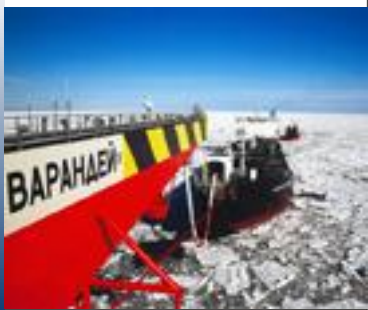
40 years of ice model testing



We build on experience

At Christmas time this year we at Aker Arctic are facing two important milestones, the five year milestone as an independent entity and 40 years since ice model testing start-up in Finland in conjunction of the famous project and experimental voyage of T/T "Manhattan" in the North West Passage. Shipbuilding and ship design are an art of traditions, which carry forward experience from generations to generations.

The decision by Aker Yards in 2004 to separate the Ice Technology and to safe-guard it from the turbulent shipyards and invite other industrial partners inter-ested in Arctic operations, like ABB, Wärtsilä and Aker Solutions, to join for a shareholding has appeared to be a right one. The first five years of Aker Arctic Technology Inc have turned out to be very successful. From the modest 12 person staff we have already grown to 35 with a turnover close to 7 Mill. EUR. Our invoicing from Finland, however, has remained very modest and has not exceeded 10 per cent in any single year of our existence as an independent and neutral naval architectural and consulting entity. Today we have framework agreements in place with most of the oil majors and many other industries, we assist the Classification Societies in introducing better rules and regulations for the ice-going units and we consult shipping companies, shipyards as well as authorities on a continued and regular basis.

The Arctic operations seem to be again in the rising, as they were in the early 1980´s. Oil and gas are the drivers and major development activities are under-way on three continents. We already launched to the market new innovations like the "double-acting" concept and our targets include large size Arctic floating moored and dynamically moored units,

Arctic LNG carriers as well as gas driven offshore support icebreakers. We, The Ice Technology Partner, also aim to be among the first to sail commercially on the Northern Sea Routes.

A lot of the knowledge we base our work on is inherited from the previous generations; those people who where ready to set up the first facility in 1969 and to meet the challenges of a 100.000 tdw steam driven tanker in polar ice; a challenge that has not yet been fully solved and turned into practice!

I started my thesis work in 1969 for Wärtsilä along with the "Manhattan" model tests and offered my heart to the Arctic Passion in 2004 when such an opportunity was given.

Göran Wilkman, our Research and Testing Services Manager, has spent whole of his working life with the ice model testing. He has put together the enclosed summary of the four decades in our ice model testing.

Mikko Niini

40 years of ice model testing

The author, Mr Göran Wilkman, Manager of Research and Testing Services in Aker Arctic tells with his huge experience of over 100 field tests and over 400 model tests about the milestones of ice model testing during the 40 past years.

Wärtsilä Icebreaking Model Basin **WIMB**, 1969-1983

In the middle of the 1960's as oil had been found in Alaskan North Slope there rose a need to study the possibility to transport the Alaskan oil with tankers through the North-West Passage to the market.
It was chosen to modify an existing 106 000 DWT tanker, SS Manhattan, to perform the job, see Figure 1. The design of the modification of the tanker was done by Wärtsilä Shipbuilding as they had already gained experience from building icebreakers both to the subarctic and arctic conditions. At the same time as the full-scale experiment was planned the oil company, Esso (Humble Oil), rose the question whether the performance of the vessel could be modelled in an ice model basin to study the possible consequences and alterations to the design in thinking of the future vessels.

Figure 1. SS Manhattan in the Arctic

The Wärtsilä Icebreaking Model Basin, WIMB was ready for testing in the end of 1969. The modelling technique was adopted from Arctic and Antarctic Research Institute of Leningrad, USSR.
The model ice used was produced from high saline basin water (10-20 ‰) by spraying once fresh water on to the basin water surface. This sprayed water formed first tiny crystals which started to grow vertically downwards forming the bulk part of the ice. The ice produced with this method comprised of 2-3 mm thick hard upper layer and 10-60 mm thick softer part. The maximum ice thickness that could be grown daily was 65 mm. Figure 2 shows the layout of the WIMB basin. Soon after WIMB was constructed two other institutions also built new facilities. The existing model basins for ice are shown in Table 1.

