Aurora Borealis – Development of a New Research Icebreaker with Drilling Capability

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Introduction

The International Polar Year (IPY), with its attempts to coordinate and foster cooperation on an international level in an unprecedented way, offers a unique chance for a leap of progress in our understanding of polar processes and their dynamics with their influence on the adjacent continents and the global environment. However, polar research both on land and in the sea cannot achieve the progress needed without novel and state of the art technologies and infrastructure.

There are many novel tools presently being developed for polar research. In this report we will concentrate on the planning for a new research icebreaker, *Aurora Borealis* (Fig. 1), with an all-season capability of endurance in permanently ice-covered waters and with the possibility to carry out deep-sea drilling in ice-covered basins.

Scientific Relevance of the *Aurora Borealis* Project

Polar research and, in particular, the properties of northern and southern high latitude oceans are currently a subject of intense scientific debate and investigations, because they are (in real time) and have been (over historic and geologic time scales) subject to rapid and dramatic climatic variations. Polar regions react more rapidly and intensively to global change than other regions of the Earth. Examples of these modern changes include news about shrinking of the Arctic sea-ice cover (potentially leading to an opening of sea passages to the north of North America and Eurasia, and in the long run to a "blue" Arctic Ocean) and news about the calving of giant table icebergs from the ice shelves of Antarctica. Until now it has not been clear how many of these profound shifts in all parts of the Arctic are natural fluctuations or are due to human activity. Since this is a phenomenon occurring over decades, long time data series of atmospheric and oceanic conditions are needed for its understanding and prediction of its further development.

Global climate models demonstrate the importance of the polar areas in forcing of the ocean/climate system. The presence or absence of snow and ice influences global heat distribution through its effect on the albedo, and the polar oceans are the source of dense, cold bottom waters, which influence thermohaline circulation in the world oceans. This global conveyor is a major determinant of Earth's climate.

Despite the strong seasonality of polar environmental conditions, research in the central Arctic Ocean up to now could essentially only be conducted during the summer months, when the Arctic Ocean is accessible only by the strongest research icebreakers.

In spite of the critical role of the Arctic Ocean in climate control, it is the only sub-basin of the world's oceans that has essentially not been sampled by the drill ships of the Deep-Sea Drilling Project (DSDP) or the Ocean Drilling Program (ODP), and its long-term environmental history and tectonic structure is therefore poorly understood. Exceptions are the ODP Leg 151 and the more recent Integrated Ocean Drilling Program's (IODP) Expedition 302 (Arctic Coring Expedition, ACEX, within the central Arctic; Myhre et al., 1995; Moran et al., 2006). The lack of data represents one of the largest gaps of information in modern Earth science (Nansen Arctic Drilling Program, 1992, 1997), also relevant for the field of hydrocarbon exploration. Therefore, the new research icebreaker *Aurora Borealis* (Fig. 1) should be equipped with proper drilling facilities to drill in deep, permanently ice-covered ocean basins. The icebreaker must also be powerful enough to keep station against the drifting sea-ice cover and will have to be equipped with dynamic positioning.

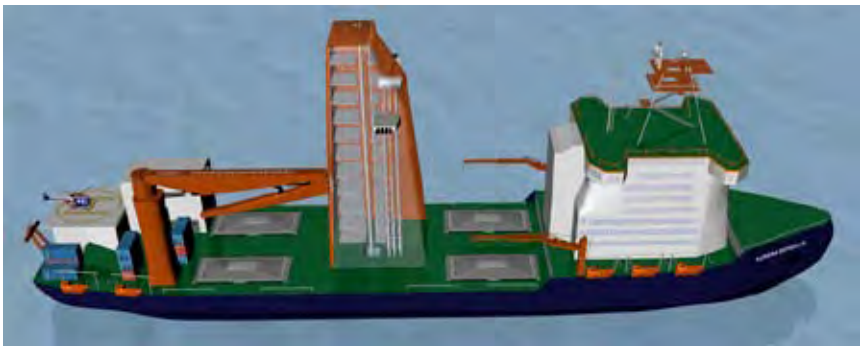

Figure 1. Initial design of the Aurora Borealis

The *Aurora Borealis* project impacts on two scientific communities which in part overlap in interests. The first one is

