Status and foreseeable evolution of the European and International Polar Research Fleets & Equipment

21 January 2014 V0.7

Grant Agreement n° 312762

Acronym: EUROFLEETS2

Title: New operational steps towards an alliance of European research fleets

Activity type: Networking
WP N°: 3
Task N°: 3.1 Determination of available capacities
Deliverable N°: 3.1

Reference : EUROFLEETS2-WP3-D3.1-210114-V0.7.doc
Security : Public

Document information	
Document Name	**Status and foreseeable evolution of the European and International Polar Research Fleets & Equipment**
Document ID	EUROFLEETS2-WP3-D3.1-210114-V0.7.doc
Revision	V0.7
Revision Date	21/01/2014
Author	CSIC-UTM
Security	Public

Approvals				
	Name	**Organisation**	**Date**	**Visa**
Coordinator				
Activity Coordinator				
WP Leaders	JJ Dañobeitia	CSIC		

History			
Revision	**Date**	**Modification**	**Author**
0.1	18.12.2013	First release	JJ Dañobeitia
0.2	30.12.2013	Revised version	JJ Dañobeitia
0.3	09.01.2014	Revised version	N Biebow & V. Willmott
0.4	10.01.2014	Second release version	J.J. Dañobeitia & M. A. Ojeda
0.5	14.01.2014	Revised version	Thomsen, Helge
0.6	18.01.2014	Revised version	N Biebow & V. Willmott
0.7	20.01.2014	Third revised version	Magnus Tannerfeldt & J.J. Dañobeitia

Diffusion list				
AWI	Biebow, Nicole	Willmott Puig, Veronica		
CSIC-UTM	Ojeda, Miguel Angel	Dañobeitia, Juanjo		
DTU-Aqua	Thomsen, Helge Abildhauge			
SPRS	Tannerfeldt, Magnus			

1. General Introduction

The WP3, Polar Vision is aiming at integrating the European Polar Research Vessel (PRV) fleet by establishing models for implementing a joint coordination of this fleet. It is pointing to find appropriate ways at optimizing the usage of the European Polar Research Vessels by:

- Determining the available capacities of PRV´s
- Comparing that with the scientific demand, in accordance with IASC (International Arctic Science Committee) and SCAR (Scientific Committee on Antarctic Research) for Research in the Polar Oceans
- Establishing Models for optimization of this fleet by better coordination of the vessels scheduling and by harmonizing the deployment of ice-strengthened research vessels with the heavy icebreakers

2. Description of task 3.1 from DoW

Task 3.1 – Determination of available capacities (M1-M24): This task will cover the following aspects:

The first step to establish a joint Polar Research Fleet will be to identify the existing capacities of Polar Research Vessels. This task should go beyond a simple technical description of the Polar Fleet (European and International) and should provide an overview of the real availability and the capacities of the vessels (Ice-Class, capacity to deploy heavy equipment etc.), interoperable equipment, working areas and also plans for building new Polar vessels. The compilation will not be limited to European capabilities but also the international Polar Research Fleet and further possibilities for marine polar research (e.g., drifting ice stations, tourist vessels) will be considered when relevant.

The following topics will be addressed:

- Which ships have worked in the Polar Oceans during the last 5 to 10 years and where do they operate (topic to be covered in cooperation with COMNAP, FARO, IRSO and ERVO
- What kind of equipment and capabilities are available aboard the PRV´s and what are the new requirements from the science? How will the upcoming Polar Code effect PRV deployment, development and research in the Polar Areas?
- How can these vessels be accessed (including Russian icebreakers, US and Canadian Coast Guard ships, etc.?)
- Timeline for life time of vessels
- Foreseeable evolution of the Polar Fleet
- General information on the standard plans of operations of each vessel (in which region, to which boundary) and their technical capabilities will be compiled and synthesized and kept up-to-date;

3. Meetings

A kick-off meeting was held in Brest, 19-21 March 2013, discussing the goals to be achieved. All beneficiaries participated.

A second meeting took place in Barcelona, 7-8 October 2013, where first progressing results were discussed and a general strategy was formulated. All beneficiaries involved in Task 3.1 joined the meeting.

The partners responsible for Task 3.1 participated in a workshop devoted to Icebreakers organized by COMNAP, Council of Managers of National Antarctic Programs, and managed by Heinz Miller (AWI). This meeting took place 19-21 October 2013 in Cape Town, where an oral presentation entitled *Polar Vision initiative for Access to Polar Vessels* was given by JJ Dañobeitia. Miguel A. Ojeda and Juanjo Dañobeitia attended the meeting.

The task leader Juanjo Dañobeitia attended as well the 26th IRSO meeting (International Research Ship Operators), 30 October till 1st November in St. Johns Newfoundland, Canada. He gave an oral presentation entitled *EUROFLEETS Polar Research*.

A progress meeting took place in Barcelona at 13th December 2013 in association with the 2nd Scientific Review Panel Meeting to discuss the first draft report. Nicole Biebow, Veronica Willmott, Miguel A. Ojeda and Juanjo Dañobeitia participated.

