Arctic Passion News

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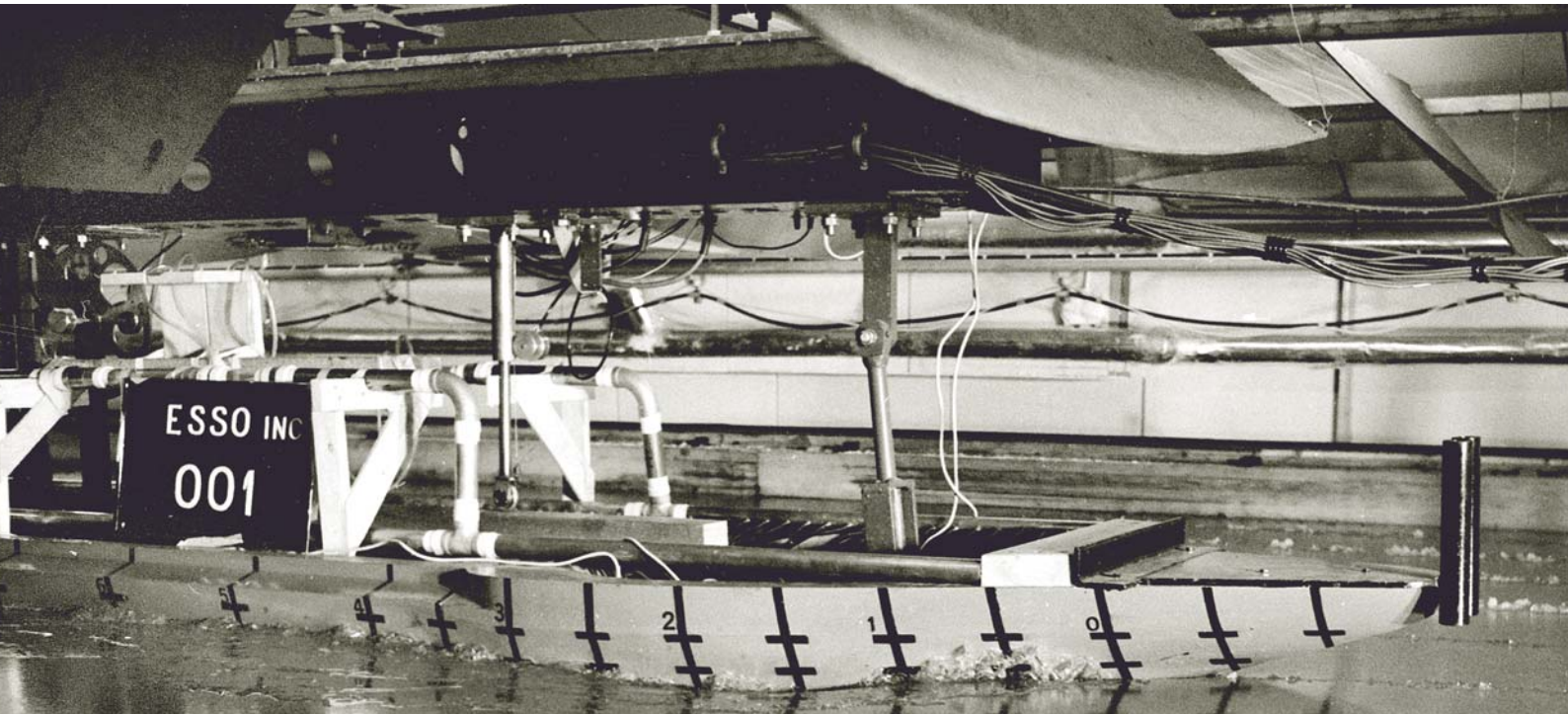

50 years of successful model testing -

From manual models to autonomous tests

In this issue

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Front cover: *This year, we celebrate 50 years of model testing, which began with testing the newly designed bow of SS Manhattan. Model testing techniques reflect trends in shipping, with the most recent tests supporting the development of autonomous vessels.*
Read about the history of the model testing laboratory on page 4.

Announcements

Kari Selonen, our long-term graphic designer, will retire from Aker Arctic on March 1st, 2019. Kari began his career at Wärtsilä Shipyard in 1986 and has since successfully managed ten corporate visual image changes. Responsible for marketing communications, his work has ranged from holding company presentations to layout, editing and printing annual reports and marketing material, including the company magazine Arctic Passion News.
“It has been a fantastic experience to be part of the changes in the Finnish shipbuilding industry,” Kari says. “Although my job description has remained more or less the same for 30 years, all processes in graphic design have transformed during this time.”
He will now pursue another passion: working with youth welfare support.
We wish Kari a happy retirement and success in his new endeavours.

Dear reader,

Around the world there is an increasing emphasis on climate issues, which have a significant impact on people and the natural environment. The growing concern of pollution and the consequences of global warming have also forced the IMO to take important actions towards a common goal of limiting emissions and minimizing CO_2 effects. In the coming years, all ships will have to meet high restrictions on sulphur emissions which will impact shipping on a large scale. Currently scrubbers are being installed in high volumes while new fuel options are being implemented. According to estimates shipping produces 2.5 % of the world's total CO_2 emissions. It is clear that many stakeholders, including ship owners, ship designers, engine manufacturers and fuel developers, must make improvements in their products. You, as a reader of this magazine, are probably most interested in shipping in the polar regions. While shipping in these areas only covers a small part of the world, with mainstream shipping lines located further south, the same improvements are still needed in the polar regions. The Arctic is affected dramatically by climate change with tangible changes in sea ice conditions already visible. The warming effects have been more pronounced than in the southern latitudes.

Then how can we, as Arctic operators, react? I can assure you that we have already reacted. Ship operations in the polar regions are challenged by ice, winter temperatures and remoteness, with availability of fuel being one of the largest operational challenges. Transportation of fuel requires long distances and special ships, as no ordinary product tanker can be used to supply Arctic villages or industrial locations, especially in winter time. One past solution was to use nuclear-powered vessels. Naturally, this decision needed careful consideration, but if we look back 60 years to the first nuclear-powered icebreaker, *Lenin*, we can easily conclude that operation of this icebreaker has been a success overall. Nuclear technology will continue to be in use in the future, as there are three icebreakers under construction in St. Petersburg today. We can expect to still see these vessels in operation when the Arctic ice cover has shrunk even more. China is also planning to begin their own development programme for nuclear-powered vessels. However, this path will not become a common solution for commercial ships, as current development encourages LNG to replace fuel oil. LNG-powered vessels are also strongly coming into polar use. In this respect, the challenge of refuelling is made easier by local LNG production, therefore making it a viable alternative for ships in the Arctic region.

It is evident that shipping activity in the polar regions will increase in the coming decades, but by how much is still difficult to estimate. Nevertheless, the selections that are made now regarding energy sources for the ships are highly interesting and important. Shall we see LNG as the main solution, will there be nuclear energy on a larger scale and how will energy storage technology develop in order to make electric ships possible on the longer routes? All this must be supported by other technical developments aiming to save energy and improve efficiency. This element is always emphasized in Aker Arctic's solutions and development targets. This year, we celebrate 50 years of ice model testing in Finland. The main target for our laboratory testing capability has always been to produce more efficient designs for ice going vessels. This is even more relevant today with the international moves to reduce emissions and address the impacts of climate change.

I hope that you enjoy the articles in this magazine and join us in looking with great interest towards the next clean developments for the polar regions.
Sincerely,
Reko-Antti Suojanen
Managing Director

Arctic condensate tanker delivered

The Arctic condensate tanker Boris Sokolov was delivered in December 2018 and began its journey from China along the Northern Sea Route, arriving to the port of Sabetta in mid-January 2019. The tanker was accompanied by the LNG carrier Boris Davydov which was delivered from a Korean shipyard around the same time. While the ships sailed together as a convoy, they were not accompanied by an icebreaker.

Boris Sokolov arrived in Sabetta in mid- January 2019.

The naming ceremony of *Boris Sokolov* was held at Guangzhou Shipyard International on 4 December 2018. The high ice class ship is named after Captain Sokolov who commanded the world's first nuclear-powered icebreaker for almost 40 years. The vessel's godmother is Yuliya Zobova from PAO NOVATEK.

Boris Sokolov has now joined the Dynacom Tankers Management's fleet. The product tanker will be used primarily to transport gas condensate oil from the Sabetta LNG terminal to customers in Europe and Asia, but it is also designed to carry other types of oil cargoes.

Design work

In 2014, Aker Arctic began investigating options for year-round transportation of gas condensate, a liquid by-product from natural gas fields, in co-operation with Yamal LNG. Gas condensate is a low-density mix of oils and is a valuable raw material in the petrochemical industry.

Following the development of the Aker ARC 212, a design licensing agreement for the basic design and construction of the vessel was signed with the Chinese shipbuilder Guangzhou Shipyard International Co. Ltd. Aker Arctic supported the shipyard during construction whenever there were questions about the design and ice-going characteristics.

The propulsion system is based on diesel-electric machinery with two azimuthing propulsion units. The tanker has a high ice class, RMRS Arc7, which enables year-round, independent navigation in areas west of the Yamal peninsula and for about six months in areas east of the Yamal peninsula. In hard ice conditions, the vessel can take advantage of the frequent traffic of large arctic LNG carriers and navigate in convoy with them.

Testing is important

The inclining test was performed in November 2018, during which the ship's lightweight and centre of gravity were confirmed. Two weeks later, open water sea trials verified that the ship fulfilled the design targets. The sea trials test the fundamental aspects such as speed, manoeuvrability, anchoring, fuel consumption and propulsion endurance. Additionally, the firefighting system, the ballast system, the navigation system, the cargo handling and heating systems were all proven to work. Finally, the ship was examined for excessive noise and vibration. “All design targets were met,” says Project Manager Riku Kiili.

