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Winmos activity 2.3 Conclusions

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CONCLUSIONS:

ICE PERFORMANCE EVALUATION

FOR

WINMOS ACTIVITY 2.3

Co-financed by the European Union
Trans-European Transport Network (TEN-T)

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1 INTRODUCTION

This report is a part of a larger WINMOS project and more specifically Activity 2 that is co-financed by the European Union (EU). The main objective of this report is to present the activity 2.3 Conclusions of the ice performance of the different concepts reported separately in Activity 2.

2 CONCEPTS

1. Basic concept URHO/ATLE Class
2. NB-510 (Finnish Government New Building)
3. Trimaran Icebreaker Concept
4. Oblique Icebreaker
5. Removable Bow Icebreaker

2.1 BASIC CONCEPT URHO/ATLE CLASS ICEBREAKER

The Urho / Atle class icebreakers has been selected as the basic type for Baltic Sea icebreaker due to their well-known capacities in icebreaking duties. In totally 5 vessels were built in the mid-seventies, 2 for the Finnish and 3 for the Swedish Maritime administrations. The reference icebreakers are well known by the users and recognized of the highest standard of ability in ice.

Icebreaker Urho Completed in 1975, followed the traditions of four propeller propulsion, one in each corner. Two rudders were installed at the first time, resulting in improved maneuverability, but at the same decreasing the astern going capability especially in level ice. The flushing effect of the bow propellers when moving forward is appreciated, this especially in a compressive ice and ridges. In compressive ice the Urho / Alte series icebreakers also benefits from a slender hull form almost without any parallel mid-ship part.

The main dimensions of the vessel are the following:

Length, over all	104.6 m
Length, dwl	96.0 m
Breadth, dwl	22.5 m
Draft, design	7.3 m
Draft, max	8.5 m

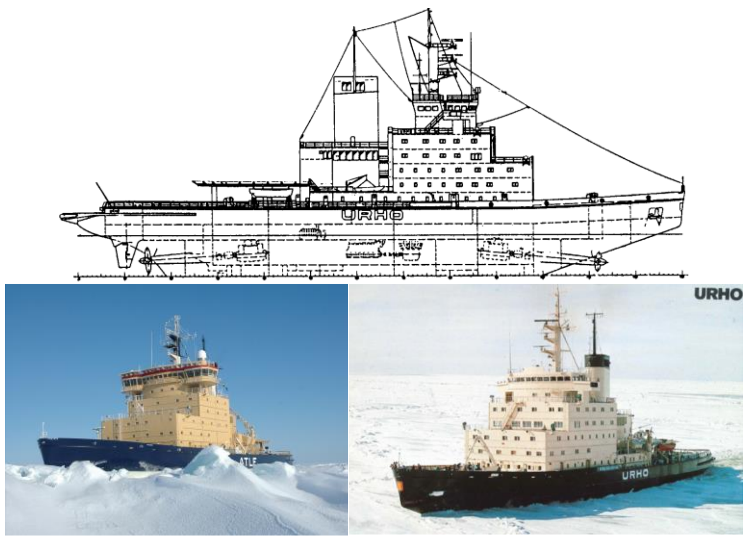

Figure 1 Urho / Atle class icebreaker

The propulsion power of the four shaft propellers are dived to 2 times 4.85 MW in stern and 2 * 3.24 MW in bow. The bollard pull ahead is measured to be about 185 tons.

2.2 POLARIS (FINNISH GOVERNMENT NEW BUILDING)

The New design is intended for year-round independent operation in thick first-year level ice and all other ice conditions appearing in the Baltic Sea region, in particular in the main operation area in the Bay of Bothnia.

One of the main criteria for the design was to have an ice-breaking capability equal to or better than the Urho / Atle class icebreakers. The ice going capability is achieved by optimizing the required ice performance with minimum power by designing the hull form to have minimized ice resistance in general ice operations.

The criterion of the propulsion system is to maximize the propulsion efficiency in occurring ice conditions, such as compressive ice and in heavy ridge fields.

Main dimensions

The main dimensions of the vessel are the following:

Length, over all ....110 m
Length, dwl ....98 m
Breadth, dwl..24 m
Draft, design ....8.0 m
Draft, max ....9.0 m

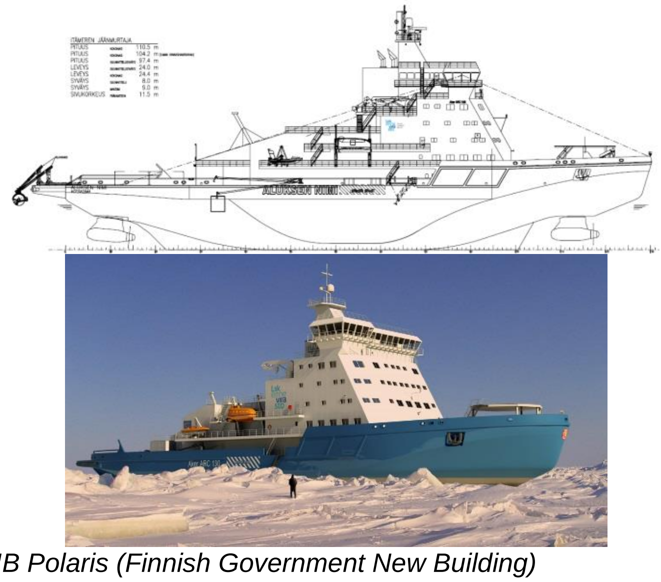

Figure 2 IB Polaris (Finnish Government New Building)

The vessel is designed with three azimuth thrusters, one in bow and two in stern. The total propulsion power is 19 MW (2*6.5 Mw+1*6 MW). The estimated bollard pull will be about 194 tons.

2.3 TRIMARAN ICEBREAKER CONCEPT

The vessel is an icebreaking trimaran with a large main hull and two smaller side hulls. The main hull and side hulls are connected to each other with a stiff cross deck. The hull form is developed primarily for icebreaking operations with a sloping stem and no forefoot. In addition, the side hulls have highly sloping sides to provide high maneuvering capability in ice. High forecastle and covered mooring deck prevent green water in heavy seas

The main dimensions of the vessel are the following:

Length, over all .... 100.0 m
Length, dwl .... 92.2 m
Breadth, dwl .... 38.6 m
Breadth, main hull .... 17.5 m
Draft, design .... 8.0 m
Draft, max .... 8.5 m

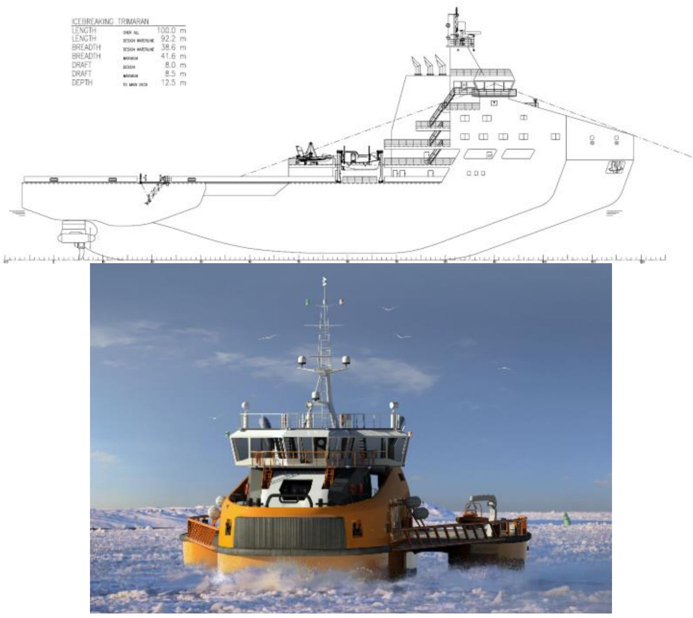

Figure 3 Trimaran icebreaker concept

In the current design the azimuth thrusters in the side hulls are of ABB Azipod ICE 1400 type, rated at 3,500 kW each. Together with the controllable pitch propeller, the maximum propulsion power is about 13.5 MW. The bollard pull of the vessel is 150 tons.

2.4 OBLIQUE ICEBREAKER

The vessel is a compact size Icebreaker provided with diesel-electric propulsion with three azimuthing thruster propellers. The propulsion solution and the unique hull form allow the vessel to operate efficiently ahead, astern and obliquely (sideways). One of the propulsors is located in the bow, one aft and one on side in the aft part of the vessel.

