Ice Trials of the RRS Sir David Attenborough

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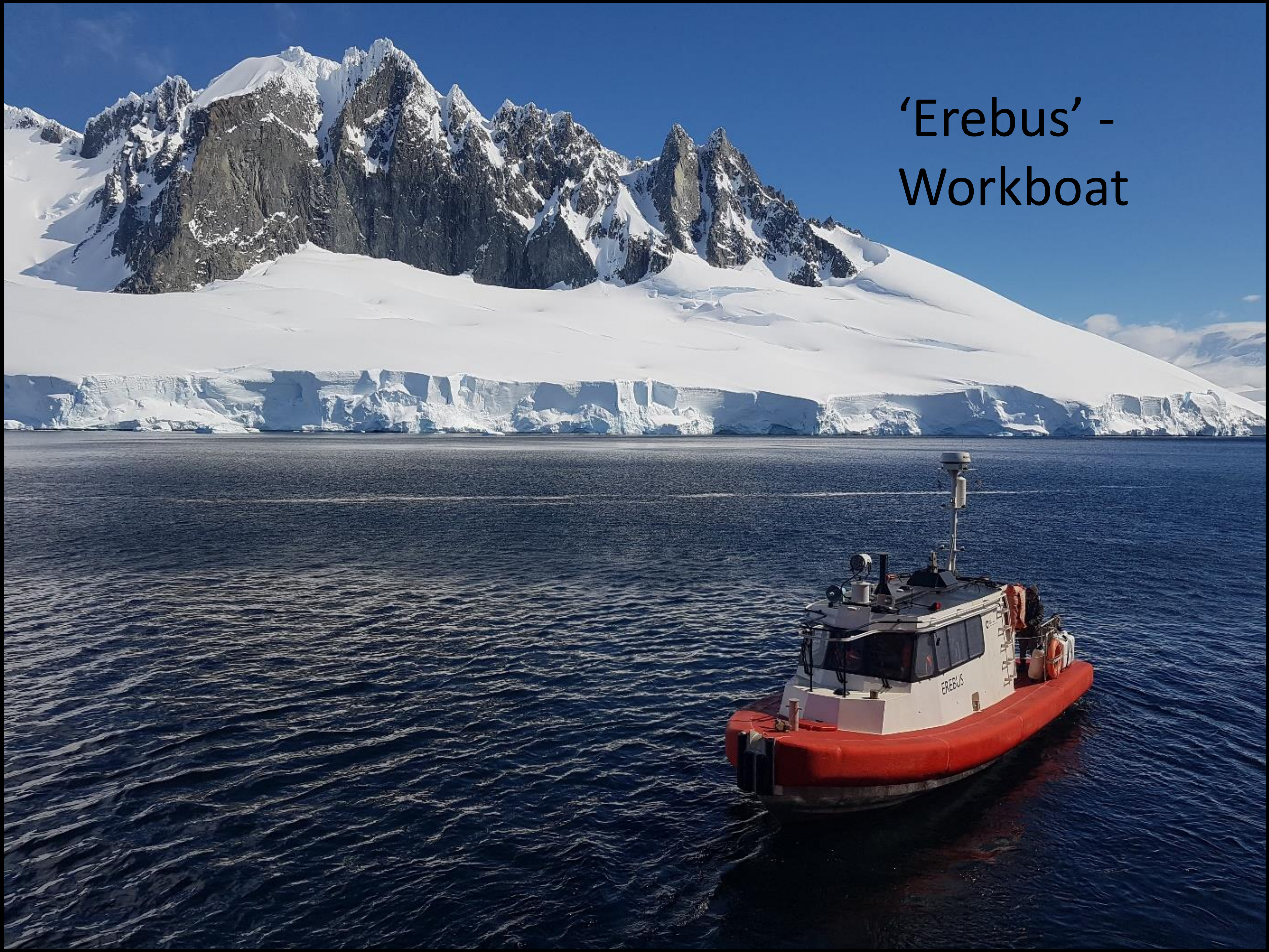
A multi-disciplinary research vessel

LR Classed

- ✠100A1 Polar Research Vessel
- Helideck
- LI
- PC4 Hull and Rudder
- PC5 propulsion
- LFPL
- ECO
- ✠LMC
- UMS
- PSMR*
- NAV1
- CAC1
- DP(AA)
- IBS
- SCM
- Winterisation D(-35), H(-35)
- Helicopter Landing Area

