DEVELOPMENT IN THE CANADIAN ARCTIC:
Issues associated with logistics and transportation

Dr. Malcolm Cairns - Malcolm Cairns Research and Consulting[1]

This survey paper arose out of a vacation taken by the author into the Canadian high arctic by ship in the fall of 2017: onboard were a number of experts on matters concerned with the arctic. Some of their information has been supplemented here by subsequent research to provide an overview of current development in the Canadian arctic – with particular emphasis on issues associated with logistics and transportation.

I BACKGROUND

What constitutes the Canadian arctic is ambiguous, and may involve political, geographic and geophysical boundaries – see Exhibits 1and 2:

- *Political:* Nunavut, Northwest Territories, Yukon, northern Quebec, and northern Labrador;
- *Geographic*: North of the Arctic Circle or the islands of the Canadian Archipelago;
- *Geophysical*: North of the Tree Line or north of a 50F average July isotherm.

For purposes of this paper, the Canadian Arctic is defined as follows:

- All of Nunavut – which includes the islands in Hudson and James Bays;
- The Beaufort Delta region of the Northwest Territories (NWT);
- The part of the Yukon north of the Arctic Circle;
- Nunavik which is the northern part of Quebec; and
- Nunatsiavut which is the northern coast of Labrador.

This Arctic region is generally above the tree line, and the following points may be noted:

- The total land and sea area at approximately 2,930,000 km^2 is about the size of India, and the largest island, Baffin, is 50% larger than the UK;
- The total population is just 57,000 of which 84% is aboriginal, mostly Inuit;
- The population is centered in 53 mostly coastal communities, of which the largest[i] are Iqaluit (7,740), Inuvik (3,170), Rankin Inlet (2,840) and Arviat (2,660);
- There are no road connections with the south, with one exception: The Dempster Highway connects Dawson City, Yukon, with the arctic's NWT communities of Fort McPherson, Tsiigehtchic, Inuvik, and an all-weather extension was completed in 2017 to Tuktoyaktuk;
- The communities do have gravel roads and vehicles, but there are no roads between communities, with the exception of a 21 km stretch between Arctic Bay and Nanisvik on north Baffin Island;
- All the communities have airports, except Tsiigehtchic, but they generally consist of short, gravel runways – Iqaluit has just built a new modern airport with paved runways, and Rankin Inlet has a paved runway. Larger airplanes are especially equipped with protection for their landing gear;
- None of the communities have ports, harbours, docks or quays: passengers are landed from ships by zodiac to beaches; goods are offloaded by cranes onto flat barges which are then beached for offloading using barge landing push outs;

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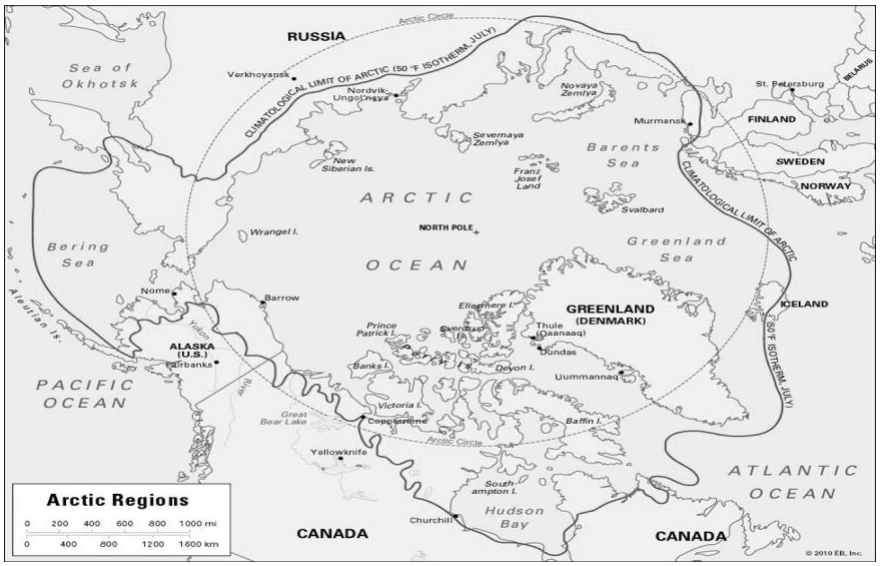
EXHIBIT 1

EXHIBIT 2



- The shipping season is short – between June and October – and the re-supply of the communities is conducted by the sealift: all of the communities in Nunavut and Nunavik are served by NEAS shipping line, while the NWT Beaufort Delta region is served by GNWT Marine Transportation Services, and the Labrador region is served by Nunatsiavut Marine Services.

