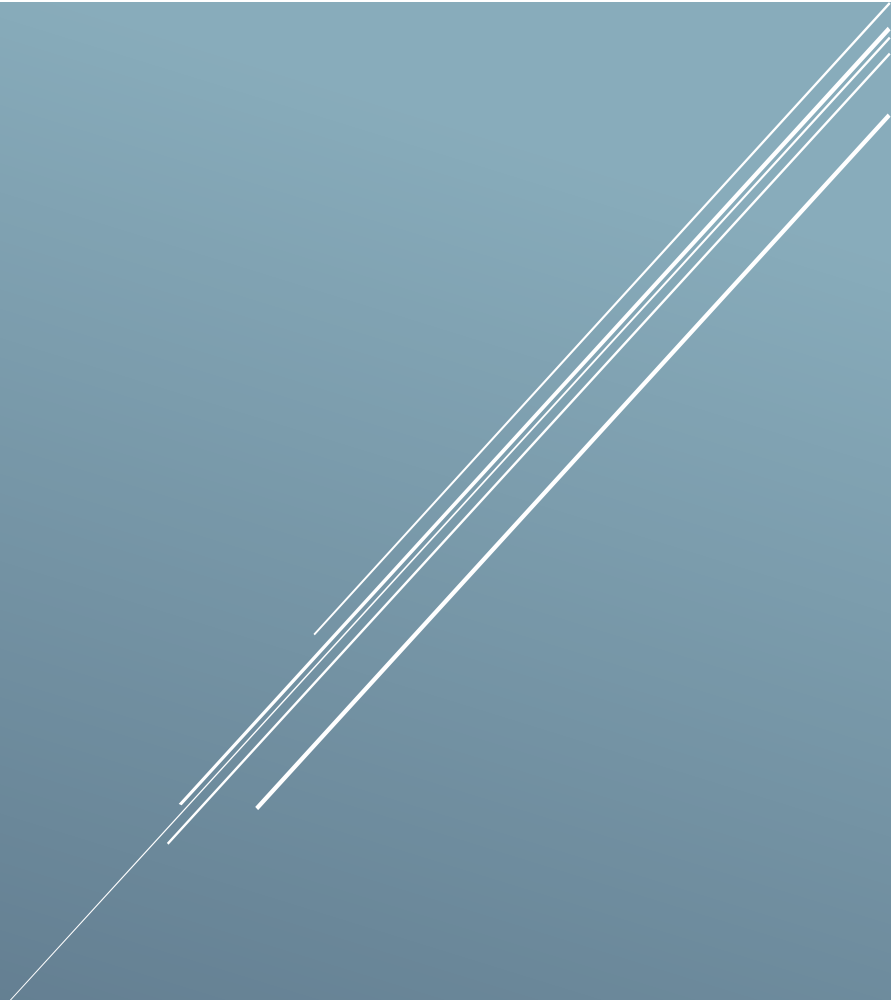




ASSETPAE (AUTONOMOUS SUBSEA SYSTEMS FOR EXTRACTION AND TRANSPORTATION OF PETROLEUM IN THE ARCTIC ENVIRONMENT)

Travision 2014

Contents

Introduction	2
Arctic Marine Geography	3
The nature of Ice at Sea.....	5
Future Natural Resource Development.....	6
Human Dimensions.....	7
Arctic Marine Infrastructure	8
Definition of the Arctic	8
Work Conditions in Arctic Environment.....	9
The Role of the Arctic in Future Global Petroleum Supply	10
Risks, Safety and Environment.....	12
Subsea Arctic Oil Platform (Autonomous Subsea Systems for Extraction and Transportation of Petroleum in the Arctic Environment) (ASSETPAE)	12
Transportation System.....	14
Tube System.....	14
Capsule.....	16
Conclusion.....	18

Introduction

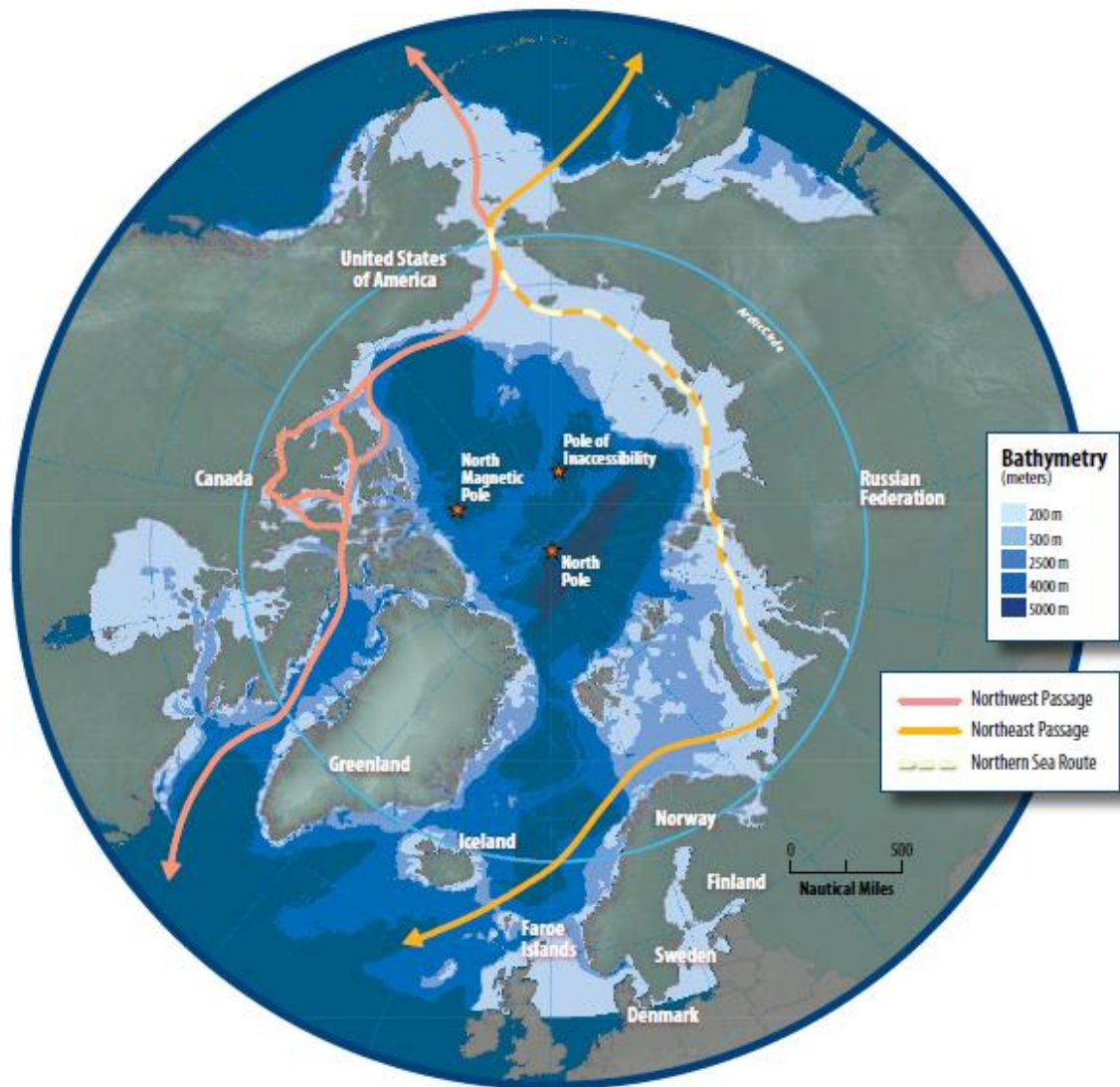
The Arctic is regarded as containing some of the last physically undisturbed marine spaces on earth. Early in the 21st century, the Arctic has also been undergoing extraordinary environmental and developmental changes.

