# An extraordinary icebreaker for the United States Coast Guard

The United States Coast Guard (USCG) has launched a Polar Icebreaker Acquisition Program to replace two existing heavy icebreakers built in the 1970s with a new vessel. Aker Arctic is committed to help the USCG to find the best solution to their needs.

Since the 1950s, heavy polar icebreakers have been used to support Operation Deep Freeze, the annual resupply mission to Antarctica, where the icebreakers open a channel through the Ross Sea ice pack and escort tankers and freighters to the world's southernmost harbor at the McMurdo Station. During this month-long voyage that begins and ends in Seattle, the icebreaker will experience extreme temperatures from tropical heat at the equator to the freezing polar climate, strong winds and heavy seas, and finally ice up to eight feet thick. The vessel required for this task has to be an extraordinarily versatile, heavy-duty icebreaker with excellent seakeeping and open water features.

In addition to the resupply mission to Antarctica, the new polar icebreaker will also be used to support science missions in the Arctic and will feature an extensive scientific outfit and laboratories. Due to increasing activity in the Arctic, it will also remain in constant stand-by for demanding search-and-rescue and marine environment protection operations in the ice-covered seas.

"There is neither existing nor planned vessels in the world that fulfill all the demanding mission objectives and requirements set by the USCG," Naval Architect Tuomas Romu at Aker Arctic emphasizes.

"Most icebreakers that work in northern latitudes are not designed for long transits in open water and heavy seas, and most Antarctic vessels are primarily scientific research and supply vessels with lower icebreaking capability. None of them can first manage rough seas with waves up to 45 ft high in tropical heat and then break thick multi-year ice in freezing temperatures."

**The optimal vessel**

Aker Arctic has already started drafting an icebreaker concept to find out what kind of vessel could meet the objective requirements defined by the United States Coast Guard in the recently published Polar Icebreaker Industry Data Package. "We are looking into a relatively compact vessel which can fulfill all the objectives, but still be affordable to build and economical to use and maintain," says Romu. “A larger vessel would require more powerful engines and bigger fuel tanks. Aiming for a vessel that is not larger than it needs to be to complete its mission successfully keeps the construction and operational costs at bay.”

Based on Aker Arctic's preliminary estimates, the new heavy polar icebreaker would have a displacement of about 20,000 metric tons, making it slightly larger than the existing US-flagged icebreakers. It would feature a highly redundant diesel-electric power plant, which is the current standard worldwide in icebreakers, and a propulsion system with electrically driven fixed-pitch propellers. Possible propulsion alternatives include a conventional triple shaft arrangement as well as azimuth thruster/shaftline hybrids.

"The end result will most likely be a heavy icebreaker that may look somewhat conventional from the outside, but inside has modern technology which has proven to be efficient and reliable over the years," Romu adds. "Icebreaking technology has made a huge leap in the past forty years since the USCGC *Polar Sea* and USCGC *Polar Star* were built."

Since the heavy icebreaker is expected to encounter extremely hard multi-year polar ice, it will be designed to break ice primarily bow-first. The hull form needs to have the right balance between icebreaking and open water operations in order to efficiently fulfill all the operational requirements set by the United States Coast Guard.

"In addition to giving an accurate performance prediction, our in-house model testing facility gives the benefit of evaluating different hull form and propulsion concepts before making any final decisions," says Romu.

The ice strengthening in the hull needs to be sufficient to withstand collision with

*Aker Arctic provided extensive conceptual development and design support, including hull form development and propulsion line engineering for the medium icebreaker USCGC Healy.*

*The highly advanced polar research icebreaker for China is soon ready for construction. Its main tasks will be research operations in the Antarctic. Aker Arctic provided the concept and basic design of the vessel.*

*Taymyr and Vaygach are the only nuclear-powered icebreakers built outside the Soviet Union or Russia. Aker Arctic employees were involved in the development of these highly capable shallow-draft icebreakers.*

*Aker Arctic was part of the design team for the new icebreaker for the Canadian Coast Guard, CCGS John G. Diefenbaker. We developed the hull form and performed the model tests for this advanced polar icebreaker.*

photo: United States Coast Guard/ Public Affairs Specialist 2nd Class NyxoLyno Cangemi


thick ice floes at high speeds without risking structural damage. For this reason, cold-resistant high-strength steel will be extensively used in the ice belt. On deck, all exposed equipment must be winterized against cold ambient temperatures. The crew should also be protected from sea spray and icing.