‘Terror’ – Cargo Tender

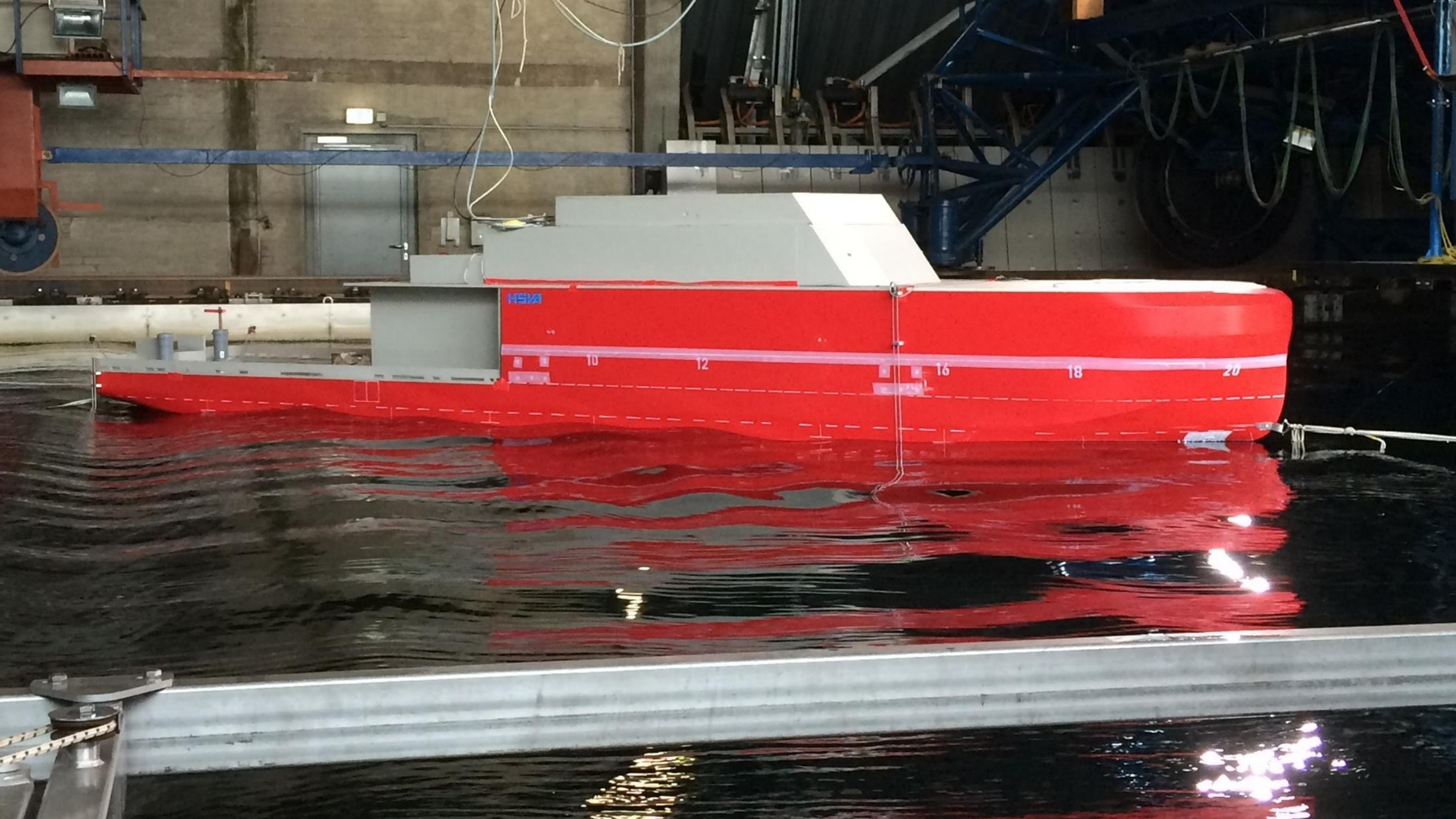
'Erebus' - Workboat




‘SDA 1 + SDA 2’ –
Humber inflatables

Design Challenges:

- Limiting Length
- Limiting Draft
- Balancing Tried & Tested V. Cutting Edge Tech
- Managing Expectations