Boris Sokolov is based on the proven Double Acting Ship (DAS™) principle that allows tankers and cargo ships to operate independently without icebreaker assistance in challenging ice conditions. When operating stern-first, the vessel can break up to 1.8 m thick ice in a continuous motion and penetrate ice ridges without backing and ramming. In moderate ice conditions and in open water, the vessel sails ahead normally. The icebreaking capability has been verified in Aker Arctic's ice model test laboratory in Helsinki, Finland.

“We are now hoping to perform full-scale ice trials during the next few months to ensure that the vessel meets the icebreaking targets and manoeuvring in ice,” says Kiili. “Full-scale tests are not only valuable for the customer but they will also give us important feedback about our design work. Their results can be used to validate the results of our model tests for future development projects.”

Technical characteristics

Ship type:	*Product tanker*
Length:	214 m
Beam:	34 m
Loaded draught (design/max):	11.7/12.65 m
Deadweight:	43,300 tons (gas condensate), 49,700 tons (oil)
Cargo and slop tanks:	60,200 m³
Gross tonnage:	38,692
Power plant:	2 × Wärtsilä 12V32 2 × Wärtsilä 16V32
Propulsion:	Diesel-electric, ABB Azipod (2×11 MW)
Ice class:	RMRS Arc7

10th LNG tanker arrived in Sabetta

The LNG tanker *Boris Davydov,* accompanying *Boris Sokolov* en route to Sabetta, was built at Daewoo Shipbuilding and Marine Engineering (DSME) yard in South Korea. It is the 10th vessel of its kind built for the Yamal LNG project. It can carry 170,000 cubic metres of LNG. Aker Arctic participated in the development and design work of the LNG-tanker and joined the successful full-scale tests onboard the first vessel in the series, *Christophe de Margerie,* in February 2017. (Read more in Arctic Passion News, issue 14).

The last five ships in the series will be delivered by DSME during 2019.

50 years of successful model testing in Finland

The history of the ice model testing laboratory is a true success story of Finnish technology. This year, we celebrate 50 years of ice model testing, which began with studying the performance of the newly designed bow for *SS Manhattan,* and continued with ice model tests for icebreakers, oil platforms and Azipod evolution. More recently, model tests in ice have been used in the development of Arctic tankers, LNG fuelled icebreakers, polar research vessels and autonomous vessels.

The first ever ice model test conducted in Finland was a resistance test in level ice of SS Manhattan.

The history of modern icebreaker design and construction in Finland began in the late 1930s with the diesel-electric icebreaker *Sisu.* Until the development of ice model testing, icebreakers were built based on the designers' experience with previous vessels, and the primary way to evaluate the hull form was through full-scale experimental tests.

In the mid-1960s, studies indicated that oil found in the Alaskan North Slope could be feasibly transported to the market through the Northwest Passage. A decision was taken to modify an existing 106,000 DWT tanker, *SS Manhattan,* for the arctic voyage by retrofitting it with a new icebreaking bow. Wärtsilä provided support for the project since the Finnish shipyard had previous experience from building icebreakers both for the subarctic and arctic conditions.

During the retrofit process, the oil company Esso (Humble Oil) suggested to study the performance in ice of the newly designed bow in model-scale in an ice model basin, before making the decision to start the expensive conversion. Esso decided to invest in the construction of the first ice model testing facility in Finland, which was built in an old underground bomb shelter in Helsinki. Wärtsilä shipyard later became the owner.

The first Finnish model test basin

The Wärtsilä Icebreaking Model Basin (WIMB), the first ice model test basin in Finland, was ready for testing at the end of 1969. The technique to create the model ice was adopted from the Arctic and Antarctic Research Institute in Leningrad, USSR. The model tests were conducted by towing the model ships and the data was recorded on paper with an oscillograph.

The first years in the new model testing facility were a time of calibration. Concurrent with the calibration period, the development of new icebreaking hull forms was in full speed and in the 1970s and 1980s, many new icebreaking vessel designs were developed and tested through model tests in ice. The first icebreaking vessels developed and built utilizing the results of ice model tests were the five *Atle/Urho*-class icebreakers, which were built for the Maritime Administrations of Finland and Sweden in 1974-1977.

In the 1980s, operational model tests were often conducted by manoeuvring the model manually. Model of icebreaker Otso, assisting another vessel in heavy brash ice, is steered by her future captain, Atso Uusiaho.

Atle/Urho-class icebreaker Sisu in operation

The first Azipod unit was installed to fairway supply vessel Seili.

The real breakthrough for the Azipod, and the DAS™ concept, occurred with the conversions of the ice-going tankers Uikku (1993) and Lunni (1994).

Comprehensive research centre

The knowledge gained from the WIMB was used to build an improved, modern facility, the Wärtsilä Arctic Research Center (WARC). A new type of model ice was also developed at the same time and the new laboratory was intended to be a comprehensive research centre, in addition to a commercial ice model test basin.

The new facility was inaugurated in February 1983. The timing was excellent; an arctic boom started in the beginning of 1980s and the Northern Sea Route was increasingly attracting interest in the shipping industry. The newly developed fine-grained model ice was also significantly different from all other model ice types used at the time. The ice was made by spraying saline water in the air, and as the freezing droplets fell on the water surface, they created a layer of slush. The slush was then hardened overnight to achieve the appropriate mechanical properties.

One of the key research objectives, was to gain a better understanding of the entire icebreaking process by studying many aspects of ship-interactions. Some key experiments involved bow shapes, the influence of friction using friction panels on the Finnish icebreaker *Otso,* and removable icebreaking bows.

A crisis in the global marine industry led Wärtsilä to pool its marine resources with Valmet, resulting in the establishment of Wärtsilä Marine in 1986. WARC became part of Wärtsilä Marine Arctic Technology, which was a unit within the Helsinki Shipyard. The emphasis on the research continued until the bankruptcy of Wärtsilä Marine near the end of 1989.

Commercial era

In the early 1990s, there was a dramatic slump in the shipbuilding industry in Finland due to the dissolution of the Soviet Union. As a result, the future of the ice laboratory was very uncertain. However, a new shipbuilding company Masa-Yards was established to continue the operations of Wärtsilä Marine. Kvaerner group took over Masa-Yards in 1991 and created Kvaerner Masa-Yards Technology Group. Due to this change in ownership, the research and development work in the ice laboratory decreased dramatically and practically all work in the facility, now called Kvaerner Masa-Yards Arctic Research Centre (MARC), was commercial.

Azipod development

In late 1980s, Wärtsilä, ABB and the Finnish Maritime Administration started the development of a new azimuthing podded propulsion unit, the Azipod. The first prototype was installed onboard the ice-going fairway supply vessel *Seili.* After the validation of the model during the full-scale tests of *Seili,* the development of a high ice class Azipod continued with the Tarmo II project.

In 1992, a team dedicated to developing the commercial Azipod was established within the ice laboratory. This allowed designers access to the model test basin to perform extensive model tests for the new Azipods. The main principles of the Azipod design are still based on the ice model and open water tests from the 1990s.

The invention of the Azipod created many new possibilities in icebreaking practices. One of the most significant concepts was the Double Acting Ship (DAS™), where a ship is designed to advance ahead in open water and thin ice, and to use the stern to proceed in heavy ice conditions. The real breakthrough for the Azipod, and the DAS™ concept, occurred with the conversions of the ice-going tankers *Uikku* (1993) and *Lunni* (1994).

In 2004, Aker Finnyards, owner of the Rauma shipyard, took over Kvaerner's shipbuilding industry. In 2006, the company changed its name to Aker Yards. Up until the early 2000s, the ice model testing and the related consulting was an integral part of the different shipbuilding companies. However, following the turbulent shipyard ownership changes, a decision was made to establish a new independent company focusing on design of ice breaking vessels. A brand-new state of art testing facility was built to support the design development process.

Next generation testing facility

The new technology company, Aker Arctic Technology Inc, was founded in January 2005. The site for the construction of the next generation ice model testing facility was chosen next to Vuosaari Harbour in Helsinki and the new facility was inaugurated in February 2006. At this point the company employed about 20 persons, consisting of 12 employees from the old facility and a group of ship design engineers from the former design department of the Helsinki Shipyard. Over the years, as the business of arctic shipping expanded, the number of personnel steadily increased to be approximately 50 people in 2018.

While the 1990s saw only 35-70 test days per year, the opening of the new facility coincided with a boom in the shipbuilding market. The oil exploration activities around the world increased and so did demand for Aker Arctic's services. During the peak years, the number of ice model test days exceeded 100 per year. The new Arctic exploration activities changed the requirements for the supporting icebreakers, ultimately leading to many new developments in vessel design.

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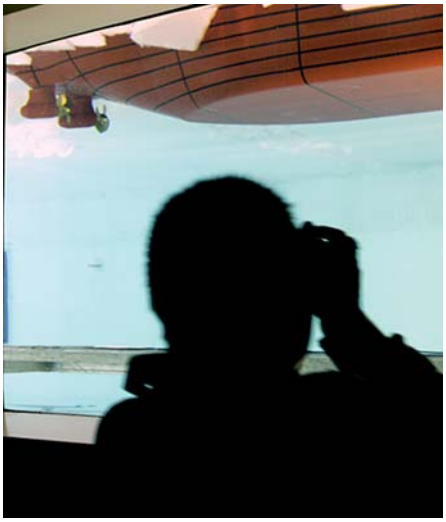

The current ice model test basin is unique in several respects. One of the outstanding features includes the glass bottom of the test basin, allowing designers to view and record the tests from below. Additionally, there are observation windows on both sides from which the amount of ice gathering under the model can be seen.

Computer controlled ship model approaching docking on quay represents the future trend in model testing.

The customers have ranged from the world's biggest oil companies to shipyards and shipowners. To meet the market demand, new test types were developed:

- fixed offshore structures,
- floaters,
- drill ships,
- artificial islands,
- harbour ice melting system,
- new ice management methods, and
- friction tests.

Future of model testing

Aker Arctic is constantly striving to improve its model testing services to give customers the best possible designs of ice going vessels and structures. The quality is ensured by the continuous study of model ice properties and behaviour in many different ice conditions such as level ice, brash ice and ice ridges. New model testing techniques have also been developed to reflect the trends in modern shipping.