4.1 Polar code

The retreat of Arctic sea ice due to global warming is rapidly opening up the Arctic to increased international and intra-Arctic shipping. It is now possible, and may soon be common, to ship goods from Asia to Europe and eastern North America via the Northern Sea Route or even further north. The increasing industrialization of the Arctic is also a major factor in the growth of Arctic shipping.

The IMO began working on the mandatory Polar Code in 2010 within its Subcommittee on Design and Equipment (DE) and since then the DE meetings and the intercessional Correspondence Group, has made considerable effort to focus on the development of a Code. During 2013, the DE sub-Committee made significant progress in further developing the draft Polar Code, in particular with the finalization of a draft chapter on environmental protection. An intercessional meeting of the Polar Code Working Group was held in October 2013, to further progress the work. The working group also further developed the technical parts of the draft Code during the session.

The Polar Code is intended to cover the full range of shipping-related matters relevant to navigation in waters surrounding the two poles – ship design, construction and equipment; operational and training concerns; search and rescue; and, equally important, the protection of the unique environment and eco-systems of the polar regions. All these recommendations and concerns are bound to impact on new constructions of PRV's, especially with reference to the requirements included in part A of the Code becoming mandatory.

Some agreements are at the moment clearly defined by the DE subcommittee as:

- Polar Ship Categories.

• Category A ship: means a ship capable to operate at least in medium first-year ice which may include old ice inclusions in accordance with an ice class at least equivalent to those acceptable to the Organization.
• Category B ship: means a ship capable to operate in sea ice conditions other than those included in Category A with an ice class at least equivalent to those acceptable to the Organization.
• Category C ship: means any ship which is not a Category A or Category B ship.

- All ships operating in polar waters should have a Polar Ship Certificate and a Polar Water Operation Manual.

- The Code will be adopted by separate Maritime Safety Committee MSC and Marine Environment Protection Committee (MEPC) resolutions, with amendments to mandatory instruments to be developed to make the Code mandatory. The aim is to finalize the draft Code in 2014 for adoption by the (MSC) and (MEPC).

POLAR CLASS	GENERAL DESCRIPTION
PC 1	Year-round operation in all Polar 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 which may include old ice inclusions

4.2. Status of the European and International Polar Research Fleets

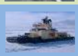
Introduction

We have collected information on Polar Research Vessels (PRV) operating at both Poles (Arctic and Antarctic). In a first approach, we have distributed the PRV´s in two categories, i.e**., a) Heavy Icebreakers** and **b) Ice Classified.** These classes will be modified once the new classification is approved by the coming Polar Code unifying the different existing classes into only three categories: A, B and C. Most of the information has been assimilated from different workshops and meetings and also provided by EurOcean, COMNAP Icebreaker workshop, IRSO, ERVO, etc.

4.2.1 General Description of Heavy Icebreakers

We have identified 14 Heavy Icebreakers (Table I) potentially empowered to accomplish research in the Polar Oceans. However, these ships show great variability with reference to capacities, equipment, schedules, access, etc. All of these Research Vessels, to some extent, also have capacities to support polar stations within the Antarctic or Arctic zones, having helideck facilities to operate at least one helicopter. Most of them have some capacity to support research, and a few of them are fully equipped for multidisciplinary science. During 2013 major refits have been accomplished for the Aurora Australis (AUS) and Xue Long (CHIN). Only two of the heavy icebreakers are based within the European Union (‘Polarstern’ from Germany and ‘Oden’ from Sweden). Russia operates a large PRV fleet mainly in the Arctic Ocean, but most of the vessels are not used for research.
The heavy Icebreakers are generally long vessels (95-167 m) with high draft and well prepared for long endurance voyages. The crew ranges mostly from 25-45 members, except for the Russian Icebreaker Akademik Federov which reports 80 people and the Swedish PRV Oden which reports only 23 crew members.

TABLE – I. General characteristics of Polar Research Vessels, Heavy Icebreakers

	Ship Name	Picture	Country	Length	Built year	Operator	Ice Class	Operating area		Underwater Vehicles supporting	Heli deck/h an	Heli	Supply to station	Major Refit
Full range Icebreakers	Agulhas II,		Souht Africa	134	2012	SANAP	PC5	Antarctic		no	yes/yes	2	yes	
	Akademik Federov		Russia	141	1987	AARI	KM * ULA [2]A2	Antarctic	Arctic	Saab Seaeye Falcon 300 m	yes/yes	2	yes	
	Akademik Tryoshnikov		Russia	134	2011	AARI	PC4-PC5	Antarctic	Arctic	no	yes/yes	2	yes	
	Almirante Irizar		Argentina	121	1978	Argentina Navy	1m thick	Antarctic		no	yes/yes	2	yes	underway
	Amundsen		Canada	98	1979	CCG	100 A3		Arctic	ROV SuperMohawk	yes/yes	1	yes	2003
	Araon		South Korea	110	2009	KOPRI	PC5	Antarctic	Arctic	yes	yes/yes	1	yes	
	Aurora Australis		Australia	95	1989	P & O / ADD	A1	Antarctic		no	yes/yes	2	yes	2013
	Healy		USA	128	1997	USACGC	PC3 ?	Antarctic	Arctic	yes (AUVS)	yes/yes	1	eventually	
	Louis S. St-Laurent		Canada	120	1969	CCG	A4		Arctic	yes (AUVS)	yes/yes	2	yes	decommisi soned 2017
	Nathaniel B. Palmer		USA	94	1992	USAP	A2	Antarctic		no	yes/yes	2	yes	
	Oden		Sweden	108	1988	SMA	DNV-Polar 20		Arctic	no	yes/yes	1	yes	
	Polarstern		Germany	118	1982	AWI	100 A5	Antarctic	Arctic	ROV till 6000 m	yes/yes	2	yes	2002
	Shirase II		Japan	138	2008	Ministry of Defence & JARE	PC5	Antarctic		no ?	yes/yes	3	yes	
	Xue Long		China	167	1993	CAA	CCS B1	Antarctic	Artic	Artic class AUVS	yes/yes	2	yes	2013