HSVA
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20

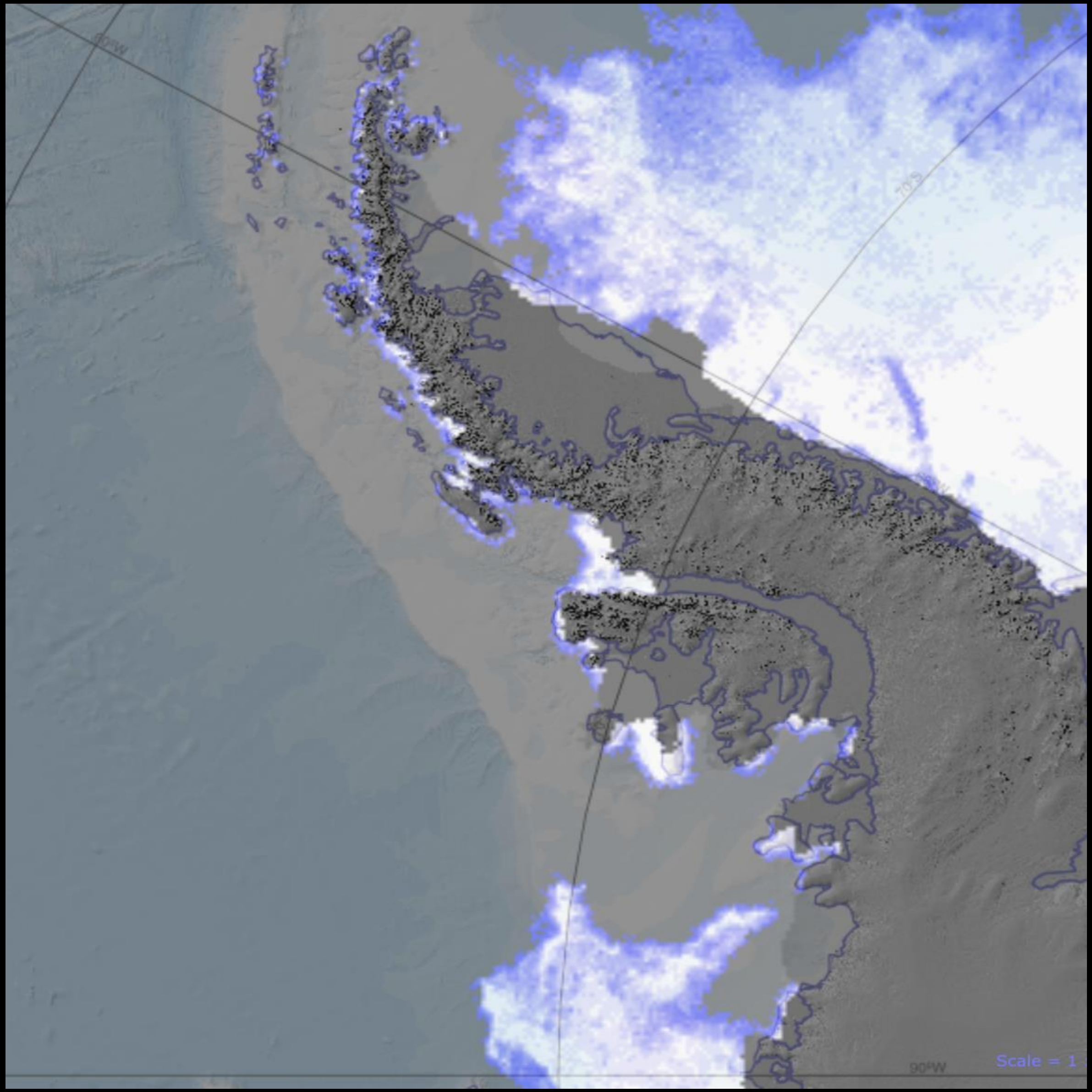

HSVA

ICE TRIALS

13th January to 14th February 2022
Antarctic Peninsula

Challenges

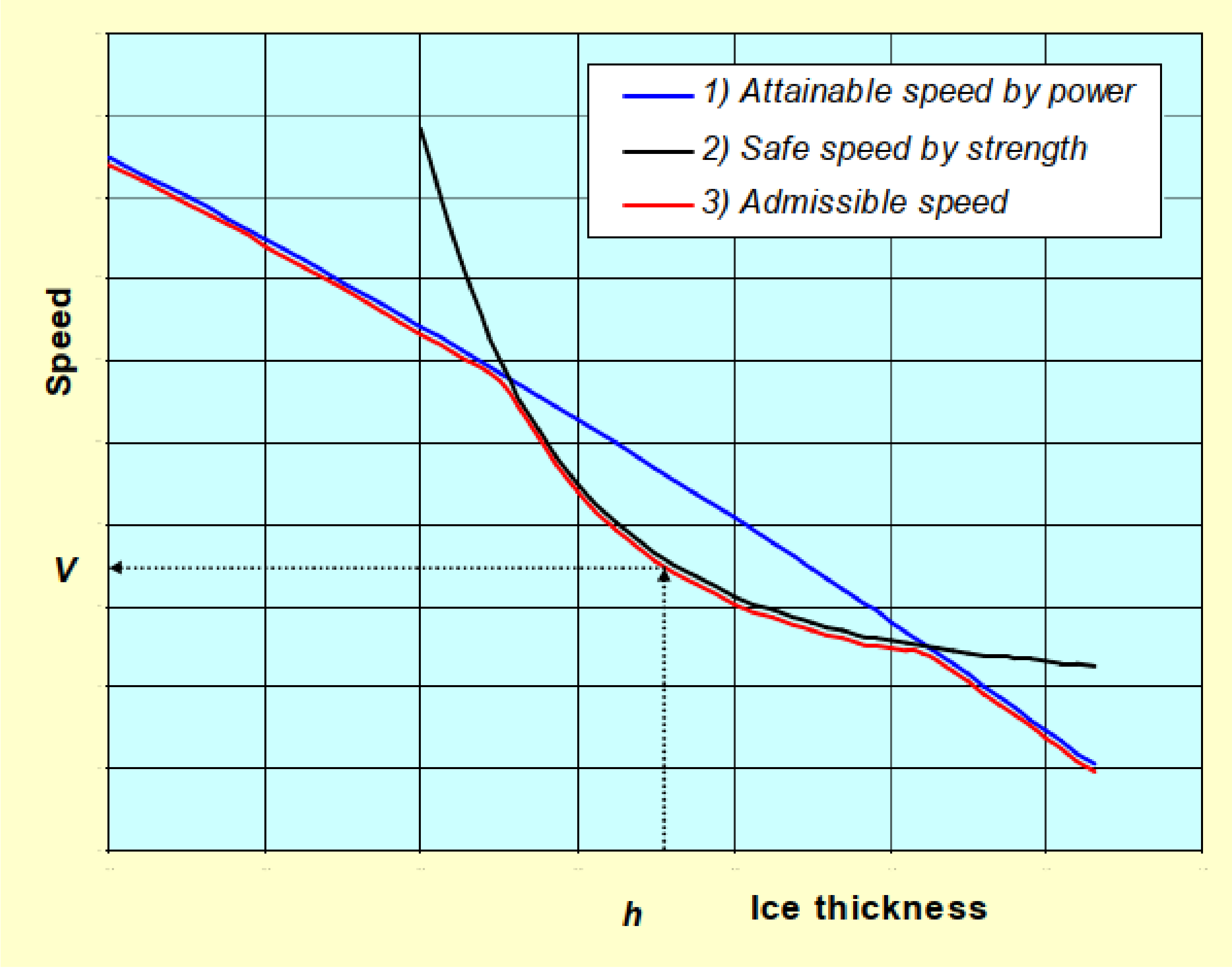
- Too late in the season – most of the fast ice around the Peninsula had disappeared
- High air temperatures
- Very thick snow layer / humidity
- Competing schedules

