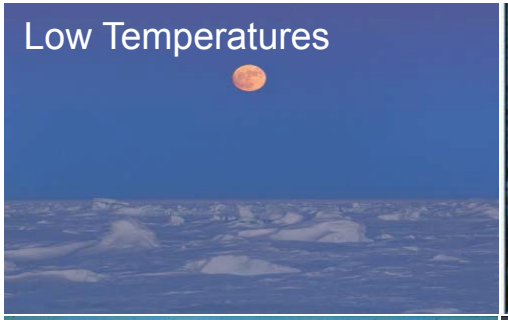
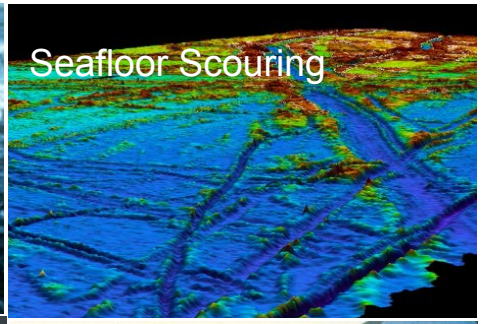
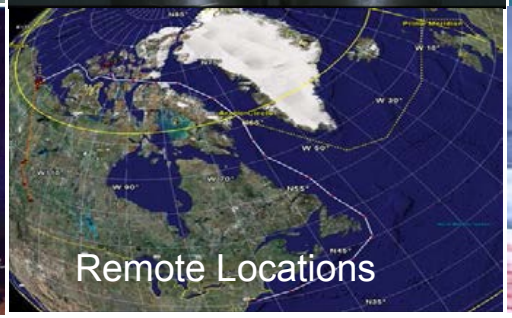
SHIPS AND SHIPPING IN NORTHERN WATERS

Some Arctic Marine & Offshore Challenges







NORTH WEST PASSAGES

North West Passages

Many attempts to use the NW Passage as a route from Northern Europe to China and Spices islands after Pope Alexander VI, in the treaty of Tordesillas, 1494. divided the new world between Spain and Portugal.

St Roch First NW Passage Voyage

Vancouver built ***St. Roch***

RCMP Schooner St. Roch the first vessel to make a <u>continuous voyage</u> through the NW Passage in 1944 – Halifax to Vancouver in 86 days

SS Manhattan Voyages

To test out the feasibility of shipping Alaska North Slope oil to the US East Coast a super-tanker the *SS Manhattan* was converted to an icebreaking ship and in 1969 transited the NW Passage to Point Barrow AK.

Icebreaking Tanker *Manhattan* with CCGS *Louis S. St Laurent*

SS Manhattan 1969 Voyage through the NW Passage

Icebreaking Tanker *Manhattan* with CCGS *John A. MacDonald*

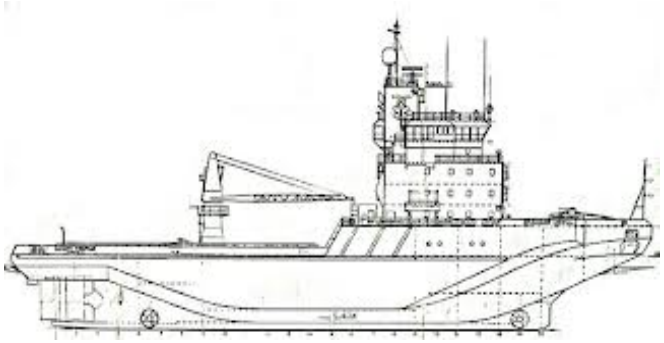
1970’S – A ZENITH OF CANADIAN ICEBREAKER DESIGN & CONSTRUCTION

Canmar Icebreaking OSV Fleet

- Starting in the mid 1970s, a Canadian company Dome Petroleum, commenced serious activities to explore for oil in the Beaufort Sea.
- The first series of vessels built were evolved from “traditional” offshore supply vessel and anchor handling tug designs of the time with the application of icebreaking hull forms and ice strengthened hull structures.
- These vessels were designed to operate in the open water season and into the new ice of early winter