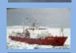
Most of these Heavy Icebreakers are operated by National Science Agencies; exceptions being those operated by the USA and Canada Coast Guards, and the ones operated by the Navy in Argentina and the Ministry of Defence in Japan. Within the last few years, only five of the vessels listed have operated in both Polar Oceans, the general rule being that a specific ship is dedicated to operation at one Pole or the other. The heavy icebreakers are generally old ships and only three of the 14 ships listed are less than 5 years old. The rest of them have more than 20 years of activity. We have identified only the Araon, Amundsen and the Polarstern capable of working with **Deep Sea ROV´s**. the PRV´s Polarstern, Healy, Louis S. St Laurent and Xue Long have AUV´s capacities.

Technical information and scientific equipment

Most of the ships have the primary mission to resupply their national Polar stations. Thus they have large capacity to both handle cargo, either in containers or in the hold, and transport researchers – a capacity which is also relevant and beneficial in the context of research cruises at large. However, just a few vessels actually combine a high carrying capacity of cargo and passengers with state-of-the art cranes/winches capabilities. There is therefore within the fleet a noteworthy lack of large scale multidisciplinary science capacity. Only a few vessels have DP systems enabling the manoeuvring of a ROV system, and/or the MARUM Mebo.

Concerning the technical capabilities for basic surveying, all ships are - with few exceptions - fully equipped for all kinds of basic scientific work especially for sampling both the water column and the sea bed, i.e. different types of coring devices, dredges, CTD’s, etc. Most of the research vessels, with the exception of the older ones and surprisingly also the new PRV Agulhas II, are equipped with elaborate acoustic systems like multibeam echosounder and subbottom profiler. However, only a few vessels are well equipped to perform marine geophysics at large. Polarstern, Nathaniel B. Palmer, Louis S. St-Laurent, and Araon maintain high standard capacities for 2-D seismic surveys, and Polarstern, Nathaniel B. Palmer, Healy, Araon, Amundsen, and Agulhas II have coring tools capacities. Also Oden, with its swing-role functionality, is de facto utilized to carry out seismics and coring. With regard to measuring potential fields (gravity and magnetics) the Polarstern, Nathaniel B. Palmer, Healy, Araon, and Amundsen are particularly well equipped. Very few vessels have a moon pool, which is a useful feature for the deployment of equipment under hard ice conditions.

TABLE – II. General characteristics of Polar Research Vessels, Ice Class

	Ship Name	Picture	Country	Length	Built year	Operator	Ice Class	Operating area	Underwater Vehicles supporting	Heli deck/hangar	Heli	Supply to station	Major Refit
RV's Ice classified	**Almirante Maximiniano**		Brasil	93,4	1974	Brasil Navy	Ice 1C	Antarctic	no	yes/yes	1	yes	
	Aranda		Finland	59,2	1989	Finnish Env. Insti.	1A Super	Artic	BENTHOS (375 m cable)	yes/yes	2	no	
	Arni Fridriksson		Iceland	69,9	2000	MRI	1B	Artic	no	no	no	no	
	Dana		Denmark	78	1981	DTU Aqua	1C	Artic	ROV till 300 m	no	no	no	
	Ernest Shackleton		UK	80	1995	BAS	DNV; ICE05	Antarctic Artic	yes	yes	1	yes	
	G.O. Sars		Norway	77,5	2003	UiB	Ice 1C	Artic	yes	no	no	no	
	Helmer Hanssen		Norway	64	1988	Tromsoffshore/ University of Tromso	Dnv 1A	Artic	yes (Aglanta 2000m)	no	no	??	1992
	Hesperides		Spain	82,5	1991	Spain Navy/UTM	Ice 1C	Antarctic Artic	no	no	no	yes	2001
	James Clark Ross		UK	99	1990	BAS	Lloyds IAS	Antarctic	yes	no	no	yes	
	Lance		Norway	61	1978	Tromsooffshore/ Norwegin Polar Ins.	Dnv 1A	Antarctic Artic	no	yes	1	yes	1992
	Laurence M. Gould		USA	70,2	1997	USAP	ABS A1	Antarctic	no	no	no	yes	
	Maria S Merian		Germany	95	2005	IOW_Warnemunde	PC 7	Artic	yes	no	no	no	
	Multanovski		Russia	72	1983	Russian register	Lloyds 1D	Antarctic Artic	no	no	no	??	
	OGS-Explora		Italy	73	1973	OGS -Trieste	1c	Antarctic Artic	no	no	no	no	
	Oscar Viel		Chile	90	1969	Chile Navy	Ice 1C	Antarctic	no	yes	2	yes	
	Sagar Kanya		India	100	1983	NACAOR		Antarctic Artic	no	no	no	yes ?	
	Sanna		Greenland	32,3	2012	GINR	Ice 1A	Artic	no	no	no	no	
	Tangaroa		New Zealand	70	1991	NIWA	Ice 1C	Antarctic	yes	no	no	yes	