The main dimensions of the vessel are the following:

Length, over all .... 87.5 m
Length, dwl .... 78.5 m
Breadth, dwl... 20.0 m
Draft, design .... 7.5 m

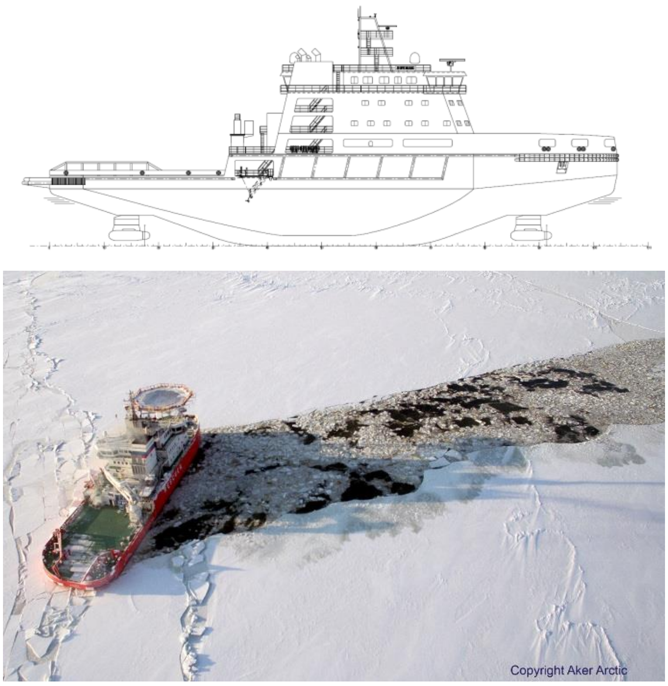

Figure 4 Oblique icebreaker concept

In the current design the azimuth thrusters are of ABB Azipod ICE 1400 type, rated at 3,500 kW each. The maximum propulsion power is about 10.5 MW. The bollard pull of the vessel is 105 tons.

2.5 REMOVABLE BOW ICEBREAKER

The removable bow icebreaker is designed for Baltic ice conditions excluding hard Gulf of Bothnia operations. The presented designs are based on moderate sized pusher with power less than required for an icebreaker. Thus the removable bow has an own propulsion. If e.g. strong enough supply ship is used as a pusher unit it is possible to have a removable bow without propulsion. Also if smaller less efficient icebreaker is designed the pusher power may be enough.

To give realistic basis for the design M/S Louhi has been used as an example pusher. It fulfills well the set requirements and thus gives a good basis for the study. The azimuth thruster propulsion gives maneuvering, backing and ice management power in ice.

However the presented design can be easily adjusted according any suitable pusher vessel requirements and even (by rebuilding the aft part of the removable bow) the bow section could be relatively easily changed to suit for another pusher if necessary.

The results of the design process can be also used when considering smaller versions of the concept.

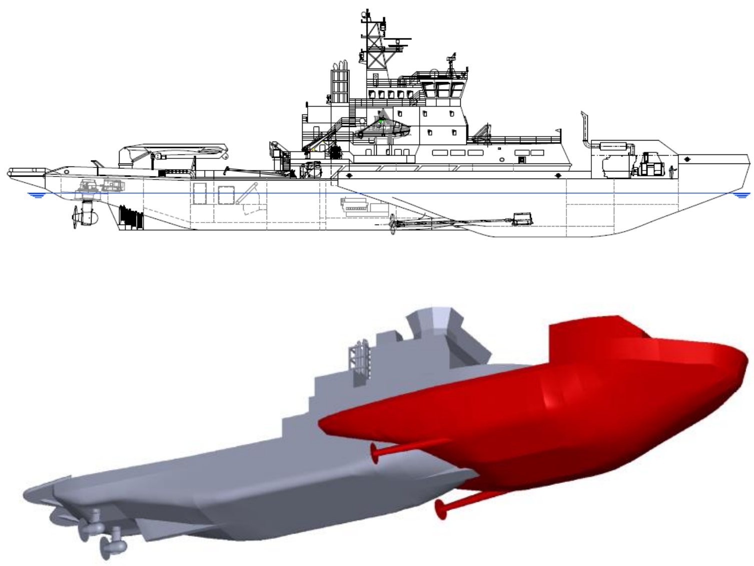

Figure 5 The removable bow icebreaker concept

The main dimensions of Louhi, removable bow section and combination are:

	Louhi	Removable bow	Combination
Lcwl	67.4 m	50.3 m (44.7 m)	91.8 m (86.2 m)
Bcwl	14.5 m	24.0 m	24.0 m
T	5.0 m	6.0 m	6.0 m

The propulsion power of the two azimuth thruster of Louhi is in total 5.4 MW. The Power of the removable bow is 2* 3 MW. The total power (11.4 MW) is estimated to given a bollard pull of 125 tons.

3 ICE CONDITIONS TO STUDY

Full-scale trials and model-scale test in ice are usually done in conditions set by requirements defined for the vessel. Therefore the achieved ice performance might be differing form the experience achieved in daily operations. This study compare model-scale and full-scale results, and tries in that way to give an overview of the actual ice performance of the conceptual icebreakers.