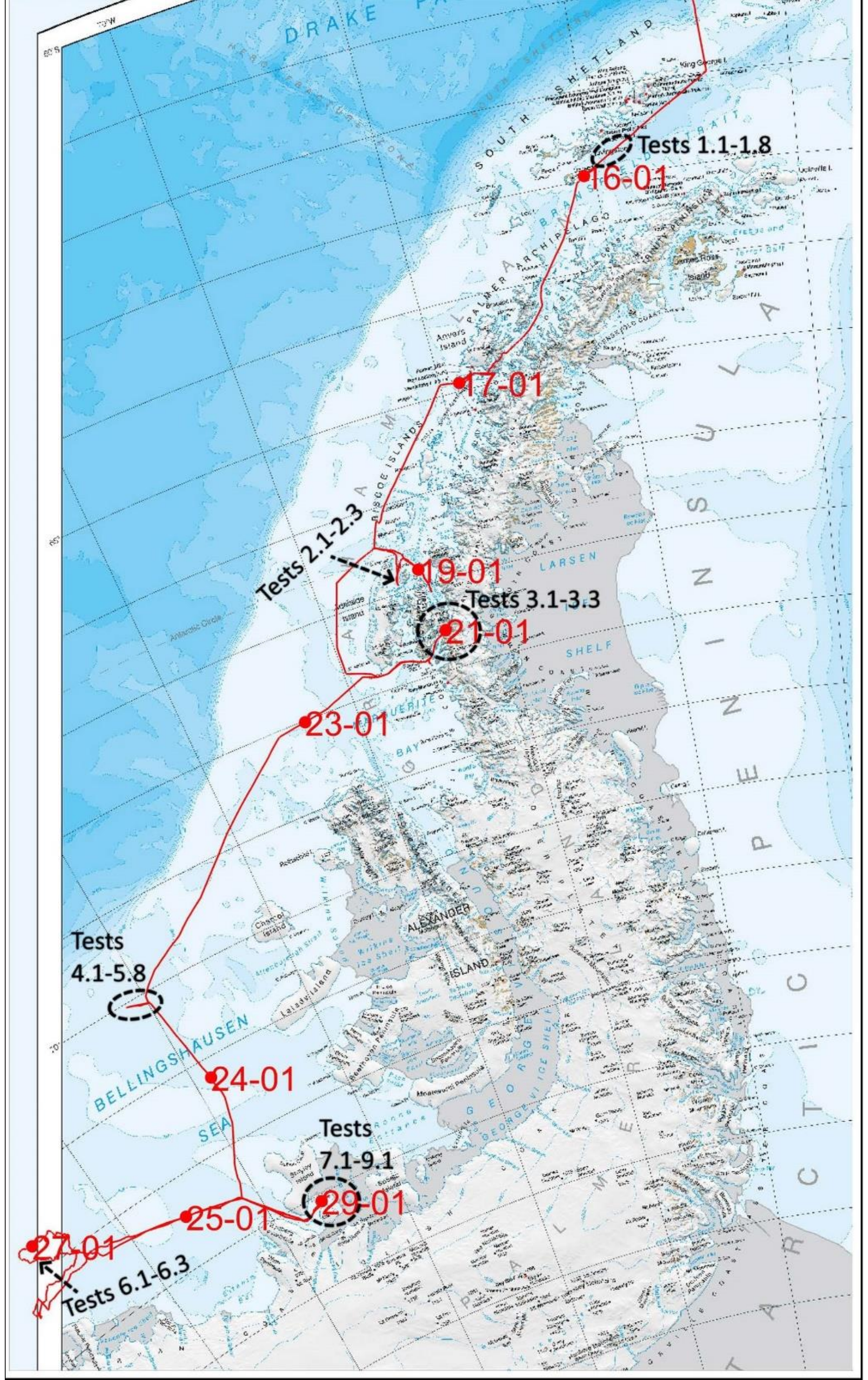


Our first ramming operation in Lallemand Fjord

Reasons for undertaking ice trials

- To formulate operational guidance and to understand the capabilities and limitations of the ship
- ”Extended” operational envelope compared with Polar Code limitations
- Tuned operational limitations specific for the ship and the ship’s environment
- Tuning of warnings from the ice load monitoring system
- To find technical problems/issues for resolution





Date	Test #	Test type	Ice thickness	Direction	Notes
15.1.2022	1.1 – 1.8	Open-water testing	-	Ahead	Bransfield strait ~80% pitch, RPM Mode
17.1.2022	2.1 – 2.3	Bollard "pull"	-	Ahead	RPM, Power and Ice Modes
21.1.2022	3.1 – 3.3	Performance in level ice	~77 cm	Ahead	Landfast ice at Blind Bay
21.1.2022	-	Load vs. speed in level ice	~77 cm	Ahead	Landfast ice at Blind Bay Reported in phase III
23.1.2022	4.1 – 4.8	Open-water testing	-	Ahead	Bellingshausen Sea Power Mode
23.1.2022	5.1 – 5.8	Open-water testing	-	Ahead	Bellingshausen Sea RPM Mode
25.1.2022	-	Glancing tests	-	Ahead	Bellingshausen sea Reported in phase III
27.1.2022	-	Load vs. speed in closed pack	-	Ahead	Bellingshausen sea Reported in phase III
27.1.2022	6.1 – 6.3	Performance in level ice	~110 cm	Ahead	Drifting ice floe at Bellingshausen Sea
27.1.2022	-	Load vs. speed in closed pack	-	Ahead	Bellingshausen sea Reported in phase III
1.2.2022	7.1	Ramming tests	~155 ice, ~145 cm snow	Ahead	Case corner Performance reported in this report Loads reported in phase III
8.2.2022	8.1	Bollard "pull"	-	Ahead	Case corner Ice Mode
8.2.2022	9.1	Bollard "pull"	-	Astern	Case corner Ice Mode

Target ice conditions

<u>Ice Performance tests</u>

- Fast ice
- 100cm thick
- 20cm snow layer
- Level ice / minimal ridging
- No inclusions of ice of land origin
- Ideally 5 x 2km minimum extent

<u>Operational tests in Pack Ice</u>

- Ice floe
- Min. 1km diameter
- Strong ice, not rotten

Measurements

- Ice Property Measurements
- Ship Related Measurements

To understand the mechanics then we need to know:

- Shape of ship
- Ship Mass
- Ship Speed
- Ship Thrust
- Contact Geometry
- Thickness of ice
- Mass of ice
- Strength of ice (bending)
- Strength of ice (crushing)
- Temperature, Salinity, Density of ice
- Snow thickness, density

These we know already

These were measured during the test

These were measured on the ice

By knowing the ice properties of the test conditions we can make reasonable corrections / adjustments / projections about how the ship will perform in other conditions and what ice conditions become the limiting ones from a safety and operational perspective