Long known as a storehouse of untapped natural resources, high commodity prices and a growing worldwide demand in recent years have the Arctic poised as a significant contributor to the global economy. Increasing regional and coastal marine transport to support the exploration and extraction of oil, gas and hard minerals, coupled with the increasing presence of the global marine tourism industry, have brought a complex set of users to the maritime Arctic. The potential impacts of these new marine uses - social, environmental, cultural and economic - are unknown, but will be significant for Arctic indigenous people and the marine environment already undergoing significant changes due to climate change. Simultaneous with the globalization of the Arctic, marine access in the Arctic Ocean has been changing in unprecedented ways driven by global climate change. Arctic sea ice is undergoing an historic transformation - thinning, extent reduction in all seasons and substantial reductions in the area of multi-year ice in the central Arctic Ocean - which has significant implications for longer seasons of navigation and new access to previously difficult to reach coastal regions. The international scientific community has already taken advantage of these changes through pioneering voyages in the central Arctic Ocean. The same sea ice retreat also has important influences on the regional, Arctic marine ecosystems and future fisheries. Taken together, these changes present increased demands on the existing legal and regulatory structures challenged to meet the needs for enhanced marine safety and environmental protection in the face of increasing Arctic marine activity. Such challenges will require unprecedented levels of cooperation among the eight Arctic states and broad engagement with many non-Arctic stakeholders within the global maritime industry.

Arctic Marine Geography

Arctic Marine Geography, Climate and Sea Ice: Arctic sea ice has been observed to be decreasing in extent and thickness during the second half of the 20th century and early 21st century. Global Climate Model simulations indicate a continuing retreat of sea ice, but also show that the winter sea ice cover will remain. There is a possibility of an ice-free Arctic Ocean for a short period in summer perhaps as early as 2015. This would mean the disappearance of multi-year ice, as no sea ice would survive the summer melt season. It is highly plausible there will be greater marine access and longer seasons of navigation, except perhaps during winter, but not necessarily less difficult ice conditions for marine operations.

Our Earth has two Polar Regions, each with a large marine environment, that are vital to the well-being of the planet: Antarctica and the Arctic. Unlike Antarctica, though, which is a continent surrounded by an ocean, the Arctic is an ocean surrounded by continents. The Arctic Ocean, at 14.056 million km², is the smallest of the world's five oceans (Table 2.1). It is mostly an enclosed sea that has limited exchange of deep water with other oceans. Compared to the Mediterranean Sea, the Arctic has a much greater exchange of water, and it is more than 5.6 times larger. Consequently, the International Hydrographic Organization along with the International Maritime Organization recognizes the Arctic Ocean as one of the five major components of the world ocean that covers almost 71 percent of the Earth's surface. More importantly, the Arctic Ocean is the least sampled of the world's oceans and many areas remain where few, if any, soundings have been recorded. The implications of this lack of basic marine information are profound for charting hydrography and for basic Arctic navigation. The Arctic is bordered by numerous coastal seas, all of which are seasonally covered with sea ice. Working from Greenland eastwards, the waters adjacent to the Arctic basin itself are Greenland Sea, Norwegian Sea, Barents Sea, White Sea, Kara Sea, Laptev Sea, East Siberian Sea and Chukchi Sea - all fronting on the Eurasia continental land mass. The Bering Sea, the Beaufort Sea, the waters in the Canadian Archipelago including those of the Northwest Passage, Hudson Bay and Hudson Strait, Lincoln Sea, Baffin Bay, Davis Strait and Labrador Sea are all bordering on the North American continent. Most Arctic marine activity, such as fishing, offshore hydrocarbon development and ship transits, takes place in these coastal seas. Bathymetrically, the Arctic marine area is relatively shallow (Map 2.1) with broad continental shelves. The shelf extends 100 to 200 kilometres from the United States and Canada, and more than 1,000 kilometres in places extending north from the Russian Federation. Depths over the shelves average between 100 and 200 meters but are variable, especially as the continental landmasses and islands are approached. At the continental slopes, the break between the shelf and the deep ocean basin, depths are between 300 and 500 meters.