Figure 2. Aurora Borealis will have two moon pools for drilling and the deployment of ROVs or similar devices.

the general polar science community that requires a ship for conducting year-round field and marine work and has a wide spectrum of scientific perspectives. The second is the deep-sea drilling community that would use the ship mainly during the summer months with optimal ice conditions to study the structure and properties of the crust below the Arctic Ocean and to unravel the history of environmental and climate changes. While the ACEX expedition in 2004 is the only case of high Arctic drilling, substantial progress has been made around Antarctica by the drilling platforms of the DSDP and ODP during ice-free seasons. Also, deployment of small drill rigs from sea-ice very close to shore (ANDRILL, Cape-Roberts-Project) and shallow drilling from the ice-breaker *R/V Nathaniel B. Palmer* (SHALDRILL) have taken place.

The scientific objectives of the *Aurora Borealis* project are outlined in the "Science Perspective", published under the same name by the European Polar Board (EPB) of the European Science Foundation (ESF) in collaboration with ECORD (European Consortium of Ocean Research Drilling). A detailed accounting of the scientific objectives and research prospects can be found in these documents (Thiede and Egerton, 2004).

Technical Details

The research icebreaker *Aurora Borealis* will be the most advanced polar research vessel in the world with a multi-functional role of drilling in deep ocean basins and supporting climate/environmental research and decision support for stakeholder governments for the next few decades. The new technological features will include azimuth propulsion systems, satellite navigation, ice-management support, and the deployment and operation of remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs) from the twin moon pools (Fig. 2). The most unique feature of the vessel is the deep drilling rig, which will enable sampling of the ocean floor and sub-sea in up to 4000 m of water and with 1000 m penetration at the most inhospitable places on Earth. In the long term the drilling capability will be deployed in both polar regions, and *Aurora Borealis* will be the only vessel worldwide that could undertake this type of scientific investigation. The possibility to flexibly equip the ship with laboratory and supply containers, and the variable arrangement of other modular infrastructure (in particular, winches, cranes, etc.), free deck-space, and separate protected deck areas, will allow the planned research vessel to cover the needs of most disciplines in marine research, including the capability to carry out geophysical investigations (seismic reflection and refraction, gravity, magnetic, swath bathymetry mapping system, sediment echo sounder). The ship can be deployed as a research icebreaker in polar seas because it will meet the specifications of the highest ice-class for polar icebreakers. The vessel will be a powerful research ice-breaker with 44,000 tons displacement and a length of 196 m, with 50-megawatt azimuth propulsion systems. It will have high ice performance to penetrate autonomously (single ship operation) into the central Arctic Ocean with 2.5 meters of ice cover, during all seasons of the year. A large fuel capacity is required because of the excessive power requirements for drilling and maintaining station in the central Arctic (or other severely ice covered waters) during what are envisaged to be long expeditions. This factor is decisive for the large size of the ship. The construction of *Aurora Borealis* requires several new technical solutions and will provide an extended technical potential and knowledge for marine technologies and the ship building industry

Perspectives of the *Aurora Borealis* Project

Many northern nations have a particular interest in understanding the Arctic environment with its high potential for environmental change in response to global warning. In addition, considerable living and non-living resources are likely to be found below the Arctic Ocean and its adjacent continental margins. However, modern research vessels capable of penetrating into the central Arctic are few and mostly inadequate. Therefore, a new state-of-the-art research icebreaker is urgently required to fulfill the needs of polar research. This new icebreaker would be conceived as an optimized and multi-national science platform from the keel up and will allow long international and interdisciplinary expeditions into the central Arctic Ocean during all seasons of the year.

