic Marine Environment Protection Commission (HELCOM) is the governing body, working through intergovernmental co-operation. **Status:** The text of the convention was adopted in 1992 and entered into force on 17 January 2000. **Type:** Multilateral treaty. **Coverage:** The Convention covers the whole of the Baltic Sea area (the Baltic Sea and the entrance to the Baltic Sea bounded by the parallel of the Skaw in the Skagerrak at 57° 44.43'N), including internal waters as well as the water of the sea itself and the sea-bed with their living resources and other forms of marine life. Measures are also taken in the whole catchment area of the Baltic Sea to reduce land-based pollution. **Web link:** http://www.helcom.fi/Convention/en_GB/text/ (Home), http://www.helcom.fi/stc/files/Convention/Conv1108.pdf (PDF)
Policy Objectives	The Convention aims to prevent and eliminate pollution in order to promote the ecological restoration of the Baltic Sea Area and the preservation of its ecological balance. The Parties will • Follow the precautionary principle • Promote the use of best environmental practice and best available technology • Apply the polluter-pays principle • Monitor emissions of pollutants in a scientifically appropriate manner • Avoid risks in the implementation of the convention resulting in transboundary pollution affecting regions outside the Baltic Sea area, or involving increases or changes in waste disposal or other activities that could increase health risks. Any measures taken must not lead to unacceptable environmental strains on the atmosphere, soils, water bodies or groundwater.

Convention on the Protection of the Marine Environment of the Baltic Sea Area		
Policy Implications	Sovereignty	N/A
	Safety	In relation to the prevention of pollution from ships the policy aims at improved hydrographic services and promotion of the use of Electronic Navigational Charts and Automatic Identification Systems with positive implications on maritime safety. The policy is also aimed at reducing harmful substances that are toxic or have other noxious properties affecting living organisms including humans.
	Environment	The policy is directly aimed at the prevention and elimination of pollution in order to promote the ecological restoration of the Baltic Sea Area and the preservation of its ecological balance. The ecological balance is a key property of the environment of the Baltic Sea Area. The policy is focussed on the reduction of the impact on the environment of: • Harmful substances; • Pollution from land-based sources; • Pollution from ships; • Pollution, noise, hydrodynamic effects and waste from pleasure crafts; • Incineration at sea; • Dumping from ships • Exploration and exploitation of the seabed and its subsoil • The policy also promotes: • The exchange of information on pollution incidents; • Co-operation in combating marine pollution; and • The conservation of natural habitats and biological diversity and the protection of ecological processes ensuring the sustainable use of the natural resources.
	Economic Development	The sustainable use of marine natural resources is promoted by the policy which may obviously have implications in the economic development of the States surrounding the Baltic Sea.
	Indigenous and Social Development	N/A
Capability Requirements	Capability to: • Monitor pollution (harmful substances, land-based, ship originated, incineration, dumping) and pollution incidents • Monitor traffic in the Baltic Sea. • Monitor exploration and exploitation of the seabed and its subsoil • Report periodically on the measures taken for the implementation of the convention, the effectiveness of such measures and problems encountered in the implementation of the convention. • Monitor the overall state of the marine environment	
Information Requirements	Information on: • Distribution of harmful substances (including oil slicks and marine debris). • Distribution of pollution (source, qualitative, quantitative) leading to adverse effects in the marine environment including eutrophication (monitoring of chlorophyll concentration in surface waters). • Ship position and navigation routes and reliable statistics on ships' traffic marine traffic and transport. • Distribution of marine operations including mineral exploration and exploitation. • Information on the distribution of biodiversity including marine and coastal habitats and ecosystems. • Information on water properties • Physical properties: Sea surface temperature, salinity, turbidity • Chemical properties: pH, dissolved oxygen, nutrients • Biological properties: surface chlorophyll concentration for primary productivity estimates, dissolved organic matter, suspended particulate organic matter.	

B.2.3 Stockholm Convention on Persistent Organic Pollutants

Stockholm Convention on Persistent Organic Pollutants	
Facts in Brief	**Jurisdiction:** 176 Parties. Of the Arctic States, Canada, Norway, Sweden, Denmark, Finland, Russian Federation, and Iceland have ratified the Convention, but USA, though a signatory, has not ratified it yet. **Responsible Organizations:** Respective governments of the Parties **Status:** The text of the convention was adopted 22 May 2001 and entered into force on 17 May 2004. **Type:** A legally-binding international convention, open to ratification. The convention is administered by UNEP. **Coverage:** Geographic area belonging to the respective Parties. **Web link:** http://chm.pops.int/Convention/ConventionText/tabid/2232/Default.aspx
Policy Objectives	The overall objective of the Stockholm Convention is to protect human health and the environment from persistent organic pollutants (POPs). Parties need to take measures to reduce or eliminate the release of POPs into the environment by prohibiting, phasing out as soon as possible, or restricting the unintentional and intentional production, placing on the market, and use of substances subject to the Convention, as well as reducing or eliminating their release from stockpiles and wastes.

Stockholm Convention on Persistent Organic Pollutants		
Policy Implications	Sovereignty	N/A
	Safety	The policy will contribute to increased safety measures for transporting and handling POPs. The policy will lead to the increased protection of human health from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have adverse effects to human health (e.g. cancer, birth defects, disrupting immune systems) or to the environment.
	Environment	The policy will lead to the increased protection of the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have adverse effects on the environment.
	Economic Development	N/A
	Indigenous and Social Development	The policy will contribute to increased public awareness on the impact and presence of harmful POPs
Capability Requirements	Capability to undertake and report – periodically – the research, assessment and monitoring of POPs, new pesticides and new industrial chemicals, namely their: • Sources and releases into the environment; • Presence, levels and trends in humans and the environment; • Environmental transport, fate and transformation, including long range transport; • Effects on human health and the environment; • Socio-economic and cultural impacts; • Release, reduction and/or elimination; and • Harmonized methodologies for making inventories of generating sources and analytical techniques for the measurement of releases. • Quantities of production, disposal, import and export from and to Capability to search and promote the use of substitute products or processes which are less harmful Capability to indentify, manage, handle, collect and transport stockpiles or waste	
Information Requirements	Information on: • Production and use of POPs • Import and export of POPs • Source and Release of POPs • Concentration level of POPs • Disposal of POPs • New pesticides or industrial chemicals • Stockpiles and wastes • Transport of POPs and other chemicals	

B.2.4 United Nations Declaration on the Rights of Indigenous Peoples

United Nations Declaration on the Rights of Indigenous Peoples	
Facts in Brief	**Jurisdiction:** Voted in favour by 143 States (incl. Sweden, Finland, Norway, Denmark and Iceland), against by 4 (incl. United States and Canada who later revised their position and endorsed the declaration), and with abstention of 11 (incl. the Russian Federation) **Responsible Organizations:** The Declaration provides guidance to States, the United Nations, and other international organizations on harmonious, cooperative relationships with Indigenous peoples **Status:** The Declaration was adopted on 13 September 2007. **Type:** International declaration – non-legally-binding aspiration document. **Coverage:** In applying the Declaration, governments shall respect the special importance of the cultures and spiritual values of indigenous peoples. **Web link:** http://social.un.org/index/IndigenousPeoples/DeclarationontheRightsofIndigenousPeoples.aspx
Policy Objectives	UNDRIP is a non-legally binding document that describes both individual and collective rights of Indigenous peoples around the world. It addresses issues such as culture, identity, language, health and education and provides guidance to States, the United Nations, and other international organizations on harmonious, cooperative relationships with Indigenous peoples. It is based on the principles of equality, partnership, good faith and mutual respect.

United Nations Declaration on the Rights of Indigenous Peoples		
Policy Implications	Sovereignty	N/A
	Safety	States shall take effective measures to ensure that no storage or disposal of hazardous materials shall take place in the lands or territories of indigenous peoples without their free, prior and informed consent. States shall also take effective measures to ensure that programmes for monitoring, maintaining and restoring the health of indigenous peoples, as developed and implemented by the peoples affected by such materials, are duly implemented. States shall in consultation and cooperation with indigenous peoples take specific measures to protect indigenous children from economic exploitation and from performing any work that is likely to be hazardous or to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral or social development.
	Environment	Indigenous peoples have the right to the conservation and protection of the environment and the productive capacity of their lands or territories and resources. States shall establish and implement assistance programmes for indigenous peoples for such conservation and protection, without discrimination.
	Economic Development	The Declaration promotes the right of indigenous people to pursue their own economic development. The Declaration also establishes the need to consult with peoples before exploration or exploitation of natural resources, including water, would happen on their land.
	Indigenous and Social Development	The Declaration addresses issues such as, identity, language, health, traditional livelihoods, connectivity and education and provides guidance on harmonious, cooperative relationships with Indigenous peoples. It also states the right to self-determination of indigenous peoples, which implies the right to autonomy or self-government and rights to lands, territories and resources.
Capability Requirements	States shall take effective measures, consult, and cooperate with Indigenous Peoples to comply with all articles in this Declaration Capability to: • Have access to education in their own culture and in their own language • Protect indigenous people from discrimination • Promote and ensure fair treatment of indigenous people • Monitor and assess the situation of indigenous people • Improve economic and social conditions of indigenous people • Monitor use/misuse of land and territory • Mitigate adverse environmental, economic, social, cultural or spiritual impact of development or use of the land or territories	
Information Requirements	• Distribution of the population of indigenous and tribal peoples • Distribution of the lands inhabited and used by indigenous and tribal peoples. • Distribution of lands with the same or better quality inhabited and used by indigenous and tribal peoples. • Distribution and status of natural resources within the lands inhabited and used by indigenous and tribal peoples. • Information on land use by indigenous and tribal peoples including rural activities, hunting, fishing, trapping and gathering. • Information on social and cultural identity and customs of indigenous peoples, language • Distribution of service facilities (health, education) in the vicinity of the lands inhabited by indigenous and tribal peoples. • Information on existing laws • Information on adverse environmental, economic, social, cultural or spiritual impact of development or use of the land or territories of indigenous people	

B.2.5 Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic

Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic

Facts in Brief

Jurisdiction: The Parties are: Sweden, Finland, Norway, Russian Federation, USA, Canada, Denmark, and Iceland.

Responsible Organizations:

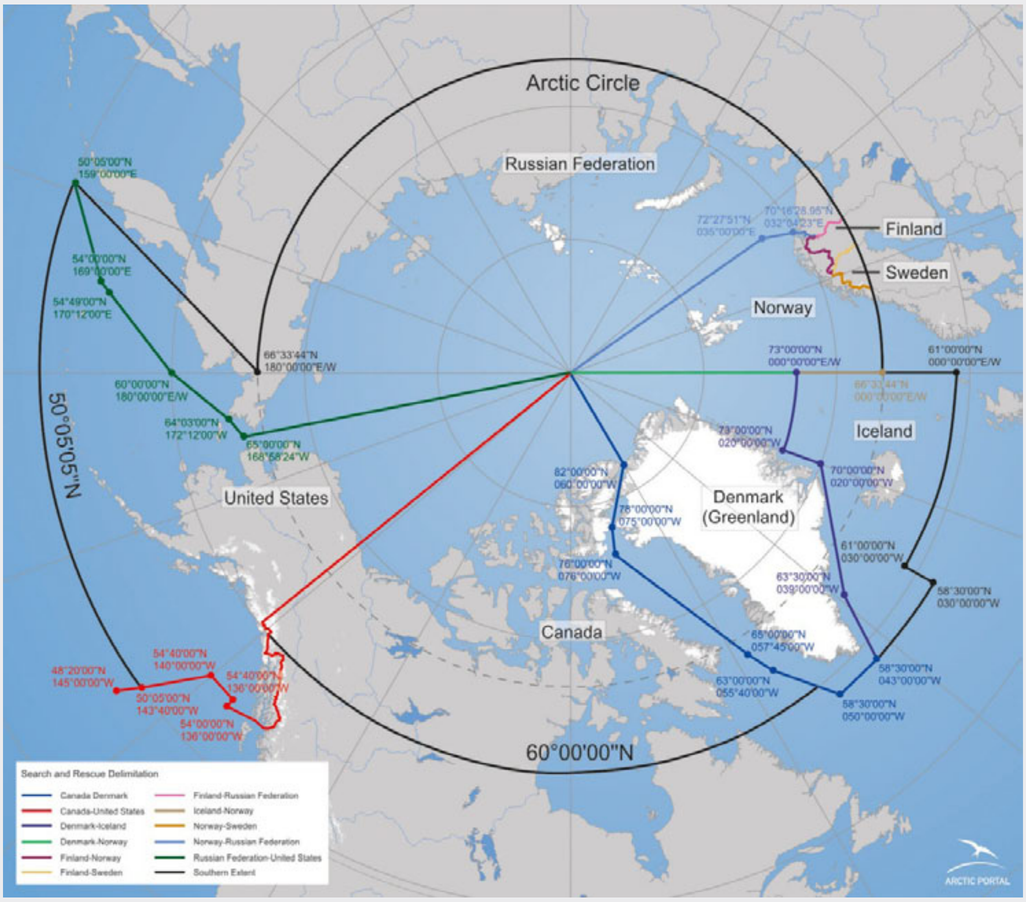
The Competent Authorities of the Parties are specified in Appendix I to the Agreement: **Canada** – Minister of National Defence; **Denmark** – Danish Maritime Authority; **Finland** –Ministry of the Interior; Finnish Transport Safety Agency; **Iceland** –Ministry of the Interior; **Norway** –Ministry of Justice and the Police; **Russian Federation** – Ministry of Transport of the Russian Federation; Ministry of the Russian Federation for Civil Defense, Emergency and Elimination of Consequences of Natural Disasters; **Sweden** – Swedish Maritime Administration; and **United States of America** – United States Coast Guard.

The agencies responsible for aeronautical and maritime search and rescue, are specified in Appendix II to the Agreement: **Canada** – Canadian Forces; Canadian Coast Guard; **Denmark** – Danish Maritime Authority, Danish Transport Authority, Ministry of Fisheries – Faroe Islands; **Finland** – Finnish Border Guard; Iceland – Icelandic Coast Guard; **Norway** – Joint Rescue Coordination Centre, Northern Norway (JRCC NN Bodø); **Russian Federation** – Federal Air Transport Agency; Federal Agency for Marine and River Transport; **Sweden** – Swedish Maritime Administration; and **United States of America** – United States Coast Guard; United States Department of Defense.

Status: The agreement was signed by all the Parties during the Arctic Council Ministerial Meeting in Nuuk, Greenland on 12 May 2011 and it will enter into force 30 days after the Depositary (Canada) has received notification from all eight Members that they have completed their respective internal procedures.

Type: Multilateral treaty. The agreement was negotiated under the auspices of the Arctic Council.

Coverage: The agreement coordinates life-saving international maritime and aeronautical coverage and response across an area of about 13 million square miles in the Arctic in the event of a plane crash, cruise ship sinking, oil spill ,or other minor or major disaster. For each Party, the Agreement defines an area of the Arctic in which it will have lead responsibility in organizing responses to SAR incidents. Parties to the Agreement commit to provide SAR assistance regardless of the nationality or status of persons who may need it.



The delimitations of the aeronautical and maritime search and rescue regions relevant to this Agreement are specified in paragraph 1 of the Annex to this Agreement. The area in which each Party shall apply this Agreement is set forth in paragraph 2 of the Annex to this Agreement.

Web link: http://library.arcticportal.org/1474/1/Arctic_SAR_Agreement_EN_FINAL_for_signature_21-Apr-2011.pdf (home http://www.arctic-council.org/index.php/en/oceans/search-and-rescue)

Policy Objectives

The objective of this Agreement is to strengthen aeronautical and maritime search and rescue cooperation and coordination in the Arctic.

Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic		
Policy Implications	Sovereignty	No implications. The delimitation of search and rescue regions is not related to and shall not prejudice the delimitation of any boundary between States or their sovereignty, sovereign rights or jurisdiction.
	Safety	Increased safety. Overall improved search and rescue response through cooperation and coordination of appropriate assistance to those in distress due to small or large incidents
	Environment	N/A
	Economic Development	N/A
	Indigenous and Social Development	Not specific but improved search and rescue response and assistance to those in distress
Capability Requirements	Each Party will promote the establishment, operation and maintenance of an adequate and effective search and rescue capability (Rescue Coordination Centers = RCCs) within its area. The RCCs need to: • Be able to assess and monitor meteorological conditions • Be able to assess and monitor oceanographic conditions • Be able to find locate and monitor the person/craft in distress • Have adequate means of communication, including the use of alternative means of communications for handling communication overloads during major search and rescue operations • Have the means (equipment, facility, trained people) to carry out search and rescue operations	
Information Requirements	Information on: • Communication systems details • Search and rescue facilities • Available airfields and ports and their refueling and resupply capabilities • Fuelling, supply and medical facilities • Meteorological conditions and forecast • Oceanographic conditions and forecast • Distribution of sea ice and forecast • Accurate positioning of aircrafts and vessels • Location of refueling and medical facilities and supplies	

B.2.6 C169 Indigenous and Tribal Peoples Convention, 1989 – ILO169

C169 Indigenous and Tribal Peoples Convention, 1989 – ILO169	
Facts in Brief	**Jurisdiction:** Several States, but of the Arctic States only Denmark and Norway. **Responsible Organizations:** The respective governments/appointed governmental authority of Denmark and Norway. The governmental authority responsible for the matters covered in this Convention shall ensure that agencies or other appropriate mechanisms exist to administer the programmes affecting the peoples concerned, and shall ensure that they have the means necessary for the proper fulfillment of the functions assigned to them. **Status:** The convention came into effect in 1991. Today it is ratified by 22 States – Norway ratified in 1990 and Denmark ratified in 1996. **Type:** A legally-binding international convention, open to ratification. **Coverage:** Within the Arctic, indigenous peoples able to use this instrument are limited to Greenlandic Inuit and Sami of Norway. **Web link:** http://www.ilo.org/wcmsp5/groups/public/---ed_norm/---normes/documents/publication/wcms_100897.pdf
Policy Objectives	This instrument is specifically aimed at protecting the rights of indigenous and tribal peoples and guaranteeing respect for their integrity by: • Overcoming discrimination and ensuring that indigenous peoples benefit on an equal footing in the national society. • Ensuring that indigenous peoples can develop their social and cultural identity, customs, traditions and institutions, in accordance with their own aspirations.

