



"Engineering for Canada's Northern Oceans".

A study being conducted under the auspices of the Canadian Academy of Engineering (CAE).

By

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Outline of talk

- Canadian Academy of Engineering
- Origins of this study
- Study objectives
- The driving premises
- Some key issues & topics
- A glimpse of the recommendations

THE CANADIAN ACADEMY
OF ENGINEERING

*Leadership in Engineering Advice
for Canada*



L'ACADÉMIE CANADIENNE
DU GÉNIE

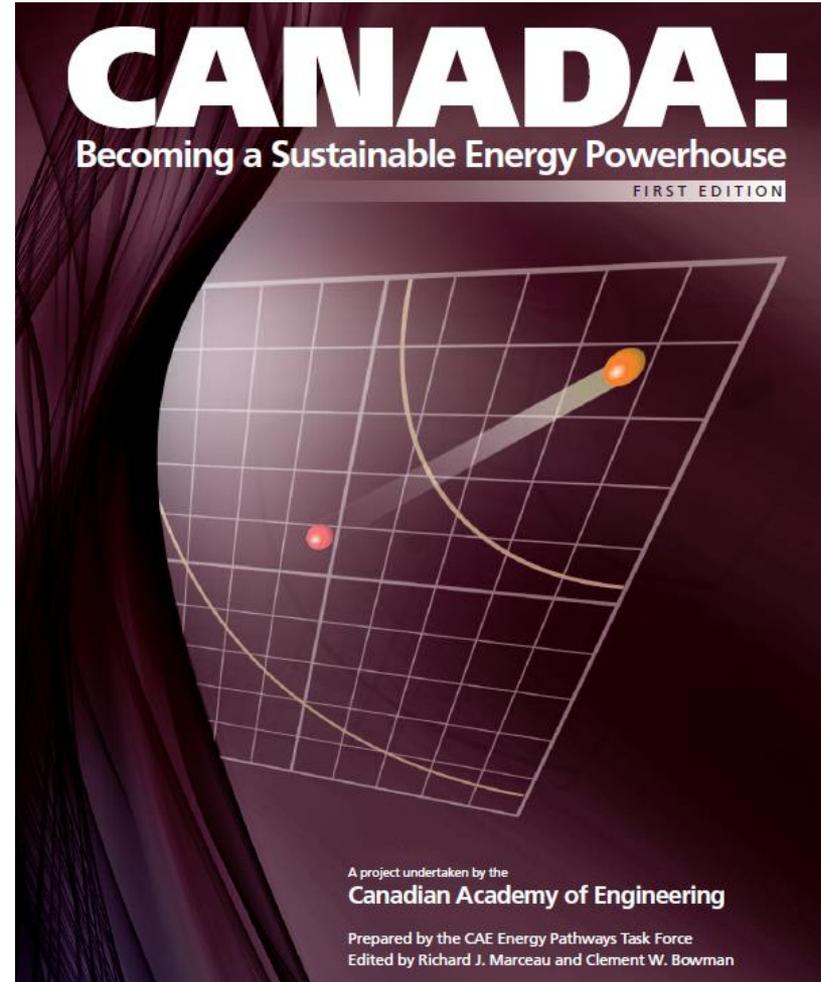
*Chef de file en matière d'expertise-conseil
en génie pour le Canada*

- The Mission of the CAE is to provide leadership in engineering advice and to enhance, the promotion of engineering, the well-being of Canadians and the creation of wealth in Canada.
- The Academy is an independent, self-governing and non-profit organization established in 1987. Fellows of the Academy are nominated and elected by their peers.
- Those interested in further information can go to www.cae-acg.ca.

"To create and to preserve".

Origins of this study

- In the past few years CAE has undertaken studies relating to key Canadian issues
 - *Canada: Becoming a Sustainable Energy Powerhouse* →
 - *Trottier Energy Futures Project* (strategies for reducing greenhouse gas (GHG) emissions in Canada by 80% by 2050, relative to 1990).
- At the 2012 Annual meeting in Ottawa the CAE President requested ideas for other studies of importance to Canada.
- Ian Jordaan and I suggested a study relating to Arctic offshore engineering for Canada.
- It was approved, and we recruited Bob Frederking and Peter Noble to the team.



General study goals

- To assess Canada's offshore Arctic capabilities, past achievements and future challenges; and to provide recommendations for exploiting future opportunities, maintaining expertise and Arctic sovereignty.
- We use the term Northern Oceans rather than Arctic – to avoid strict geographical boundaries.