3.1 SIMULATED ICE CONDTIONS

3.1.1 RUNNING AHEAD IN 0.6 AND 0.8 M THICK LEVEL ICE

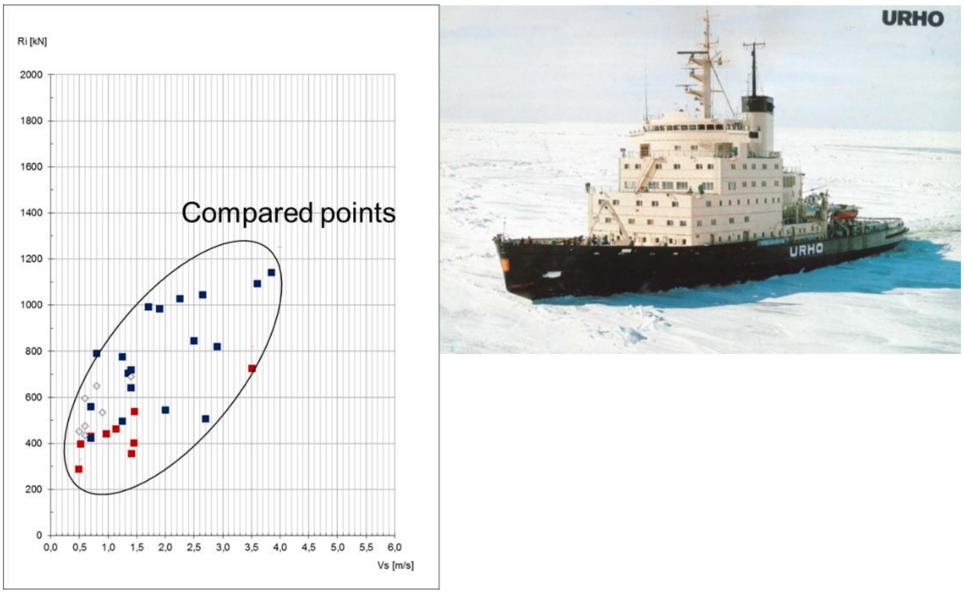

Figure 6 Performance of Urho/Sisu/Ymer in level ice

3.1.2 RUNNING ASTERN IN 0.8 M THICK LEVEL ICE

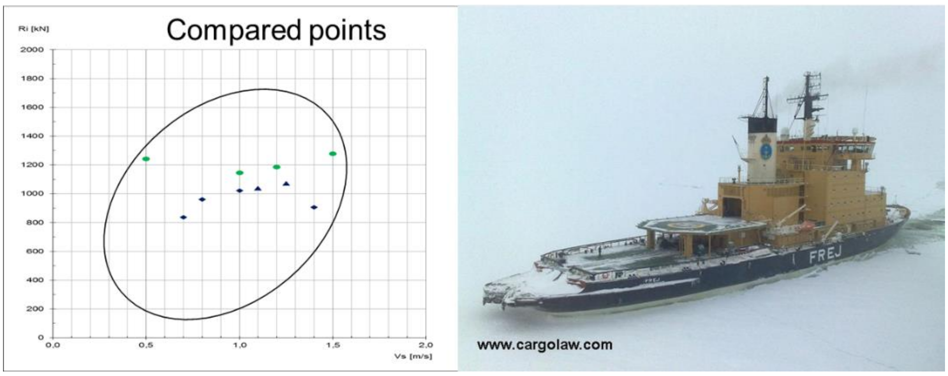

Figure 7 Level ice results astern in full-scale

3.1.3 RIDGE PENETRATION CAPABILITY

Ridge penetration, Maximum keel thickness about 15 m

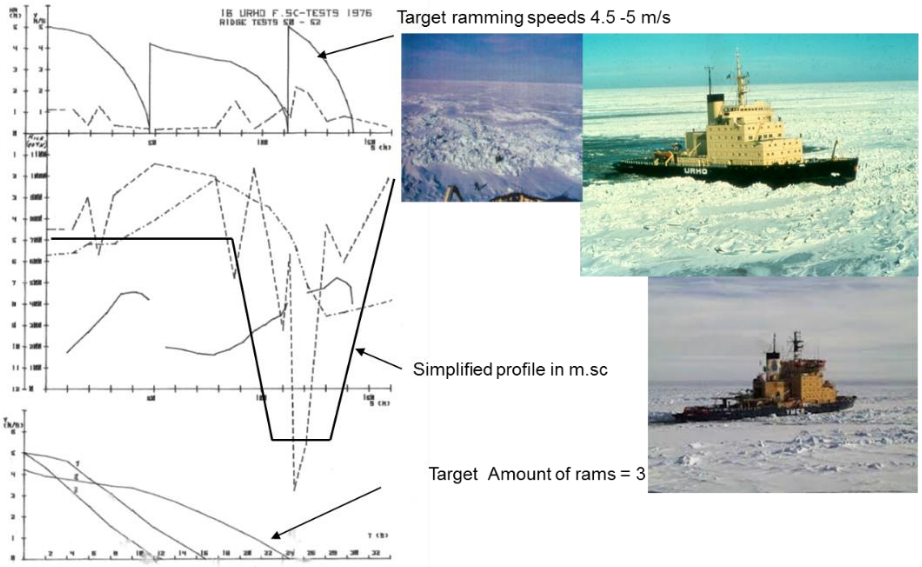

Figure 8 Ridge penetration through selected tested ridge profile

3.1.4 MANEUVERABILITY IN ICE

3.1.4.1 Turning Circle in level ice

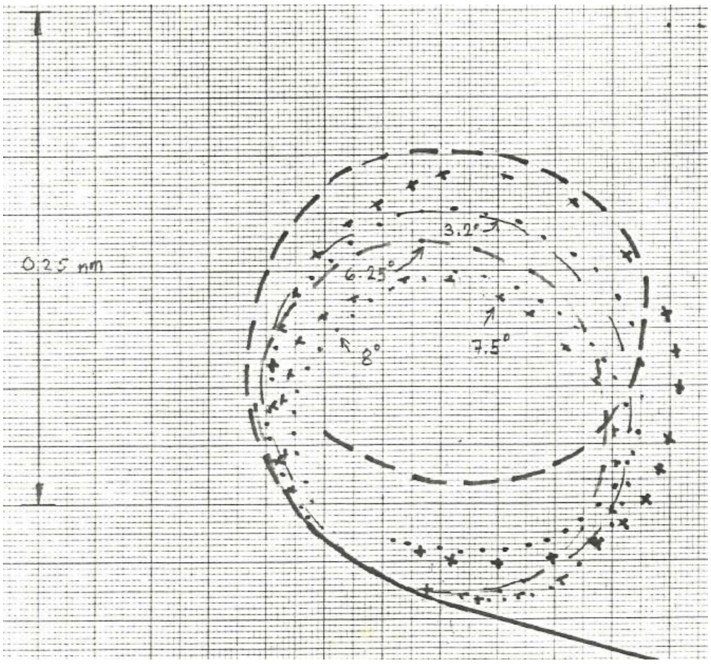

Figure 9 Turning circle in level ice

4 FULL-SCALE TRIALS VERSUS MODEL-SCALE TEST RESULTS COMPARISON

To increase the understanding about icebreakers operational performance in ice based on performance estimated by model tests and measured during full-scale trials a comparison has been done with Urho / Atle class icebreakers results achieved from test in different ice conditions. One of the main reasons to make this comparison is the fact that both full- and model-scale tests usually are done in ice conditions corresponding to requirements and not in real operational conditions in ice. By comparing the results and possible confirmation of correlation, the performance can be translated to the operative ones. The intention is to get a new tool to evaluate operational performance of new concepts.

The Urho / Atle class icebreakers were chosen as basic vessel due to that reference icebreakers are well known by the users and recognized of the highest standard of ability in ice in Baltic Sea area

For the comparison, a new model of Urho / Atle was built and both open water and ice model tests were made with new technologies.

4.1 BOLLARD PULL

The bollard pull measured in the trials with icebreaker Urho is 185 tons (1815 kN). In the new model test the measured and estimated bollard pull was about 190 tons (1865 kN). The difference is 2.7 % and might depend on uncertainties during the full-scale tests. Hence all of the full-scale results are based on the 185 tons in bollard pull, this value will be used to evaluate the performance of the ship.

The astern bollard has not been measured for the ships, therefore the result estimated in model-scale will be used. The estimated bollard pull astern will be close enough to be considered as valid.

4.2 LEVEL ICE AHEAD

Test results for level ice for the Urho / Atle class were originally presented as two different ice thicknesses, 0.6 m and 0.8 m. However the ice thickness was during the ice trials, in the thicker ice, differing much from the target of 0.8 m. The ice was varying from about 0.75 m to nearly 1 m. This results in a large scatter of the measured points, especially when correcting all of the results to 0.8 m thick level ice. Therefore a new analyze of the results were done, where the each test point corresponds to an ice closer to the measured ice thickness. This results in two different thicknesses for the ice trials performed in 1976. The thicknesses presented for the full-scale test are 0.6, 0.8 and 0.9 m thick ice. The corresponding model test were performed in 0.6 m and 0.87 m thick ice.

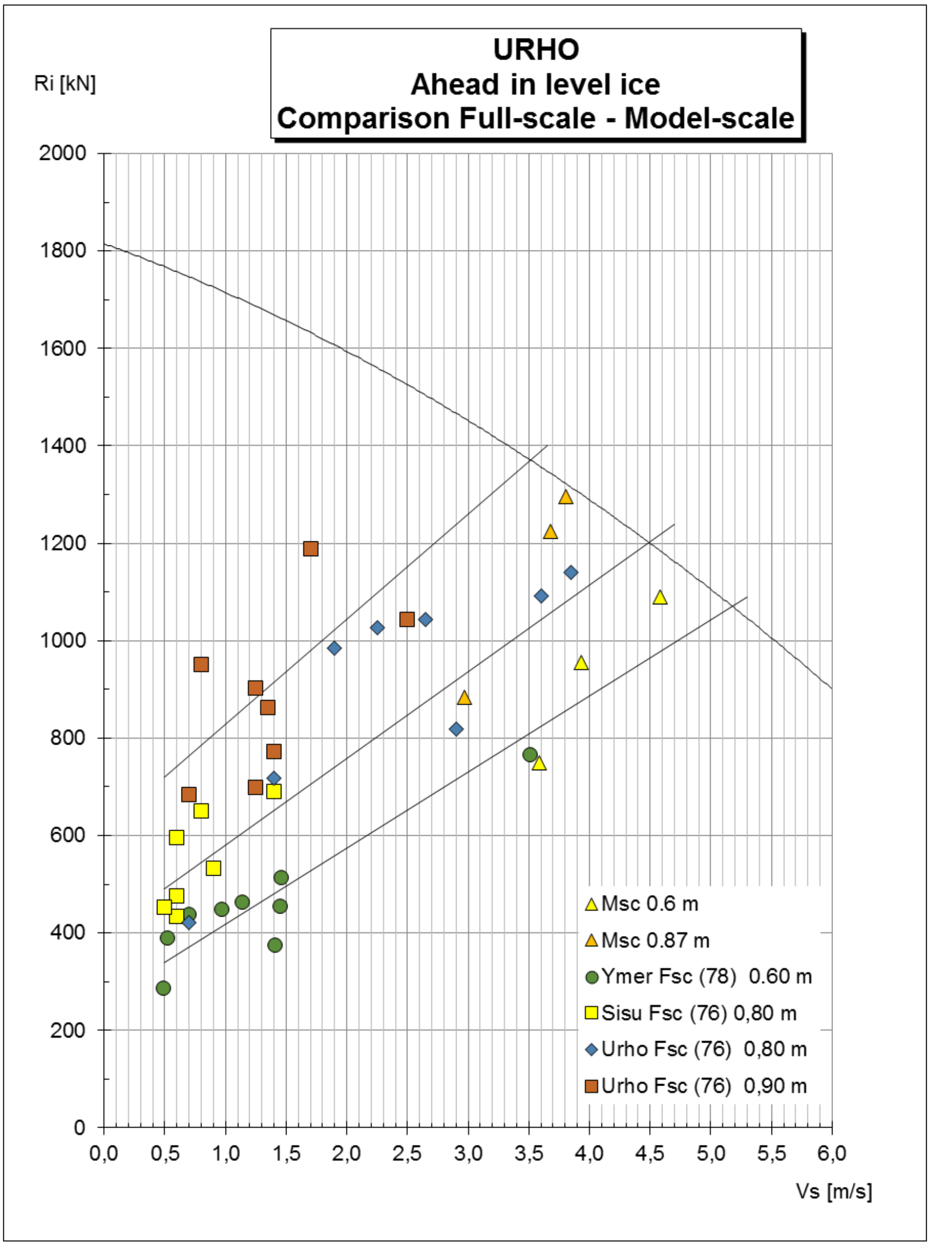

Figure 10 The measured level ice resistance in different ice thicknesses (lines represents F.sc regressions)