Aker Arctic has developed a model propulsion system that is capable of full computer control of the model. In addition to standard model testing, the propulsion system can be used with dynamic positioning, autopilot and other external control systems. This system also serves as part of a testing platform for autonomous vessels, which are actively being developed in the maritime industry. Aker Arctic's propulsion system allows testing of full-scale control systems in a challenging, but controllable and safe model-scale environment.

Model tests are also used to support the development of Aker Arctic's simulator. The data collected from model tests in ice is used in the simulator's database to more accurately portray the ship's response in ice. One aim for the future of the simulator is to estimate the effects of different hull features on the ship's ice resistance. The optimization of the hull form could then be started before the model tests.

Read the full history at www.akerarctic.fi/publications.

Polaris, built in 2016, is the most powerful icebreaker ever to fly the Finnish flag and the first icebreaker in the world to feature environmentally friendly dual-fuel engines capable of using both low-sulphur marine diesel oil (LSMDO) and liquefied natural gas (LNG). It has excellent manoeuvrability due to the two Azipod units in stern and one in bow.

Aker Arctic has been leading the development of Arctic LNG carriers over the years resulting in Yamalmax icebreaking LNG carriers. The vessels are based on the DAS™ concept and capable of operating independently without icebreaker escort along the Northern Sea Route. The hull form has been extensively tested in Aker Arctic's ice model test laboratory. The first Yamalmax carrier, Christophe de Margerie, was delivered in 2016.

The icebreaking research vessel Xue Long 2 is almost ready for delivery in China.

Best practices in developing modern Polar research vessels

With the growth in environmental awareness, polar areas are attracting increasing attention both commercially and scientifically. More information and research are needed to understand the complex phenomena affecting our planet. Simultaneously with evolving scientific methods, ship technology is developing, offering enhanced possibilities for research in new areas with more efficient vessels.

Recent years have seen an upswing in polar research and logistic vessel new buildings. As every research vessel is a one-of-a-kind prototype, regulated by government acquisition laws with long timelines between projects, the procurement and design process become more complex.

Based on Aker Arctic's practical experiences gained during recent successful polar research vessel projects, we have compiled a few guidelines to help out in the planning of an acquisition.

Early phase is crucial

The importance of the early phase of the acquisition process cannot be emphasized enough. Overall, the effects of early phase decisions and selections are felt throughout the entire project. The initial technical and commercial requirements should be realistic and possible conflicts resolved early. The technical requirements should also match the budget.

The technical requirements can be divided into logistic and scientific requirements. The logistical demands derive from the intended operation area and season and are, therefore, fairly straight forward. However, the scientific requirements are more multi-faceted as there are a multitude of scientific disciplines with various equipment requirements, which need to be located coherently into the ship's design. It is therefore useful to begin the process with listing the various missions the vessel will have.

Elements for a successful design

"Each acquisition is individual due to the variation in technical requirements, local content requirements, laws, budgetary process, the political situation and even possible upcoming elections," says Sales Manager Arto Uuskallio. "There are, however, recognizable elements which help in understanding and achieving a successful project that meets the technical and operational requirements within the budget and schedule:

- how technical requirements affect the ship price;
- contradictory requirements;
- roles and responsibilities of different stakeholders;
- benefits and disadvantages of acquisition models;
- ship design, shipbuilding and ship acquisition process;
- legal, political, scientific, ship operation, design, and shipyard experts in the acquisition team; and
- acquisition law affects the commercial and technical process."

One major factor affecting the schedule is the approval and decision-making process. The acquisition project's length and budget can be reduced considerably if decisions can be made without extensive studies.

Compromises

The trend in the latest icebreaking research vessels has been to replace aging individual vessels with multipurpose vessels.

"While combining different research roles into one multi-role vessel is beneficial, it also requires the understanding that design aspects might often include contradictions," Uuskallio emphasises. "It is therefore of utmost importance to first establish what the different roles of the vessel should be, what are the cost and design implications of various roles and then make a decision on which are the most important ones, in order to stay within the budget."

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S. A. Agulhas II carries out both scientific research and delivers supplies to Antarctica.

A ship with multiple operational profiles in both polar regions will require more detailed calculations of the ship endurance, the necessary capacities and the performance in both open water and ice in the initial phase of the design process.

Recent designs have combined demanding scientific tasks and fulfilling logistical needs for Antarctic stations. This has required planning for easy cargo handling and optimising stability and icebreaking performance at an early stage of the design.

In general, when designing a polar research vessel, there is always a trade-off between ice and open water performance due to harsh operating conditions in both. Fulfilling these demands governs fundamental decisions with regards to the ship concept. For instance, a higher ice-class results in more demanding requirements for the design and structure of the propellers to withstand ice interaction. However, with an increased ice-class, the propeller will radiate more underwater noise, which impacts acoustic research with sonars.

A sleek and axe shaped bow can be made to improve the hydrodynamical performance, but it is detrimental to the icebreaking performance. Another solution is to increase the draught of the vessel, but maximum water depths in harbours may limit this.

Long trips of 60 to 90 days require providing a level of comfort for the people on board. Anti-rolling tanks help achieve that but require substantial space that must be incorporated in early planning. “These are only a few examples to illustrate the compromises, which need to be discussed and agreed with the ship operator,” Uuskallio says.

Cold environment features

Designing for a cold environment forms an integral part of the design of polar research vessels and their systems. It is a rather demanding design process that affects many ship systems. In typical ice-going vessels, the cold environment influences the hull form, structural design, propulsion power, visibility through windows, sea chests, escape routes, cargo cranes and stairs/ladders. However, in polar research vessels there are additional systems that much be considered. Some aspects to be considered are the winterization of the aft working deck, the scientific hangar, the shell/bulwark gates, the helicopter landing pad and the handling equipment that are exposed to the weather.

Critical technical requirements

Each new icebreaking research vessel is usually considered a “state-of-the-art” product with new technologies. As a result, there are many conceptual requirements that need to be solved in an early phase, in order to optimise the procurement process and mitigate risks. Many of the important research discipline factors affect the conceptual ship design. For instance, research winches are needed for many purposes such as lowering equipment into the sea or taking samples. It is therefore useful to list all required winches, including technical details, in order to find overlapping similarities and avoid exaggerating the total amount required. The same should be done with scientific equipment, laboratories, etc.

From an onboard logistical point-of-view, multiple locations of winches as well as optimal location of laboratories, the ship's freeboard, the hydro acoustic equipment and the atmospheric equipment should also be planned early.

Aker Arctic has been part of various polar research vessel acquisition projects. All our findings are results from these successful projects.

“We strongly recommend involving a ship designer in the project team from the beginning, because so many of the early decisions will have implications on later outcomes. A ship designer can also clarify the costs of different options or suggest alternatives in order to stay within the budget,” Uuskallio says. “Otherwise there is a risk that the ship will become either too complicated to build, not functional, or way too expensive.”

Optimal path:
Design concept ▸ Vessel contract ▸ Basic Design ▸ Shipyard selection and construction

Arto Uuskallio

Arto joined Aker Arctic for the second time in 2009, after having worked ten years at ABB with sales and Azipod development. Today he is working with activities focusing on shipyards and clients. Arto is a Naval Architect and has additionally practical experience of ice from his many ice expeditions to the Arctic; Pechora Sea, Kara Sea, Gulf of Ob and to the Sakhalin area, among other destinations. In his free-time, Arto enjoys outdoor sports.

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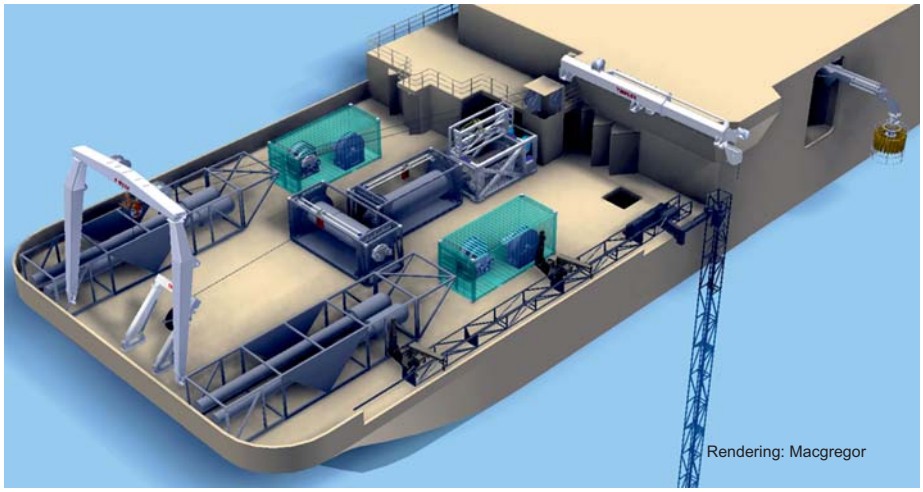
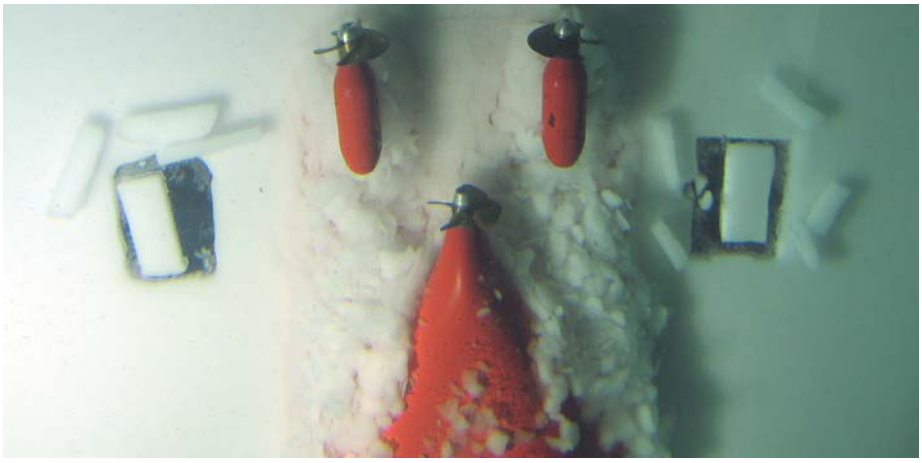


Modularity is commonly implemented by placing equipment inside containers, which can be easily moved or replaced according to mission needs.

