Aker Arctic
The Ice Technology Partner

Arctic Passion News

No. 1 | 2021 | issue 21

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Front cover

Construction of the next generation icebreaking Arctic LNG carriers will begin in South Korea later this year. From 2023, all six Arc7 classed vessels will be ready to transport liquefied natural gas from the Gydan Peninsula year-round along the Northern Sea Route, improving overall cost-efficiency of the transportation system. Read all about the design project and technical highlights on page 4.

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March	Acquisition of Polar Research Vessels – early phase is crucial.
April	Cost efficient icebreaking options for lakes and ports. Detachable bow and other solutions.
May	Designer's role in shipbuilding projects (in Russian).
June	Propellers and shaft line delivery package. Ice Load Monitoring System for high ice class.
August	Polar Cruise vessel, our unique reference Ponant.
October	Full-scale testing of ice going ships as the basis for further vessel technology development. Ice model testing is essential for design verification.

Arctic Passion News, Aker Arctic Technology Inc's customer magazine 1/2021
ISSN 2342–7965, ISSN 2342–7973, Editor in chief: Reko-Antti Suojanen, Texts: CS Communications Oy, Layout: adeve.fi, Printed in March 2021, Grano Oy

Arctic Passion News 1 / 2021

Dear Reader,

The significance of the Northern Sea Route as an export corridor from Arctic Russia to Europe and Asia has notably increased during the past years.

Special vessels and icebreakers are necessary to ensure safe, reliable passage in the icy Arctic waters. Technical and economic factors mean that carrying out shipping during winter is considerably more demanding and expensive compared to other normal shipping. Traditionally, transportation has taken place mostly in the summer season using routes with easier and single-year ice conditions.

However, recent industrial activities in the Arctic region have required shipping to become possible year round. A similar development transpired in the Baltic and Great Lakes regions many decades earlier.

Advancements in ship technology, information and communication systems, weather forecasting, and using satellite data to guide vessels through ice, have made daily navigation possible in Arctic ice conditions.

The breakthrough innovation to enable large-scale commercial transport in the Arctic was the Aker Arctic-developed and trademarked Double Acting Ship (DAS™) concept. To understand its components we have to look below the ice to explain the main reasons how an icebreaker works.

Unlike it might appear, an icebreaker does not crush ice, but breaks it by gradually bending it downwards. This is the reason an icebreaking ship's hull is not sharp and vertical – instead it is flat and flared. This type of shape is natural for the stern of the ship.

To enable steering when moving astern, shaft lines and rudders are replaced by azimuthing propulsion units. Utilising them gives us a vessel that can sail in two directions: ahead in open water and stern-first when breaking ice. Astern mode is so efficient that these ships can overcome even the thickest ice ridges, making commercial transport viable in the Arctic.

The first Arctic-class vessel designed by Aker Arctic using this technology was the container ship Norilskiy Nickel. Since 2006, it has been sailing year-round in the Kara Sea region. Today, there are in total 37 double-acting cargo ships, LNG carriers and oil tankers in service, and more are in the order books. They have been constructed at various yards in Finland, South Korea, Russia, China, Germany and Japan.

This winter, both Sovcomflot and Teekay have made test voyages to see how navigation can be managed through the entire Northern Sea Route. These voyages have been supported by Atomflot's nuclear-powered icebreakers. The results are encouraging and shipping through the NSR will increase in the future: in wintertime only with special vessels, but with normal vessels in summer when ice conditions allow.

In this issue, we present our completely new Arctic LNG carrier, in addition to many other topics relevant to today's icebreaking practices. Our main target is to continue the successful development of new ships, with particular focus on reducing energy consumption and making substantial improvements regarding emission targets. For icebreaking ships, these are no easy tasks, but our mission is to rise to the challenge and to design such vessels for their owners' use and benefit.

Sincerely yours,
Reko-Antti Suojanen
Managing Director

Year-round Arctic LNG carriers

The next generation Arctic icebreaking LNG carrier comes with improved transport economies, no seasonal limitations and higher cargo turnaround than the previous generation of ships.

Construction of the next generation icebreaking LNG carriers will begin in South Korea later this year. From 2023, all six Arc7 classed vessels will be ready to transport liquefied natural gas from the Gydan Peninsula year-round along the Northern Sea Route, improving overall cost-efficiency of the transportation system.

Fifteen Arctic LNG carriers that Aker Arctic participated in developing for Yamal LNG have been transporting LNG to the markets in Europe and Asia since 2017. At the same time, Novatek has been expanding its liquefied natural gas production in the Gulf of Ob with construction of the Arctic LNG 2 production site, located in the Gydan Peninsula across the Gulf of Ob, as well as in Sabetta.

The first generation of Arctic LNG carriers were designed to use the Northern Sea Route (NSR) to Asia only in summertime, and to voyage west to Europe during winter. Although the vessels are extremely capable of icebreaking, their design is optimised for less arduous conditions, having more emphasis on efficiency in open water.

No seasonal limitations

The economic advantage of using the shorter NSR route to Asia all year without seasonal limitations was the incentive to start development of an improved vessel which could bring LNG from the new production site to the Asian markets faster and with lower transportation cost.

"The goal was to find a technical solution for the most cost-efficient transportation," says Managing Director Reko-Antti Suojanen. "The vessels' sole purpose is to transport LNG; with higher overall load capacity and speed, more savings can be achieved."

Transit speed in ice

The initial development of the second-generation of icebreaking LNG carriers began in late 2018 with a study focusing on improving the overall efficiency of the year-round transportation system.

"In our calculations, we noted at an early stage, that transit speed in ice was a crucial factor, as the ice-covered area on the NSR accounts for a major part of the route and is very difficult to navigate. Speed in open water was secondary, as this area is limited and has less importance for the overall system," Suojanen adds.

Transportation from Yamal LNG will, in the future, focus on the west-bound route to Europe, and from Arctic LNG 2 on the east-bound route to Asia along the NSR. The new Arc7 design allows transportation all year round on this challenging itinerary.

Natural gas is produced at a nearly constant rate, and the amount of LNG to be transported remains the same throughout the year. As a consequence, the winter navigating season and average transit speeds in ice-covered waters determine how many vessels are required. Although the fleet size may be excessive for summer months, this provides the opportunity to save fuel through slow steaming during the open water season.

The target is to transport LNG with special vessels through ice-covered areas to reshipping terminals in Kamchatka and Murmansk, and from there with open water vessels further to the market. This solution proved to be the most economical.

Holistic approach

"We also reached the conclusion that while the second -generation Arctic LNG carries have an extremely high, independent operational capability in ice, icebreaker escorts can further improve the overall efficiency of the transportation system," Suojanen explains. "Instead of over-dimensioning the LNG carriers to manage independently in every possible situation, we could choose a safe and sensible level of performance in ice."

The holistic approach was to design a vessel which works in an optimal way together with the existing icebreaker fleet.

New technical solutions for LNG containment systems were developed together with French company GTT, the world's largest LNG tank provider, which allow the carriers to transport larger cargo volumes.

Fewer vessels needed

The new Arc7 LNG carriers will be able to travel at an increased average speed in and through ice-covered waters.

"This means that 2 to 3 vessels fewer will be needed for the same amount of cargo compared to the previous generation of vessels designed for Yamal LNG," Suojanen highlights.

The speed can be increased even more with icebreaker assistance.

"As a result, the overall cost-efficiency of the year-round transportation system will be noticeably improved, and also show the importance of optimization over particular routes, which in the Arctic are quite different."

Delivery in 2023

The vessel concept design was developed in close cooperation with Novatek and then the design was finalised with DSME, who signed a shipbuilding contract with Sovcomflot and Mitsui O.S.K. Lines for the construction of six Arc7 LNG carriers based on the new design in October 2020. The first vessel will be ready in spring 2023, and the remaining five before the end of that year. ■

Novatek developments in Gulf of Ob

Novatek is expanding its LNG production in the Gulf of Ob with the construction of the Arctic LNG 2 production site, located on the Gydan Peninsula across the Gulf of Ob from the fully operational Yamal LNG.

The first stage is scheduled to be ready in 2023, the second in 2024, and full operational speed will be reached by 2026 when the facility is expected to produce 19.8 million tons of LNG. Three liquefaction trains of 6.6 million tons per year each, as well as a cumulative gas condensate production capacity of 1.6 million tons per year, are planned.

The project utilises an innovative concept with gravity-based structure platforms to reduce overall capital costs and minimise the project's environmental footprint.

Apart from Yamal LNG and Arctic LNG 2, there is a smaller production facility under construction, Ob LNG, which will produce 4 million tons of LNG.

The estimate is that a total of 20 to 24 new Arctic LNG vessels will be needed to transport the increased amount of LNG to the markets in Asia. Currently, there are 15 LNG carriers in use, based on Aker Arctic's previous concept design.