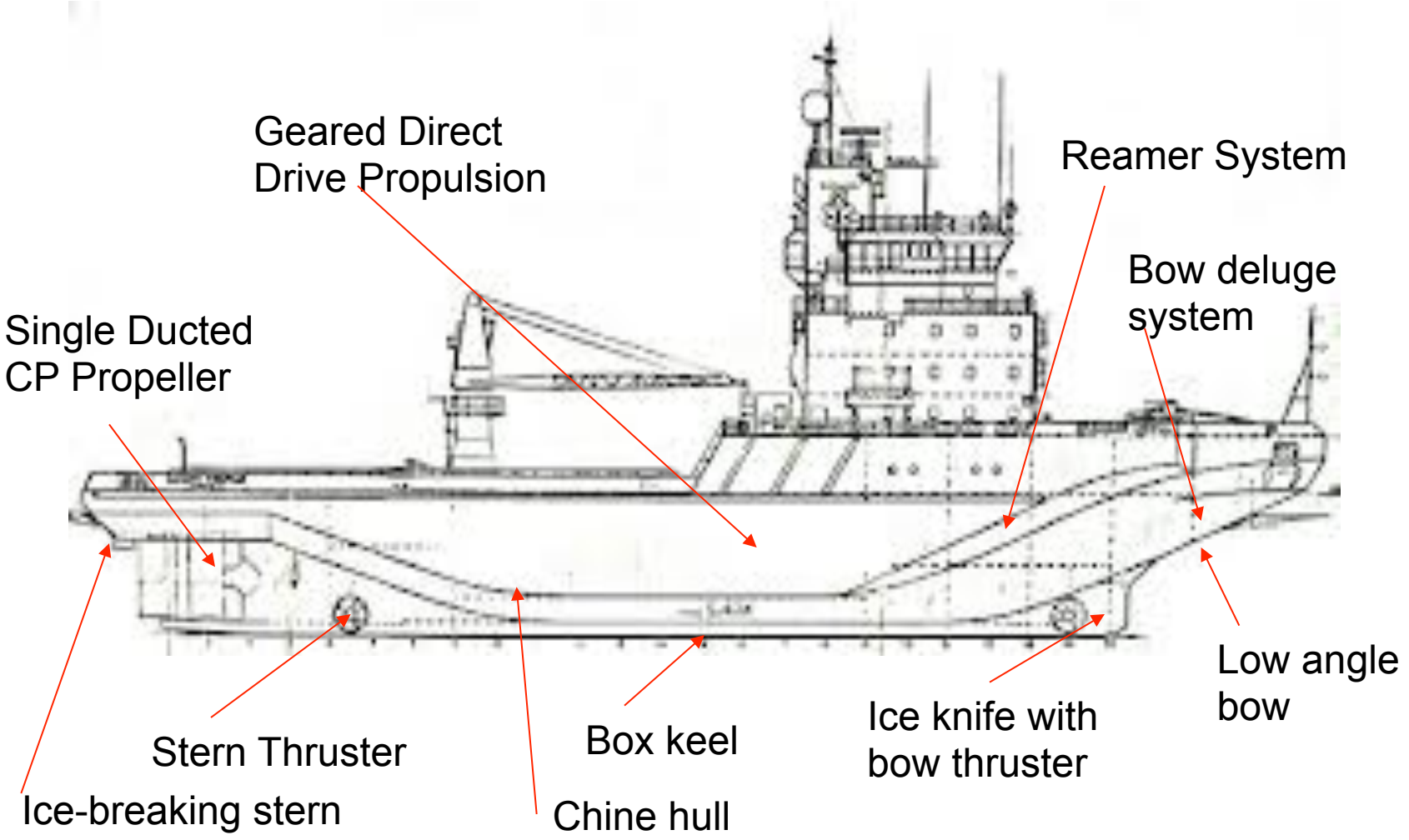
Innovation in the Canmar Fleet Icebreaker ***Kigoriak***

- By the late 1970s it became apparent that successful drilling in the Beaufort Sea would depend on the availability of significant ice management capabilities
- Dome-Canmar contracted for a new major icebreaking vessel which incorporated a number of unique features:
  - Ice reamers extending beyond the moulded hull lines
  - Spoon shaped bow with water lubrication system
  - Single screw mechanical drive propulsion system with ducted propeller
- The resulting vessel was the ***Kigoriak,*** which is still in service today as the ***Talagy***
- Already recognized at the time of her construction, but even more in retrospect from today, the ***Kigoriak*** represents a turning point in icebreaker design



Icebreaker *Kigoriak*

Novel Icebreaking Features



Gulf Canada
Beaudril Icebreaker Fleet

Following the Dome Petroleum lead Gulf Oil Canada decided to undertake a Beaufort Sea exploration program of its own. Gulf ordered two special drilling units, one floating, the conical drill barge, ***Kulluk,*** and one bottom founded unit, ***Molikpaq.***

To support these two Arctic MODUs, Gulf ordered 4 icebreaking support ships, two designed primarily for heavy ice management duties and two designed for more general offshore anchor handling and resupply duties.

These vessel performed well and three are now in Russian service and one, the ***Terry Fox,*** is in service as Canadian Coast Guard icebreaker

Canadian Coast Guard icebreakers

Heavy Icebreaker Louis S. St. Laurent

Ex Oil Industry Icebreaker Terry Fox

Heavy Icebreaker Louis S. St. Laurent

Icebreaking Buoy Tender Griffon

R Class Icebreaker Pierre Radisson

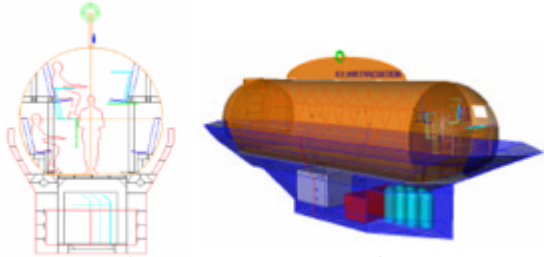
R Class Icebreaker Des Grosseille

ARCTIC MARINE EVACUATION, ESCAPE AND RESCUE

Canada Leads the World in EER for Ice-Prone Waters

Ice-worthy lifeboat tests

Caspian Icebreaking Lifeboat



Iceworthy Escape Capsule

ARKTOS Amphibious Lifeboat

Archimedean Screw Vehicle in ice

CURRENT NORTHERN WATERS SHIPPING ACTIVITY

Recent Eastern Arctic Shipping

Year Round Arctic Shipping - Russia

Norilsk Nickel Double Acting Ship in Kara Sea

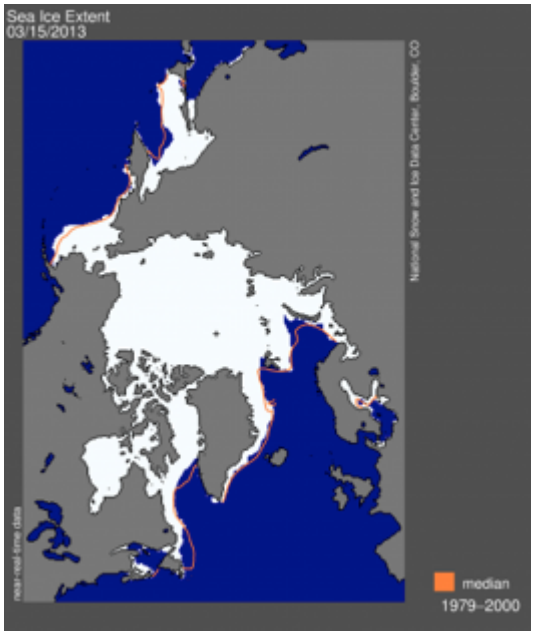
Tanker Loading at Varandey Terminal in Pechora Sea

Export Shipping Routes – Kara and Pechora Seas

Trans-Polar Shipping

- Recent changes in summer ice cover in the Arctic have led to much speculation on using trans-polar shipping routes to connect Pacific and Atlantic ports.
- The potential for significant trans-arctic shipping is probably not high in general and relatively low for the NW Passage due to uncertainty of conditions, lack of infrastructure such as accurate charting, and availability of icebreaker assistance.