Figure 3, WIMB

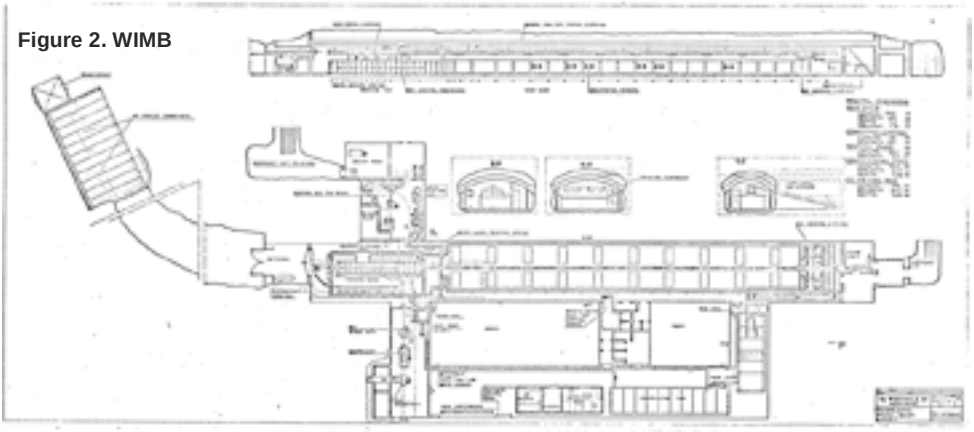


Figure 2. WIMB

Table 1, Model basins in the early 1970s

Year	Location	Owner	Length (m)	Width (m)	Depth (m)
1955	Leningrad, USSR	Arctic and Antarctic Reseach Institute	13.4	1.85	1.1
1969	Helsinki Finland	Wärtsilä Helsinki Shipyard	50.0	4.8	1.15
1970	Columbia USA	Arctec Inc.	18.3	2.4	1.2
1971	Hamburg W-Germany	Hamburgische Schiffbauversuch-sanstalt	30.0	6.0	1.2

The first years of the new facility were time of calibration. That time WIMB had experience of six (6) ships tested in full-scale and correlation tests were done significantly to improve the capability of making prognosis for vessel performance. Among the first calibration testing the development of hull forms for post Manhattan era was in full swing. A lot of work was directed also for traffic in the Great Lakes. Views of the WIMB are in Figures 3.






Figure 3, WIMB

The first vessel developed from the beginning utilizing ice model tests was the Baltic Icebreaker Urho and altogether 5 units were built (Atle, Sisu, Urho, Frei, Ymer). In the 1970's the icebreaker development continued to bloom. In addition to Urho-class a number of built vessels were developed utilizing ice model testing, see Table 2. The vessels can be seen in Figures 4.

Table 2, Ships developed at WIMB

Year	Type	Name	# of units
1974-77	Baltic icebreaker	Urho-class	5
1977-81	Arctic icebreaker	Sorokin-class	4
1977-78	River icebreaker	Chechkin-class	6
1982-83	Sub Arctic icebreaker	Mudyug-class	3
1983-86	River icebreaker	Evdokimov-class	9
1982-87	Arctic cargo ship	SA 15, Norilsk-class	19
1986-87	Baltic icebreaker	Otso-class	2
1988-89	Arctic icebreaker	Taymyr-class	2

Urho- class

Sorokin- class

Chechkin- class

Mudyug- class

Evdokimov- class

SA 15, Norilsk- class

Taymyr- class

Otso- class

In addition to the vessels mentioned in Table 2, WIMB was active in the market serving many kinds of projects like:

- Tankers
- Ferries
- LNG- carriers
- Anchor Handling vessels
- Tugs
- Bulk carriers
- RO-RO carriers
- Coast Guard cutters
- Lash/container carries
- Fishing vessels
- Coastal road ferries
- Dredgers

During the existence of WIMB also different kind of research projects were carried out like:

- friction between ice and ship hull coating
- air bubbling system development
- propeller loads
- operational docking tests
- offshore structures
- modeling development

In 1970's in addition to testing ships in full-scale, also some effort was put to study ice conditions in two major areas:

- Canadian Arctic Islands, for LNG export
- Antarctica, development of new support vessels

In 1980 the story of WIMB started to be complete as in Wärtsilä the decision was made to build a new facility, this time above ground. The new facility was to be commenced in 1983. During 1969 - 1982 altogether 100 test series were performed and reported. Simultaneously the full-scale activity was continued as well and some 65 test programs were carried out and reported in different parts of the icy world.