A Mari usque ad Mare

Premises* to build on during the study

- A large area of Canada is in the Arctic and/or influenced by Northern Oceans, so as a country we have a stake in these regions - - and a responsibility !
- Canadians have already developed world-class expertise in Arctic engineering and have applied it both at home and abroad.
- There are future opportunities in developing Arctic resources and infrastructure which will create wealth for Canadians (as the existing offshore oil and gas and mining developments are doing now).
- There are engineering challenges associated with these future activities. (These include climate change).

* A basis, stated or assumed, on which reasoning proceeds.

Premises to build on during the study (contd.)

- Canada can build on its current expertise to address these challenges. But we also need to enhance it and sustain it through boom and bust cycles
- Education, training and experience needs to be sustained and involve Northerners.
- How do we better coordinate current efforts and groups (e.g. NRC, C-CORE, Industry, Consultants, Governments) - An Arctic Engineering network?
- In addition to wealth creation from resources in Canada, the knowledge developed can be applied world-wide.
- There are some flagship developments, logistics and infrastructure projects which can create wealth and help enhance expertise and sustain it.

“Life is the art of drawing sufficient conclusions from insufficient premises”.

Samuel Butler (1835–1902)

Case histories demonstrating Canadian expertise

- Beaufort Sea
- Arctic Islands
- Grand Banks
- Confederation Bridge
- North Caspian Sea
- Russia/Sakhalin
- Polaris and Voisey's Bay
- Arctic Pilot Project



“In almost every art, experience is worth more than precepts” - Quintilian

Canadian expertise – Early milestones

- 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 studied the possibility of reinforced ice to make aircraft carriers to defend the Atlantic convoys during WW2 (Habbakuk Project).
- Commencing on about 1970, Canadians were leaders in developing methods for offshore drilling and production in the Beaufort Sea.

“Thus fortune on our first endeavours smiles” Virgil

Quote from the draft report

“It should be remembered that at its zenith in the late 1970s – early 1980s, oil and gas exploration in the Canadian Beaufort Sea was a considerable enterprise. It involved thousands of Canadians (many local Northerners) as well as new technology developed mostly in Canada. It is an important case-history, because it created a significant body of Canadian Arctic engineering expertise and demonstrated how new methods for offshore operations in ice were developed and safely implemented”.

Today's 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 International Companies headquarter their Arctic R&D in their home countries (e.g. Houston!).
- They do use Canadian expertise – but control it from their HQs

“This is not the end. It is not even the beginning of the end.

But it is, perhaps, the end of the beginning “ -----Winston Churchill, 1943

Today's Capabilities

A survey conducted for this study indicates a total of about 125 Canadian Arctic “engineering” experts.

By location

- BC – 16
- Calgary – 42
- Ottawa -- 20
- St John`s – 38
- Other Canadian and International – 9

By organization

- Oil Companies – 20
- Large Consulting Companies – 11
- Small Consulting Companies – 30
- Universities - 7
- Institutes - 25
- Government – 32

Inventory of current expertise in our “Canadian Arctic network”

- R&D into the fundamentals of ice mechanics.
- Ice-structure and ice-ship interactions.
- Ice detection and ice management.
- On-ice field work to measure ice morphology and strength.
- Ice characterization and forecasting – usually based on satellite imagery analysis.
- Development of statistical descriptions of the ice environment.
- Ice motion modelling and its application to environmental issues such as oil spills.
- Development of ice design criteria especially ice loads on platforms and ice resistance of ships.
- Platform designs for ice covered waters.
- Logistics and operations in ice covered waters including escape and evacuation.
- Offshore construction in ice
- Ice model tank experiments to aid in the above topics.
- Ice roads and ice platforms.
- Ice design criteria for offshore pipelines, especially burial depths to avoid ice gouging of the sea floor.
- Training on ice topics including courses to industry personnel.
- Leadership and contributions to development of International Codes and Standards.

“The more to help the greater deed is done” - Homer

“Traditional” Experience

- It is recognized that traditional knowledge is an important source of Canadian expertise.
- There is benefit from close relationships between engineers and Northern residents
- We will be recommending that Northern residents be provided with the opportunity to be educated in and to practice Arctic engineering.