Country	Closest Point to the North	Distance to Pole (km)
Greenland	Kaffeklubben Island,	707
Iceland	Kolbeinsey,	2552
Norway	Rossoya Sjuoyane,	1024
Russian Federation	Cape Fligely, Rudolf Island, Franz Josef	911
USA	Point Barrow, Alaska	2078
Canada	Cape Columbia, Ellesmere	769

Distance from nearest land of Arctic states to the North Pole. Source AMSA

An important geographical limit and a defining line is the Arctic Circle (66 degrees 33 minutes north). At this latitude places receive continuous light for 24 hours per day once a year and as one moves pole ward the number of days of continuous light increases until at the North Pole continuous light is experienced for six months between the Vernal (March 21) and Autumnal equinoxes (September 21). Conversely, continuous dark is experienced at the pole for the other six months and decreasingly in time as one moves south. Significant for marine operations is that much of the central Arctic Ocean is shrouded in winter darkness with very low temperatures for half the year. This seasonal or diurnal cycle in the polar environment, while highly influential in the rhythmic behaviour and adaptation of Arctic communities and animal populations, has broad implications for maritime use throughout the Arctic Ocean and its coastal seas.

The nature of Ice at Sea



Several forms of floating ice may be encountered at sea. The most extensive is that which results from the freezing of the sea surface, namely sea ice; but mariners must also be concerned with “ice of land origin” - icebergs, ice islands, bergy bits and growlers. Both icebergs and sea ice can be dangerous to shipping and always have an effect on navigation. Young ice: newly formed sea ice less than 30 centimetres thick. It forms extensively in the autumn as ocean surface temperatures fall below freezing and on leads that open in mid-winter due to shifts in the pack ice. It is not a significant safety hazard for most Arctic vessels although, when placed under pressure by winds or currents, it can impede progress.

- First-year ice: can easily attain a thickness of 1 meter but rarely grows beyond 2 meters by the end of the winter. It is relatively soft due to inclusions of brine cells and air pockets and will not generally hole an ice-strengthened ship operated with due caution. Under pressure from winds or currents, first-year ice can impede progress to the point where even powerful vessels can become beset for hours or even days.

- Old ice: If first-year ice survives the summer melt season, it is then classified as old ice (subdivided into second-year and multi-year ice). It is typically 1 to 5 meters thick and is extremely hard. During the summer melt process, the brine cells and air pockets that characterize first-year ice drain out the bottom of the ice, leaving a clear, solid ice mass that is harder than concrete. Even ice-strengthened vessels are at risk of being holed by old ice. When under pressure, old ice can stop the most powerful icebreakers.
- Icebergs: are large masses of floating ice originating from glaciers. They are very hard and can cause considerable damage to a ship in a collision. Ice islands are vast tabular icebergs originating from floating ice shelves. Smaller pieces of icebergs are called bergy bits and growlers and are especially dangerous to ships because they are extremely difficult to detect.

Future Natural Resource Development

A U.S. Geological Survey report, issued in July 2008, indicates the Arctic may contain as much as one-fifth of the world's undiscovered oil and natural gas. More specifically, the assessment found the Arctic to potentially contain 90 billion barrels of undiscovered oil and 1,670 trillion cubic feet (47 trillion cubic meters) of undiscovered natural gas, representing 13 percent of the undiscovered oil and 30 percent undiscovered natural gas. Of the total for undiscovered oil reserves, more than half are estimated to occur in geologic provinces in the Alaska Arctic (offshore and onshore), the Amerasian Basin (offshore north of the Beaufort Sea) and in West and East Greenland (offshore). More than 70 percent of the undiscovered natural gas is estimated to be located in three areas: the West Siberian Basin (Yamal Peninsula and offshore in the Kara Sea), the East Barents Basin (location of the Russian Federation's giant offshore Shtokman field) and the Alaska Arctic (offshore and onshore). Each of these regions would require vastly expanded Arctic marine operations to support future exploration and development. Several regions, such as offshore Greenland, would require fully developed Arctic marine transport systems to carry hydrocarbons to global markets. Despite the recent global recession, two Arctic nations, Norway and the Russian Federation, have already made significant investments during recent decades in developing Arctic hydrocarbons in offshore Arctic Norway and northwest Russia's offshore systems in the Pechora Sea. Arctic marine transport systems support each of these developments, and oil and LNG tanker traffic from the Barents

Sea to world markets is expected to continue for several decades. For the Russian Federation, future investments in developing the Shtokman gas field west of Novaya Zemlya in the east Barents Sea are evolving. This field, understood to be one of the world's largest gas fields, lies 600 kilometres offshore and in depths of water to 2,000 meters. Exploration and development of this large, offshore region will require extraordinary levels of Arctic marine operations, most conducted in waters that are not ice-covered, but under extreme cold temperatures. Natural gas from Shtokman would be transported by sub-sea pipeline or a marine tanker system, either of which would increase marine operations in this region of the Arctic. For the United States (Alaska) and Canada, where offshore Arctic lease sales were held for the Chukchi (U.S.) and Beaufort (Canada) seas in 2008, the future remains uncertain. The leases represent long-term, strategic investments. Marine exploration of the Arctic offshore should continue during the next