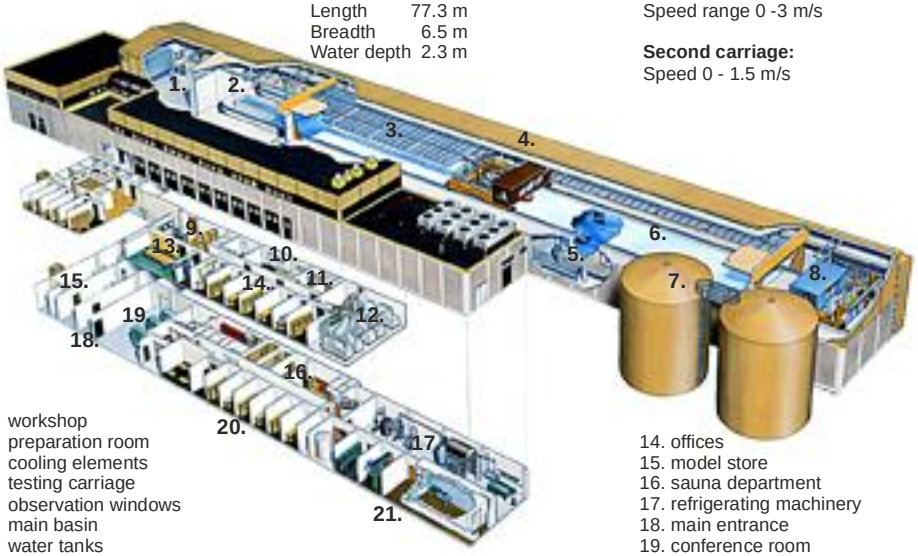
Wärtsilä Arctic Research Centre **WARC**, 1983-1989, Masa- Yards Arctic Research Centre **MARC** 1989-2005

The new laboratory, based on the experience from the first one was targeted to be the leading facility in the world. It was to bigger. A new type of model ice was to be developed. The facility was to be a research centre as such. All this came through and the new facility was inaugurated in February 1983. In 1980's an Arctic exploration boom was on and also more activity was planned for the Northern Sea Route (NSR) north of Russia.

Test basin:
Length 77.3 m
Breadth 6.5 m
Water depth 2.3 m

Test carriage:
Speed range 0 -3 m/s

Second carriage:
Speed 0 - 1.5 m/s



1. workshop
2. preparation room
3. cooling elements
4. testing carriage
5. observation windows
6. main basin
7. water tanks
8. second carriage
9. entrance hall
10. workshop
11. apparatus room
12. ventilation
13. conference room
14. offices
15. model store
16. sauna department
17. refrigerating machinery
18. main entrance
19. conference room
20. offices
21. heating & electricity
22. cold room

Bigger:
The new facility was to have bigger basing than the first one. The main dimensions of the basin were to be:

Total length 77.3 m	
Length of ice sheet	60.0 m

Better ice modeling:
Simultaneously with construction of the facility a project to develop new type of model ice was com menced. The result was Fine-Grain ice, FG-ice. This ice differs from everything available that time quite remarcably. The idea is to spray saline (1.3-1.5%) basin water into the cold air and the water droplets will somewhat freeze before they reach the water surface. This is done with the help of an auxiliary carriage running back and forth above the basin.

Each round trip of the carriage produces a 2-2.5 mm layer of soft granular white ice slush. The carriage is run as long as the required thickness is received. Later the material is hardened with the cooling process during the night. Varying the temperature and time the ice properties can be controlled in a wide range.

The advantages of FG-ice are:

- Better brittleness/ less elastic
- Ice breaks into realistic pieces
- Better ice control
- Crushing strength/ flexural strength is more realistic

The FG-ice was further developed in 1986 by adding the possibility to adjust the salinity of the spray water between each layer.

Facility above ground:
The new facility was built by the Bay of Vanhakaupunki (Old Town) near the original birth place of Helsinki. Figure 6 illustrates some views of the WARC facility.

The planned activity at WARC was four-fold:

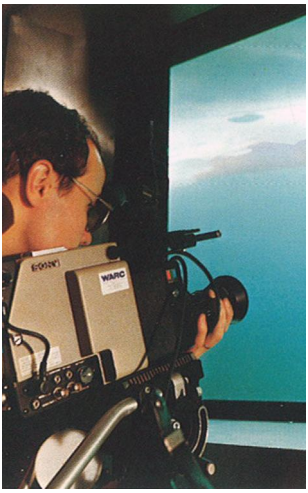
- Basic research - post graduate student research
- Finnish government reseach quote
- Wärtsilä R&D
- Commercial work

This composition of work was true till the end of 1989 when Wärtsilä Marine went bankrupt and Masa-Yards started the activity on new grounds. In the nineties most of the work done was commercial and the facility belonged to the Kvaerner Masa-Yards Technology Group.