In the Arctic, there are yearly variations in the ice coverage and ice thickness. The past few years have been fairly easy, and although climate change is diminishing the overall ice cover, there are no guarantees that every year in the future will be as easy. Photo: Alfred-Wegener-Institute/ Michael Gutsche (CC-BY 4.0)

Tailored solution saves capital

In 2018, when Novatek announced that they wanted to explore year-round use of the NSR, Aker Arctic began to investigate how the first generation of LNG carriers could be improved in order to lower overall transportation costs. The calculations showed that a more cost-efficient vessel was indeed achievable.

A joint development project with Novatek was initiated, first with transit simulations for different vessel concepts, seeking the optimal solution for the new route and period of time, followed by design work for the improved vessel concept.

Icebreaking in narrow channel

"The idea from the start was to improve the vessel's efficiency in ice to reach increased transit speeds," says Mika Hovilainen, head of Aker Arctic's ship design. "As a result, fewer vessels are needed to transport the same amount of cargo, which means lower capital costs."

Currently, there are not enough icebreakers on the NSR to ensure safe transits in winter for the number of vessels envisaged on the route. Additionally, the icebreakers available are 34 metres wide.

"The hull form was therefore developed for independent operation in ice and particularly for efficient use in a narrow ice channel," Hovilainen explains. "The 47-metre-wide LNG carrier will be able to follow a 34-metre-wide icebreaker opening a narrow channel and breaking the ice on the channel sides to make it wider."

Hybrid propulsion suggested

Increased propulsion power was a second focus area. The most powerful solution in ice is a hybrid propulsion

The first generation design of Arctic LNG carriers is extremely capable in ice and can sail independently through 2.1-metre-thick ice. The fifteen carriers, built to date, can manage on the NSR from July to December, whereas the second generation will manage year-round with a high transit speed through ice. In January 2021, three of the existing vessels undertook a test voyage along the NSR without icebreaker escort.

solution with two azimuthing propulsion units flanking a shaft line in the middle. The shaft line can be equipped with a large propeller, which gives more thrust in water while improving fuel efficiency.

"A hull optimised for ice uses more fuel in open water. By using a hybrid propulsion solution, this can be compensated," says Hovilainen.

Azimuthing propulsion improves manoeuvrability and shaft line propulsion increases thrust. Combining the two would give the optimal cost-benefit on the NSR. However, in the final solution, three azimuthing propulsion units with boosted power were opted for by the ship owners, selecting a similar solution to the Yamal LNG carriers' design.

Risk of multi-year ice

The new carriers will use high transit speeds in narrow ice channels and consequently travel bow first. "This is the safest option when there is a risk of encountering multi-year ice," Hovilainen emphasises.

"From an engineering perspective, the safest and most economical route is through areas with one-year ice. However, ice is dynamic, and it is impossible to ensure that there is no multi-year ice mixed in. Multi-year ice means amplified rigorous strength requirements on the hull and propulsion, and we have thus also taken this risk into account in the design."

In the Arctic, there are yearly variations in the ice coverage and ice thickness. The past few years have been fairly easy, and although climate change is diminishing the overall ice cover, there are no guarantees that every year in the future will be as easy.

"Our aim was to design a vessel that can fulfil its task independently even in the worst winters," Hovilainen says.

High block coefficient

Compared to the previous generation LNG carrier, the size has been adjusted. The new vessel will be about 47 metres wide and almost 300 metres long. Nonetheless, the ice-optimised hull has a higher block coefficient, which means that the cargo capacity remains the same 170,000 m^3, despite the narrower hull.

Breadth is the most important parameter concerning ice resistance and efficiency.

"The narrower hull will allow an average speed of 10 to12 knots. With icebreaker assistance the speed can be increased a further 2 knots. On a 10-day trip this means turnaround speed is categorically higher. Or, if the same speed is used, fuel savings are achieved," Hovilainen underlines.

Final design verified with tests

After DSME, the world's most experienced builder of icebreaking LNG carriers, was chosen to construct the new vessels, naval architect Maximilian Vocke joined the project to finalise the concept in close cooperation with the shipyard.

"The hull form was slightly modified for the chosen propulsion, and CFD-calculations were performed for improved open-water capabilities," Vocke says. "The performance requirements are significantly superior to the previous generation of LNG carriers, so a 28-day ice model test series was undertaken to verify all operational capabilities before construction."

These included tests in deep water, shallow water, different types of ice, entering harbours, berthing, leaving harbours. The hull form also underwent open water tests at SSPA to confirm the open water targets for the project.

"Cooperation with DSME was, once again, intense and fruitful and we managed to finalise a vessel which fulfils all the rigorous requirements," Vocke highlights. ■

New energy-efficient icebreaker for the Baltic Sea

Seven weeks of ice model tests were conducted at the beginning of 2021 to evaluate the concept designs.

The Swedish Maritime Administration and the Finnish Transport Infrastructure Agency launched a joint project with Aker Arctic last year, aiming to develop an icebreaker concept with lower environmental impact for the Baltic Sea, as well as an ability to escort wider ships.

The size of merchant vessels entering the Finnish and Swedish ports is growing. At the same time, more stringent environmental requirements gradually limit the engine power of the ships. These combined factors weaken the vessels' ability to navigate through ice. The next generation of icebreakers will hence have to be able to break a channel as wide as 32 metres to more effectively assist the future merchant fleet.

"For the Baltic Sea, this is an entirely new size of icebreaker," says Project Manager Maximilian Vocke. "Current icebreakers break channels with a width of around 25 metres."

Fossil-free fuel

As winters are getting warmer, the ice moves around more, increasing the amount of pack ice and ridges in the Bay of Bothnia. Therefore, the new icebreaker will also be efficient for tackling these demanding conditions.

The biggest challenge in the design work is the requirement for lower environmental impact. Compared to the Atle/ Urho-class, which it is replacing, the greenhouse gas emissions should be reduced by 70%, and the icebreaker has to be able to use at least one fossil-free fuel.

The Atle/ Urho-class icebreakers have successfully kept sea channels and Baltic ports open for merchant vessels during winters for more than fifty years. They are now nearing the end of their operational lifetime.

"To reach this goal calls for innovations, some of which we don't even know yet," Vocke underlines.

In-depth analysis before selection

The project advances in two phases, of which the first is now almost concluded.

The Swedish Maritime Administration prepared four different propulsion concepts that Aker Arctic then evaluated. These included an in-depth feasibility study, identification of applicable regulations, class notations and completion of a number of studies.

Aker Arctic prepared a concept design for all propulsion concepts to evaluate the technical feasibility of each solution. Three of the four concepts were tested in model

scale in ice at Aker Arctic's own ice basin in Finland, and in open water at SSPA in Sweden. Based on these results and other calculations, Aker Arctic carries out lifetime cycle cost (LCC) and life cycle assessment (LCA) analyses, evaluating construction and lifetime costs, as well as environmental impact.

"Once the final concept is chosen, we will continue to develop the design, including the tender specification, which will be used for construction proposals from shipyards. This will include further technical development and verifying model tests with the chosen design," Vocke explains.

Joint development project

Tender requests for the new icebreakers will likely go out to shipyards later this year and construction contracts are aimed for 2022, although no decisions on construction have yet been made. The current Swedish icebreakers are approaching the end of their operational lifetime, as well as some of the Finnish fleet, and need replacing soon.

The Finnish Transport Infrastructure Agency partnered the Swedish Maritime Administration in the development work in March 2020.

Finland and Sweden have cooperated in icebreaker acquisitions before with successful results. In the 1970s, when the Atle/ Urho-class was developed, the two countries engaged in a similar collaboration.

Four propulsion concepts

The in-depth studies comprised four different propulsion concepts, three of which were tested in Aker Arctic's ice model basin over seven weeks:

1. A reference vessel, a 32-metre-beam icebreaker, equipped with two forward straight shafts and two aft straight shafts with rudders, similar to the Atle/ Urho-class.

2. An icebreaker equipped with two straight shafts forward and two straight shafts aft with rudders as in #1, but with the 32 m channel width to be created by other means.

3. An icebreaker equipped with one azimuth propulsion unit forward and two azimuth propulsion units aft. This is the same propulsion concept as the latest Finnish icebreaker *Polaris*.

4. An icebreaker equipped with two straight shafts forward and two azimuthing propulsion units aft, combining the propulsion solutions from #2 and #3.

Inventions to reduce emissions

To reach the goal of reduced emissions, new technologies will need to be implemented.

"These can include new hull forms, engine technology, and emission treatment systems, to mention a few possibilities," Vocke says.