Goods are generally shipped directly from the southern port of departure to communities without being unloaded or trans-shipped onto different vessels. Marine transport has undergone change in recent years. Barge and tug operations and smaller vessels with the ability to come in close to the communities for offloading operations are being phased out in favour of larger vessels, which anchor offshore and shuttle goods to the communities by barge;

- Most fuel consumption in the arctic is imported, mainly by oil tanker, including fuel oil or propane for heat, or diesel for transport and electricity. Diesel generators are affordable and a reliable way to produce electricity, and Nunavut relies completely on diesel for generating electricity;
- Satellite television and internet services are available to arctic communities, but service can be unreliable and internet speeds slow: according to Nunavut Tourism, *'Internet service is limited in Nunavut and slower than elsewhere. Wi-Fi service is uncommon. Visitors to Nunavut should not plan to spend much time on the internet'*. However, the federal government announced in 2017 that Nunavut will have faster internet by 2019 '*after a new satellite to be launched next year gives the territory access to a different frequency with more capacity'*;
- Again, according to Nunavut Tourism, '*Telephone service is direct dial in every community of Nunavut. In the smaller communities, pay phones are limited to a few locations. Some remote communities and wilderness lodges in Nunavut offer HF radio or satellite phone service. Mobile phone service is available in select communities. Bell Canada is the only satellite service provider. International mobile phones won't work unless linked to Bell Canada or possibly through the Ice Wireless network in certain circumstances'*;
- Arctic communities have indoor plumbing with holding tanks and trucked collection service of household wastewater. To treat domestic wastewater, most communities use passive systems using natural processes in wetlands or marine waters;
- Prices are high in the arctic. To illustrate: in 2017, a return economy flight from Ottawa to Grise Fiord on Ellesmere Island cost some $10,000; food in Nunavut costs twice as much as the Canadian average[ii];
- With the exception of the largest communities, there are no visitor accommodations available.

II CLIMATE CHANGE

The Canadian arctic is cold due to a heat deficit. The extent of the deficit has however varied dramatically over Earth's history. Consider the following:

- **Sea Currents**: During the early Jurassic Period, following the breakup of Pangea, warm Pacific sea currents reached into the arctic ocean, and the Canadian arctic had a temperate climate – with trees and camel-like animals. In modern times, it is only the Gulf Stream that flows northeast to warm the UK and northern Europe that provides heat into the arctic. Troms in northern Norway has an average daytime temperature in January of -4C while Clyde River on Baffin Island at a similar latitude has an average daytime temperature in January of –27C. This difference has an implication for commercial shipping through the arctic – see section VI;

- **Ice Ages**: Earth's Ice Ages – the last of which was 25,000 years ago, covered much of Canada with a kilometre of ice, and was definitely not due to mankind – have been elegantly explained by Milankovitch Cycles[iii]. The theory suggests that variations in eccentricity, axial tilt, and precession of the Earth's orbit resulted in cyclical variation in the solar radiation reaching the Earth, and that this orbital forcing strongly influenced climatic patterns on Earth. This theory does not explain all recent observations, but, thankfully, the theory forecasts the next Ice Age will not be for another 100,000 years;

- **Recent Arctic Warming**: Although contentious, there is a general view that an increase in GHG emissions is warming the earth. Some places are warming faster than others, and faster rates are observed in polar regions. Why does the Arctic warm faster than elsewhere? There are a number of positive and negative feedback loops, but it is generally recognized that as snow and ice melts, darker land and ocean surfaces absorb more solar energy – the Albedo effect. There is also a permafrost carbon feedback – thawing permafrost releases more GHG emissions – which may also result in instability in arctic facilities. These effects are resulting in ecological changes to both flora and fauna. The sea level is also anticipated to rise so that some coastal arctic communities may be threatened. This was the case in the 1950s when Inuvik was created to replace Aklavik, which was prone to flooding and had no room for expansion. It is currently indicated[iv] that Tuktoyaktuk, Arctic Bay and Kimmirut are vulnerable to a rising sea level;

- **Weather**: The increase in snow and ice melt is increasing evaporation which is creating clouds and sea fog in the short summer season. During periods of better weather, wind speeds increase. These effects have an impact on shipping, both commercial and for tourism – see section V.