Arctic Ice Cover - March

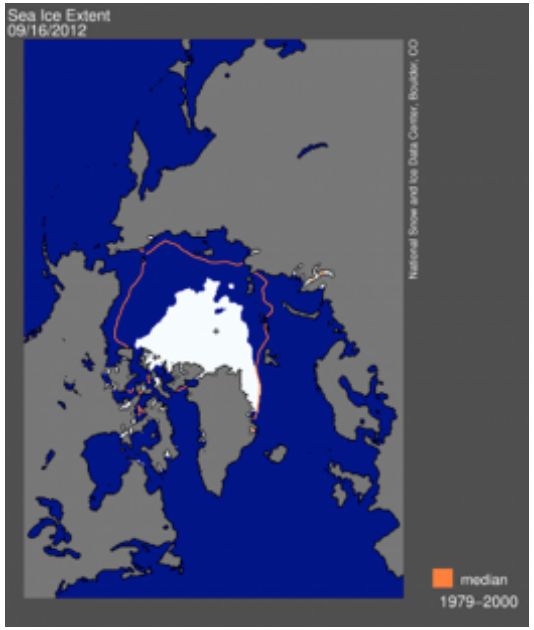


March 2012

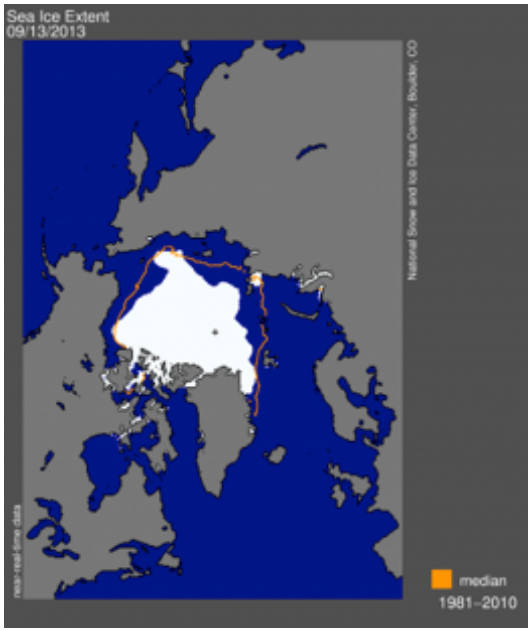
March 2013

March 2014

Arctic Ice Cover - September



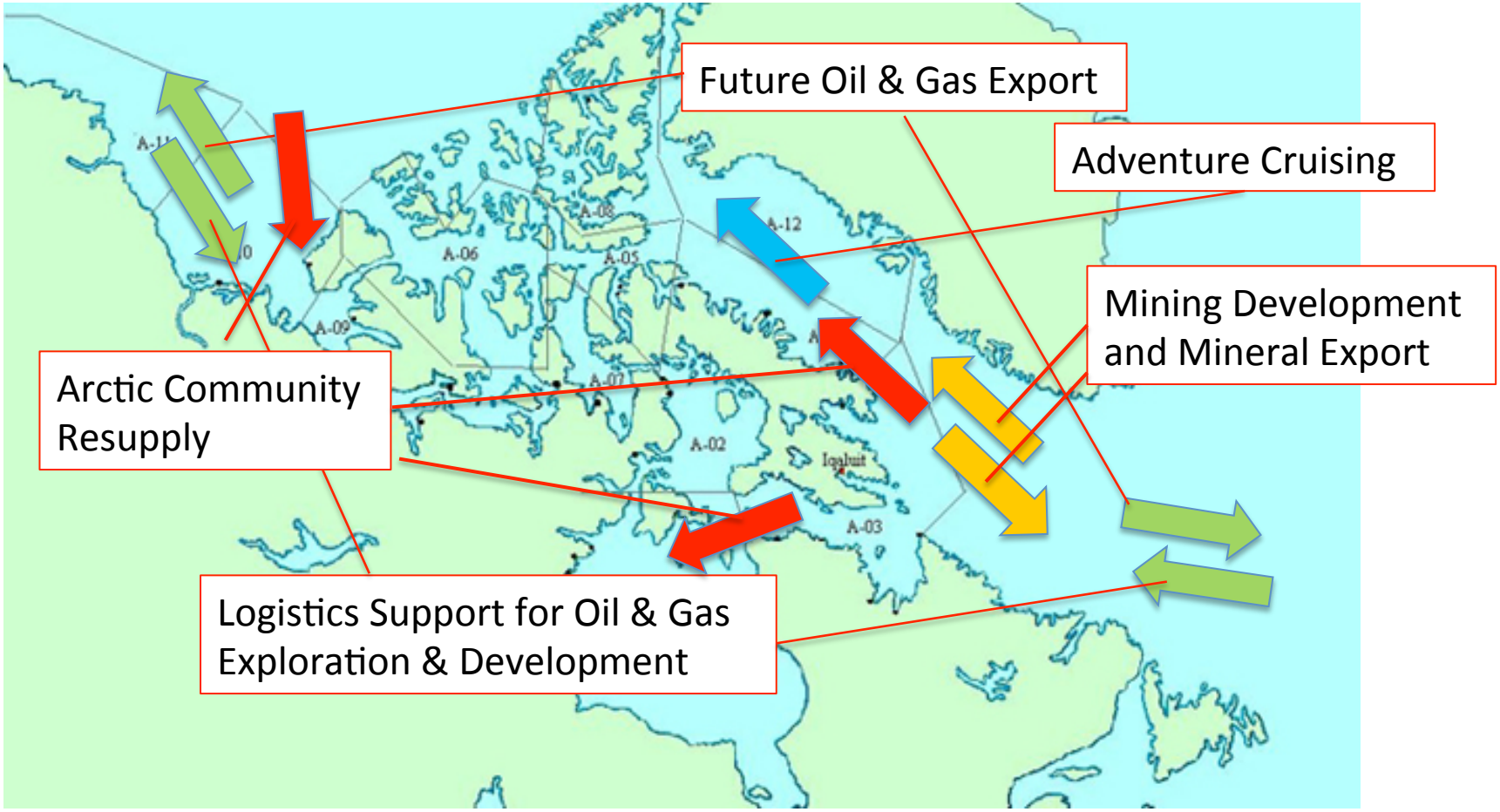
September 2012



September 2013

September 2014

Arctic Destination Shipping



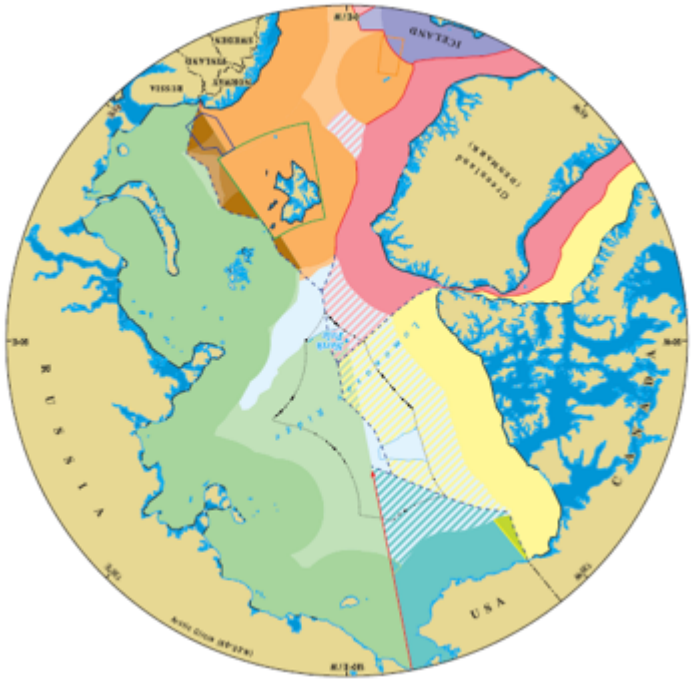
"Canada's new government understands that the first principle of Arctic sovereignty is: Use it or lose it,"

Prime Minister Harper 2007

SOVEREIGNTY

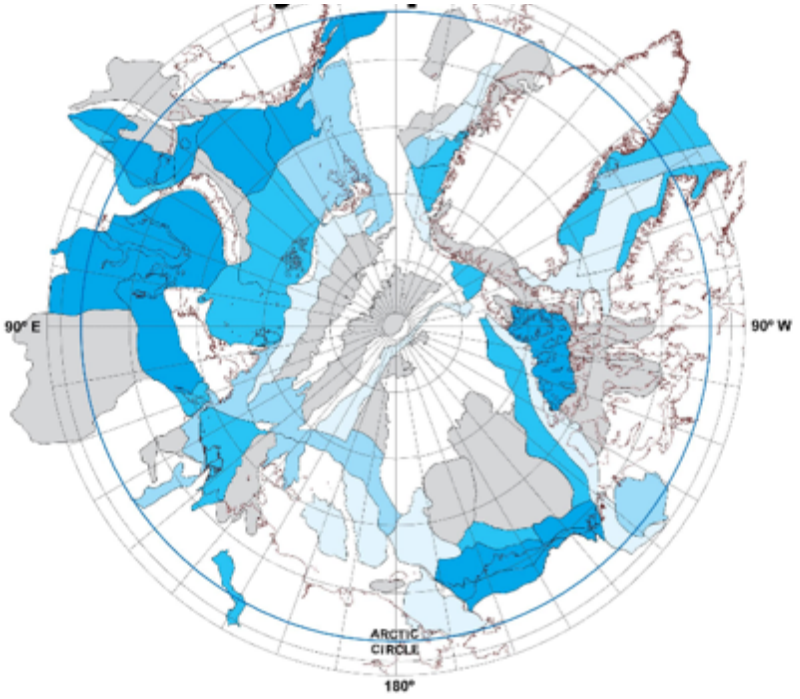
Arctic Boundaries and Yet To Find, YTF, Oil & Gas

Arctic Boundaries



Source: International Boundaries Research Unit, University of Durham 2008

Arctic YTF Oil & Gas



Source: USGS 2008

The Intersection of Sovereignty & Technology

Sovereign Nation Responsibilities