Additionally, Sweden has a target of fossil-free shipping by 2030. The demand is that the icebreaker will use fossil-free fuel by then. This technology is only in development stages right now. LNG, which the Finnish icebreaker *Polaris* uses, is not fossil-free, although emissions are lower than those of marine diesel oil, and therefore other options are needed.

"Alternative fuel engines are being developed and we are in close dialogue with engine manufacturers. For instance, hydrogen, ammonia or methanol are being investigated in addition to super capacitors and battery technology," Vocke explains.

New engine technology

The new icebreaker will be designed with the new engine technology integrated so that it can take fossil-free fuel into use either directly, when it is available, or following a retro-fit.

Energy density in different fuels vary substantially, which affects the size of fuel tanks. This also has to be taken into account already in the design stage.

"For example, methanol requires almost triple the tank size compared to marine diesel oil. If the operational endurance is required to be the same, the larger tank sizes have to be included in the design already from the beginning. Alternatively, the autonomy time is cut shorter," says Vocke.

Innovating totally new concepts and solutions is one of Aker Arctic's strengths and trademarks.

"This project is definitely an intriguing challenge, where we are looking well into the future and inventing new ways to do things." ■

Finland's newest icebreaker Polaris was delivered in 2016 and incorporated the latest technologies available for lowering emissions. The new icebreaker being planned will go even further with a fossil-free target by 2030.

Icebreaking keeps the Great Lakes open in winter

The Great Lakes are the heart of American industry, bringing jobs not only to the region but also to the nation. This vital marine transportation system is relying on icebreaking to keep the waterways open and commerce moving.
Photo: Icy Lake Michigan shoreline, Grand Haven, February 1, 2011, R. Greaves. (CC-BY-2.0)

The Great Lakes, the vast freshwater lake area on the border between Canada and the United States, provide transportation systems along a contiguous body of water that is a vital artery to the economies of both countries. From approximately mid-December to mid-April, the waters are susceptible to freezing and ice impedes navigation, requiring icebreakers to keep waterways open

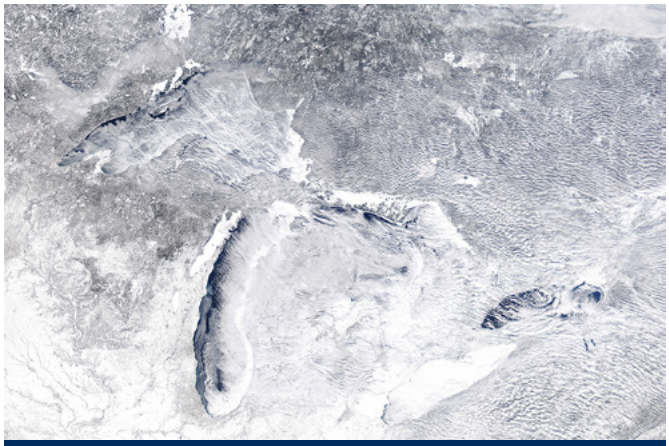
The Great Lakes waterways support 1.3 million jobs and $82 billion (USD) in annual wages, according to a recent report from Michigan Sea Grant. The area has been called the growth engine of North America. The lakes hold 21% of the world's surface freshwater and serve as a source of drinking water for more than 30 million citizens in the U.S. and Canada.

The five freshwater lakes are connected by a series of rivers or locks to allow for trade throughout the whole lake region. It supports not only a critical economic highway of agriculture, industrial and manufacturing goods, but also a multi-billion dollar outdoor recreation and tourism industry

Ice coverage varies every winter

The annual ice coverage depends on the severity of the winter. Over the past 42 years, the Great Lakes annual maximum ice coverage has been as much as 94.7 percent and as little as 9.5 percent.

During a typical winter, the Great Lakes icebreaking program extends the navigation season by 4 months, ensuring the continued flow of maritime commerce.



The annual ice coverage depends on the severity of the winter. Over the past 42 years, the Great Lakes annual maximum ice coverage has been as much as 94.7 percent and as little as 9.5 percent.
Photo: MODIS Image of ice cover on the Great Lakes, NOAA Great Lakes CoastWatch.

Keeping routes open

The United States Coast Guard (USCG) is responsible for icebreaking operations on the Great Lakes in cooperation with the Canadian Coast Guard (CCG), keeping certain shipping routes and ports open during the parts of winter when they otherwise would be impassable by commercial vessels. It responds to vessel requests for assistance when they are disabled or are stranded in ice-covered waters. The USCG, in coordination with the U.S. Army Corps of Engineers, also breaks ice to control flooding caused by ice jams during the spring thaw.

The current USCG icebreaking fleet in the area consists of nine vessels: the heavy Great Lakes icebreaker USC-

GC *Mackinaw*, two smaller buoy tenders USCGC *Alder* and USCGC *Hollyhock*, and six Bay-class icebreaking tugboats.

The annual icebreaking operation, referred to as Operation Taconite, is the USCG's largest domestic icebreaking operation and encompasses Lake Superior, Lake Michigan, the St. Mary's River, the Straits of Mackinac and Georgian Bay.

Wide area to cover

Lake freighters, ships transporting cargo within the Great Lakes, are famously long-lived; the oldest "lakers" date back to the 1940s. Like the ships they assist, the Great Lakes icebreaking fleet also has a significantly longer lifespan, as the freshwater is much kinder to hulls compared to saline sea water.

"For example, the 2006-built USCGC *Mackinaw* replaced a 1944-built icebreaker of the same name," says Naval Architect Aaron Tam. "The 140-foot icebreaking tugboats built in the late 1970s and 1980s are expected to remain in service until the 2030s."

Despite its long experience of difficult winters, the USCG fleet still faces challenges during its operational season in this extensive area covering 1500 miles of open lake, connecting waterways and rivers. Therefore, the winter navigation system is currently being reviewed in order to increase icebreaking capacity and support the 90 million tons of cargo shipped annually on the Great Lakes. One new heavy Great Lakes icebreaker is planned for now, as well as a revision of other capacities.

Expert in icebreaking

The Finnish company Aker Arctic Technology participated in the design of the Coast Guard's newest Great Lakes icebreaker USCGC *Mackinaw*, delivered in 2006. Since then, technological advancements and environmental issues have grown apace. As an established expert in providing advanced icebreaking technology, Aker Arctic offers the Coast Guard a fast track solution to fulfilling its need for increased modern icebreaking capacity where environment considerations are also to the fore.

Finland is located by the Baltic Sea, an area with many similarities to the Great Lakes area. The efficient winter navigation system in place includes icebreakers of various sizes, many of them designed by Aker Arctic, keeping ports open and assisting vessels during the winter season December to May. The most recent one is the first LNG-fuelled, agile icebreaker *Polaris* delivered in 2016.

Always tailored to needs

"We have a fifty-year-long history of designing icebreakers, all of which are tailored to a specific purpose and area," says sales manager Jukka Salminen.

Photo courtesy of USCG.

USCGC Mackinaw

Aker Arctic Technology Inc together with Kvaerner Masa-Marine (today Vard Marine) developed the concept for the current Great Lakes heavy icebreaker, USCGC *Mackinaw*, together with the United States Coast Guard. The vessel was delivered in 2006 and features twin Azipod propulsion with a double-acting hull capable of breaking ice in both ahead and astern directions.

Length: 73 m | Beam: 17.8 m | Draught: 4.9 m

Polaris – the first LNG-fuelled icebreaker

The Finnish icebreaker *Polaris* was delivered in 2016 and designed for icebreaking and assisting commercial vessels in the Baltic Sea ports. To combat climate change and pollution, she was the first icebreaker in the world to use LNG as fuel and does not discharge any waste or grey water into the sea, not even shower water.

Everything is transported to the shore every ten days when she is on duty. Polaris has an advanced oil spill response system and features a triple azimuth propulsion solution. The captain has praised her agility and says dislodging vessels stuck in ice is fast and efficient. Her turning ratio is 1, meaning she can make a circle her own length.

Length: 110 m | Beam: 24 m | Draught: 8/9 m

"Highly innovative concepts such as the oblique icebreaker concept, where the icebreaker can break ice forwards and sideways when a larger channel is needed, and the technically advanced port icebreaker *Ob*, delivered last year for harbour assistance in the Arctic, are other medium-sized signature concepts we have designed recently."

Aker Arctic not only designs icebreakers, but also supports the shipyards constructing them in all matters regarding ice strengthening and icebreaking when needed. The in-house ice model testing laboratory is used to verify designs and icebreaking capability before construction begins.

Technology has advanced

The heavy Great Lakes icebreaker USCGC *Mackinaw* still has a life-span of 30 years. While the old concept could easily be duplicated, technology has evolved in 15 years and there are many new features a modern icebreaker should encompass today.

"In an environmentally critical area such as the Great Lakes, alternative fuels could be considered in addition to hybrid solutions and battery packs allowing zero emissions in ports, for instance," Salminen adds.