III ACTIVE MINING IN THE ARCTIC

3.1 Northern Yukon and the Beaufort Delta Region of the NWT

There are no mines in the Yukon north of the arctic circle. The Yukon is involved in gold mining but this occurs to the south in the areas around Dawson City. There are no mines in the north region of the NWT, but there are diamond mines to the south.

3.2 Nunavut

Mines actively producing in Nunavut are described as follows.

Mary River Iron Mine

The Mary River Iron Mine[v] is located on northern Baffin Island, 100 kms south of Milne Inlet on the north shore and 150 kms north of Steensby Inlet on the south-west shore. The Mary River mine site is one of the most northern and richest in iron ore in the world. The iron ore is sufficiently pure not to require any processing before shipping, and it is estimated that production could be 18 million tonnes per year for 20 years or more. There have been two options for delivery: one by road to Milne Inlet and one by rail to Steensby Inlet. Currently delivery is made by road using large trucks over a "tote" road to a stockpile at a dedicated port facility at Milne Inlet, and bulk carrier ships move the ore onward to markets in Europe during the four-month shipping season.

The mine is operated by Baffinland Corp. and the operation runs 24/7, 365 days a year. The majority of employees work on site, operating on a two-weeks-on, two-weeks-off rotation. With an airstrip on site, there are charter jet flights out of Montreal for the employees from southern Canada. Also smaller daily flights throughout the week are used to transport employees from the north Baffin communities.

Meadowbank Gold Mine

The Meadowbank gold mine[vi] is located in the Kivalliq region of Nunavut, 300 kms west of Hudson Bay and 110 kms by road north of Baker Lake, the nearest community. Meadowbank was Agnico

Eagle's largest gold producer in 2015, and has 0.9 million ounces of gold in proven and probable reserves. Meadowbank depends on the annual, warm-weather sealift by barge from Hudson Bay to Baker Lake for transportation of bulk supplies and heavy equipment. An all-weather road links Baker Lake to the site. An on-site airstrip is used for shipping food and goods and for transporting employees, who work on a fly-in, fly-out basis.

Mine commissioning and first gold production from the Portage deposit began in early 2010. The mine is now producing some 300,000 ounces of gold but the life of the mine is expected to end in 2018. The company is actively exploring the Amaruq deposit with the goal of developing the deposit as a satellite operation to Meadowbank in 2019, extending the life by a further seven years.

Doris Gold Mine at Hope Bay

The Doris Gold mine[vii] is located at Hope Bay in the Kitikmeot region, is managed by TMAC Resources, and commercial production and operation was achieved in 2017. The Hope Bay Project is a high-grade gold deposit with established measured and indicated mineral resources totaling approximately 4.91 million ounces of gold. The Hope Bay Project encompasses the Hope Bay greenstone belt which is eighty kms long by twenty kms wide and includes three camps with significant infrastructure. Infrastructure currently there includes a 1,000 tonne per day processing plant, air strips, roads, fuel storage, power plants, administration, geology and lab buildings, and underground mine development at Doris and Boston deposits. The Madrid and Boston properties are expected to commence production in 2020 and 2022, respectively. Employees access the site by air, and work on a rotational basis.

3.3 Nunavik – Northern Quebec

Two active mines in Nunavik are described as follows.

