
# AKER ARCTIC TECHNOLOGY

## Ship Design Developments in the Polar Regions

Rob Hindley

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# Overview

- Objective
- Expansion of Arctic Shipping?
- Transit vs. Destinational Shipping
- Arctic Containerships Feasibility Study
- Alternative Fuels for a Baltic Icebreaker
- Technology Challenges for all Arctic Ships of the Future



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# Objective

*Present an opinion on the design development direction for Polar Ships*



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# What ship Design Developments are there in Arctic Shipping?

Design-wise

- Cargo ships are no operating year-round in the Arctic
- Non-nuclear icebreakers have reached the North Pole (in Summer)
- Icebreaking Cruise Ship has reached the North Pole (will be a regular occurrence
- O&G Terminals in the Arctic can be kept open all year

…Only incremental developments left?



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# Arctic Containership – DOA?

Given that Arctic shipping is mostly destinational in nature

Given that we have just said that transit volumes on the NSR are small and likely to stay that way

Given that there is political uncertainty with using the route

***Why investigate feasibility of an Arctic Containership at all?***

- There is political motivation to use the NSR as a transportation route
- Many of the logistic hurdles could be overcome with significant state investment
- A good way to investigate technical challenges for Arctic ships in general

*Energy efficiency requirements are driving the industry to look at different ways of operating and many of the energy efficiency requirements are framed around fuel burn vs. cargo carried…does the Arctic have a role to play?*



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# Arctic Containership Transit Study

- Hamburg – Shanghai
  - Suez
  - NSR
  - NSR (transshipment at Kamchatka and Murmansk)
- Aker Arctic's transit simulation model for ice and open water performance
- To investigate main factors infulencing economic viability and size of vessel
- Costs for each route are calculated as average price per container transported over an entire year and considering the CAPEX and OPEX cost distributed over the whole vessels life
- With this approach is possible to take in account the number of containers transported, the seasonal ice conditions variations and the transit times.



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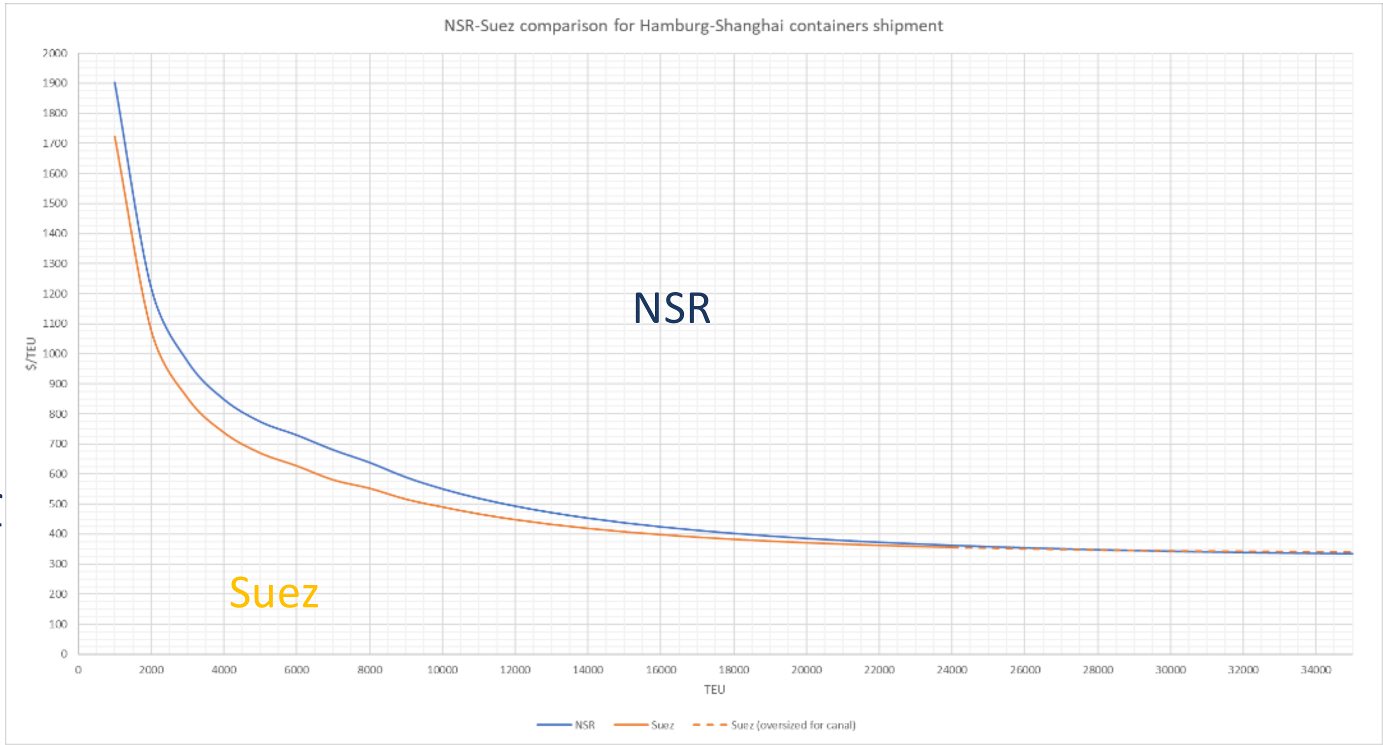
# Direct Comparison NSR vs. Suez

$ / TEU




TEU (size of ship)

- In the scenario studied the crossing point where the NSR becomes more advantageous is at very high TEU.
- This crossing point position is heavily affected by the fuel price and the ship load factor.
- During the Suez route the vessel has the possibility of doing multiple stops in intermediate ports, keeping the ship load factor always very high.