Aker Arctic is presently developing next-generation icebreakers for Sweden and Finland. In addition to striving for unprecedented overall energy efficiency using the latest available technologies and being ready for fossil-free operation by 2030, the new icebreakers will be designed to escort larger merchant ships than their predecessors. Many of the recent learnings and developments could be applicable in the new Great Lakes icebreaker.

A recent article in the National Geographic magazine cited pollution and climate change as great risks for the lakes area. Compared to other means of transportation, shipping is an efficient and sustainable method. It is the most economical way to transport and has the lowest emissions per tonne. With modern technology, impacts on the environment can be lowered even further.

Glen Haven Beach ice caves.
Photo: US National Park Service (CC-BY-2.0)

Economic gains from icebreaking

According to a study commissioned by the Lake Carrier's Association, businesses that depend upon the Great Lakes maritime industry lost over USD 1 billion in revenues during the 2018-2019 ice-season because of delays in icebreaking. These economic losses resulted in the loss of over 5000 jobs throughout the Great Lakes region.

"Looking at the trade results, there is a clear correlation between difficult winters and the amount of cargo traded. In a year with a difficult winter, like 2019 that shipped 84 million tons, there was a reduction of about 5.5% in the year's total potentially traded cargo," adds Tam.

In the case of the recent 2018/19 season, over 4 million tons of iron and almost 900 thousand tons of coal was unable to be traded due to the difficult winter. The industry cited delays from icebreaking assistance and convoy formations, as well as ice damage to vessels and inadequate broken ice tracks.

"The benefit to the economy of an improved winter navigation system is obvious, the sooner the better," Salminen underlines.

Baltika – the world's first sideways-moving icebreaker

The oblique icebreaker *Baltika* was designed to operate in the Baltic Sea, especially for assisting large vessels in icy harbours, but has since shown that she can break ice successfully also in the Arctic. Her asymmetric hull form means she can break ice conventionally moving forwards, but when a wider channel is needed, she can turn up to 85° sideways to break ice. The angle is not pre-set and can be selected according to needs. Rubble clearing, manoeuvring and ice management performance is also excellent, and she is equipped with an oil spill response system. Compared to conventional icebreakers, Baltika can carry out the same operations with only half the propulsion power, thus saving fuel and reducing emissions.

Length: 76.4 m | Beam: 20.5 m | Draught: 6.3 m

Photo: Dmitri Lobusov

Ob – the most advanced port icebreaker in the world

Our newest port icebreaker design, *Ob*, was designed for assisting very large LNG carriers in the Arctic harbour of Sabetta. She can break 1.5-metre-thick level ice in both ahead and astern directions and the quad-screw propulsion configuration provides superior manoeuvrability and control when operating in close proximity to vessels. She is powered by the world's most efficient four-stroke diesel engine and features a DC grid to further improve efficiency and reduce fuel consumption.

Length: 89.2 m | Beam: 21.9 m | Draught: 6.5/7.5 m

Shallow icebreaking tug Mangystau

The Mangystau series of five shallow icebreaking tugs was designed in 2009 – 2010. Since delivery, the tugs have been working at the Kashagan oil field supporting the oil drilling platforms in the north Caspian Sea. The tugs are used for towing and pushing barges as well as ice management operations in astern working mode in ice rubbles reaching the sea floor.

Length: 66 m | Beam: 16.4 m | Draught: 3 m

Photo: Ilari Rainio/ Finnish Transport Infrastructure Agency

Innovative self-propelled detachable icebreaking bow

A totally new concept of a detachable icebreaking bow, which is self-propelled and connected to a tugboat during the winter season, has been taken into use in Lake Saimaa, Finland's largest freshwater lake, and the Saimaa Canal. The lake has a number of industries located on its wide shores and the canal connects the lake district with the Gulf of Finland. It is a vital transport channel for exports and imports of goods. The detachable bow brings more efficient icebreaking and ice management operations to the area. The concept was developed by ILS Oy for the Finnish Transport Infrastructure Agency. Aker Arctic designed and delivered the two shaft lines and propellers for the bow, two bronze propellers for the tug and the Ice Load Monitoring System, which can be supervised remotely, as well as performing the ice model tests to verify the design before construction.

Length: 25.3 m | Beam: 12.6 m

Aker Arctic Technology

Shipyards in Finland have built the majority of the world's icebreakers during the past 70 years. This development has created long term know-how and a successful industry around icebreaking ships.

In 2005, the development and design activities were separated from the yards to the newly established company Aker Arctic Technology. On-going projects and ship design engineers were transferred to their own facility in Vuosaari, Helsinki. Since then, numerous new icebreakers and icebreaking ships have been developed, designed and built by various shipyards.

Aker Arctic Technology is today known all over the world for its innovative, high quality solutions in icebreaking and ice management. All designs are verified with model tests before construction, with most undergoing full-scale tests after delivery.

Introducing an icebreaking Arctic container ship

Aker Arctic has designed an 8000 TEU container ship for independent use in both summer and winter along the Northern Sea Route (NSR).

Aker Arctic has developed a completely new concept for the Northern Sea Route, an icebreaking Arctic container ship, which can be used year-round to cover the much shorter distance between Asia and Europe.

Using the experience gained from the breakthrough Arc7 LNG carriers, which have now successfully transported liquefied natural gas from Sabetta for more than three years, and the new Arctic LNG carrier design for independent year-round operation in the Arctic, Aker Arctic designed an 8000 TEU container ship for independent use in both summer and winter along the Northern Sea Route (NSR).

"No such type of container ship has been available before," says Luigi Portunato, Naval Architect at Aker Arctic.

Double-acting containership

Besides an ice-strengthened hull, an icebreaking bow and winterisation features, there are other specialities incorporated in the design which sets the vessel apart.

"The vessel comes with two optional designs: either using our Double Acting Ship (DAS™) technology with a hybrid propulsion solution of one shaftline with propeller in the centre and two azimuthing propulsion units on the sides, or a design with two conventional shaftlines and rudders," Portunato explains.

The double-acting ship can manage independently on the NSR year-round by turning stern-first in heavy ice, whereas the shaftline version will need the assistance of an icebreaker during extreme winter conditions, as it has lower icebreaking capabilities.

Secondary steering position

In other double acting ships, the deckhouse is usually located in the stern and it is possible to navigate backwards from the bridge. In a container vessel, this is not practical as the area is needed for containers, and the deckhouse is usually positioned in a midship location.

"Therefore, in this case, we have positioned a special aft wheelhouse at the aft mooring deck for navigating stern first," says Portunato.

The machinery is separated from the accommodation and wheelhouse. Because of the freezing temperatures in the Arctic winter, a covered passageway has been arranged under the deck instead of the usual transfer path along the deck.

Profitability explored

In the economic study, prior to beginning the vessel design, three possible options were explored and compared in terms of profitability:

1. A normal open water vessel using the Suez Canal; the only route currently available for container shipping.
2. A new Arctic container vessel for shipments between Asian and European ports.
3. A new Arctic containership used only on the icy parts of the NSR, with two new reloading hubs at either end for further transportation of containers, one in Murmansk and another in Kamchatka.

The results showed the obvious: the unit cost per TEU decreases when the size of the vessel increases for all options. Although the drop was more significant for the Arctic alternatives, it is, however, difficult to establish the exact point when either of the two Northern Sea Route options becomes more profitable than the Suez Canal route, as there are many factors influencing the costs, such as fuel price, type of fuel and filling ratio of the container ship.

"In the current market situation, transportation with the independent Arctic container ship is slightly more costly than with a Suez Canal open water vessel," Portunato says. "Yet, using LNG as fuel would be

more profitable, and is additionally available in the area. The new Arctic containership design with hybrid propulsion can also manage on its own without icebreaker assistance, which further lowers the cost. The smaller size, 8000 TEU, is additionally more flexible in terms of cargo compared to open water container ships."

Reloading adds time

The currently-used Suez Canal option has the economic advantage of allowing big vessels carrying up to 20,000 TEU of cargo, which would be too large for the NSR. There are also many ports along the way, allowing cargo to be added when the ship is not full.

"The third option we investigated is also economically feasible, but comes with the drawback of reloading which is time-consuming. Additionally, the entire route is in Russian waters along with the envisaged transshipment hubs, hence it would most likely have to be a Russian internal ship unless cabotage is allowed."

Schedules are essential

Shipping with containers is a different market from other shipments. The advantage with containers is that they are of standard size and model, making them easy to use in worldwide shipping. For optimal business profitability, a large flow of goods, fully-loaded ships and a fast turnaround is best. The traffic also has to be steady as the schedule is fixed for all players.