- A **sovereign state** is a nonphysical juridical entity of the international legal system that is represented by one centralized government that has supreme independent authority over a geographic area

National and International Obligations of a Coastal State

- Border security, including maritime boundaries
- Control of EEZ
- IMO obligations, regulations and treaties
- SAR and Environmental Protection
- Aids to Navigation

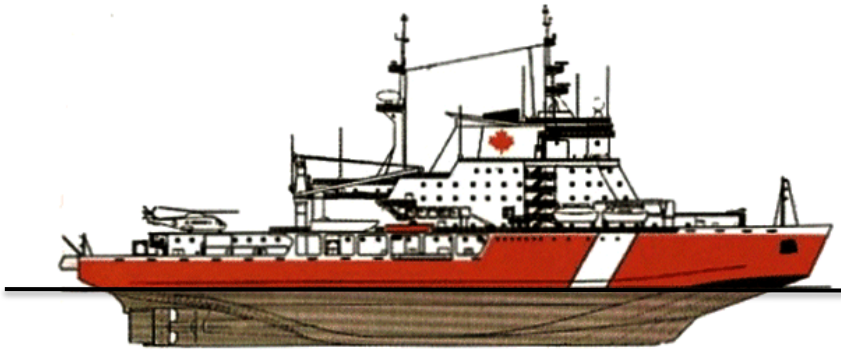
For an Arctic State, in the 21st century, these responsibilities and obligations can only be satisfied by the extensive use of technology, including ships, aircraft, and remote monitoring systems

Canada's new Polar Icebreaker CCGS Diefenbaker

A single polar icebreaking ship will be available for arctic duties, for 9 month per year when built – 2022+??

