Energy-efficient Baltic Sea icebreaker concept chosen

Ice-covered Baltic Sea between Sweden and Finland, March 2021. Photo taken from icebreaker *Ymer* by Dan Broström.

Fossil-free fuel options, battery solutions and a 32-metre-wide icebreaking capability make this the world's most modern assistance icebreaker.

The Swedish Maritime Administration and the Finnish Transport Infrastructure Agency, partnering in this joint project to design new energy-efficient assistance icebreakers for the Baltic Sea, have chosen to proceed with an icebreaker design incorporating three azimuthing propulsion units. The propulsion design is similar to the Finnish icebreaker *Polaris*, also an Aker Arctic design, with one azimuthing propulsion unit in the bow and two in the aft.

"The icebreaking capabilities, the manoeuvrability and life-cycle costs showed that this was the best concept for the future," says project manager Dan Broström from the Swedish Maritime Administration.

Three different propulsion concepts were initially evaluated, along with a fourth reference vessel: a 32-metre-beam icebreaker with similar propulsion to the *Atle/Urho* class icebreakers, which are planned for replacement. All test results and life-cycle costs were compared to the reference vessel.

Multi-fuel vessel design

Using fossil-free fuel in the icebreaker has been one important design criteria, as well as a major challenge. Sweden has a target of fossil-free shipping by 2030 and the demand is that the new icebreaker is ready for this.

"The icebreaker will have a life-span of 50 years, which is a very long time," Broström continues. "Today, we don't know what all the future fuel options could be, and it is therefore difficult to decide which fuel to use. Aker Arctic has successfully dealt with this problem by designing an innovative concept which is prepared for several alternatives, giving us the possibility to decide at a later stage."

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The concept designs were evaluated in ice model tests at Aker Arctic. Photos by Catarina Stewen.

The current alternatives are hydrotreated vegetable oil (HVO), a fossil-free diesel fuel; liquid biogas (LBG), made from waste products in food production, replacing liquefied natural gas (LNG); and fossil-free biomethanol. All of these are already available, but costs, infra-structure, production capacity and logistics are still big question marks. Experts currently estimate that the aviation industry might swallow most of the production of HVO, leaving scarce amounts for other industries.

Batteries for quick energy

Battery-driven vessels have slowly been introduced on the market, but this is the first full-size icebreaker design with battery packs or supercapacitors augmenting the main engines.

Although this part of the development is still in its initial phase, Broström is convinced that using an electric hybrid installation in the new icebreaker will provide many benefits, when, for instance, additional energy is needed quickly or in situations where it is not necessary to start an additional main engine.
"It will be exciting to see how much fuel we can save using batteries," he says. "They may also be employed in harbours to avoid emissions."

Wide channel with narrow hull

Future commercial vessels entering the Baltic Sea will be longer and wider, and therefore the most important requirement overall is that the new icebreaker must be capable of breaking channels of up to 32 metres wide.

Finland and Sweden have a long tradition of successful cooperation, both in icebreaking and icebreaker acquisitions. In the picture Swedish icebreakers *Atle*, *Ymer*, *Frej* and *Ale*. Photo by Maria Asén, courtesy of Swedish Maritime Administration.

At the same time, the aim is to build an icebreaker with a narrower hull, as the construction price will be lower and fuel will be saved in operations.

"We want to be able to break a channel width on demand, ranging from the icebreaker's beam and up to 32 metres. This has required much innovative thinking in order to provide the solutions," Broström says.

In the chosen concept, the thrusters can be angled outboard to achieve a water flush effect to widen the channel.
"In this way, the width can be chosen effectively and flexibly," underlines Helena Orädd from the Finnish Transport Infrastructure Agency, project manager for Finland in the project.

Lifetime costs evaluated

In big projects spanning long periods of time, life cycle costs (LCC) are important to consider and thoroughly analyse.

"In this case, where we are looking at 50 years of service, low acquisition costs combined with high maintenance costs could result in extremely high lifetime costs," Broström explains. "Conversely, high acquisition costs but low maintenance costs might turn out to be the cheapest alternative."

In the life cycle assessment (LCA), the environmental impact is added to the cost to ensure that any choices are not detrimental in this regard.

"With the help of these analyses we have looked at multiple aspects and costs over time: what does transfer from fossil fuel to fossil-free fuel mean, what is the balance between cheap and expensive acquisition prices, what can we expect in terms of fuel prices combined with fuel consumption. As an example, our reference concept required more energy to advance because it is a wider ship," says Broström.

"On top of the LCC and LCA analyses, we have strived to look at costs and emissions on a system level," Orädd adds. "With a properly sized and efficient icebreaker fleet assisting modern and future commercial vessels equipped with decreasing installed power, the total amount of all shipping emissions, along with the cost to the taxpayer, will be minimized."

Decision to construct

The project is advancing well and on-time. Aker Arctic will deliver the final tender design in mid- February 2022. The Swedish Maritime Administration is hoping for a construction decision as soon as possible, whereas the Finnish schedule is open.

"Sweden needs new icebreakers very soon. The old icebreakers date back to the early 1970s, with technology from the 1960s. They use components no longer available which have to be specially manufactured if they break. This is both difficult and expensive," Broström says.

The Finnish icebreaker fleet is more modern, with *Otso, Kontio, Fennica, Nordica* and *Polaris* built later than the *Atle/ Urho* class.
"In addition to the Bay of Bothnia, the Gulf of Finland also requires large icebreakers," Orädd adds.

According to Broström, the project team is planning to be fully prepared before a decision to construct. "The earliest date we could hope to begin construction is June 2023," says Broström.

If Sweden and Finland achieve a joint order of five A-class icebreakers, three for Sweden and two for Finland, Broström believes the price tag would be less than if separate construction decisions were made.
To receive cost indications and possible construction schedules, a request for information (RFI) will be sent out to shipyards this autumn.

Long tradition of cooperation

Finland and Sweden have a long tradition of successful cooperation, both in icebreaking and icebreaker acquisitions. The *Atle/Urho* class vessels built in the 1970s in Helsinki, which are now being replaced, were developed together.

"During the ice season, we work together daily, especially in the Bay of Bothnia. We have joint technical follow-up systems and a well-functioning system of cooperation using both country's icebreakers flexibly. Therefore, it made perfect sense to partner up in this project," both Broström and Orädd emphasize.

Broström adds that they have an excellent working relationship with Aker Arctic, especially in finding new solutions quickly to advance the project. "It is a pleasure to work with Aker Arctic; the design spiral approach they use is very efficient."

"Both our countries are learning thoroughly about icebreaker design and acquisition," Orädd adds.

Furthermore, both are convinced that this will be the world's most modern assistance icebreaker, once it is ready. ■

Night-time icebreaking to release a vessel from ice north of the lighthouse Nordvalen located between Sweden and Finland, March 2021. Photo by Dan Broström.