"Therefore, the much shorter northern distance becomes interesting if a decent speed can be achieved in winter and schedules can be relied on, which is now possible with our new design," Portunato highlights. "Summer traffic speed and timetable reliability is not a problem."

The environmental impact of growing traffic on the NSR has raised concerns, as the Arctic area is fragile. However, looking at the overall picture; the much shorter voyage requires less fuel and creates fewer emissions, especially as cleaner fuel options can be utilised.

Freezing challenges

Although the Arctic containership concept design is ready, there are still certain questions which have to evaluated.

"We need to investigate if there are any types of cargo which cannot be transported in cold winter conditions. Heated containers or coverage inside or outside the containers could be solutions," Portunato ponders.

"However, refrigerated containers are commonly used, so inventing other types of special containers should not pose a problem."

Previous reference concepts

Aker Arctic has, over the years, designed a wide range of different icebreakers and cargo vessels. The closest existing concept would be the first double-acting cargo vessels designed for Norilsk Nickel in 2006, although they are half the length of the new Arctic containership and used for general cargo. The container cargo capacity is 648 TEU as opposed to the new 8000-TEU design.

The module carriers built for transporting construction modules to Sabetta harbour were the first Arc7 carriers for the NSR, but they were not intended for regular traffic.

"The most similar vessel in terms of size is the Arc7 LNG carrier design used for the *Christophe de Margerie* and its sister ships. The Arctic container ship will also incorporate design ideas and solutions from the soon to be built, advanced Arctic LNG 2 concept," Portunato adds.

Technical details:

- Container capacity 8000 TEU
- Length over all 300 m
- Breadth 46 m
- Draught 13 m

Installed propulsion power

- A version 56 MW (1x22 MW shaftline, 2x17 MW thrusters)
- B version 44 MW (2 x 22 MW shaftlines)

Icebreaking capability, level ice performances ahead (3 knots)

- A version 2.3 m
- B version 1.9 m

Ice class RMRS Arc7

Meet Luigi Portunato

Luigi originally comes from Genova in Italy, where his family still lives. He finished his Bachelor of Science degree in his hometown and then pursued his Master of Science at TU Delft in the Netherlands, becoming increasingly interested in Arctic shipping and offshore operations. He took Arctic courses at the University Centre in Svalbard and wrote his Master's thesis on the concept design of a drifting research vessel. He applied for an open position at Aker Arctic and moved to Finland 18 months ago, a decision he has not regretted.

Luigi likes the cold and snow and enjoys the nature in Finland. The past year was not the best time to explore the country, but he has, nevertheless, managed to indulge in his favourite pastimes of hiking, mountain biking and being outdoors. ■

Arctic semi-submersible transport vessel developed

Two new Arctic semi-submersible heavy transport vessel concepts of ice classes Arc5 and Arc7 have been developed recently. They are designed to operate independently or with icebreaker assistance. Bow form, stability, propulsion options and dual-fuelling have been part of the research.

Aker Arctic conducted the feasibility study in co-operation with JSC Atomenergo and developed the Arc5 and Arc7 ice classed Arctic semi-submersible heavy transport vessel (SSHTV) concept designs for JSC Atomenergomash (AEM).

Focus on bow geometry

The Arc5 SSHTV is designed to operate independently in open floating first-year ice and with icebreaker escort in more challenging ice conditions.

The bow geometry incorporates Aker Arctic's latest research and development work related to escorting large vessels with icebreakers that have a smaller beam than the following cargo ship. This allows efficient escort operations, not only with the huge LK-120 type (Project 10510 "Leader"), but also with the big LK-60 type (Project 22220) icebreakers that will be built in greater numbers.

Arc7 independent operations

The Arc7 SSHTV is designed to operate independently in challenging ice conditions including up to 1.4 m-thick close floating first-year ice (essentially unbroken level ice) without icebreaker escort. For this purpose, the second concept features a flared icebreaking bow which incorporates operational experience from the existing heavy transport vessels *Audax* and *Pugnax*, designed earlier by Aker Arctic.

Both Arc5 and Arc7 SSHTVs represent the contemporary type with a raised forecastle, open aft cargo deck, and detachable buoyancy casings. The removable buoyancy casings increase the vessels' flexibility and allow the transporting of modular cargo without submerging the SSHTV for loading and unloading.

Propulsion options

While the feasibility study showed that both shaft line and azimuthing propulsion are suitable for both vessel concepts, the Arc5 SSHTV was developed with twin shaft lines and rudders while the Arc7 SSHTV features two azimuthing propulsion units.

In both cases, the propulsion system is diesel-electric with the power plant located in the forward part of the vessel. Additional transverse thrusters are fitted to provide IMO Class 2-level dynamic positioning capability.

Ballast water arrangement

During the development of the concepts, significant effort was put into developing a ballast water tank arrangement. In addition to providing the ability to submerge the vessel to the desired depth, the ballast water system must be capable of maintaining the vessel on an even keel with no heel in all intermediate and final floating positions, as well as provide sufficient stability during cargo loading and unloading operations.

Both SSHTVs are designed to operate in cold ambient temperatures.

Tank heating is not necessary, but the energy need must be minimized when the vessel is transiting in ballast.

Ensuring stability

One of the principal challenges in the development of SSHTV designs is to ensure sufficient stability during cargo loading and unloading operations. The critical phase of such operation is the moment when the cargo deck submerges into or emerges from the water, resulting in a sudden significant change in a vessel's waterplane geometry and stability characteristics.

"In order to evaluate the extent of the stability challenge, we investigated several types of theoretical cargo geometries. The analysis gave an insight into cargo handling limits and defined the maximum allowed vertical centre of gravity above cargo deck as a function of cargo weight and dimensions," says Head of Ship Design Mika Hovilainen.

Dual-fuel is possible

The feasibility of using a dual-fuel power plant in the SSHTV was also evaluated.

Liquefied natural gas (LNG) has a number of advantages over traditional marine fuels such as heavy fuel oil and marine diesel oil. In addition to lower emissions and reduced risk to the environment, LNG is produced locally and therefore ready-to-use in the Russian Arctic.

It was found that in a semi-submersible vessel the only technically feasible location for the LNG fuel tank would be above the maximum submerged waterline where the low-density liquid would not require additional ballast to offset its buoyancy. Alternative locations were also considered with the conclusion that both designs can be modified to use LNG as primary fuel. The vessels may become the world's first LNG powered semi-submersible transport vessels.

Operations in the Arctic

"Through the feasibility study, we identified the major challenges and potential issues related to adapting this specialized ship type for operation in ice-covered waters," says Naval Architect Tuomas Romu.

The study concluded with proposing technical solutions for future successful construction and operation of semi-submersible heavy transport vessels in the Arctic, as well as identifying issues that should be investigated in further development stages to ensure safe operation in extreme conditions.

"The design of the Arctic SSHTV is unique and it was a challenging project, especially considering the dual-fuel concept. However, these kinds of innovative projects are Aker Arctic's specialty, and with the accumulated competence and experience, we are happy to solve challenges and help our clients," says Project Manager Alexey Dudal.

Transportation vessels are needed

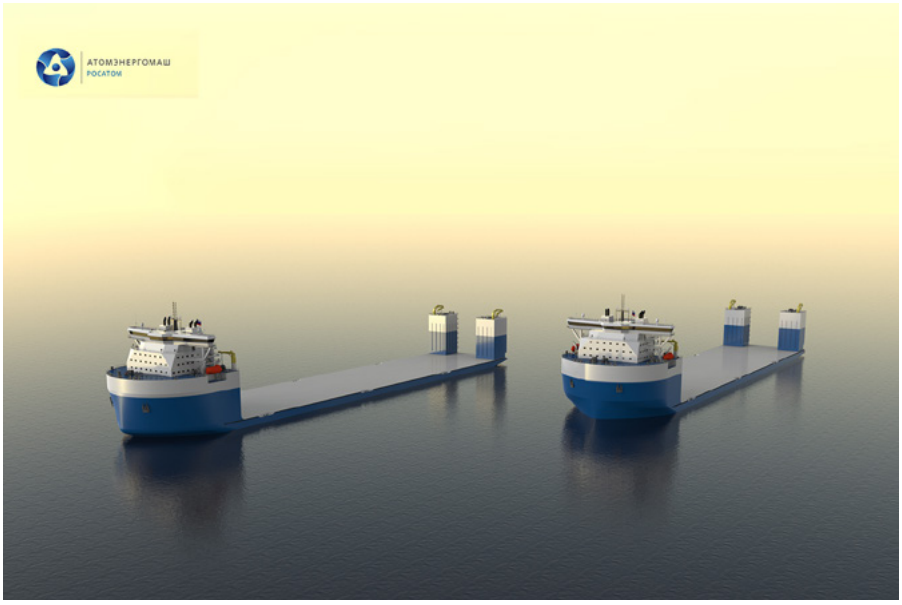
Steady development of hydrocarbon production in the Russian Arctic and active new projects in the Arctic demand vessels for the transportation of heavy modules and other oversized cargo. Presently, there is not a single Russian shipping company operating heavy transportation vessels, thus creating significant risks for proper project execution.