C169 Indigenous and Tribal Peoples Convention, 1989 – ILO169		
Policy Implications	Sovereignty	Many indigenous peoples have been involuntarily divided or separated by state borders that run across their territories and hamper contact for members of their people divided by the border (e.g. the Sami people). Governments shall take appropriate measures, including by means of international agreements, to facilitate contacts and co-operation between indigenous and tribal peoples across borders, including activities in the economic, social, cultural, spiritual and environmental fields.
	Safety	The policy has implications on the availability of health services to indigenous and tribal peoples.
	Environment	Protection and preservation of the environment of the territories inhabited by indigenous and tribal peoples. Areas for traditional use (fisheries, reindeer husbandry) must be safeguarded
	Economic Development	Handicrafts, rural and community-based industries, and subsistence economy and traditional activities of the peoples concerned, are to be promoted and strengthened. The policy also promotes the effective protection with regard to recruitment and conditions of employment of workers belonging to these peoples. It also establishes the need to consult with peoples before exploration or exploitation of natural resources happen on their land and participate in the benefits of such activities or receive compensation for the damages resulting from them.
	Indigenous and Social Development	Non-discrimination of indigenous peoples, special measures, special recognition, consultation and participation, as well as right to decide priorities. Contribution to peoples' aspiration to exercise control over their own institutions, ways of life and economic development and to maintain and develop their identities, languages and religions, within the framework of the States in which they live. Social security schemes shall be extended progressively to cover the peoples concerned, and applied without discrimination against them.
Capability Requirements	Capability to: • Ensure coherence among the various government institutions that hold responsibilities vis-à-vis indigenous peoples; • Establish adequate institutions and mechanisms with the necessary resources that enable them to fulfill their function; • Develop special measures to safeguard the persons, institutions, property, labour, cultures and environment of indigenous peoples; • Establish institutionalized mechanisms that ensure adequate consultation and participation of indigenous peoples in all stages of implementation, including planning, co-ordination, execution and evaluation • Analyze and amend existing laws, policies and programs in all sectors, in consultation with the peoples concerned, to ensure that these are in line with the Convention	
Information Requirements	• Distribution of the population of indigenous and tribal peoples • Distribution of the lands inhabited and used by indigenous and tribal peoples. • Distribution of lands with the same or better quality inhabited and used by indigenous and tribal peoples. • Distribution and status of natural resources within the lands inhabited and used by indigenous and tribal peoples. • Information on land use by indigenous and tribal peoples including rural activities, hunting, fishing, trapping and gathering. • Information on social and cultural identity and customs of indigenous peoples • Distribution of service facilities (health, education) in the vicinity of the lands inhabited by indigenous and tribal peoples. • Information on existing laws	

B.2.7 Convention on Biological Diversity

Convention on Biological Diversity	
Facts in Brief	**Jurisdiction:** 193 Parties. Of the Arctic States, Canada, Norway, Sweden, Denmark, Finland, Russian Federation, and Iceland are Parties to the Convention, but USA, though a signatory, has not ratified it yet. **Responsible Organizations:** The governments of the contracting Parties. However, unlike other international agreements that set compulsory targets and obligations, the CBD takes a flexible approach to implementation. It identifies general goals and policies, and countries are free to determine how they want to implement them. **Status:** The text of the convention was adopted 5 June 1992 and entered into force on 29 December 1993. Supplementary agreements to the CBD: The Cartagena Protocol on Biosafety of the Convention, also known as the Biosafety Protocol, was adopted in January 2000. The Protocol entered into force on 11 September 2003. The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits. It was adopted on 29 October 2010 and will enter into force 90 days after the deposit of the 50th instrument of ratification. **Type:** International legally binding treaty **Coverage:** Global. The provisions of the CBD apply to the areas within national jurisdiction of each Party with respect to biological diversity, and to areas within and beyond its national jurisdiction with respect to activities and processes. The Convention recognizes that the conservation of biological diversity is "a common concern of humankind" and an integral part of the development process. **Web link:** http://www.cbd.int/convention/text/

Convention on Biological Diversity		
Policy Objectives	The Convention on Biological Diversity is an international treaty to sustain the rich diversity of life on Earth. The overarching objective is to develop national strategies for the conservation and sustainable use of biological diversity. It is often seen as the primary treaty for sustainable development. It has three main goals: • The conservation of biological diversity • The sustainable use of the components of biological diversity • The fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate • Access to genetic resources • Transfer of relevant technologies, • Funding.	
Policy Implications	Sovereignty	States are obliged to prevent activities within their jurisdiction or control from damaging the environment in other parts of the world. Hence it is a challenge to have enough information and knowledge about human activities and biological processes to manage the biological diversity well. It is also a challenge to reach consensus on a liability regime covering cases of transboundary damage to biodiversity.
	Safety	N/A
	Environment	The convention is aimed at the conservation and sustainable use of biological diversity. The Convention is the first agreement to address all aspects of biological diversity: species, ecosystems and genetic resources.
	Economic Development	All States have sovereignty over their own genetic resources and are entitled to the "fair and equitable sharing of the benefits" that these resources provide. Value of biodiversity should be quantified and internalized into market prices, and perverse government-financed incentives that accelerate the loss of biodiversity need to be addressed. Ecotourism is a very fast growing industry and needs to be wisely managed (ecotourism) so it has the potential to reconcile economic and environmental concerns and give a practical meaning to sustainable development. Biodiversity is just part of a broader discussion within the international community on the need to ensure harmony between trade rules and environmental law. Overall challenge is to maximize the benefit and minimize the adverse impacts of economic activities
	Indigenous and Social Development	The Convention recognizes that many indigenous and local communities interact closely with biological diversity. They contribute to the conservation and sustainable use of biological diversity through their role as natural resource managers. Traditional knowledge should be respected and maintained and benefits arisen from their utilization should be equitable shared.
Capability Requirements	• Identify and monitor components of biological diversity important for its conservation and sustainable use • Identify and monitor the effects of processes and activities which have adverse impact on conservation and biological diversity • Conserve ecosystems and natural habitats and protect and restore populations of species in and outside their natural habitats (e.g., by establishing protected areas) • Adopt measures for sustainable use of biological resources • Adopt economically and socially sound measures that act as incentives for the conservation and sustainable use of components of biological diversity. • Conduct research and training on the identification, conservation and sustainable use of biodiversity • Promote public education to raise awareness about the importance of biodiversity • Exchange of information relevant to the conservation and sustainable use of biological diversity • Conduct impact assessments of proposed projects that are likely to have significant adverse effects on biodiversity • Regulate access to genetic resources and fair and equitable sharing of the benefits of their utilization • Promote the transfer of technology among parties to the Convention to promote the conservation and sustainable use of biodiversity • Cooperate on technical and scientific issues for meeting the objectives of the Convention • Regulate the handling of biotechnology to ensure the safe transfer, handling and use of genetically modified organisms • Monitor and report on the effectiveness of measures taken to implement the Convention • Facilitate the exchange of information	
Information Requirements	• Information on: • Habitat, ecosystem and species distribution • Routes of migratory species • Productivity • Sea-surface temperature • surface chlorophyll concentration • Human-activities and infrastructure (e.g., Land-use, shipping) and its effects (e.g. pollution, oil spill)	

B.2.8 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal		
Facts in Brief	**Jurisdiction:** 178 Parties. Of the Arctic States, Canada, Norway, Sweden, Denmark, Finland, Russian Federation, and Iceland have ratified the Convention, but the US, although a signatory, has not ratified it yet. **Responsible Organizations:** Parties are required to designate or establish one or more competent authorities to facilitate the implementation of the Convention. This is the governmental authority designated to be responsible for receiving notifications of transboundary movements and any related information and for responding to such notifications. To facilitate the implementation of the Convention Parties have to appoint one focal point which is responsible for receiving and submitting information to other Parties. **Status:** The text of the convention was adopted 22 March 1989 and entered into force on 22 May 1992. **Type:** A legally-binding international convention, open to ratification. **Coverage:** Globally, "Transboundary movement" meaning, any movement from an area under the national jurisdiction of one State to or through an area under the national jurisdiction of another State or to or through an area not under the national jurisdiction of any State, provided at least two States are involved in the movement, or through a State or States which are not parties **Web link:** http://www.basel.int/TheConvention/Overview/TextoftheConvention/tabid/1275/Default.aspx	
Policy Objectives	The objective of the Convention is to protect human health and the environment against the adverse effects resulting from the generation, management, transboundary movements and disposal of hazardous and other wastes. Its level of application covers a wide range of hazardous wastes based on their origin and/or composition and their characteristics, as well as two types of other wastes (household waste and incinerator ash). The aims and provisions of the Convention center around the following principal aims: • The reduction of hazardous waste generation and the promotion of environmentally sound management of hazardous wastes, wherever the place of disposal; • The restriction of transboundary movements of hazardous wastes except where it is perceived to be in accordance with the principles of environmentally sound management; and, • A regulatory system applying to cases where transboundary movements are permissible.	
Policy Implications	Sovereignty	N/A
	Safety	Increased protection of human health and environment by minimizing the generation and regulating the management (collection, transport, disposal) of hazardous and other wastes hereby reducing risks This might create challenges for monitoring and tracking of transport, dumping, accidents and their consequences,
	Environment	Increased protection of the environment against the adverse effects of hazardous and other wastes which may result from the generation and management of these. Need to be able to monitor effects and extent of hazardous and other wastes on the environment.
	Economic Development	N/A
	Indigenous and Social Development	N/A
Capability Requirements	Capability to: • Monitor and report on the (legal/illegal) transport, collection and disposal of hazardous wastes and other wastes • Reduce as much as possible the amount of hazardous wastes and other wastes and the transboundary movement of these • Monitor, assess the effects of managing hazardous and other wastes on human health and the environment • Regulate any transboundary movements of hazardous wastes in an environmental sound way • Strictly control hazardous waste from the moment of generation to its storage, transport, treatment, reuse, recycling, recovery and final disposal	
Information Requirements	Information on: • Quantitative and qualitative transboundary movements of hazardous wastes or other wastes and their detailed characteristics • Legal/illegal disposal, collection or transport or traffic • Research of development of technologies for the reduction and or elimination of production of hazardous wastes • Accidents and measures taken • Disposal, collection and transport that didn't proceed as intended • Transport, treatment, reuse, recycling, recovery and final disposal of hazardous and other wastes.	

B.2.9 SOLAS – International Convention for the Safety of Life at Sea

SOLAS – International Convention for the Safety of Life at Sea	
Facts in Brief	**Jurisdiction:** International Maritime Organization and its member states. **Responsible Organizations:** Each IMO member of convention is responsible for compliance with the Convention's regulations. **Status:** The Convention is in force today and is sometimes referred to as SOLAS, 1974, as amended. **Type:** Convention **Coverage:** Flag States are responsible for ensuring that ships under their flag comply with its requirements, and a number of certificates are prescribed in the Convention as proof that this has been done. **Web link:** http://www.imo.org/about/conventions/listofconventions/pages/international-convention-for-the-safety-of-life-at-sea-%28solas%29,-1974.aspx

<table>
<tr><th colspan="3">SOLAS – International Convention for the Safety of Life at Sea</th></tr>
<tr><td>Description</td><td colspan="2">International maritime safety treaty specifying the minimum standards for the construction, equipage, and operation of ships.</td></tr>
<tr><td>Baseline</td><td colspan="2">The first version of the treaty was passed in 1914 in response to the sinking of the RMS Titanic. It prescribed numbers of lifeboats and other emergency equipment along with safety procedures, including continuous radio watches.</td></tr>
<tr><td>Objectives</td><td colspan="2">The International Convention for the Safety of Life at Sea (SOLAS), 1974, requires flag States to ensure that their ships comply with minimum safety standards in construction, equipment and operation. It includes articles setting out general obligations, followed by an annex divided into twelve chapters. Of these, chapter five (often called ‹SOLAS V›) is the only one that applies to all vessels on the sea, including private yachts and small craft on local trips as well as to commercial vessels on international passages. Many countries have turned these international requirements into national laws so that anybody on the sea who is in breach of SOLAS V requirements may find themselves subject to legal proceedings.
The twelve chapters:
1. General Provisions
2. Construction - Subdivision and stability, machinery and electrical installations
Fire protection, fire detection and fire extinction
3. Life-saving appliances and arrangements
4. Radio communications
5. Safety of navigation
6. Carriage of Cargoes
7. Carriage of dangerous goods
8. Nuclear ships
9. Management for the Safe Operation of Ships
10. Safety measures for high-speed craft
11. Special measures to enhance maritime safety
Special measures to enhance maritime security
12. Additional safety measures for bulk carriers</td></tr>
<tr><td rowspan="5">Policy Implications</td><td>Sovereignty</td><td>N/A</td></tr>
<tr><td>Safety</td><td>• The primary safety risks in the Arctic are from sea ice, icebergs and ice islands
• Search and Rescue is important in case of disaster or emergency</td></tr>
<tr><td>Environment</td><td>N/A</td></tr>
<tr><td>Economic Development</td><td>N/A</td></tr>
<tr><td>Indigenous and Social Development</td><td>N/A</td></tr>
<tr><td>Capability Requirements</td><td colspan="2">• Safety of navigation - (particularly Chapter V) every mariner must take account of all potential dangers to navigation, weather forecasts, tidal predictions, the competence of the crew, and all other relevant factors. It also adds an obligation for all vessels' masters to offer assistance to those in distress and controls the use of lifesaving signals with specific requirements regarding danger and distress messages.
• Weather - marine safety is greatly affected by the ability to predict and understand weather patterns.
• EO - critical information on sea ice and iceberg location and characteristics derived from satellite imagery is used routinely for helping to protect vessels in the Arctic from collisions with ice.</td></tr>
<tr><td>Information Requirements</td><td colspan="2">• Communications - broadband satellite communication systems for crew welfare
• Danger messages for safe navigation
• Radio communication in emergencies - The Global Maritime Distress Safety System (GMDSS) requires passenger and cargo ships on international voyages to carry radio equipment, including satellite Emergency Position Indicating Radio Beacons (EPIRBs) and Search and Rescue Transponders (SARTs).</td></tr>
</table>

B.2.10 The MARPOL Convention

<table>
<tr><th colspan="2">The MARPOL Convention</th></tr>
<tr><td>Facts in Brief</td><td>Jurisdiction: International Maritime Organization and its member states.
Responsible Organizations: Each IMO member of the Convention is responsible for complying with the Convention's regulations. Out of total 170 countries, there are 150 countries who are parties to the Convention as of December 31, 2010
Status: The Convention is in force today and has been updated by amendments through the years
Type: Convention with six technical Annexes
Coverage: All ships flagged under countries that are signatories to MARPOL are subject to its requirements, regardless of where they sail, and member nations are responsible for vessels registered under their respective nationalities
Web link: http://www.imo.org/about/conventions/listofconventions/pages/international-convention-for-the-prevention-of-pollution-from-ships-%28marpol%29.aspx
Additional considerations:
http://www.arctic.gov/publications/AMSA/environmental.pdf</td></tr>
<tr><td>Description</td><td>The MARPOL Convention is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 respectively and also includes the Protocol of 1997 (Annex VI). It has been updated by amendments through the years.</td></tr>
</table>

The MARPOL Convention		
Baseline for Polar zones	The Arctic marine environment is especially vulnerable to impacts from marine activity. The most common threats: • Release of substances through emissions to air or discharges to water • Accidental releases of oil or hazardous cargo • Disturbances of wildlife through sound and sight and collisions • Disturbance of arctic marine environment through introduction of invasive alien species from shipping (risk may be enhanced due to changing climate) • Migration corridors correspond broadly to the current main shipping routes and travel through geographic chokepoints • The black carbon emitted from shipping in the arctic could have significant regional impacts by accelerating ice melt. The threats can be mitigated through careful planning and effective regulation in areas of high risk.	
Objectives	The Convention includes regulations aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations - and currently includes six technical Annexes: Annex I - Oil Annex II - Noxious Liquid Substances carried in Bulk Annex III - Harmful Substances carried in Packaged Form Annex IV - Sewage Annex V - Garbage Annex VI - Air Pollution	
Policy Implications	Sovereignty	N/A
	Safety	N/A
	Environment	The accidental release of oil or toxic chemicals can be considered one of the most serious threats to Arctic ecosystems as a result of shipping. Accidental oil spills are seen as the largest threat. This is connected to: - monitoring and response to accidental release of harmful substances or oil, and evacuation in case of emergencies, - monitoring navigation hazards: checking up on the general ice conditions, identifying ice conditions and monitoring ice-drift, its direction and speed, - higher importance of communications and broadband connections both for day to day use and in emergencies. As climate and sea ice conditions continue to change, animals' activity will also be modified, making predictions of the potential interactions between shipping and animals increasingly complex.
	Economic Development	N/A
	Indigenous and Social Development	N/A
Capability Requirements	• Meteorological services and warnings (collection examination, dissemination and exchange of meteorological data) • Projecting change in sea ice - research on climate change, assessing the ice coverage • Monitoring of accidental releases, oil spills	
Information Requirements	• Danger messages (obliging masters to communicate information on dangers to navigation (navigation hazards), including dangerous ice, and specifications) • Communications and broadband connections in emergencies	

B.2.11 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	
Facts in Brief	**Jurisdiction:** 175 Parties. All eight of the Arctic states have ratified **Responsible Organizations:** Respective Governments. CITES provides a framework to be respected by each Party, which has to adopt its own domestic legislation to ensure that CITES is implemented at the national level. Each Party to the Convention must designate one or more Management Authorities to be in charge of administering the licensing system and one or more Scientific Authorities to advise them on the effects of trade on the status of the species. **Status:** The Convention was adopted on 3 March 1973, and entered in force on 1 July 1975. **Type:** A legally-binding international convention, open to ratification. **Coverage:** Geographic areas belonging to the respective Parties **Web link:** http://www.cites.org/eng/disc/text.php
Policy Objectives	CITES is an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Because trade in wild animals and plants crosses borders between countries, the effort to regulate it requires international cooperation. Today, the convention gives varying degrees of protection to more than 30,000 species of animals and plants, whether they are traded as live specimens or products.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)		
Policy Implications	Sovereignty	N/A
	Safety	N/A
	Environment	Protection of habitat and avoidance of population depletion.
	Economic Development	Annually, international wildlife trade is estimated to be worth billions of dollars and includes hundreds of millions of plant and animal specimens. The trade is diverse, ranging from live animals and plants to a vast array of wildlife products derived from them, including food products, exotic leather goods, wooden musical instruments, timber, tourist curios and medicines. CITES works by subjecting international trade in specimens of selected species to certain controls. All import, export, re-export and introduction from species covered by the Convention must be authorized through a licensing system.
	Indigenous and Social Development	Protection of natural habitat on which indigenous people depend.
Capability Requirements	Capability to: • Monitor and assess populations of species • Monitor what species are used for • Monitor, identify and track the trade • Assess the effect of trade • Assess ecosystems and habitats • Adequately react when trade is not following the provisions of the convention • Undertake scientific and technical studies to contribute to the implementation of the Convention, including studies concerning standards for appropriate preparation and shipment of living specimens and the means of identifying specimens.	
Information Requirements	Information on: • Effects of trade on the status of the species • Natural habitat of species • Habitat loss • Level of exploitation • What the species is used for • Status of the species & trends • High risk areas • Typical and atypical trade routes	

B.2.12 Convention on the Conservation of Migratory Species of Wild Animals (CMS)

Convention on the Conservation of Migratory Species of Wild Animals (CMS)	
Facts in Brief	**Jurisdiction:** 116 Parties. Of the Arctic states: Denmark, Finland, Norway and Sweden are Parties. **Responsible Organizations:** Respective Governments of the Parties. A Scientific Council, consisting of experts appointed by individual member States and by the COP, gives advice on technical and scientific matters. **Status:** CMS was adopted on 23 June 1979 and entered into force on 1983. Supplementary agreements Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) African-Eurasian Waterbird Agreement (AEWA) **Type:** CMS acts as a framework Convention. The Agreements may range from legally binding treaties (called Agreements) to less formal instruments, such as Memoranda of Understanding, and can be adapted to the requirements of particular regions. The development of models tailored according to the conservation needs throughout the migratory range is a unique capacity to CMS. Countries do not have to be a party to the parent convention to be able to join one of its associate agreements. These agreements can be adapted to the requirements of particular regions with the aim of enhancing the effectiveness of the Convention's efforts. **Coverage:** Geographic areas belonging to the respective Parties and all the areas of land or water that a migratory species inhabits, stays in temporarily, crosses or overflies at any time on its normal migration route **Web link:** http://www.cms.int/documents/convtxt/cms_convtxt.htm
Policy Objectives	The Convention on the Conservation of Migratory Species of Wild Animals (CMS) aims to conserve terrestrial, aquatic and avian migratory species throughout their range. It is an intergovernmental treaty, concluded under the aegis of UNEP, concerned with the conservation of wildlife and habitats on a global scale. The Convention brings together the states through which migratory animals pass, and lays the legal foundation for conservation measures throughout the species' migratory range. Measures are embedded in detailed conservation and management plans. The common goal is achieved by two means: • Concerted actions for endangered species, and • Co-operative agreements for migratory species that have an unfavourable conservation status.