4.2.2 General Description of Ice Classified PRV

The Ice Class research vessels are mostly designed for science purposes, except the PRV Oscar Viel which is basically a station supplier. This is clearly exposed in terms of equipment and personnel capacities. Most of the ships have e.g. underwater vehicle capacity for both AUV´s and ROV´s. It is also noticeable that most vessels (with the exception of some naval ships) have ample space for scientist and technicians due to a reduced crew. There is a reasonably good balance between vessels operating at either pole.

Technical information and scientific equipment

Ice Class Research Vessels are very well equipped for all types of marine research. The list of major equipment encompasses e.g. sophisticated acoustic systems (multibeam sonars mapping, subbottom profilers, hydroacoustic systems, adcp, fisheries acoustics, etc.) and modern navigation devices. All vessels have significant laboratory spaces comprising both wet and dry laboratories, as well as powerful winches, A-frames, cranes, and handling equipment with variable types of cables, that support almost all water column and bottom sampling scenarios (CTD, multinets, dredges, etc.) as well as a broad variety of towed equipment. Some of the vessels support marine geoscience scenarios with high equipment standards in deep sea coring and 2-D seismics (multichannel or high resolution, air compressors, etc.).

4.2.3 New constructions/projects of Polar Vessel

Here, we report on new projects and/or construction of modern heavy icebreakers. The most advanced project is 'Kronprins Haakon', a Norwegian Icebreaker (polar class; PC 3) who's tendering finished by the end of year 2013 aiming for delivery by mid to late 2016. A second advanced project is the replacement of the German icebreaker, Polarstern, which is scheduled to start building in 2016. There are other ongoing icebreaker projects, in e.g. Australia, where feasibility studies are at different stages of maturing.

.

4.2.3.1 Norwegian Icebreaker, Kronprins Haakon

This is a new Norwegian icebreaker owned by the Norwegian Polar Institute (NPI) that will be operated by the Institute of Marine Research (IMR) having as its main user the Norwegian Polar Community.

- First proposal from NPI end of 1999
- Feasibility study completed June 2007
- Design contract won by Rolls Royce Marine in 2008
- The initially proposed design has been modified and detailed in close cooperation with the user community.
- Concept approved by Ministry of Finance in 2011
- Funding approved by the Norwegian parliament for the 2013 budget
- Tender deadline by 28 October 2013
- Shipyard contract signed December 2013?
- Ship delivery mid to late 2016

Length over all (LOA):	100.0 m
Breadth:	21.0 m
Draft:	8.0 m
Gross tonnage:	9000 T
4 diesel gensets (A/C)	17 MW
2X5MW and 2x33,5 MW	
Two (Z-drives) aft	11 MW
Two tunnel thrusters fwd.	2.2 MW
LNG-gensets for ice station use	
DP-2	
DNV-Class: polar 10 Icebreaker	
PC 3 Year-round operations in second year ice which may include multiyear ice inclusion	

Technical details

- Accommodation for 55 persons in 38 cabins (15-17 crew)
- Maximum cruising range of approx. 15.000 nautical miles
- Endurance 65 days at cruising speed
- Designed to operate in winter ice with pressure ridges and multi-year ice
- Continuous ship speed when breaking 1,0 m ice thickness: 5 knots
- Continuous ship speed when breaking 0,4 m ice thickness: 12 knots
- Hull structure, appendages and cranes to operate to at least -35º C