During the eighties the major achievements are listed in Table 3.

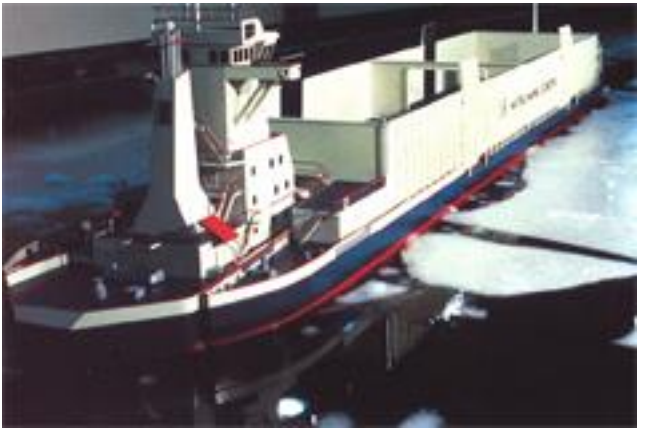
Year	Project Name
1982-83	FG-ice
1986	FGX- ice
1984	New bow of MV Arctic
1983-84	GVA 5000 Arctic Semi-submersible
1985	Push-Barge system
1985-86	Arco ALNGS
1986-87	Wärtsilä BOW
1985-86	100 000 DWT tanker for IHI
1983-87	Friction panel project
1985-87	Ice deflecting bottom ribs
1987	Sea train concept
1987	River train concept
1987	Bow concept development for L. St. Laurent
1987-88	Cylinder impact project
1987-88	Development of Aurora Australis
1987-88	Development of James Clark Ross
1988	Lake Saimaa Icebreaker
1987-93	Small Icebreaker for IHI
1987-88	Mingeo research icebreaker
1987-88	IB Karhu nozzle and open propeller

Most of the activities at WARC were related to in-house development projects for vessels intended to be built at Wärtsilä's own shipyard. During the eighties the number of ice sheets tested in the ice basin was 130-190.



Everything changed in 1989 as Wärtsilä Marine went bankcrupty. A new company Masa-Yards was founded and WARC was changed to MARC. Figures 7 show some of the projects carried out at WARC.


WARC



SA- 15 class

Research project of the different types cylinder figurations with Buoy Tender Lonna

RSS James Clark Ross

RSV Aurora Australis

Figure 7
WARC projects

Arctic push barge model

In the early 1990's the continuation of activity was very uncertain as the whole continuation of shipbuilding in Finland was. However, ownership changes and acquisition of the facility guaranteed that development work could continue, i.e. all work from 1990 on was commercial.

Also in the 1990 started the research for studying ice conditions, especially in The Russian Federation, see Table 4.

Table 4, MARC field activities in the 1990's

Year	Project Name
1989-91	Sakhalin ice research
1992	Sakhalin icebreaker tour, IB Krasin
1992-94	Pechora Sea JIP ice studies
1998-99	
1995-00	Ob Bay ice studies
1993	Kara Sea ice studies
1998-99	Pechora Sea JIP ice study

In oil exploration activities the 1990's was more quiet than the previous decade. However, more and more model tests were directed to offshore structures.
In late 1980's Wärtsilä, ABB and the Finnish Board of Navigation started the development of new azimuthing electric thruster; AZIPOD. This development lead to Double Acting Ship (DAS) concepts, a new way of thinking of icebreaking. This opened completely new possibilities in icebreaking practices, where in the eighties was the feeling that everything has been invented already.

In the eighties the FGX model ice was found very succesfull and the technology was adapted in two other laboratories (AORC of Helsinki University of technlogy and KSRI, Krylov shipbuilding research institute in St. Petersburg) on licence arrangement. At KSRI MARC also delivered the full set of equipment and supervised the installation.

During the nineties the number of personnel grew to 15 and the activity produced annually positive results. The number of ice sheets tested in the ice basin varied between 35 and 70.

Table 5. illustrates the major testing activities in the 1990's and Figure 8 shows some of the projects carried out.

Table 5, Model testing activities in 1989-2005.