Convention on the Conservation of Migratory Species of Wild Animals (CMS)		
Policy Implications	Sovereignty	N/A
	Safety	N/A
	Environment	CMS Parties strive towards strictly protecting those animals which are threatened with extinction, conserving or restoring the places where they live, mitigating obstacles to migration and controlling other factors that might endanger them.
	Economic Development	N/A
	Indigenous and Social Development	N/A
Capability Requirements	Capability to: • Take action to avoid any migratory species becoming endangered. • Promote, co-operate in and support research relating to migratory species; • Provide immediate protection for migratory species • Monitor, track, identify and assess migratory species and their migration routes • Monitor, identify and assess habitats of migratory species	
Information Requirements	Information on: • Migratory species • Migratory routes • Habitats and ecosystems • What's harmful for migratory species	

B.2.13 Convention on Wetlands of International Importance especially as Waterfowl Habitat (RAMSAR Convention)

Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention)		
Facts in Brief	**Jurisdiction:** 160 Contracting Parties. All of the Arctic States are Parties. **Responsible Organizations:** Governments and the International Union for Conservation of Nature that performs the continuing bureau duties. **Status:** The text of the convention was adopted in 1971 and entered into force on 21 December 1975. **Type:** Multilateral treaty not affiliated with the United Nations system of Multilateral Environmental Agreements. **Coverage:** The Ramsar Convention deals with Wetlands of International Importance within the territory of each of the Contracting Parties. The Parties are responsible themselves for designating "Wetlands of International Importance". These wetlands should be selected on account of their international significance in terms of ecology, botany, zoology, limnology or hydrology. In the first instance, wetlands of international importance to waterfowl at any season should be considered for designation. **Web link:** http://www.ramsar.org/cda/en/ramsar-documents-official-docs/main/ramsar/1-31%5E7761_4000_0__	
Policy Objectives	The Convention on Wetlands -- called the «Ramsar Convention» -- is an intergovernmental treaty that embodies the commitments of its member countries to maintain/conserve the ecological character of their Wetlands of International Importance and to plan for the «wise use» of all of the wetlands in their territories. The wise use of wetlands is defined as "the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development". "Wise use" therefore has at its heart the conservation and sustainable use of wetlands and their resources, for the benefit of humankind. The Convention uses a broad definition of the types of wetlands covered in its mission, including lakes and rivers, swamps and marshes, wet grasslands and peatlands, oases, estuaries, deltas and tidal flats, near-shore marine areas, mangroves and coral reefs, and human-made sites such as fish ponds, rice paddies, reservoirs, and salt pans.	
Policy Implications	Sovereignty	N/A
	Safety	N/A
	Environment	The Ramsar Contracting Parties, or Member States, have committed themselves to implementing the "three pillars" of the Convention: to designate suitable wetlands for the List of Wetlands of International Importance ("Ramsar List") and ensure their effective management; to work towards the 'wise use' of all their wetlands through national land-use planning, appropriate policies and legislation, management actions, and public education; and to cooperate internationally concerning transboundary wetlands, shared wetland systems, shared species, and development projects that may affect wetlands. Parties shall also endeavour through management to increase waterfowl populations on appropriate wetlands.
	Economic Development	N/A
	Indigenous and Social Development	N/A
Capability Requirements	In order to implement the Ramsar Convention there is a need for expertise in wetland research (including ecology, botany, zoology, limnology and hydrology), management and wardening. Expertise in the designation and management of nature reserves will also be required for the adequate implementation. Specifically there will be a need for capability to: • Monitor, identify, assess and map the extent and characteristics of wetlands • Monitor, identify and asses the population, distribution (also seasonal) of waterfowl • Monitor, assess and police human activities within the boundaries of wetlands especially if protected	

Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention)	
Information Requirements	The information required will be: • Wetland physical characteristics (climatology, hydrology) • Wetland habitats distribution • Wetland flora distribution (qualitative and quantitative) • Wetland fauna distribution (qualitative and quantitative) • Wetland land uses (agricultural, infrastructure, etc) • Positioning systems in order to accurately map the distribution and location of waterfowl • Positioning systems to locate accurately the site of certain human activities.

B.2.14 1982 United Nations Convention on the Law of the Sea (UNCLOS)

1982 United Nations Convention on the Law of the Sea (UNCLOS)	
Facts in Brief	**Jurisdiction:** 162 Parties. Of the Arctic States, Canada, Norway, Sweden, Denmark, Finland, Russian Federation, and Iceland have ratified the Convention, but the US has not. **Responsible Organizations:** Respective governments of the Parties. The treaty relies upon national legislation to implement its provisions. **Status:** The text of the convention was adopted on 10 December 1982 and entered into force on 16 November 1994. Supplementary agreements to UNCLOS: The 1995 UN Fish Stocks Agreement was adopted on 4 August 1995 and entered into force on 11 December 2001. It relates to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. The Agreement relating to the implementation of Part XI was adopted on 28 July 1994 and entered into force on 28 July 1996. The Agreement addresses certain difficulties with the seabed mining provisions contained in Part XI of the Convention. **Type:** A legally-binding international convention, open to ratification. **Coverage:** World's Oceans: Geographic marine and coastal area of the respective governments and Areas Beyond National Jurisdiction **Web link:** http://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf
Policy Objectives	UNCLOS is the most comprehensive attempt at creating a unified regime for governance of the rights and responsibilities of nations in their use of ocean space. It governs all aspects of ocean space including: delimitation; environmental control; marine scientific research; economic and commercial activities; transfer of technology; piracy, and the settlement of disputes relating to ocean matters. It applies the notion that all problems of ocean space are closely interrelated, and need to be addressed as a whole.

1982 United Nations Convention on the Law of the Sea (UNCLOS)		
Policy Implications	Sovereignty	One of the most powerful features of UNCLOS is that it settled the question of the extent of national sovereignty over the oceans and seabed. Parts II, V, VI, and VII establish the various regions of the oceans, who has sovereignty over each, and to what degree (e.g. for international navigation, submarine cables, exploitation of natural resources, installations and structures).
	Safety	UNCLOS provides some general provisions with respect to safety of maritime operations and rescue, and for the prevention of harm to human health (e.g. with respect to pollution). Article 234 allows Arctic states to adopt and enforce non-discriminatory laws and regulations for the prevention, reduction, and control of marine pollution from vessels operating in ice-covered waters within the EEZ.
	Environment	Although UNCLOS is not an environmental treaty, it frequently addresses environmental concerns. In addition to having an entire section dedicated to the protection and preservation of the marine environment (Part XII), the treaty also contains numerous references to environmental duties and obligations throughout its many articles. Article 192: States have an obligation to protect and preserve the marine environment. On pollution in general, UNCLOS requires nations 1) to prevent, reduce and control pollution in the marine environment from land-based sources, seabed activities (drilling/mining), dumping, vessels, from or through the atmosphere, 2) to notify of imminent danger to the marine environment from pollution or actual damage from pollution, 3) to observe and evaluate the risks posed by pollution to the marine environment , 4) to monitor the effects of any activities that they permit or engage in, and 5) to prevent the transference of pollution to another nation, or from turning one type of pollution into another. The prohibition on changing one pollutant into another may have impacts on future carbon mitigation schemes such as water-column carbon sequestration or sub-seabed sequestration. Fishing in the EEZ: Coastal states are required to maintain the existing fish stock and protect it from over-exploitation – there are special provisions for straddling stocks, migratory species. Fishing on the high seas: all nations have a duty to take measures to ensure the conservation of living resources on the high seas. States shall cooperate to conserve marine mammals. Biodiversity: States need to take measures to prevent the introduction of alien species that may cause significant and harmful changes to the local environment.
	Economic Development	The treaty addresses a number of provisions with respect to economic rights. Article 193: States have the sovereign right to exploit their natural resources (living and non-living) pursuant to their environmental policies. It regulates payments and contributions with respect to the exploitation of the continental shelf beyond 200 M The treaty also provides provisions for marine scientific research
	Indigenous and Social Development	UNCLOS calls for technology transfers and wealth transfers from developed to undeveloped nations
Capability Requirements	Capability to • Monitor traffic and other human activities, installations, structures • Communication at sea • Detect pollution (+source of pollution) • Monitoring and environmental assessment of ○ Risks or effects of pollution ○ Assessment of potential effects of activities ○ Pollution (land-based sources, seabed activities, dumping, vessels, atmosphere • Monitor, control and surveillance (MCS) of fish stocks, migratory species, fishing, overfishing, marine mammals, alien species • Monitor ice drift and thickness • Assess marine environment • Derive Sediment thickness and morphology of the seabed (article 76)	
Information Requirements	Information on • Human activities, structures and installations • Marine environment • Fish stocks, species, marine mammals, alien and migratory species • Distribution of marine ecosystem, species • Pollution and its effects • Seafloor morphology, bathymetry and sediment thickness on the ocean floor (gravity) • Distribution of non-living resources	

B.2.15 Nordic Cooperation on Foreign and Security Policy

Nordic Cooperation on Foreign and Security Policy		
Facts in Brief	**Jurisdiction:** The Nordic Countries: Norway, Sweden, Finland, Denmark and Iceland **Responsible Organizations:** The Foreign Ministries of each national government. **Status:** The report was submitted jointly to the Foreign Ministers in February 2009. **Type:** A study commissioned by the Foreign Ministers to develop proposals for closer foreign and security policy cooperation between the Nordic countries. The author's work involved several visits to the Nordic capitals and talks with a wide range of people, especially politicians from both government and opposition parties and a variety of experts. **Coverage:** The report covers the following foreign policy areas: Peacebuilding; Air surveillance; Maritime monitoring and arctic issues; Societal security; Foreign services; Military cooperation; and Declaration of solidarity. **Web link:** http://www.mfa.is/media/Frettatilkynning/Nordic_report.pdf	
Policy Objectives	Policy Proposal 1: A Nordic stabilisation task force should be established that can be deployed to states affected by major internal unrest or other critical situations where international assistance is desirable. Policy Proposal 2: The Nordic countries should take on part of the responsibility for air surveillance and air patrolling over Iceland. Policy Proposal 3: A Nordic system should be established for monitoring and early warning in the Nordic sea areas. Policy Proposal 4: A Nordic maritime response force should be established, consisting of elements from the Nordic countries' coast guards and rescue services. Policy Proposal 5: A Nordic polar orbit satellite system should be established in connection with the development of a Nordic maritime monitoring system. Policy Proposal 6: The Nordic countries should develop cooperation on Arctic issues focusing on more practical matters, such as the environment, climate change, maritime safety and search and rescue services. Policy Proposal 7: A Nordic resource network should be established to defend the Nordic countries against cyber attacks. Policy Proposal 8: A Nordic disaster response unit should be established for dealing with large-scale disasters and accidents in the Nordic region and in other countries. Policy Proposal 9: A joint investigation unit should be established to coordinate the Nordic countries' investigation of genocide, crimes against humanity and war crimes committed by persons residing in the Nordic countries. Policy Proposal 10: In countries and areas where no Nordic country has an embassy or consulate general, the countries could establish and run joint diplomatic and consular missions. Policy Proposal 11: The Nordic countries should strengthen their defence cooperation on medical services, education, materiel and exercise ranges. Policy Proposal 12: A Nordic amphibious unit should be established based on existing units and the current cooperation between Sweden and Finland and, in the longer term, the unit should develop its own Arctic expertise. Policy Proposal 13: The Nordic governments should issue a mutual declaration of solidarity in which they commit themselves to clarifying how they would respond if a Nordic country were subject to external attack or undue pressure.	
Policy Implications	Sovereignty	See Policy Proposals 1, 2, 3, 5, 11, 12 and 13 above.
	Safety	See Policy Proposals 4, 6, 7, 8, and 9 above
	Environment	See Policy Proposal 6 above.
	Economic Development	N/A
	Indigenous and Social Development	N/A
Capability Requirements	Capability to: • Achieve surveillance and defense of Nordic countries • Monitor traffic and other human activities, installations, structures • Communicate at sea • Monitor climate change and the environment	
Information Requirements	Information on: • Human activities, structures and installations • Border locations • Locations of people in distress • Illegal activities (e.g., fishing, importation of illegal goods, etc.)	

B.3 Industry Interests

B.3.1 Shipping – Royal Arctic Line

Royal Arctic Line a/s	
Facts in Brief	**Sector/industry:** Shipping **Geographic area of operations:** Denmark/Greenland **Status of operations:** **Ownership and key stakeholders:** Greenland Home Rule **Web link:** http://www.ral.gl/

Royal Arctic Line a/s	
Company overview	The Royal Arctic Line a/s is a joint stock company fully owned by the Greenland Government. Royal Arctic Line Ltd. was established in 1993, when a number of divisions in the Home Rule›s trading company KNI, was incorporated. One of them became the container liner service called Royal Arctic Line. The company has more than 200 years of experience with sailing around Greenland, first as the Royal Trading Company, then as KNI, and since 1993, as Royal Arctic Line. Greenland›s Self-Rule authority has awarded Royal Arctic Line the monopoly concession to sail regularly scheduled routes between the towns in Greenland and between Greenland and Reykjavik, Iceland, and Aalborg, Denmark, as well as a number of other overseas destinations. However, the concession must meet a number of conditions concerning call-in frequencies, capacity and security of supply for all towns on both the east and west coasts of Greenland.
Information needs	The main hurdles are lack of communication north of app. 75 degrees and in the satellite shadow of mountains in fjords. Other challenges are connected to the cost of Internet use and the need for communication satellites. The company is satisfied with the ice alerts and ice forecasts. Maps are often incorrect or inaccurate
Current use of satellite systems	The company uses Vsat, Sat C and Sat B for communication with Iridium as backup. GPS for navigation.
Current use of satellite systems	Communications Weather Navigation

B.3.2 Shipping – Tschudi Arctic Transit

Tschudi Arctic Transit	
Facts in Brief	**Sector/industry:** Shipping **Geographic area of operations:** Svalbard, Northern Norway and the Nort-West Passage **Status of operations:** Operative **Ownership and key stakeholders:** Owned by Tschudi Shipping, local municipalities, Syd –Varanger gruver as. **Web link:** http://www.tschudiarctictransit.com/
Company overview	Tschudi Arctic Transit AS, formerly Kirkenes Transit AS, was founded in 1996 to develop and conduct transportation solutions for goods to and from Russia using Honningsvaag and Kirkenes as an ice-free deepwater transit port. Tschudi Arctic Transit is owned by Tschudi Shipping Company AS who for many years has been involved with a number of projects to encourage and develop commerce and industry between Norway and Russia. Tschudi Shipping was established in 1883 and has worked on projects in Russia, the Baltic States, and Northern Norway. Tschudi Shipping Company is also the owner of Tschudi Kirkenes AS, located in Kirkenes, Norway. Through the establishment of Kirkenes Industrial Logistics Area (KILA), Tschudi Kirkenes AS is an important element of the international business cluster aimed at serving the oil and gas industry and maritime transport sector in the Barents Sea region.
Information needs	The two main hurdles for operations in the Arctic are lack of accurate and timely ice information in the Russian sector of the North-West passage and some gaps in communication coverage through the passage. They also see it as a problem that ships that have to wait for transit or transshipping often do not receive good TV signals, which has Implications for the welfare of the crew.
Current use of satellite systems	The company uses satellites for communication and navigation
Current use of satellite systems	Communications Weather Navigation

B.3.3 Fishing – Nordland Havfiske

Nordland Havfiske	
Facts in Brief	**Sector/industry:** Fisheries **Geographic area of operations:** Fishing the North Sea, Norwegian Sea, Barents Sea and north of Svalbard **Status of operations:** Operative **Ownership and key stakeholders:** Aker Seafoods **Web link:** http://www.akerseafoods.com/text.cfm?id=1-0&path=2,14,19
Company overview	Nordland Havfiske is a Norwegian trawling company that operates five freeze and fresh fish trawlers and is a part of Akers Seafoods Group. One of their trawlers is classified for light ice conditions. They mainly trawl for white fish (cod, haddock and saithe) and shrimp. The company has been operating since 1953. It is based in Stamsund, Lofoten in Norway.
Information needs	The main challenge is communication north of about 78 degrees. The ships use internet more and more for price information, weather forecast, crew welfare and generally for ship operations. Internet does not work in the far north. Generally where it does work the price is very high and the capacity is low.