Continously recording ship parameters throughout the trip

Speed

Power

RPM

Pitch

Torque

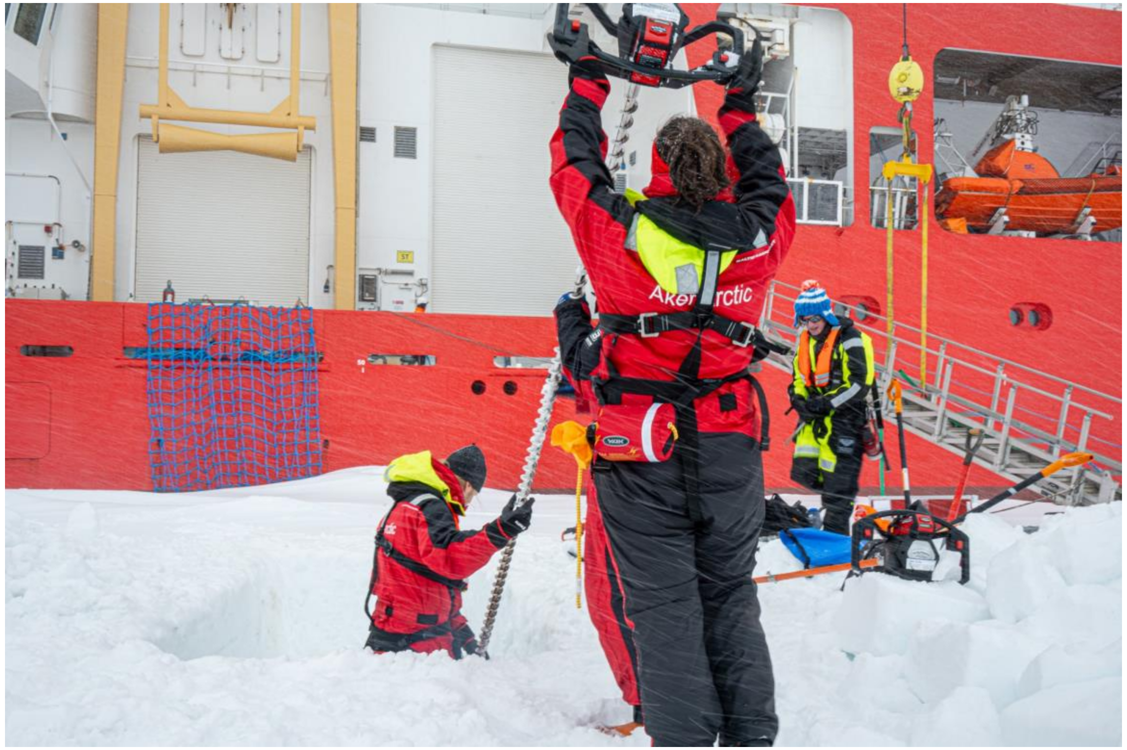
On-ice work

- Undertaken by the Aker Arctic team
- Thickness measurements snow & ice
- Ice core extraction temperature, salinity & compressive strength




Aker Arctic Measurements on Ice - **Thickness**

- Measurements undertaken in many locations to understand variation in thickness
- Relatively consistent thickness is especially important for performance tests
- The thickness of the snow layer is also important
- Ice that is too thick means the ship will not move continuously (we need continuous motion to get an understanding of the power level required to move the ship through the ice)
- Ice that is too thin means we are too far away from the target thickness to accurately extrapolate to the target thickness

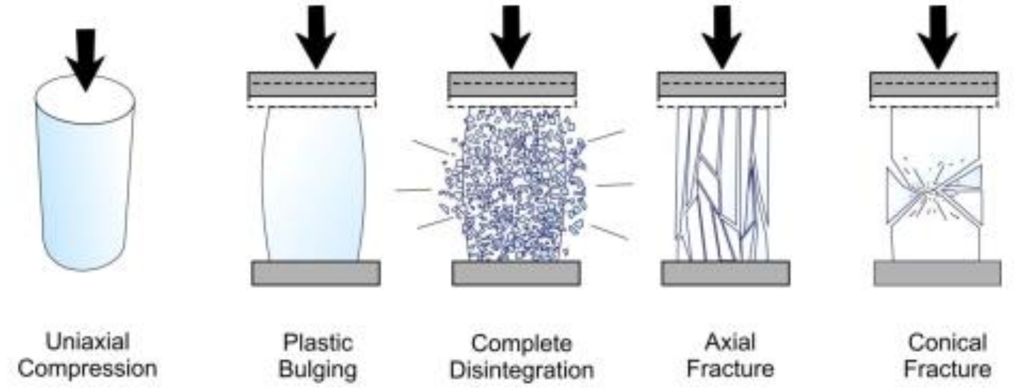


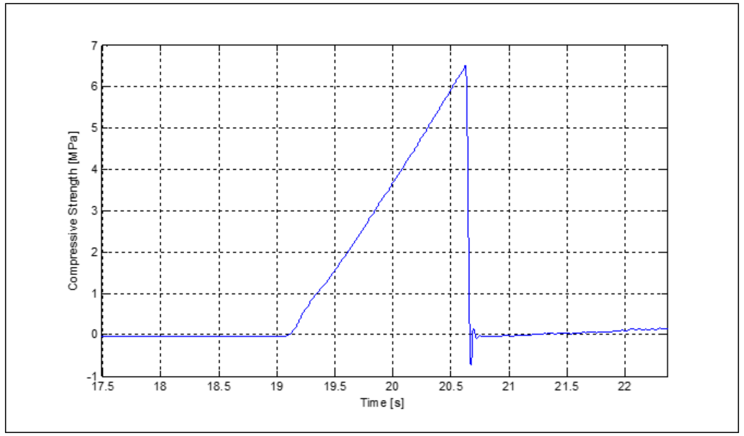
Aker Measurements on Ice - **Coring**

- Coring the ice gives the ice profile:
    - Temperature
    - Salinity
    - Density
- This gives a way of determining the flexural strength of the ice (through an empirical relationship)