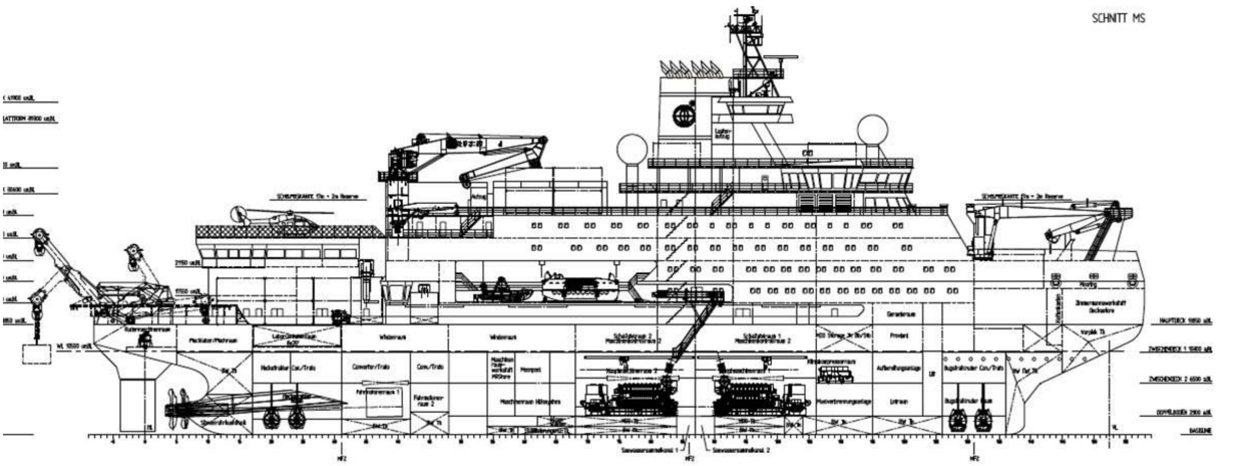
Layout

- Arranged and equipped with state of the art scientific instrumentation for
- Oceanography
- Marine biology
- Geology (bottom coring and grabbing)
- Trawling
- ROV and AUV operations
- Most of main working desk dedicated to laboratories and work deck area
- Moonpool and hangar for sampling in low temperatures

4.2.3.3 German Icebreaker, Polarstern II

- **Length ~ 140 m**
- **Width ~ 27 m**
- **Draft ~ 10.6 m**
- **Main engines 24 MW**

2016: start building



Present concept- General 1

- PC 2 or PC 3" - classification and relevant requirements MARPOL for the Antarctic
- Extreme Temperatures (+45°C to – 50°C) and lifecycle of 30+ years; winterization concept
- Main dimensions (present design study): length: ca. 133 m, width: ca. 27 m, draught 10.5 m
- Cruising range up to 10.000 nm (at v=12 kn)
- Endurance up to 90 days
- Cargo up to 1200 t (incl. supply to Neumayer III)
- Max. 130 Persons on board, incl. 44 crew; single and double cabins
- Rooms for seminars etc.

Present concept- General 2

- Survival (Lifeboats) 100% each side
- Safe Return to Port concept and survival concept in case beset by ice
- Highest possible reliability
- Excellent manoeuvring capability, incl. dynamic positioning
- Stabilising capability on station as well as during transit
- Helicopter landing pad and hangar for 2 helicopters
- Open working deck, labs, winches, cranes etc. as required by science
- Laboratory and supply containers (max 80 x 20") + bulk cargo capability

Requirements hull / hull lines/

- Structure according to max. ice loads; hull optimized for navigating in ice as well as breaking ridges
- Hull optimized for transit in open water (benign in heavy seas, resistance, energy efficiency, …)
- Hull optimized with respect to noise and vibration (ICES 209)
- Hull optimized with respect to hydroacoustics (e.g. air bubble problems)
- Optimizing airflow around the ship (atmospheric chemistry requirement)
- etc., etc., etc. .

Requirements propulsion and energy

- Diesel – electric propulsion
- IMO Tier III
- ICES 209
- "Silent ship"
- Dynamic Positioning
- High level energy efficiency- and environmental standards e.g. „Blauer Engel"
- High level redundancy of all systems

4.2.3.4 Other Non-European Projects

USA Project RV Sikuliaq

The Sikuliaq is a research vessel being built by Fincantieri for the US's National Science Foundation (NSF) and will be one of the most sophisticated university research vessels in the world. Its home port will be at the UAF Seward Marine Center in Seward, Alaska, where the vessel will be used by US scientists and the international oceanographic community. The design of the ship was completed in 2004. Its construction began in April 2011 and it was launched in October 2012, it will be ready for unrestricted science operations in 2014.

GENERAL CHARACTERISTICS		
Length, Overall	LOA	261 feet
Length, Design Waterline	LWL	237 feet 0 inch.
Beam, Max across reamer	Bmax	52 feet
Beam, Max across hull amidship	Bmidship	48 feet
Depth, Keel to Main Deck	D	28 feet
Draft, Design Waterline	TDWL	18 feet 9 inch.
Freeboard, Design Waterline	FDWL	8 feet 9 inch.
Displacement at Design Waterline		3,665 long tons
Propulsion Power	P	5,750 BHP

RV SIKULIAQ

The research vessel is an almost 80 m long and will be able to break ice up to 80 cm thick. It is intended for work in the Arctic, the Bering Strait and the Gulf of Alaska. It will be used for oceanographic research for a minimum of 30 years.

Australian Project for Research Supply Icebreaker

- Open approach to market via Austender on 9 January 2013and closed on 9 May 2013
- Process was no-binding and proposals were submitted by industry on understanding that funding was not approved
- Stated intention was to create a shortlist of Respondents from the RFP process who would be invited to respond to a subsequent prequalified/select Request for Tender

		ICEBREAKING CAPABLITIES		
		1.50 m	1.65 m	1.80 m
CARGO CAPACITY	800 tonnes dry cargo; plus 1,100,000 Llitres of bulk fuel comprising a minimum of 800,000 litres station fuel and balance compising aviation fuel)	# 1	# 2	# 3
	1000 tonnes dry cargo; plus 1,300,000 litres of bulk fuel (comprising a minimum of 800,000 litres station and fuel balance comprising aviation fuel)	# 4	# 5	# 6
	1,200 tonnes dry cargo; plus 1,900,000 litres of bulk fuel (comprising a minimum of 1,100,000 litres station fuel and balance comprising aviation fuel)	# 7	# 8	