Nordland Havfiske	
Current use of satellite systems	The company uses GPS for navigation, Satellite for Internet and telephony with Iridium and Inmarsat as backup solutions. They are generally satisfied with the available ice information and weather forecast in the area they operate, however there could be more frequent measurements of weather for more reliable forecasts.
Current use of satellite systems	Communications Weather Navigation

B.3.4 Mining – Baffinland's Mary River Project

Baffinland Iron Mines Corp.	
Facts in Brief	**Sector/industry:** Mining, Iron Ore **Geographic area of operations:** Mary River Property, located in the Qikiqtani Region of Baffin Island in Nunavut, Canada. It is located 160 kms south of Pond Inlet. The property consists of nine plus high-grade lump and fine iron ore deposits. **Status of operations: The h**Have submitted their Environmental Impact Statement. They are currently under-review by the Nunavut Impact Review Board, with public hearings commencing later in 2012. Construction on the project is expected to begin in Spring 2013, although the pre-construction phases (bulk sampling) have already exported some product. **Ownership and key stakeholders:** Owned 70% by ArcelorMittal and 30% by Iron Ore Holdings LP. **Web link:** http://www.baffinland.com/MaryRiverProject/default.aspx
Company overview	ArcelorMittal is the world›s largest steel company, with 262,000 employees in more than 60 countries. It acquired Baffinland in 2010. Baffinland began exploration on the property in 2004, though the deposit was originally found in 1962. The project will be the largest mining project ever developed in Northern Canada, requiring a $4 billion investment. The site deposits are expected to hold 365 mil/tonnes of 64% grade iron. Production is expected to be 21 million tonnes annually, over 21 years. Operations will involve mining, ore crushing and screening, rail transport and marine shipping to market. Highlights include a 150km railroad, a deep water port, year-round shipping, construction of 10 Polar Class 4 transport vessels capable of 190,000 tonnes, and 2,400 jobs created during the construction and operation phases. If all goes according to plan with the EIS, construction is scheduled to begin in 2013. It would also be an important cornerstone to Nunavut's economy, accounting for over $20 million annually to government and aboriginal groups in royalties, as well as business and employment spin-offs.
Information needs	Baffinland has submitted their EIS for the Mary River project and responded to over 300 comments/questions arising from a review of their draft EIS. At least some of these issues will require further investigation and longer term monitoring efforts. One of their biggest concerns is the impact of shipping on marine mammals and the technology solution for baseline marine mammal studies and on-going monitoring. Based on the comments/questions in response to the draft EIS, there are also important information requirements associated with year round mining and rail transportation of ore, including permafrost issues, habitat disruption and mammal migration pattern disruption.
Current use of satellite systems	They have used satellites at different stages: mapping the area during exploration, contracting work on ecosystem and habitat for regulatory approval, ice charting for shipping navigation, and infrastructure development. Opportunities exist for expanding this scope.

B.3.5 Mining – Norilsk Nickel

Norilsk Nickel	
Facts in Brief	**Sector/industry:** Mining, primarily nickel and palladium. Also producers of platinum, copper, and various by-products like cobalt, rhodium, silver, gold, iridium, ruthenium, selenium, tellurium and sulfur. **Geographic area of operations:** Norilsk Nickel's activities are located in five countries: Russia, Australia, Botswana, Finland, and South Africa. Its largest operations are located in the Norilsk–Talnakh area, in northern Russia. Its headquarters are in Moscow. **Status of operations:** Involved in prospecting, exploration, extraction, refining and metallurgical processing of minerals, as well as in production, marketing and sale of base and precious metals. **Ownership and key stakeholders:** Key shareholders are Interros and Rusal. **Web link:** http://www.nornik.ru/en/
Company overview	Norilsk Nickel is the largest nickel and palladium producer in the world. It currently has five main operational divisions, two of which are located in the Russian North: the Polar Division and Kola Mining and Metallurgical Company. The Polar Division is located in Russia at the Taimyr Peninsula above the Arctic Circle, on the 69th parallel. Seven Polar Division mines produce copper-nickel sulfide ores from the Oktyabrsky, Talnakh, and Norilsk-1 deposits. As of the beginning of 2010, the proven and probable reserves of the Taimyr and Kola Peninsulas amount to over 473 million tonnes and contain ca. 5.8 million tonnes of nickel, over 8.7 million tonnes of copper, and ca. 2.6 thousand tonnes of platinum group metals.
Information needs	For logistics in the North Sea Route: to identify the route accessibility given ice conditions (ice breakers require additional costs, and are supplied upon request from a NN partner organization) Meteorological data for safety Communications and rescue Navigation and GPS

Norilsk Nickel	
Current use of satellite systems	Assessment of known and estimated resource base Comprehensive information on weather and ice conditions Detection and monitoring of pollution events Real-time satellite imagery and navigation data streams In-situ environmental observations Up-to-date infrastructure to support movement of goods and services Communications and broadband connections

B.3.6 Oil and Gas – Overview

Oil and Gas Industry Perspectives	
Facts in Brief	**Sector/industry:** Oil and Gas **Geographic area of operations:** Arctic **Consulted stakeholders:** ExxonMobil, Suncor, Husky Energy, Statoil, Chevron, Shell, ConocoPhillips, Imperial Oil, ABS, Memorial University, CJK Engineering, AKAC, Marintek, NTNU **Source:** CARD (2012) Arctic Development Roadmap, C-CORE Report R-11-275001-CARD v2, January 2012.
Information needs and priorities	**Environmental protection:** constitutes the highest priority area since offshore activities in the Arctic cannot proceed until regulatory approvals are obtained and outstanding issues are addressed. Emergency scenarios (oil spill prevention and response) and operational considerations (emissions, pollution, noise and environmental footprint) constitute critical requirements. **Ice management:** detection, monitoring and forecasting of ice conditions, as well as physical ice management issues. The management of ice to support emergency response is critical. Field trials are necessary to demonstrate the effectiveness of ice management for different operating conditions, such as detecting and towing multi-year and glacial ice embedded in first-year pack ice. **Ice mechanics and loading:** improving understanding and modeling of ice loads and associated mechanics for different ice-structure interaction scenarios (e.g. ridge loads on sloping structures). **Station-keeping in Ice:** maintaining station during operations in ice using either mooring or dynamic positioning systems. Station-keeping during emergency response is the limiting case used for design. Environmental characterization: **technology and data used in the characterization of ice and metocean conditions, as well as** bathymetric, geotechnical, geophysical and other geospatial information. **Offshore safety and escape, evacuation, and rescue:** issues related to the safety of personnel both in terms of operational safety and during emergency response scenarios. **Dredging and trenching:** technology used to conduct and support dredging/trenching operations. A key issue is the design and development of improved dredging and trenching technologies capable of operation in harsh Arctic metocean, ice and geotechnical conditions. Another major issue is the very high cost associated with dredging and trenching operations. **Simulation and training:** development and use of simulation-based tools to evaluate the effectiveness of operational processes, and to assist in the training of personnel. The two main priority areas identified for application of simulation and training technology are in training personnel for escape, evacuation and rescue scenarios, and also for training personnel for oil spill response scenarios. Hydrocarbon export technologies: issues associated with delivering produced hydrocarbons to market. The main long-term issue identified in this category was the exploitation of stranded natural gas reserves. Floating liquefied natural gas technology was identified as an export technology of high priority due to its potential applicability in Arctic regions. **Arctic drilling:** drilling and completion of wells in Arctic regions. The top priority issues identified for this category were finding ways to reduce the extremely high cost of drilling in the Arctic and extending the drilling season to enable year-round drilling.
Current use of satellite systems	Satellite-based technologies are currently being used to support navigation, communication and ice management operations in Arctic and ice-affected waters.
Current use of satellite systems	Communications Weather and climate Navigation Earth observation Surveillance

C. INVENTORY OF SPACE SYSTEMS

This Appendix presents an inventory of Satellite Systems categorized by type: (i) Communications, (ii) Weather and Climate, (iii) Surveillance, (iv) Navigation, (v) Earth Observation, and (vi) Science. Both existing and planned systems are included.

C.1. Communications Satellite Systems Inventory

The following pages contain templates of existing and planned communications satellite systems.

C.1.1 Existing Communications Satellite Systems

Globalstar	
Facts in Brief	**Country:** Operations worldwide, US headquarters located in Louisiana **Operations:** Globalstar **Status:** The first of four launches of six new second-generation satellites was successfully completed on October, 2010. Two additional launches were successfully conducted in July and December of 2011, respectively. The fourth launch is expected to take place in 2012. **Coverage:** 120 countries worldwide; 80% of the Earth's surface, everywhere outside the extreme polar regions and some mid-ocean regions. **Orbit:** Low Earth Orbiting satellite constellation **Key Service Areas:** Phone and accessories, voice services, data and tracking **Web link:** http://ca.globalstar.com/en/index.php?cid=100
Mission Objectives	Globalstar is one of the world's largest providers of mobile satellite voice and data services and offers services to commercial and recreational users in more than 120 countries. Company products include mobile and fixed satellite telephones, simplex and duplex satellite data modems and satellite data services. In October 2010, Globalstar began launching its second-generation satellite constellation designed to restore its industry leading commercial voice and duplex data services. Once fully deployed the advanced second-generation constellation and next-generation ground network will provide Globalstar customers with enhanced services featuring increased data speeds of up to 256 kbps in a flexible Internet protocol multimedia subsystem (IMS) configuration.
System Capabilities	Globalstar offers communications services that provide several key capabilities including clarity of voice; QUALCOMM's CDMA (Code Division Multiple Access) technology makes Globalstar calls secure and clear, often with better voice quality than cellular networks, and greater system capacity. Minimal perceptible voice delay-Use of Low Earth Orbiting (LEO) satellites, moving at an altitude of 1,414 kilometres, means almost no perceptible voice delay, as compared with the noticeable time delay and echo effect of calls utilizing geosynchronous satellites. Next generation products and services supported are expected to include: Push-to-talk and multicasting; Advanced messaging capabilities such as multimedia messaging or MMS; Mobile video; Geo-location services; Multi-band and multi-mode handsets; Data devices with GPS integration.
Relevance to Arctic Interests	The Globalstar portfolio of products assists customers to keep in contact from remote locations or worksites, namely those located in the high north, with the use of the Handheld Phone while traveling in remote areas, or one of their Fixed Phones for remote offices or dwellings. Globalstar products and accessories can connect in places where cellular and landline are unavailable. Globalstar also offers specialized data modems to send and/or receive information from remote jobsites or track and monitor company assets.

Inmarsat	
Facts in Brief	**Country:** Global presence with offices located in 40 countries world-wide, headquarters in London, England **Operations:** Inmarsat Inc. **Status:** Inmarsat-4 series currently in operation; these three satellites make up the global I-4 constellation and are part of an 11-strong fleet of spacecraft owned and operated by Inmarsat; planned launch of three new Ka-band mobile satellites starting in 2013 to introduce global broadband mobile satellite services by end of 2014 (Inmarsat-5 ***Global Xpress™***) **Mission Duration:** Expected operation life of Inmarsat- 4 series into the 2020s. **Coverage:** Broadband Global Area Network (BGAN) services worldwide **Orbit:** Geosynchronous orbit at 35,786 km above Earth **Key Service Areas:** voice and high-speed data services to almost anywhere on the planet (land, sea and air) including fixed and mobile satellite phones, email, internet and intranet services, telex, distress calls, text and data messaging **Web link:** http://www.inmarsat.com/About/Our_satellites/default.aspx?language=EN&textonly=False
Mission Objectives	Inmarsat has provided mobile satellite services for more than 32 years with key service areas including global voice, data and IP communications solutions that deliver communications services where terrestrial networks don't go or are ineffective. Inmarsat owns and operates a fleet of 11 satellites in geostationary orbit that provide these services on land, at sea or in the air. Inmarsat also offers expertise in a range of cross-platform mobile and fixed satellite, microwave and wireless technologies.
System Capabilities	Inmarsat provides the following system capabilities: (i) standard IP, which allows for email internet and intranet access at speeds up to 492 kbps over a shared channel; (ii) streaming IP- providing guaranteed data on demand at rates in excess of 384 kbps. (iii) Phone and data applications available simultaneously. Voicemail and other stand 3G mobile supplementary services are also available; (iv) Send and receive text message to or from any mobile phone.

Inmarsat	
Relevance to Arctic Interests	With the construction of its new constellation of Inmarsat-5 satellites – part of a new US$1.2 billion worldwide wireless broadband network called Inmarsat ***Global Xpress™*** full global coverage is expected by the end of 2014. The spacecraft will break new ground by transmitting in a portion of the radio spectrum not available previously by commercial operators of global satellite systems – the extremely high frequency Ka-band. Each Inmarsat-5 will carry a payload of 89 Ka-band beams - capable of flexing capacity across the globe and enabling Inmarsat to adapt to shifting subscriber usage patterns over their projected lifetime of 15 years. The system will be tailored initially for the government, energy and maritime markets and will make critical communication technology services more readily available for environment, economic, security and social concerns in the northern regions.

C.1.2 Planned Communications Satellite Systems

Thor 7	
Facts in Brief	**Country:** Norway **Operations:** Telenor Satellite Broadcasting **Status:** Planned launch date latter half of 2013 **Mission Duration:** Assumed life span of 15 years **Coverage:** Northern Europe, Baltic Sea, Mediterranean **Orbit:** Geostationary **Key Service Areas:** Telnor's first use of Ka band **Web link:** http://www.telenorsbc.com/templates/Page.aspx?id=1125
Mission Objectives	The Norwegian Telnor Thor family of satellites provides coverage over northern parts of Europe with existing satellites including Thor 4, Thor 5, and Thor 6 that are operational Ku-band satellites. Thor 7 is the recently announce (Feb 2011) planned Ka -band Thor 7. The planned intention is to offer ka-band capacity for high-bandwidth transmissions to maritime customer in Northern Europe as well as the Baltic and Mediterranean sea.
System Capabilities	Ka band high speed communication services
Relevance to Polar Interests	Thor 7 will have capacity to provide the Norwegian troll base located at the South Pole with increased satellite capacity for the distribution of key meteorological data from the research station, Trollsat. The additional capacity will also provide faster and more stable broadband connections, essential for employees working at the base, as its current data capacity is limited.

Iridium NEXT	
Facts in Brief	**Country:** Global presence, Corporate HQ in Virginia, USA **Operations:** Iridium Communications Inc. **Status:** Anticipated first launch in 2015, with subsequent launches thru to 2017 **Mission Duration:** 10 year design and 15 year mission life **Coverage:** 100 percent global coverage **Orbit:** Low earth orbit, 66 operational cross- linked satellites in polar orbit with 6 in-orbit spares at 86.4 degrees inclination. Altitude at 780 km **Key Service Areas:** higher data rates up to 1Mbps, Ka-band service, flexible bandwidth allocation and IP-based routing, 24/7 global coverage **Web link:** http://www.iridium.com/about/IridiumNEXT.aspx
Mission Objectives	From 2015 to 2017 Iridium plans to replace it current LEO satellite constellation with a total of 72 new satellites, including 6 in-orbit spares. The mission will provide enhanced as well as entirely new services for a growing range of industries and geographical areas including the high north. Iridium NEXT will offer innovation in areas such as: enterprise global voice and data connectivity, asset tracking and other machine-to-machine (M2M) applications, new data-centric applications and more power enabling new opportunities.
System Capabilities	Iridium NEXT plans to offer higher data speeds, more flexible bandwidth allocation and IP-based routing. More specifically its improvements will include data rates up to 1Mbps, Ka-band service (2 20/30 GHz steerable feeder links to terrestrial gateways and 4 23 GHz cross links to adjacent Iridium NEXT satellites for relay communications), private network gateways and broadcast and network services. Iridium NEXT will also offer commercial, government and scientist organizations a potential opportunity to place secondary payloads on its satellite constellation to address a variety of near and long term requirements (i.e. dedicated communications, EO, signals collection, space weather etc.).
Relevance to Arctic Interests	The current Iridium system is the only mobile satellite service that provides complete coverage over 100% of the Earth's surface, including the extreme Polar Regions. Iridium NEXT will continue to remain the only system to provide real-time communication services above 75 degrees north as well as providing 24/7 real-time visibility over the entire Earth's surface and atmosphere; thus allowing it to provide critical technology for communication services as well as environmental, economic, security and social concerns across the Arctic.

Polar Communication and Weather Mission (PCW)	
Facts in Brief	**Country:** Canada **Operations:** Canadian Space Agency, in partnership with Environment Canada and National Defence **Status:** Under study, planned launch date 2017 **Mission Duration:** Satellite design life of six years **Coverage:** Arctic circumpolar region **Orbit:** 2 satellites in Highly Elliptic Orbit (HEO), Molniya-type, with a period of 12 hours, inclination of 63.4 degrees and an apogee of approximately 39,900 km above Northern Hemisphere. TAP (Three Apogees) orbit also under consideration. **Key Service Areas:** climate change monitoring, meteorological observations, broadband communications **Web link:** http://www.asc-csa.gc.ca/eng/satellites/pcw/
Mission Objectives	PCW aims to support Canadian sovereignty and security, to improve quality of life and to facilitate economic development and world-class scientific research in the Arctic by providing reliable 24/7 high data rate (HDR) communications services. PCW also aims to monitor Arctic weather and climate change for the benefits of Canadians and the Global community.
System Capabilities	The main instrument for the meteorological payload will be an imaging spectroradiometer, similar to imagers being developed for the next generation of geostationary weather satellites. A secondary weather instrument (broadband radiometer) is also being considered. The primary Ka-band telecommunications payload consists of a high-speed two-way system capable of providing continuous broadband services to users throughout the Arctic. A suite of compact space weather instruments to study ionizing radiation completes the list of primary payloads. A list of secondary scientific payloads is currently being evaluated with possible atmospheric science applications.
Measured Parameters	Temperature, wind, precipitation, humidity, ice/snow coverage, clouds, water
Relevance to Arctic Interests	Currently, parts of the Canadian territory in the Arctic region are without access to secure, highly reliable and high capacity telecommunication solutions, particularly for mobile services such as ships, planes and Unmanned Aerial Vehicles (UAVs). PCW offers potential for provision of continuous 24/7 broadband two-way communications services throughout the entire Arctic region. The mission will also offer climate change monitoring and weather forecasting with improved temporal and spatial resolution supported by robust systems.

