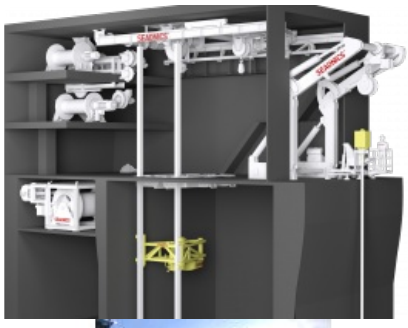
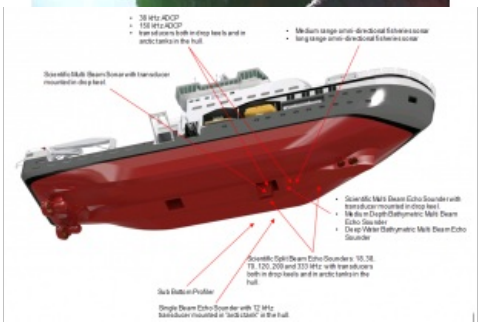
NEW NORWEGIAN ICE-BREAKING RESEARCH VESSEL

The Making of RV 'Kronprins Haakon'





Norway is a maritime country with a very long coastline, plus it is very much a polar nation with 80% of its sea territory and 45% of its land mass north of the Arctic circle. It is the only country with territorial claims both in the Arctic and the Antarctic. In spite of this, Norway has not had a purpose-built polar research vessel since Roald Amundsen's '*Maud*' (1917), having instead relied on converted commercial vessels for such purposes. That has all changed, however, now that '*Kronprins Haakon*' has come into service. This article provides insight into the making of this new multi-purpose research vessel.

Kronprins Haakon was a long time in the making. The design contract was awarded to Rolls Royce Marine in 2008, but it was not until 2013 that the Norwegian Parliament allotted €145 million for the construction and outfitting of the vessel. The vessel underwent final outfitting at VARD Langstein on behalf of Fincanteri, Norway and was delivered in March 2018.

Year-round Operations

Kronprins Haakon is a multi-purpose research vessel built according to the new Polar Code as a PC3 Ice-breaker class ship, suitable for year-round operations in multi-year ice. The Norwegian Polar Institute, the Institute of Marine Research, and the University of Tromsø will use her jointly, mainly in the Arctic, but also in the Antarctic.

With its 100 metres (330 feet) in length and 21 metres (70 feet) breadth, the vessel caters for up to 55 persons, including scientists, researchers, students and crew members. It will be a good observation platform for researchers for their work under extreme climate conditions. The ship is a multi-purpose vessel that covers different fields of research work such as stock assessment, oceanography, geophysics, marine biology and marine geology.

Kronprins Haakon has been designed to carry two helicopters.

The vessel is designed to carry two helicopters, with the helicopter hangar and the landing platform in the bow area. The vessel is designed with a large open work deck where the stern is formed like a stern trawler. In addition to 'ice gallows', trawl winches have been installed for both pelagic and bottom trawling, enabling the vessel to trawl in both open and ice-covered waters. On the port side of the stern there is a hangar for deploying the Hugin AUV.

The work deck also has facilities for seismic operations and a seafloor drill rig, such as the MeBo driller, and with its grid of container fixing points it can deploy, tow and recover a variety of mobile equipment and towed vehicles, using the A-frame installed at the stern.

Handling Equipment

In front of the working deck there is the main hangar, with a 3 x 4m moon pool and opening to the starboard side, for deployment of ROVs such as the Ægir6000, Kley France Giant Calypso corer and other instruments for sampling the water column or the seafloor. There is also a separate CTD hangar for water samples next to the main hangar. The Norwegian company Seaonics has delivered complete state-of-the-art handling equipment for extreme conditions, and the package includes winches, cursor system for safe moon pool deployment of ROV and scientific equipment, deck cranes, and overboard systems, including A-frames and launch and recovery systems (LARS).

The cursor system for deployment through the moon pool.

Laboratories

Inside the ship there are 15 laboratories for the researchers on scientific cruises, including Wet Geology/Benthos laboratories for analysing coring samples, ice samples and to determine invertebrate species composition, abundance and size from benthic sediments, and an isotopic lab to monitor radioactive contamination (gamma and beta emitters) in the environment and an environment toxicology laboratory to study the harmful effects of various chemical, biological and physical agents on living organisms. There are also laboratories to examine water samples, collections from plankton net and fish collected from the trawl. Most of the laboratories are located on the 3rd deck, which is the same as the working deck, to make the workflow as easy as possible. To store and conserve samples during the cruise there are four cooler rooms and two freezer rooms. In addition, there is space for three container laboratories outside on the work deck. The vessel also hosts an auditorium for 50 persons and a separate education lab. On the 9th deck, above the bridge, there is an observation room for sea mammal and bird observations.