The box keel protects from ice pieces and ensures a stable flow field around scientific equipment.



A new invention is to use a hybrid propulsion solution to minimise underwater radiated noise.

New solutions for Polar Research Vessels

Polar research vessels technology is continuously developing. What is regarded as state-of-the-art today might not be the top choice in five years-time. Nevertheless, steep changes are relatively rare, but rather improvements in small steps. One top trend right now, is to include more features in one vessel, which means that vessel sizes tend to become bigger in order to fit more equipment, resulting in more expensive vessels. One reason is that new vessels often have multiple roles and replace more than one vessel.

Modules are easy to replace

Modularity is becoming the key word to keep up with the latest developments and fit more into one vessel. With exchangeable modules a vessel can be equipped differently for each trip making it more versatile. It is also easier to upgrade equipment when new innovations come to the market. Modularity is commonly implemented by placing equipment inside containers which can easily be moved or replaced according to mission needs. For instance, winches, Remotely Operated underwater Vehicles (ROVs), Autonomous Underwater Vehicles (AUVs), meteorological research equipment and a variety of other scientific equipment can be exchanged when needs change, new tools come to the market, or when the ship's destination changes.

"For example, logistic vessels travelling to Antarctica often carry a substantial amount of cargo and need extra space for the supplies they deliver to the research stations. Containers carrying equipment which is not needed for a resupply trip can easily be removed to allow for more cargo space," says Development Engineer Cayetana Ruiz de Almirón.

Creating an ice-free area using a sidepool

The sidepool is a new Aker Arctic innovation for creating a cost-effective ice-free area at the side of the research vessel. It offers the opportunity for better space arrangement possibilities in the centre of the ship as well as displacement and deadweight savings compared to a traditional moonpool. The sidepool is based on a retractable set of hatches that creates and maintains an ice-free area at the side of the ship in drift ice conditions.

Minimising underwater disturbance

A box keel tailored for ice conditions can be installed in the bow of the vessel at the waterline to ensure that underwater equipment is protected from ice pieces and to ensure a stable flow field. The box keel pushes ice pieces aside and protects hydro acoustic measurement equipment from damage or disturbance. It also minimises vortices, which could otherwise result in measurement errors for the scientific equipment. The box keel has to be tailored for each vessel to retain icebreaking properties without increasing open water resistance.

Hybrid propulsion for less noise

With the growing size of research vessels more powerful propulsion is needed and underwater radiated noise increases. This can cause problems for research activities e.g. underwater radiated noise can disturb the natural behaviour of fish. A new invention is to use a hybrid propulsion solution with both a shaft line and azimuthing thrusters. The shaft line can be used as the prime propulsion during research mode, in order to minimise noise, while the thrusters are used for better manoeuvrability, especially in ice. Electric propulsion with batteries or fuel cells further improves silent solutions.

The figure presents the extended position of the sidepool, where the integrated hatches are pushed outwards from the side creating an ice-free area at the side. As a result, research equipment and persons can be deployed safely.

The polar logistics vessel L'Astrolabe combines resupply of the French research station in Antarctica with patrolling duties in the Indian Ocean.

The 2015-built Sikuliaq is an ice-strengthened research vessel operated by the University of Alaska Fairbanks School of Fisheries and Ocean Sciences.

"From a ship designer's point of view, new innovations always offer advantages but also challenges in how to incorporate them in the best way in the design. Every Polar Research Vessel is an individual project customised for its intended use and the client's wishes, therefore every solution is carefully evaluated each time," says Chief Designer, Naval Architect Lars Lönnberg.

Examples of icebreaking research vessels and logistics vessels built in the 2010s

Akademik Tryoshnikov
Russia's newest ice-capable research and resupply vessel was built in 2012 and has been used in both the Arctic and in the Antarctic to carry out scientific research and resupply missions to Russian research bases.

L'Astrolabe
The French polar logistics vessel combines resupply of the scientific research station in Antarctica with patrolling duties in the Indian Ocean. Aker Arctic performed the basic design and model testing for the vessel, delivered in 2017, followed by technical support during the construction period. The new vessel replaced two older ships, *L'Albatros* and the former *L'Astrolabe*.

S. A. Agulhas II
The South African polar research vessel carries out both scientific research and delivers supplies to Antarctica. The vessel was built by the STX Finland in Romania and Rauma. Aker Arctic was responsible for model tests and hull form development and participated in the ice trials after the delivery of the vessel in 2012. *S. A. Agulhas II* replaced the 35-year-old *S. A. Agulhas*.

Kronprins Haakon
Norway's new icebreaking research vessel *Kronprins Haakon* was delivered in 2018 and will provide a platform for scientists to monitor the environment and state of the climate in both the Arctic and Antarctic.

Sikuliaq
The 2015-built *Sikuliaq* is an ice-strengthened research vessel operated by the University of Alaska Fairbanks School of Fisheries and Ocean Sciences. Aker Arctic supported the design work and carried out full-scale trials and model tests of the vessel.

Icebreaking research and logistics vessels under construction

Xue Long 2
The icebreaking research vessel will be used for research and logistics tasks in the polar oceans, mainly Antarctica, where China has four permanent research stations. Aker Arctic was responsible for the conceptual and basic design as well as model tests in open water and ice for *Xue Long 2*. The vessel is almost ready for delivery and will be tested in ice during winter of 2020 as part of Aker Arctic's scope of work. She will complement the existing research vessel *Xue Long*.

Antártica 1

Construction of the icebreaking research vessel for the Chilean Navy began last year with delivery expected during 2021. Its tasks will include logistic support, search and rescue, and scientific research south from the Antarctic Polar Circle. She will replace the icebreaker *Almirante Óscar Viel* which was acquired from Canada in the 1990s. Aker Arctic supported Canada-based Vard Marine in the design of the hull form and performed model tests.

RSV Nuyina
Australia's new Antarctic icebreaker is due to arrive in Hobart in 2020. She will be the main lifeline to Australia's Antarctic and sub-Antarctic research stations and the central platform of their Antarctic and Southern Ocean scientific research.

Sir David Attenborough
The new polar ship for the United Kingdom will spend the northern summer supporting Arctic research and the austral summer in Antarctica carrying out research programmes and resupplying the British Antarctic Survey's research stations. Her expected delivery is in summer 2019 and the vessel will replace the two polar ships RRS *Ernest Shackleton* and RRS *James Clark Ross.*

Vessels in acquisition phase or under consideration

Polar Logistics Vessel for Argentina

Polar Research Vessel for Germany, Polarstern II

Polar Security Cutter (heavy polar icebreaker) for the United States Coast Guard

Polar Research Vessel for Japan

Polar Research Vessel for Korea

Polar Research Vessel for Brazil

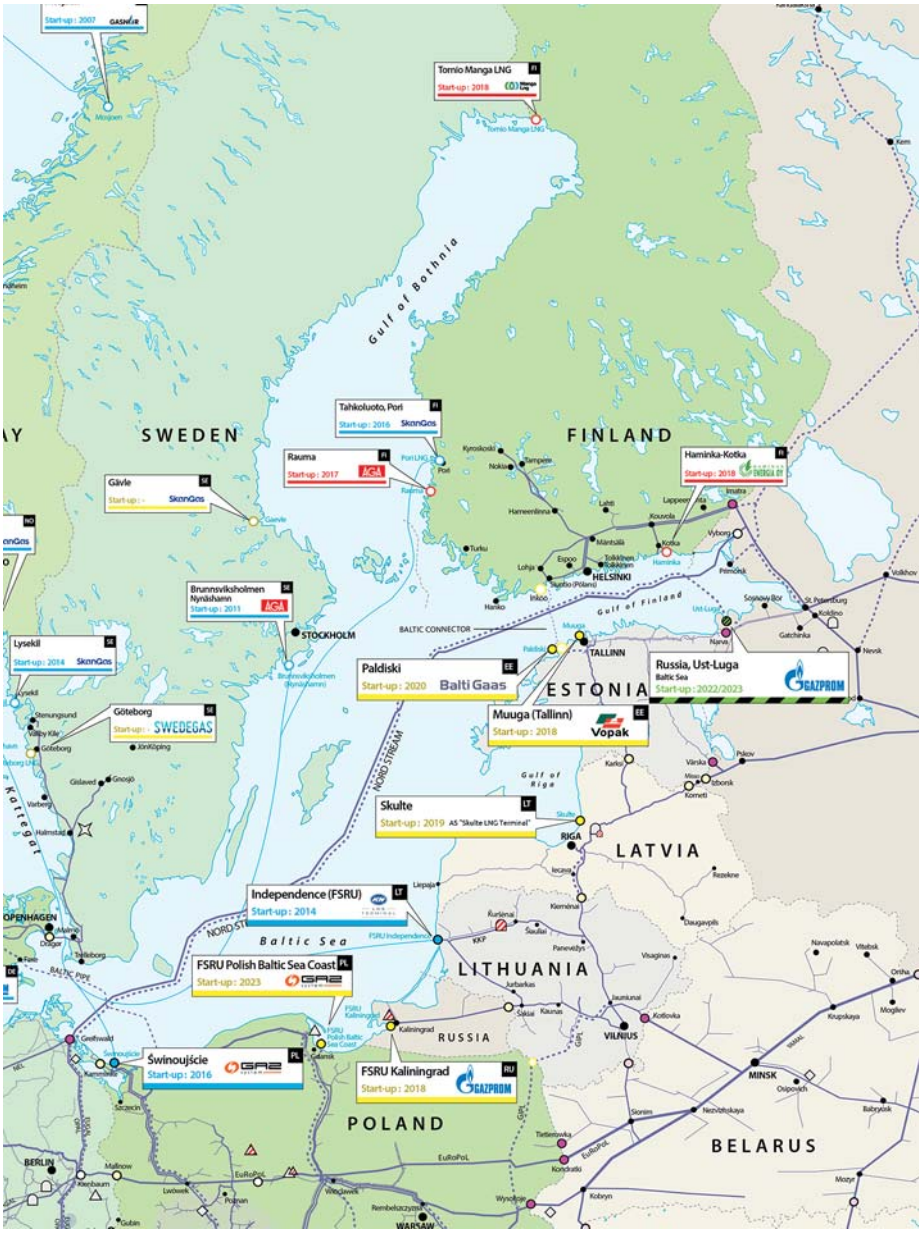
Polar Research Vessel for India

LNG distribution around the Baltic Sea

From 2005 onwards, the Baltic Sea has been subject to ever stricter environmental regulations as part of it being designated as an Emission Control Area (ECA). By using liquefied natural gas (LNG) as fuel in vessels the ECA regulations are fulfilled and even surpassed. One of the challenges is the availability of LNG, but the situation is rapidly improving.