C.2 Weather and Climate Satellite Systems Inventory

The following pages contain templates of existing and planned climate and weather satellite systems.

C.2.1 Existing Weather and Climate Satellite Systems

EUMETSAT Polar System (EPS) Metop	
Facts in Brief	**Country:** 26 European member states **Operations:** EUMETSAT - European Organization for the Exploitation of Meteorological Satellites **Status:** In operation, series of 3 satellites (Metop A, B & C), first satellite launched 2006. **Mission Duration:** Satellite mission design life span of 14 years; each of 3 satellite has a nominal lifetime in orbit of five years, with six month overlap between consecutive satellites. **Coverage:** Global coverage (in conjunction with NOAA satellite from USA) **Orbit:** Metop satellite from Europe and NOAA satellite from USA fly in complimentary LEO polar orbits designed to ensure global data coverage at intervals of no more than six hours. **Key Service Areas:** operational meteorological and environmental forecasting and global climate monitoring **Web link:** http://www.eumetsat.int/Home/Main/Satellites/Metop/MissionOverview/index.htm?l=en
Mission Objectives	The prime objective of the EUMETSAT Polar System (EPS) Metop mission series is to provide continuous, long-term data sets, in support of operational meteorological and environmental forecasting and global climate monitoring. The Metop series is part of the Initial Joint Polar-Orbiting Operational Satellite System (IJPS) constellation, along with the NOAA-N and -N' satellites. Together, the satellite series provide global coverage.
System Capabilities	The launch of Metop has brought about improved capacity and sophistication in the way the Earth's weather, climate and environment are observed and aims to improve operational meteorology, in particular Numerical Weather Prediction (NWP). Measurements from infrared and microwave radiometers and sounders provide NWP models with information on the global atmospheric temperature and humidity structure, with a high vertical and horizontal resolution. EPS also ensures continuity in the long-term monitoring of factors that impact climate change. In particular, the Infrared Atmospheric Sounding Interferometer (IASI) instrument has the ability to detect and accurately measure the levels and circulation patterns of gases that are known to influence the climate, such as carbon dioxide.
Measured Parameters	Temperature, wind, gases, precipitation, humidity, ice/snow coverage, clouds, water, ocean surface temperatures and winds
Relevance to Arctic Interests	An ongoing understanding of climate change and weather patterns is important to effectively managing Arctic activities ranging from commercial shipping and fishing, to the exploitation of natural resources and energy and the continuity of the traditional indigenous ways of life. To this end, Metop services include monitoring global atmospheric temperatures and humidity; monitoring seasonal variations in ozone and tracking any developments; providing data for vegetation indices, displaying the changing vegetation on the surface of the Earth; providing maps of snow and ice cover, used by, for example, in transport and tourism industries and ocean monitoring as a key indicator of climate changes.

Meteor-M Series (1,2,3)

Facts in Brief	**Country:** Russia **Operations:** Russian Federal Space Agency (ROSCOSMOS) **Status:** Meteor-M, No. 1 launched 2009, second and third Meteor-M satellites to be launched 2012 **Mission Duration:** Operational life span of 5 years **Coverage:** Global coverage **Orbit:** Non sun-synchronous orbit **Key Service Areas:** weather forecasting, along with monitoring of the ozone layer, radiation levels in space, observation of sea and ocean ice cover, climate change indicators **Web link:** http://www.russianspaceweb.com/meteor.html
Mission Objectives	The main goal of the first two satellites in the series is to provide weather forecasting, along with monitoring of the ozone layer, radiation levels in space, and observations of sea and ocean ice cover. Meteor-M No. 3 will offer similar services and will also be equipped with a new-generation phased antenna radar for improved ocean monitoring.
System Capabilities	The capabilities of the Meteor-M series aim to restore the Russian weather constellation in orbit. The Meteor-M satellites comprise unique payloads including multi-zone satellite imaging systems, multichannel low-resolution scanning devices, radiolocation systems, atmosphere temperature and humidity sounding systems. The goal is for Meteor-M series, supported by other planned systems, (including different LEO, GEO and high-elliptical ones), to significantly improve Russia's ability to contribute to global climate change studies.
Measured Parameters	Cloud coverage, ice and flood levels, monitoring of radiation levels, ecological and weather activities
Relevance to Arctic Interests	Meteor-M satellite series marks the re-institution of the Russia's space weather-forecasting capabilities in the Arctic at a new technological level, in particular snow and ice coverage. The goal, according to ROSCOSMOS, is to build up the Russian meteorological network to include three satellites in the sun-synchronous orbit and three in the geostationary orbit. Prior to this mission, Russia had no functioning meteorological satellites in orbit to monitor Arctic conditions, and, according to the national press, had to purchase weather-forecasting data abroad. The Meteor-M series is also set to improve global climate change monitoring which can contribute to overall understanding of arctic climate change.

NOAA Polar Orbiting Satellites (TIROS-Next Generation)

Facts in Brief	**Country:** USA **Operations:** National Oceanic and Atmospheric Administration (NOAA) and NASA **Status:** Five polar orbiting satellites are in operation. The newest, NOAA-19, was launched February 2009. NOAA-15, 16, 17 and 18 all continue to transmit data as stand-by satellites. NOAA-19 is classified as the "operational" satellite. **Mission Duration:** Satellite design life of six years **Coverage:** Operating as a pair, satellites provide global cover with repeat data no more than six hours old. **Orbit:** Continuous circling of the Earth in an almost north-south orbit, passing close to both poles. The orbits are circular, with an altitude between 830 (morning orbit) and 870 (afternoon orbit) km, and are sun synchronous. **Key Service Areas:** Provision of complete global weather monitoring system; also supports SAR activities. **Weblink:** http://noaasis.noaa.gov/NOAASIS/ml/genlsatl.html
Mission Objectives	The polar orbiting satellites' main objective is to monitor the entire Earth providing day and night quantitative data on a local and global scale, tracking atmospheric variables and cloud images. The mission tracks weather conditions that eventually affect the weather and climate of the United States. Satellite information is also shared with various Federal agencies, such as the Departments of Agriculture, Interior, Defense, and Transportation; and with other countries, such as Japan, India, and Russia, and members of the European Space Agency (ESA) and the United Kingdom Meteorological Office; and with the private sector.
System Capabilities	A suite of instruments is able to measure parameters of the Earth's atmosphere, its surface, cloud cover, incoming solar protons, positive ions, electron-flux sensitivity, and the energy spectrum at satellite altitude. As a part of the mission, the satellites can also receive process and retransmit data from Search and Rescue beacon transmitters, and provide automatic data collection platforms on land, ocean buoys or aboard free-floating balloons. The primary instrument aboard the satellite is the Advanced Very High Resolution Radiometer (AVHRR). Other sensors included ultraviolet spectral radiometer, microwave sounder units, and advanced data collection systems.
Measured Parameters	Longer term weather forecasting including many parameters of the Earth's atmosphere, its surface, temperature, cloud cover, incoming solar protons, positive ions, electron-flux density, the energy spectrum, as well as ice and snow conditions.
Relevance to Arctic Interests	The satellites provide visible and infrared radiometer data that are used for imaging purposes, radiation measurements, and temperature profiles which can support climate change monitoring. The polar orbiters' ultraviolet sensors also provide ozone levels in the atmosphere and are able to detect the «ozone hole» over Arctic/Antarctica during mid-September to mid-November.

C.2.1 Planned Weather and Climate Satellite Systems

Meteosat Third Generation (MTG)	
Facts in Brief	**Country:** EU **Operations:** EUMETSAT (with ESA funding for initial research and development activities) **Status:** Under study, planned launch date for first spacecraft is 2017 **Mission Duration:** Access to space-acquired meteorological data until, at least, the late 2030s. **Coverage:** Arctic circumpolar region **Orbit:** two parallel in orbit positioned satellites, the MTG-I (imager) and MTG-S (sounder) platforms. **Key Service Areas:** Improved imagery at 10-minute full disc repeat cycles, in addition to the provision of data from the MTG infrared and ultraviolet/visible sounding missions which will be crucial for the derivation of quantitative products in future. **Web link:** http://www.eumetsat.int/Home/Main/Satellites/MeteosatThirdGeneration/index.htm?l=en
Mission Objectives	The Meteosat Third Generation (MTG) objective is to bring a significant improvement to the capabilities of operational meteorology. It will comprise six satellites, with the first spacecraft likely to be ready for launch from 2017. The in-orbit configuration will consist of two parallel positioned satellites, the MTG-I (imager) and the MTG-S (sounder) platforms. Unlike the first and second generation Meteosat series, MTG will be based on three axes stabilized platforms, meaning the instruments will be pointed at the Earth for 100% of their in orbit time. Such improvements are necessary to meet more demanding user requirements on spatial resolution; repeat cycle, signal to noise ratio; and are a prerequisite to conduct soundings from geostationary orbit.
System Capabilities	The planned MTG imaging capability will include a 3-tonne satellite with 16 nominal channels. MTG adds a second platform, a sounding satellite to observe the different layers within the atmosphere. The sounder will be one of the key innovations in the new program allowing Meteosat satellites, for the first time, to not just image weather systems but to analyze the atmosphere layer-by-layer and perform far more detailed chemical composition studies.
Measured Parameters	Temperature, wind, precipitation, humidity, ice/snow coverage, clouds, water, improved severe weather forecasts, air quality monitoring, atmospheric monitoring.
Relevance to Arctic Interests	Current weather satellite systems that look to the Polar Regions employ Low-Earth orbits that provide high–quality spatial resolution information over high latitudes but on a narrow flight pattern, sometimes taking 6 hours before the same area is imaged again. This mission will address many of the deficiencies of the current systems. In addition to improved imagery at 10-minute full disc repeat cycles, the provision of data from the MTG infrared and ultraviolet/visible sounding missions will be crucial for the derivation of improved quantitative products related to environmental forecasting. This will assist in monitoring Arctic interests ranging from oil and gas exploration to managing natural habitats and maintaining indigenous ways of life.

Arktika	
Facts in Brief	**Country:** Russia **Operations:** Russian Federal Space Agency (ROSCOSMOS) **Status:** Under study, planned launch date 2014 **Mission Duration:** Unknown **Coverage:** Arctic circumpolar region **Orbit:** Highly elliptical 12-hour Molniya orbit to monitor high-altitude areas of the Earth. **Key Service Areas:** climate change monitoring, meteorological observations, broadband communications, survey of energy resources **Web link:** http://www.federalspace.ru/main.php?id=2&nid=10111&hl=arktika
Mission Objectives	The Arktika system, estimated to be worth around 70 billion rubles ($2.5 billion US), will monitor climatic changes, survey energy resources in the Arctic region as well as provide high-speed communications services. The system has been recently approved by the Russian Economic Development Agency and according to ROSCOSMOS has also received support from the World Meteorological Organization. The new Arctic Satellite cluster will be based on already operational remote-sensing weather and telecommunication satellites and will also receive radio signals from the COSPAS-SARSAT international search and rescue (SAR) system.
System Capabilities	The planned system will be comprised of six satellites that will feature optical systems; the Arktika-R satellites will carry radars, particularly important during polar nights, and the Arktika-MS telecommunications satellites will handle telephone communications and relay television and FM radio broadcasts to aircraft and ships in northern Russia and other polar countries.
Measured Parameters	Temperature, wind, precipitation, humidity, ice/snow coverage, clouds, water
Relevance to Arctic Interests	The purely civilian system will monitor the weather and environment of the North Pole, pinpoint hydrocarbon deposits on the Arctic shelf, provide telecommunications over the hard-to-access areas and ensure safe air traffic and commercial shipping in the region. There has been some indication that Canada, as well as Italy and a number of Asian countries, have shown interest in the project.

CASSIOPE	
Facts in Brief	**Country:** Canada **Operations:** Canadian Space Agency (with support from eight Canadian Universities, lead by the University of Calgary as well as Canadian Communications Research Centre, the Institute of Space and Astronautical Science of Japan and the U.S. Naval Research Laboratory); Bristol Aerospace (construction of satellite platform) and MDA (project's prime contractor). **Status:** Final stages of development, projected launch 2012 **Mission Duration:** Projected lifetime of 2 years **Coverage:** Arctic circumpolar region **Orbit:** Highly elliptical polar orbit, 300 x 1500 km, 80° inclination, projected orbital period 103 minutes (14 orbits per day) **Key Service Areas:** hybrid satellite to offer both scientific observations of the Earth's ionosphere and first digital broadband courier service for commercial use. **Web link:** http://www.asc-csa.gc.ca/eng/satellites/cassiope.asp
Mission Objectives	With a dual payload consisting of e-POP (enhanced polar outflow probe), and Cascade, this mission will achieve both a scientific and a commercial objective: e-POP will provide scientists with unprecedented details about the Earth's ionosphere, thermosphere and magnetosphere, helping scientists understand the cause and effects of potentially dangerous space weather, while Cascade will demonstrate a new digital communications 'courier' service which will provide high data rate, high-capacity store and forward technology.
System Capabilities	This generic, low-cost satellite platform will carry two payloads: e-POP, a scientific payload consisting of eight high-resolution instruments used to probe the characteristics of near-Earth space. These onboard sensors include: VHF/UHF transmitter (CER), VLF/HF receiver (RRI), auroral imagers (2) (FAI), GPS receivers (5) (GAP), ion detector (IRM), electron detector (SEI), neutral particle detector (NMS), magnetometers (2) (MGF). Cascade is a high data rate, high capacity store and forward technology payload offering a data down link of Ka—band, ›300 Mbps and data storage up to 1.5 GB/orbit.
Measured Parameters	Characteristics of new-Earth space weather including ionosphere, thermosphere and magnetosphere parameters.
Relevance to Arctic Interests	As the new platform produced for the CASSIOPE mission will be versatile, it will be possible to adapt and use it for various missions involving science, technology, Earth observation, geologic exploration and information delivery all addressing the current service gap that exists in Arctic coverage above 70° latitude north. In particular, an improved understanding of space weather will assist Arctic interests to better predict potential impacts on technology systems (i.e. communication cables, power systems, pipelines and radio communication and navigation systems) as well as better prepare systems to be more robust and resilient.

C.3 Navigation Satellite Systems Inventory

The following pages contain templates of existing and planned navigation satellite systems.

C.3.1 Existing Navigation Satellite Systems

Global Positioning System (GPS)	
Facts in Brief	**Country:** United States **Operations:** United States Air Force **Status:** Operational since 1995, 31 operational satellites with 3-4 decommissioned satellites that can be reactivated if needed **Mission Duration:** Design life of 5 years **Coverage:** Global coverage, with at least 8 satellites visible at any time from any place; each satellite circles the Earth twice daily **Orbit:** Medium earth orbit at 20,200 km altitude **Key Service Areas:** Positioning (surveying, location based services, etc.); navigation (air, marine, road and rail transportation, personal direction-finding, tracking and surveillance, etc.); and timing (synchronization of telecom and computer networks, power grids, time stamping for banking, legal, and shipping transactions, etc.) **Web link:** http://www.gps.gov/systems/gps/
Mission Objectives	GPS satellites provide service to civilian and military users. The civilian service is freely available to all users on a continuous, worldwide basis. The military service is available to US and allied armed forces, as well as approved Government agencies.
System Capabilities	The Global Positioning System (GPS) provides a «worst case» pseudorange accuracy of 7.8 meters at a 95% confidence level. The actual accuracy users attain depends on factors including atmospheric effects and receiver quality. Some high-quality GPS SPS receivers currently provide better than 3 meter horizontal accuracy. Higher accuracy is available by using augmentation systems, which enable real-time positioning to within a few centimeters, and post-mission measurements at the millimeter level. Improvements to GPS have been ongoing, and as new generations of GPS satellites replace old, the accuracy and reliability of the system have steadily improved. The GPS modernization program involves a series of consecutive satellite acquisitions, including: GPS IIR (M) – 2005-17, which added a second civilian GPS signal (L2C) for improved performance in commercial applications; GPS IIF – 2010-25, which included an operational version of the third civilian GPS signal (L5) for transportation safety; and GPS III – 2014-ongoing, which will add a fourth civilian GPS signal (L1C) for international interoperability. It also involves improvements to the GPS control segment, including the Architecture Evolution Plan (AEP) and the Advanced Control Segment (OCX).
Measured Parameters	Position and changes in position

Global Positioning System (GPS)	
Relevance to Arctic Interests	As one of several Global Navigation Satellite Systems (GNSS), GPS contributes to all policy priorities in the Arctic – environment, economic development, sovereignty and security and indigenous and social development. GPS provides the critical positioning, navigation and timing services that are essential for Arctic operations, including development of resources, movement of people and goods under extreme conditions, voice and data communications, and disaster response.

GLObal NAvigation Satellite System (GLONASS)	
Facts in Brief	**Country:** Russia **Operations:** Russian Aerospace Defence Forces **Status:** Operational since 1982, 31 satellites in orbit 24 operational, 3 spares, 1 each in commissioning and flight test, and 2 in maintenance **Mission Duration:** Continuous **Coverage:** Global coverage, with at least 5 satellites visible at any time from any place; each satellite circles the Earth twice daily **Orbit:** Medium earth orbit at 19,100 km altitude **Key Service Areas:** Positioning (surveying, location based services, etc.); navigation (air, marine, road and rail transportation, personal direction-finding, tracking and surveillance, etc.); and timing (synchronization of telecom and computer networks, power grids, time stamping for banking, legal, and shipping transactions, etc.) **Web link:** http://www.glonass-ianc.rsa.ru/en/index.php
Mission Objectives	GLONASS complements and provides an alternative to the United States' Global Positioning System (GPS) and serves the needs of military and civilian users in Russia and civilian users worldwide.
System Capabilities	According to data published by the Russian System of Differential Correction and Monitoring, as of 2010 the precisions of GLONASS navigation definitions for latitude and longitude at the 95% confidence level were 4.46-7.38 m, as compared to 2.00-8.76 m for GPS. At high latitudes, GLONASS' accuracy is better than that of GPS due to the orbital position of its satellites. Some modern receivers are able to use both GLONASS and GPS satellites together, and when using both navigation systems simultaneously, precisions of GLONASS/GPS navigation definitions were 2.37—4.65 m. In May 2009, the Russian Federal Space Agency advised that the expansion of GLONASS's constellation and improvements in the ground segment would increase the navigation definition of GLONASS to an accuracy of 2.8 m by 2011. In particular, the latest satellite design, GLONASS-K, which is a substantial improvement over the previous generation, has the ability to double the system's accuracy.
Measured Parameters	Position and changes in position
Relevance to Arctic Interests	As one of several GNSS, GLONASS contributes to all policy priorities in the Arctic – environment, economic development, sovereignty and security and indigenous and social development. GLONASS provides the critical positioning, navigation and timing services that are essential for Arctic operations, including development of resources, movement of people and goods under extreme conditions, voice and data communications, and disaster response.