Raglan Nickel Mine

Raglan Mine[viii] is a large nickel mining complex located approximately 100 kms south of Deception Bay. It is owned and operated by Glencore. The complex operates the Kattiniq/Donaldson Airport, operated by Glencore, which is 19 km west of the mine site. There is a gravel road leading from the mine site to the seaport on Deception Bay. It is the only road of any distance in the province north of the 55th parallel. As the complex is remote from even the region's Inuit communities, workers must lodge at the mine site, typically for weeks at a time. From the mine site employees are flown to Rouyn-Noranda, or in the case of Inuit employees, their home community. Ore produced from the mine is milled on-site then trucked to Deception Bay. From Deception Bay the concentrate is sent via cargo ship during the short shipping season (even by ice breaker it is only accessible 8 months of the year) to Quebec City, and then via rail to be smelted at Glencore's facilities in Falconbridge, Ontario. Following smelting in Ontario, the concentrate is sent back to Quebec City via rail, loaded onto a ship and sent to Norway to be refined. The mine is anticipated to operate until 2023.

Nunavik Nickel Mine

The Nunavik Nickel Mine, owned by Canadian Royalties Inc. a wholly-owned subsidiary of Jilin Jien Nickel Industry Co. of China, is 20 km south of the Raglan Mine, and a road connects with the Kattiniq/Donaldson Airport to share the airstrip. The nickel concentrates and copper products began to be shipped in 2013 by road to Deception Bay and from there by sea to a smelter, and the project has an anticipated lifespan of 8 years.

3.4 Nunatsiavut – Norther Labrador

Voisey's Bay Nickel and Copper

Operations at Vale's open-pit mine and concentrator at Voisey's Bay in Labrador began in 2005[ix]. This 6,000 tonnes-per-day facility produces two types of concentrate: nickel-cobalt-copper concentrate and copper concentrate. Nickel concentrate produced at Voisey's Bay is currently processed at Vale's operations in Sudbury and Thompson, but processing will eventually shift to the new hydrometallurgical processing facility in Long Harbour, Newfoundland. Voisey's Bay is a fly-in/fly-out operation.

Overall, it may be noted that there are proposals for uranium mining in the arctic but at time of writing there are no active uranium mines.

IV OIL AND GAS PRODUCTION IN THE CANADIAN ARCTIC

A 2014 report by The Oxford Institute for Energy Studies[x] concluded: *"It seems very likely that, if the Arctic region is to become a major oil and gas province within the next two to three decades, it will be in Norway and Russia that the major activity takes place. Russia has by far the largest resource base but lacks the experience and technology to develop it alone. Norway has significant offshore experience and has at least started the long process of developing infrastructure in the Barents Sea. Moreover, both countries are highly motivated to find new oil (and gas) resources to bolster their economies in the long term. Beyond the geo-political difficulties that Russia is currently facing, all these factors may provide the catalyst for the development of the Arctic as an oil-producing region, although the realistic timetable for significant output must surely be after 2030, not before"*

With respect to the Canadian arctic, the report concluded as follows: *"Canada's Arctic waters have significant hydrocarbon potential and have been subject to sporadic exploration activity since the early 1970s. However, environmental concerns, combined with high costs and, to a lesser extent, border disputes, are constraining such activity at present, although there have been recent applications for deep-water drilling by Imperial Oil and others. As a result, it would appear that any new drilling activity is some years away, possibly not until 2020 at the earliest; and even then, the possible $1billion cost of each well may prove prohibitive. At the same time, the current regulation requiring sufficient time to be left in each drilling season to drill a relief well may likewise prove too much of a disincentive for any company to begin serious exploration. Given all these concerns and given the opportunities for non-conventional activity in the more southern regions of the country, it seems likely that, though laying claim to ever larger portions of the Arctic region, Canada will not begin exploiting its Arctic resources in the near or medium term."*

These conclusions regarding the Canadian arctic were reinforced by the 2017 agreement to create the Lancaster Sound marine conservation area[xi]: *"Shell Canada contributed to the marine conservation*

area by voluntarily relinquishing 30 oil and gas exploration leases covering about 8,600 square kms of Arctic waters in the area".