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

“Though we are not now of that strength which in old days moved earth and heaven ---
we are what we are ”

Alfred Lord Tennyson - Ulysses

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 Northerners who show interest in the Arctic engineering***
- Provide opportunities for professional engineering experience through
 - Internships
 - Project experience
 - Field Studies
 - Icebreaker deployments
 - *Visionary projects (as will be described later)*

CURRENT NORTHERN WATERS SHIPPING ACTIVITY

WITH A COMMENT ON CLIMATE CHANGE EFFECTS

Recent Eastern Arctic Shipping

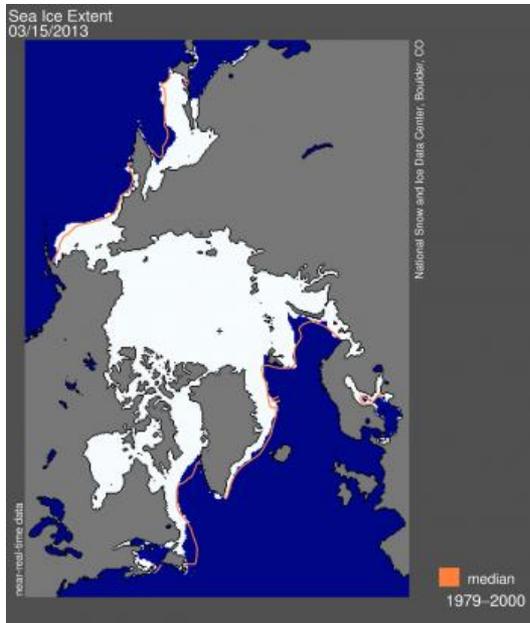


Trans-Polar Shipping

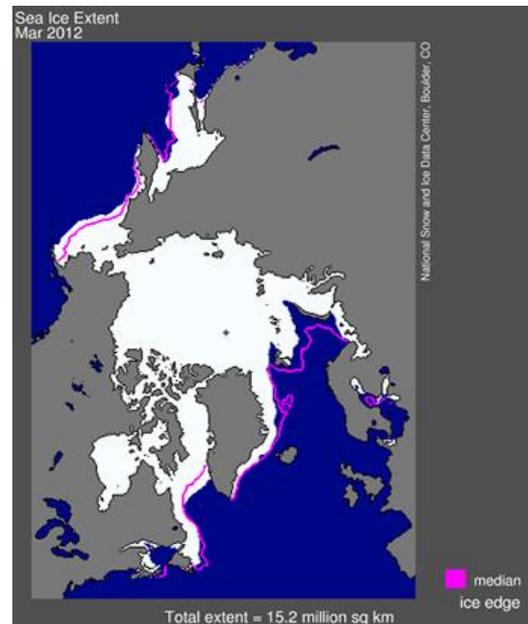


- Recent changes in summer ice cover in the Arctic have led to much speculation on using trans-polar shipping routes to connect Pacific and Atlantic ports.
- The potential for significant trans-arctic shipping is probably not high in general and relatively low for the NW Passage due to uncertainty of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