JSC Atomenergomash (AEM) had the task to develop a new cutting-edge Arctic semi-submersible heavy transport vessel (SSHTV) featuring the latest technologies, and decided to work with Aker Arctic to complete it.

"We expect that the new vessel will be built in Russia and operated under the Russian flag to ensure transportation of heavy cargo, including new floating power plants developed by Energy Corporation Rosatom," states Kirill Selyutin, Head of Shipbuilding and Marine Technics Department at JSC Atomenergomash. ■

Technical details:

- Length overall: 254.4 m
- Beam: 49.6 m
- Design draught: 10.5 m (Arc5)/12.0 m (Arc7)
- Design deadweight: 70,000 tonnes
- Cargo deck: length 200 m; maximum submersion 14 m



Simulation tool assists in environmental decisions

IMO's control measures aim to gradually reduce ships' fuel oil consumption and carbon dioxide emissions. Lower carbon intensity is the target by reducing CO_2 transportation emissions. Finnish icebreaker Polaris uses liquefied natural gas as fuel, with lower emissions as a result. Photo: Catarina Stewen

Environmental concerns guide investments and hence new solutions appear at a fast pace. A simulation tool to calculate and compare overall energy efficiency can help to make the right decisions.

In 2018, the International Maritime Organisation (IMO) adopted a strategy to reduce greenhouse gas emissions from shipping. The strategy included a roadmap with possible short term, mid-term and long-term measures to support its strategy towards a less carbon-intensive shipping sector.

In November 2020, IMO approved some amendments to its control measures, including an earlier starting date of the Energy Efficiency Design Index (EEDI) Phase 3. Draft changes have also introduced further control means to lower greenhouse gas emissions from ships, such as the Energy Efficiency Existing Ships Index (EEXI), which includes equivalent requirements as for EEDI, but will apply to existing built vessels.

Pressure on icebreaking vessels

IMO's control measures aim to gradually reduce ships' fuel oil consumption and carbon dioxide emissions. Lower carbon intensity is the target by reducing CO_2 transportation emissions.

IMO's energy efficiency requirements are not, however, focused on icebreaking vessels, and EEDI requirements are not applicable for Polar Code Category A ships. Icebreaking vessels generally have to be powerful to perform in ice in order to ensure safe and reliable icebreaker assistance for commercial vessels. Also, it would be difficult to set a baseline to enable gradual reduction of greenhouse gas emissions.

Nevertheless, even if IMO control measures do not have a direct impact on icebreaking vessels in general, there will likely be indirect influences and also general pressure to reduce greenhouse gas emissions. Operators may have their own climate strategies and different countries may have high ambitions and national goals to cut greenhouse gas emissions.

Variety of fuels

IMO is also likely to introduce requirements that will lead to the adoption of less carbon intensive fuels, at least in the mid-term. Additionally, there are a lot of ongoing developments regarding the use of alternative fuels.

These, together with current advancements in engine technology, will probably result in an increased variety of available fuels in the future.

Energy efficiency calculations

Aker Arctic is following these developments closely, as well as innovating new energy-efficient solutions in icebreaking ships for clients. For that purpose, a simulation tool is needed which can be used to study different energy efficiency solutions. Various energy saving, energy storage and energy recovery systems can then be studied for specific operations.

"The tool is a simulation model consisting of expandable equipment blocks and system parts based on a set

operational profile," says Esa Hakanen, Lead Engineer, Machinery Systems. "The input operational profile can be either generic, more accurate and dynamic, or even based on full-scale measurements from real operations of a reference vessel."

Comparing emissions

The tool will be highly useful when studying the feasibility and simultaneous operation of different systems contributing to energy consumption in changing operational profiles and conditions.

"Various fuels, their characteristics, and their emission factors can be studied. They can then be compared for use in specific conditions and specific operations," Hakanen continues.

The luxury icebreaking cruise vessel Le Commandant Charcot, designed for cruise company Ponant, is an LNG-electric hybrid fulfilling clean ship requirements. Photo: Sasha Lalane/ Ponant

Recent study

A recent study investigated how to reduce emissions from vessels used in Arctic rivers. The conclusion was that one ship design is not necessarily applicable to all rivers, as each river has its own characteristics.

"Each river has to be studied individually and every vessel has to be designed fit for purpose. The infrastructure in place; ice, environmental and port conditions; distances in open water and distances in ice; the ice period; what type of fuel is available in the area. All these factors must be taken into account," says Alexey Dudal.

The study also included investigating the possibility of using an energy storage (battery) system.

"A comprehensive understanding of a ship's operational profile is required to determine if a battery system is feasible or not, both from economic and environmental perspectives. Boundary conditions, such as when it is practical to charge batteries and when power may be utilized has to be known," says Hakanen.

Emissions as a whole

Different technologies such as liquefied natural gas as fuel, catalytic reduction system (SCR), usage of diesel particulate filter (DPF) to reduce particulate matter (PM), and black carbon (BC) emissions were additionally studied.

"Emissions should be considered as a whole. There is no point in focusing on only reducing one thing, as it might increase something else," Hakanen highlights. ■

Meet Esa Hakanen

Esa works as Lead Engineer for Machinery Systems, mainly as discipline leader in various ship projects.

He is a mechanical engineer and joined Aker Arctic 15 years ago, having previously worked at Helsinki Shipyard in the machinery design department.

Examples of recent projects in which Esa was responsible for the machinery and HVAC design are: icebreaker *Ob*, icebreaker *Polaris*, icebreakers *Aleksandr Sannikov* and *Andrey Vilkitsky*, and polar icebreaking research vessel *Xue Long 2*. ■

Predicting the safest route through ice

When moving in ice areas, it is hard to predict an exact arrival time as ice is dynamic and changes from day to day. The Tactical Ice Navigation Tool (TINT) combines real-time ice charts with ice performance calculations to predict the safest and most economical route for the ship to reach its destination.

The shortest route is rarely the fastest or most economical when moving in ice-covered waters. Aker Arctic has developed a prediction tool in cooperation with the Finnish Meteorological Institute and the European Space Agency to optimise ship-specific routes through varying ice conditions.

Route predicting tools are widely available, showing the shortest route to a destination. However, in ice conditions, the shortest route is usually not the safest, as ice is dynamic and conditions vary from day to day. Additionally, every vessel has its own ice capabilities which allow it to move in areas it is designed for but limits others.

Optimised route planning

In every ship project, Aker Arctic performs ice performance calculations and can predict what kind of conditions a vessel can manage in safely. These studies can now be combined with real-time ice charts from the Finnish Meteorological Institute (FMI) to give a vessel its own optimal route, speed and arrival time on any chosen day.

"The route prediction tool we have developed is completely automated, and can be updated as frequently as required," Project Manager Jukka Salminen explains. "Network transfers in high latitudes utilise satellite connections, so the amount of data has to be compact."

"The benefit for the ship operator is to reduce the likelihood of their vessel becoming trapped in ice and having to wait for icebreaker assistance; instead, the crew can choose a route which is suitable for their vessel's own capabilities. It can keep to its schedule, ensure safety for the people onboard, avoid accidents and environmental hazards, while saving on fuel and decreasing emissions," he adds.

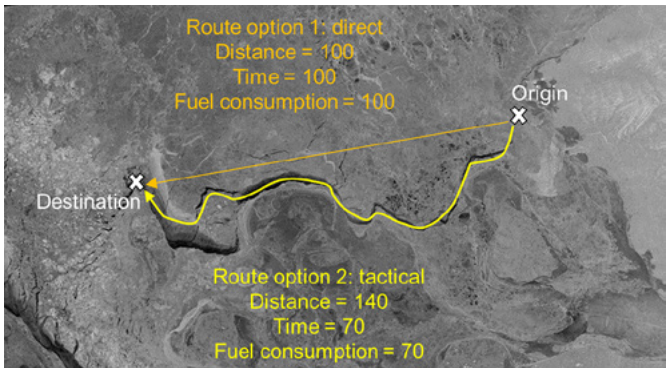
Test installation

The Tactical Ice Navigation Tool (TINT) is currently ready for test use. In order to proceed, Aker Arctic is looking for a vessel owner who would be interested in installing it onboard to test stability, user interface and data transfer. This would allow more detailed calculations on, e.g., saved time and fuel, as well as gaining valuable user feedback.

Ice performance analyses can be made for any vessel, not only Aker Arctic designed ones, so there are no limitations on what kind of vessels can use the tool.