Other features include accommodation for a crew of 100-150 as well as 50 additional personnel such as scientists, a helicopter hangar for two helicopters, and large onboard stores. The requirement is that the polar icebreaker has to be able to sail 21,500 nautical miles at a speed of 12 knots in open water. In addition, it has to be able to manage up to three months without refueling or stocking up on supplies.

**Tailor made for the best result**

While there are many icebreaking vessels and icebreaker designs on the market, they are all designed with specific missions, operating areas and ice conditions in mind. The best end result is always achieved when a vessel is designed for its intended use.

According to Romu, trying to modify an existing design for this project does not make sense. “The result would likely be a compromise where the designer tries to balance between keeping features from the parent vessel in order to save time and making small modifications to adapt the vessel to a new role. Regardless of the end result, most of the classification and production design would have to be re-made, so neither money nor time would be saved at the end.”

"For us, being specialized in designing icebreakers, the time required to design a new icebreaking vessel concept is measured in months, not years. In the total acquisition process, which lasts many years, this is no time at all. The cost of a new concept design is also a fraction of the total investment and the end result is a tailor made vessel that fully meets all requirements and is perfect for its intended use."

"To acquire a new icebreaker is a huge investment both in terms of money and time: it is not worth a compromise," Romu adds.

**Time frame for icebreaker**

Acquisition processes can take everything from two to ten years. It all depends on the efficiency of the process and the ability to make decisions. The United States Coast Guard has accelerated its timetable for the recapitalization of the icebreaker fleet under President Barack Obama, and aims to begin production activities in 2020. This is two years earlier than what was initially proposed.

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“This kind of the timetable is clearly achievable, for example The PC 3/Arc7 iceclass arctic module carriers took 28 months from start of concept design to delivery of the first vessel, even though there was no preceding design and the Chinese shipyard had never built icebreaking vessels before," says Romu.

"Working with us makes the process very straightforward as this is our everyday work. We know what needs to be done and in which order," Romu underlines.

**Two previous joint projects**

Aker Arctic and its predecessors have had a strong involvement in the previous USCG icebreaker projects.

"We provided extensive conceptual development and design support, including hull form development and propulsion line engineering for the medium icebreaker USCGC *Healy*," says Managing Director Reko-Antti Suojanen.

"We also developed the vessel concept for the Great Lakes icebreaker USCGC *Mackinaw* in cooperation with the US Coast Guard. It is one of the first vessels using the "double acting" ship principle, we have developed and the podded propulsion system, invented in Finland. In both projects, model testing was used in the concept evaluations and to support the final work as well."

Aker Arctic has a long history of successful icebreaker designs, including the most advanced and innovative icebreakers designed within the past few years.

**Support for shipyards**

Aker Arctic always works in close cooperation with its customers, in order to make sure that the final vessel meets the customers' wishes and demands. Another close cooperation partner is the shipyard that will build the vessel.

"There are capable shipyards in the US so there is no doubt that, with assistance in specific matters related to operations in ice and cold environment, they could construct a heavy polar icebreaker," Romu says. "This is where our construction-time support for shipyards comes in handy. We are, for instance, currently assisting the French shipyard Piriou, which is constructing the new French polar supply vessel, in ice related matters. We also supported Guangzhou shipyard in China during the construction of the arctic module carriers, delivered at the beginning of this year."

**Successful icebreakers**

Aker Arctic has designed one successful icebreaker class after another and has also gained valuable feedback from the operators as well as trials over the past few decades.

"We know what is needed for efficient icebreaking and especially what is needed in extreme conditions. In full-scale ice trials, our icebreaking innovations continue to outperform other designs," Romu highlights.

"Based on this we know that we can design a polar icebreaker, which meets all the USCG requirements without becoming the most expensive icebreaker in the world. A compact vessel, which is economical to build, use, and maintain has many benefits."