Year	Project Name
1989-90	Ice rubble formation for Chuchki Sea
1989-90	Early concepts for Sakhalin platforms
1991-92	Next generation Baltic Icebreaker
1991-92	Fast ferry, Telakka 2000
1993	Azipod in ridges
1993	Development of river IB Röthelstein
1994	IB Healy
1993-97	60 000 dwt Arctic tanker for IHI
1995-2000	Development of Double Acting Tankers
1996	Offloading in the Arctic
1996-98	Development of Oblique Icebreaker
1997	Development of IBSV Arcticaborg
1998-99	Development of ships for Finnish inland
1999-2000	Development of barge system for the Caspian Sea
2000	Development of MT Tempera
2001-03	Tanker parametric development
2002-03	Harbour icebreaker development
2003, 04	Optical cable project
1998,2002	Great Lakes Icebreaker project
2003,2005	Development of MV Norilskiy Nickel
2003-05	Ice class tankers, multiple projects
2003	Rescue operation from a Sakhalin platform
2003	Development of Fesco Sakhalin

In 1999 to 2004 it was very uncertain how the activity would continue if at all. The parent company Kvaerner Masa-Yards was facing tough times and through several ownership arrangements Kvaerner disappeared from the picture as Aker started to penetrate more actively into the shipbuilding world.

Finally in 2004 it was decided to:

- establish a new separate company
- build a new testing facility

Figure 8
MARC projects

Oblique Icebreaker

IBSSV Fesco Sakhalin

ISV Antarcticaborg

River Icebreaker Röthelstein

Great Lakes Icebreaker Glib

Polar Icebreaker Healy

MT Lunni

Aker Arctic Technology Inc

The new technology company Aker Arctic Technology Inc started operation in January 2005. Simultaneously the construction of the new facility in Vuosaari Marine Business Park was started. The new facility was ready for start-up in February 2006 and the AARC personnel moved in.

Figure 9 illustrates the layout of the facility and a view in the neighbourhood.

The operation started quite fast and the facility was fully operative by mid March 2006.

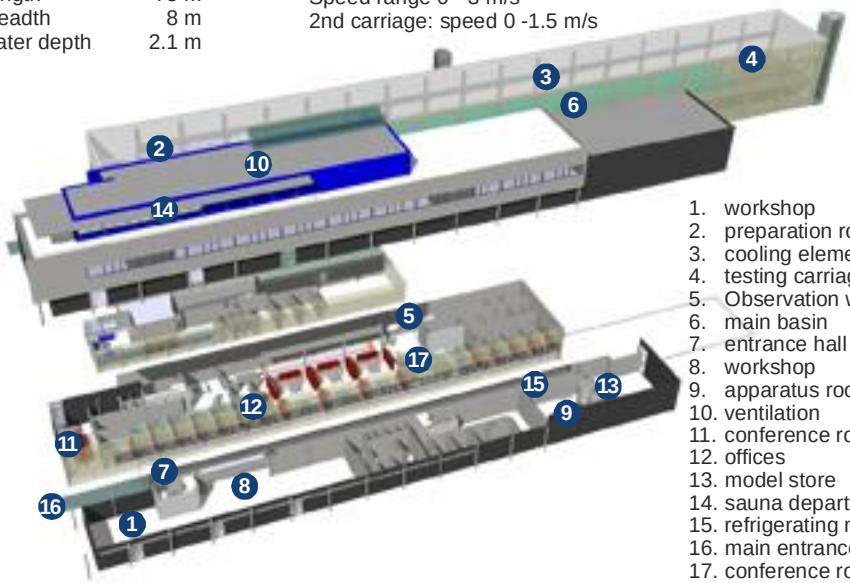
Simultaneously as the new facility was taken into operation the model test market seemed to increase. During the previous 15 years the number of annual test days varied between 35 and 70. In 2006-2008 the test days by different test types is listed in Table 5.

Figure 9
New AARC facility

Test basin:

Length	75 m
Breadth	8 m
Water depth	2.1 m

Test carriage:
Speed range 0 - 3 m/s
2nd carriage: speed 0 -1.5 m/s



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11. conference room
12. offices
13. model store
14. sauna department
15. refrigerating machinery
16. main entrance
17. conference room

Table 5, Tests of a different types in 2006 - 2009

	2006	2007	2008	2009
Ice class Tankers	38	21	10	
Icebreaking LNG carriers	20	9	4	
Icebreakers	5	21		
Offshore structures/ drill ships	6	20	48	
Oil spill (old basin)	4			
Cargo vessels	1	13	6	
Calibration/ ice development	8		2	
Offshore service vessels	3	9	7	
Ferries			1	
R&D			11	
Total	80	77	110	100

In 2008 the activity increased especially around oil exploration structures and vessels.

