AURORA BOREALIS – Unique Technical Characteristics for Scientific Ocean Drilling in Comparison to Existing Drilling Vessels

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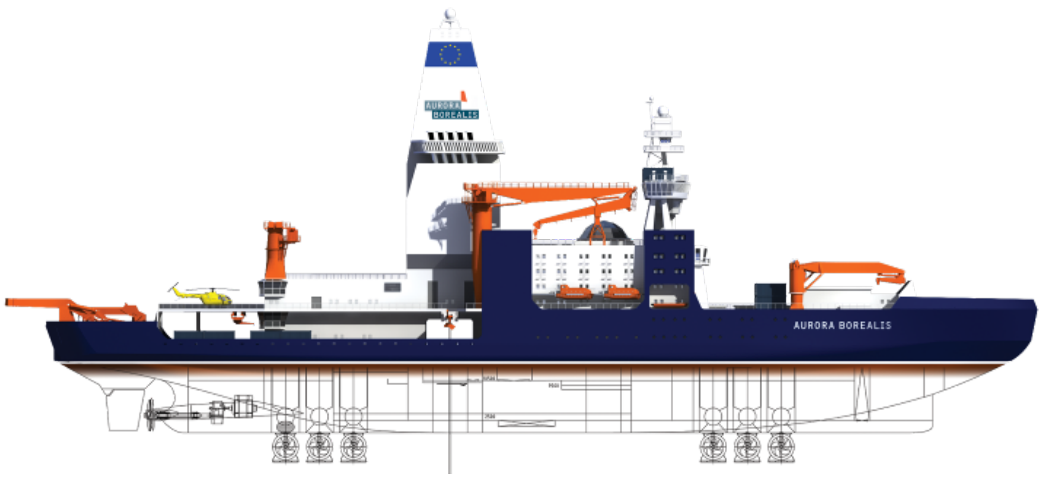

Background

This document summarizes unique technical performance characteristics of the European Research Icebreaker and Deep-Sea Drilling Vessel AURORA BOREALIS. It compares these features to commercial drilling vessels that are currently planned or commissioned.

Scientific deep-sea drilling in the Arctic and polar Southern Ocean will be a scientific, technical and logistical challenge for the next decades; it would enable to generate data that is indispensable for understanding the evolution of Earth's climate and resolving the northern hemisphere plate tectonic and palaeo-geographic evolution. The unique capacity of AURORA BOREALIS to autonomously drill in ocean basins that are covered by pack ice defines this vessel concept as a unique future international research platform.

Due to rapidly changing ice conditions in the Arctic Ocean that will likely lead to an increase in seasonally ice-free waters the international oil and gas (O&G) industry in conjunction with service and ship suppliers foresee an increasing research, surveying and exploration potential for oil and gas (O&G) reservoirs in the Arctic Ocean and it's marginal seas. As a result, demand for commercial drilling vessels capable of operating in "Arctic Environments" has increased over the past years. Specifically, vessels are needed that can maintain their position in ice-infested waters and under cold conditions in remote environments either by mooring or dynamic positioning.

During the initial technical specification phase of the AURORA BOREALIS project between 2001 and 2006 this development in the private sector was not envisioned to the extent seen today. Therefore, we here give a brief assessment whether other drilling vessel designs that are currently planned or executed for the offshore oil and gas industry are suited to be used for scientific ocean drilling in all regions of the Arctic Ocean or the polar Southern Ocean.

How do Commercial Drilling Vessels operate in Polar Regions?

Most drilling activities for oil and gas exploration is located in marginal seas of the Arctic ocean or regions that are seasonally ice free, with only modest ice conditions that are easier to manage than the thick pack ice fields of the central Arctic Ocean, where AURORA BOREALIS is needed to operate. Commercial drilling often happens relatively close to logistical bases and aiming at reaching great target depths (often several thousands of meters) under temporal pressure but for extended amounts of time in a restricted region (often multiple months). This is different from scientific drilling expeditions that are targeting multiple, but comparably shallow holes on various sites with longer distances to transfer between drilling sites, all in a limited amount of one expedition (typically 4 to 8 weeks). Thus, one principal difference between commercial drilling activities and the AURORA BOREALIS operational portfolio is the location and timing of operations.

As a result, design specifications differ substantially between commercially used vessels and the AURORA BOREALIS. The latter is specified to the highest attainable ice class according to the Polar Code of the International Association of Classification Societies (IACS PC 1). Commercial drilling vessels are designed to withstand occasional ice floes while being supported on location by multiple other ships for supply, environmental monitoring and ice management. They usually don't need to be capable icebreakers in their own.