decade. One of the key factors in future Arctic offshore developments is that a majority of the seabed oil and gas resources are located within the Exclusive Economic Zones (EEZs) of the Arctic states (i.e., Arctic offshore regions of Alaska, Canada, Norway, Greenland and the Russian Federation). While there remain several, regional boundary disputes where potential resources may overlap, the general jurisdictional issues are clear and do not appear to be significant obstacles to future Arctic hydrocarbon development. Hard minerals development in the Arctic will continue to be influenced by global commodities markets and prices. However, the largest zinc mine in the world (Red Dog in the Alaska Arctic) and the largest nickel mine (Norilsk in Siberia) will continue to be solely dependent on marine transport systems - seasonal in the case of Red Dog and year-round operations for Norilsk Nickel. It is plausible that the summer, ice-free season for support to the Red Dog mine could be extended as Arctic sea ice continues to retreat in the Chukchi Sea. The Mary River iron ore deposits on Baffin Island, Nunavut in the Canadian Arctic represent a highly valuable mineral resource (high grade iron ore of 67 percent iron). Plans have been underway for some time to develop a mining operation and ship to European markets 18 million tons of ore each year, estimated to last for a minimum of 25 years. This is a large Arctic project that would involve a fleet of ice-capable cargo carriers operating on a year-round basis between Baffin Island and Europe. Ice navigation would be required for operations in the winter and early spring. Greenland geology records more than four billion years of earth history, preserving significant mineral deposits. For example, the Kvanefjeld Project near the southwest tip of Greenland represents a multi-element deposit containing rare elements, uranium and sodium fluoride. Potentially world class and multi-commodity ore deposits exist in other regions of coastal Greenland. The exploration and development of these mines will require Arctic marine transport systems to carry these scarce commodities to global markets.

Human Dimensions

Marine shipping is one of many factors impacting Arctic communities. There may be some positive economic impacts to increased shipping. However, Arctic residents express concern for the social, cultural and environmental effects of such expansion. The possibility of oil spills is a major concern and hunters are especially concerned about the disruption of marine species and their hunting practices. The costs and benefit of Arctic shipping will likely be unevenly distributed among and within communities and regions. Constructive and early engagement of local residents in planned Arctic marine development projects can help to reduce negative impacts and to increase positive benefits. Importantly, many local Arctic residents today depend heavily on marine resources for subsistence and the local economy; over-the-ice travel and boat transport allow the use of large marine areas during much of the year. Such life in the Arctic is dependent on movement over the ice and ocean and sea ice is integral to this movement.

Arctic Marine Infrastructure

There is a general lack of marine infrastructure in the Arctic, except for areas along the Norwegian coast and northwest Russia, compared with other marine regions of the world with high concentrations of ship traffic. Gaps in hydrographic data exist for significant portions of primary shipping routes important to support safe navigation. In addition, for safe operations in the Arctic there is a need for the same suite of meteorological and oceanographic data, products and services as in other oceans, plus comprehensive information on sea ice and icebergs. Except in limited areas of the Arctic, there is a lack of emergency response capacity for saving lives and for pollution mitigation. There are serious limitations to radio and satellite communications and few systems to monitor and control the movement of ships in ice-covered waters. The current lack of marine infrastructure in all but a limited number of areas, coupled with the vastness and harshness of the environment, makes conduct of emergency response significantly more difficult in the Arctic.

Definition of the Arctic

The most common and well-known definition of the Arctic describes the region as the land and sea of the Arctic Circle which is a circle of latitude at about 66.5 North. The area is approximately 30 million square kilometres, about half of which is covered by ocean surface. As it might be known, the Arctic is an ocean surrounded by several land pieces. Nearly 90 per cent of the sea is permanently ice-covered; the rest is constituted by the territories of the United States (Alaska), the Russian Federation, Norway, Denmark (Greenland), Canada, as well as many islands under the sovereignty of these countries.

There are four million of human population in this region. It also has a great natural resources. Plus, compared with most of areas of the World, it can be said that it is one of the cleanest region.

The extreme harsh environment is the main factor that gives the Arctic its extraordinary nature: low temperatures during the year, snow, high geographic latitude, storm, the special magnetic phenomena and extraordinary light conditions, all of which slow down the processes of organic decomposition and soil formation.

Work Conditions in Arctic Environment

Because of the harsh environment, main marine installation works, offshore operations can be done only during summer months. It brings high pressure on personnel due to short season, which can be harmful for worker health and work safety.

One of the most faced situation is winterisation, which is the freezing of splashed water onto surfaces of structures. It can cause big amount of unwanted weight on floating vessels and can create serious security problems. However, with the approach of this project; this risk will be diminished.

One of the other criteria is the working environment underwater. Sea water temperature is in general lower than in other areas. However, the same or nearly the same minimum temperature is found in deeper waters elsewhere hence sea water temperature is not recognized as a particular challenge in the Arctic region down to -2 degree Celsius can be expected.

Nonetheless, with the autonomous unmanned systems, it can be reached 24/7 of full performance, with zero risk of environmental and health problems.

According to the researches, hydrocarbon resources are distributed around the entire Arctic Region, however the most promising sources are on the continental shelves and in water depth less than 500 meter and few if any in the deep water basins.

In the Arctic Region, the winter period is completely dark whereas the summer has daylight for 24 hours. For the areas where ice does not preclude operation during the winter season, the darkness has implications for operation of vessels, in particular when icebergs are present. That is why the ASSETPAE (Autonomous Subsea Systems for Extraction and Transportation of Petroleum in the Arctic Environment) can be submerged in the water during a summer season and start its drilling & extracting operation in a better condition.

The Role of the Arctic in Future Global Petroleum Supply

The Arctic has a considerable share of global petroleum resources, but at higher costs and higher technology requirements than in most other petroleum provinces. Countries around Arctic and petroleum companies are carefully considering the potential for future extraction in the Arctic.

Nearly 22% of the total undiscovered oil and gas resources in the world are expected to be located in Arctic region.

Considering the earlier stages, oil and gas exploration and exploitation in the Arctic started in the 1920s; especially in the second half of the 20th century it increased fastly. Furthermore, it can be seen a hectic affection of the companies and Arctic states over the research and development about Arctic Petroleum & Gas Extraction. Offshore oil and gas exploitation in the Arctic is already the major economic driver in many areas in the region. In the past, due to the harsh climatic conditions it was difficult to drill for hydrocarbons in the Arctic. It was hard for the companies to make profits due to the very high costs of exploitation and transportation of the product. Recently, both energy industries and Arctic states have found oil and gas exploitation in the Arctic interesting. One of the reason is considered as the high price of oil and gas. Secondly, rapidly increasing demand on petroleum leads companies to find another solution. With ASSETPAE, It may become more feasible in the Arctic.