Aker Arctic Measurements on Ice – **Compressive Strength**

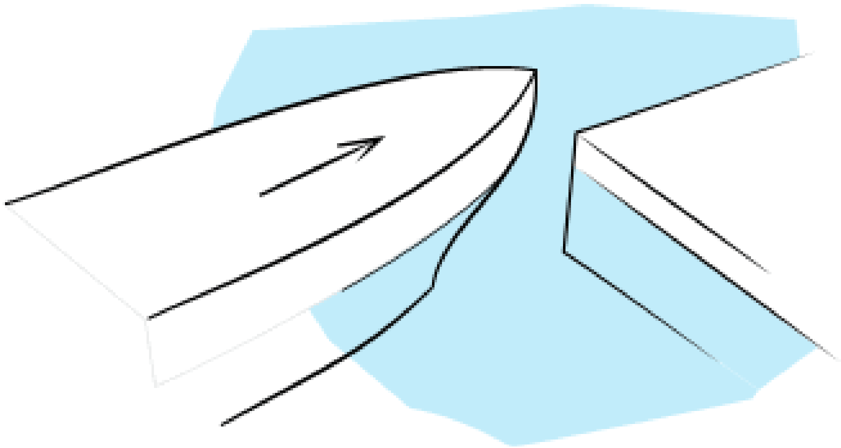
- The ice cores are also used for measuring the compressive strength of ice
- It's important for understanding loads on hull, especially propeller loads
- A lot of scatter in the results, so many measurement points are required

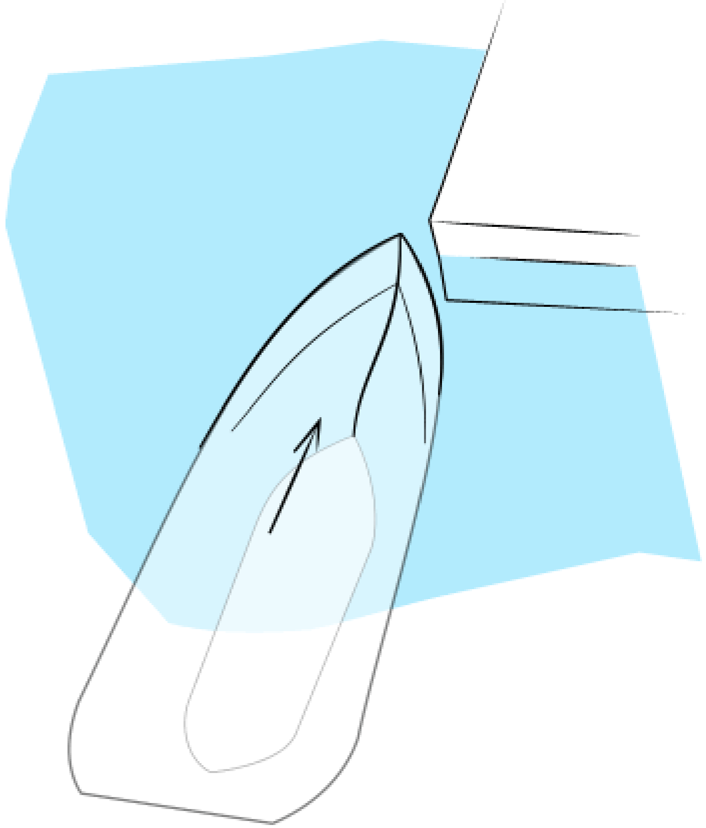




Vessel Glancing Impact Tests

- Purpose
  - Safety Limitations
  - Ideally Undertaken with Different Impact Speeds in different floe masses
- In Open Pack Conditions
  - Ideally a range of floe sizes (thickness here doesnt matter so much, but overall mass does)
  - Ideally for larger floes we would still do ice properies (may be just thickness and salinity)
- Need to "aim" the bow array at the ice edge FRAME 135 – A stick on the helideck was used as an aiming point for the navigators
- Need good sync between ice edge and impact using cameras
- Will help to correlate ice conditions, speed, geometry and ice load monitoring system output