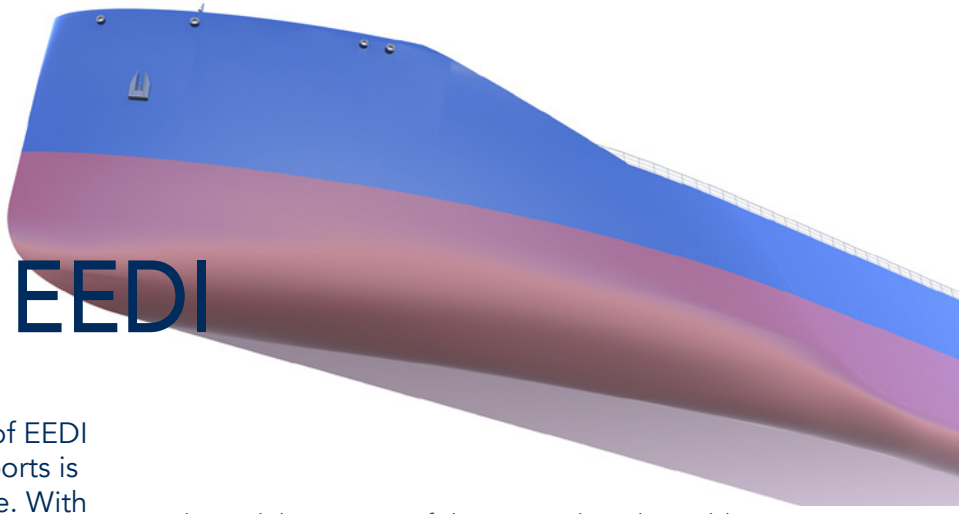
"With traffic in Polar areas continuing to increase, we believe there is an urgent need for a real-time ice prediction tool which is tailored for each specific vessel, including special features such as iceberg-spotting guidance or ice alerts," Salminen says.

The Tactical Ice Navigation Tool (TINT) has been jointly developed by the European Space Agency, the Finnish Meteorological Institute and Aker Arctic. ■



Aker Arctic, The Finnish Meteorological Institute and the European Space Agency have developed a service that optimises ship-specific routes through varying ice conditions thus enabling reduced fuel costs, reduced emissions and increased safety.

More ships comply with EEDI



A recent study shows that the number of EEDI vessels calling at Finnish and Swedish ports is still small but keeps growing all the time. With low power-to-deadweight ratios and upright bow forms, they are more likely to require icebreaker assistance in ice.

Development engineer Teemu Heinonen at Aker Arctic has continued to research how new vessels built according to the Energy Efficiency Design Index (EEDI), introduced by the International Maritime Organisation (IMO), can manage in ice conditions in the Baltic Sea. The results confirm the findings of his previous research project that he finished two years ago (see Arctic Passion News, issue 18).

This time, the research project was divided into two parts:

Part 1: Continue the previous research project regarding the need for icebreaker assistance, conducted for winters 2016 to 2018, to confirm the results over a longer period. The newly-investigated time comprised winters 2019 and 2020.

Part 2: Compare ship particulars between ice-classed EEDI vessels and older vessels built before EEDI regulations. The project would then investigate design trends in new vessels which could affect the need for icebreaker assistance.

30% needed assistance

All vessels were divided into four categories, as in the previous study: new ships designed and built to meet EEDI requirements applicable to them; older ships that predate EEDI but nonetheless meet the requirements; older ships that do not meet EEDI requirements for similar ships built today; and ships of any age not covered by EEDI.

In the winter of 2018-2019, 30% of built to comply EEDI vessels needed icebreaker assistance in Finnish and Swedish ports, whereas 20% of the older but EEDI compliant vessels needed assistance. Those vessels which were not EEDI compliant clearly needed less help.

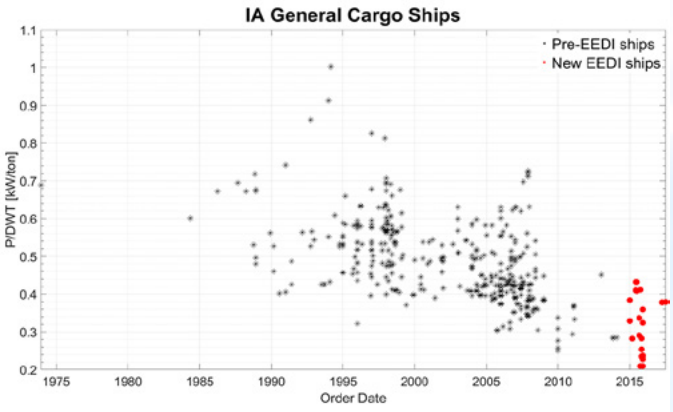
Similar trends were also visible for winter 2019-2020 as the non-EEDI compliant vessels needed less assistance than the EEDI compliant vessels. However, the winter 2019-2020 was one of the mildest ever recorded, which limited the amount of data, even though a mild winter can be navigationally challenging due to mobile ice forming ridges and brash ice barriers.

Ratio tells assistance need

In the second part of the study, ice-strengthened EEDI compliant ships were compared to other types of ice-strengthened ships which have visited Finnish and Swedish harbours in previous years.

Ships of a similar category were compared to each other, i.e. container ships to container ships and tankers to tankers. The results showed that the new EEDI ships clearly have a lower power-to-deadweight ratio than older ships.

"For example, ice class IA general cargo vessels are the most common cargo vessels in this environment," Heinonen says. "The new EEDI general cargo vessels have dropped their power-to-deadweight ratio by 30% compared to pre-EEDI vessels. This ratio is widely used as an indicator for icebreakers of how likely a vessel will need assistance. The assumption can therefore be made that the EEDI-compliant ice class IA general cargo vessels will very likely need assistance."



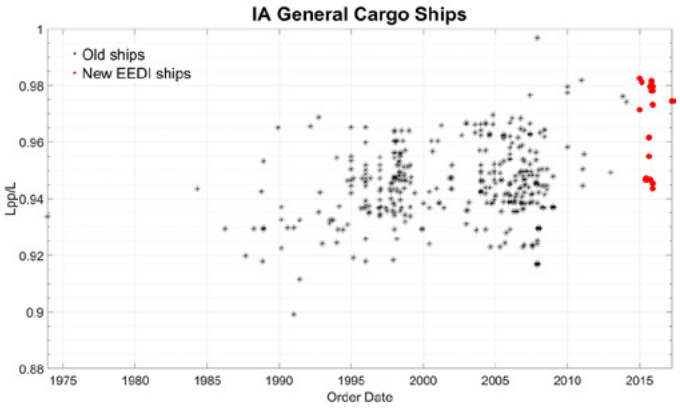
Ice class IA general cargo vessels are the most common cargo vessels in this environment. The new EEDI general cargo vessels have dropped their power-to-deadweight ratio by 30% compared to pre-EEDI vessels.

A straight bow form is weak in ice

Another interesting finding was that the length between perpendiculars (LPP) to overall length (LOA) ratio was closer to 1.0 for EEDI vessels, which indicates that many

EEDI vessels have a very straight bow with a practically vertical stem in order to maximize the waterline length and improve efficiency in open-water.

"This type of bow is not efficient in ice, especially if there is any unbroken level ice. The vessels' ability to operate independently in ice is weak and they will therefore need more assistance," Heinonen underlines.



The length between perpendiculars (LPP) to overall length (LOA) ratio was closer to 1.0 for EEDI vessels, which indicates that many EEDI vessels have a very straight bow with a practically vertical stem in order to maximize the waterline length and improve efficiency in open-water.

This is further intensified by the fact, that the large LPP/LOA-ratio (vertical bow) is often linked to a small power-to-deadweight ratio.

Tighter requirements for old vessels

Heinonen adds that EEDI regulates only new ships.

Currently, IMO is planning to adopt new energy efficiency regulations: the Energy Efficiency Existing Ship Index (EEXI). The regulations will apply to all existing ships, including EEDI ships, from 1 January 2023. It is anticipated that, in many cases, the EEXI regulations would limit the engine power of the older merchant ships with an overridable Engine Power Limitation (EPL) system.

"Basically, the EPL system could be overridden when operating in ice-infested waters, but how the system will actually be used in the future, the possible effects to the winter navigation system, and needs for icebreaker assistance are yet to be seen," he says.

Traficom aware of the situation

Maritime authorities from the Finnish Transport and Communications Agency, Traficom, have also noticed the downward trend of power-to-deadweight ratios and bowform optimisation for open-water operations. Special advisor Lauri Kuuliala from Traficom comments:

"There is a clear trend of decreasing the power-to-deadweight ratio in ice-classed ships, especially in the higher ice classes. It seems that this trend is not driven solely by environmental regulations such as EEDI but also by commercial concerns. Ice-classed vessels operate in a very competitive freight market and keeping costs to a minimum is essential for operators. Furthermore, a very significant portion of the ships calling at Finnish ports when assistance restrictions are in force only have a single visit per year to Finland. Therefore, it is understandable that those ships are optimised more towards open water operations, despite being ice-classed."