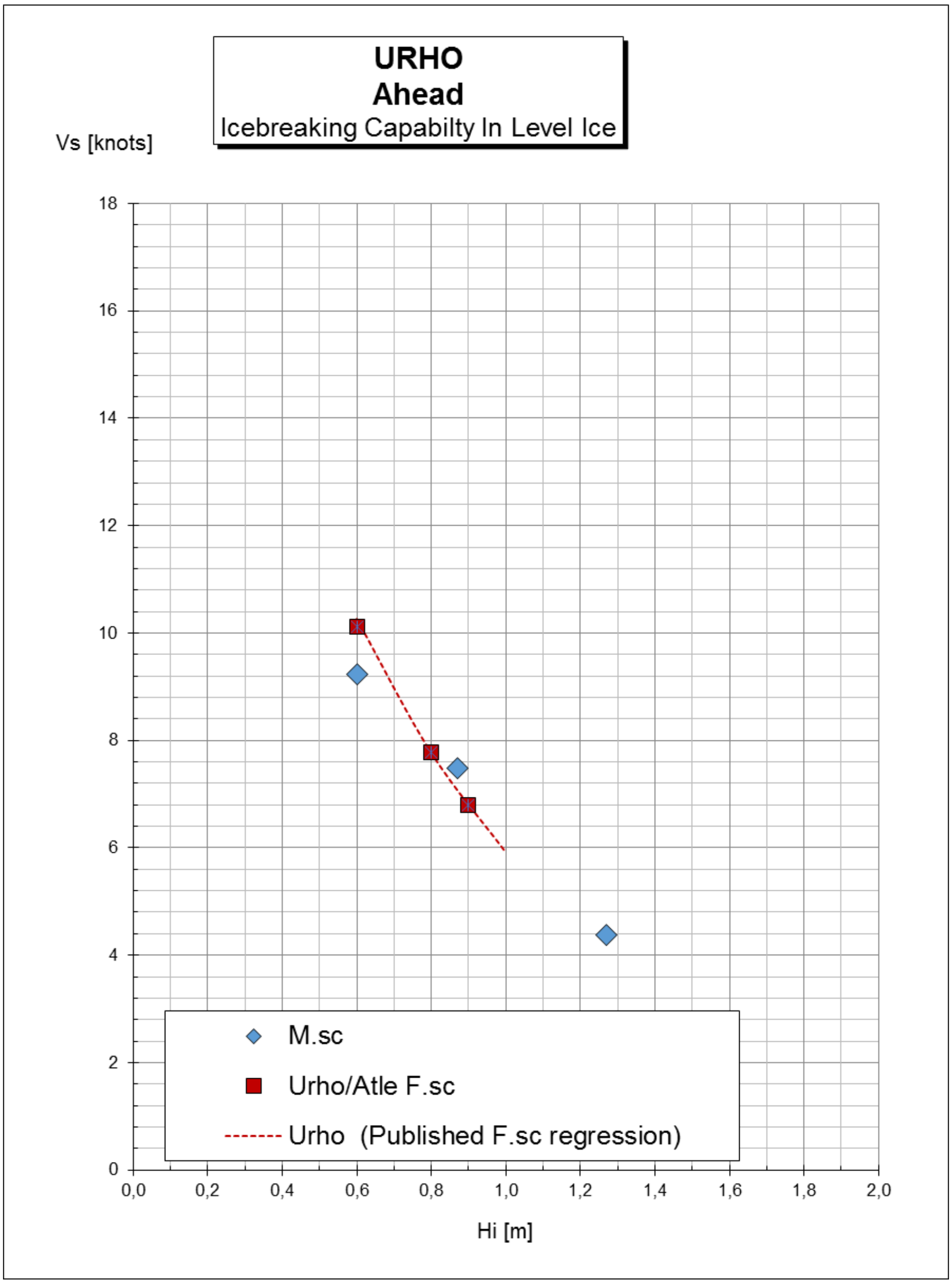

Figure 11 The ice breaking performance of Urho / Atle ahead in level ice

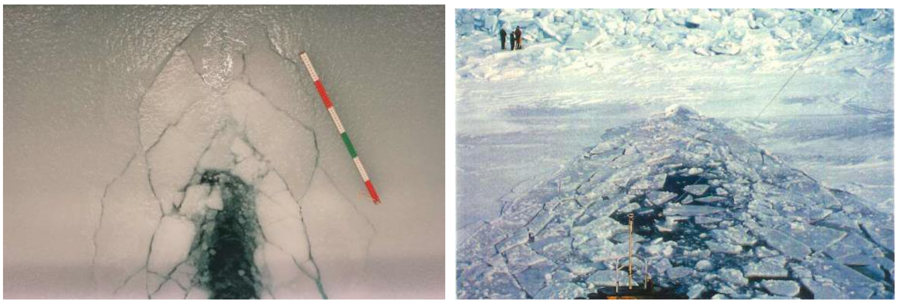

Figure 12 Comparison of breaking pattern

4.3 LEVEL ICE ASTERN

Test results for level ice running astern for the Urho / Atle class were available in only one ice thicknesses 0.8 m, but the test has been performed at three different stern drafts varying from 7.3 m to 8.3 m, of which the two closest to the draft tested in model scale (T =7.3 m) has been compared. Notable is that the ice knife configuration of Urho / Atle class is quite sensitive of used stern draft. Already a small change in it will influence on the ice going performance astern.