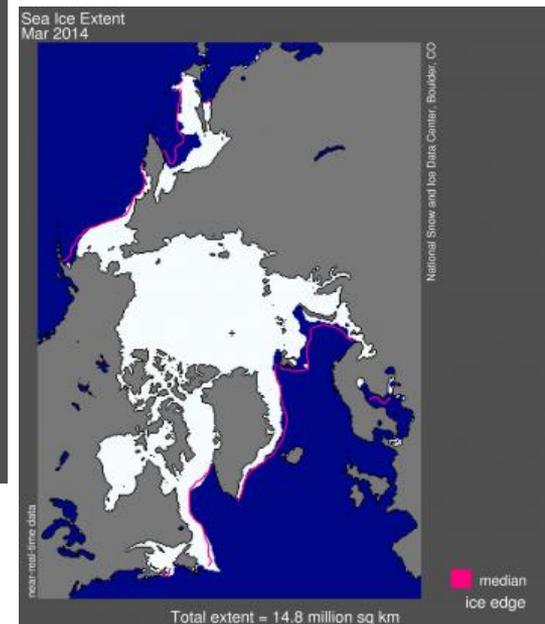
Arctic Ice Cover - March



March 2012

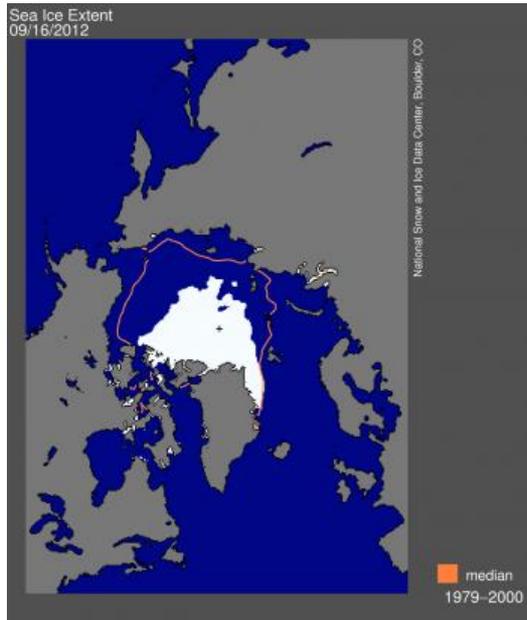


March 2013

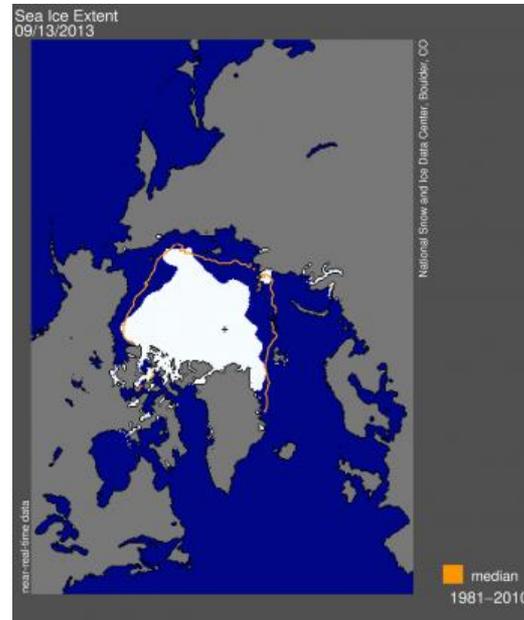


March 2014

Arctic Ice Cover - September



September 2012



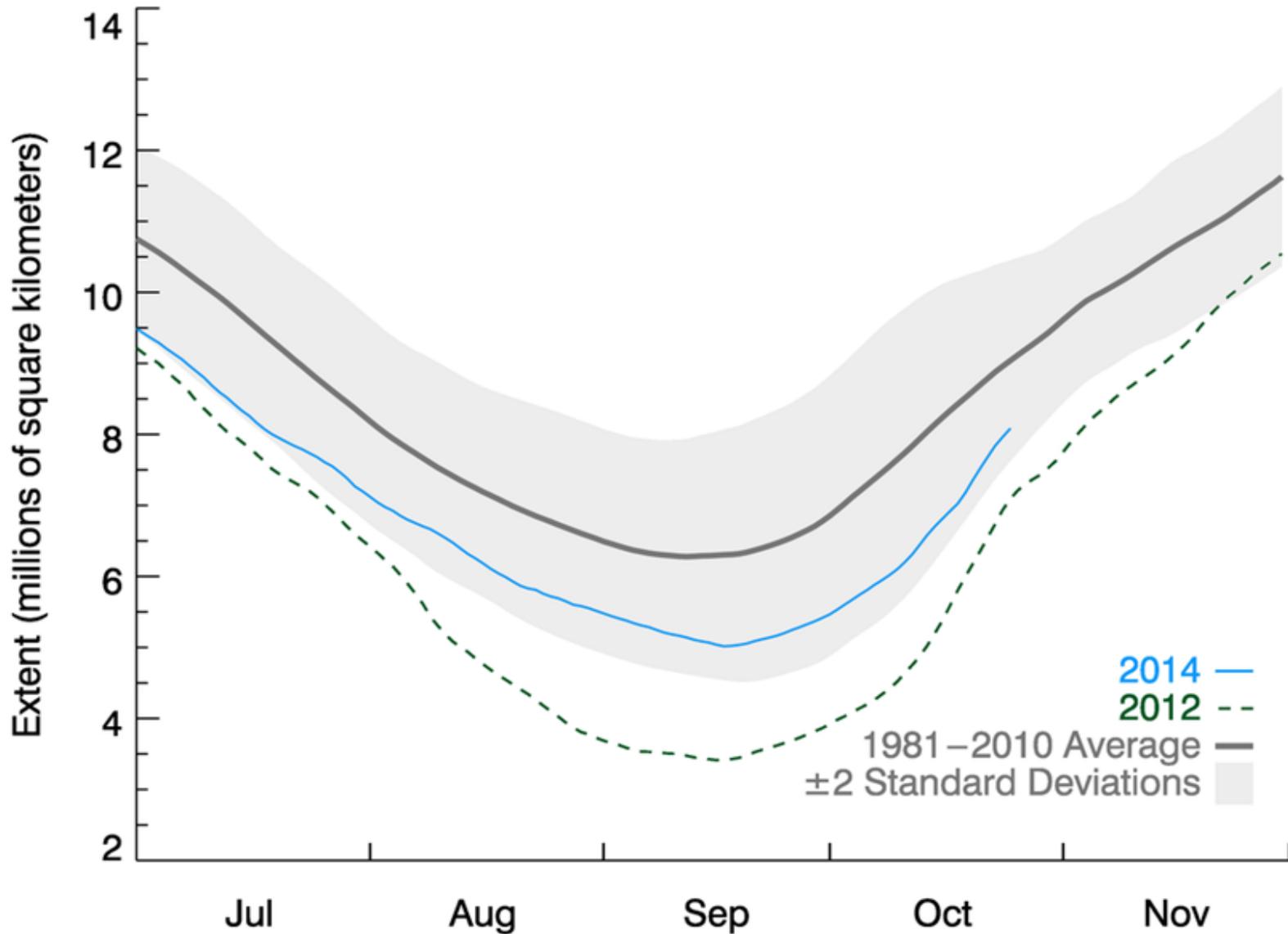
September 2013



September 2014

Arctic Sea Ice Extent

(Area of ocean with at least 15% sea ice)



