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

Best practices in developing modern Polar research vessels

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

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

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

Early phase is crucial

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

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

Elements for a successful design

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

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

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

Compromises

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

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

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

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

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

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

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

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

Cold environment features

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

Critical technical requirements

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

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

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

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

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

Arto Uuskallio

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

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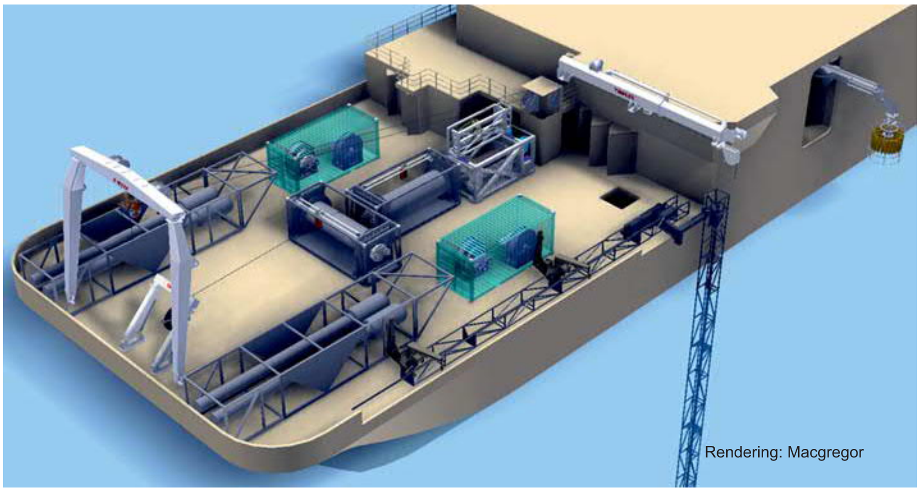
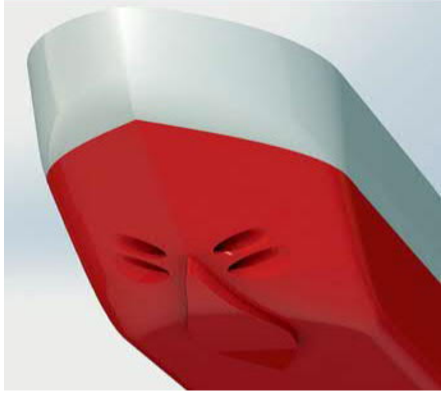


Modularity is commonly implemented by placing equipment inside containers, which can be easily moved or replaced according to mission needs.



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

New solutions for Polar Research Vessels

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

Modules are easy to replace

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

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

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

Creating an ice-free area using a sidepool

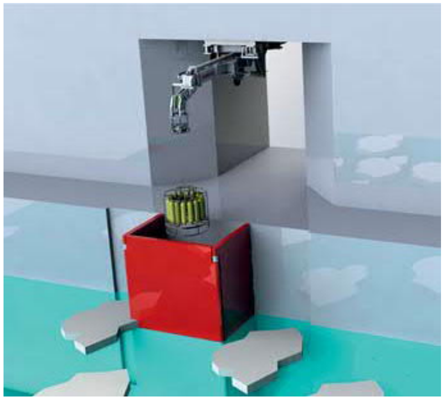
The sidepool is a new Aker Arctic innovation for creating a cost-effective ice-free area at the side of the research vessel. It offers the opportunity for better space arrangement possibilities in the centre of the ship as well as displacement and deadweight savings compared to a traditional moonpool.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

Minimising underwater disturbance

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

Hybrid propulsion for less noise

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



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

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

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

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

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

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

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

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

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

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

Icebreaking research and logistics vessels under construction

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

Antártica 1

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

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

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

Vessels in acquisition phase or under consideration

Polar Logistics Vessel for Argentina

Polar Research Vessel for Germany, Polarstern II

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

Polar Research Vessel for Japan

Polar Research Vessel for Korea

Polar Research Vessel for Brazil

Polar Research Vessel for India