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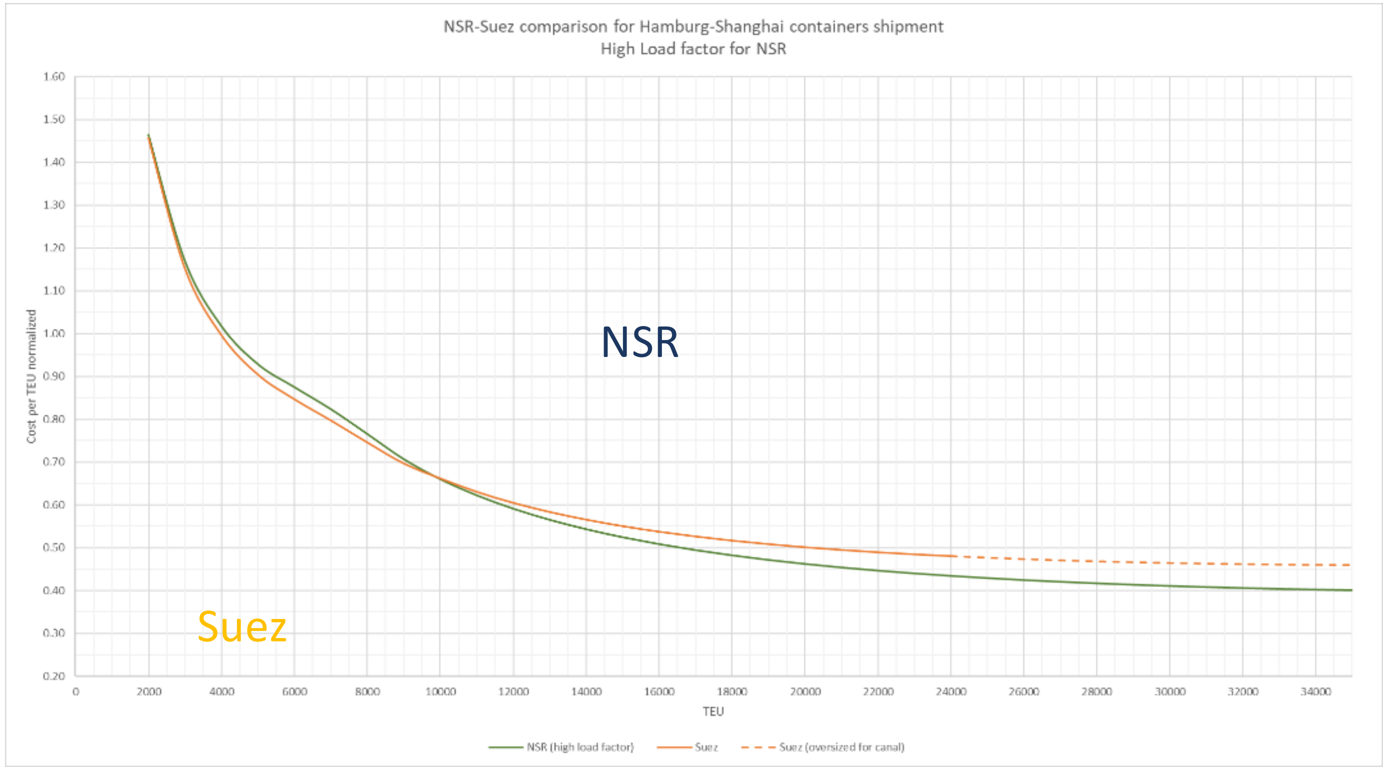
# Transhipment NSR vs. Suez




$ / TEU

TEU (size of ship)


- In this way, multiple regular open water container vessels would be able to bring containers to the hubs from different ports and then some high-capacity Arctic container vessels would travel between the two hubs with very high load factor
- Increases container transit time due to offloading / loading



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# Feasible Arctic Containership Design

- Two sizes of containership studied
  - 8,000 and 18,000 TEU
  - 8,000 basis if YamalMAX LNG Carrier hull form
  - 18,000 TEU version is a stretched version
  - Two propulsion configurations used for each size of ship – based around "double acting concept" or conventional shaft lines
    - Independent operation for DAS version
    - Shaft line version requires assistance in heavy winters
  - Azimuth thruster size limited to those currently available at high ice class
  - Note Southern route around New Siberian Islands draft limited to 13m



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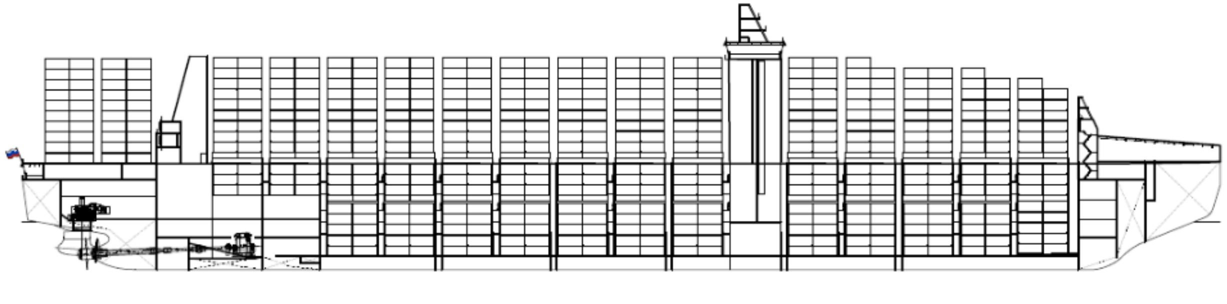
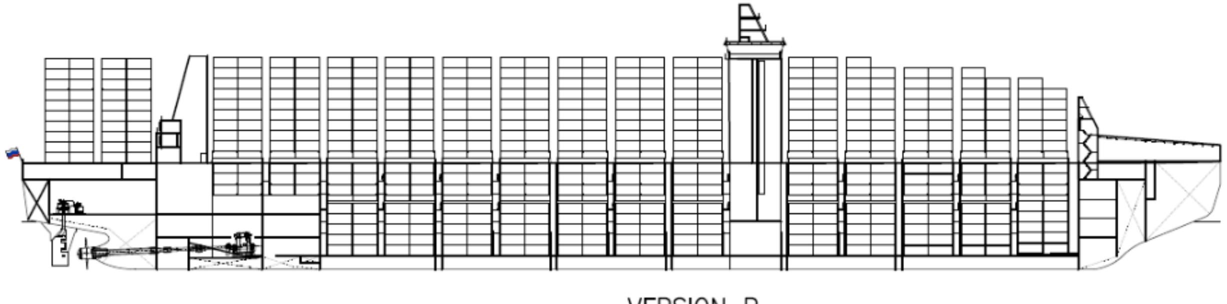
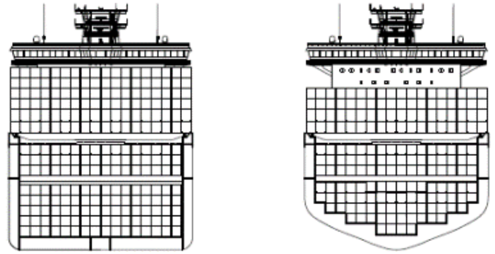
# 8000 TEU Arctic Containership



| Aker ARC 220 | |
|---|---|
| **CONTAINER CAPACITY** | 8,000 TEU |
| **LENGTH OVER ALL** | 300 m |
| **LENGTH AT DESIGN WATERLINE** | 290 m |
| **BREADTH** | 46 m |
| **DRAUGHT AT DESIGN WATERLINE** | 13 m |
| **INSTALLED PROPULSION POWER** | |
| VERSION A<br>1x22MW Shafts<br>2x17MW Thrusters | 56 MW |
| VERSION B<br>2x22MW Shafts | 44 MW |
| **LEVERL ICE PERFORMANCE AHEAD (3kts)** | |
| VERSION A | 2.3 m |
| VERSION B | 1.9 m |
| ICE CLASS | RMRS Arc7+ |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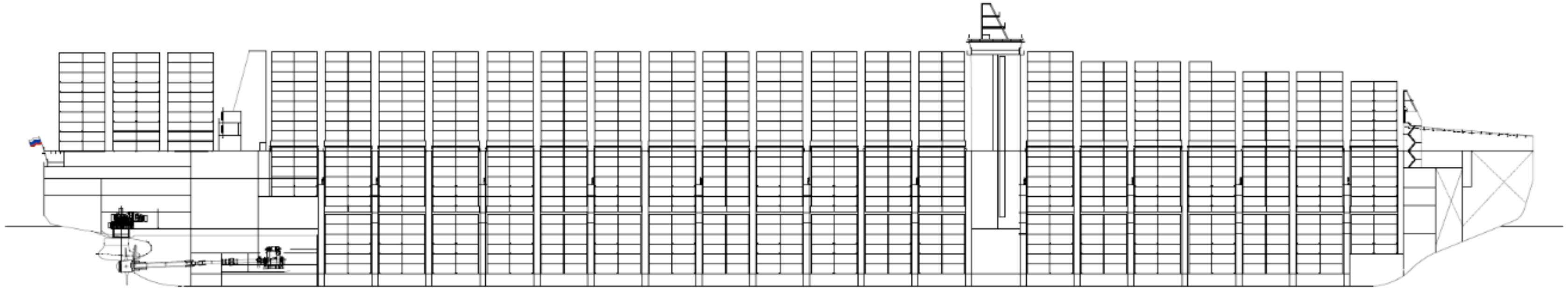
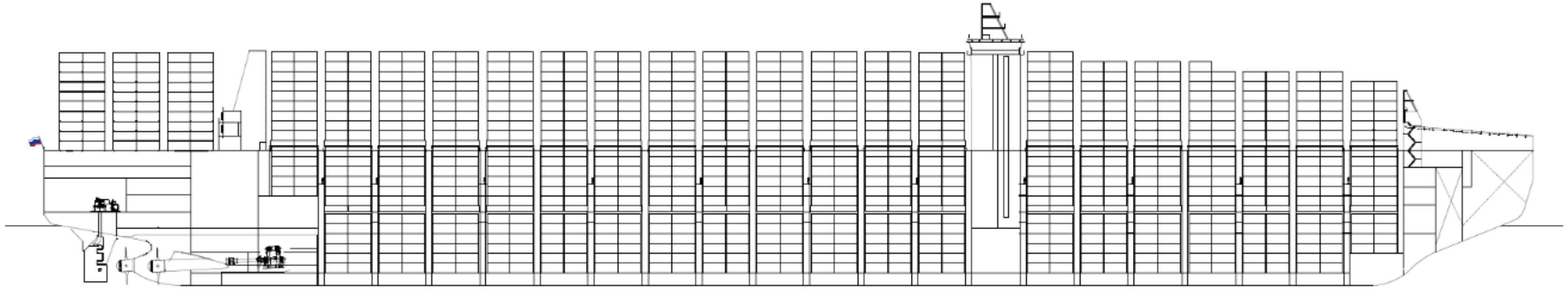
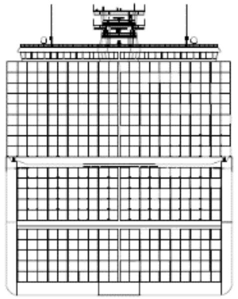
# 18000 TEU Arctic Containership



VERSION A
2 SHAFTLINES – 2 THRUSTERS



VERSION B
3 SHAFTLINES



| Aker ARC 220 HD | |
|---|---|
| **CONTAINER CAPACITY** | 18,000 TEU |
| **LENGTH OVER ALL** | 397 m |
| **LENGTH AT DESIGN WATERLINE** | 384 m |
| **BREADTH** | 56.4 m |
| **DRAUGHT AT DESIGN WATERLINE** | 16 m |
| **INSTALLED PROPULSION POWER** | |
| VERSION A<br>2x22MW Shafts<br>2x17MW Thrusters | 78 MW |
| VERSION B<br>3x22MW Shafts | 66 MW |
| **LEVERL ICE PERFORMANCE AHEAD (3kts)** | |
| VERSION A | 2.5 m |
| VERSION B | 2.4 m |
| ICE CLASS | RMRS Arc7+ |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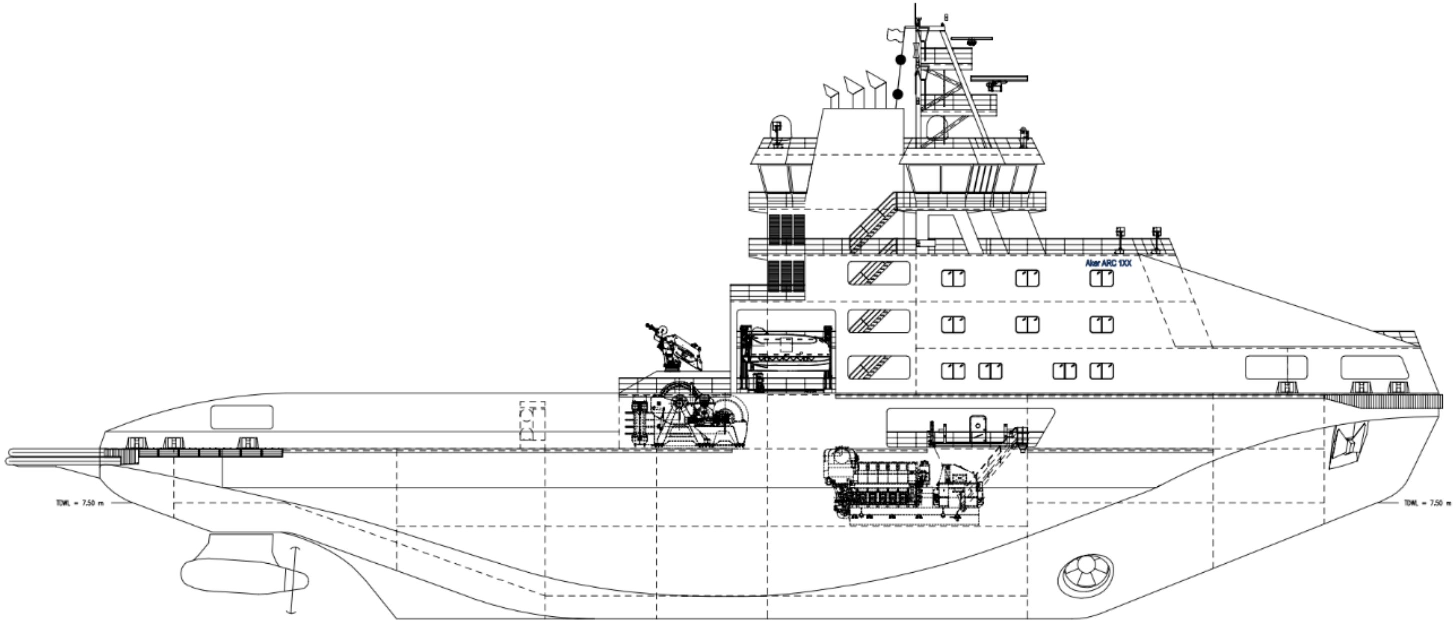
# Alternative Fuel Study for Baltic Icebreaker

- Scoping study to understand the implications of different fuels on icebreaker operations
- ***Icebreaking is power intensive!!!***
- 12 MW, PC4 Icebreaker (+) as baseline
- Length 86m
- Breadth 22.4m
- Draft 7-7.5m
- 8 knots / 80cm ~ Otso Class

- Baseline using Renewable Diesel

(hydrotreated vegetable oil)

- Autonomy time 22.4 days





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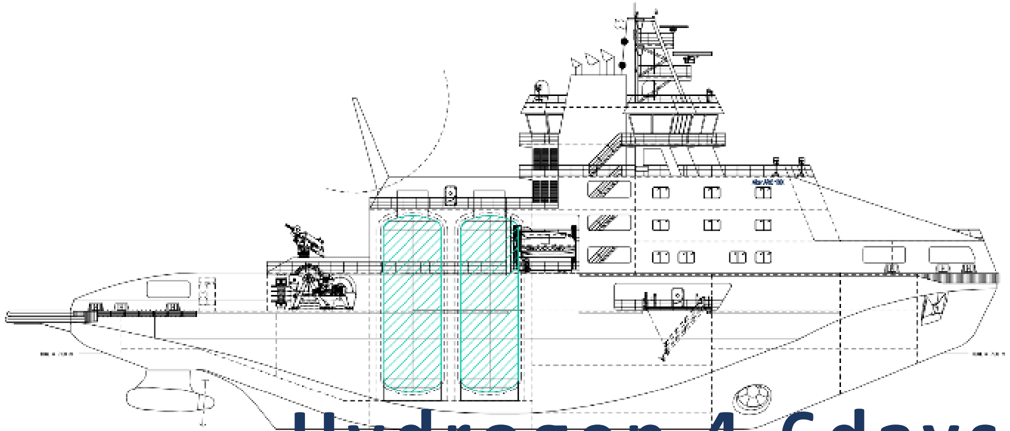
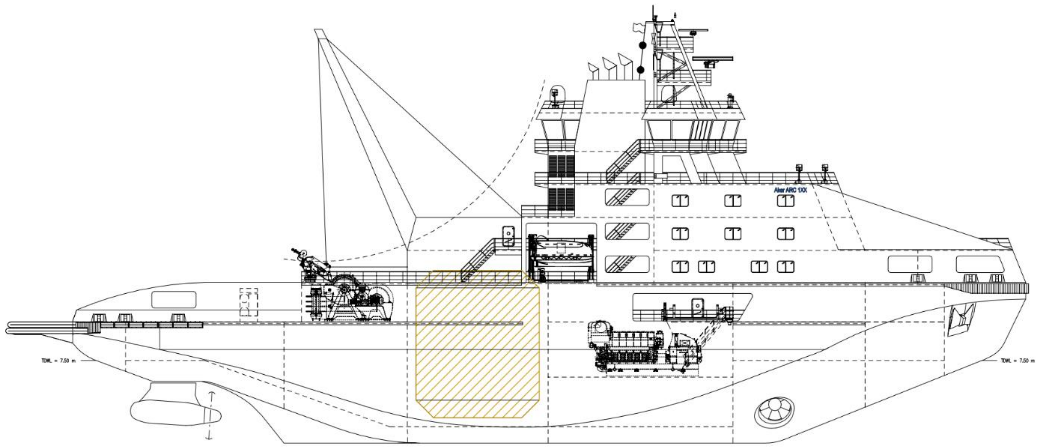
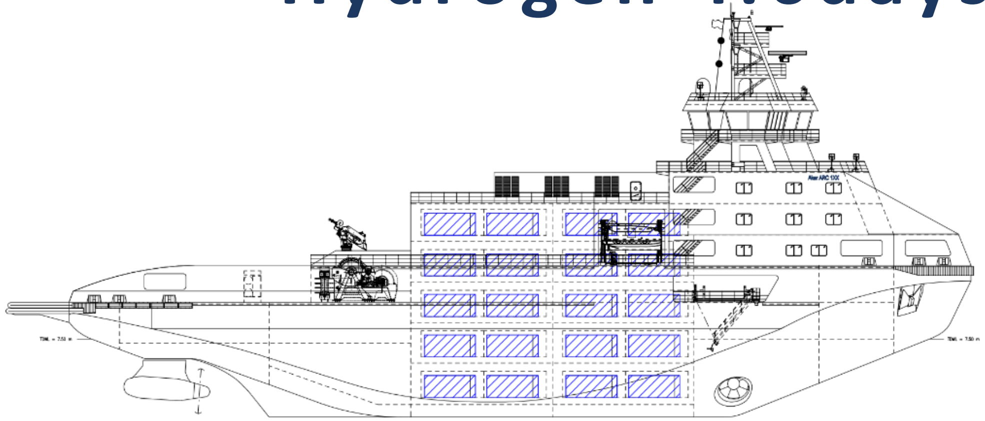
# Concept Variants (Baseline 22.54 days)



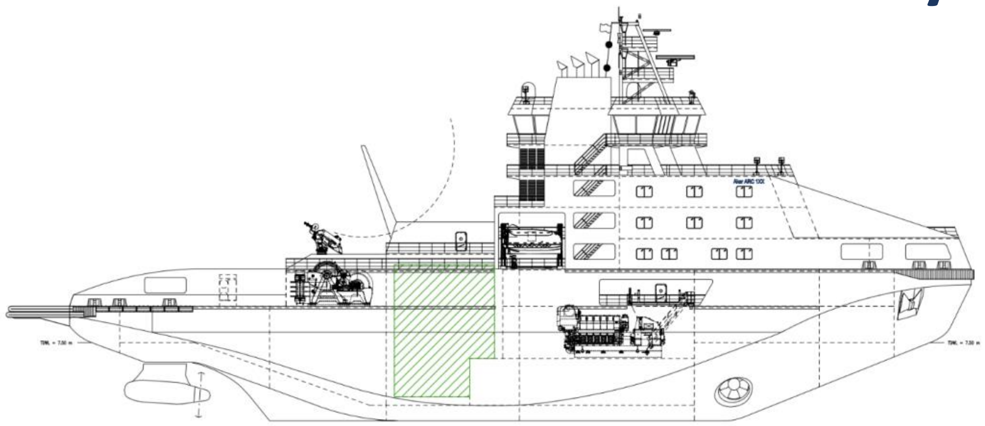
Hydrogen 4.6days



Ammonia 7.3days



Battery 6hrs



Methanol 9 days



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# Technology Challenges for all future Arctic Ships including containerships!

- Ships designed for ice need to operate in ice to be economically competitive
- Ship's equipped with extreme icebreaking bows, higher powers and winterisation features (suitable for spring/autumn/winter trade in the Arctic) are not competitive with ships designed for "open water"
- Increased initial cost, increased steel weight = decreased cargo carrying capacity
- Increased resistance (higher fuel consumption) in open water, higher maintenance costs




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| Ice Class | Non Ice Class / low ice class | Arc4 / Ice Class IA (~PC6) | Arc7 (~PC3) |
|---|---|---|---|
| Bow type | Bulbous bow | Bulbous bow (ice-going type) | Moderate Icebreaking bow (Double acting) |
| Newbuild cost | 100% | 110% | 160-170% |
| Installed Propulsion power | 100 % | 120% | 160-170% |
| Power at service speed in open water | 100% | 105-110% | 170% |
| Speed in 0,6m level ice | Not Achievable (2 knots in 0,4m) | 5 knots | 12 knots / 10 knots |
| Speed in 1,0m level ice | Not Achievable | 1 knot | 7,5 knots / 7,5 knots |


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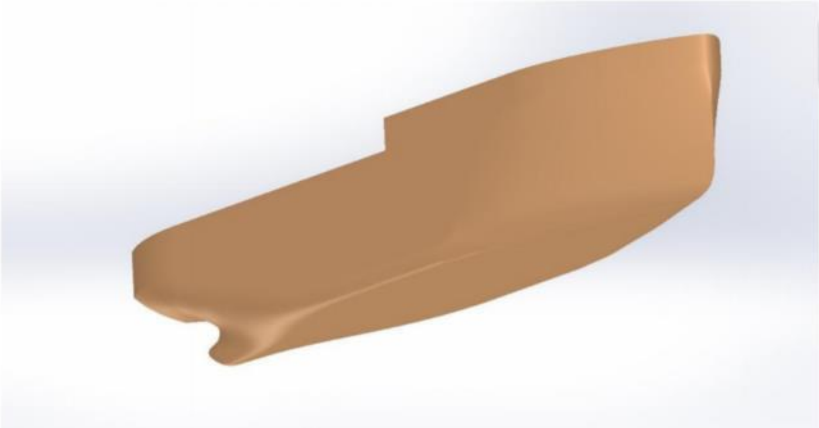
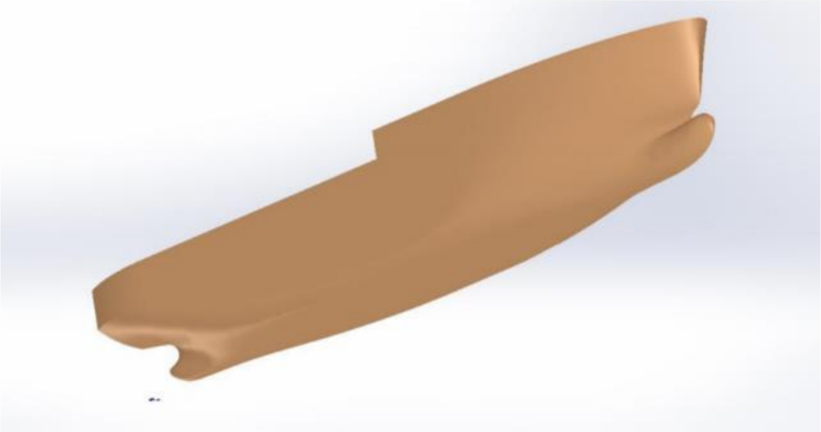
# New energy efficiency requirements are increasing the gap between open water ships and ice capable ships

- New efficiency (EEDI) regulations for open water ships are driving bow designs which are less effective in ice – this is actually reducing the independent ice going capability of lower ice class ships – something that is needed outside of summer transit months

| | Bulbous bow (Pre EEDI) | Thinner bulb | Vertical | Extreme Vertical |
|---|---|---|---|---|
| **Installed power** | 100% | 83% | 78% | 75% |
| **0,25 Level ice** | 4 knots | 1 knot | <1 knot | <1 knot |
| **Brash ice channel** | 7,5 knots | 7,0 knots | 4,5 knots | 4,0 knots |
| **Frozen brash ice** | 4,3 knots | 3,8 | 0 | 0 |







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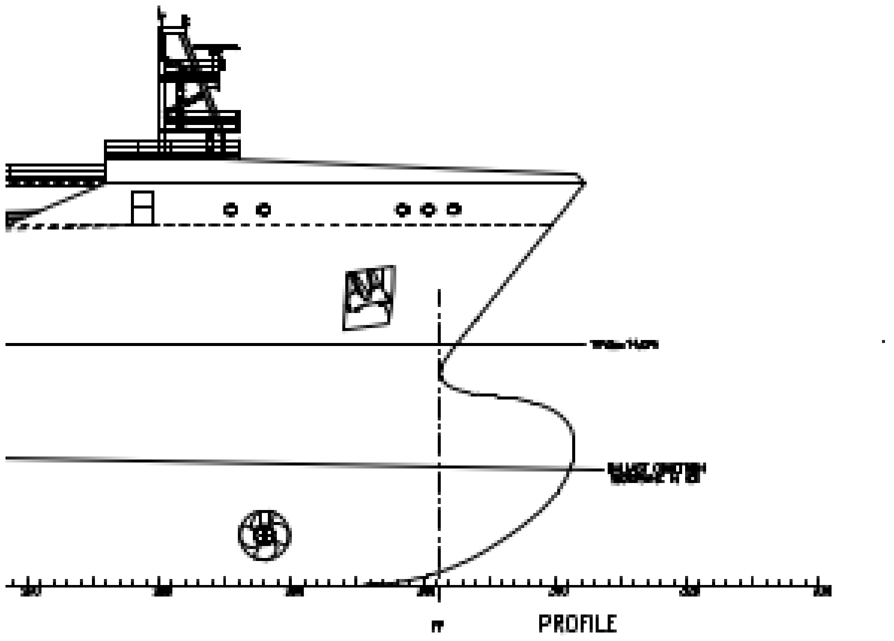
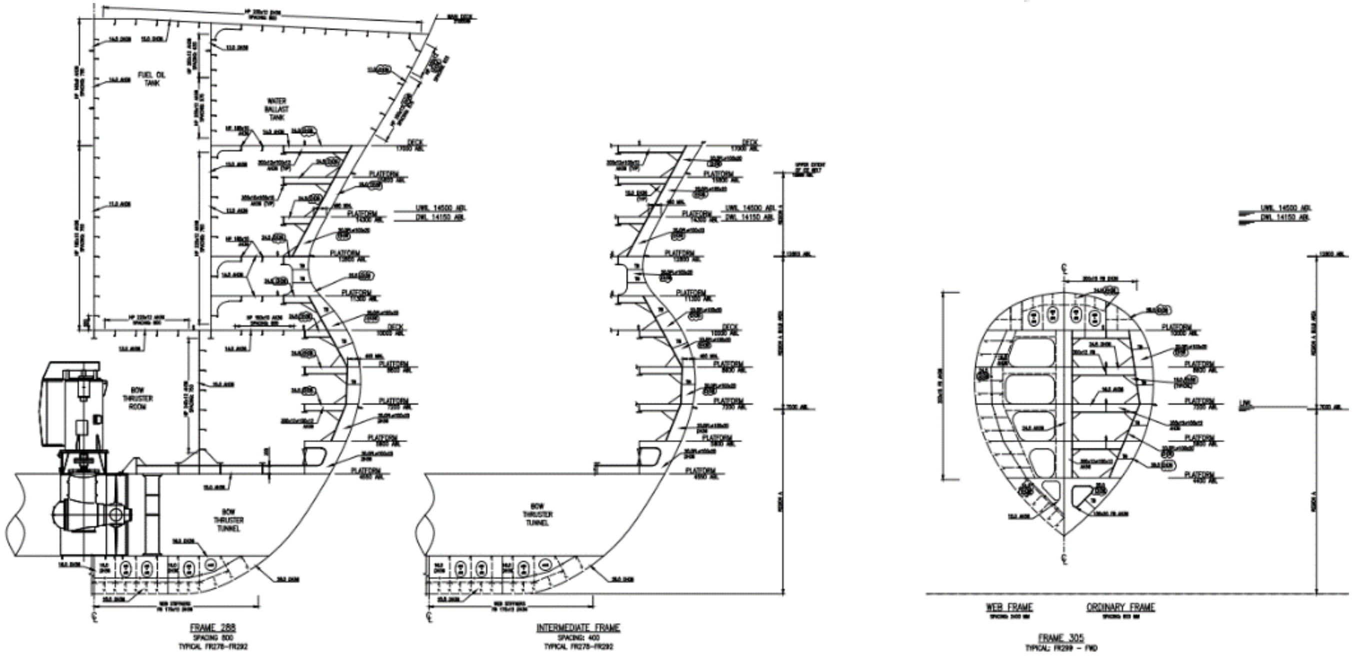
# Non-conventional bow forms for Arctic ships

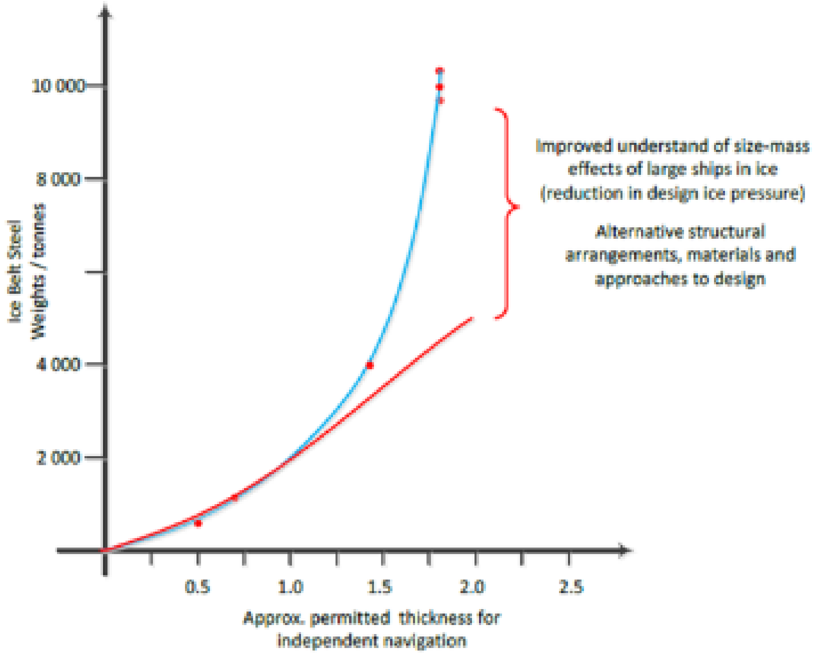
- ”Double acting” concept was a conceived as a means to increase open water efficiency - allowing the bow to be optimised for open water while the stern is optimized for icebreaking
- In this sense Mastera and Tempera are the only ”true” double acting ships
- Many other Arctic ships have different performance points ahead and astern, but not a bulbous bow
- RMRS regulations / NSR previously prohibited bulbs above Arc5 (PC6)
- New RMRS rule allow for dimensioning up to Arc8/9 (PC1) although scantlings are extremely heavy



# High Strength Steels for Arctic ships

- Basic need to efficiently use steel in Arctic ships – reduces the total steelweight, brings Deadweight closer to open water ships and increases operational efficiency
- Study of implement high and extra high strength steels into containership design (EH50, EH70)
- Abt. 14% steel weight savings can be made utilising these steels in ice strengthened areas
- Not efficient to use these extra high strength steels in non-ice strengthened areas, as other requirements dominate (in the case of containerships it is stiffness requirements for global hull girder loads)
    - i.e. the steelweight gap can be closed between open water and Arctic ships by adopting EHSS
- Steel availability improvements
- Improved structural analysis methods (non linear) and agreed acceptance criteria




| Ship Type | Length | Steel Weight Reduction Due to Extra High Strength Steel |
|---|---|---|
| **Shallow Draft Icebreaker** | Abt. 45m | Abt. 3% |
| **Line Icebreaker** | Abt. 120m | Abt. 5% |
| **Arctic Containership** | Abt. 380m | Abt. 14% |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# EEDI, CII & … for Polar Code Category B & C ships (and Arctic ships)

- EEDI = Cost for the Environment / Benefit for Society
- Theoretical CO2 emissions / total transport capacity of ship (g C02 / y nm)
- Very simply

$$\underset{\text{(g/ton mile)}}{\text{EEDI}} = \frac{\text{Engine Power} \times \text{SFC} \times C_F}{\text{Capacity(dwt)} \times \text{Speed}}$$

$$\frac{\left(\prod_{j=1}^{n} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}\right) + \left(P_{AE} \cdot C_{FAE} \cdot SFC_{AE} *\right) + \left(\left(\prod_{j=1}^{n} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEeff(i)}\right) C_{FAE} \cdot SFC_{AE}\right) - \left(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME} **\right)}{f_i \cdot f_c \cdot f_l \cdot Capacity \cdot f_w \cdot V_{ref}}$$

- For ice class (up to IA Super / Cat B) two factors, which take into account the increased power and increased lightweight adjust the EEDI requirement
  - Power correction factor, $f_j$ ($f_{j\_max}$ = 1)
  - Capacity factor for any technical/ regulatory limitation on transportation capacity $f_i$ ($f_{i\_min}$ = 1 )
  - These factors are derived from a statistical comparison of existing ice classed and non-ice classed tonnage



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# How does CII fit in?

- G1 – CII calculation (similar format to EEDI)

$$\frac{CO2\ Emissions}{Deadweight\ (GT) * Distance\ Sailed}$$

- G2 – CII reference line (ship type specific)

$$CII\ ref\ = a\ Capacity^{-C}$$

*Based on existing fleet statistics*

- G3 - required CII … Z is a reduction factor based on year

$$Required\ CII = \frac{100 - Z}{100} CII_{Ref}$$

- G4 – CII rating – basically a rating of how well the ship does against the required reference lines (rated A to E)
- G5 – Correction Factor & Voyage Adjustment – basically what can be deducted from the attained CII calculation

Voyage adjustment inc. sailing in ice

$$\frac{DCS\ reported\ annual\ CO2\ Emission - (deductible\ CO2\ Emissions\ )}{EEDI\ correction\ factor\ x\ Capacity * (DCS\ reported\ Distance\ travelled - deductable\ Distance\ travelled) * Port\ time\ correction\ factor}$$

Incl. Ice class correction factors (capacity side)

Voyage adjustment inc. sailing in ice



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# Voyage Correction factors

- Potential to exclude voyages in ice from fuel oil consumption and distance sailed from calculation of attained CII proposed
- BUT this does not make up for the fact that for the rest of the time when operating in open water the vessels are less efficient due to their “icebreaking” nature

## For Category A and B ships

- EEDI is currently not applicable to category A ships as defined in the Polar Code
- Consequently CII requirements do not currently apply to category A ships (i.e. most non-seasonal Arctic ships)

**Regulation 19**
*Application*

1 This chapter shall apply to all ships of 400 gross tonnage and above.

2 The provisions of this chapter shall not apply to:

.1 ships solely engaged in voyages within waters subject to the sovereignty or jurisdiction of the State the flag of which the ship is entitled to fly. However, each Party should ensure, by the adoption of appropriate measures, that such ships are constructed and act in a manner consistent with the requirements of chapter 4 of this Annex, so far as is reasonable and practicable.

.2 ships not propelled by mechanical means, and platforms including FPSOs and FSUs and drilling rigs, regardless of their propulsion.

3 Regulations 22, 23, 24 and 25 of this Annex shall not apply to ships which have non-conventional propulsion, except that regulations 22 and 24 shall apply to cruise passenger ships having non-conventional propulsion and LNG carriers having conventional or non-conventional propulsion, delivered on or after 1 September 2019, as defined in regulation 2.2.1, and regulations 23 and 25 shall apply to cruise passenger ships having non-conventional propulsion and LNG carriers having conventional or non-conventional propulsion. Regulations 22, 23, 24, 25 and 28 shall not apply to category A ships as defined in the Polar Code.

- **How long will these exclusions last for?**
- **Ice Classed, especially Arctic (Category A) fleet is so small – using a statistical approach for adjustments is dubious**



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# Future Arctic Ships

- Designs are available for extreme conditions – probably no more envelope pushing!
- Technical features to close the gap on energy efficiency must be made:
  - Adoption of high strength steels will reduce the added steel weight Arctic ships carry (this should increase the carried deadweight which improves the energy efficiency)
  - Adoption of a "true" double acting concept
    - Open water performance is still part of the energy efficiency equation, even if there are correction factors
    - Arctic ships need to be more efficient on the open water parts of their transits
    - Technically and regulatory feasible to adopt ice strengthened bulbous bows – brings us a step closer
    - Proven Arctic experience of similar hull form configurations going stern first in Arctic conditions
  - Lack of infrastructure on Arctic routes means alternative fuels may not be readily available
- No silver bullet – not one single feature, but a combination of technical advances
- Icebreaking is still power intensive!
- We shouldn't rely on exemptions from current regulations to remain – actively need to work to close the efficiency gap as well as understand how to measure operational efficiency in ice



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