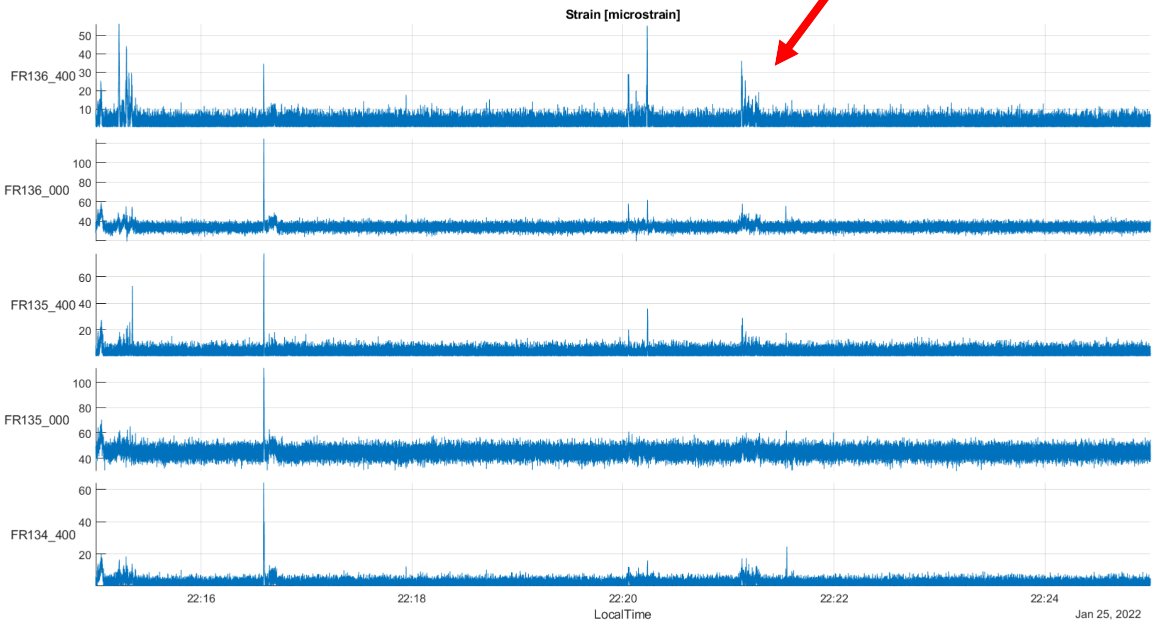


Vessel Glancing Impact Tests

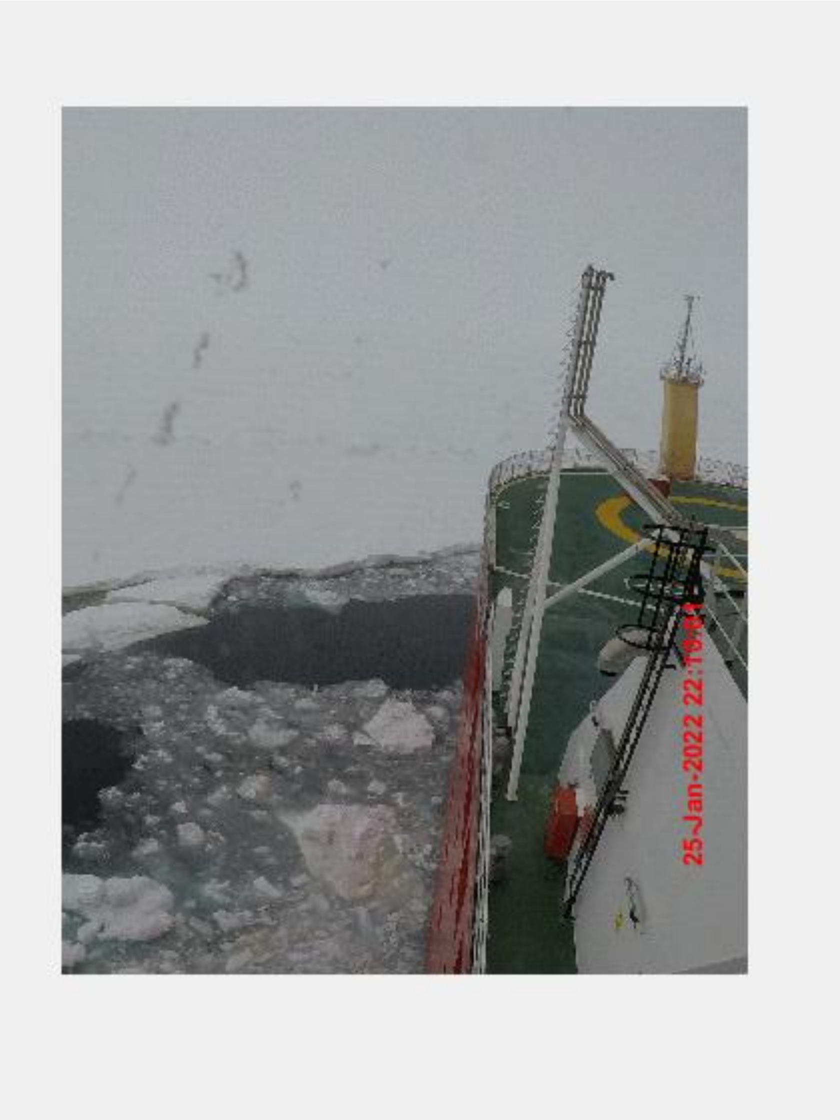
- Glancing impact tests on one vast Second Year Floe in the Bellingshausen Sea
- Controlled impacts at a range of speeds

Impact Peak

Different bow strain gauges



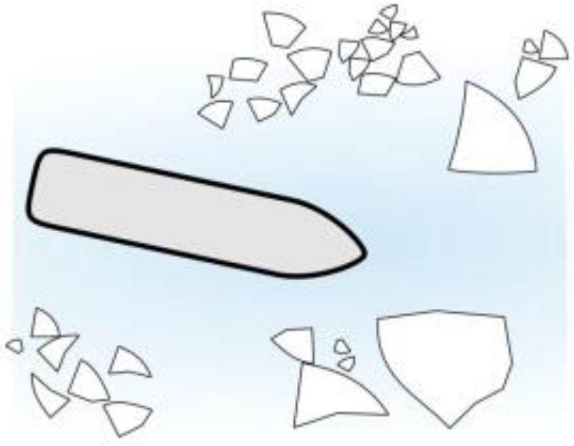
Time history of measured strain on each frame

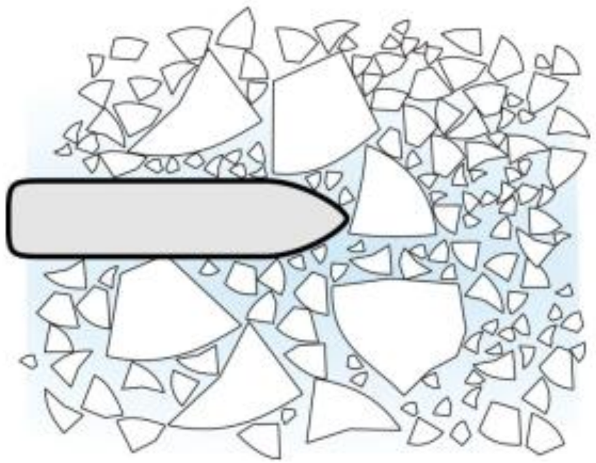


Aker Arctic
The Ice Technology Partner

Vessel Operation in Pack Ice

- Carried out during evening of 27th January 2022 (and also opportunistically along the route)
- Range of pack concentrations (3/4 tenths to 9 tenths), speed range 5-9 knots
- Data to be processed (ILMS data correlated with camera data showing ice concentration)