AURORA BOREALIS is a fully functional heavy icebreaker (currently the most powerful design worldwide), an entirely different type of ship. She is specified to autonomously perform dynamic position on spot location within pack ice fields of more than 2.5 m thickness. She can break ice of more than 2.5 m thickness with a speed of 4 knots or thicker ridges of more than 12 m by ramming.

To date, no vessel exists that has the same combination of technical features and offers the same level of sophistication in ice management on site. Other drillship designs exist and are under planning for cold environments. These vessels are designed with a low to medium ice class hull so that they can withstand the impact of ice floes on the hull and continue operations while ice floes are accumulating around the vessel in sub-polar and Polar Regions. As a major performance difference these vessel have no autonomous icebreaking performance in closed thick sea ice cover while operating in Dynamic Positioning Mode. Instead, these vessels are drilling within a zone of managed ice that is broken and monitored by smaller supporting icebreakers. In this "managed ice" the vessel is dynamically positioning on a location or moored by anchors that are often handled by additional anchor handling vessels.

These "Arctic Class" drill ship designs that are currently built or operated by O&G service suppliers are based on previously available proven designs of regular deepwater drilling vessels. These existing designs that are usually not capable of operating in any ice conditions have been modified for cold regions and sea ice conditions. In principle, these modifications comprise two main categories:

1. The vessel's hull is strengthened and modified in shape and material to withstand the impact of drifting ice floes and enable the vessel to continue operations or maintain a stand-by position in sea ice conditions. Without these modifications all operations would need to be terminated, even when few isolated ice floes would come within sight of the vessel.
2. The equipment on the vessel (e.g. drilling rig components, decks, open storage and maintenance areas) that is usually found in the open are sheltered or heated to enable to perform under Arctic conditions. Allowed minimum temperatures vary on existing commercial designs between existing designs between 0 and –20° C.

Commercial "Arctic Class" Drill Ship Designs and Alternative Operational Scenarios

1. Stena Drillmax Ice

The "DrillMax Ice" (Stena Drilling Inc., Aberdeeen, UK) is designed to withstand Arctic conditions. Based on the original DrillMax series of ultra-deepwater[3] drilling vessels, this vessel received an ice-strengthened hull with ice class PC 5 (i.e. a lower medium icebreaker ice classification) and additional winterisation features in the drilling rig and superstructure. The vessel is dynamically positioned and able to continue drilling or well works, but exclusively in ice that is **managed,** i.e. already broken up into small ice floes, by dedicated additional support icebreakers and supply ships in the vicinity of the drilling.

“We have not chosen to build a ship that can break ice [...]. But we have had to invest heavily in thrusters, they weigh 50% more than on the DrillMAX series, as they have to be ice-classed. [...] With good ice management in place, the vessel can remain in operation in the Arctic much longer [...], enabling better economics for the client,” (Tom Welo, CEO, Stena Drilling, 2009[1]).

2. The Bully Compact Drillship

The Bully Class drilling vessels are based on a previous, proprietary innovative drilling vessel design by Gusto MSC, the PRD12,000 Compact Drillship that is ordered by Shell EP Offshore Ventures and Frontier Drillships. Two vessels are under contract to be built as of mid-2010. The Bully design is a vessel suited for deepwater and arctic drilling. The planned design will be capable of drilling with surface blow-out preventers for controlled borehole conditions in up to 3,700 m water depth. The total drilling depth below the drill floor is 12,200 m. The vessel features an ice-classed hull with an icebreaker bow that permits safe and efficient operation under arctic conditions and has Dynamic Positioning capabilities in **managed first-year ice** of less than 1 m thickness. Heating systems will be installed for piping. Special heating units will also protect the ballast tanks. Operations under high Arctic conditions with harder, more demanding multi-year ice and under colder conditions are not considered in the design specifications, according to available doumentation.[4]

Table 1: Comparison of technical characteristics for AURORA BOREALIS and other dynamically positioned commercial drilling ships for Arctic operations.