Naval Architect Joakim Konsin has been following closely the situation with new LNG investments around the world and especially in the Baltic Sea area. "There are currently a huge number of activities taking place led by several parties," Konsin says. "Shipowners are investing in new vessels which use LNG as fuel, natural gas is being delivered to new liquefaction plants, energy companies are investing in terminals and bunkering vessels to store and distribute LNG, and governments are supporting investments in clean technology and infrastructure necessary for the distribution."

The availability of LNG has been a challenge that has been resolved in various ways. Some vessels have been fuelled at the quayside by LNG-trucks or from local small storage tanks while some vessels have bunkered elsewhere, e.g. in Rotterdam before sailing into the Baltic Sea. As we can see from the table on page 12, the situation will improve soon. Two terminals are already operating in Poland and Lithuania, another is almost ready in Kaliningrad and one more is planned in Poland for 2023. The bunkering vessel *Kairos* is additionally operating from the port of Klaipeda in Lithuania. Finland, Sweden, Estonia, Latvia and Russia all have new facilities planned.



Overview map of the Baltic Sea. (Source: Gas Infrastructure Europe)

Storage vessels instead of tanks

Some of the terminals are using or planning to use existing LNG carriers, which are to be converted into floating storage units (FSUs) or floating storage and regasification units (FSRUs). A regasification plant may be mounted onboard or on land for supplying gas to a pipeline. For example, the port of Klaipeda in Lithuania is using a bunkering vessel as an addition to their FSRU, *Independence*. The bunkering vessel *Kairos* can also deliver LNG fuel to vessels in other ports. At present it is the largest bunkering vessel in the world with a tank capacity of 7500 m³.

"A reasonable sized LNG storage capacity should be provided to serve the regasification plant. The easiest and most cost-efficient way is to use an existing LNG carrier and convert it into a floating storage unit," Konsin adds. "Such a storage vessel can act also as bunker storage for other ships that can be moored alongside for bunkering."

To convert an existing LNG carrier into a floating LNG storage unit is also recognized as an attractive alternative for LNG transportation. The vessel can, for example, be stationary moored in a harbour or it can be moored further offshore.

Aker Arctic has made studies for the winter marine operations required when applying converted LNG carriers for LNG transportation. "In the first phase of such projects, Aker Arctic typically evaluates the ice conditions and ▶

LNG facilities in Baltic ports

	Start of operations	Type of facility	Storage capacity of tanks, m³	Operator
Świnoujście, Poland	2016	Land-based tank	2 x 160 000	Polskie LNG S.A.
Klaipeda, Lithuania	2014	FSRU *Independence* in Klaipeda harbour	170000	Klaipedos Nafta
Polish Baltic Sea Coast	2023	FSRU	Unknown	Polskie LNG S.A.
Kaliningrad, Russia	2019	Underground storage + FSRU *Marshal Vasilevskiy*	174000	Gazprom
Gävle, Sweden	Planned	Land-based tank	30000	Gasum
Nynäshamn, Sweden	2011	Land-based tank	20000	AGA
Oxelösund, Sweden	Planned for 2020	Land-based tank	500	The Port of Oxelösund
Paldiski, Estonia	2020	Land-based tank	160000	Alexela
Muuga, Estonia	Planned for 2018	Land-based tank	4000	Vopak
Skulte, Latvia	Planned for 2019	FRU + connection to the Inčukalns underground gas storage	No storage in port	No investor yet
Baltic LNG, Ust-Luga, Russia	2023	Large export terminal	Unknown	Gazprom
Portovaya	Planned for 2019	FSU	138000	Gazprom
Vysotsk LNG, Russia	Planned for 2018	Land-based tank	42000	CryoGAS-Vysotsk
Tornio, Finland	2019	Land-based tank	50000	Manga LNG
Pori, Finland	2016	Land-based tank	30000	Gasum
Hamina, Finland	2020	Land-based tank	30000	Hamina Energia Oy and Alexela

Photo: KN

The port of Klaipeda in Lithuania is using bunkering vessel Kairos as an addition to their FSRU, Independence.

anticipated shipping activities in the intended operation area around the LNG terminal," says Project Manager Sami Saarinen. "The number of assisting tugs / icebreakers, their duties and their optimised ice performance requirements are then determined accordingly, so that the assisting operations at the terminal can be performed adequately and cost effectively throughout different winters." Sometimes it may even be possible to suggest modifications for the terminal layouts and arrangements. This is an important benefit for the clients, because even small modifications to existing terminal designs may significantly ease and decrease operational costs of winter operations in the terminal.

Finally, some ice strengthening of the converted LNG carrier is typically required. Aker Arctic has made such analyses and "conversion plans" for the clients so that the converted LNG Carrier has capacity to withstand external ice loadings during winter season.

Urgent need for a distribution system

Recent vessel acquisitions for the Baltic Sea have all looked towards the future and opted for LNG as fuel. They are waiting eagerly for the new distribution terminals to start operation.

Viking Grace, which was the first large LNG-fuelled passenger ship in the world has, since entry into service in 2013, received her gas fuel from an LNG bunkering vessel *Seagas* that is supplied by LNG trucks. The drawback with the present fuel gas supply chain is its complexity, as significant number of trucks are required to provide the fuel.

Polaris, the newest Finnish icebreaker, and the patrol vessel *Turva* have both been fuelled by LNG trucks, but are also now beginning to refuel in dedicated Finnish harbours.

Tallink's *Megastar* is currently fuelled by LNG trucks but Eesti Gas Tallink has opted to invest in their own LNG bunkering vessel that will be operating in Tallinn and start operation in 2020. The bunkering vessel will also serve their new LNG-fuelled ro-pax ferry entering into service in 2021.

Containerships plc has invested in four smaller LNG-fuelled container vessels due to commence operations later this year. They will initially receive LNG fuel in Rotterdam as the LNG infrastructure in the Baltic Sea still is limited.

ESL Shipping has invested in two large bulk carriers (M/S *Haaga*, M/S *Viikki*) which are already sailing in the Baltic Sea. They are the most environmentally friendly bulk carriers in the world and refuel from the bunkering vessel *Kairos*.

Sovcomflot has ordered eight LNG-fuelled Aframax tankers as well as three smaller LNG-fuelled vessels for Baltic Sea traffic. Additionally, there are two passenger ferries on order intended for traffic between Gotland and mainland Sweden.

"There are over 8,000 unique vessels sailing in the Baltic Sea annually and so far, only a small portion using LNG as fuel today," Konsin adds. "However, if we look at the newbuilding order book, most of the new vessels will be using LNG."

Jack Sharples of the Oxford Research Institute for Energy Studies recently published a research paper, about LNG supply chains and development of shipping fuel in Northern Europe. He estimates that the demand for LNG is likely to grow even more quickly given the increasing size of LNG-fuelled vessels. Further restrictions on global SOx emission from next year and limitations on NOx emissions in the ECA areas will add more vessels using LNG to the order book.

Designing LNG vessels
In recent years Aker Arctic has been deeply involved in various LNG-fuelled vessels for the Baltic as well as LNG transportation in the Arctic. An entire transportation system was developed for Yamal LNG, including support during the initial planning, studies for alternative hull forms and machinery concepts, fleet studies, ice management studies for the harbour, shipping infrastructure investigations in addition to involvement with the design of the port fleet and the Arctic LNG carriers. Successful LNG-fuelled icebreaker *Polaris* and coast guard patrol vessel *Turva* are operating on the Baltic Sea. A number of powerful icebreakers using LNG as fuel are being designed. Recently the keel was laid of the LNG-powered, icebreaking, luxury cruise ship, *Le Commandant Charcot*, for Ponant

"Designing vessels for ice infested waters is not only about strengthening the vessel to withstand the ice loads. The total operation profile of the vessel has to be evaluated to optimize the hull form between open water performance and ice performance," says Sales Manager Arto Uuskallio. "Aker Arctic takes a holistic approach to the design work, which also includes planning for possible risks in advance. Ice going vessels, icebreakers, assisting tugs for harbours and mooring, ice management studies and optimal harbour designs are all part of our services."

Photo: Meyer Turku Shipyard

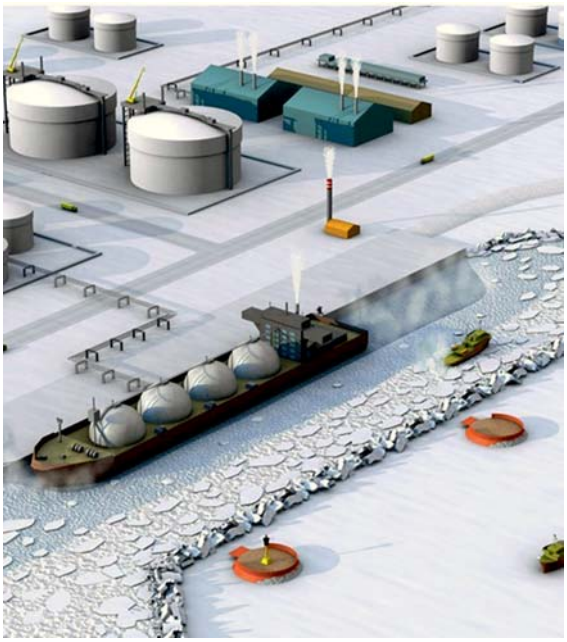
Current LNG vessels
Polaris, Turva and Viking Grace.