Compass/BeiDou-2	
Facts in Brief	**Country:** China **Operations:** China National Space Administration **Status:** As of the end of 2011, nine satellites were operational; the constellation will consist of 35 satellites when fully operational (5 geostationary orbit satellites, 27 in medium earth orbit and three in inclined geostationary orbit) by 2020. **Mission Duration:** Design life of five years **Coverage:** Global coverage, with at least six satellites visible at any time from any place; each satellite circles the Earth in approximately 14 hours **Orbit:** Medium earth orbit at 23, 222 km altitude **Key Service Areas:** Positioning (surveying, location based services, etc.); navigation (air, marine, road and rail transportation, personal direction-finding, tracking and surveillance, etc.); and timing (synchronization of telecom and computer networks, power grids, time stamping for banking, legal, and shipping transactions, etc.) **Web link:** http://www.esa.int/esaNA/galileo.html
Mission Objectives	Compass/BeiDou-2 will bring China into the global satellite radionavigation market and will provide global access to the free service, providing a location-tracking accuracy of 10 m.
System Capabilities	Compass /Beidou-2 is being developed in three phases. Phase I was BeiDou Navigation Satellite Demonstration System, which was established in 2000 and has been offering limited services with three satellites. Phase II is BeiDou Navigation Satellite (regional) System to provide service for areas in China and its surrounding areas from 2012 with 10 satellites. Phase III is BeiDou Navigation Satellite System to be established completely and provide global service by 2020 with 35 satellites. Compass/BeiDou-2 will provide two levels of service: free service to civilians (available globally) and licensed service to Chinese government and military users. The free service will have a 10 meter location-tracking accuracy, will synchronize clocks with an accuracy of 10 ns, and measure speeds within 0.2 m/s. The licensed service will be more accurate than the free service, can be used for communication, and will supply information about the system status to the users.
Measured Parameters	Position and changes in position

Compass/BeiDou-2	
Relevance to Arctic Interests	As one of several GNSS, Compass/BeiDou-2 contributes to all policy priorities in the Arctic – environment, economic development, sovereignty and security and indigenous and social development. Compass/BeiDou-2 provides the critical positioning, navigation and timing services that are essential for Arctic operations, including development of resources, movement of people and goods under extreme conditions, voice and data communications, and disaster response.

C.3.2 Planned Navigation Satellite Systems

Galileo	
Facts in Brief	**Country:** 26 European member states **Operations:** Spaceopal, company created by DLR (DE) and Telespazio (IT) **Status:** 2 In-Orbit Validation (IOV) satellites were launched in October 2011, 2 more IOV satellites are scheduled for launch in 2012, 18 satellites will be in place by 2015 and the full constellation of 30 satellites will be in orbit by 2020 (27 operational and 3 reserve). **Mission Duration:** Design life of 5 years **Coverage:** Global coverage, with at least 6 satellites visible at any time from any place; each satellite circles the Earth in approximately 14 hours **Orbit:** Medium earth orbit at 23, 222 km altitude **Key Service Areas:** Positioning (surveying, location based services, etc.); navigation (air, marine, road and rail transportation, personal direction-finding, tracking and surveillance, etc.); and timing (synchronization of telecom and computer networks, power grids, time stamping for banking, legal, and shipping transactions, etc.) **Web link:** http://www.esa.int/esaNA/galileo.html
Mission Objectives	Galileo is the European programme for a global navigation satellite system, providing a highly accurate, guaranteed global positioning service under civilian control. Its modern and efficient infrastructure will enhance Europe's technological independence, and make it interoperable with GPS and GLONASS.
System Capabilities	Galileo is intended to provide horizontal and vertical positions measurements with metre-class precision. The use of basic (low-precision) Galileo services will be free and open to everyone. The high-precision capabilities will be available for paying commercial users and for military use. By placing satellites in orbits at a greater inclination to the equatorial plane than GPS, Galileo will achieve better coverage at high latitudes. This will make it particularly suitable for operation over northern Europe, an area not well covered by GPS and GLONASS. Galileo will also provide a global Search and Rescue (SAR) function. To do so, each satellite will be equipped with a transponder, which is able to transfer the distress signals from the user's transmitter to the Rescue Co-ordination Centre, which will then initiate the rescue operation. At the same time, the system will provide a signal to the user, informing them that their situation has been detected and that help is on the way.
Measured Parameters	Position and changes in position
Relevance to Arctic Interests	As one of several GNSS, Galileo will contribute to all policy priorities in the Arctic – environment, economic development, sovereignty and security and indigenous and social development. Galileo provides the critical positioning, navigation and timing services that are essential for Arctic operations, including development of resources, movement of people and goods under extreme conditions, voice and data communications, and disaster response.

C.4 Earth Observation Satellite Systems Inventory

The following pages contain templates of existing and planned earth observation satellite systems.

C.4.1 Existing Earth Observation Satellite Systems

Landsat 7	
Facts in Brief	**Country:** United States **Operations:** United States Geological Survey **Status:** Launched in April 1999 **Mission Duration:** Design life of minimum 5 years **Coverage:** Global coverage, covers the entire globe every 16 days (except for the highest polar latitudes), circles the Earth every 98.9 minutes. **Orbit:** Sun synchronous polar orbit at 700 km altitude **Key Service Areas:** Land use planning and monitoring, support of disaster response and evaluations, water use monitoring, and research on climate, carbon cycle, ecosystems, water cycle, biogeochemistry, and Earth surface/ interior. **Web link:** http://landsat.usgs.gov/about_landsat7.php
Mission Objectives	Using a mirror assembly similar to that of Landsat 5, Landsat 7 was designed to continue providing the global science community with a wealth of land-surface data.

Landsat 7	
System Capabilities	Use of Spectral Bands: 1 Blue-green – Used for bathymetric mapping; distinguishes soil from vegetation and deciduous from coniferous vegetation 2 Green – Emphasizes peak vegetation, which is useful for assessing plant vigor 3 Red – Emphasizes vegetation slopes 4 Reflected IR – Emphasizes biomass content and shorelines 5 Reflected IR – Discriminates moisture content of soil and vegetation; penetrates thin clouds 6 Thermal IR – Useful for thermal mapping and estimated soil moisture 7 Reflected IR – Useful for mapping hydrothermally altered rocks associated with mineral deposits 8 Panchromatic – Landsat 7 carries a panchromatic band (visible through near infrared) with 15-meter resolution for "sharpening" of multispectral images
Measured Parameters	Multispectral images
Relevance to Arctic Interests	Landsat 7 contributes to economic development, environment, and sovereignty and security policy priorities in the Arctic, providing beneficial data for monitoring of changes in land and water use, mineral exploration and disaster response.

SPOT 5	
Facts in Brief	**Country:** France **Operations:** National Centre for Space Studies (CNES) **Status:** Launched in 2002 (SPOT 6 and 7 to be launched in 2012 and 2014, respectively) **Mission Duration:** SPOT 5 designed for 5 year life, but currently planned to end in 2014 **Coverage:** Global coverage, 26 day cycle, with repeat coverage of 5 days (northern areas) down to 2 days (equatorial areas) **Orbit:** Sun synchronous, near polar and almost circular orbit at 822 km altitude **Key Service Areas:** Natural disaster management, geology, oil and mineral exploration, water resource management, iceberg detection, oil spill tracking, military operations and crisis response. **Web link:** http://spot5.cnes.fr/gb/programme/programme.htm
Mission Objectives	SPOT 5 was designed with the dual objective of continuity of service and ever-improving image quality. While retaining the main characteristics that have earned SPOT a worldwide reputation for its acquisition capability, with the same orbit, spectral bands and imaging swath of 60 kilometres either side of the ground track, the SPOT 5 satellite offers improved ground resolutions of 10 metres in multispectral mode and 2.5 to 5 metres in panchromatic and infrared mode.
System Capabilities	SPOT Earth observation satellites were designed to improve the knowledge and management of the Earth by exploring the Earth's resources, detecting and forecasting phenomena involving climatology and oceanography, and monitoring human activities and natural phenomena. The SPOT 5 system includes a series of satellites and ground control resources for satellite control and programming, image production, and distribution. Covering a wide area (60 km x 60 km) SPOT imagery comes in a full range of resolutions from 20 m down to 2.5 m. Higher 2.5-metre resolution is achieved using an innovative sampling concept called Supermode. SPOT 5 also features a new HRS imaging (High Resolution Stereoscopic) instrument operating in panchromatic mode and able to point forward and aft of the satellite. In a single pass, the forward-pointing camera acquires images of the ground, and then the rearward-pointing camera covers the same strip 90 seconds later. HRS is thus able to acquire stereo pair images almost simultaneously to map relief, produce digital elevation models (DEMs) of wide areas and generate high quality orthorectified image products.
Measured Parameters	Panchromatic and multispectral images (simultaneously)
Relevance to Arctic Interests	SPOT 5 contributes to environmental, sovereignty and security and economic development policy priorities in the Arctic. The availability of high resolution imagery at relatively short repeat coverage provides beneficial data for environmental monitoring on land and ocean, exploration for valuable mineral and oil resources in the region and support of any necessary emergency response or sovereignty protection needs.

Pleiades HR-1 and HR-2	
Facts in Brief	**Country:** France **Operations:** National Centre for Space Studies (CNES) **Status:** HR-1 launched in 2011, HR-2 to be launched in 2013. **Mission Duration:** 5 years **Coverage:** Global coverage, 26 day cycle, with repeat coverage of 2 days (one satellite) and 1 day (two satellites) **Orbit:** Sun-synchronous, phased and almost circular orbit at 694 km altitude **Key Service Areas:** Defence (operations and crisis response); emergency management; cartography; geological risk assessment (volcanoes, slides, etc.); hydrological risk assessment (floods); forestry yield estimation; and coastal zone monitoring. **Web link:** http://smsc.cnes.fr/PLEIADES/
Mission Objectives	As part of ORFEO, Pleiades is a Dual Use System devoted to providing high resolution optical products/services for both civilian and military applications, while respecting the strong requirements of each one. The system must ensure: the protection of defence interests in terms of security and priority of mission requests; and that civilian users' needs are satisfied in terms of general operational capacity, quick access to data, image availability and quality and the competitiveness of the services supplied.

Pleiades HR-1 and HR-2	
System Capabilities	Pleiades is the optical component of the ORFEO system developed in cooperation with Italy. Pleiades offers stereoscopic coverage capability at high resolution with a single pass. A resolution of 0.7 m in vertical viewing is possible in panchromatic mode, with a resolution of 2.8 m in vertical viewing in multispectral mode (blue, green, red and near infrared). The system also offers the possibility to artificially increase the instantaneous field of view, depending on the de-pointing angle authorized by the user. The system currently enables to program two work plans per day, and three work plans per day to decrease the delays over the American continent is being investigated.
Measured Parameters	Panchromatic and multispectral images (simultaneously)
Relevance to Arctic Interests	Pleiades satellites provide data to address several priority needs in the Arctic. The data can be used, for example, to support military and emergency response operations, for coastal erosion monitoring, and flood forecasting. These satellites can contribute data primarily for environmental monitoring, and security and sovereignty in the Arctic.

Radarsat 1 and 2	
Facts in Brief	**Country:** Canada **Operations:** RS-1: Canadian Space Agency; RS-2: MacDonald, Dettwiler and Associates **Status:** In operation, single satellites; RS-1 launched in 1995; RS-2 launched in 2007. **Mission Duration:** RS-1 was originally designed for a life of five years, and RS-2 for a life of seven years. **Coverage:** Global coverage **Orbit:** Sun-synchronous polar orbit of about 800-km altitude, with a repeat cycle of 24 days, providing complete coverage of the globe within six days and daily coverage north of 70° N. **Key Service Areas:** sea and river ice monitoring, ship detection, oil spill monitoring, and wind and surface-wave field estimation, disaster responses (e.g., earthquakes, tsunamis, floods, landslides, forest fires), hydrology, clear-cut mapping, and crop monitoring. **Web link:** http://www.asc-csa.gc.ca/eng/satellites/radarsat1/default.asp and http://www.asc-csa.gc.ca/eng/satellites/radarsat2/default.asp
Mission Objectives	Earth observation is a key priority of the Canadian Space Program, and RADARSAT-1 was developed as Canada›s flagship to pursue this priority. A key priority of the Canadian Space Program is responding to the twin challenges of monitoring the environment and managing natural resources. The hardy, versatile RADARSAT Earth Observation satellites are a major data source for commercial applications and remote sensing science. The RS-2 primary mission objective is the supply and distribution of data and products to meet the needs of present and future markets using a commercially viable approach. This is achieved by leveraging the knowledge and experience gained through the long and successful RADARSAT-1 mission while taking advantage of new technologies.
System Capabilities	Along with additional beam modes, RADARSAT-2 is designed with RADARSAT-1 compatible beam modes and follows the same orbit, repeat cycle, and ground track as RADARSAT-1. Other key features of RADARSAT-2 include the ability to select all beam modes in both left- and right-looking modes allowing more frequent revisits of targets, high downlink power resulting in a lower cost of entry for new ground stations, secure data and telemetry transfers, solid-state recorders, on-board GPS receiver for real-time position knowledge, and the use of a high-precision attitude control system. The system can operate in three beam modes: Selective Polarization (transmit H or V / receive H and/or V); Polarimetric (transmit H and V on alternate pulses / receive H and V on any pulse); and Selective Single Polarization (transmit H or V / receive H or V).
Measured Parameters	Synthetic aperture radar (SAR) images (C-band)
Relevance to Arctic Interests	The Radarsat program provides data to address priority needs in the Arctic. Designed for 24 hour all weather operation, Radarsat is ideally suited to monitoring of the region. Since they are particularly effective at monitoring ice, snow and soil moisture, these satellites can contribute vital data for environmental monitoring and economic development in the Arctic, including resource development, fisheries and northern shipping.

COSMO-SkyMed	
Facts in Brief	**Country:** Italy **Operations:** Italian Space Agency **Status:** Four-satellite mission in operation; two satellites launched in 2007, one in 2008 and one in 2010. **Mission Duration:** Unknown **Coverage:** Global coverage **Orbit:** Sun-synchronous orbit of about 620 km altitude, providing coverage of equatorial regions every 11 days and polar regions every 3-4 days. **Key Service Areas:** Risk management, cartography, agriculture, forest, hydrology, geology, marine, and archaeology **Web link:** http://www.cosmo-skymed.it/en/index.htm
Mission Objectives	As part of ORFEO, COSMO-SkyMed is a Space-based Earth Observation Dual Use System devoted to providing products/services for environmental monitoring and surveillance applications for the management of exogenous, endogenous and anthropogenic risks, and provision of commercial products and services.
System Capabilities	COSMO-SkyMed is the radar component of the ORFEO system developed in cooperation with France. The system consists of a constellation of four mid-sized satellites, each equipped with a multi-mode high-resolution Synthetic Aperture Radar (SAR) operating at X-band. COSMO-SkyMed has a dual nature (i.e., capable of satisfying civilian and defence customers), and is able to provide information and services to a number of activities and applications. The SAR operates in: Spotlight mode, for 1 m resolutions over small images; two Stripmap modes, for 3-15 m resolutions over tenth of km images (one mode is polarimetric with images acquired in two polarizations); and two ScanSAR modes, for medium to coarse (330-100 m) resolution over large swaths.

Measured Parameters	Synthetic aperture radar (SAR) images (X-band)
Relevance to Arctic Interests	COSMO-SkyMed satellites provide data to address a few priority needs in the Arctic. The data can be used, for example, for land cover differentiation, coastal erosion, and pollution monitoring and flood forecasting. These satellites can contribute data primarily for environmental monitoring and security and sovereignty in the Arctic.

Cryosat-2	
Facts in Brief	**Country:** 26 European member states **Operations:** European Space Operations Centre **Status:** Satellite launched in 2010 **Mission Duration:** Design life of 3 years; upgraded to 5 years **Coverage:** Primarily focusing on the north and south polar regions **Orbit:** Low earth orbit at 720 km altitude **Key Service Areas:** **Web link:** http://www.esa.int/esaLP/SEMBRS4KXMF_LPgmes_0.html
Mission Objectives	CryoSat-2's mission is to study the Earth's polar ice caps, and is dedicated to precise monitoring of the changes in the thickness of marine ice floating in the polar oceans and variations in the thickness of the vast ice sheets that overlie Greenland and Antarctica. CryoSat-2 will primarily: determine regional trends in Arctic perennial sea-ice thickness and mass; and determine the contribution that the Antarctic and Greenland ice sheets are making to mean global rise in sea level.
System Capabilities	CryoSat-2 provides scientists with data about the polar ice caps and tracks changes in the thickness of the ice with a resolution of about 1.3 cm. The satellite carries an interferometric radar range-finder with twin antennas, the SAR/Interferometric Radar Altimeter (SIRAL-2), which uses radar to determine and monitor the spacecraft's altitude in order to measure the elevation of the ice and the height difference between floating ice and open water. SIRAL operates in three modes. Over the oceans and ice sheet interiors, CryoSat operates like a traditional radar altimeter. Over sea ice, coherently transmitted echoes are combined to reduce the surface footprint so that CryoSat can map smaller ice floes. Around ice sheet margins and over mountain glaciers, the altimeter performs synthetic aperture processing and uses a second antenna as an interferometer to determine the across-track angle to the earliest radar return. This provides the exact surface location being measured when the surface is sloping.
Measured Parameters	Sea ice thickness and mass
Relevance to Arctic Interests	This mission will contribute directly to the environment policy priority in the Arctic region, but will also have impacts on the other three priorities. The information provided about the thickness of polar ice, both on land and on the sea, will be key to better predictions of future sea-level rise. Higher sea levels will impact the indigenous people`s way of life and will have implications for northern shipping, a key component of economic development in the north.