A conceptual study for Chilean Icebreaker

It seems that the project is freezing until the new Ministry is taken care

4.3. New requirements from the science community regarding equipment and capabilities aboard PRVs

Due to ever increasing costs for ship deployment, and increasing needs for transdisciplinary research, the next generation of PRV's must be multifunctional, and comprise modular components that are easily interchanged, mobilized and demobilized depending on the type of research scheduled for an upcoming cruise. The ship should have the capacity to operate in winter ice with pressure ridges and multi-year ice. The ship should be equipped with a centreline moon pool to facilitate sampling of the water column under extreme conditions and to enable also e.g. the deployment of autonomous underwater vehicles (AUV) and remotely operated vehicles (ROV) through this access point. As the Antarctic Research Vessel Oversight Committee (ARVOC, USA) suggests, new technological capabilities are expected to support the investigation of atmospheric sciences using remote sensing instruments based on laser and microwave technologies. This also includes unmanned aerial drones for use in the atmosphere, sea ice, and studies of glacier ice in areas where polar research vessel will be required to serve as the main base. Acoustic instruments are crucial to both physical and biological marine research. These include multibeam sonars mapping, subbottom profilers, acoustic current meters, fisheries acoustics, and acoustic underwater positioning and navigation systems. An optimized hull design is therefore required to achieve a certain acoustic data noise reduction level (ringing, reverberation, background noise, acoustic blocking, etc.) as well as for transit in open water (benign in heavy seas, resistance, energy efficiency etc.). Powerful and versatile winch and crane arrangements are key elements.

4.4. Access to Polar Research Vessels

Access to research vessels, whether icebreakers or ice classed ships is relatively well regulated in most countries, whether it's for marine research or more specifically for polar research. Most national R & D programs have regular marine research project calls that provide also access to large scale marine infrastructures. The application follows in most countries an almost identical procedure of quality control and peer review. In the case of countries which operate specific polar institutions, typically identified as National Polar Institutes, the proposals are received directly by the polar institute and evaluated according to their own regulations.

Once research projects are prioritized the allocation process for operating days on a vessel may depend, in the case of large icebreakers, on the logistics for resupply of their stations. Ice classified vessels do not depend so much on other logistic demands and are generally more focused on the research scheduled so allocation of ship-time should prove more easy. Access for a researcher to a vessel belonging to a different country is always difficult. Usually such access can only be secured if the researcher collaborates with a PI from the country that owns the vessel in question. However, good scientific collaboration exist among countries and it is therefore not uncommon that a single researcher or a group of scientists are invited to complement multidisciplinary research planned for and carried out on board a vessel owned and operated in a different country. However, for a research group to gain access to an entire vessel belonging to a different country is only possible under very special circumstances further elaborated upon below.

One opportunity that exists for this type of collaboration is through application for ship time through the EU funded EUROFLEETS project (see: http://www.eurofleets.eu/np4/57). EUROFLEETS2 is a EU funded project providing scientists with 73 fully funded days of ship time on 8 Global/Ocean class research vessels and 127 days of ship time on 14 Regional class research ships including the use of large equipment such as ROVs and submersibles. In addition, EUROFLEETS2 provides for the first time 104 fully funded days of marine equipment-time to carry out ship-based research activities within any field of marine science.

A second example of a set up that opens up for conducting research cruises on ships from different countries is the barter system implanted in OFEG (Ocean Facilities exchange Group). Since 2002 a group of institutions from 6 European countries have agreed on mutual cooperation with reference to marine scientific interests and activities on a 'no-money-flow' basis (i.e. barter). From the perspective of each participating organization this arrangement has two significant advantages. It allows their scientist's access to a wider range of facilities and equipment than would otherwise be possible. This includes de facto 21 research ships and other facilities such as manned submersibles, remotely operated vehicles (ROVs), towed arrays and shipboard surveying systems. Such facilities are required to carry out “cutting edge” research, but are frequently so expensive that it makes little sense for each country to purchase their own facilities. Among the vessels included in the OFEG barter system are some of the ice classified vessels (Maria S. Merian, G.O. Sars, James Clark Ross and Hespérides), and one heavy icebreaker, i.e. the German Polarstern. However, this vessel cannot be exchanged for points in the barter system but can instead be used for joint cruises.