Cooperation agreement between Aker Arctic and Eranti Engineering Oy

Aker Arctic and Eranti Engineering have signed a cooperation agreement for designing fixed arctic offshore and coastal structures together.

"Harbours which encounter ice need to be planned as a holistic entity including the layout, the geometry, the mooring places, the piers and evaluating the cargo vessel operation with possible assisting tugs. Ice management is an essential part of designing harbours," says Sales Manager Arto Uuskallio. "Through our cooperation with Eranti Engineering, we can offer more complete design packages to our customers."

"Backed by superior ice and arctic engineering know-how, the design solutions aim to provide significant cost savings for our clients," says Dr. Esa Eranti.

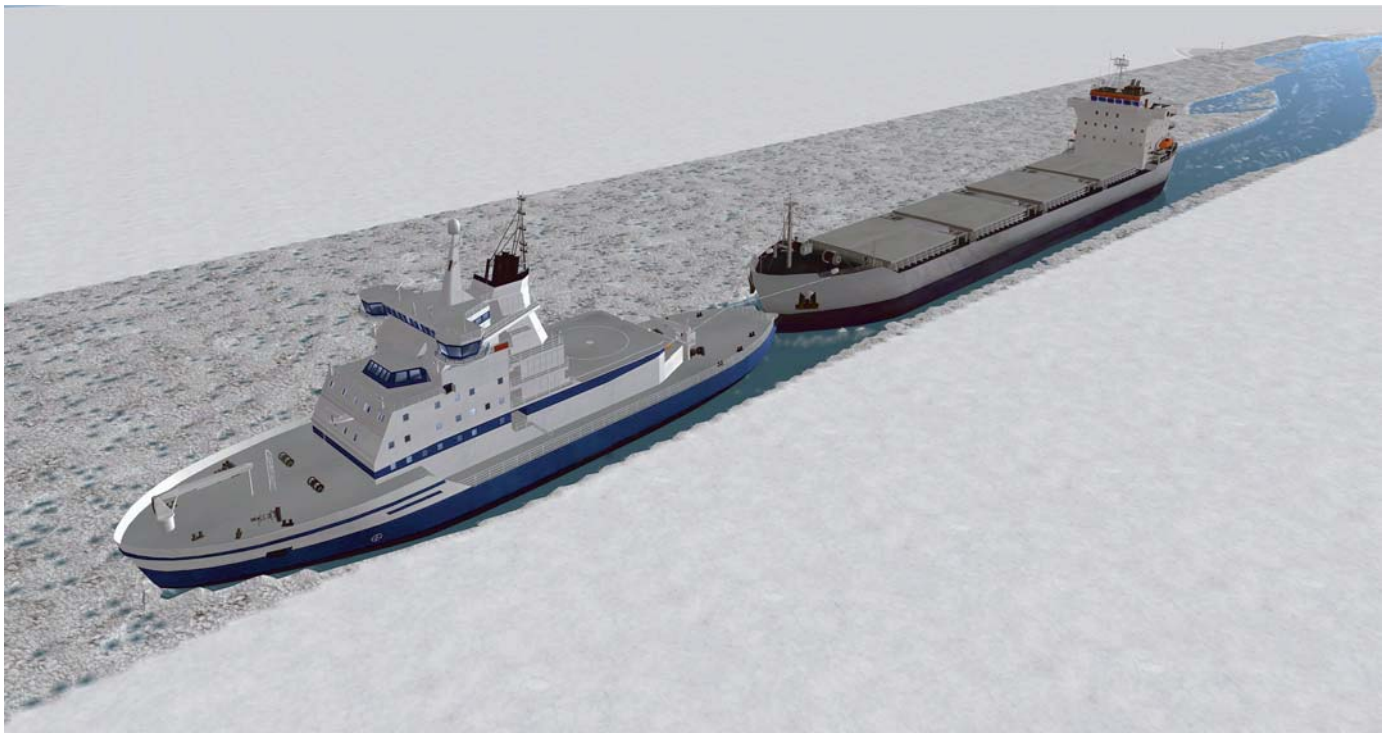


Arctic harbour design may include layout, planning of ship and icebreaker operations, brash ice control system and ice barrier design.

Meet Joakim Konsin

Joakim joined Aker Arctic two years ago and works with designing ice-going cargo ships, especially focusing on LNG vessels. He works closely with Mauri Lindholm, the Aker Arctic LNG expert, and divides his time between Turku and Helsinki offices. Before joining Aker Arctic, Joakim worked for 14 years in various companies in the shipbuilding industry, both in Finland and Switzerland. He graduated as a Naval Architect from Aalto University in Espoo and has recently moved back to his home town together with his three sons. Joakim enjoys sailing and playing basketball.

Enhanced vessel handling skills with Ice Simulator



Finnish Otso- class icebreaker escorting cargo ship in Aker Arctic Ice Simulator.

Handling large vessels in confined areas such as harbours, is a challenging task. When ice resistance, wind and other vessels are added, the challenges multiply. With the Ice Simulator that Aker Arctic has developed over the past ten years, operations in ice can be practiced in advance.

The Ice Simulator is an educational tool used for simulating ice navigation. Maritime students and ship officers can learn how to operate a vessel in various ice conditions and gain experience in a safe and controlled manner before handling the real vessel where the risks are higher. Existing vessels are programmed into the simulator so that the training is realistic, useful and fun.

Aker Arctic's Ice Simulator is currently installed on two simulation bridges at The Finnish Maritime Academy Aboa Mare in Turku, where it can be used in educational programs by enrolled students and ship crews from all over the world. Aboa Mare has educated sea captains for over 200 years and also offers ice navigation courses that meet Polar Code Operation and Manning requirements.

The Ice Simulator is also in use at maritime academies in the Philippines and Romania.

Operational studies

In addition to education, the Ice Simulator is useful for operational studies before a vessel is constructed. A feasibility study was, for instance, conducted for Yamal LNG before Sabetta harbour was ready.

"A model of the Arctic heavy module carrier we designed for transporting construction modules was added to the Ice Simulator along with the exact design of the planned Sabetta harbour and an icebreaking tug," explains Sales Manager Jukka Salminen from Aker Arctic. The customer could then navigate the module carrier in different weather and ice conditions in the harbour and practice how to manoeuvre the vessel to the pier with the assistance of the tug. After that, plans were jointly evaluated to see if any adjustments would be needed.

Training in advance

Risk prevention is a top priority in shipping. When acquiring a new vessel with new dimensions and propulsion arrangements than previous vessels, it is beneficial to practice how to handle the vessel before it is delivered. This is even more important when the vessel will operate in ice. "The crew for the Finnish icebreaker *Polaris* was trained using simulation," says Director Tom Ekegren, Arctia Icebreaking Oy. "We wanted to prepare the crew how to handle *Polaris* in advance, taking into consideration her propulsion solution which differs from previous icebreakers. The crew was trained how to operate her in general, as well as in ice fields." *Polaris* has a propulsion configuration with a triple azimuth solution; two propulsion units in the stern and one in the bow. This makes her agile but at the same time the captain has to be cautious of sudden moves as she turns quickly.

"Training with the Ice Simulator before *Polaris* was delivered was very useful, especially for those who had not steered a vessel with azimuth propulsion before," says Captain Pasi Järvelin, who commands *Polaris.*

The Ice Simulator can also be used as a tool to further develop skills or to refresh operators on icebreaking operations during the ice-free months. "Some of Arctia's Icebreaking officers have continued with the advanced skills level, while taking the 'Ice Operator course' at Aboa Mare," Järvelin adds.

Salminen highlights that Aker Arctic can offer clients a tailored package including ship design, operational study, support during construction and training in both open water and ice before a vessel is delivered.

Captain Sampo Karppinen from ZPMC – Red Box Energy Services used the Ice Simulator to reverse the Arctic Heavy Module Carrier in Sabetta Harbour as part of a feasibility study for Yamal LNG.

The crew of Finnish Icebreaker Polaris practiced manoeuvring the vessel in general and in ice fields with simulation at Aboa Mare before the icebreaker was delivered.

Basic and Advanced Ice Navigation Courses are offered at The Finnish Maritime Academy Aboa Mare in Turku, Finland. Courses include training with the Ice Simulator.

Upgraded features

The Ice Simulator is a system that requires continuous development and it is regularly upgraded with new features. "We have recently added more target-ships, which can be used when practicing assisting as well as operational features needed when assisting ships in ice," says Project Manager Jukka-Pekka Sallinen, Aker Arctic. "For example, cutting a vessel loose from ice in a realistic way and how to react in various situations. It is now also possible to learn how to release a vessel stuck in ice by flushing the propellers."

Towing in ice is one of the most challenging tasks as the vessels are very close to each other during the operation. However, icebreakers operating in the Baltic Sea is a common practice when commercial vessels cannot manage in the ice conditions. Close towing is one of the recent upgrades of the Ice Simulator.

The newest addition, which is still pending final visual details, is dynamic icefields. Until now, the ice has been static. "We have improved the Ice Simulator to include ice movement with wind and currents. For example, when a ship interacts with an ice field, the ice actually moves away enhancing the real-feel of using the simulator," Sallinen says.

The development work of the simulator includes cooperation with various partners, such as ImageSoft, Simulco, Aboa Mare, Finnpilot, Alfons Håkans and Arctia. "Our partners help us with feedback and visual appearance, while our four-person team at Aker Arctic focuses on programming the simulator, as well as developing other software and modelling services for our customers, such as the Ice Load Monitoring System and solutions for autonomous vessels," Sallinen says.