V TOURISM

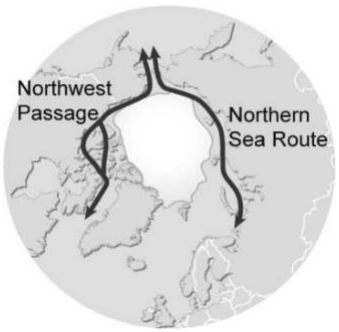
The overriding point to note is the very high cost of tourism to the Canadian arctic which makes it a niche market. There are private companies such as Arctic Kingdom[xii] that offer fly-in/fly-out vacations to many of the communities, or to remote lodges such as Bathurst Inlet, or to isolated locations for an adventure safari, such as a trek to the sea ice edge in the spring. Accommodations are in upscale tents and a typical 8-day safari can cost $13,000 plus $3,500 in airfare.

There are also expensive ship cruises in the summer months, however they can encounter sea fog or high winds that can result in the cancellation of 30-40% of the proposed landings. One particular cruise on the Crystal Serenity[xiii] ship is a 32-day voyage from Seward, Alaska, through the Bering Straits, transit of the north-west passage, and on to Greenland with a termination in New York. The cost for two people starts at US$44,000, there are around 1,000 passengers, and the ship stopped at Cambridge Bay and Pond Inlet in the Canadian arctic in 2017 – to land from this ship requires a transfer to an escort vessel (which has icebreaking capabilities), boarding of the vessel, and then transfer to zodiacs for the beach landing.

Then there is the very recent finding of the 1845 Franklin Expedition shipwrecks Erebus and Terror in the waters near King Williams Island. The wrecks are submerged some 30 metres and are being explored by an underwater archeology team from Parks Canada. The short exploration season suggests it may take years to complete, meanwhile in 2017 the UK agreed to grant Canada ownership of the wrecks and their contents with a few artifacts to be held in the UK. Meanwhile, the sites are being protected to discourage trophy hunters, and the likelihood of tourist activity is negligible.

VI COMMERCIAL SHIPPING THROUGH THE NORTH-WEST PASSAGE (NWP)

The opening up of the Arctic sea ice raises the possibility of commercial shipping routes through the Arctic to reduce transit distances and shipping times. There are two Artic alternatives, the NWP and the Northern Sea Route (NSR) across northern Russia.



There are several important factors at play besides time and distance, but if an arctic sea route is longer then it is unlikely to be utilized. Consider the following:

- **East Asia to Europe**: The current routing is via the Suez Canal – with a recent possibility of an all land route by rail. The NSR can reduce the distance by 8,000 kms (Yokohama to Rotterdam), but in all instances the NSR is shorter than the NWP, and given the warming impact of the gulf stream on the European end of the NSR, the NWP is unlikely to be used. Furthermore, the NSR was given a boost with a recent proposal from China among others to build a fibre-optic telecommunications link along the NSR by 2020;
- **East Asia to the west coast of the Americas and east coast of south America**: Direct shipping across the Pacific and through the Panama Canal – no reason for an arctic route;
- **East Asia to the northern east coast of North America**: The current routings are through the Panama Canal, or shipping to the west coast and a land bridge by rail to the east coast. Here the NWP can reduce the sea distance by 4,500 kms (Busan, South Korea to New York) and is a possibility;
- **West coast of North America to Europe**: The current route is via the Panama Canal, or rail to the east coast and a subsequent Atlantic crossing. Here the NWP can reduce the sea distance by nearly 2,000 kms (Vancouver to Scandinavia) and is a possibility.

The passage of a Chinese icebreaker through the NWP in 2017, suggests a possible interest in shipping say to New York. As for the NWP itself, and its economic viability, consider the following:

- There are several different routes through the Canadian arctic archipelago which may be considered as the NWP[xiv]. The shortest route over the north of Banks Island and through the McClure Strait is unsuitable due to ice conditions. The usual route designated as the NWP around King William Island has a low depth and only vessels with a draft of less than 10 metres can pass. The more likely route for larger vessels is south of Banks Island through the Prince of Wales Strait. Whether any of the routings are deemed international waterways or Canadian waterways remains a matter of dispute;
- The economic viability of the NWP is hampered by a number of factors:
    - The seasonality of the NWP: open only four months has limited commercial appeal
    - There is no economic activity along the NWP which makes it a transit route only
    - The uncertainty of weather and ice conditions makes it unreliable, and the need for ships to be certified and insured to operate in arctic conditions increases costs

Overall, the prospects for commercial shipping through the NWP are not promising.