The MeBO seafloor drill platform installed on Celtic Explorer.

Contradictory Requirements

Designing a research ice-breaker is not an easy task. On the one hand, you have the demand for a silent vessel with minimum Underwater Radiated Noise (URN) and bubble-free zones for all transducers, and on the other, there is the need for extreme force when breaking ice. Head of design at Rolls-Royce Marine, Mr Einar Vegsund, was responsible for the design of *Kronprins Haakon*, and says the following about his work on this design:

“Noise signature and air bubble sweep down is a challenging task for all oceanographic research vessels and even more challenging for ice-going vessels since the hull and propulsion systems must be designed to meet the extreme environmental conditions in polar areas.

As ship designers, we have to balance several contradictory requirements and find the optimum balance between efficiency, noise, ice-breaking capability, redundancy, reliability, manoeuvrability, seakeeping, etc.

The main source of underwater radiated noise is normally the propellers. Due to the requirements for manoeuvrability in ice-covered areas an azimuthing type of propulsion system was selected, even though this is not the type of system with the lowest noise signature, and a huge effort was made to optimise the system and make it acceptable (propeller, electric motors, steering gear etc.).

The new RV *Kronprins Haakon* is ice classed according to PC-3 ICE-BREAKER notation and the propellers must have the strength to ‘eat’ ice of 1.5m thickness. The vessel is equipped with two ducted, 5-bladed fixed pitch propellers with a diameter of 4,500mm and has been designed to be free of sheet cavitation at speed up to 11 knots.

Ã†gir 6000 ROV on Kronprins Haakon.

Design propellers have been tested and verified in the large HYKAT cavitation tank at HSVA, Germany. Other machinery and auxiliary systems have been designed according to low noise principles being resiliently mounted on well-stiffened foundations.

A high number of acoustic sensors are hull mounted in the forward part of the vessel and exposed to disturbances from air and particles generated by the bow as it pierces the water and waves. In order to avoid damage to the sensors from ice they are flush mounted and protected by titanium windows. Any piece of equipment protruding the hull will be damaged when the vessel is ice-breaking and therefore no gondola or appendix is allowed. The hull itself has an extreme requirement for smoothness and welded connections are grinded to avoid vortexes. The vessel is also designed with a carefully designed keel diverting the water flow from the bow away from the sensors at the bottom of the hull. Computational Fluid Dynamics (CFD) software are probably the best tool to use when investigating details of hull design and arrangement of hydroacoustic sensors and Rolls-Royce used this actively during the entire ship design process.”

Acoustics package

Under the keel, the ship is outfitted with a large acoustics package from Kongsberg Maritime (KM). This package includes deep and medium depth multibeam systems for bottom mapping, including the EM 302, EM 710 and EA 600, while systems such as SBP300 and TOPAS can be used to look at sub-bottom structures. Position reference will be provided by the state-of-the-art and industry standard HiPAP 501 system. Also part of the delivery is the KM series of Simrad scientific systems, including

a new EK80 wideband split beam fisheries acoustics system, modern scientific multibeam systems ME70 (looking downwards) and MS70 (looking sideways), and omnidirectional sonar SH90 in addition to the new SU90 that can detect and track biology for several kilometres around the vessel. *Kronprins Haakon* also carries the new Simrad FX80 trawl monitoring system, which can provide a live camera feed from the vessel's sampling trawl.

Unlike other existing research ice-breakers, the *Kronprins Haakon* is designed and equipped with acoustics that can both measure and quantify biology in all components of the marine ecosystem. Quantitative multibeam (ME 70 and MS 70) and omnidirectional sonar systems (SU 90 and SH 90) target areas close to the surface and near the bottom where traditional echo sounders cannot be used.

The hull as seen from below.

Two keels

Also unique to the *Kronprins Haakon* is its ability to collect scientific data both when operating in ice and in open waters. To achieve this, the vessel is equipped with two retractable keels (drop keels) that secure an optimal environment for the acoustic instruments. Two drop keels are needed because there is not enough space for all the equipment in one keel. The port drop keel contains: ADCP 38 kHz and EM 710. The starboard drop keel contains: EK 80, MS 70, ME 79, ADCP 150 kHz. However, as the drop keels cannot be deployed when the vessel is breaking ice, the *Kronprins Haakon* also carries an additional acoustic package of flush mounted EK 80 echosounders in ice protected arctic tanks, so data can be collected even when the vessel is operating in ice.

Communications and navigation systems are mainly supplied by Norwegian companies, such as the K-Bridge Integrated bridge system from Kongsberg Maritime and Dynamic Positioning (DP) system from Rolls Royce Marine. These systems will assist the crew with safe sailing and operations.

Acknowledgement

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