Principal Data	Aurora Borealis [5]	Stena Drillmax IV "ICE"	Bully I and II
length overall [m]	199.95	228	187.5
width [m]	49	42	32
Displacement [Mt]	66,300	98,000	45,000
draught [m]	11.50/13.00/13.25	8.5/11.0/12.0	15.6
Constrcution year	2012-14 (planned)	2011	
Operational from	2014-2016 (planned)	2011	2009+2010
Principal Design base	New: SCHIFFKO PRV200	Stena DrillMAX	GustoMSC PRD12,000
Shipyard	TBD	Samsung Heavy Industries, Korea	Hull: Shanghai, China; Outfitting: Keppel Shipyard, Singapore
Owner Company	ERICON/TBD	Stena Drilling ltd.	Frontier Drilling / Shell E&O
tot. installed power [MW]	94	44.4	45.7
total crew	120	180	180
bunker capacity	12,300	11,500	3530
max endurance	90 days w/o re-supply	N/A	35 days w/o re-supply

Icebreaking and Dynamic positioning performance	**Aurora Borealis [5]**	**Stena Drillmax IV "ICE"**	**Bully I and II**
Ice Class	IACS PC 1	Hull: PC 5 / thrusters: ICE 10 (1 m level ice)	Hull: DNV ICE-05 E0
max Ice thickness	> 2.5 m level ice with 3 kt	> 1 m (?)	0.5 m level 1st year ice
Test in Icetanks	yes / > 2.5 m level ice, > 12 m ridges (HSVA & Aker Arctic)	Yes / HSVA (0.5, 1.0, 1.5, 2.2 m level ice, in managed ice)	yes / HSVA
max significant wave height [m]	5.5–7.5 m drilling	6.7 drilling/ 11.5 standby/ 16.o m survival	5m drilling, 6 m standby
max. wind speed [m/s]	20.7	27	N/A
Dynamic Positioning in open water/ice	yes / yes (DP2+)	yes / only in managed ice (DP3)	yes / only in managed ice (DP2)
Autonous/managed Ice	Autonomous	managed	managed
tot. thruster power	6x4.5 = 27MW	6x5.5 MW= 33 MW	25.5 MW
Cost			
Construction [Mill. €]	800	860	N/A
Operation/estimated day-rate	125,000-250,000	300,000-500,000 USD	N/A
Contracts	basic research	To be announced in future	800 Mill US $ for 5-yr contract excl. mob.
Drilling and Winterisation			
Nominal designation	Scientific Drilling (incl. ultra-deepwater)	Ultra-deepwater	Ultra-deepwater
max. Water depth	6000	3000 (2286 m currently)	2514 (8,250 ft) / 3657 (12,00 ft)
Moon pool [m]	7x7 (2x)	25.60 x 12.50	
Riser Equipment	only as addition	yes	yes
Minimum operational temperatures	–25° C (Drilling), –30° C science, –50° C ship operation	–20° C	about -15
Winterisation Class	DNV WINTERIZED(-50)	N/A	DNV WINTERIZED(-10)
ROV	1 mid-size ROV	ROV onboard, unspecified	2 ROV in hangar near Moon pool
offshore repair DP	thruster retrieval and repair mechanism	N/A	thruster retrieval and repair mechanism
helicopters	2 mid-size helicopters + 1 VTOL aircrat, or 3 helicopters or combined UAV	Helideck f. Sikorsky S-92A and EH-1 01	Helideck f. Sikorsky S-92A
add. Features	heeling tanks, full rig enclosure, seismic survey capacity, mooring arrangements	ice-classed "hat on top the drilling equipment	mooring arrangement for shallow water, heated installation and tanks

3. The ACEX Set-up

The first successful scientific deep-sea drilling in the ice-covered central Arctic Ocean was carried out during the Arctic Coring Expedition (ACEX) in 2004. In the ACEX expedition set-up organized by the Integrated Ocean Drilling Program (IODP), three ships had to be used: a offshore supply and survey vessel (Vidar Viking), heavily modified to become a geotechnical drilling ship, a conventional icebreaker (Oden) for ice management of smaller ice floes close to the drilling ship and a large Russian (Sovietsky

Soyuz) for breaking big ice flows at a certain distance. The operational demands on officers and crew were extremely high and the expedition was lucky to encounter lighter than average ice conditions at the drilling sites. A dedicated analytical workflow offshore was constrained to a minimum or non-existent and no possibilities existed to re-enter boreholes or apply cement casings, features that are standard techniques otherwise.[6] To date, any further drilling operations in the Arctic Ocean remain to be executed yet. This is mainly due to unresolved problems in icebreaking and dynamic positioning capacity of the drilling vessel in thick pack ice, logistical hurdles and high associated costs for execution of expeditions in sea-ice covered oceans with multi-ship set-ups.

Are Commercial Drilling Vessels Alternatives? — Financial Limitations

A non-technical, but limiting factor to take into consideration is that such highly specialised vessels are not foreseen to be available on the short-term charter market for the future ten to fifteen years, as demand exceeds the availability of these platforms.[7] They are mostly leased to O&G industry customers on a medium to long-term basis (i.e. for multi-year contracts) or are owned by O&G companies.

Day rates for "Arctic Class" commercial drilling vessel call up charter rates that can reach 500,000 US $ (mobilization and demobilisation not included). The additional chartering costs for the ice management vessels have to be added to the drilling vessel rates. The Bully I drilling vessel is reported to start operating based on a five year contract with a total contract value of about $800 million (mobilization not included), with optional four additional one-year extensions. The "Stena DrillMAX IV ICE" vessel is supposed to be leased like her sister vessels, on long-term contracts. Contract values for the non-reinforced sister vessels average at day rates between US $ 450,000 and 550,000 thus raising the total contractual values to the range of US $ 500 to 800 Mill. over the chartering periods.

In the ACEX setup the overall accumulated costs of the expedition were about 13 Mill. € resulting in a day rate for operations of about 350,000 €. Based on the works of the ERICON-AB ship operator expert advisory panel, the AURORA BOREALIS day rate for drilling is calculated to remain below 200,000 €. Normal day rates for other expeditions shall range even lower, between 125,000 and 135,000 €, bringing the cost for a scientist on board of AURORA BOREALIS below a competitive 3000 to 1800 € per day (capacity for 70 scientists/science support) combined with unique technical capabilities this platform provides.

It remains to be determined whether the European Consortium for Ocean Research Drilling (ECORD) of IODP (or future comparable programs) could leverage enough financial resources even under long-term planning to reach favourable contractual agreements with the respective ship operators and owners. This is deemed particularly relevant as the market situation is forecasted to recover within the next years, especially for the few highly-specialized ultra-deepwater "Arctic class" vessels.

Summary

AURORA BOREALIS is a demonstrator of innovation and features cutting-edge technology in ice breaking techniques and dynamic positioning. The vessel opens a door to autonomous station-keeping in drifting pack ice[5]. This design realises a worldwide unique multi-disciplinary research vessel with the ability to conduct autonomous drilling operations in all Polar Regions of the world ocean for the first time. It provides scientists unprecedented technical capacities and analytical facilities for marine polar research. The concept of AURORA BOREALIS is projected to realise these new scientific opportunities with comparably lower expedition costs than potential alternative multi-ship set-ups that are used in the commercial sector under less demanding ice and weather conditions.

References

[1]http://www.dnv.com/industry/maritime/publicationsanddownloads/publications/arctic_update/2009/01_2009/StenasDrillMAXICEtoDNVClass.asp

[2] POLAR CLASS GENERAL DESCRIPTION
PC 1 Year-round operation in all Arctic ice-covered waters
PC 2 Year-round operation in moderate multi-year ice conditions
PC 3 Year-round operation in second-year ice which may include multi-year ice inclusions
PC 4 Year-round operation in thick first-year ice which may include old ice inclusions
PC 5 Year-round operation in medium first-year ice which may include old ice inclusions
PC 6 Summer/autumn operation in medium first-year ice which may include old ice inclusions
PC 7 Summer/autumn operation in thin first-year ice with which may include old ice inclusions

[3] A common definition of "ultra-deepwater drilling capability" are operation in water depths greater than 12,000 ft.

[4] from: "Frontier Drilling USA, Inc.", Presentation 3rd Arctic Passion Seminar, 06 March, 2008. Helsinki, Finland.http://www.akerarctic.fi/3rdArcticPassionSeminar/FrontierDrilling%20Arctic%20Passion%20Seminar%202008%20edited.pdf

[5] for further technical information on station-keeping: Deter D; Doelling W and Lembke-Jene L "Station Keeping in Solid Drift Ice", *Proceedings of the 2009 DP-Conference*, Houston, Texas, 2009.

[6] for further information, please see: http://www.eso.ecord.org/expeditions/302/302.php

[7] e.g. *Lloyd'sList*, Friday, October 1, 2010. Offshore Energy, p. 7

The exploration market for the high-latitudes is evolving rapidly as well as the push for exploration farther north in more demanding cold environments. Thus, this summary constitutes no comprehensive analysis of all platforms available or under planning. The information in this document to the technical capacities and limitations is simplified, but provides information to operational constraints and the financial framework limitations that alternative drilling scenarios face.