Also different types of icebreakers started to be active again, especially in the Russian Arctic.

As the new facility was taken into use , the activity of AARC also was broadened. In addition to testing services and concept development, also more deep project services were taken into the menu.

The personnel increased by eight (8) experienced engineers raising the total number of personnel into 26 in 2006.

Projects executed in 2005-2009 are listed in Table 6.

Table 6, Projects in 2005 - 2009

Year	Project Name
2006	Norilskiy Nickel full-scale tests
2006-2009	Norilskiy Nickel sister ships
2006	Modification of Frontier Discoverer, drillship
2006	Drilling platform Kulluk modification
2005-09	Arctic Tanker Vasily Dinkov (3 units)
2005-09	Arctic Tanker (2 units)
2008	Jack-up model tests
2008	North Star arctic island model tests
2007-08	Multipurpose platform service IB for Estonia,
2008	Arctic Anchor Handling vessel for Shell
2008-09	Arctic Anchor Handling vessel for Transatlantic
2006-09	Arctic LNG carriers
2006-09	Arctic Cruise vessel
2006-09	Various drill ship projects
2008-09	Aurora Borealis drilling vessel, model tests
2006,08	Arctic Container carrier
2006-08	Arctic Ore Carrier for Baffinland iron mines
2008-09	Arctic PSV for Shell
2006-09	Various drill ship projects
2006-09	AARC 101-108 vessel series
2009	Caspian 50 t tug, Basic design

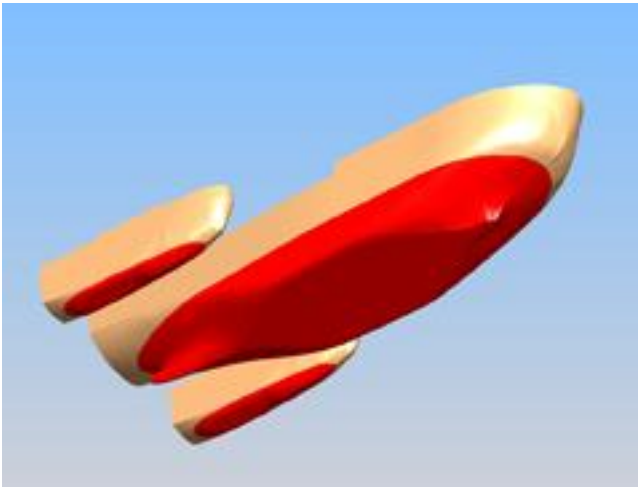
Arctic drilling platform Kulluk in model tests

Drill ship Frontier Drilling, Bully in model tests

AST Vasily Dinkov

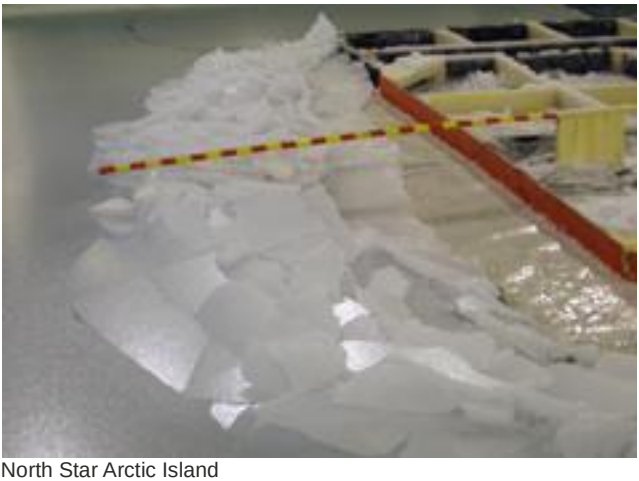
Varandey FOIROT

ACV Norilskiy Nickel propulsion



Trimaran Icebreaker

AARC projects



North Star Arctic Island

Drill Ship Frontier Discoverer

Operations in the Alaskan Beaufort Sea; Multipurpose Icebreaker Fennica, Kulluk Platform

ARC 106 Baltic Multipurpose Icebreaker and Offshore Construction Vessel

Aker ARC 104 Shallow Draught Icebreaking Tug

ARC 105 Icebreaking Platform Supply Vessel

The Ice Technology Partner

40 years of ice model testing

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