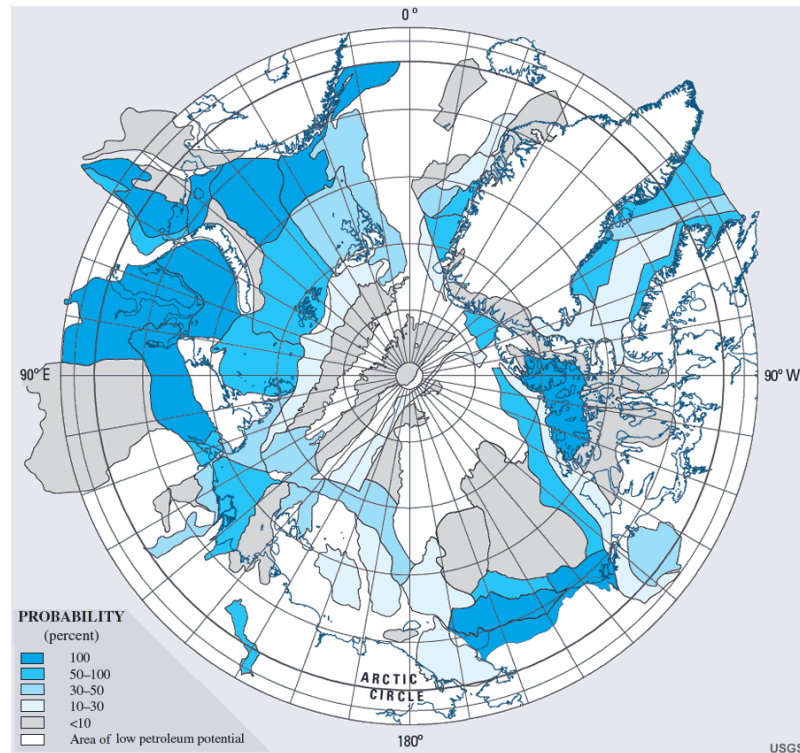


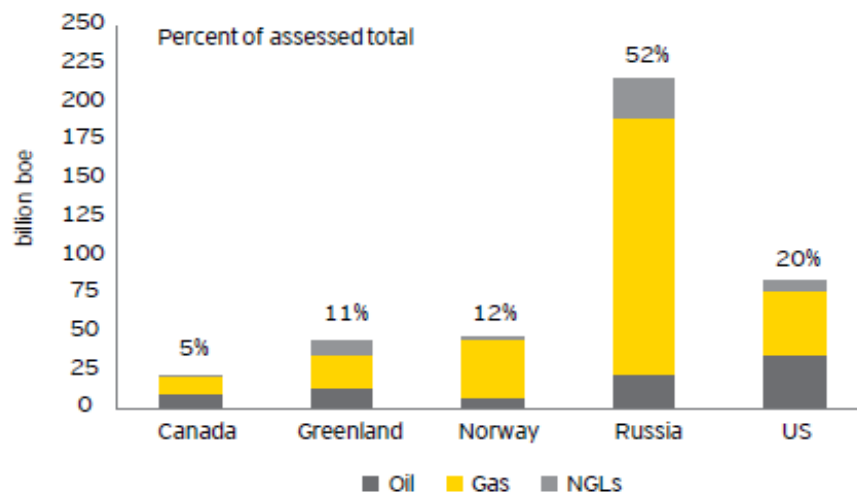
Figure: Estimates of Undiscovered Oil and Gas North of the Arctic Circle.

US and the EU, which are the large importers of petroleum look to the Arctic for petroleum supply to decrease dependence on a limited number of large suppliers.

According to USGS (2008), the total amount of undiscovered petroleum resources in the Arctic is 413 bboe, about 22 per cent of the global undiscovered conventional oil and gas resources. Further, they find that the Arctic contains 134 bboe of oil (incl. natural gas liquids, NGL) or about 15 per cent of total global oil resources. Hence 279 bboe or close to 70 per cent of the arctic petroleum is gas.

Potential Arctic oil and gas resources

(total assessed resources = 412 billion boe)



Source: Ernst & Young calculations from US DOE and US GS data

	US	Canada	Greenland	Norway	Russia
General fiscal terms					
Access to resources					
Competition for resources					
Cost environment					
Existing infrastructure					
Access to infrastructure					
Access to markets					
Potential for material discoveries					
Potential for material value creation					

Very favorable Favorable Moderate Unfavorable Very unfavorable

Source: Ernst & Young adaptation from Deutsche Bank Markets Research, "Is the Arctic the future of Russian oil?" 24 September 2012

Risks, Safety and Environment

Compared to other ship operations, navigation in Arctic is quite unique. Navigational mistakes can be fatal, for both the operators and the environment. Its biggest challenge is ice, requiring specially constructed ships and experienced navigational skills.

Shipping is nevertheless expected to increase in the future. A single oil tanker accident can have serious consequences and contribute to major environmental pollution. Besides accidents, one has to keep in mind operational impacts of shipping such as influencing bio-diversity with ballast waters.

It is highly important to protect the Arctic environment. This importance has added another dimension to the concept of maritime safety. Maritime safety is defined as *'the material state resulting from the absence of exposure to maritime dangers, as well as the organizational and administrative factors designed to create or perpetuate such a situation'*. From this we can conclude that safety at sea holds the safety of navigation thus having the purpose of protecting and saving lives.