In the meantime Canada has very limited capability to exercise any control or to fulfill obligations in Northern Waters

Artist's Impression CCGS Diefenbaker



Polar 8 – 1980s

Planned CCGS Diefenbaker

Stated CCG Polar Icebreaker Missions

1. Sovereignty and presence
2. Arctic science
3. Weather and ice information
4. Economic and commercial development
5. National security
6. Northern re-supply and logistics support
7. SAR, environmental and emergency response
8. Fisheries conservation and protection

Russian Arctic Capability

Nuclear Icebreakers in Murmansk

Nuclear Icebreakers in service

Shallow Draft Nuc. Icebreakers

Commercial ship under escort

- Russian has an extensive and expanding capability for Arctic marine operations
- First Russian nuclear icebreaker in built in 1950s
- Current fleet allows year round operations with a mix of large nucler and conventional icebreakers, backed-up with medium and shallow draft icebreakers to assist in port access
- Russia also has a mature regulatory regime for managing shipping in the Northern Sea Route

US Arctic Capability

- Similar situation to Canada
- US government has neglected its Arctic
- Has one heavy icebreaker which is primarily used for science in both the Arctic and Antarctic
- Has 2 older, 1970s, polar icebreakers only one of which is operational

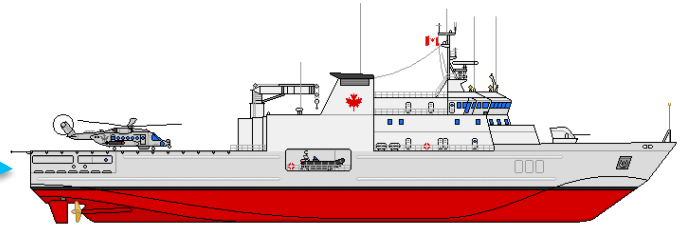
USCGC Healy


USCGC Polar Sea and USCG Polar Star

RCN Arctic Offshore Patrol Vessels

"Canada's new government understands that the first principle of Arctic sovereignty is: Use it or lose it,"

“Parent Ship” - NoCGS Svalbard



RCN - AOPS

With limited ice transiting capability these ships may not be a very effective way to project Canada’s sovereignty in the Arctic

Scientists seek to explain the world as it is

Engineers seek to develop a world that has never been

Theodore Von Karman

ARCTIC ENGINEERING INNOVATION, DEVELOPMENT AND RESEARCH

How to Innovate in Northern Waters?

- When, in the early 1960s, US President Kennedy said gave the challenge to land a man on the moon within the decade he established a vision which was not only achieved but, in the process, also developed an immense pool of useful knowledge and technology.
- It is postulated that setting visionary development goals are likely to have a similar effect on technology development and engineering for Canada's northern waters

Required Engineering R&D

- Engineering is about innovation and creativity
- Mostly research follow innovation
  - Watt vs Kelvin etc.
- Advances in Arctic Engineering as in other technology fields are made by doing
  - Kigoriak, Kulluk, SDC, Tarsiut Caissons, Molikpaq etc.
- Engineering research needed in the areas of
  - Ice structure vibration interaction issues
  - Ice loads on ship hulls in heavy ice
  - Efficient ice worthy propulsion systems

Proverbs 29:18

“Where there is no vision, the people perish”

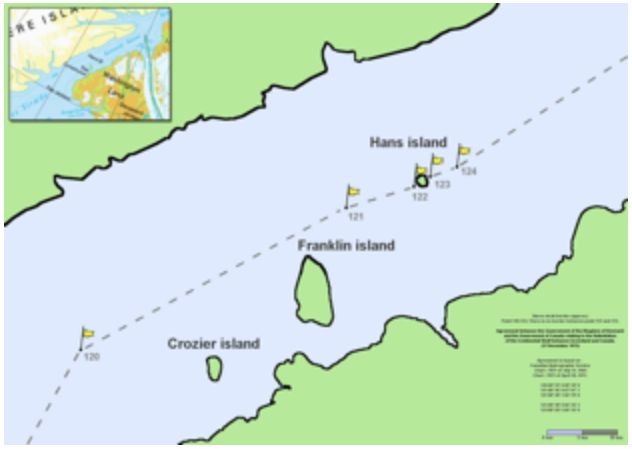
CONCEPTUAL VISIONARY PROJECTS & PROGRAMS

INTERNATIONAL ARCTIC OCEAN-SPACE ENGINEERING EXPERIMENTAL STATION, IAOSEES

International Arctic Ocean-Space Engineering Experimental Station

- There is a need for large scale experimentation to further advance Arctic marine & offshore engineering development
- In the past this has been done on an ad-hoc basis and has been limited by the high logistical costs of operating in the Arctic environment.
- The IAOSEES concept would see development of a permanent base on Hans Island, which is currently disputed territory between Canada and Denmark
- The IAOSEES would be jointly managed by Canada and Denmark and base funding would be under-written by the Arctic Council – both member and observer nations
- The concept could be similar to the Ny-Ålesund research facility in Svalbard which is managed by the Norwegian government and has ~10 countries working on arctic scientific research.
- This facility could be operated under the new Canadian High Arctic Research Station, CHARS, now being developed in Cambridge bay