National Snow and Ice Data Center, Boulder CO

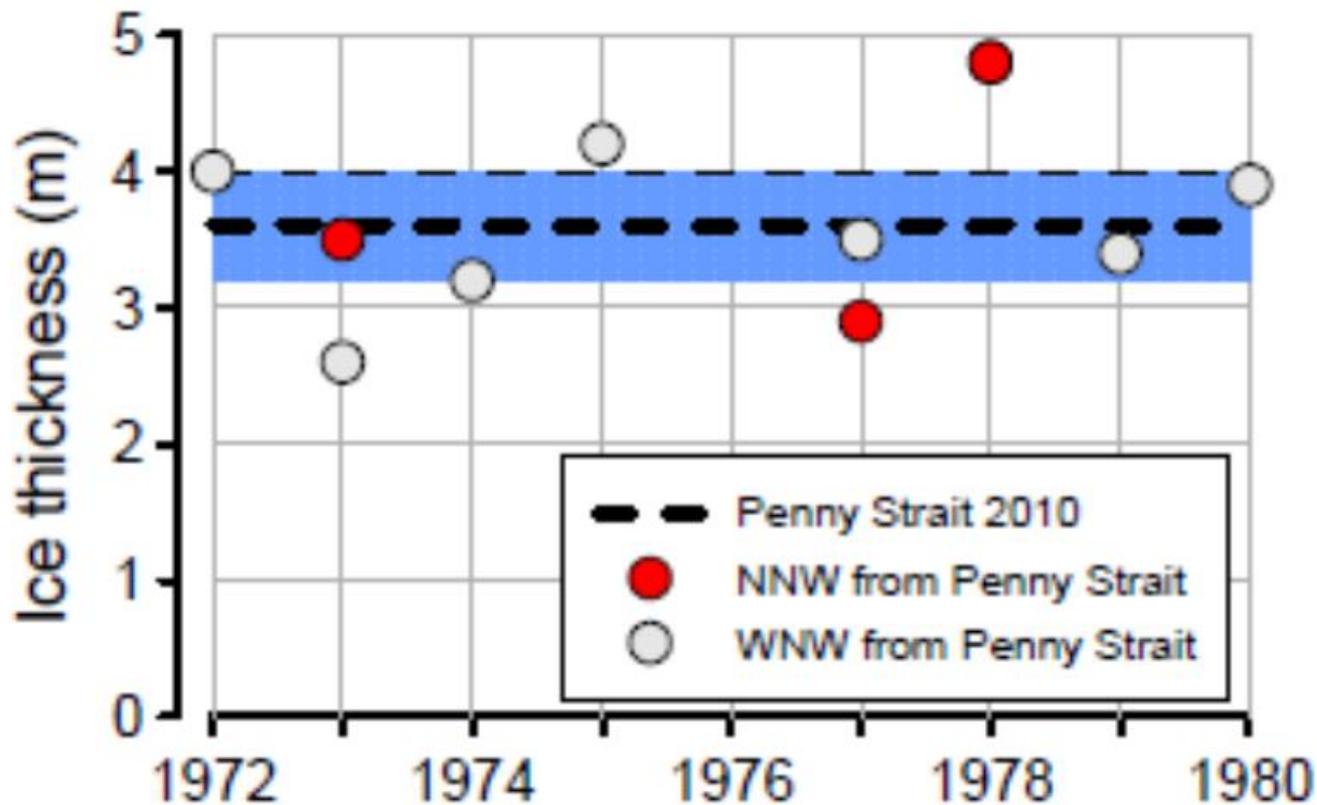
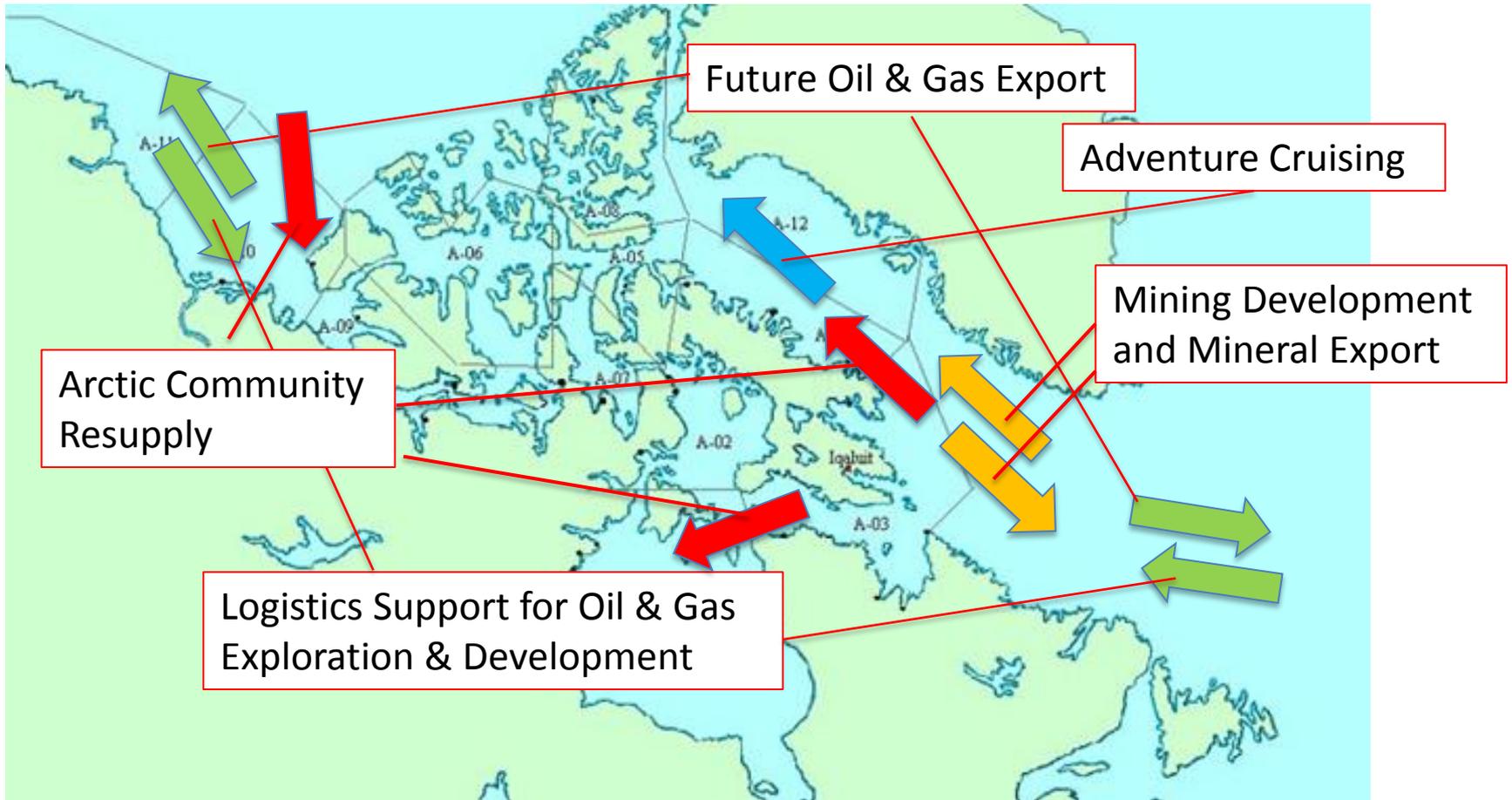


Figure 25. Track-mean ice thickness from drill-hole surveys north-west of Penny Strait during late winter in the 1970s, compared with values based on 2009 data (shaded band is $\pm\sigma$).