Safe and efficient winter navigation important

The decreasing power level of merchant vessels is a fact to which the winter navigation system has to adapt. However, ice operations must also be taken into account in ice-classed merchant vessel designs.

"While environmental and economic concerns are driving the power levels of new merchant vessels down, it is essential that care is taken to ensure that new ships can be assisted safely and efficiently by icebreakers. Sufficient ballast capacity to allow suitable draught and trim for ice navigation, as well as efficient towing arrangements, will become even more important for future ice-classed ships operating to northern Baltic ports," Kuuliala states.

Additionally, EEDI-regulated vessels need not have weak performance in ice. "It is possible to design a vessel which is competitive and efficient, both in open-water and in ice, with Aker Arctic's comprehensive design know-how," Heinonen adds. ■

EEXI – Energy Efficiency Existing Ship Index

IMO aims to reduce the carbon intensity of international shipping by 40% by 2030, compared to 2008. During the Marine Environment Protection Committee (MEPC) 75 session in November 2020, the IMO approved draft amendments to MARPOL Annex VI, introducing an Energy Efficiency Existing Ship Index (EEXI).

Ships are required to meet a specific EEXI, which is based on a reduction factor expressed as a percentage relative to the EEDI baseline. This will be applicable for specific ship types and sizes (same as for EEDI) regardless of contract date. The draft amendments are expected to be adopted at MEPC 76 in June 2021 with entry into force on 1 January 2023.

One possible method to reduce older ships' emissions is an overridable Engine Power Limitation (EPL) system. This is a verified and approved system for the limitation of the maximum engine power by technical means that can only be overridden by the ship's master for the purpose of securing the safety of a ship or saving life at sea.

www.imo.org, www.dnvgl.com, Traficom

Self-propelled icebreaking bow Saimaa commissioned

Photo: Ilari Rainio/ Finnish Transport Infrastructure Agency

The totally new concept of a detachable icebreaking bow which is self-propelled and connected to the tugboat Calypso (pusher) during the winter season has been taken into use on Lake Saimaa, Finland's largest freshwater lake, and the Saimaa Canal.

Lake Saimaa has a number of industries located on its wide shores and the Saimaa Canal connects the lake district with the Gulf of Finland. It is a vital transport channel for exports and imports of goods.

The detachable bow *Saimaa* brings more efficient icebreaking and ice management operations to the area, as the bow can break a wider channel than existing tugboats. The concept was developed by ILS Ship Design & Engineering for the Finnish Transport Infrastructure Agency, and she was built at Turku Repair Yard as part of the EU-funded (CEF) WINMOS II project.

Ship operations monitored

Aker Arctic designed and delivered the two shaft lines and propellers for the *Saimaa*, two bronze propellers for the pusher *Calypso* and the Ice Load Monitoring System (ILMS) for the shafts which can be monitored remotely. Aker Arctic also performed the ice model tests to verify the combination's icebreaking performance before the final design and construction.

ILMS measures the propulsion loads and pin forces at the connection between the detachable bow and the pusher. The propulsion load monitoring system receives signals from both *Saimaa's* own two shaft lines as well as from *Calypso's* azimuthing propulsion units.

"The sensors installed on the hull and the shaft lines send information to a central computer for real-time processing," says Kari Laukia, Head of Equipment Business at Aker Arctic. "This data is available on the ship's control and monitoring system, in the bow's engine room, on *Calypso´s* bridge, as well as online. It can be used to monitor various aspects related to the ship's operations, such as bow connection forces and propulsion load during operation, in addition to ensuring safe bow disconnection from *Calypso* and optimising power share between the bow and the tugboat."

Full-scale trials

The ship arrived in the Saimaa lake area in January 2021 and has now operated part of her first season. The ship's full-scale trials are planned to be performed during this spring, as soon as the ice cover on Lake Saimaa is thick enough. The pusher-bow combination should break up to 70 cm-thick ice.

Göran Wilkman in Memoriam

Our dear friend and colleague of many years, Göran Wilkman, passed away in December 2020, just before Christmas.

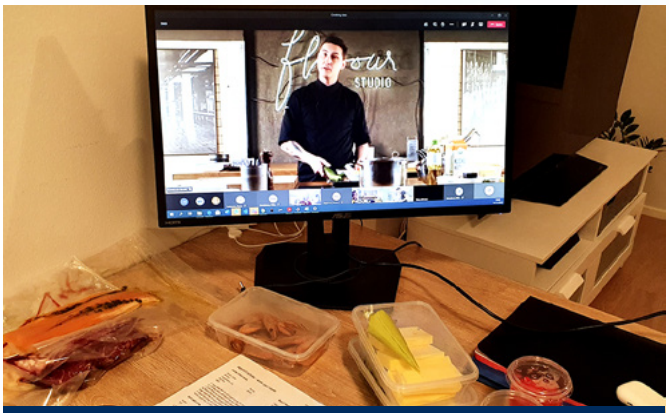
Göran worked as Senior Advisor in Research & Testing until he retired at the end of 2012. He began his career in the ice business in 1973 and worked mainly in R & D, testing and sales. He also participated in more than one hundred field trips and ice reconnaissance trips to many harsh Arctic and Antarctic areas during his forty-year-career. He was one of the most experienced ice expedition and full-scale trial leaders in the world.

In addition, he travelled the world giving presentations on countless projects and published two books after he retired from daily work. Göran was always taking care of customers, telling stories of his experiences in shipbuilding and life in general. He was the heart and soul of Aker Arctic's rowing team and participated in the traditional Sulkava rowing race every summer.

Even after retiring, Göran was a regular visitor to Aker Arctic's office and you could always count on his advice when you needed it. He will be greatly missed.

Tom Mattsson *All colleagues from Aker Arctic*

Friday night with colleagues



Arctic char confit for starters, beef in two ways for the main course and chocolate mousse topped with caramel and sugared peanuts for dessert. A vegetarian alternative could also be chosen with allergies accommodated for.

In the middle of the darkest autumn weather in Finland, Aker Arctic's social committee organised an online cooking class to cheer the staff up.

Most of the fun events that Jillian Adams and Heikki Juvani had planned for their colleagues last year were postponed due to COVID-19, until they thought of arranging a joint online cooking class on a Friday night in November.

Flavour Studio delivered all the ingredients pre-prepared in individual cooler boxes to the Helsinki office. All participants picked up a cooler box to take home, set themselves up in their own kitchens and tuned into an online video meeting.

Three-course dinner

"Chef Patricio Saksa then guided us through the steps in preparing the delicious three-course dinner," Adams explains. – The menu was planned as a dinner for two but could be topped up to include the whole family or friends cooking together.

"The company had a professional camera team alternating angles in the studio. We could also see our colleagues at the bottom of the screen, and were given breaks to chat, which enhanced the experience of cooking together," Juvani adds.

"The best thing with the cooking class was to actually do something together," both Adams and Juvani emphasize. "Although the ultimate option would have been to gather in a large kitchen for the class, as we have done twice before, this was definitely a great way to spend a fun Friday evening with colleagues." ■

Monthly webinars about icebreaking

Last year, Aker Arctic began holding open webinars for professionals with an interest in icebreaking vessels and topics related to shipping in ice. The feedback has been overwhelmingly positive, and the monthly webinars have been well attended. Here is an overview of the past topics covered. Let us know if you find one that you missed but would have been keen to attend.

- Ice Class Power Requirement And Ice Model Tests
- Power and Propulsion Selection For Ice-classed Ships
- Polar Code – What We Learned?
- Ice Class Selection & Ice Strengthening Beyond The Rules
- Ship Operations In Ice
- Practical Winterisation

Upcoming webinars at www.akerarctic.fi/en/news

ANNOUNCEMENT

Hanyang Gong has joined Aker Arctic as a research engineer in the Ice Model Test and Testing Services team. She has recently completed a doctoral degree in Mechanical Engineering (Arctic Marine Technology and Ice Mechanics) at Aalto University. Her doctoral study focused on discrete element numerical and laboratory modelling of the interaction between ships and ice ridges. The study provides new understanding of the ice ridge failure process and ridge resistance on ships, particularly the role of ridge dimensions and hull forms. This study supports the evaluation of ship performance in ridged ice fields, e.g., in the context of shipping route planning. Before moving to Finland, Hanyang was involved in various ocean engineering research projects, both at Harbin Engineering University (Harbin, China) and at the Graduate School of Tsinghua University (Shenzhen, China).