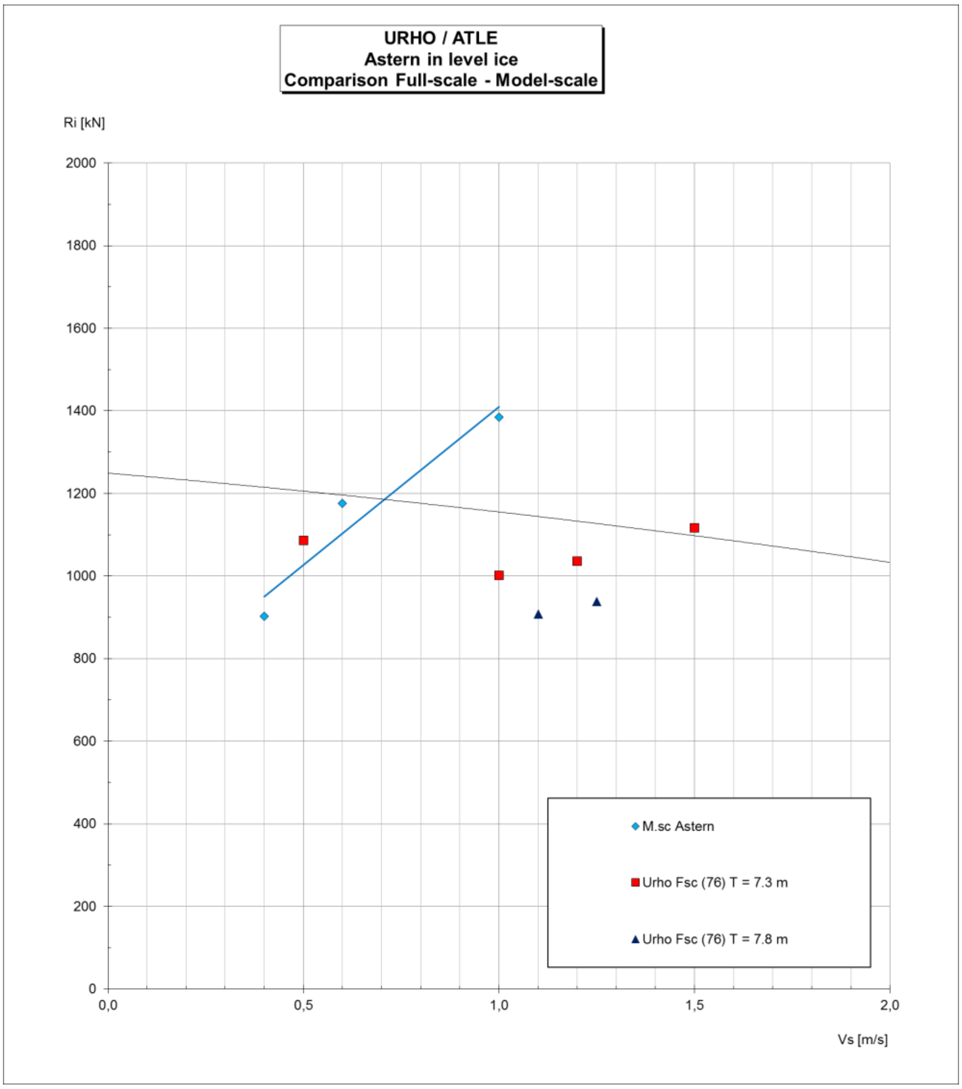

Figure 13 Determined level resistance astern

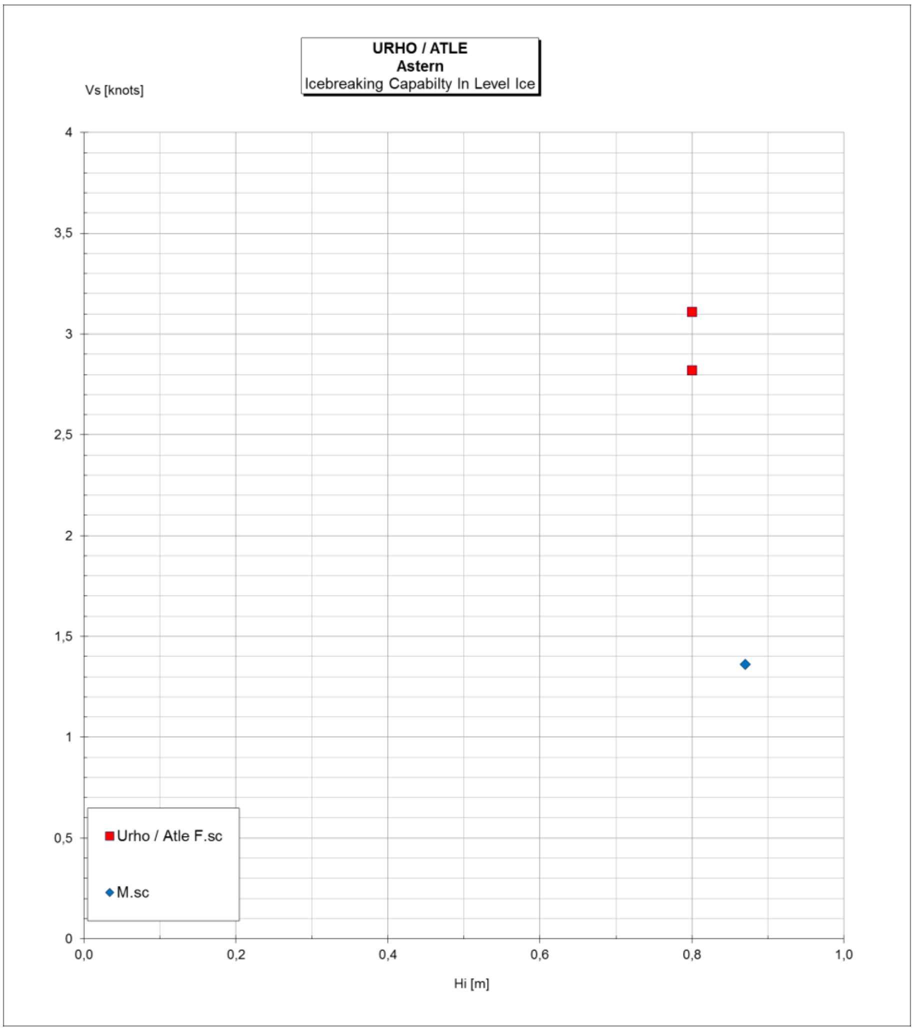

Figure 14 The ice breaking performance of Urho / Atle astern

4.4 RIDGE PENETRATION

For the comparison two tested and measured ridges in full-scale were chosen as to be simulated in the model tests. The profile of the ridge was simplified but was in length and the mass equal to the full-scale ridge.

The figures presents the ramming speed and deaccelerating of the speed. The penetration length for each ramming and the measured ridge profile at each ramming.

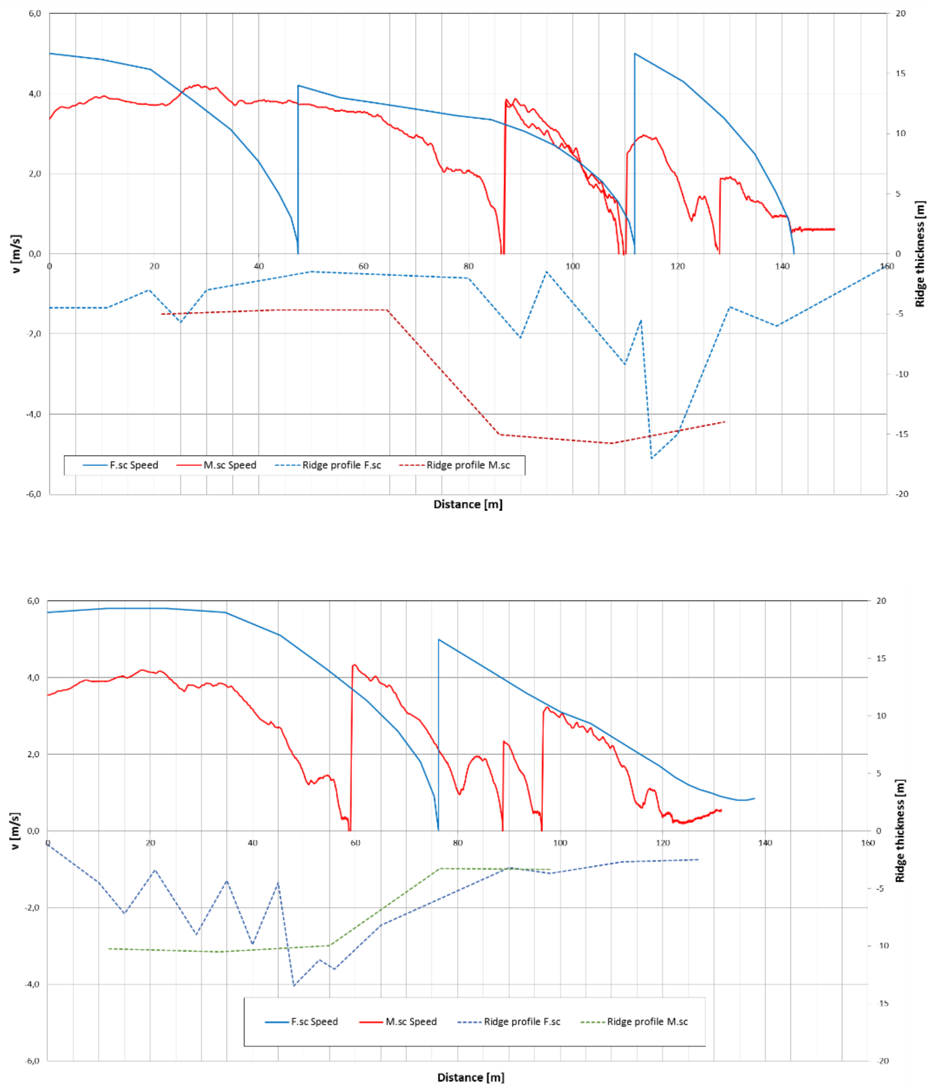

Figure 15 Comparison of ridge penetration, ramming cycle

4.5 MANEUVERABILITY IN ICE

4.5.1 TURNING CIRCLE IN LEVEL ICE

The available result from full-scale trials are in a range of 0,62 - 0,73 m thick level ice, and in that way differs from model-scale tested thickness (0.87 m). This of course will make a direct comparison difficult, but an estimation of correlation is still possible to do. However extrapolating of the full-scale results to same thickness, will only give an indication of the correlation I Note the smallest turning radius in full-scale was achieved by reversing one side propellers (R/L = 1.6).

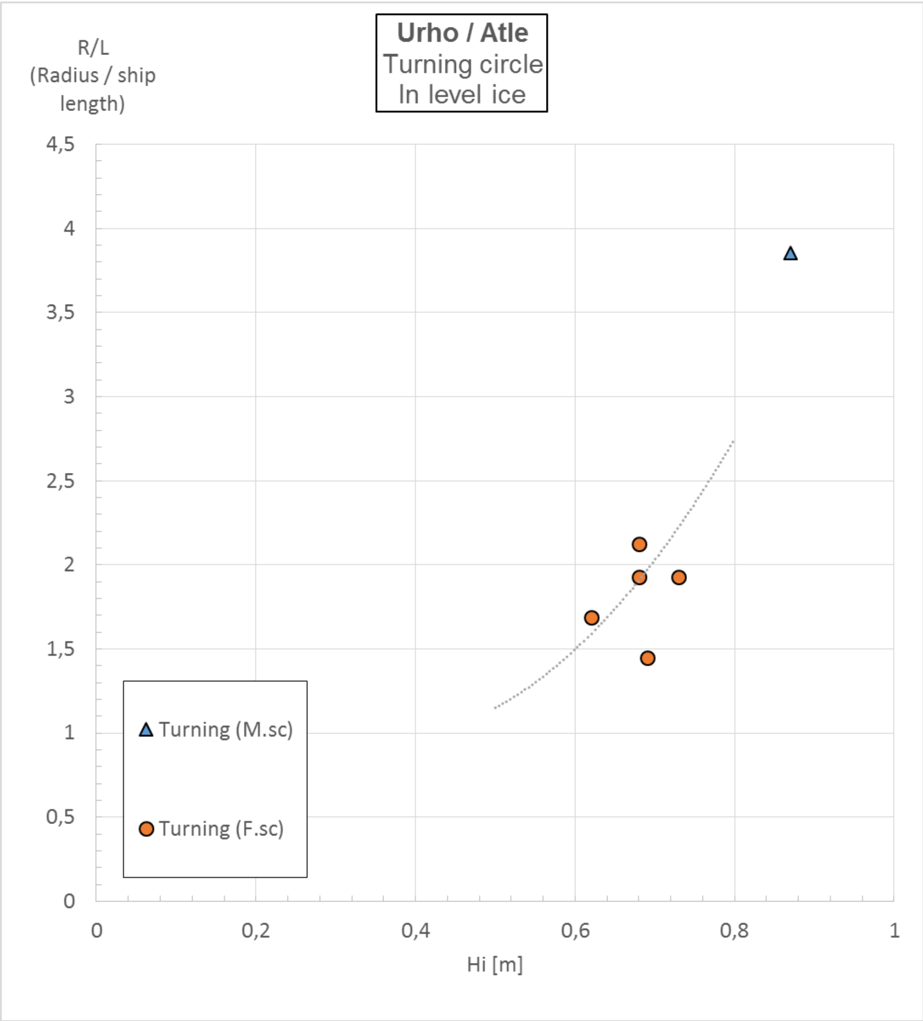

Figure 16 Turning circle of Urho / Atle class icebreakers

5 ICE PERFORMANCE CONCEPT COMPARISON

The ice performance of the concepts has been estimated with design main dimensions and propulsion power. The results presents in that respect the performance of the vessel