Multi-year ice between the Arctic Islands has not thinned !

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

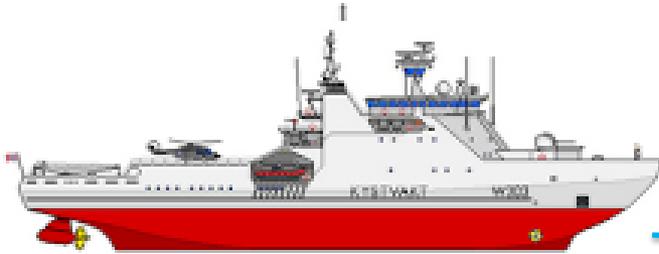
Stated CCG Polar Icebreaker Missions

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

RCN Arctic Offshore Patrol Vessels



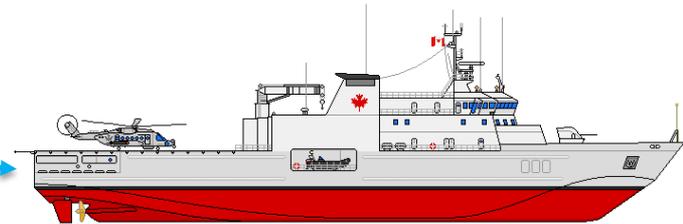
"Canada's new government understands that the first principle of Arctic sovereignty is: Use it or lose it,"



"Parent Ship" - NoCGS Svalbard



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



RCN - AOPS

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

“The best laid plans of mice and men gang oft agley” --- Robert Burns

Other routes to Sovereignty ?

Visionary Projects

Proverbs 29:18

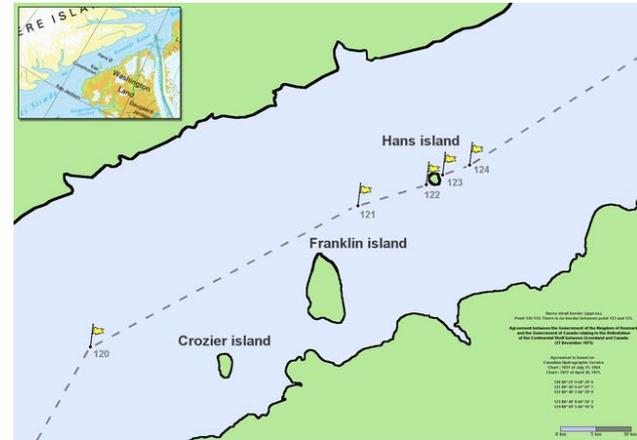
“Where there is no vision, the people perish”

CONCEPTUAL VISIONARY PROJECTS & PROGRAMS

**INTERNATIONAL ARCTIC ENGINEERING
EXPERIMENTAL STATION (IAEES)**

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 IAEES 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.