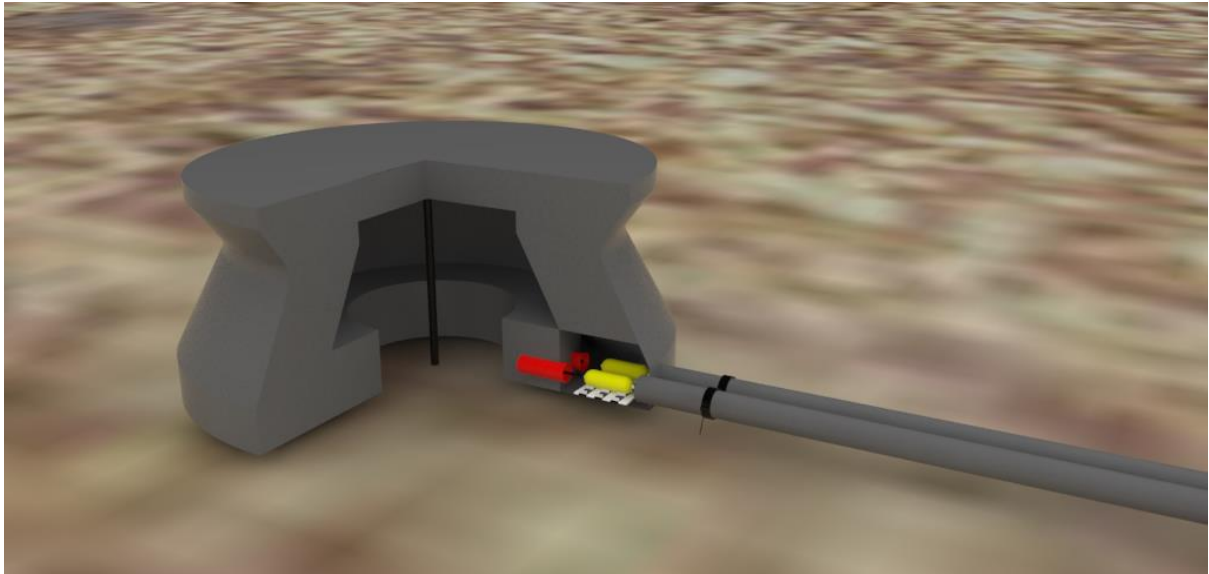
Subsea Arctic Oil Platform (Autonomous Subsea Systems for Extraction and Transportation of Petroleum in the Arctic Environment) (ASSETPAE)

There are a numerous reasons why one may choose to install subsea processing equipment. Subsea processing contributes to flow management and assurance by enhancing the efficiency of flow lines and risers. Furthermore, it enables development of challenging subsea fields.

With production equipment located on the seabed, subsea processing provides a less expensive solution. Subsea processing has become a reasonable solution for fields located in harsh conditions where processing equipment on the water's surface might be at risk such as Arctic.

The main types of subsea processing include subsea water removal, sand and solid separation, gas and liquid separation as well as treatment and compression.

By separating unwanted component, riser will not be lifting them to the facility on the surface, therefore making the subsea system more economical on that point of view.



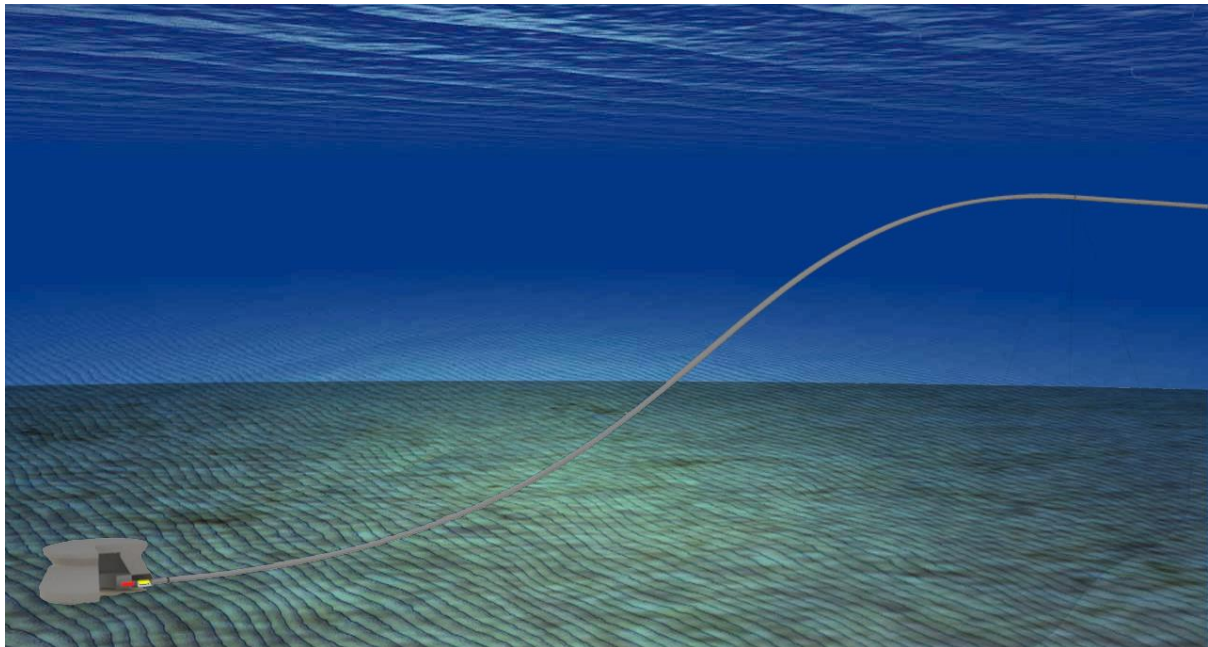
Round shape has been chosen due to its lower resistance and easier work flow. The riser is located in the middle extracting the oil and sending it to higher ring of the rig where the separation of oil is performed. The oil is then sent to the storage area above the lower ring. In the lower ring the filling of the capsules is being done which are then delivered to the transport system.