Hans Island – Kennedy Channel Canada - Denmark



Engineering R&D which might be carried out

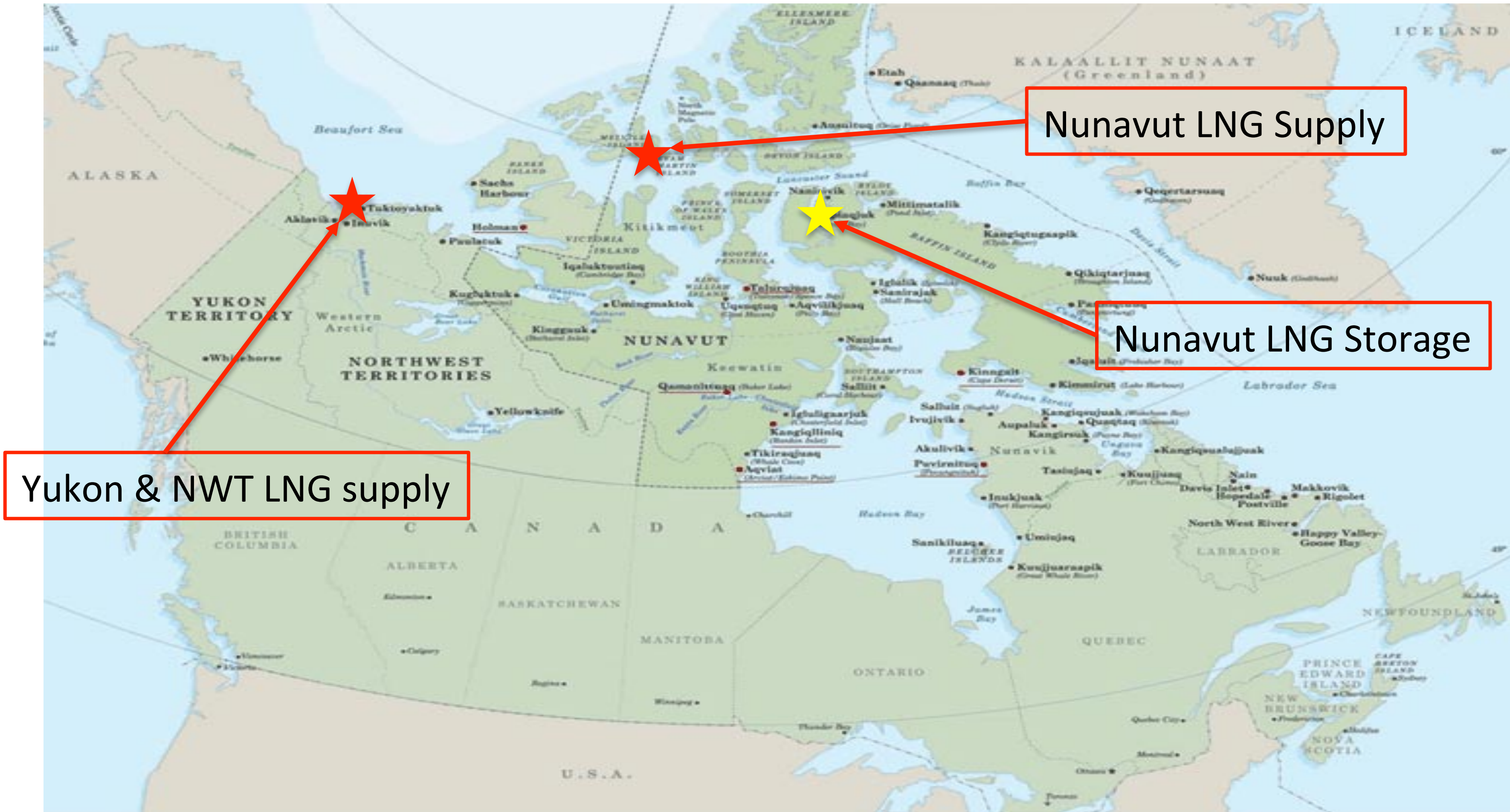
- Hans Island has already been used to investigate global ice impact loads on fixed structures 3 decades ago.
- The IAOSEES could be used to experiment and study –
  - Ice loads on structures, spill response, power generation, water supply, Arctic aviation, drone technology for data collection in the high Arctic, and many other needed technologies.

ARCTIC LNG - CLEAN GREEN FUEL FOR THE NORTH

Concept

- The Arctic has an abundant supply of natural gas both in the Beaufort Sea region and in the Arctic Archipelago
- Arctic communities and activities need fuel and when brought north traditional fuels are expensive, delivered in a way that puts the environment at risk and sometimes limited in supply.
- Developing an Arctic LNG Public Private partnership to be able to supply LNG both for fuelling government Arctic operations and supplying local community needs would provide clean green fuel Arctic fuel which would, for example, allow year round icebreaker operations

Arctic LNG



Nunavut LNG Supply
Nunavut LNG Storage
Yukon & NWT LNG supply
ALASKA
YUKON TERRITORY
NORTHWEST TERRITORIES
NUNAVUT
C A N A D A
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
LABRADOR
NEWFOUNDLAND
NEW BRUNSWICK
NOVA SCOTIA
U.S.A.
ICELAND
KALAALLIT NUNAAT (Greenland)
Beaufort Sea
Hudson Bay
Labrador Sea
Baffin Bay

LNG Icebreakers and Floating Plant

New Finnish State Icebreaker – LNG Powered

Barge Mounted LNG Liquefaction Plant

Concept Design – Icebreaking LNG Ships - Yamal

Ice class LNG ship Kenai Alaska

MOBILE ARCTIC ENGINEERING RESEARCH PLATFORM

Ship as the Experiment

- In this concept an Iceworthy ship would be developed to be the engineering experiments itself, rather than a platform for science laboratories
- Ice transit experiments, hull and propeller loads, study of towing of arrays in ice, ice management strategy development, experiments to develop support of sub-sea developments in ice
- Nanisivik might make a good northern base?