4.5 Foreseeable evolution of the Polar Research fleet

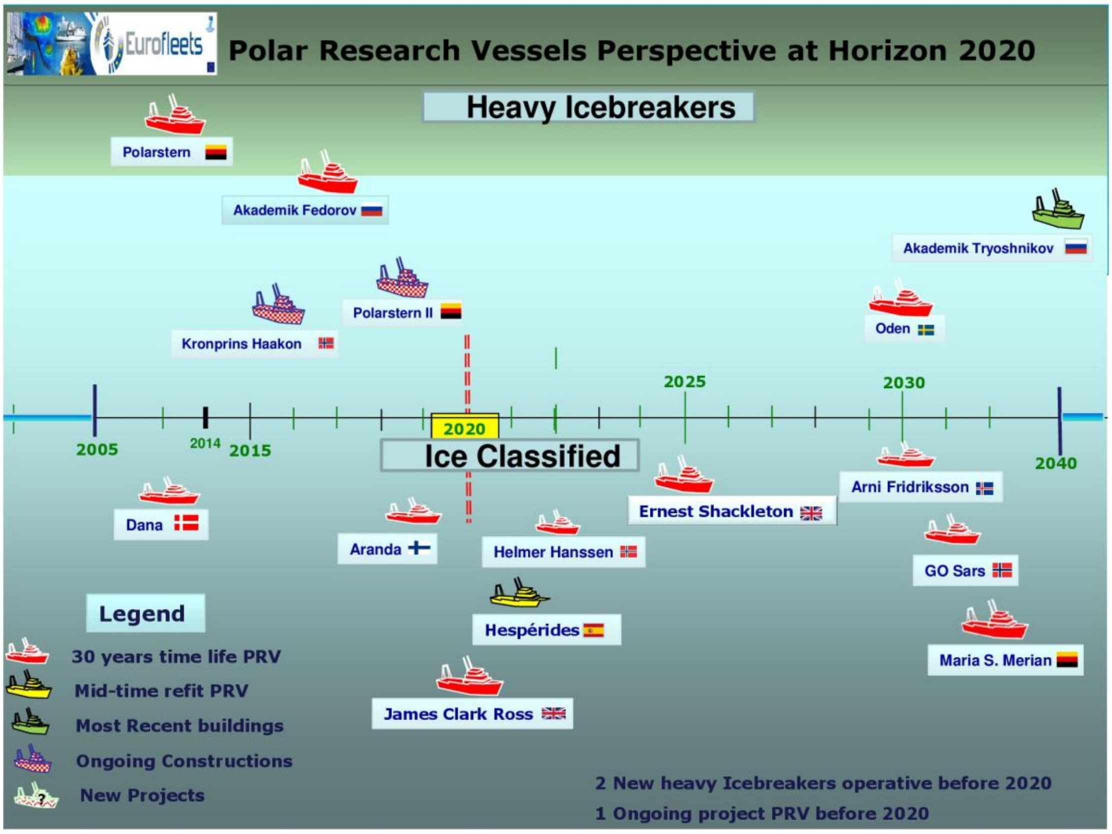
We consider here the perspective of the European Polar Research fleet (**Figure 1**) based on the scenario in the beginning of 2014. From the point of view of the heavy Icebreakers, Europe has two operative vessels, the Oden which is dedicated exclusively for Arctic research since 2011, and the Polarstern which mostly spends her time in Antarctic waters. Polarstern is reaching the end of its life time, after 30 years of continuous operation, while Oden has an estimated 15 years to go without a major refit.

There are some progressing projects such as the Norwegian 100 m length PRV Kronprins Haakon, polar class PC 3, tendering for construction at the end of 2013, which the target to be operative by mid to late 2016. This is an innovative PRV project with a LNG (liquefied natural gas) generator for ice station, with a low underwater noise radiation following ICES-209, a redundant DP system and deep sea ROV and AUVS operations, together with a moonpool and a hangar for sampling at low temperatures. This vessel is carrying state of the art equipment to support the highest possible standard in Polar science targeting areas mostly in the Arctic region. There is a second ongoing project to replace the Polarstern by Polarstern II. This is a 140 m length PRV with Ice classification PC2-PC3 and designed with an optimized hull to reduce to noise and vibration (ICES 209), high level energy efficiency- and environmental standards following “Blauer Engel” certificate, a moonpool, and a hangar for sampling at low temperatures. Polarstern II is planned to be arranged and equipped with state of the art scientific technology that will support high class research standards and with a significant cargo capacity to supply the German Antarctic station Neumayer III. It is estimated to be operational in 2019.

Concerning the other ice classified PRV’s, the James Clark Ross and the Hespérides will continue in operation until 2020 at the end of their expected life time, while the Ernest Shackleton will reach 30 years of polar service by 2025. Only three of the ice classified PRV’s, i.e. Arni Fridriksson, GO Sars and the Maria S. Merian, mostly operating in Arctic waters, will remain in operation well beyond year 2020.

The worldwide scenario for heavy icebreakers is a little bit improved due to recent constructions. The maintenance of operations at least in Antarctic waters is almost guaranteed by the three icebreakers recently built (Araon / 2009), Akademik Tryoshnikov / 2011, Agulhas II / 2012), although these vessels – with the exception of the Araon - are more specifically commissioned to polar stations supply than to perform marine research. There is additionally some progressing projects like the USA R/V Sikuliaq launched in October 2012 - the first vessel built for the National Science Foundation in more than three decades. The R/V Sikuliaq is an almost 80 m length well equipped research platform that will be operated by the University of Alaska Fairbanks School of Fisheries and Ocean Sciences when entering service by September 2014. The vessel enables up to 26 scientists. Furthermore, there is an open approach for an Australian research supply icebreaker, and a conceptual study for the replacement of the Chilean Icebreaker Viel. It should be noted than of the proposed new research vessels, European and non-European; none are planned with sufficient capacity to operate year round in Arctic waters or even in heavy summer ice conditions.

Figure 1.Outline of operative Polar Research Vessels (PRV) and of the new constructions along their time life.