5.1 LEVEL ICE AHEAD

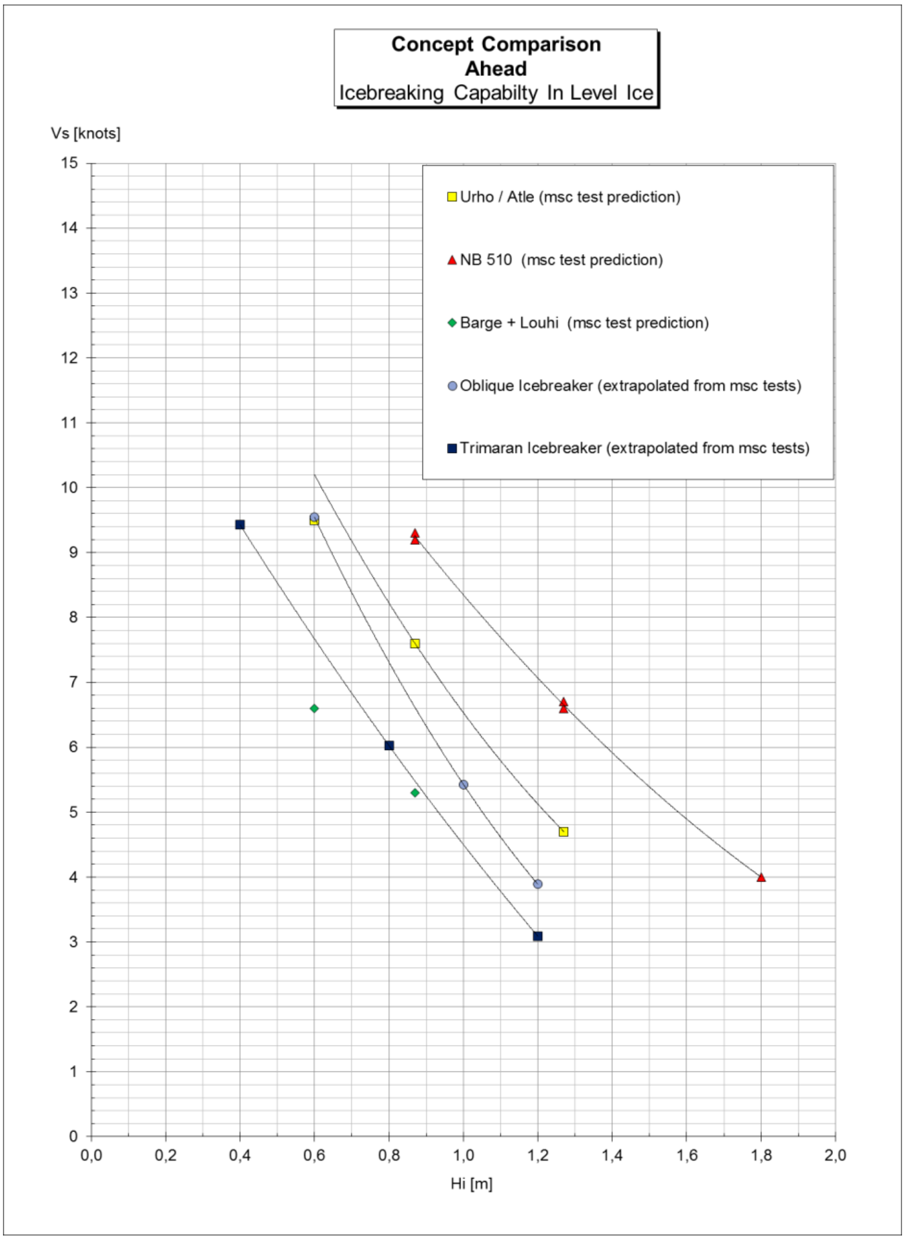

Figure 17 Ice going performance of concepts, in ahead mode

5.2 LEVEL ICE ASTERN

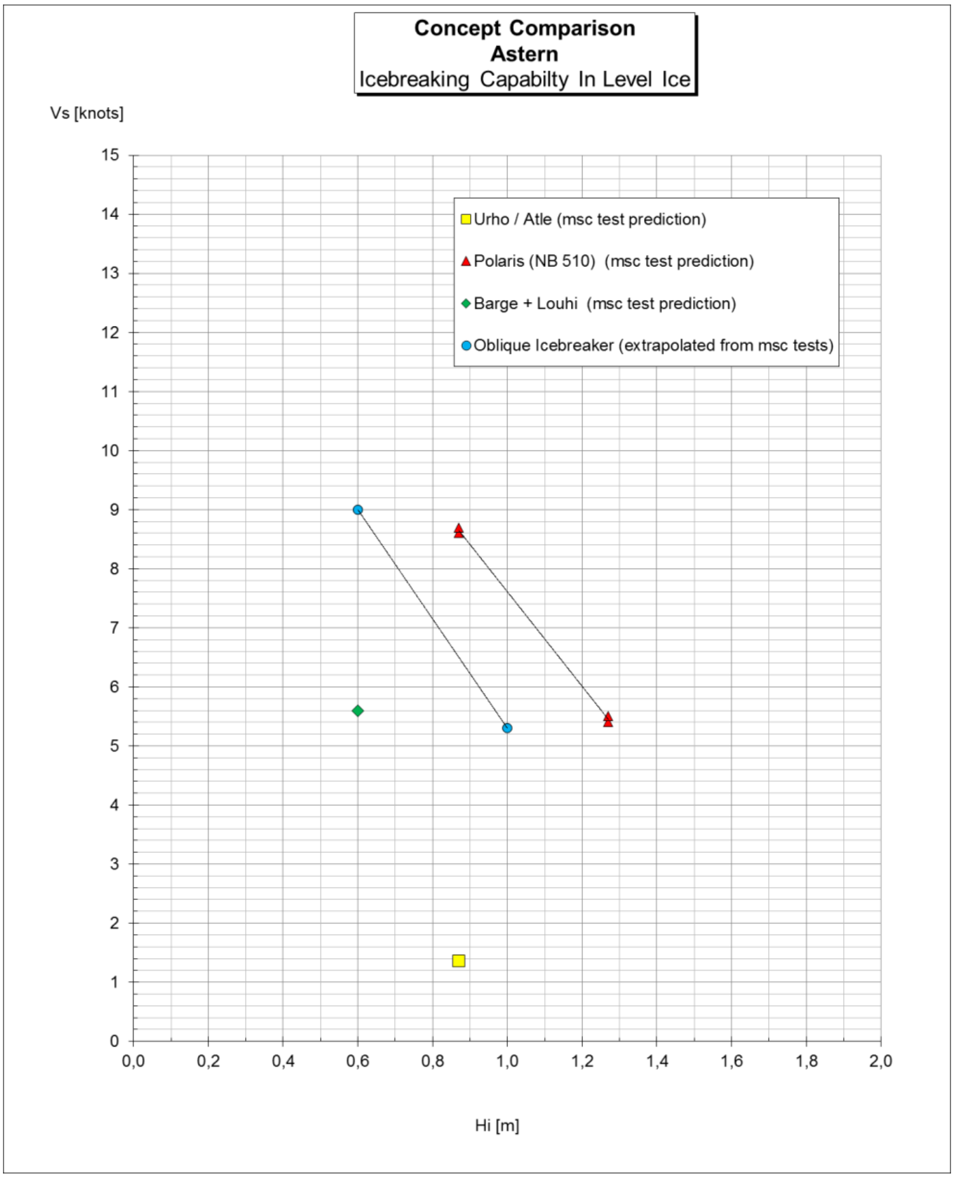

Figure 18 Ice going performance of concepts, in astern mode

5.3 BRASH ICE CHANNELS

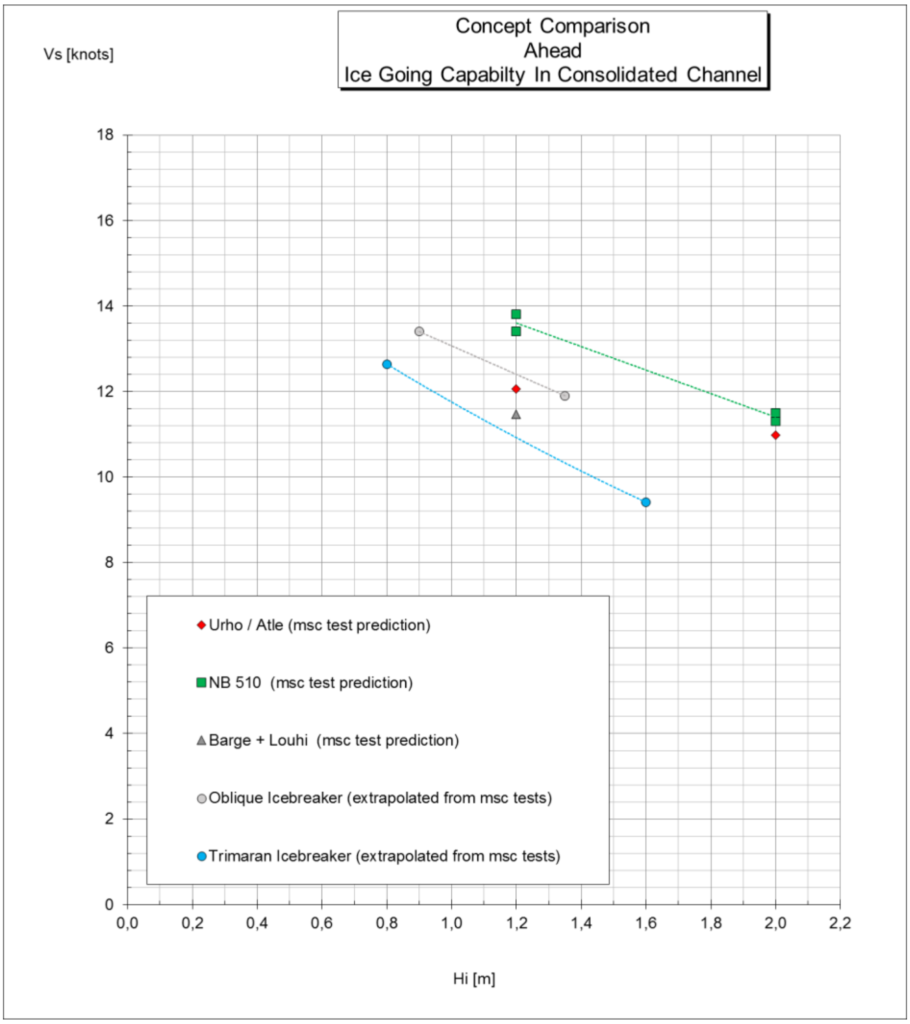

Figure 19 Performance of concepts in consolidated brash ice channels

5.4 RIDGE PENETRATION

The ridge performance is presented in ahead running mode as well as in best performance direction. The ahead running mode is most probable direction when assisting, when the best direction might be needed in most difficult ridge conditions.

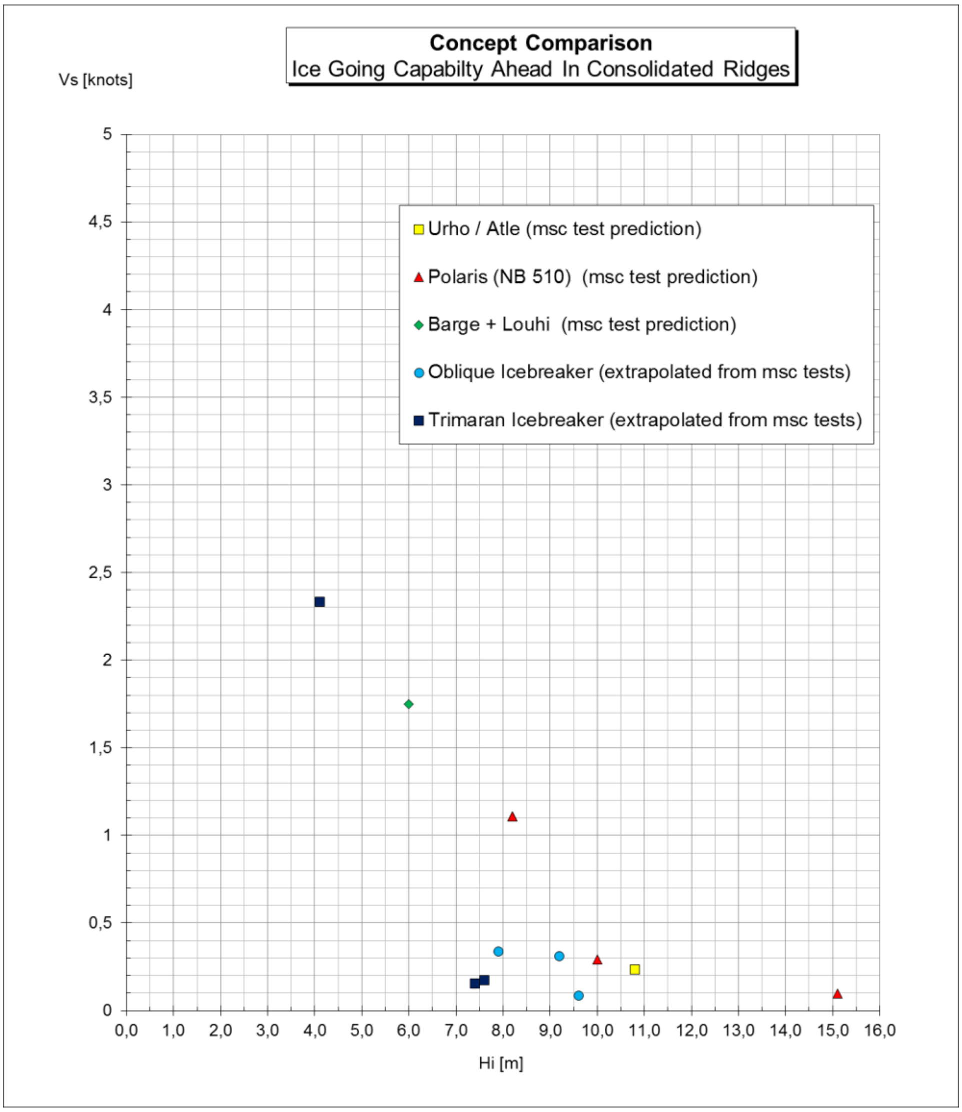

Figure 20 Ridge penetration capability, ahead