Realistic tool

The Ice Simulator has been praised as visually appealing and realistic.

"At Aboa Mare, we currently have three simulators in use, which can be connected to our ship bridges," says R & D Manager Mirva Salokorpi, Aboa Mare. "They all have different features. The Aker Arctic Ice Simulator is for instance the best one for teaching icebreaker manoeuvring and assistance such as close towing. We especially appreciate the ice modelling in the software and are looking forward to new tools and features in the future."

Icebreaker captains have helped to give valuable input which has been used when developing new features of the simulator. Captain Järvelin has for instance provided full-scale test drives with *Polaris*, which will be incorporated in the Ice Simulator.

"Our long experience in gathering ice information, analysing ice properties and designing icebreakers have given us an advantage when creating the simulation tool," Salminen adds. "We have been able to give users a realistic experience based on real vessel models and dynamics. They can maintain and enhance their professional skills, which is beneficial for themselves, their employers as well as ship owners."

Meet Jukka Salminen

Jukka's interest in icebreakers arose when he visited the Finnish icebreaker *Otso* for the first time at the age of 9. *Otso* was also the first icebreaker he worked on after graduating as a master mariner from Turku Maritime College. He worked for eleven years for the Finnish icebreaking company Arctia Ltd., first on-board various Finnish icebreakers as a navigation officer before moving to office work as a chartering manager. Jukka joined Aker Arctic as a sales manager in 2017. His background in navigating icebreakers is a great asset in a company designing icebreakers. "For me, this gives the opportunity to learn a new aspect of icebreaking, for example how the design work is performed," Jukka says.

Jukka has also competed in alpine skiing in the Finnish championships. "Although I don't compete anymore, I love downhill skiing in winter," he says. Jukka spends his summer holidays in the Finnish archipelago with his wife and two small children. He also enjoys golfing.

Performance with turn-key solutions

Aker Arctic is mostly known for its vessel design service, engineering expertise and ice model testing. Previously, we have included delivery of certain components for construction in selected vessel projects. From this year we are expanding our ship equipment deliveries, where we take full responsibility for the design and delivering of special components and systems for ice-going vessels to customers.

The propellers, based on the results of the development program, have been installed on the Finnish ice class IA ASD tug Calypso.

Over the past years Aker Arctic has been engaged in various component deliveries. These pilot projects can now benefit other customers.

"Our ship equipment service includes taking responsibility for the design, delivery, installation, supervision and finally commissioning," says Kari Laukia, Head of equipment business. "We have selected reliable partners that manufacture the components under our supervision."

The strong know-how in shipbuilding among Aker Arctic's employees is an advantage to customers engaging us in vessel design. When customers order special components for ice-going vessels through us we also take care of all the technical calculations and specifications which are part our expertise. "The benefit for the customer is that we ensure that the entire system is functional," says Laukia.

These services can either complement our design projects or be bought separately. It can, for instance, be the entire propulsion system for an ice-going vessel, only the ice-going propellers, or a certain part of the shaftline.

Laukia clarifies: "Tell us your needs and we will design and deliver it to you as a turn-key solution."

Below are some examples of successful projects from the past few years.

Bronze propellers supplied for ice operations

Bronze has a number of benefits in marine applications such as good resistance against corrosion and cavitation damage. The material is also easy to work with both during manufacturing as well as when carrying out maintenance and repairs, in addition to a competitive price. It is widely used for open water and low ice class ship propellers, but in more demanding ice conditions, the common choice has been stainless steel as it is a stronger material. Aker Arctic has for some years been researching the possibility of using bronze also in high ice class vessels and simultaneously decrease the propeller induced noise, jointly with Finnish propeller manufacturer TEVO.

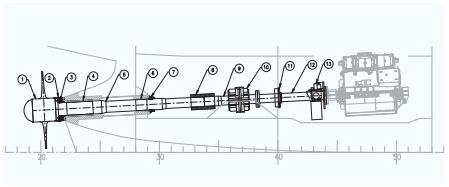
Full-scale tests

The bronze propeller concept was tested in full-scale ice trials in the Bay of Bothnia in 2016 and 2017. The Finnish multipurpose vessel *Louhi* was fitted with a bronze propeller and tested in level ice with a thickness of 60 to 85 cm, both in ahead and astern operating modes. Other tests were performed in 6 metres thick ice ridges and in ice channels.

Underwater propeller - ice interaction was also studied. These tests gave valuable information for designing bronze propellers for higher ice class vessels while fulfilling low-noise requirements.

In November 2018 the first bronze propellers based on the feedback from the ice tests were installed on the Finnish ice class IA ASD tug *Calypso.* The two NiAl bronze propellers have a diameter of 1.9 metres. The tug is now assisting vessels in seaports in Southern Finland where ice and brash ice usually appear in harbour areas during the winter. *Calypso* is owned by the Finnish towage and salvage specialist Alfons Håkans and will be used to push a self-propelled detachable icebreaking bow in Lake Saimaa next winter.

Multipurpose vessel Louhi is equipped with stainless steel propellers, but was fitted with a bronze propeller for ice tests in 2016 and 2017.



Aker Arctic can deliver the entire shaft line with propellers, or parts of it.

Two shaft lines delivered

Aker Arctic has additionally designed and delivered two full shaft lines for the detachable icebreaking bow which will be pushed by tug *Calypso*. The two 600 kW aft-facing shaft lines have been installed on both sides of the innovative bow, improving its efficiency and manoeuvrability. The Finnish Transport Agency and ILS developed the icebreaking bow while Aker Arctic performed the model tests for the design. The bow is being constructed at Turku Repair Yard and will be tested in ice in early 2020.

Aker Arctic has designed and delivered two full shaft lines for the self-propelled detachable icebreaking bow, which will be fitted to tug Calypso.

The Aker Arctic designed module carriers Audax and Pugnax are equipped with tailor-made propellers for use in extremely heavy ice conditions.

The Finnish Lake Saimaa and Saimaa Canal are important waterways for the industry in Eastern Finland. The innovative self-propelled detachable bow fitted on *Calypso* will be able to break a wider channel than the icebreaker currently in use and possibly also lengthen the use of Saimaa waterways in winter time.

Propeller delivery for the Arctic Module Carriers

In 2014 Aker Arctic designed two polar class heavy deck carriers for arctic use. After construction the carriers *Audax* and *Pugnax* have been delivering LNG liquefaction plant modules from Europe and Asia to Sabetta on the Yamal peninsula. The development work was carried out in close cooperation with the shipowner, ZPMC-Red Box Energy Services.

"Our scope was the design of propellers suitable for extremely demanding use in heavy ice conditions," says Laukia. "The customer then trusted us with the delivery of the propellers and spare blades, which took place in 2015 and 2016. Aker Arctic also supervised the installation and commissioning of the propellers." The four PC 3 ice class propellers of 5.4 metres in diameter have bolt-on blades.

Special equipment delivery

Other turn-key special equipment for ice vessels we can deliver include the complete wheelhouse (ARC BRIDGE) for ice-going vessels, a bow flushing system (BFS), our ice simulator and an ice load monitoring system.

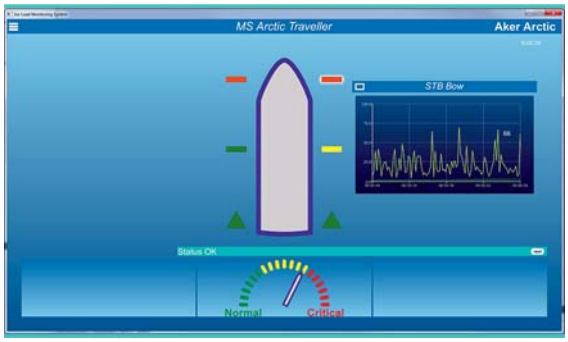
"The idea of the ARC BRIDGE is not only to bring Aker Arctic's experience in designing the wheelhouses for ice-going ships, but also to be the integrator for the entire bridge system," Laukia explains. This includes the design, the wheelhouse fabrication, the assembly of the bridge components and co-ordinating the commissioning. Delivery of the main equipment can be included in the scope of supply or they can be delivered by the customer. The bridge fabrication and assembly are normally done at the shipyard or in the vicinity of the shipyard.

Aker Arctic has developed a bow flushing system (BFS) which decreases ice resistance for certain hull forms, lowering the propulsion power needed. "This can be an advantage for ice class ships required to meet the EEDI requirements," says Laukia.

The Aker Arctic Ice Simulator is a useful tool in training, simulation and testing. It can be programmed to include the customer's vessel designs, harbour designs and real icebreaking situations.

The Ice Load Monitoring System (ILMS) supports the captain in making decisions on how to proceed in an ice field and at what speed, improving safety in ice operations. Sensors located around the ship hull monitor the ice load, peak values and predict the approaching ice load, which are displayed on a monitor for a clear overview. A shaft line monitoring module can be added to the ice load monitoring tool on request.

"Several component delivery projects are currently underway. We are happy that our turn-key services have been well received among our customers. Please contact us directly for more information," Laukia emphasises.



The Ice Load Monitoring System (ILMS) helps the captain to predict ice loads and decide how to proceed in an ice field.

Kari Laukia, Head of ship equipment business

Kari has been with Aker Arctic the past eight years, after transferring from Kone Marine Elevators. He has a strong background in Arctic shipbuilding, especially in developing propulsion systems for ice operations. In fact, he began his career as a propulsion design engineer at the Helsinki Shipyard and from there on Kari has continued being part of many successful projects. Two well-known examples are developing the propulsion system of *Taymyr*-class nuclear-powered icebreakers and being responsible for developing the azimuthing propulsion unit, Azipod, in the 1990s. At Aker Arctic, Kari has been responsible of design and engineering, while simultaneously developing the equipment business for customers. With the many new projects going on in this field, Kari now continues full-time as Head of Equipment business.