Transportation System

Tube System

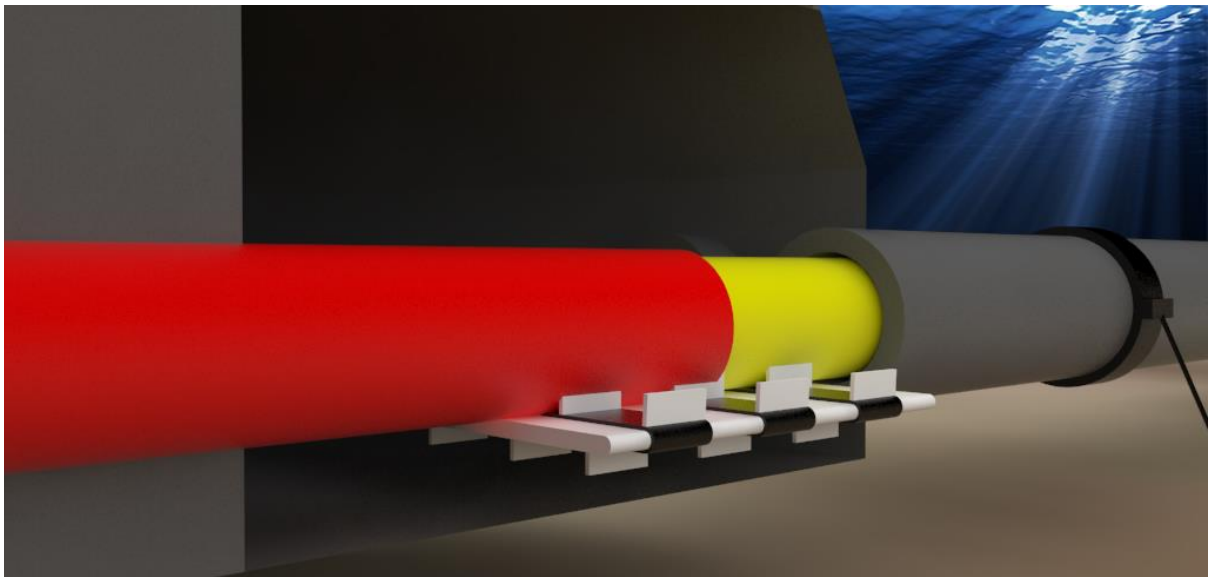
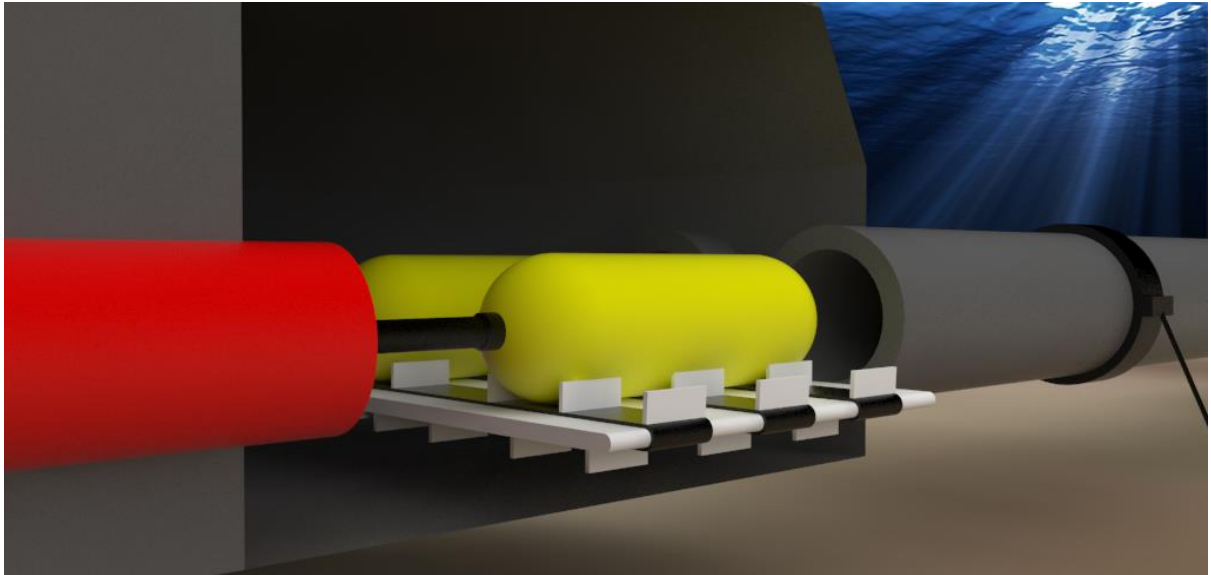
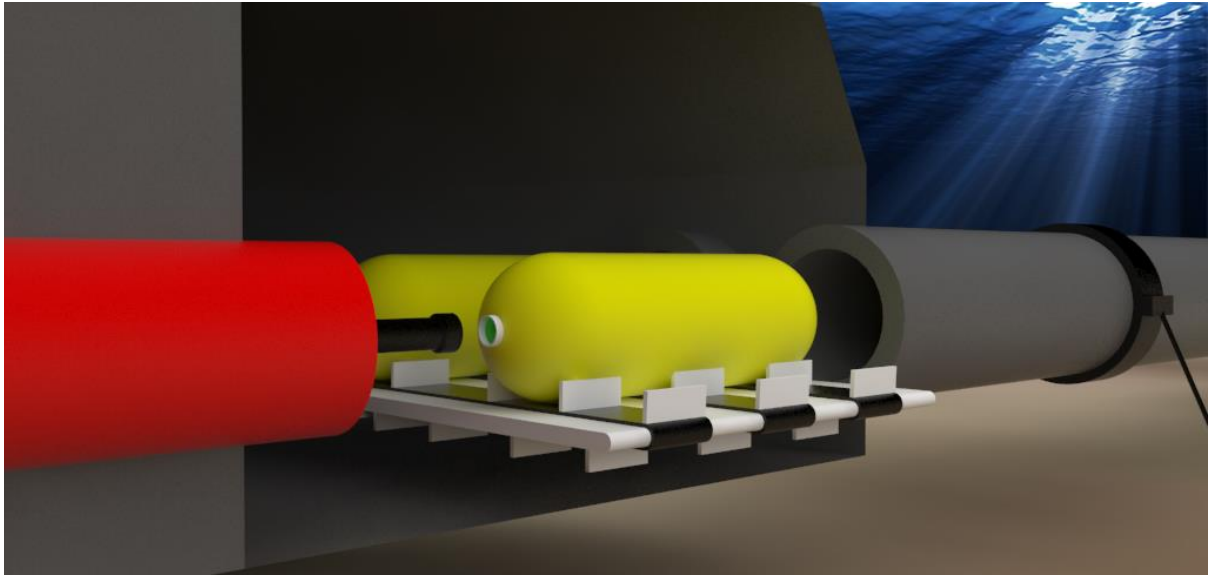
The method to transport the oil extracted in the underwater platform is using capsules launched through a tube distribution system. The reason to use this system is to improve the way to transport the oil, once extracted, to the shore with less environmental damage as possible. Using a tube system the capsules will be transported to the shore using these tunnels like a railway.