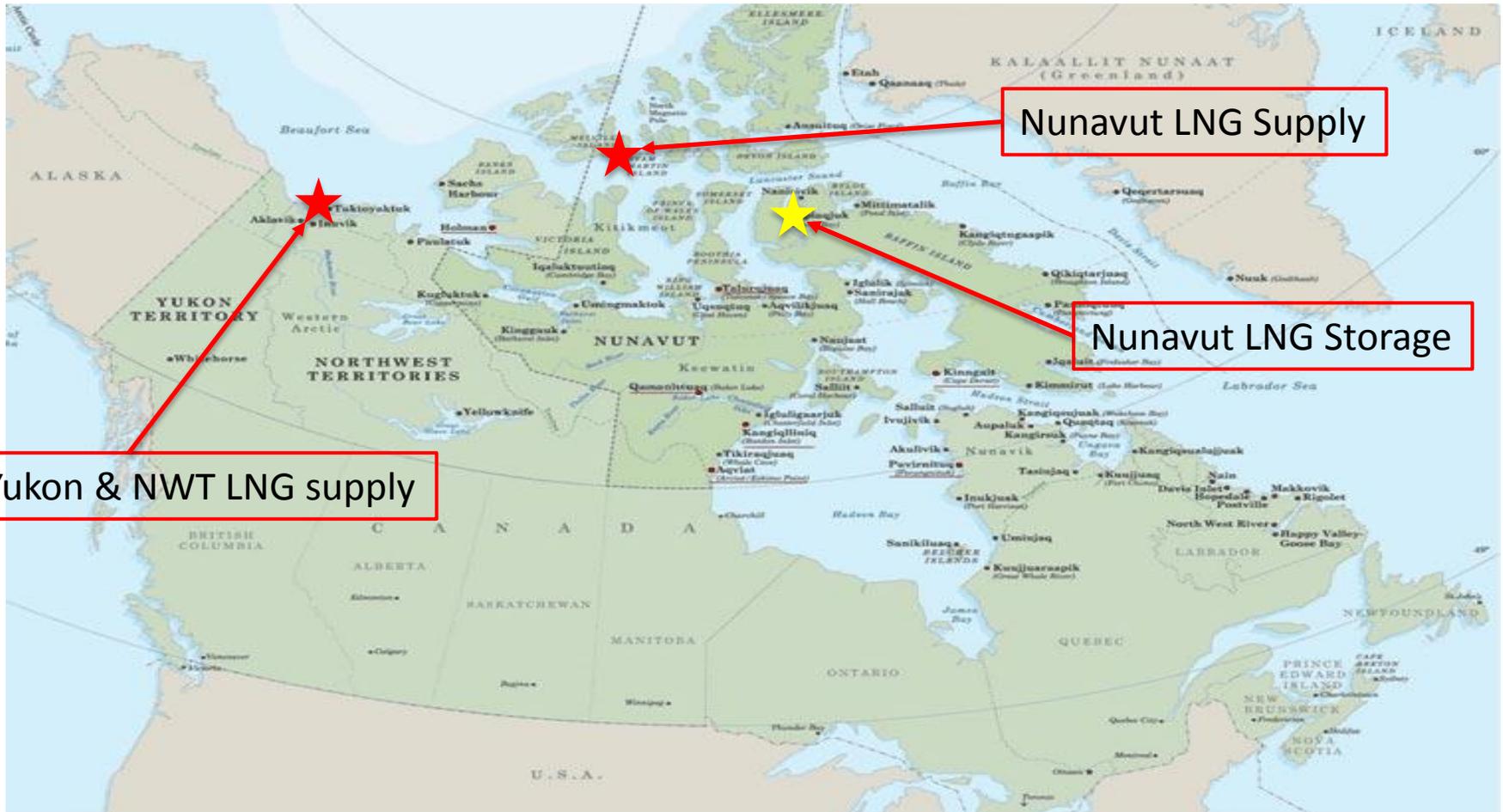
“Nothing binds men so closely as agreement in plans and desires” - Cicero

International Arctic 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 IAEES concept would see development of a permanent base on Hans Island, which is currently disputed territory between Canada and Denmark
- The IAEES 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

ARCTIC LNG - CLEAN GREEN FUEL FOR THE NORTH

Arctic LNG



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

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?

“I must go down to the seas again to the lonely sea and sky – and all I ask is a tall ship and a star to guide her by “– John Masefield

Other “visionary projects”

- Arctic Railway to the Mackenzie Delta
- Export oil terminals (e.g. at Churchill or on the Beaufort Sea coast) (as in the recent Canatec study)
- Ideas ???

Current Table of Contents -- 1

Executive Summary

1. Overview

1. Introductory Comments
2. Climate Change

2. Review of Recent Studies by Others

3. Canadian Activities and Engineering in Northern Oceans

1. Inventory of Canadian Centres oriented towards Northern Research
2. Codes and Standards
3. Canadian Expertise in Northern Offshore Engineering

Current Table of Contents – Contd.

4. Canadian Engineering Projects for Northern Oceans

1. Introduction (reference to Inventory of past (**APOA**) and current engineering projects for northern oceans)
2. Case Studies showing Canadian Experience

5. Inventory of Mineral Resources

6. Future Potential Canadian Development Scenarios

1. Inventory of Current Infrastructure
2. Assessment of Future Developments and Identification of Engineering and Technology gaps

7. Recommendations on R&D strategies to close gaps & Northern involvement

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 IAEES
- 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

In Closing

- The report is in final draft stage
- It will be subject to internal review by CAE
- Publication is planned by the Summer
- Thank you for those of you providing input to date
- Any addition suggestions can be e-mailed to me.
- Thanks for your time today.
- Discussion ?

“Adventure on, for from littlest clue has come whatever worth man ever knew,
the next to lighten all men may be you !”

John Masefield