Turn-key products available

- Propellers for operation in ice
- Shaft line including components
- ARC Bridge (Command bridge for ice vessels)
- BFS (Bow Flushing System)
- Ice Simulator
- Ice Load Monitoring System
- Air bubbling systems

News in brief

Second Novy Port icebreaker danced its way to Gulf of Ob

The icebreaker Andrey Vilkitsky, built as part of Gazprom Neft's “Time of the Arctic” programme, was delivered in St. Petersburg in December 2018. The vessel has since then joined her sister vessel, Aleksandr Sannikov, at the Arctic Gate oil terminal.

Photo: Vyborg Shipyard

The highly-manoeuvrable vessel presented herself to the residents of St. Petersburg who were able to witness a spectacular scene as the icebreaker passed along Neva River. TV reports later showed the arctic ship and called it the dancing vessel; the icebreaker can complete a full turn in open water in about a minute and has been designed for high manoeuvrability in ice conditions.

The icebreaker is named in honour of the famous Russian hydrographer, surveyor and polar explorer Andrey Vilkitsky. The vessel, based on the Aker ARC 130 A design, was built at the Vyborg Shipyard and designed to operate in shallow river estuaries in the Arctic. These waters are covered by up to two metres of ice for 200 days of the year and exposed to strong gales off the Gulf of Ob. Icebreaking vessels such as the *Aleksandr Sannikov* and the *Andrey Vilkitsky* are vital in ensuring that tankers can safely pass through the ice to reach the Arctic Gate terminal.

Andrey Vilkitsky's unique hull form allows it to cut through and break the ice efficiently, while its shallow draught and manoeuvrability ensure safe icebreaking operations at the offshore oil terminal. The vessel demonstrates icebreaking capacity comparable to the nuclear icebreakers of far greater power, advantages made possible by the highly-refined hull form and three Azipod propulsion units, two in the stern and one in the bow, capable of being rotated 360 degrees.

The captain of the icebreaker, Yuri Akhromkin, said to PortNews that during the 35 days of testing in the Baltic Sea, the vessel proved to be manoeuvrable and powerful. “In the beginning, I was sceptical about the fact that the icebreaker was called 'dancing', but now I agree with this definition,” said the captain.

According to Akhromkin, *Andrey Vilkitsky* is a wonderful vessel that will be in demand. “The icebreaker is automated and easy to manage, with all systems connected in a single computer network, allowing you to manage all the processes on the ship. Operators receive full information about the vessel itself, and about the environment.”

According to Alexander Dyukov, Chairman of the Gazprom Neft Management Board, logistics are playing a vital role, making it possible to continue shipping and transporting oil through the Kara Sea, regardless of weather conditions. “Building these icebreakers was an essential precondition to the further effective development of Novoportovskoye hydrocarbon field,” Dyukov stated in Gazprom Neft's press release.

www.gazprom-neft.com, www.gazprom-neft.ru, www.portnews.ru

More autonomous vessel tests

Components for autonomous vessel-testing in the model test laboratory is being continuously improved. Since the launch of the service in June 2018, new tests have been performed.

“The propulsion units have been upgraded and a joint project regarding dynamic positioning in ice is currently on-going,” says Development Engineer Jukka-Pekka Sallinen.

“Navis NavDP system and ABB Ability™ Marine Pilot Control systems have been successfully integrated and tested in Aker Arctic's model test facilities. DIVEC™ has proved to be a powerful tool for interfacing different DP provider's systems with Aker Arctic's model test system.”

The DIVEC™ software architecture allows adding third-party software components, according to the purpose of the testing situation. A demonstration where a model avoids changing obstacles on its way from departure to destination and back can be found on Aker Arctic's Youtube channel.

News in brief

China launched icebreaker Xue Long 2

In September, China launched its first domestically-built polar research icebreaker. Delivery is expected by summer 2019.

Xue Long 2 was jointly designed by Aker Arctic Technology and China State Shipbuilding Corporation (CSSC) institute. Construction began in 2016 at CSSC's Jiangnan Shipyard in Shanghai.

After commissioning, *Xue Long 2* will expand China's scientific missions in the polar regions with its advanced laboratories and equipment, including two on-board helicopters. It will be able to travel at 12 knots for 20,000 nautical miles and sustain a 90-person crew and researchers on board for up to 60 days.

Aker Arctic was responsible for the conceptual and basic design as well as model testing. “We are also supporting the owner in areas that are typically important for an icebreaker's operation and reliability by participating in tests such as inclining tests, open water sea trials and other checks before ship delivery,” says Kari Laukia. “Full-scale ice trials are planned for later this year.”

Keel laid of Le Commandant Charcot

The luxury icebreaking cruise vessel for PONANT is moving ahead. The ship's traditional steel cutting ceremony was held in November 2018 and the keel laying took place in Tulcea, Romania in December.

The unique hybrid electric polar exploration vessel propelled by Liquefied Natural Gas (LNG) will offer its guests a fascinating odyssey in the wake of the great polar explorers. The launch is planned for 2020, before its delivery in 2021. Final works and outfitting will take place at VARD Söviknes yard in Norway.

The vessel incorporates the latest technologies in environmental protection and surpasses the ecological standards set out in international regulations. It is named after Jean-Baptiste Charcot, an explorer and “gentleman of the poles”.

Le Commandant Charcot, with ice class PC2, was designed to combine forward sailing modes through compact ice and reverse sailing in extreme ice conditions, by using the Double Acting principle (Aker Arctic DAS™). With its innovative design, *Le Commandant Charcot* offers unrivalled ice performances compared with classic icebreakers.

Rosatom to control the Northern Sea Route

The State Duma in Russia transferred the powers of operator of the Northern Sea Route (NSR) to Rosatom in December 2018. The Ministry of Transport, which previously commanded the Northern Sea Route, retains the functions of state control and regulation of the NSR.

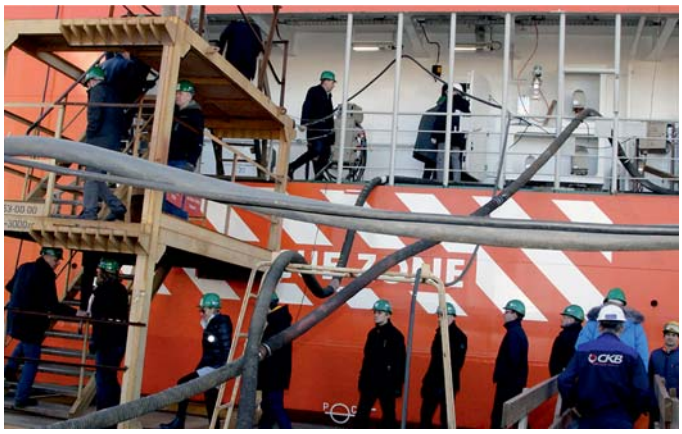
Rosatom will plan the development of infrastructure on the NSR and carry out appropriate actions. A subordinate enterprise must be defined, who will be authorized to award permits to sail via the NRS. It will also sign concession agreements related to infrastructure of sea ports located at the shore of the NRS water area, and design and construct buildings, including capital projects associated with sea port infrastructure located at the shore of the NRS water space.

The state-owned corporation also acquired rights to develop proposals on forming the state policy for development and sustainable functioning of the NSR.

A key person in the new structure is Vyacheslav Ruksha, the former leader of FSUE Atomflot.

Rosatom, together with the authorized bodies, will make navigation viable and safe in the NSR offshore areas. This will include monitoring hydrometeorological, ice and navigation situation, the coordination of the installation of navigational equipment, making recommendations on the development of routes of navigation and use of icebreakers to assist in the organization of search and rescue operations.
rosatom.ru, chelorg.com

Exploring Vyborg



Recent Aker Arctic designed vessels constructed at Vyborg Shipyard include icebreakers Aleksandr Sannikov, Andrey Vilkitsky and Ob.

Vyborg is a small appealing town in north-western Russia, near the border of Finland. It was founded in 1293 by the Swedish King Torkel Knutsson and has since jumped back and forth between being part of Sweden, Finland and Russia.

Last October, Aker Arctic staff boarded the comfortable Allegro train at Helsinki Railway Station for the 300-kilometre long trip to explore Vyborg.

The favourite activities of visitors are exploring the medieval castle of Vyborg, which has survived many wars, and walking around the cobblestone streets in the old part of the town. Many Finns have their roots in the region, that historically had a large Finnish population, but were expelled after Stalin took over the town in 1944.

Apart from being a beautiful town, Vyborg is an important rail junction and port in Gulf of Finland, and hosts Aker Arctic's valuable cooperation partner, Vyborg Shipyard.

Vyborg Shipyard PJSC is one of the largest shipbuilding companies of the north-western Region of Russia. It was founded in 1948 and has since built more than 200 different vessels with a total displacement of over 1,550,000 t. In the last 20 years, the company has taken a leading position in civil shipbuilding. The priorities of its activity are construction of icebreakers, ice-class ships, fishing trawlers, high-end vessels and drilling rigs for development of off-shore deposits.

The highlight of the trip to Vyborg was a visit to the shipyard to see its recent construction projects. During the visit, the staff were able to see the icebreaker *Andrey Vilkitsky*, a sister ship of the *Aleksandr Sannikov* that is based on the Aker ARC 130 A design, and the port icebreaker *Ob*, which is based on the Aker ARC 124 design, and will be delivered later this year.

After the interesting visit at the shipyard, the group participated in a guided tour of the historical city. Restaurant Espilya is a new version of an old restaurant from the Finnish era, where the group enjoyed dinner, accompanied with folk music and dancing. A visit to the fancy Bar Probel, claiming to be the first cocktail bar in Vyborg, was optional after the fascinating day.

Restaurant Espilya offers dinner with folk music and dancing. Aker Arctic's group joined in the performance.

Meet us here!

We will participate in the following events:

Arctic Shipping Forum, Helsinki, Finland
2 – 4 April 2019

POAC, Delft, Netherlands
9 – 13 June 2019

ISOPE, Honolulu, USA
16 – 21 June 2019

Gastech, Houston, USA
17 – 19 September 2019

Neva, St. Petersburg, Russia
17 – 20 September 2019

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