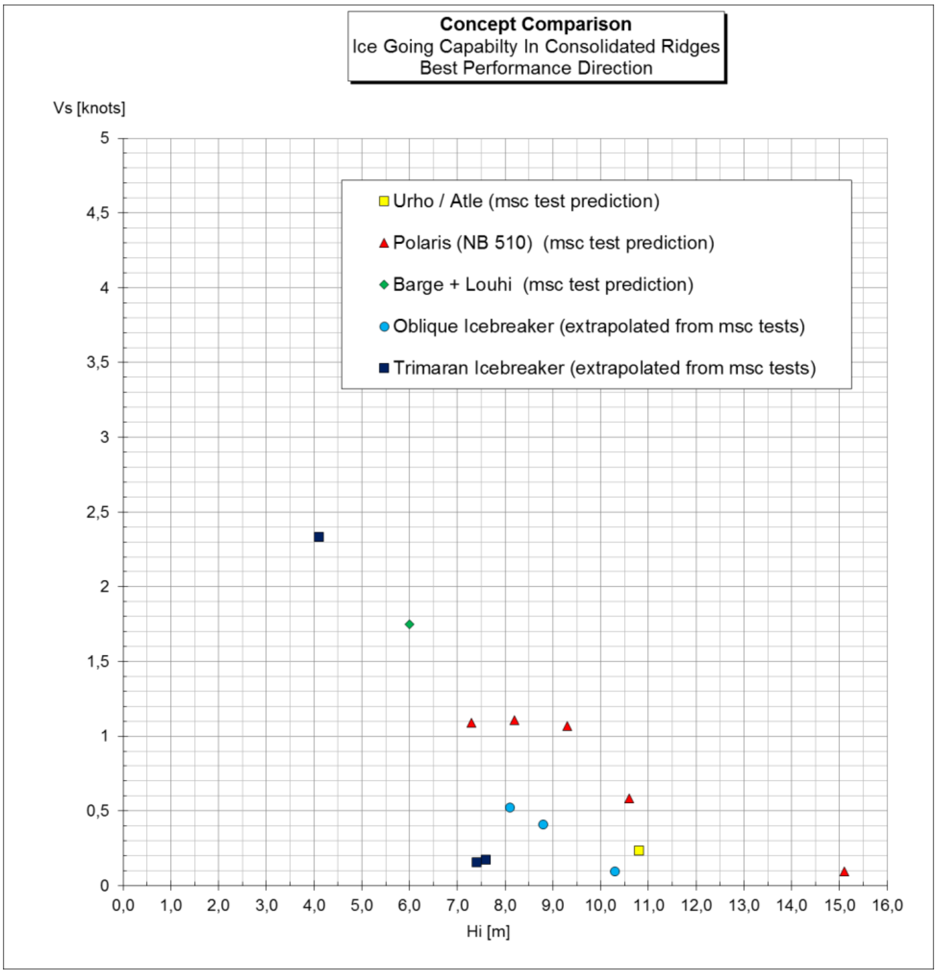

Figure 21 Ridge penetration capability, in best achieved direction

5.5 MANEUVERABILITY IN ICE

5.5.1 TURNING CIRCLE

The comparison has been done dimensionless where the measured turning radius is divided by ship length. However vessels equipped with azimuth thrusters allows the vessel to turn on spot, which gives a turning radius close to the ship length. Therefore the comparison has also been done for the average turning speed (degrees / minute), which is more representative for thruster vessels. It to be noted that turning characteristics of other concept than Oblique are about symmetric. Turning of Oblique icebreaker is considered to optimal direction