VII FUTURE OF ARCTIC DEVELOPMENT, LOGISTICS AND TRANSPORT

In 2005, the Council of the Federation released Looking to the Future, a Plan for Investing in Canada's Transportation System. That document, drafted with input from all provinces and territories, called for federal investment in a strategic national transportation network.

Nunavut recommended several priority projects in the strategy. They included major deep-sea ports to serve Iqaluit, Rankin Inlet, and Bathurst Inlet; major airport improvements at Iqaluit, Rankin Inlet, and Cambridge Bay; and connection to the National Highway System through Bathurst Inlet and Rankin Inlet. Some 12 years later the only project that has been completed is the major improvement to Iqaluit airport. However, there are detailed plans to provide port infrastructure in Iqaluit. Given the existence of the Port of Churchill – and despite current problems with the rail line to Churchill – it

would seem likely uneconomic and unnecessary to build new ports and roads to Rankin Inlet and Bathurst Inlet.

Nevertheless, there are maintenance needs to sustain existing airport infrastructure including granular production for runway surfaces, heavy equipment replacement, renewal of electrical systems and new air terminal buildings. In the marine sector, yearly maintenance is required to rebuild barge landing pushouts, remove boulders and other deposits from beach areas and channels, improve cargo marshalling areas, and replace and strengthen anchoring and mooring systems.

Smaller aircraft move passengers and freight from hubs to other communities. For routing purposes and efficiency, the same aircraft type should be able to access every community outside the hub. This allows flexibility of routing, better use of aircraft, and a much better platform for competition – all of which have the potential to lower costs. However, while the newer generation ATR-42, SAAB 340 and Dash-8 are more efficient than the previous generation of aircraft, they require longer and smoother runways. Not all of Nunavut's communities have runways that meet the standards required to land these new aircraft. The air carriers, through a resolution passed by the Northern Air Transport Association (NATA), have requested that all three territories establish 5,000 feet as a minimum length for runways. This is not possible in all of the communities, and may not be practical or necessary in others.

Overall, investment needs would probably be most economic if they were directed at maintenance and improvement of existing infrastructure, rather than into large new infrastructure projects. More recently, in August 2017 Transport Canada announced a $175 million investment in new marine-safety measures, including $29.9 million for a new aerial surveillance facility in Iqaluit. For arctic research: the federal government renewed funding in November 2017 for the Polar Environmental Atmospheric Research Laboratory in Eureka, Nunavut; has provided $18 million to upgrade the Amundsen ice breaker; and $46 million was spent on a new Polar Knowledge Canada High Arctic Research Station at Cambridge Bay, Nunavut. This in addition to the $98 million on the Sentinel North program at Laval University in 2015, bringing together scientists to study northern ecosystems.

Finally, no commercial fisheries currently exist in arctic waters, and in January 2018, the world's major fishing nations – Canada, Russia, China, the US, the European Union, Japan, Iceland, Denmark and South Korea = agreed a moratorium on commercial fishing for 16 years in an area of some 2.8 million km^2 of the Arctic Ocean before it has even become established.

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[i] 2016 Census Nunavut Bureau of Statistics and NWT Bureau of Statistics.
[ii] Nunavut Bureau of Statistics in 2016.
[iii] "Arctic Climate and Climate Change", Greg Henry, University of British Columbia
[iv] National Resources Canada, 2016
[v] www.baffinland.com
[vi] www.agnicoeagle.com
[vii] www.tmacresources.com
[viii] Raglan Mine from Wikipedia
[ix] www.vale.com
[x] "The Prospects and Challenges for Arctic Oil Development", James Henderson and Julia Loe, Oxford Institute for Energy Studies, November 2014
[xi] Boundaries set for Lancaster Sound, Nunavut, Canada's largest area of protected ocean, CBC News, August 15, 2017
[xii] www.arctickingdom.com
[xiii] Crystal Serenity, 2017, Northwest Passage Explorer
[xiv] "An Economic Analysis of Container Shipping through the Canadian Northwest Passage", International Journal of e-Navigation and Maritime Economy, December 2014