Oceansat-2 and -1	
Facts in Brief	**Country:** India **Operations:** Indian Space Research Organization **Status:** Operational, launched in 2009 **Mission Duration:** Design life of 5 years **Coverage:** Global coverage, with a revisit time of 2 days **Orbit:** Sun synchronous orbit at 720 km altitude **Key Service Areas:** Advisories of potential fishing zones, coastal water pollution and sedimentation monitoring, oil slick tracking, weather forecasting, ocean state forecasting, changes in polar sea ice. **Web link:** http://www.isro.org/satellites/oceansat-2.aspx
Mission Objectives	The mission objectives of Oceansat-2 are to gather systematic data for oceanographic, coastal and atmospheric applications. The main objectives of OceanSat-2 are: study of surface winds and ocean surface strata; observation of chlorophyll concentrations; monitoring of phytoplankton blooms; and study of atmospheric aerosols and suspended sediments in the water.
System Capabilities	Oceansat-2 payloads include: Ocean Colour Monitor (OCM), Ku-band Pencil Beam scatterometer (SCAT) developed by ISRO, and Radio Occultation Sounder for Atmosphere (ROSA) developed by the Italian Space Agency. OCM is an 8-band multi-spectral camera operating in the Visible – Near IR spectral range, which provides an instantaneous geometric field of view of 360 meter and a swath of 1,420 km. SCAT is an active microwave device used to determine ocean surface level wind vectors through estimation of radar backscatter. Two pencil beams are generated, which cover a continuous swath of 1,400 km for the inner beam and 1,840 km for the outer beam, respectively. The inner and outer beams are configured in horizontal and vertical polarization respectively for both transmit and receive modes. The aim is to provide global ocean coverage and wind vector retrieval with a revisit time of 2 days. ROSA is a GPS occultation receiver the objective of which is to characterize the lower atmosphere and the ionosphere. Oceansat-1, launched in 1999 into a similar orbit, is still providing data at the same resolution as Oceansat-2.
Measured Parameters	Multispectral and panchromatic images (simultaneously)
Relevance to Arctic Interests	Oceansat-2 (and Oceansat-1) can contribute to environmental, sovereignty and security, and economic development policy priorities in the Arctic, providing beneficial data for environmental monitoring, fisheries development and northern shipping in the region.

GeoEye-1	
Facts in Brief	**Country:** United States **Operations:** GeoEye **Status:** Operational, launched in 2008 **Mission Duration:** Design life of 7 years **Coverage:** Global coverage, with a revisit time of 3 days or less **Orbit:** Sun synchronous orbit at 681 km altitude **Key Service Areas:** Geology, oil and mineral exploration, forest resource management, water resource management, environmental monitoring, air and marine transportation, defense and intelligence. **Web link:** http://launch.geoeye.com/LaunchSite/about/
Mission Objectives	GeoEye-1 is intended to meet the needs of organizations demanding the highest image resolution available commercially. It also addresses the need for exceptional geolocation accuracy, and customers can map natural and man-made features to better than 5 meters of their actual location on the surface of the Earth without ground control points.
System Capabilities	GeoEye-1 has the highest resolution of any commercial imaging system and can provide data with a ground resolution of 0.5 m in the panchromatic or black and white mode and 1.65 m in the multispectral or color mode. GeoEye-1's camera is able to rotate or swivel forward, backward or side-to-side with high precision, enabling it to collect much more imagery during a single pass. The camera allows for side-to-side extensions of the camera's 15.2 kilometer (9.44 miles)-wide swath width or multiple images of the same target during a single pass to create a stereo image. GeoEye also operates the Ikonos satellite launched in 1999 at the same altitude as GeoEye-1, with a revisit rate of 3-5 days off-nadir and 144 days for true-nadir. Ikonos was the first to collect publicly available high-resolution imagery at 1 m (panchromatic) and 4 m (multispectral) resolution. GeoEye-1 complements Ikonos and collects imagery about 40 percent faster for panchromatic and 25 percent faster for multispectral collections.
Measured Parameters	Panchromatic and multispectral images (simultaneously)
Relevance to Arctic Interests	GeoEye-1 (and Ikonos) contributes to environmental, sovereignty and security and economic development policy priorities in the Arctic. The availability of high resolution imagery at relatively short repeat cycles provides beneficial data for environmental monitoring on land and ocean, exploration for valuable mineral and oil resources in the region and support of any necessary emergency response or sovereignty protection needs.

QuickBird	
Facts in Brief	**Country:** United States **Operations:** DigitalGlobe. Inc. **Status:** Launched in 2001 **Mission Duration:** Currently planned to end in 2014 **Coverage:** Global coverage, with repeat coverage of 2.5-5.6 days **Orbit:** Sun synchronous orbit at 450 km altitude **Key Service Areas:** Natural disaster management, humanitarian relief, geology, oil and mineral exploration, forest resource management, water resource management, defense and intelligence. **Web link:** http://www.digitalglobe.com/about-us/content-collection#satellites&quickbird
Mission Objectives	QuickBird contributes to identifying the world's natural resources, monitoring pipelines and facilities, understanding the earth's environmental condition, protecting homelands and borders, responding to emergencies and natural disasters, and then rebuilding, and planning investments in multi-million dollar infrastructure developments.
System Capabilities	DigitalGlobe's QuickBird satellite offers sub-meter resolution imagery, high geolocational accuracy, and large 128 gigabits of on-board data storage. At nadir the panchromatic imagery has a resolution of 0.65 m and the multispectral imagery (blue, green, red and infrared) has a resolution of 2.6 m. QuickBird's nominal swath width is 18 km at nadir, with an accessible ground swath of 564 km centered on the satellite ground track. A single area of interest is 18.0 km x 18.0 km, with a strip capability of 18.0 km x 360 km. Two types of imagery products are available: basic imagery (corrections for radiometric distortions and adjustments for internal sensor geometry, optical, and sensor distortions); and standard imagery (higher precision products in two forms – Basic Standard and Ortho Ready Standard). DigitalGlobe also operates WorldView-1 (high-capacity, panchromatic imaging satellite launched in 2007 and operating at an altitude of 496 kilometers with an average revisit time of 1.7 days, which features 0.5 m resolution imagery and collects in-track stereo imagery), and WorldView-2 (high-resolution 8-band multispectral satellite launched in 2009 and operating at an altitude of 770 kilometers with an average revisit time of 1.1 days, which provides 46 cm panchromatic resolution and 1.85 meter multispectral resolution imagery).
Measured Parameters	Panchromatic and multispectral images (simultaneously)
Relevance to Arctic Interests	QuickBird (and WorldView -1 and -2) contributes to environmental, sovereignty and security and economic development policy priorities in the Arctic. The availability of high resolution imagery at relatively short repeat cycles provides beneficial data for environmental monitoring on land and ocean, exploration for valuable mineral and oil resources in the region and support of any necessary emergency response or sovereignty protection needs.

C.4.2 Planned Earth Observation Satellite Systems

Sentinel 1	
Facts in Brief	**Country:** 26 European member states **Operations:** European Space Agency **Status:** Mission development began in 2005, with a two satellite configuration; 1A launch planned for 2013 and 1B for 2015 **Mission Duration:** Design life of 7 years (each satellite) **Coverage:** Global coverage, with a revisit time of 12 days **Orbit:** Sun synchronous polar orbit at 693 km altitude **Key Service Areas:** Monitoring Arctic sea-ice extent; routine sea-ice mapping; surveillance of the marine environment, including oil-spill monitoring and ship detection for maritime security; monitoring land-surface for motion risks; mapping for forest, water and soil management; and mapping to support humanitarian aid and crisis situations. **Web link:** http://www.esa.int/esaLP/SEMBRS4KXMF_LPgmes_0.html
Mission Objectives	Sentinel 1 will provide continuity of data from ERS and Envisat missions, with further enhancements in terms of revisit, coverage, timeliness and reliability of service.
System Capabilities	The Sentinel 1 Synthetic Aperture Radar sensor will have four nominal operational modes designed for interoperability with other systems: Interferometric Wide-Swath Mode with 250 km swath, 5x20 m (range x azimuth) spatial resolution and burst synchronisation for interferometry; Wave Mode with 5x5 m (range x azimuth) spatial resolution leap-frog sampled images of 20x20 km at 100 km along the orbit, with alternating 23 deg and 36.5 deg incidence angles; Extra-Wide-Swath Mode with 400 km swath and 20x40 m (range x azimuth) spatial resolution; and Strip Map Mode with 80 km swath and 5x5 m (range x azimuth) spatial resolution. The first two modes will satisfy most of the envisaged service requirements. The two other modes are provided for continuity with other SAR missions and to accommodate emerging user requirements. The Sentinel-1 pair is expected to provide coverage over Europe, Canada and main shipping routes in 1–3 days, regardless of weather conditions, with data being delivered within an hour of acquisition.
Measured Parameters	C-band radar images
Relevance to Arctic Interests	The Sentinel 1 will contribute to environmental, economic development, and sovereignty and security policy priorities in the Arctic, providing beneficial data for environmental monitoring, disaster response, resource development and northern shipping in the region.

Sentinel 2	
Facts in Brief	**Country:** 26 European member states **Operations:** European Space Agency **Status:** Mission development began in 2005, with a two satellite configuration; launch planned for 2013 **Mission Duration:** Design life of 7 years **Coverage:** Global coverage, with a revisit time of 5 days with 2 satellites flying concurrently (2 to 3 days in extended mode) **Orbit:** Sun synchronous polar orbit at 800 km altitude; twin satellites on the same orbit, 180° apart from each other **Key Service Areas:** Land cover, usage and change-detection mapping; geophysical variable mapping (leaf chlorophyll content, leaf water content, leaf area index, etc.); risk mapping; and fast imaging for disaster relief. **Web link:** http://www.esa.int/esaLP/SEMBRS4KXMF_LPgmes_0.html
Mission Objectives	The Sentinel 2 wide-swath high-resolution twin satellites, super-spectral imaging mission is designed for data continuity and enhancement of Landsat and SPOT-type missions, and for GMES operational land and security services.
System Capabilities	Sentinel 2 will carry an optical payload with visible, near infrared and shortwave infrared sensors comprising 13 spectral bands: 4 bands at 10 m, 6 bands at 20 m and 3 bands at 60 m spatial resolution (the latter is dedicated to atmospheric corrections and cloud screening), with a swath width of 290 km. The 13 spectral bands guarantee consistent time series, showing variability in land surface conditions and minimising any artefacts introduced by atmospheric variability. The increased swath width along with the short revisit time allows rapid changes to be monitored, such as vegetation during the growing season.
Measured Parameters	Multispectral images
Relevance to Arctic Interests	The Sentinel 2 will contribute to economic development, and sovereignty and security policy priorities in the Arctic, providing beneficial data for monitoring of changes in land cover, and disaster response.

Sentinel 3	
Facts in Brief	**Country:** 26 European member states **Operations:** European Space Agency **Status:** Mission development began in 2007, with a two satellite configuration; launch planned for 2013 **Mission Duration:** Design life of 7 years **Coverage:** Global coverage, with a revisit time of less than two days for OLCI, less than one day for SLSTR at the equator, and a 27-day repeat for the topography package, with a 4-day sub-cycle. **Orbit:** Sun synchronous polar orbit at 800 km altitude **Key Service Areas:** Ocean forecasting, sea-ice charting, and maritime safety services; measurements of the state of the ocean surface, including surface temperature, ocean ecosystems, water quality and pollution monitoring; and land services to monitor land-use change, forest cover, photosynthetic activity, soil quality and fire detection. **Web link:** http://www.esa.int/esaLP/SEMBRS4KXMF_LPgmes_0.html
Mission Objectives	The main mission objective is to measure sea-surface topography, sea- and land-surface temperature and ocean- and land-surface colour with high-end accuracy and reliability in support of ocean forecasting systems, and for environmental and climate monitoring.
System Capabilities	The Sentinel 3 global land and ocean monitoring mission provides 2 day global coverage Earth observation data (with 2 satellites) for sea and land applications with real-time products delivery in less than 3 hours. Its innovative instrument package includes: a Sea and Land Surface Temperature Radiometer (SLSTR), with 9 bands and a resolution of 500 m to determine global sea-surface temperatures to an accuracy of better than 0.3 K; an Ocean and Land Colour Instrument (OLCI), with 21 bands and a resolution of 300 m over all surfaces and a swath overlap with SLSTR; and a dual-frequency (Ku and C band) advanced Synthetic Aperture Radar Altimeter (SRAL), which provides measurements at a resolution of ~300 m in SAR mode along track. SRAL is supported by a microwave radiometer for atmospheric correction and a DORIS receiver for orbit positioning. The combined topography package will provide exact measurements of sea-surface height, which are essential for ocean forecasting systems and climate monitoring, and accurate topography measurements over sea ice, ice sheets, rivers and lakes.
Measured Parameters	Multispectral and radar images
Relevance to Arctic Interests	The Sentinel 3 will contribute to environment, economic development, and sovereignty and security policy priorities in the Arctic, providing beneficial data for monitoring of changes in land cover, pollution monitoring, northern shipping, and disaster response.

RADARSAT Constellation Mission	
Facts in Brief	**Country:** Canada **Operations:** Canadian Space Agency **Status:** Mission development began in 2005, with satellite launches planned for 2014 and 2015 **Mission Duration:** Design life of 7 years (each satellite) **Coverage:** Global coverage, with a revisit time of 1-4 days **Orbit:** Low earth orbit at 600 km altitude **Key Service Areas:** Maritime surveillance (ice, wind, oil pollution and ship monitoring); disaster management (mitigation, warning, response and recovery); and ecosystem monitoring (forestry, agriculture, wetlands and coastal change monitoring). **Web link:** http://www.asc-csa.gc.ca/eng/satellites/radarsat/default.asp
Mission Objectives	The RADARSAT Constellation is the evolution of the RADARSAT Program with the objective of ensuring C-band data continuity, enhanced operational use of Synthetic Aperture Radar (SAR) data and improved system reliability over the next decade. Instead of launching a single satellite, the capabilities of the system will be distributed across several satellites, increasing revisit, and introducing a more robust, flexible system that can be maintained at lower cost and launched into orbit using smaller, less expensive launch vehicles.
System Capabilities	The three-satellite configuration (designed to be scalable up to six satellites) will provide complete coverage of Canada's land and oceans offering an average daily revisit, as well as daily access to 95% of the world to Canadian and International users. While the mission design initially focused on maritime security requirements, land security, particularly in the Arctic, will be dramatically enhanced. The system offers up to four passes per day in Canada's far north and several passes per day over the Northwest Passage. The increase in revisit frequency introduces a range of applications that are based on regular collection of data and creation of composite images that highlight changes over time. Such applications are particularly useful for monitoring changes such as those induced by climate change, land use evolution, coastal change, urban subsidence and even human impacts on local environments. The system will offer a variety of resolution modes, ranging from 3 m with a 20 km swath to 100 m with a 500 km swath. There is also a secondary payload allocation for a potential Automated Identification System for ships (AIS) which is not planned as part of the baseline mission but is being considered by Department of National Defence. A feasibility study of a design of an Integrated AIS Sensor that could eventually be built and placed on the RCM satellites is scheduled to be completed by March 31, 2012.
Measured Parameters	C-band radar images
Relevance to Arctic Interests	The RADARSAT Constellation will contribute to environmental, economic development, and sovereignty and security policy priorities in the Arctic, providing beneficial data for environmental monitoring, resource development and northern shipping in the region. If the AIS capability is added to the mission, the satellite could also contribute to search and rescue operations, monitoring of environmental catastrophes and follow-up investigations, and help protect the sovereignty of Canadian waters in the region.

Landsat Data Continuity Mission (LDCM)	
Facts in Brief	**Country:** United States **Operations:** United States Geological Survey **Status:** Mission development began in 2002; launch planned for 2013 **Mission Duration:** Design life of 5 years **Coverage:** Global coverage, with a revisit time of less than two days for OLCI, less than one day for SLSTR at the equator, and a 27-day repeat for the topography package, with a 4-day sub-cycle. **Orbit:** Sun synchronous polar orbit at 700 km altitude **Key Service Areas:** Land use planning and monitoring, support of disaster response and evaluations, water use monitoring, and research on climate, carbon cycle, ecosystems, water cycle, biogeochemistry, and Earth surface/interior. **Web link:** http://ldcm.gsfc.nasa.gov/index.html
Mission Objectives	LDCM will provide continuity with the 38-year long Landsat land imaging data set, the longest continuous record of changes in Earth's surface as seen from space and the only satellite system designed and operated to repeatedly observe the global land surface at moderate resolution.
System Capabilities	The Landsat Data Continuity Mission (LDCM), a collaboration between NASA and the U.S. Geological Survey, will provide moderate-resolution (15 m–100 m, depending on spectral frequency) measurements of the Earth's terrestrial and polar regions in the visible, near-infrared, short wave infrared, and thermal infrared bands. The LDCM satellite payload consists of two science instruments—the Operational Land Imager (OLI) and the Thermal InfraRed Sensor (TIRS). These two sensors will provide seasonal coverage of the global landmass at a spatial resolution of 30 meters (visible, NIR, SWIR); 100 meters (thermal); and 15 meters (panchromatic). The spectral coverage and radiometric performance (accuracy, dynamic range, and precision) are designed to detect and characterize multi-decadal land cover change in concert with historic Landsat data. The LDCM scene size will be 185 km cross-track by 180 km along-track.
Measured Parameters	Multispectral images
Relevance to Arctic Interests	LDCM will contribute to environment and sovereignty and security policy priorities in the Arctic, providing beneficial data for monitoring of changes in land and water use, and disaster response.

C.5 Surveillance Satellite Systems Inventory

The following pages contain templates of existing and planned surveillance satellite systems.