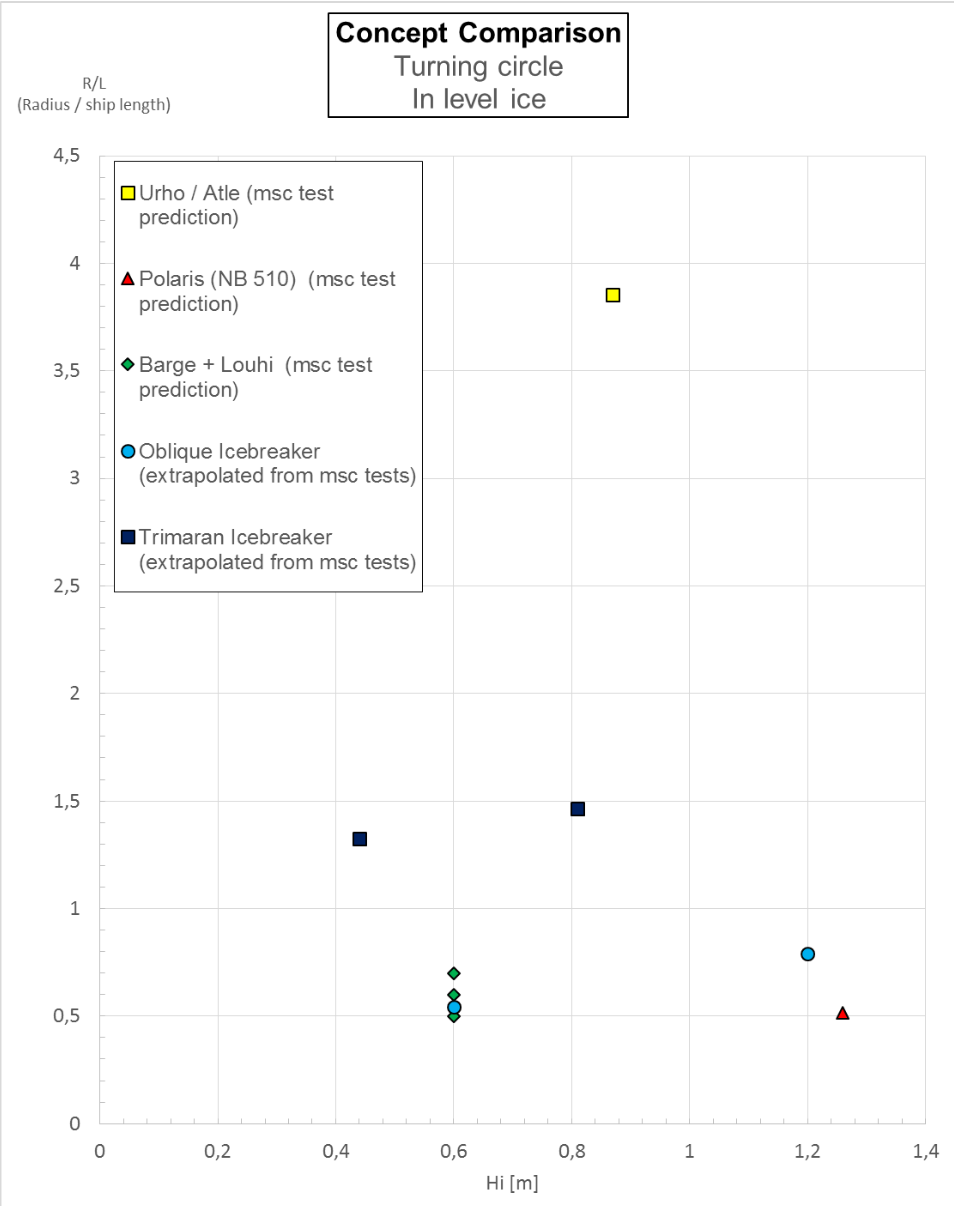

Figure 22 Turning circle of concepts

5.5.2 BREAKING OUT FROM CHANNEL

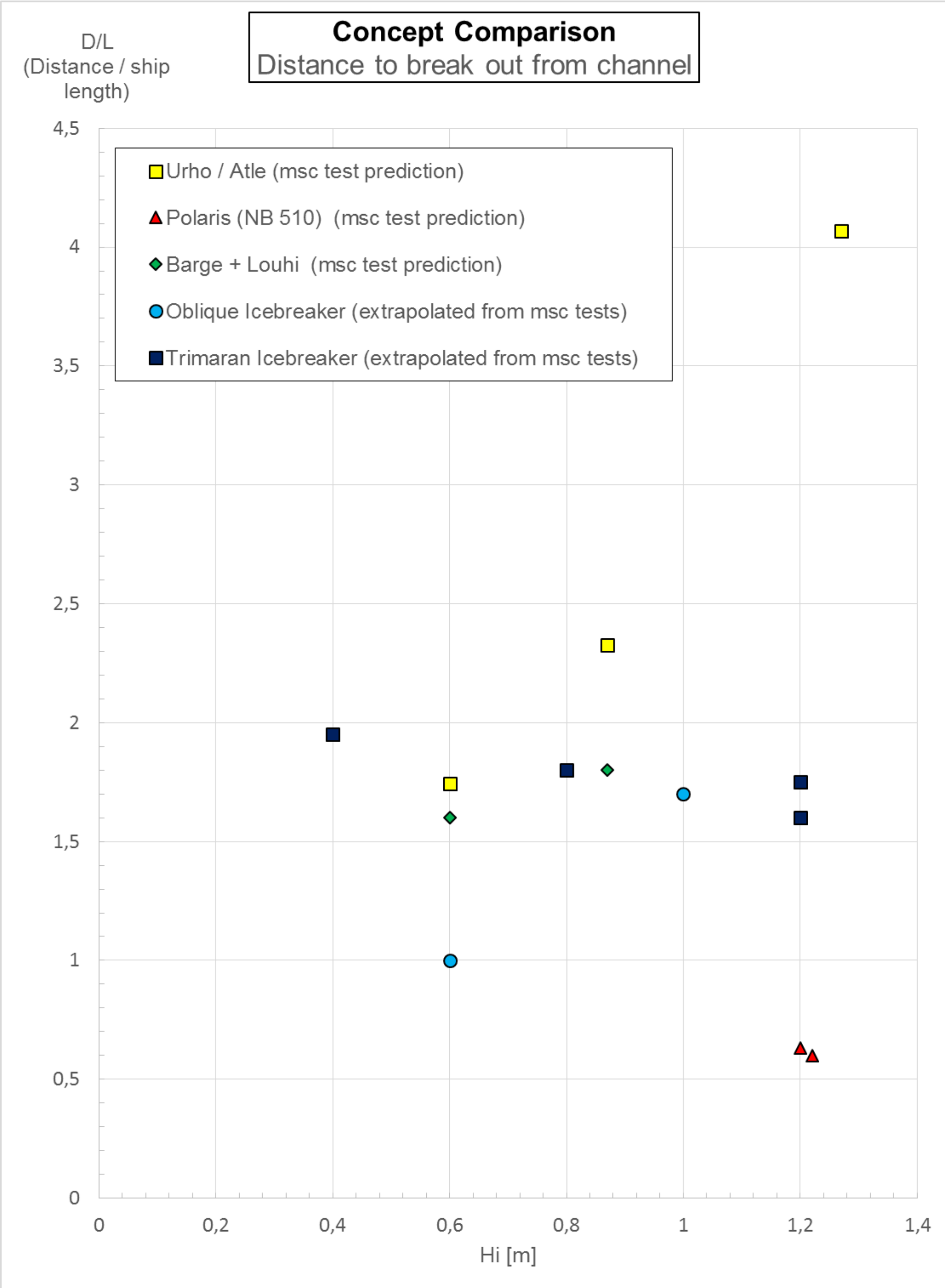

Figure 23 Distance to break out from channel

6 SUMMARY

The study shows that the performance correlation between model-scale tests and ship performance is in general quite good according to performed ice trials. The maneuvering performance in model scale is conservative compared to the real turning capabilities of ships.