The tube system is going to be suspended in 50m depth, counting from the sea surface, and held to the seabed using steel cables. The fixation of the tube system to the seabed is made by the connection of the cables to the rings, not to the tube itself. These rings are a steel structure collocated every 100m and which mission is to fixate both tube in the same lane and also provide the structure needed to allocate the cables and sustain the whole system.



The advantages of the tube system suspension at 50m depth are the following:

1. Less pressure acting along the major part of the distribution system which would make higher requirements for the design of the tubes, fixations, etc.
2. Straighter system due to the constant depth along its length.
3. The maintenance and the access is going to be easier at 50m depth than in the depth of the sea bed.
4. The structure required and the irregularity of the seabed would make the design of the distribution system more complex and expensive.



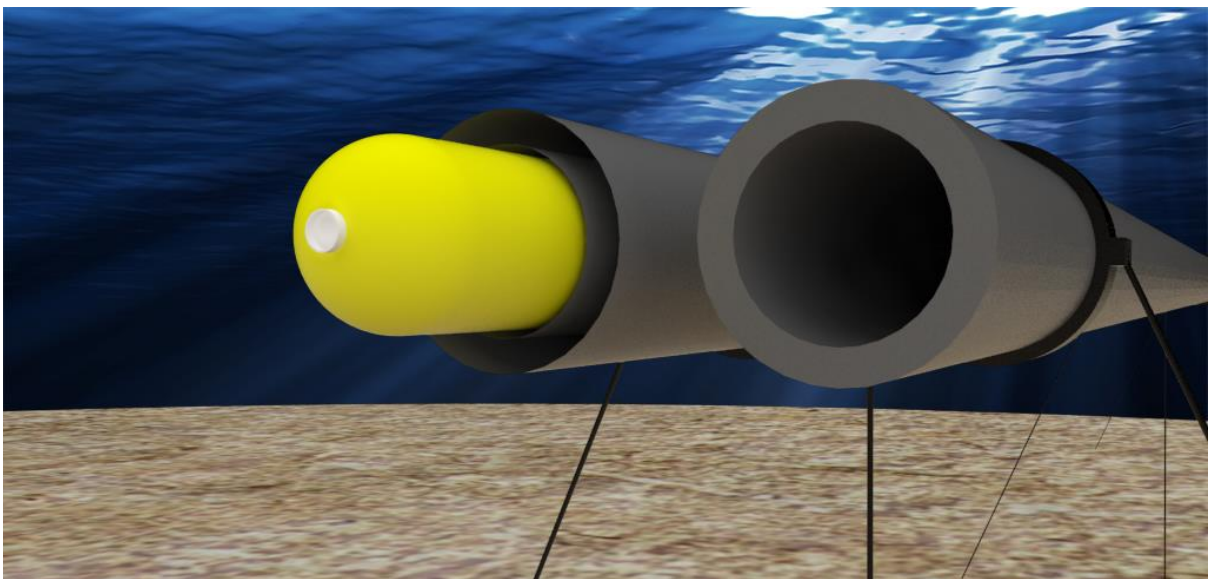
The transportation is conformed of a dual tube system unified for steel rings along its length. Each tube will have a double shell and the capsules will be launched through the tube using the Maglev transportation.

The Maglev is transportation technology based in the magnetic levitation. The functionality of the system is based on creating a magnetic field, produced by high-powered electromagnets, to make the capsules levitate above their guideway track, making it able to move on air without friction. The interaction between the electromagnets and the guideway is the actual “*motor of the system*”.

When two magnets are put together, there will be a strong magnetic attraction and they will clamp together. With one of those magnets being flipped over, there will be a strong magnetic repulsion and the magnets will push each other apart. A long line of magnets are placed along the length of the tunnel as well as the line of alternatively placed magnets on the capsules. Being properly controlled, the magnets can make the capsules levitate and travel through the tube.

Capsule

The capsule is a metal tank with two semi spheres in each extreme and with a cylindrical middle part.



The capsule dimensions:

Diameter of 2m

Cylindrical part length of 4m

Total Capsule length of 6m

Total volume of 12.57 m³

In both extremes the capsule will have an easy connection system to charge and discharge the oil, whether the capsule is in the oil extraction platform or in the onshore platform, respectively.

A rotational connection will be made with in both cases, offshore and onshore, using the same system to make the process easier and faster.

Conclusion

Advantage about this concept is that safety of life at sea has been vigorously increased due to unmanned and autonomous devices with a global remote technology to control all the systems. In order to provide maximum security, oil spillage interference and drilling systems are installed in the rig and also throughout the subsea tunnel web distribution. Furthermore, the possibilities of collision, as well as the possibility of oil spillage, have been completely eliminated, which are usually related to traditional transport by ship methods.

This kind of petroleum extraction and transport makes a perfect compromise between benefiting from the Arctic's natural resources and a maximum possible preservation of its astonishing natural environment.