Bellingshausen Sea Pack Ice Tests

Trials Findings

- Performance was in-line with the expected performance from the ice model tests
- Bollard pull was shown to be less than predicted
- Astern bollard pull was significantly lower than expected
- Main ice chests regularly clogged with ice
- Rudder protection arrangements require reinforcement
- Sheer forces were calculated without harbour allowances, which restricted the use of the crane to heel the vessel to assist in freeing her
- Tank configuration favours a head trim
- Proposed more efficient ice-breaking propeller mode
- Forward sea chest for water making blocks in most ice conditions
- ILM system output needs to be clearer

Modifications Following Ice Trials

Sea & Ice Chest Modifications Undertaken:

- Ice & Sea chest gratings altered to run fore/aft rather than athwartships (to prevent a “grater action”).
- Recirculation system allows for the dumping of hot cooling water into the top of the ice chest.
- Fully modulating recirculation and overboard control system.
- Heat exchangers fitted/uprated to increase temperature of ice chest return water and water making inlet supply as required.

Loading Instrument Modifications Undertaken:

- Harbour condition calculated to allow for crane use and tank flexibility when inducing ice heeling.

Actions & Next Steps

Further operational tests will be undertaken and followed-up in part 2 of the ice trials. Under consideration are the following points:

- Following damage during the ice trials, modifications to the rudder protection systems, particularly to the size of the ice knife and the quick acting valve speed may be undertaken.

- In order to account for the lower than expected astern bollard pull and assist with ice extraction, a friction reducing coating or bubbler system may be considered.

- Following further operational experience, the effectiveness of the ice and sea chest modifications will be quantified.

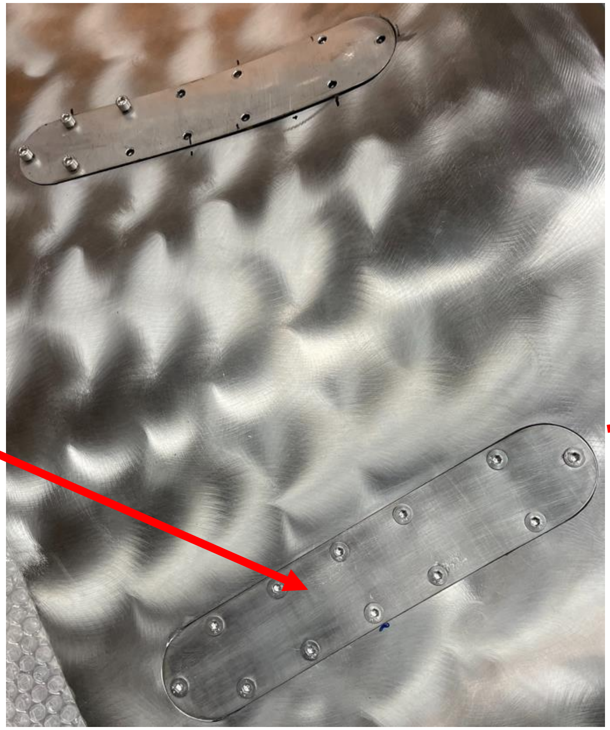
- The vessel will always favour a bow trim.

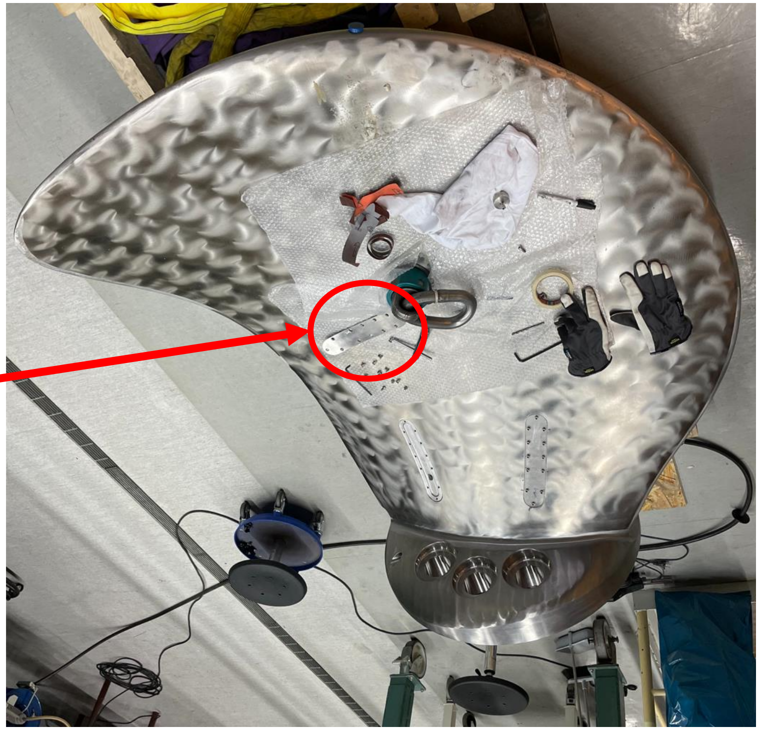
- We need to complete part 2 to assess polar class equivalence for our operational sphere within POLARIS.

Ice Trials Part 2 – In Development

- Measuring the loads on the shaftline gives us some idea of the safety level (some of the forces from the ice impacting the propeller can be felt on the shaft line)
- A blade has been fitted with sensors to measure the ice loads ***directly*** in conjunction with borescope recorded ice impacts

Recessed pockets containing strain gauges





Any Questions?