# Severe winters at the Great Lakes stops vessels

The past winters in the Great Lakes area in North America have been exceptionally hard. Local industries have reported huge financial losses after cargo ships became frozen in the ice and commercial shipping all but stopped during the winter months. The question has now been raised of investing in a new icebreaker in order to avoid similar situations in the future.

*Aker Arctic developed the concept for the Great Lakes icebreaker, USCGC Mackinaw, together with the United States Coast Guard.*

Among other smaller icebreakers and tug boats assisting commercial vessels in the Great Lakes, there is USCGC *Mackinaw*, which Aker Arctic designed in cooperation with the US Coast Guard in 2005. *Mackinaw* is based on the double acting ship principle, sailing bow first in open water and stern first in heavy ice. Its twin Azipod concept and design were created jointly by USCG, Kvaerner Masa Marine and Aker Arctic.

*The oblique icebreaker is able to proceed sideways in ice and create a wide channel for tankers or commercial vessels. The first vessel built,* Baltika*, is currently working in 1.5 meter thick ice in the Gulf of Ob. She surpassed all expectations in full-scale tests in 2015.*

Arctech Helsinki Shipyard


Arctech Helsinki Shipyard

"The new Great Lakes icebreaker would have to be capable of assisting even the biggest lake freighters or 'lakers', but unlike them, be compact enough not to be confined to inland waters," says Tuomas Romu. "Having participated in the recent full scale ice trials and seen what such a vessel is capable of, I believe the best solution for the Great Lakes would be our oblique icebreaker concept. It could break a wide channel in the Great Lakes during the winter months and then leave for other tasks through the St. Lawrence Seaway. The icebreaker could also utilize some of the technologies featured in the new Finnish icebreaker *Polaris*."

*The first LNG-powered icebreaker ever built was completed in August 2016 in Finland.* Polaris *features all the latest technology available for icebreakers.*

# Hybrid DAS propulsion adds cost efficiency

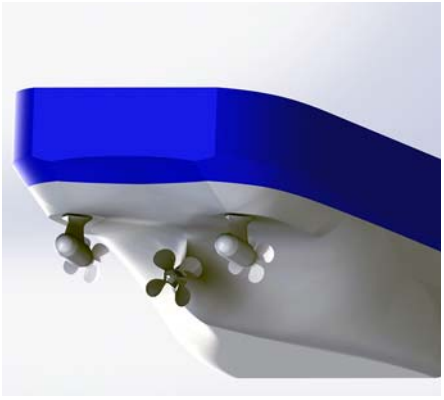
One of the latest icebreaking technologies in Aker Arctic's portfolio is the Hybrid DAS, which combines the superiority of the azimuth thruster propulsion in ice conditions with the cost efficiency of a conventional shaftline in long open water transits. This is one of the propulsion system alternatives proposed for the new United States Coast Guard heavy icebreaker.

"The design with a powerful shaft propeller at the centerline and two azimuth thrusters on the sides adds benefits in varying situations," says Tom Mattsson, senior specialist in ice performance at Aker Arctic.

"In ridges and difficult ice conditions, the vessel can move stern first and use the thrusters for maximum effect. In long open water transits, the shaftline propeller is used for cost efficiency."

Maneuverability in ice will be much better with this solution compared to a conventional icebreaker.

Additionally, the power balance between the thrusters and center propeller can be varied to maximize the efficiency in different operational situations.



## Meet Tuomas Romu

Tuomas Romu started his career at Aker Arctic in 2011. Before joining the company as a full-time naval architect, he studied shipbuilding at Aalto University in Finland and arctic technology at the University Centre in Svalbard in Norway. Tuomas has worked as the project engineer in two recent icebreaker projects, Aker ARC 130 A and Aker ARC 124. In addition, he participated in the full-scale ice trials of the oblique icebreaker *Baltika* last year.

When he is not designing icebreakers or travelling in the High Arctic, Tuomas enjoys relaxing at his family's summer cabin. He is also a voluntary SAR boat crewman in the Finnish Lifeboat Institution.