An efficient use of this icebreaker requires the formation of a consortium of several countries and a substantial build-up of their polar research institutions to ensure an efficient employment of the research vessel during all seasons of the year. Extensive and well-developed Arctic research programs exist in several countries, particularly in the Scandinavian countries, the U.S.A., Russia, and Germany. Each country has different organizations or working groups with rather diverse structures. The construction of *Aurora Borealis* as a joint European/international research ice-breaker would result from a considerable commitment of the

participating nations to coordinate and expand their polar research programs to operate this expensive ship continuously and with the necessary efficiency. *Aurora Borealis* would contribute to meet the Arctic drilling challenge within IODP; however, in a long-term perspective the *Aurora Borealis* would also be used to address Antarctic research targets, both in its mode as a regular research vessel as well as a polar drill ship.

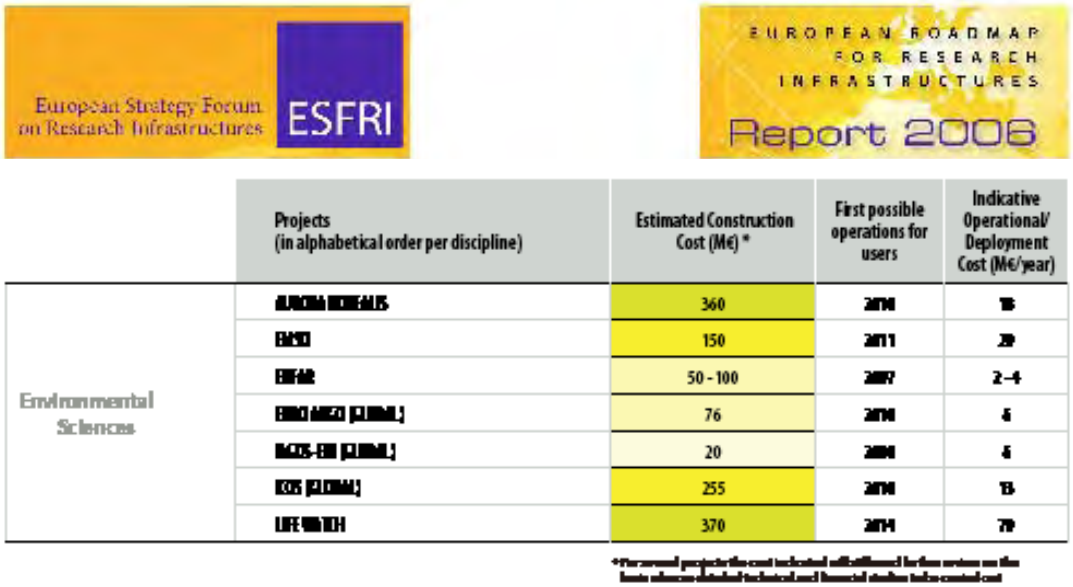

Figure 3. ESFRI Roadmap 2006 of the European Commission (http://www.eubuero.de/arbeitsbereiche/infrastrukturen/esfri/Download/dat_/fil_2076).

The German Science Council evaluated the *Aurora Borealis* project in May 2005 and recommended the construction of the research icebreaker in 2006. Since March 2007 the German Federal Ministry for Science and Education (BMBF) has been funding a portion of the preparatory work for *Aurora Borealis*. In this project the final engineering work for the development of the vessel is carried out under coordination of the Alfred-Wegener-Institute and the University of Applied Sciences in Bremen. Additionally, the engagement of the European science community will be promoted by organizing workshops in different European countries to discuss science plans and technical requirements for the *Aurora Borealis*.

The European Commission identified the project for the European Strategy Forum on Research Infrastructures (ESFRI) Roadmap (Fig. 3). The Commission found that it reached the highest scientific priority for developing this large-scale infrastructure for basic research in Europe. A European consortium of sixteen institutions, funding agencies, and companies from eleven European nations including Russia has already formed to develop management structures for this unique facility and to implement it into the European Research Area.

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