Building a railroad down the McKenzie Valley from Hay River to Inuvik could be an enabler for western Arctic development and assist in bringing offshore oil and gas projects to fruition.

CANADIAN ARCTIC RAILWAY

Canadian Arctic Railway

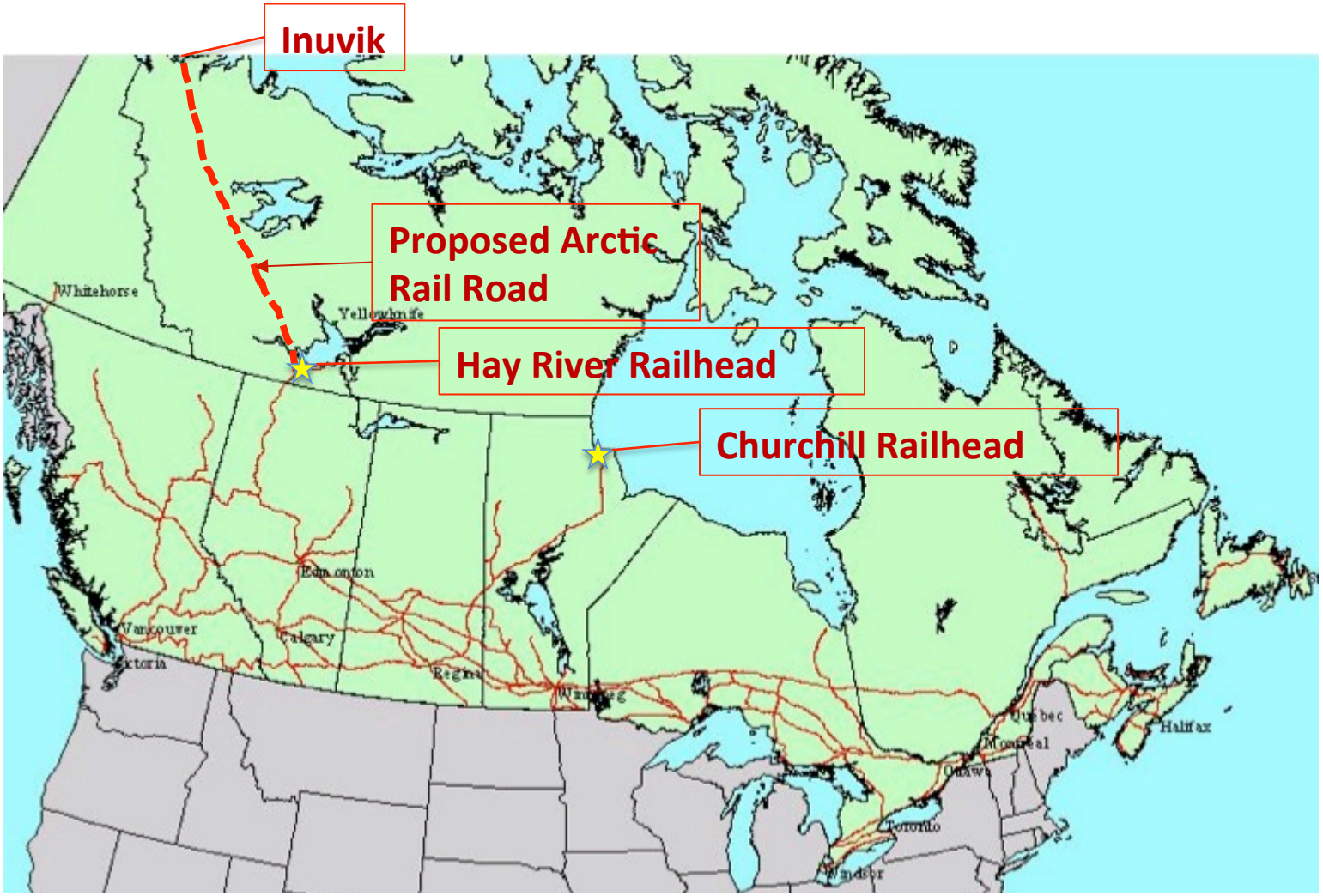
- A Canadian Arctic Railway would provide a two-way system which could be used to deliver materiel for northern construction as well as fuel and other essentials for local communities presently serviced by summer barge traffic on the McKenzie River.
- The system could bring Arctic oil to southern markets, and the rail road would provide a strong logistics link to the western arctic which would improve infrastructure; reinforce Canadian Arctic Sovereignty.
- Further the system would allow for development of other natural resources such as mining and forest product developments, along its route.

Canadian Arctic Railway 2

- Further the CAR could be fueled with LNG produced locally in the McKenzie Delta- Beaufort Sea area (and LNG could be exported to communities along the McKenzie by tank car, providing northern fuel to northern communities)

- The CAR could probably be routed along the McKenzie Valley Gas Pipeline (significant work already done and pipeline although approved will not be built anytime soon).

Canada Rail Network



Rail Systems and the Oil Industry

- Russia Crude Export by Rail
  - "Rail exports comprise roughly 5 percent of Russian oil exports…… Russia exports crude oil and petroleum products by rail through Estonia and Latvia. Additionally, crude oil is transported to China via rail to the northeast cities of Harbin and Daqing and to central China via Mongolia"
    - Eia.gov website, September 18, 2012
- Bakken Crude Transport by Rail
  - "In the space of just over one year North Dakota crude rail takeaway capacity has reached close to 1 MMBb/d"
    - RNB Energy LLC Website 02/11/2013

CANADIAN ARCTIC ENGINEERING EXPERTISE

CANADIAN EXPERTISE AND EXPERIENCE

Past glories

- The study of ice and ice mechanics dates back to the early 1900s. Professor Barnes at McGill studied ice strength and ice loads on bridge piers.
- The National Research Council in Ottawa had ice experts who studies the possibility of reinforced ice to make aircraft carriers to defend the Atlantic convoys during WW2 (Habbakuk Project).
- The case histories have outlined how commencing on about 1970, Canadians were leaders in developing methods for offshore drilling in the Beaufort Sea.