C.5.1 Existing Surveillance Satellite Systems

Cospas-Sarsat	
Facts in Brief	**Country:** Canada/United States/France/Russia **Operations:** The Cospas-Sarsat Secretariat Head Office is located in Montreal, Canada. Twenty-six countries and 2 organizations provide ground stations for the system. **Status:** Search and Rescue Signal Repeater (SARR) instruments are onboard 5 geosynchronous satellites called GEOSARs, and SARR and Search and Rescue Signal Processor (SARP) instruments are onboard 6 low-earth polar orbit satellites called LEOSARs. **Mission Duration:** Continuous **Coverage:** Global coverage **Orbit:** Low Earth orbit / geostationary Earth orbit **Key Service Areas:** Distress alert detection and location; collection, sorting and storage of distress alert data; distribution of alert and location data **Web link:** http://www.cospas-sarsat.org
Mission Objectives	The International Cospas-Sarsat Programme provides accurate, timely, and reliable distress alert and location data to help search and rescue authorities assist persons in distress.
System Capabilities	The Cospas-Sarsat System includes two types of satellites: satellites in low-altitude Earth orbit (LEO) which form the LEOSAR System (provides Beacon identification information and location information globally, but not instantaneously); and satellites in geostationary Earth orbit (GEO) which form the GEOSAR System (provides Beacon identification and location information available if encoded in beacon message, with near instantaneous alerting in the GEOSAR coverage area, which includes most of the arctic region). The System is composed of: instruments on board satellites, which detect the signals transmitted by distress radiobeacons; ground receiving stations, referred to as Local Users Terminals (LUTs), which receive and process the satellite downlink signal to generate distress alerts; and Mission Control Centers (MCCs) which receive alerts produced by LUTs and forward them to Rescue Coordination Centers (RCCs), Search and Rescue Points Of Contacts (SPOCs) or other MCCs.
Measured Parameters	Distress signals emitted by: EPIRBs (emergency position-indicating radio beacons), which signal maritime distress; ELTs (emergency locator transmitters), which signal aircraft distress; and PLBs (personal locator beacons), which indicate a person in distress who is away from normal emergency services (e.g., 9-1-1).
Relevance to Arctic Interests	Cospas-Sarsat contributes to the sovereignty and security and indigenous and social development policy priorities in the Arctic. The system provides crucial data and services for search and rescue operations, to facilitate the saving of lives if emergency response can be expedited, or recovery of assets to aid in accident investigations in the worst case.

exactView	
Facts in Brief	**Country:** Canada **Operations:** exactEarth Ltd. **Status:** Five satellites equipped with technology to collect satellite-received Automatic Identification System (S-AIS) signals are operational; exactEarth will have access to M3MSat data from Defence Research and Development Canada (DRDC), when available **Mission Duration:** Continuous **Coverage:** Global **Orbit:** Circular sun-synchronous low earth orbit at an altitude of 650 km **Key Service Areas:** Vessel monitoring, Maritime domain awareness, Surveillance and security, Data fusion with other sensors for environmental monitoring, Search and rescue, and Incident investigation. **Web link:** http://www.exactearth.com
Mission Objectives	The satellites' objective is to collect AIS transmissions from all the ships that are within their field of view of approximately 5,000 km in diameter.
System Capabilities	exactEarth's initial service, exactAIS, is a global vessel tracking and maritime domain monitoring system based on S-AIS. The exactEarth constellation of microsatellites orbits the Earth in a north-south direction, continually passing over different areas as the planet rotates, and the satellites complete one orbit in 90 to 100 minutes. exactEarth uses a patented ground and space-based processing technology to minimize interference of collided AIS signals, therefore dramatically improving detection compared with all other satellite-based systems. As more satellites are launched, refresh rates will continue to increase, with the objective of achieving and then maintaining a global revisit time of less than 90 minutes. By policy, exactEarth normally limits AIS data sales to legitimate government agencies that are concerned with maritime affairs and national security agencies (161 countries). Commercial sales to information service providers are possible provided the buyer agrees to aggregate or filter the data in such a manner that it will not include the unique exactEarth-reported AIS positions for any vessel.
Measured Parameters	AIS signals from vessels
Relevance to Arctic Interests	The exactView satellites will contribute to the environment and sovereignty and security policy priorities in the Arctic. The exactAIS system provides crucial data and services for search and rescue operations, monitoring of environmental catastrophes and follow-up investigations, and to help protect the sovereignty of Canadian waters in the region.

ORBCOMM Satellite AIS	
Facts in Brief	**Country:** United States **Operations:** ORBCOMM Inc. **Status:** Six satellites equipped with equipment to collect Automatic Identification System (AIS) signals were launched in 2008 (3 remain operational); two dedicated AIS microsatellites, one in an equatorial orbit (VesselSat1) and the other in a polar orbit (VesselSat2), were launched in October 2011 and January 2012, respectively; 18 additional AIS-equipped next generation satellites will be launched beginning in the middle of 2012. **Mission Duration:** Continuous **Coverage:** Global **Orbit:** Low earth orbit **Key Service Areas:** Maritime domain awareness, Surveillance and security, Data fusion with other sensors, Search and rescue, Logistical tracking and reporting, Energy and commodity management, Incident investigation, Counter-piracy applications, Environmental monitoring, and Area of operation compliance. **Web link:** http://www.ORBCOMM.com/services-ais.htm
Mission Objectives	To have commercially operational low-Earth-orbit (LEO) satellites providing AIS data from space that overcome the limitations of terrestrial-based AIS systems, which provide only limited shore-based coverage and are not able to provide global, open ocean coverage.
System Capabilities	The ORBCOMM network uses low-Earth-orbit (LEO) satellites to provide monitoring and messaging capabilities to and from anywhere in the world using two-way alphanumeric packets of data. The ground segment consists of 15 gateways strategically located around the world, which provide access to the satellite constellation and interface with public and private data networks including the Internet. ORBCOMM's Satellite AIS service detects AIS signals emitted by vessels. ORBCOMM provides access to their global, regional and filtered satellite AIS data through annual subscription service agreements and user applications.
Measured Parameters	AIS signals from vessels
Relevance to Arctic Interests	The ORBCOMM Satellite AIS service will contribute to the environment and sovereignty and security policy priorities in the Arctic. The system provides crucial data and services for search and rescue operations, monitoring of environmental catastrophes and follow-up investigations, and to help protect the sovereignty of Canadian waters in the region.

AIS Sat-1 and -2	
Facts in Brief	**Country:** Norway **Operations:** Norwegian Defense Research Establishment (FFI) **Status:** AISSat-1 was launched on July 12. 2010. AISSat-2, to provide increased coverage and act as a backup to AISSat-1, should be ready for launch in early 2012. **Mission Duration:** Continuous **Coverage:** Global **Orbit:** Low earth orbit **Key Service Areas:** Maritime domain awareness, Surveillance and security, Data fusion with other sensors, Search and rescue, Logistical tracking and reporting, Energy and commodity management, Incident investigation, Counter-piracy applications, Environmental monitoring, and Area of operation compliance. **Web link:** http://www.nordicspace.net/PDF/NSA239.pdf
Mission Objectives	The primary mission is to investigate the feasibility and performance of a spacecraft-based Automatic Identification System (AIS) sensor in low-Earth orbit as a means of tracking maritime assets, and the integration of space-based AIS data into a national maritime tracking information system.
System Capabilities	AISSat-1 is intended as both a research and development platform, and a demonstration mission for a larger operational capability. AISSat-1 concentrates operations on the Northern areas. The satellite transmits data 10 minutes every orbit and orbits are 90 minutes apart. The ground station located in Svalbard acquires data from AISSat-1 during all 15 daily passes over Norwegian ocean areas.
Measured Parameters	AIS signals from vessels
Relevance to Arctic Interests	AIS Sat-1 and -2 contribute to the environment and sovereignty and security policy priorities in the Arctic. The system provides crucial data and services for search and rescue operations, monitoring of environmental catastrophes and follow-up investigations, and to help protect the sovereignty of Canadian waters in the region.

C.5.2 Planned Surveillance Satellite Systems

Distress Alerting Satellite System (DASS)	
Facts in Brief	**Country:** United States/Canada **Operations:** National Aeronautics and Space Administration/Canadian Space Agency **Status:** Funds committed for development of a proof-of-concept (POC) system for DASS, which includes funding necessary to modify up to 30 instruments for deployment onboard GPS satellites, and the installation of a POC DASS ground station. **Mission Duration:** Continuous **Coverage:** Global **Orbit:** Medium earth orbit at an altitude of 20,200 km **Key Service Areas:** Distress alert detection and location; collection, sorting and storage of distress alert data; distribution of alert and location data **Web link:** http://searchandrescue.gsfc.nasa.gov/dass/index.html
Mission Objectives	DASS is intended to enhance the international Cospas-Sarsat satellite-aided search and rescue (SAR) system by installing 406 MHz repeaters (transponders) on the GPS medium Earth orbit (MEO) navigational satellites and by introducing new ground segment tracking stations and processing algorithms.
System Capabilities	DASS is expected to provide near-instantaneous detection and location of 406 MHz emergency beacons. When operational, DASS will function as a secondary mission aboard Global Positioning System Block III (GPS III) satellites, and when fully deployed will consist of 24 to 27 payloads. The geometry is such that every point on the Earth will be visible by at least 4 satellites at all times. A Canadian DASS payload will allow Canada to extend its contribution to the future Cospas-Sarsat MEOSAR system. DASS is expected to significantly enhance current Cospas-Sarsat operations by providing near-instantaneous detection and location of 406 MHz emergency beacons
Measured Parameters	Distress signals emitted by: EPIRBs (emergency position-indicating radio beacons), which signal maritime distress; ELTs (emergency locator transmitters), which signal aircraft distress; and PLBs (personal locator beacons), which indicate a person in distress who is away from normal emergency services (e.g., 9-1-1).
Relevance to Arctic Interests	DASS will contribute to the sovereignty and security and indigenous and social development policy priorities in the Arctic. The system will provide crucial data and services for search and rescue operations, to facilitate the saving of lives if emergency response can be expedited, or recovery of assets to aid in accident investigations in the worst case.

C.6 Science Satellite Systems Inventory

The following pages contain templates of existing and planned science satellite systems.

C.6.1 Existing Science Satellite Systems

Gravity Recovery and Climate Experiment (GRACE)	
Facts in Brief	**Country:** USA **Operations:** NASA **Status:** In operation, launched, March 2002 **Mission Duration:** Satellite design life of five years, however, system is currently still in operation. The duration of the mission is dependent on the health of the battery and the duration within each orbit when the battery is in use. It is currently being monitored on a weekly basis. **Coverage:** Arctic circumpolar region **Orbit:** two identical spacecrafts flying approximately 220 kilometers apart in a polar orbit 500 kilometres above the Earth **Key Science Areas:** map variations in the Earth's gravity to inform our understanding of land mass variation, water currents and ice sheet and glacier activities **Web link:** http://science.nasa.gov/missions/grace/
Mission Objectives	The primary goal of the GRACE mission is to accurately map variations in the Earth's gravity field over its lifetime. These detailed measurements of Earth's gravity field will lead to discoveries about gravity and Earth's natural systems.
System Capabilities	GRACE will be able to map the Earth's gravity fields by making accurate measurements of the distance between the two satellites, using GPS and a microwave ranging system. It will provide scientists from all over the world with an efficient and cost-effective way to map the Earth's gravity fields with unprecedented accuracy. The results from this mission will yield crucial information about the distribution and flow of mass within the Earth and its surroundings.
Measured Parameters	The gravity variations that GRACE studies include: changes due to surface and deep currents in the ocean; runoff and ground water storage on land masses; exchanges between ice sheets or glaciers and the oceans; and variations of mass within the Earth, improved profile of Earth's atmosphere.
Relevance to Arctic Interests	Due to an uneven distribution of mass inside the Earth, the Earth's gravity field is not uniform - that is, it has «lumps». By far the largest is a flattening at the Polar regions, called the Earth's oblateness. The GRACE Mission is assisting scientists to map out the precise location and size of these lumps, enabling greater understanding of the structure of the Earth. Additionally, GRACE data is also used to monitor the mass and location of water as it moves around on the surface of the Earth, cycling between the land, oceans, and polar ice caps. In particular, a recent Study (Jan/12) undertaken by NASA and the University of Washington, supported by data from the GRACE mission, allayed concerns that melting Arctic sea ice could be increasing the amount of freshwater in the Arctic enough to have an impact on the global «ocean conveyor belt» that redistributes heat around our planet

Gravity field and steady-state Ocean Circulation Explorer (GOCE)	
Facts in Brief	**Country:** EU **Operations:** ESA **Status**: In operation, launched March 2009 **Mission Duration:** Originally 20 months, including a 3-month commissioning and calibration phase, followed by science measurement phases adapted to a long-eclipse hibernation period. In November 2010, granted an 18 month extension. **Coverage:** Global circumpolar region **Orbit:** Sun-synchronous, near-circular, dusk-dawn, low-Earth. **Key Science Areas:** Measurement of Earth's gravity field and modeling the geoid with improved accuracy and spatial resolution. **Web link:** http://www.esa.int/esaLP/SEMRNIRHKHF_LPgoce_0.html
Mission Objectives	GOCE's main objective is to measure Earth's gravity field and model the geoid with improved accuracy and spatial resolution. Data from this advanced gravity mission will improve knowledge of ocean circulation, which plays a crucial role in energy exchanges around the globe, sea-level change and Earth-interior processes. GOCE will also help to make significant advances in geodesy and surveying.
System Capabilities	This low-orbiting satellite is the first mission to employ the concept of 'gradiometry' – the measurement of acceleration differences over short distances between an ensemble of proof masses inside the satellite. GOCE is equipped with three pairs of ultra-sensitive accelerometers arranged in three dimensions that respond to tiny variations in the gravitational tug of Earth as it travels along its orbital path. The three axes of the gradiometer allow the simultaneous measurement of six independent but complementary components of the gravity fields. The satellite also carries an electric ion thruster system that continuously generates tiny forces to compensate for any drag the satellite experiences at low altitude.
Measured Parameters	The gravity variations that GOGE studies will assist with the study of: oceanography, surveying and leveling, solid Earth physics, geodesy and sea-level research, and will contribute to furthering the understanding of climate change.
Relevance to Arctic Interests	GOCE is mapping variations in the gravity field with extreme detail and accuracy. This will result in a unique model of the ' geoid', which is the surface of equal gravitational potential defined by the gravity field – crucial for deriving accurate measurements of ocean circulation and sea-level change, both of which are affected by climate change and subsequently impact Arctic interests

C.6.2 Planned Science Satellite Systems

Radiation Belt Storm Probe (RBSP)	
Facts in Brief	**Country:** USA **Operations:** NASA with support from John Hopkins University, Applied Physics Laboratory **Status:** Final stages of development, planned launch date August 2012 **Duration:** Prime mission of 2 years **Orbit:** Two identically equipped Sun-oriented, spinning spacecraft that will chase each other in their common orbits around the Earth. **Key Science Areas:** study the Sun's influence on Earth and Near-Earth space by improving the understanding of the Earth's radiation belts on various scales of space and time as well as their impact on creating space weather. **Web link:** http://rbsp.jhuapl.edu/
Mission Objectives	The RBSP mission is part of NASA's Living With a Star (LWS) program, designed to understand how and why the Sun varies, how planetary systems subsequently respond, and the resulting effect on human activities in space and on the ground. RBSP will contribute to the broader understanding of heliophysics phenomena that govern space weather at Earth. More specifically, RBSP will contribute to the understanding of the transfer of energy from the Sun to the Earth, and the interaction of solar plasma and radiation with Earth, the other planets and the galaxy.
System Capabilities	The probes will carry a number of instruments and instrument suites to support five experiments that will address the mission's science objectives. Because it is vital that the two craft make identical measurements to observe changes in the radiation belts through both space and time, each probe will carry identical equipment that includes the following: (i) Energetic Particle, Composition, and Thermal Plasma Suite (ECT); (ii) Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS; (iv) Electric Field and Waves Suite (EFW); (v) Radiation Belt Storm Probes Ion Composition Experiment (RBSPICE); (vi) Relativistic Proton Spectrometer (RPS).
Measured Parameters	Magnetic fields, radiation belts, particles, physics related to the transfer of energy
Relevance to Arctic Interests	The immense clouds of material (called coronal mass ejections), that are periodically emitted during solar wind activities can cause large magnetic storms in the space environment around the planet. As the earth's magnetic field is concentrated at the poles, high latitudes are particularly impacted by these space weather disturbances. The type of research that is being undertaken by the RBSP is a key to understanding and eventually predicting, hazardous events in the Earth's radiation belts and magnetic fields. These disturbances that can subsequently impact both space-born and ground–based technologies (pipeline, communication, and power utilities) which are more vulnerable in the polar regions.

Magnetospheric Multiscale Mission (MMS)	
Facts in Brief	**Country:** USA **Operations:** NASA **Status:** Under development, planned launch date 2014 **Coverage:** Global coverage **Orbit:** Four identically equipped spacecraft, which will fly in a tight, tetrahedral formation in Earth's magnetic environment – the magnetosphere. **Key Science Areas:** Three-dimensional measurements of magnetospheric boundary regions and examination of the process of magnetic reconnection. **Web link:** http://science.nasa.gov/missions/mms/
Mission Objectives	MMS's objective is to study the mysterious process that occurs when magnetic fields cross and reconnect, releasing magnetic energy in the form of heat and charged particle kinetic energy. The mission will give scientists unprecedented insights into a little-understood physical process at the heart of all space weather. This process, known as magnetic reconnection, sparks solar flares, coronal mass ejections, and other phenomena that can imperil Earth-orbiting spacecraft and even power grids on terra firma.
System Capabilities	A fleet of four identical spacecraft will focus exclusively on the dynamic magnetic system that stretches from the sun to Earth and beyond. Crucial element of the MMS instrument suite include: the Fast Plasma Instrument (FPI) which is 100 times faster than any previous similar instrument. The FPI will collect a full sky map of data at the rate of 30 times per second – a necessary speed given that MMS will only travel through the reconnection site for under a second.
Measured Parameters	Magnetic fields, radiation, particles, physics
Relevance to Arctic Interests	The increasing deployment of space systems highlights the need for a better understanding of space weather. A space weather phenomenon occurs when energetic particles thrown out from the sun interact with earth's magnetic field producing magnetic disturbance and increased ionization in the ionosphere. The high energy particles have a variety of impacts on technology (more specifically, communication systems, pipelines, power grids, radio communication), both in space and on the ground. Since the earth's magnetic field is concentrated at the poles, high latitudes are particularly impacted by these disturbances. The MMS mission will further our ability to monitor radiation belts and magnetic fields and subsequently, further our understanding of space weather systems and their impacts, particularly in the polar regions.

Technical report prepared by: