Wide-beamed ships in ice

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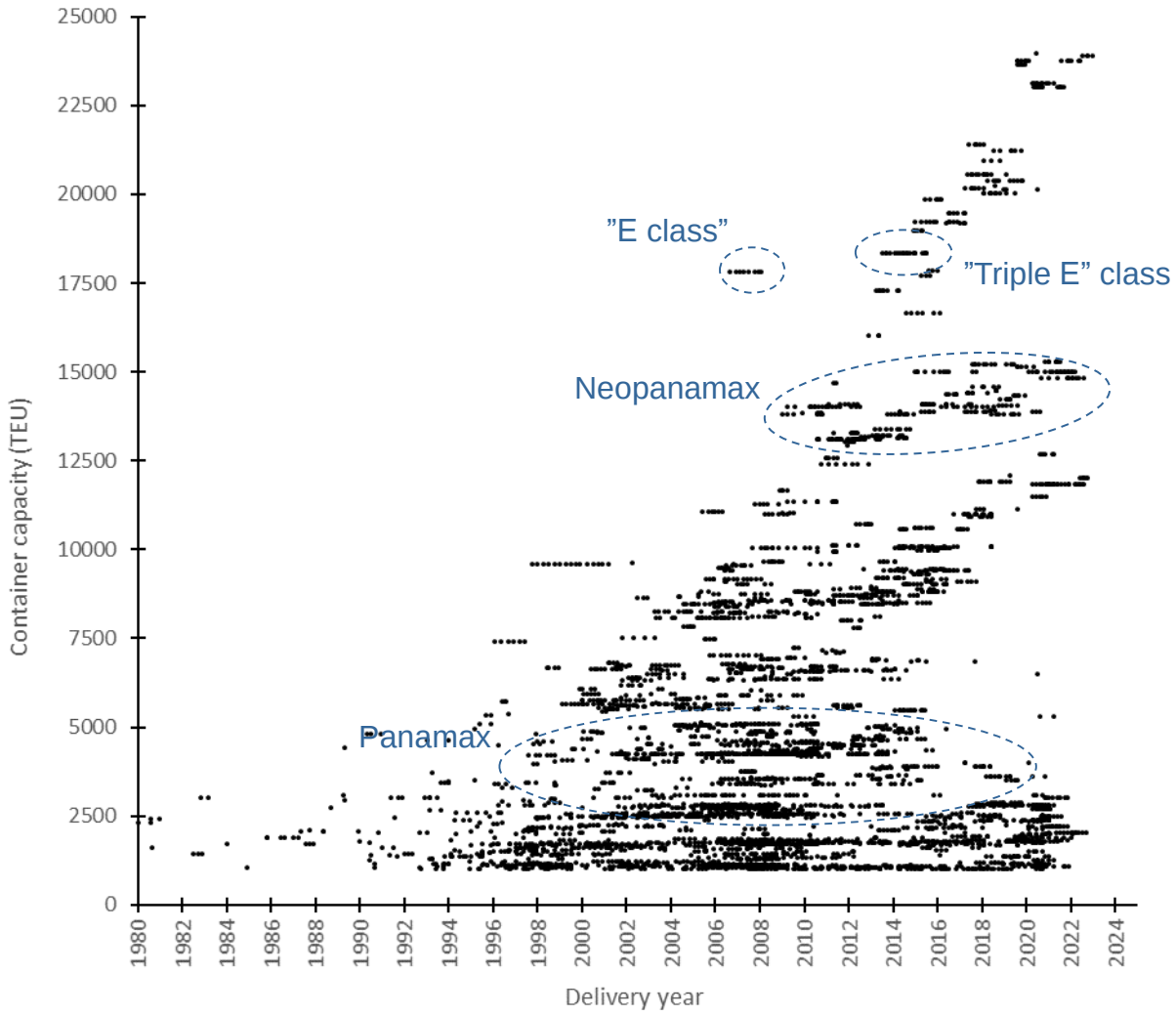
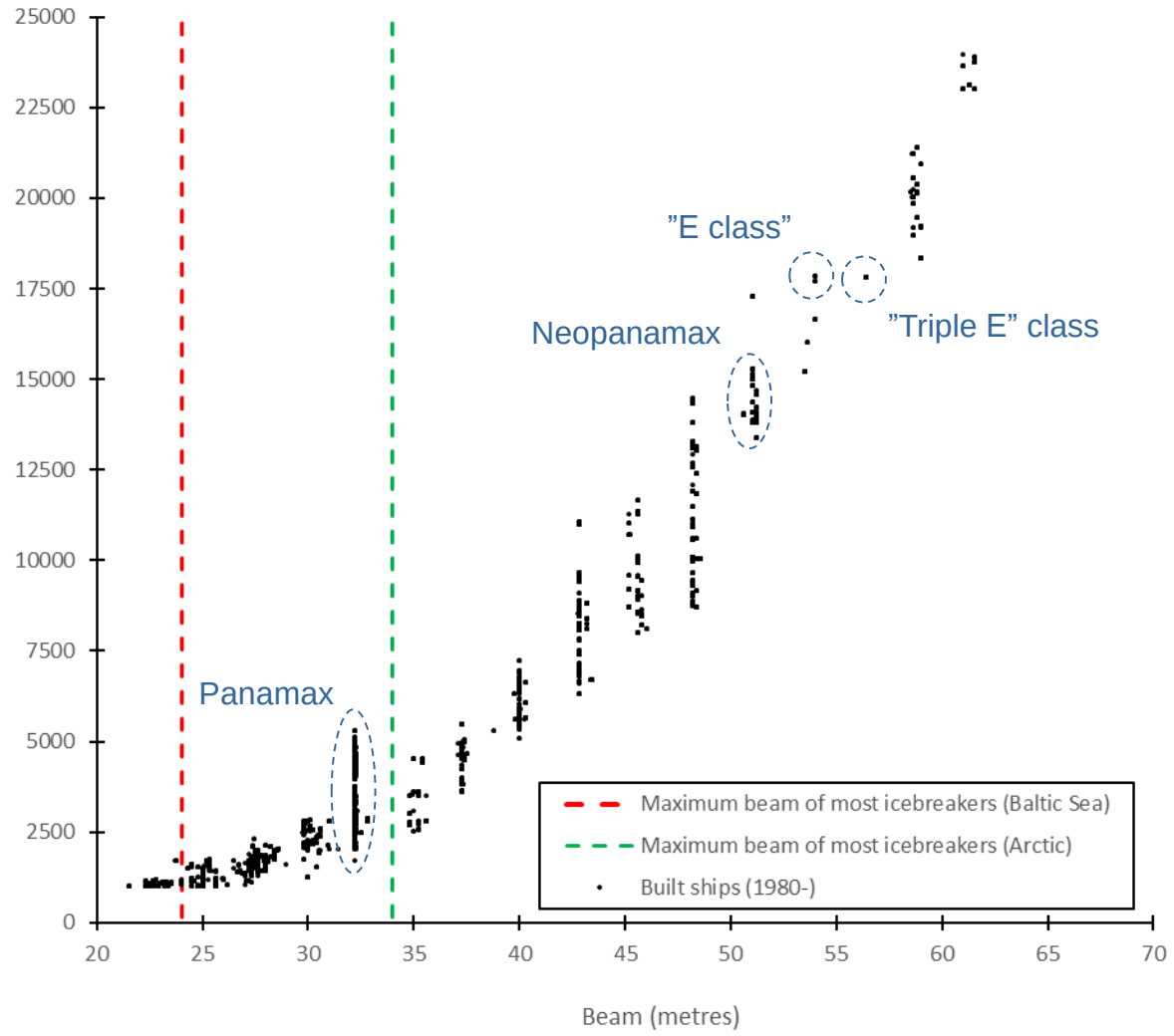
Arctic Passion Seminar 2020

Topics

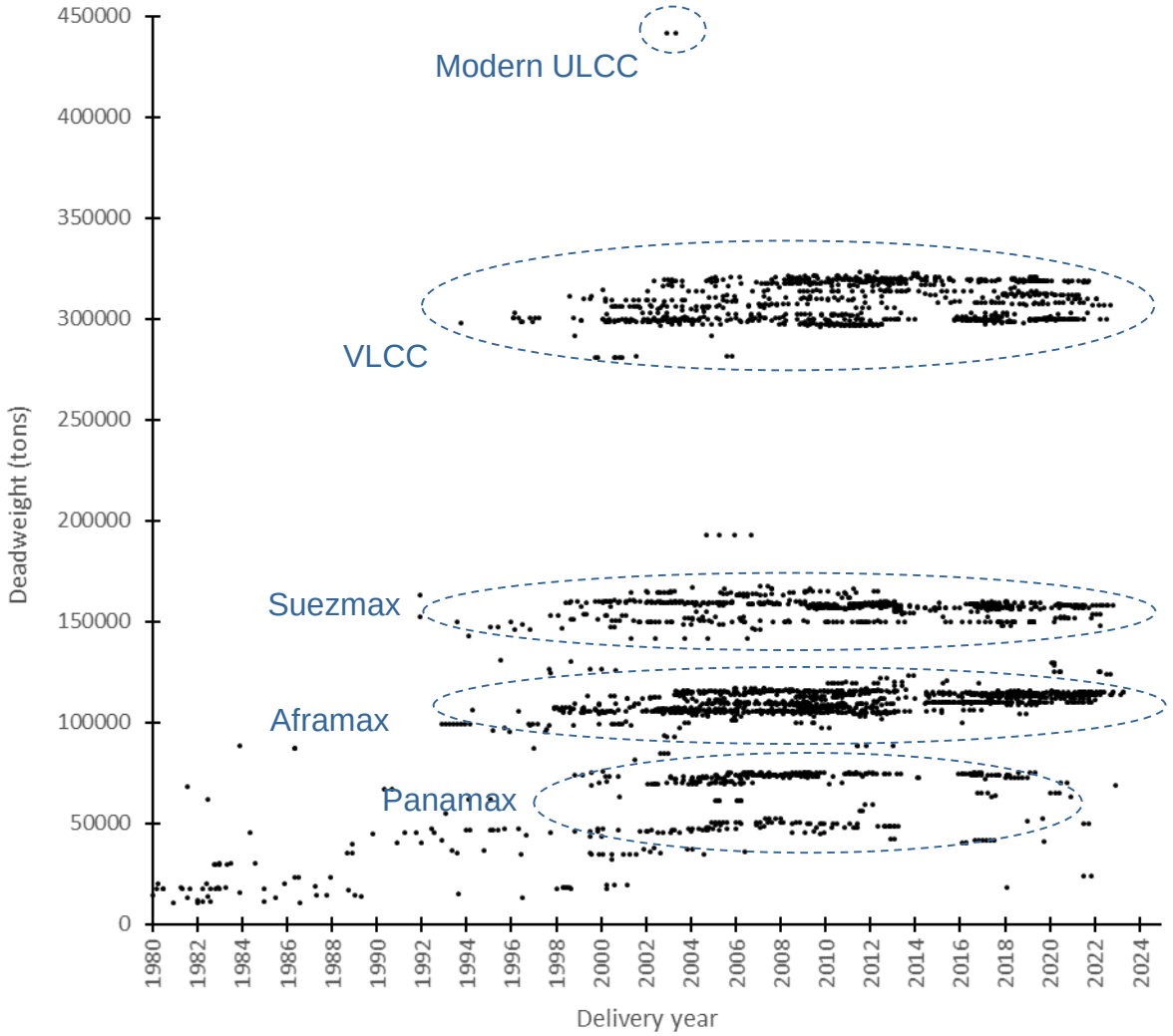
- Development of ship sizes since 1980 – “economy of scale”
  - Container ships, crude oil tankers, bulk and ore carriers, LNG carriers
  - Ice-strengthened vessels
- Independent operation or under icebreaker escort
  - Alternatives for icebreaker escort
  - Alternatives for independent operation
- Benefits of icebreaker assistance for ships that are wider than the escorting icebreaker
  - Ice performance
  - Freedoms to vessel design
  - Open water performance
  - Seakeeping
- Ice model test demonstration

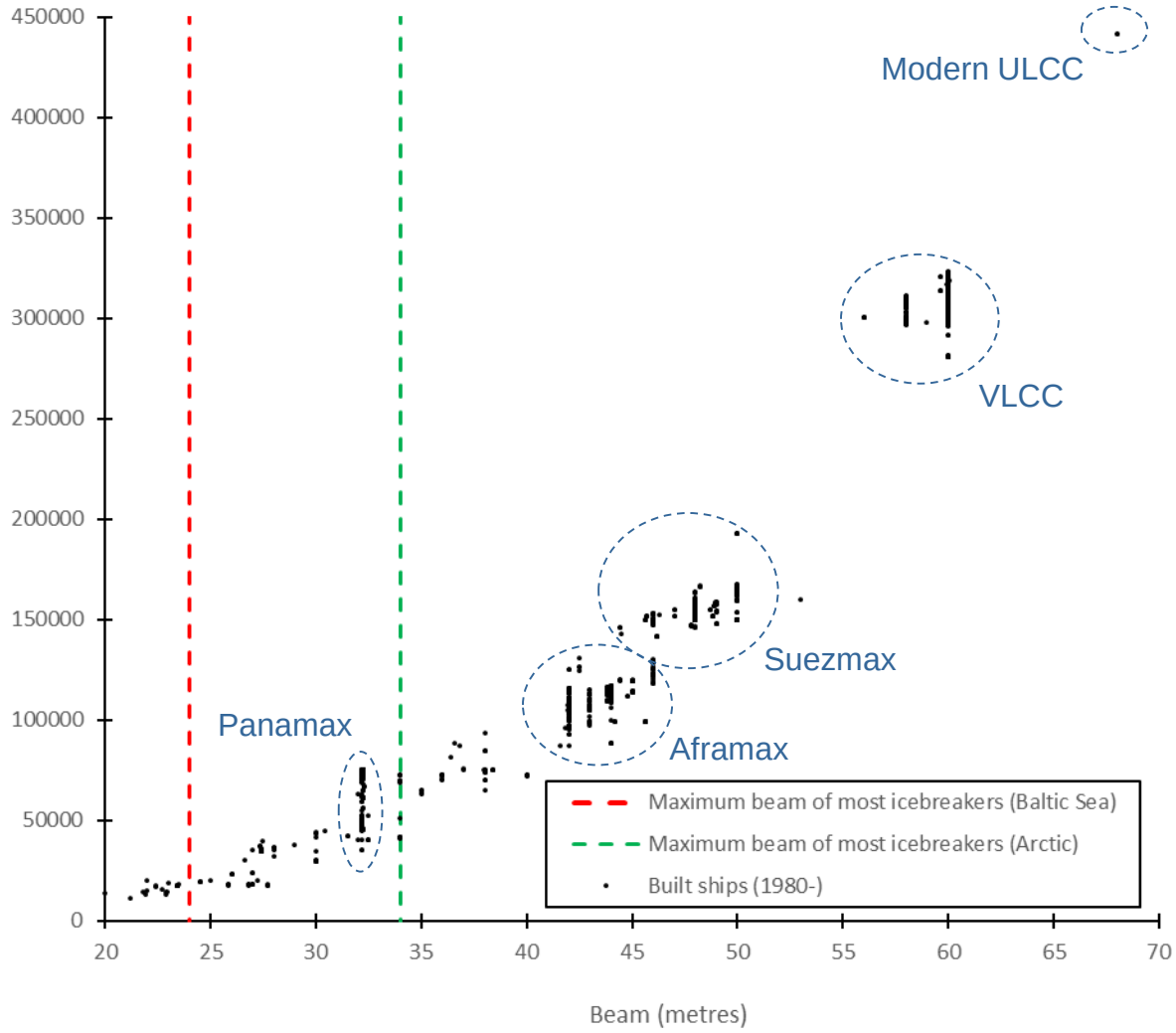
Container ships (1,000+ TEU; 1980-)



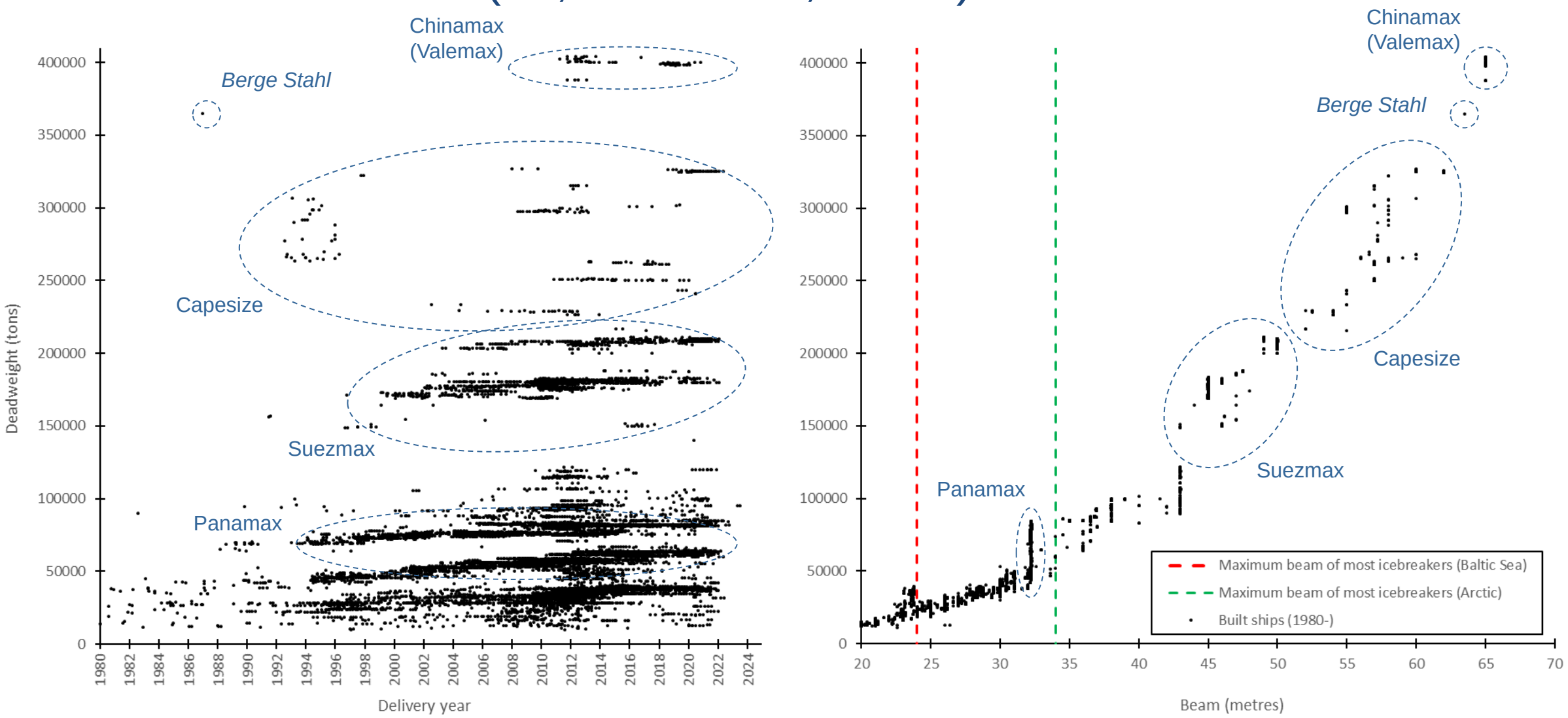


Crude oil tankers (10,000+ DWT; 1980-)

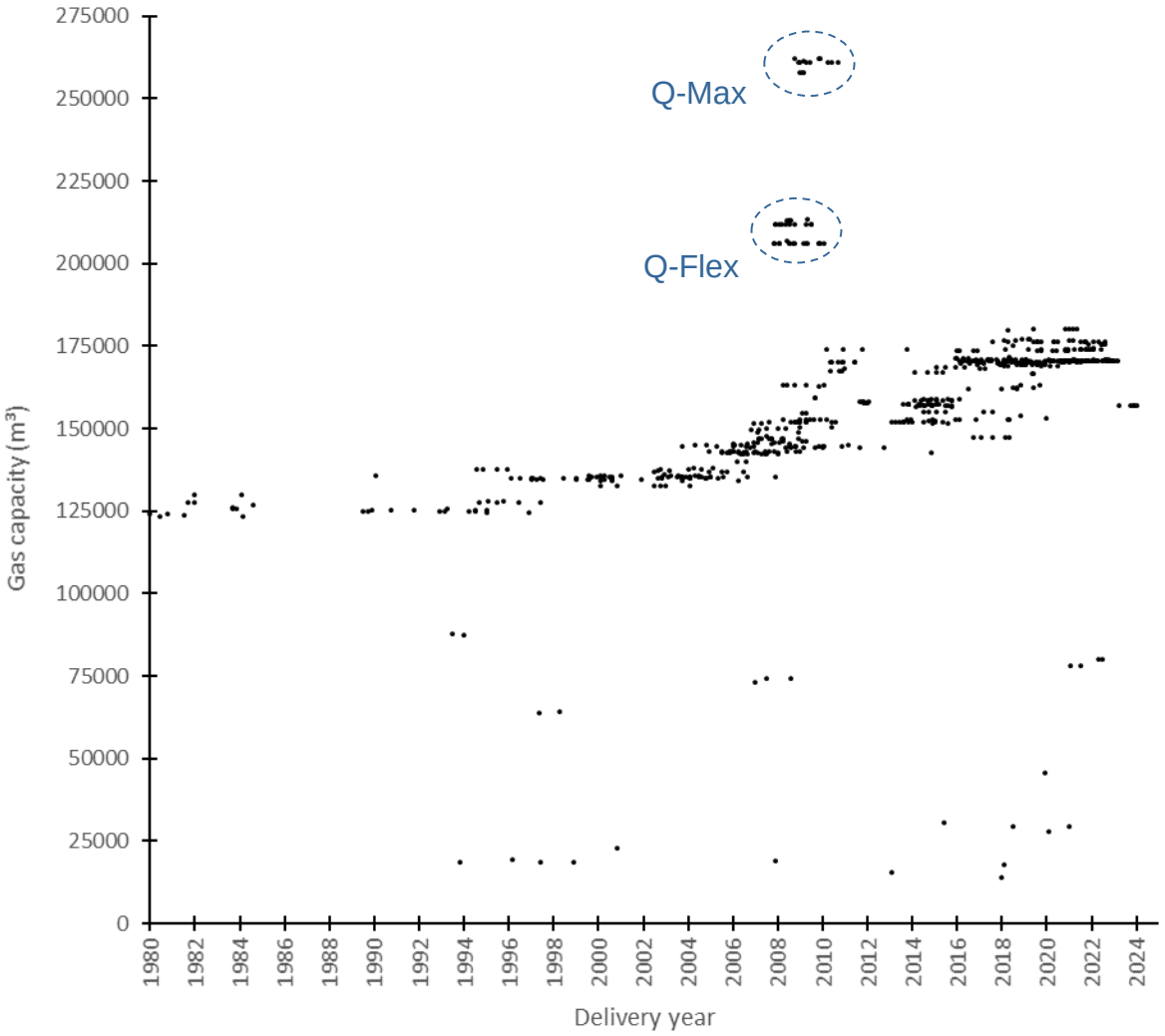


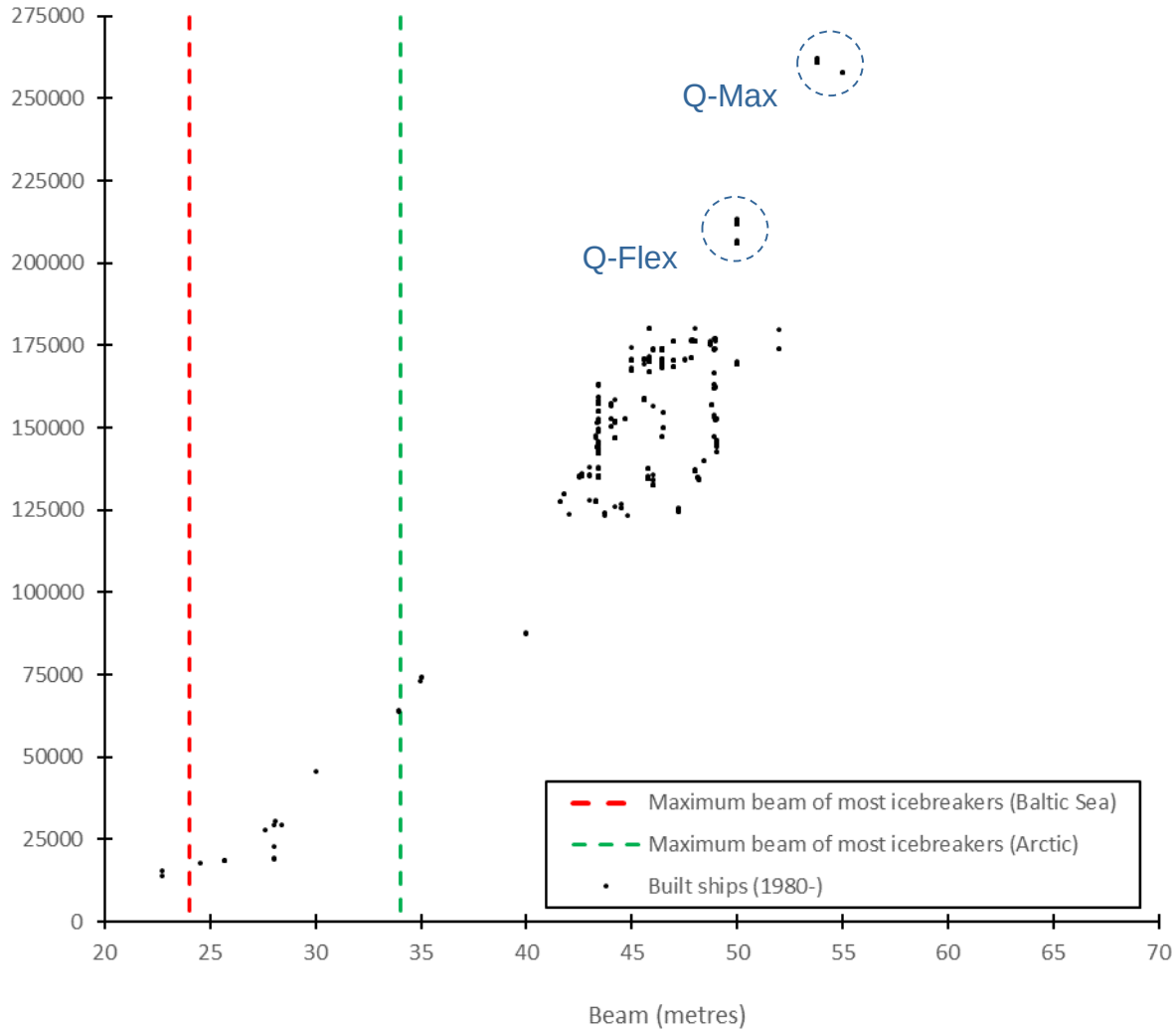


Bulk and ore carriers (10,000+ DWT; 1980-)

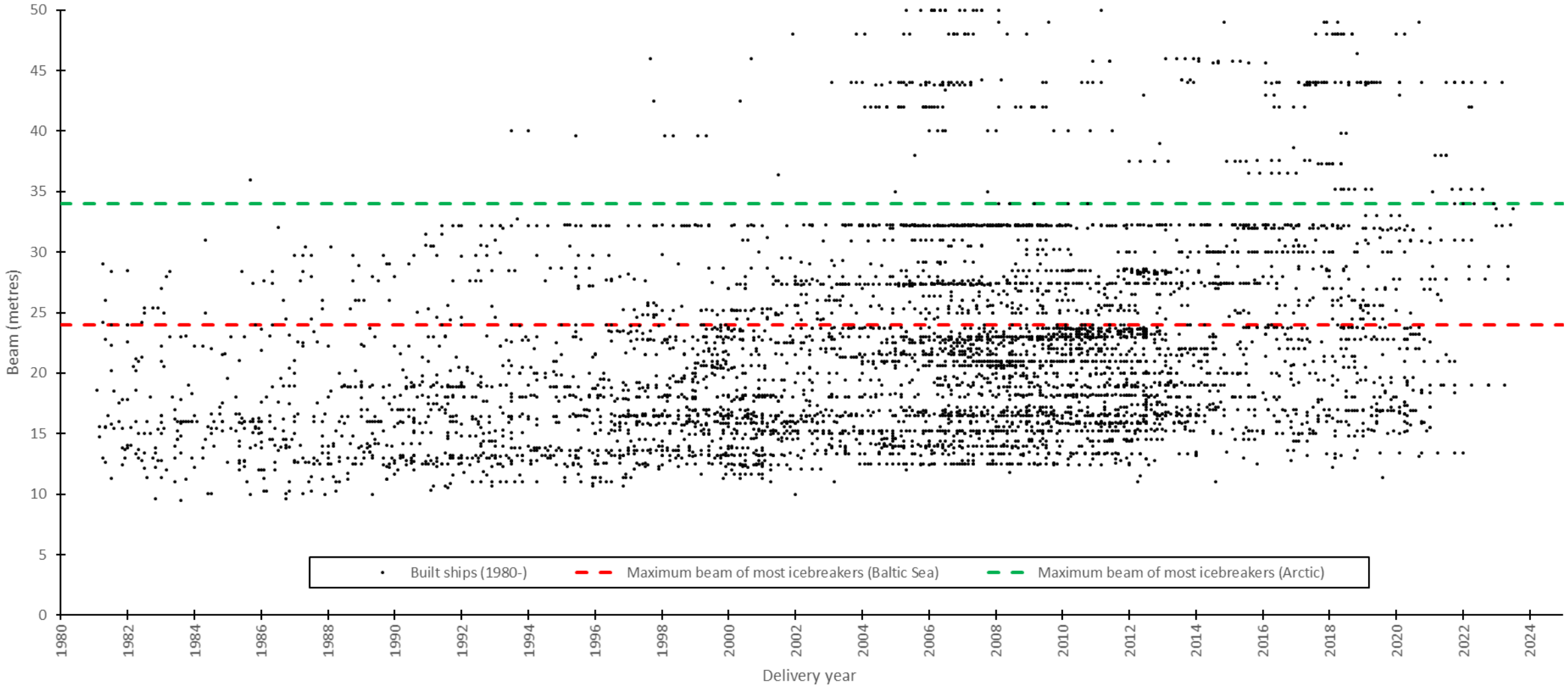


LNG carriers (1980-)



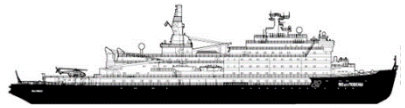


Ice-strengthened ships (1C…1A Super)



Development in ship size – polar classes

1982 ***Norilsk* (SA-15)** (14 700 DWT)
L=177.2 m, B=24.55 m, T=9.0 m

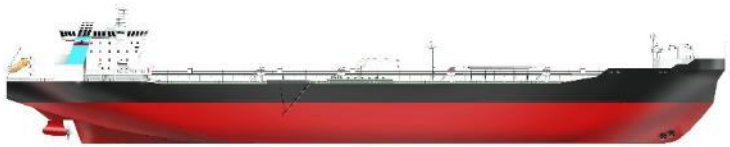


2006 ***Norilskiy Nickel*** (14 500 DWT)
L=169.5 m, B=23.1 m, T=9.0 m

2006 ***Umiak I*** (31 500 DWT)
L=188.8 m, B=26.6 m, T=11.7 m

2008 ***Vasily Dinkov*** (70 000 DWT)
L=256.0 m, B=34.0 m, T=14.0 m

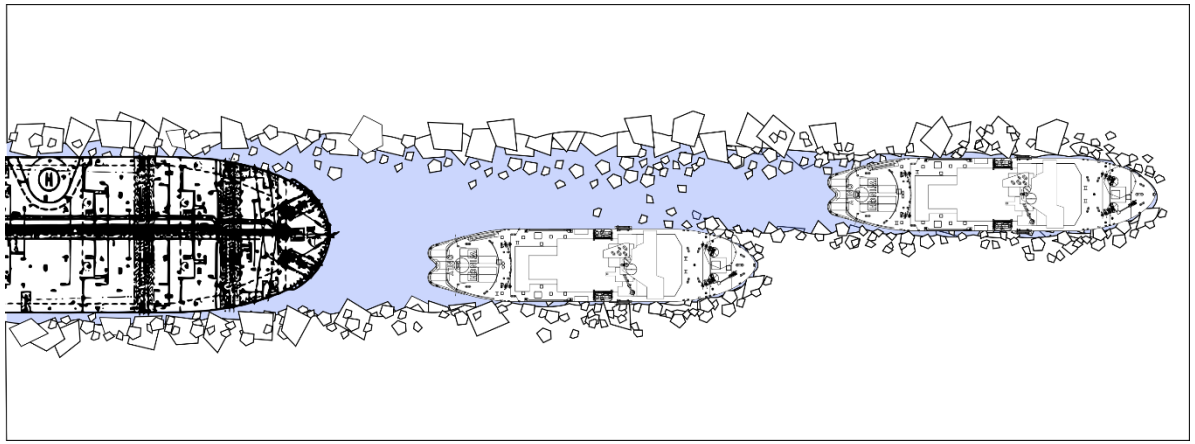
2010 ***Mikhail Ulyanov*** (70000 DWT)
L=257.0 m, B=34.0 m, T=13.6 m

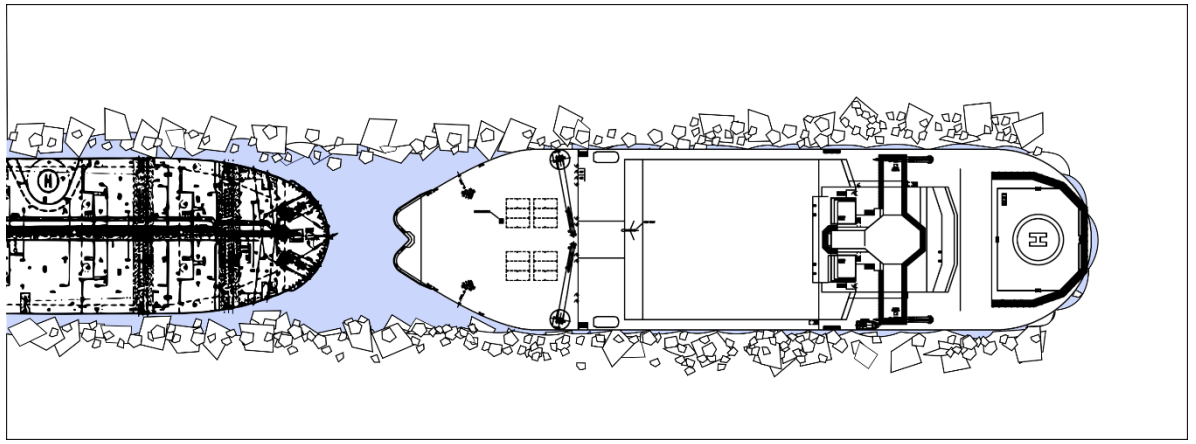


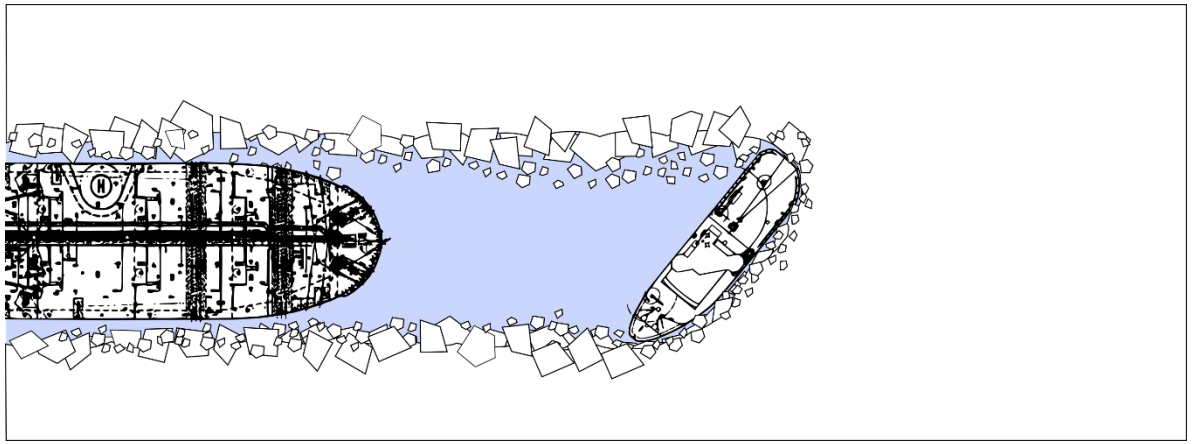
2016 ***Christophe de Margerie*** (170 000 m³)
L=299.0 m, B=50.0 m, T=11.8 m

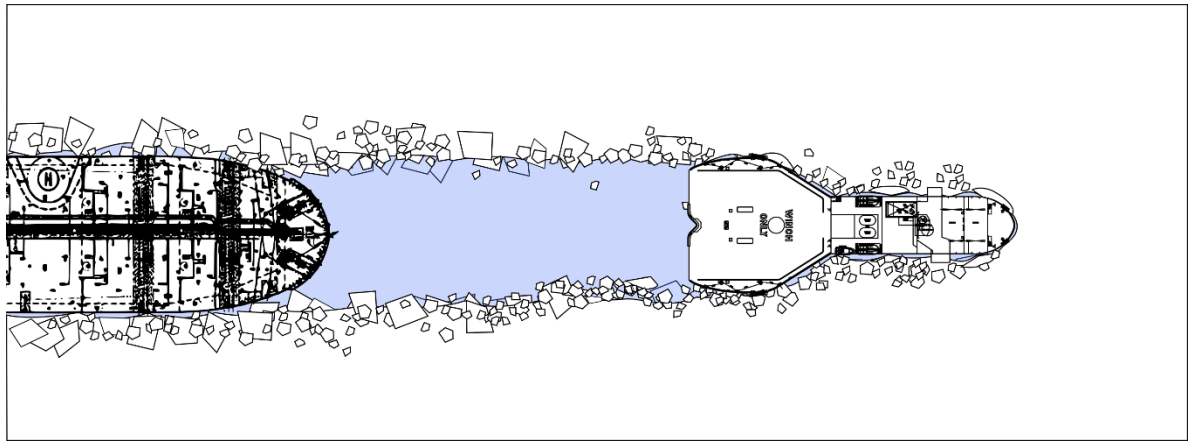
Source: https://dmitry-v-ch-l.livejournal.com/

Icebreaker escort alternatives for large ships

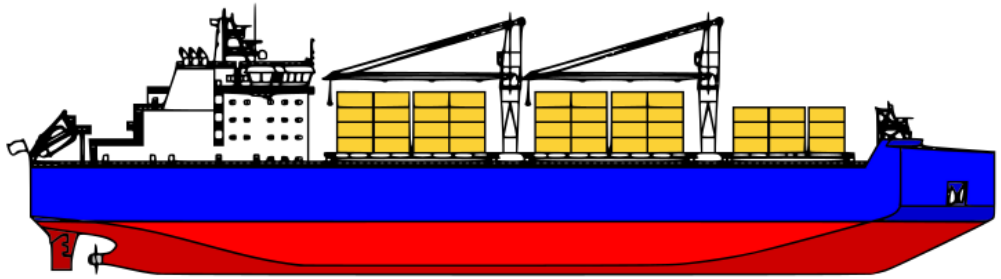




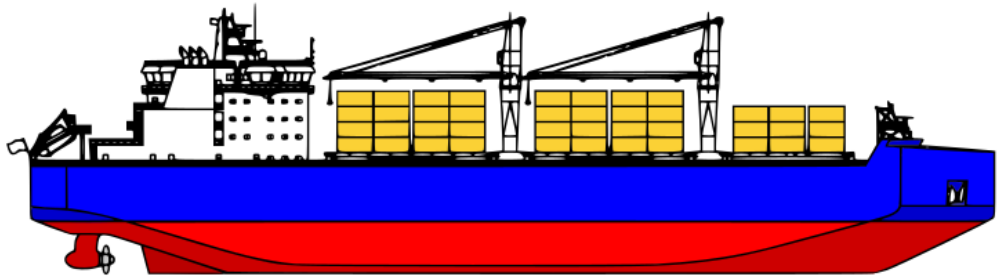




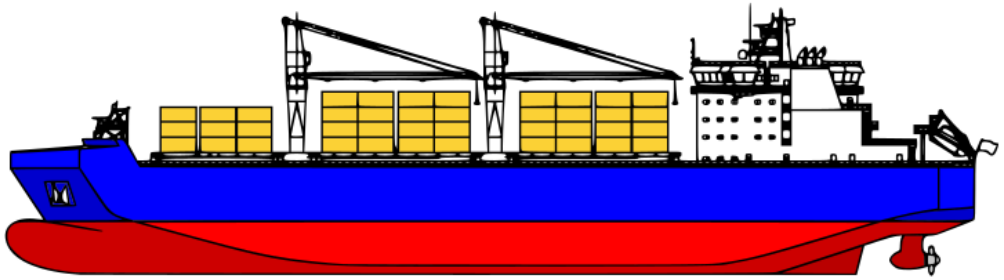
Independent operation



Power demand 100%



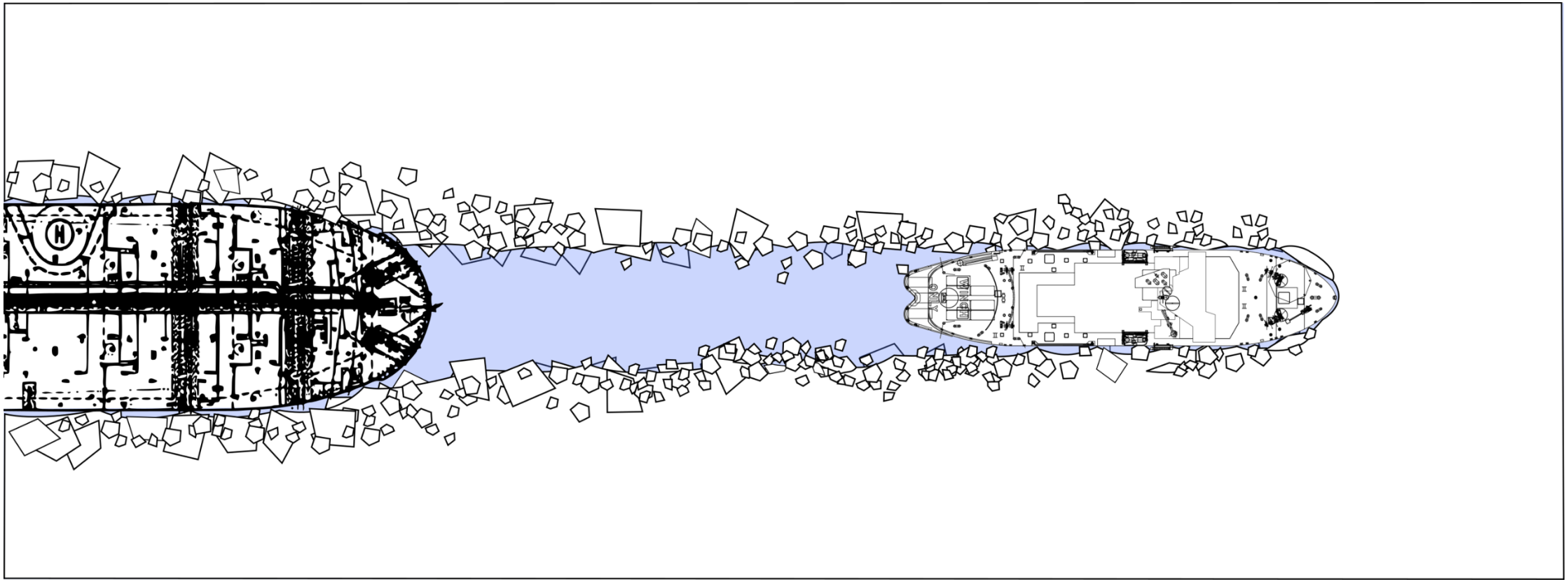
Power demand 100%



Power demand 80%

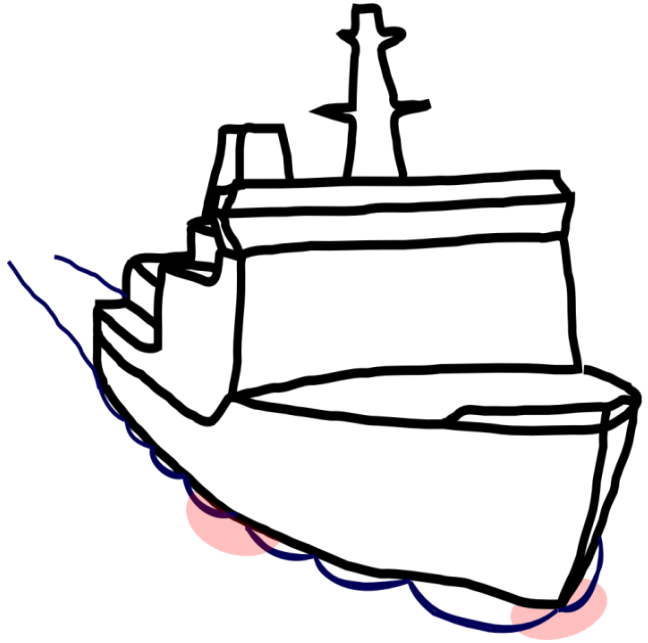
Other alternatives?

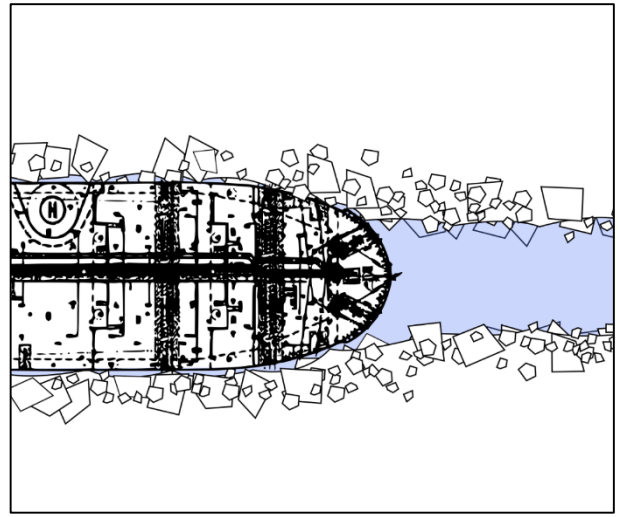
- Is it possible to design ship with good performance in narrow channel?
- Which are the pros and cons?



Ice resistance

- Ice resistance is the additional resistance resulting from hull-ice interaction
- Ice resistance is strongly influenced by the beam of the vessel
- Stem and shoulder regions form a large portion of ice resistance in icebreaking bow forms
- Operating 50 m wide vessel in 25 m wide channel means that ice resistance is reduced to about half
  - → No breaking/crushing at stem region
  - → More pre-broken ice – less ice to break – lower overall resistance from breaking the ice
  - → Submerging and friction forces are also reduced as ice coverage in the channel is <100 %
- What if there is bulbous bow?

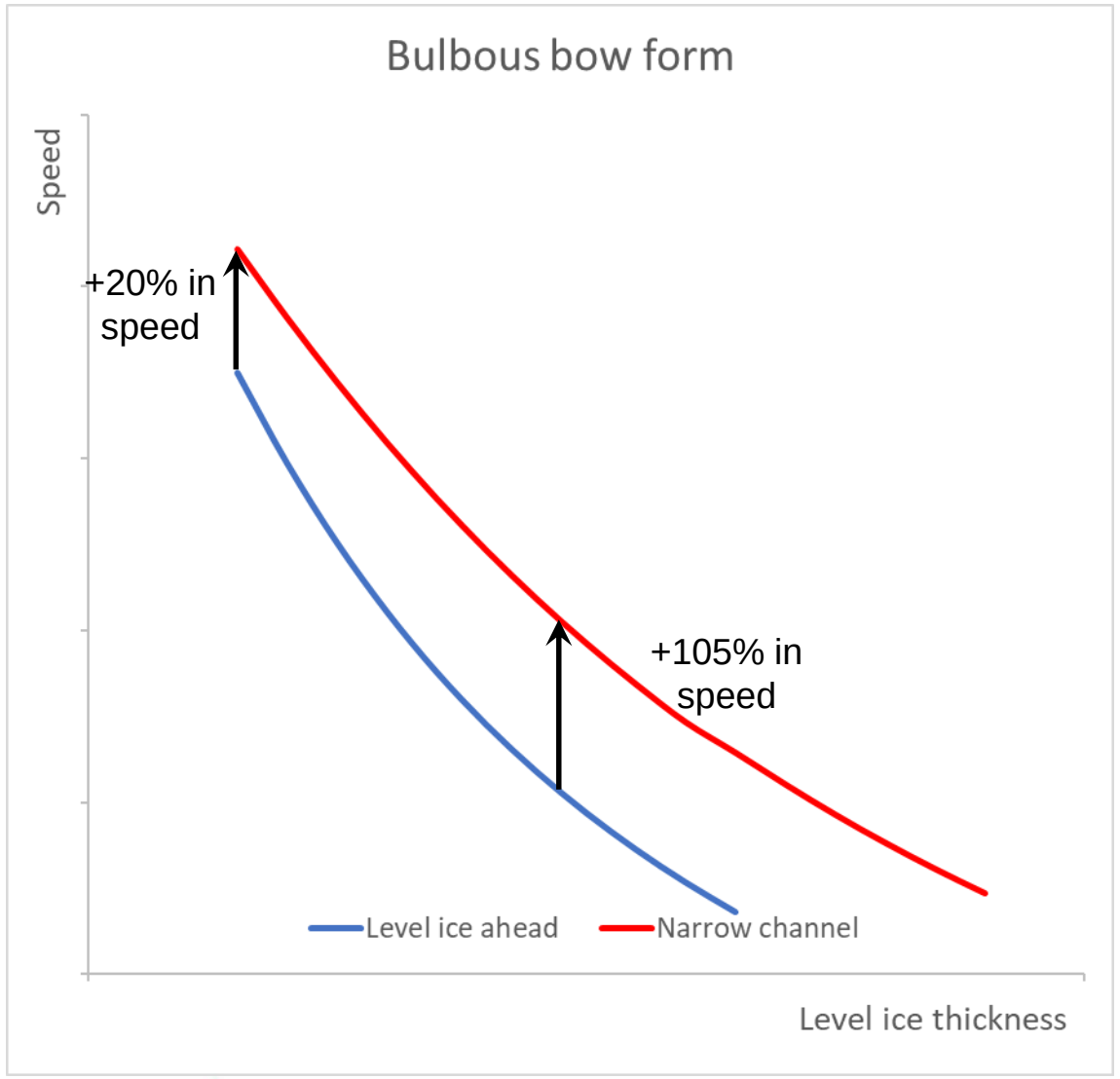


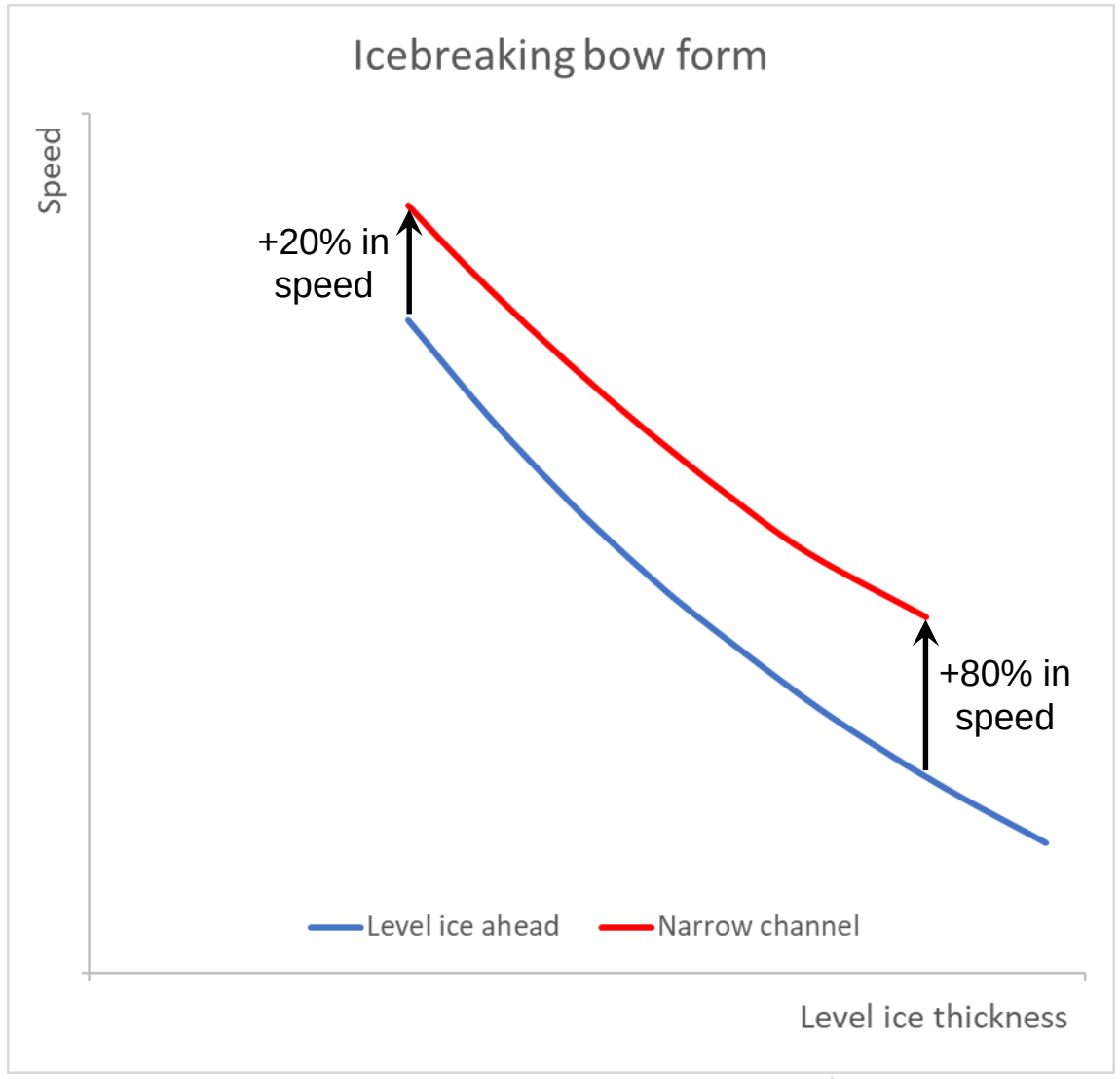


Impact to vessel design

- Icebreaking bow form compared to bow forms for open water use
  - Higher open water resistance especially in high speeds
    - Impact marginal for low speed vessels
  - Achievable speeds in heavy seas are lower
  - Seakeeping behavior worse especially slamming point of view
    - Higher slamming pressures
    - Possible vibration issues
- Hull form optimized to narrow channel
  - Special design is possible – icebreaking bow form in shoulder area but open water hull in centerline
    - Open water resistance comparable to open water vessels, especially with higher speeds typical for container ships, LNG carriers and RoPax-ferries
    - Same seakeeping characteristic than open water hull form
    - Reduced power demand compared to independent icebreaking → Lower CAPEX

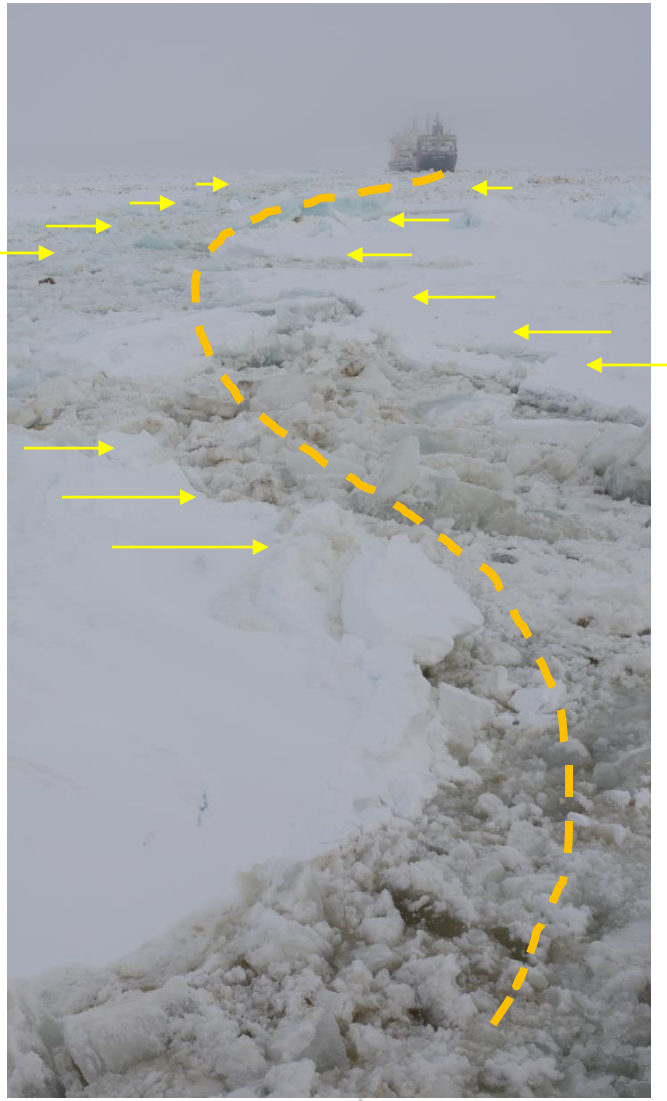
Performance estimations





Performance under icebreaker escort in real life

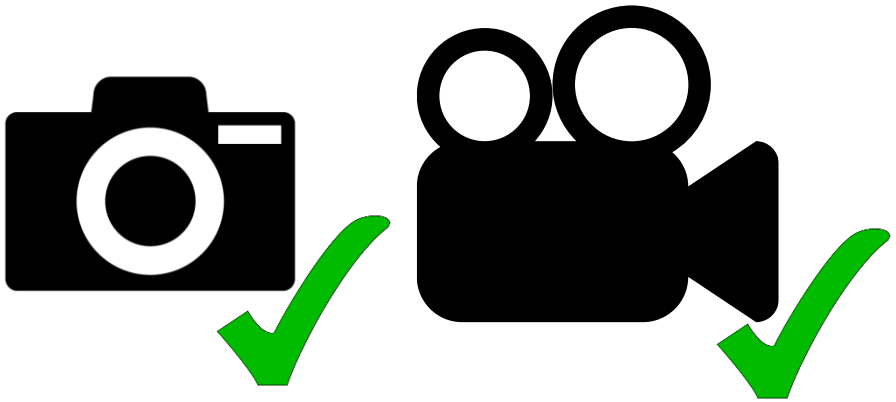
- Operation under heavy compression
  - Channel behind the icebreaker closes quickly
  - Shorter distance between vessels (or contact towing)
- Operation in ridge fields
  - Mass of cargo ship helps in small ridges or single ridges
  - Improved assistance capability (e.g. propeller flushing) from the icebreaker beneficial
- Icebreaker becomes beset in ice
  - Reserve power of icebreaker beneficial
  - Ice resistance of narrow channel reduces crash stop distance for the following cargo ship
- Breaking out of channel easier than compared to wide channel
- Maneuvering may still be difficult as with all large ships in ice

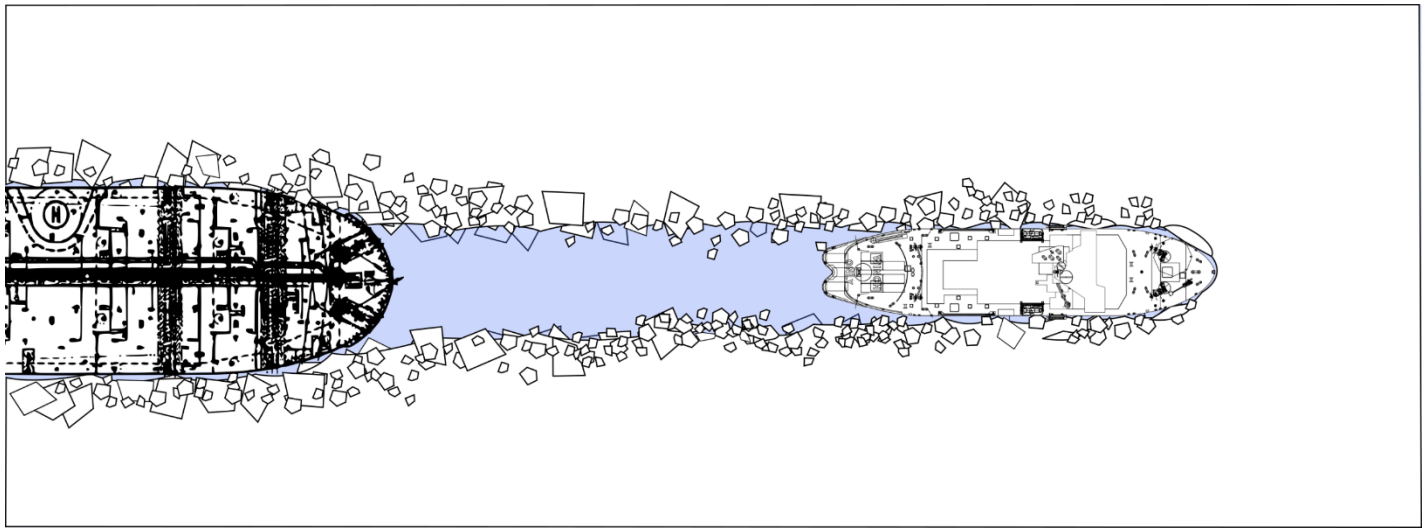


Ice model test demonstration

Ice model test demonstration

- Large ship in channel made by narrow icebreaker (model scale parameters in brackets)
  - First run with 26 m (0.7 m) wide icebreaker (scale model of MSV *Fennica*)
  - Second Run with 47 m (1.3 m) wide cargo ship in the resulting ice channel
  - 1.4 m (39 mm) thick first-year level ice with a flexural strength of 500 kPa (14 kPa)
- Filming is allowed!





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