Current Situation

- Many of today's Canadian Arctic offshore engineers developed their skills in the first phase of Beaufort Sea exploration commencing in about 1970.
- At that time the Canadian oil companies were prominent in pushing the technology envelope.
- Today, with the exception of one, most Internationals headquarter their Arctic R&D in their home countries (e.g. Houston, TX).
- They do use Canadian expertise – but control it from their HQs

Today`s Capabilities

A current survey indicates a total of about 120 internationally recognized Canadian Arctic engineering experts.

- By Location
  - BC –-16
  - Calgary – 42
  - Ottawa - 20
  - St John`s – 37
  - Canada & Intern'l – 9

- By Organization
  - Oil Companies – 20
  - Large Consulting Companies – 11
  - Small Consulting Companies – 31
  - Universities - 7
  - Institutes - 25
  - Government – 32

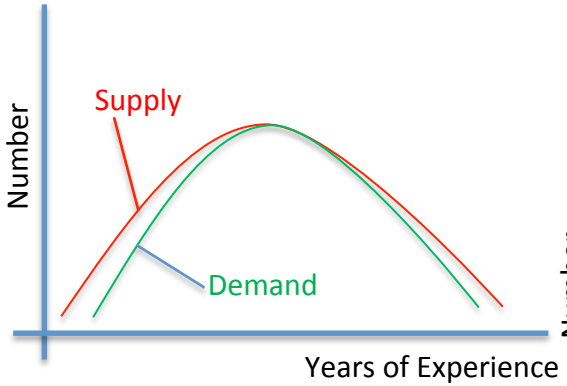
Related Experience

- It is recognized that traditional knowledge plays a role in engineering for Northern Seas and that there is benefit from close relationships between engineers and Northern residents through organizations such as the Centre for the North, CFN, which provides a forum for research and dialogue on Northern and Aboriginal issues.

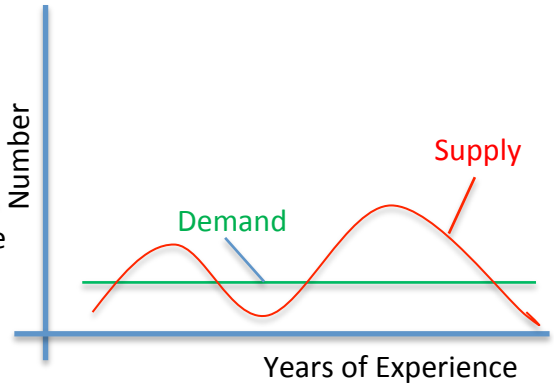
The 1st Ice Engineering Age – 1970s to mid 1980s produced a good number of Arctic Engineers, but lack of sustained engineering efforts in the North have not maintained a steady supply of new talent which we now require as we enter the 2nd Ice Engineering Age

THE AGING OF EXPERIENCED ARCTIC ENGINEERS

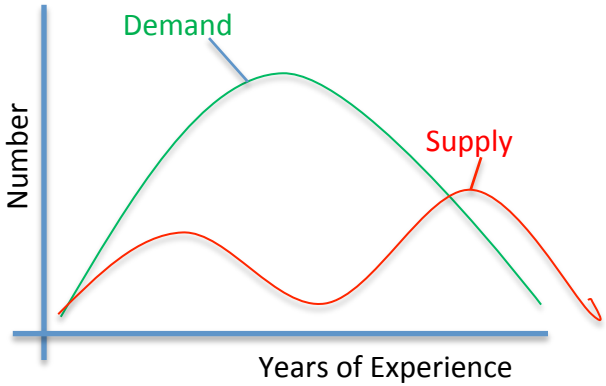
Age Demographic for Arctic Engineers



1983 – At end of 1st Ice Engineering Age – supply and demand balanced



2005 - Just before the 2nd ice Engineering Age demand was low and supply consisted mostly of a small number of aging ice engineers with few new recruits



2014 – A few years into the 2nd Ice Engineering Age demand has grown substantially but supply still consists of a pool which has a large percentage of ever aging ice engineers with a small number of new recruits

Potential Solutions

- Capture Knowledge from Experienced Arctic Engineers through
  - Mentoring
  - Narrative Knowledge Transfer (Engineering Story Telling)
  - Webinars and Web-based Learning
- Provide enhanced education opportunities and experience for young engineers who show interest in the Arctic (perhaps using Professors of Practice?)
- Provide opportunities for professional engineering experience through
  - Internships
  - Project experience
  - Field Studies
  - Icebreaker deployments

HURDLES TO NORTHERN SEAS DEVELOPMENTS

Big Issues

- Transport –
  - need safe, reliable, cost effective solutions
- Infrastructure –
  - need development of port facilities, support systems (icebreakers, aids to navigation etc)
- Energy –
  - the north is rich in energy, but producing and supplying it to the required consumers will take serious development
- Environmental Protection
  - Any northern seas development must be carried out with full respect for the environment in which systems will operate
- People –
  - most important element: includes education, through-career professional development, competence certification

RECOMMENDATIONS

Preliminary Recommendations

- Create visionary projects to enable development in Canada's northern seas.
- Possibly integrate some of the proposed idea, e.g. develop Arctic LNG and use it to power Arctic Railway and Mobile Arctic Engineering Research Platform.
- Develop Arctic Engineering Field Research by extending Cambridge Bay CHARS to include the proposed IAOSEES
- Continue to explore how to develop the "people" aspects of Arctic Engineering through University-Government-Industry partnerships to maintain Canada's global leadership in Engineering for Northern Seas

QUESTIONS?

THE CANADIAN ACADEMY OF ENGINEERING

Leadership in Engineering Advice for Canada

L'ACADÉMIE CANADIENNE DU GÉNIE

Chef de file en matière d'expertise-conseil en génie pour le Canada