4.7. – Conclusions

The capacity and infrastructure of the European Polar fleet does not reach the level that is needed by the European Polar Research Community, even when considering the ongoing construction projects of Kronprins Haakon and Polarstern II, to support the societal demands and needs for multifaceted polar research targeting critical thematic issues such as climate change impacts at large, e.g. ocean circulation patterns, and sustainability in exploitation of natural resources addressing e.g. environmental issues, biodiversity, and systems ecology. There is beyond doubt an increased interest within the European society for Polar Research involving both an Arctic and an Antarctic dimension. The Arctic scenario is currently in the public dominated by both open disputes between the costal nations with regard to claims for sea territories and access to natural resources, and awareness and concern about the increasing marine traffic at high latitudes. The Antarctic scenario is somewhat different, possibly due to the strength of the Antarctic Treaty. However, in both regions the study of recent and past climate processes, oceanic circulation and other topics require a complex and expensive scientific infrastructure as well as a significant international cooperation.

On a global scale the current heavy icebreaker fleet analyzed here show signs of aging as a whole (**Figure 2**). When estimating an average vessel lifespan of 30 years and correcting where midlife refit is reported, the life-time termination of the fleet will be about year 2025. This scenario predicts that few of the current European Heavy Icebreakers will be operating beyond the 2020 horizon, and as well predicts higher global reduction when considering vessels fully equipped for high standards quality science. This discouraging scenario is partly ameliorated by the ongoing Norwegian and German construction projects, but requires thorough reflection by ship operators, research agencies, funding agencies, etc.

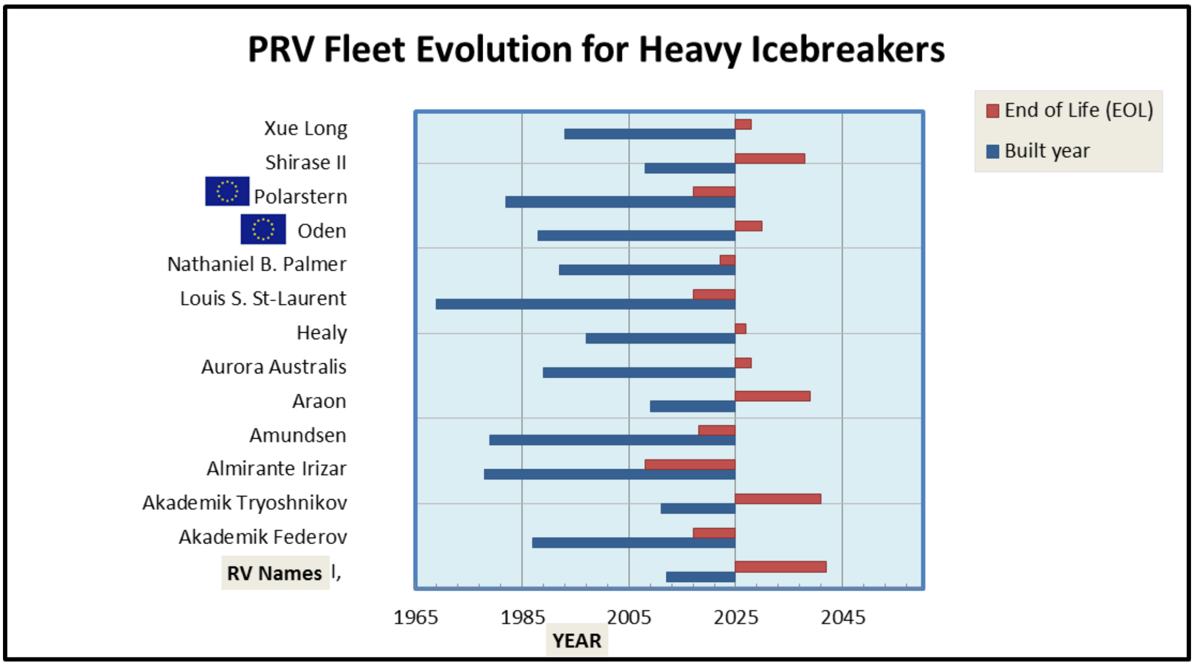


Figure2: Age evolution of the PRV Global Fleet

This scenario points to where efforts should be made to maintain the competitiveness of European polar research, through more and better cooperation within the European Union. A line of action already initiated by Norway and Germany is the planned construction of highly interoperable medium-size ships with research and cargo capacities - and finding mechanisms to share them. In this respect the lesson learned from the grounded Aurora Borealis project, possibly as consequence of the enormous building costs and essentially the huge maintenance cost, has to be taken into account. Furthermore, due the low possibility of new PRV's constructions, strategies for sharing existing European ship capacities, as intended by the initiative ARICE (Arctic Research Icebreaker Consortium for Europe), should be supported in the European Union, where in the 2020 horizon only two heavy icebreakers will be available and most PRV's will overtake their lifetime.

If we consider the age evolution for the Ice Classified polar vessels (**Figure 3**) the European scenario is much better due to the recent constructions and of some mid-life refits. The average life-time termination of the global fleet will be about year 2020, beyond that date mostly European research vessels are available and there is not much information on new vessel constructions around the world.

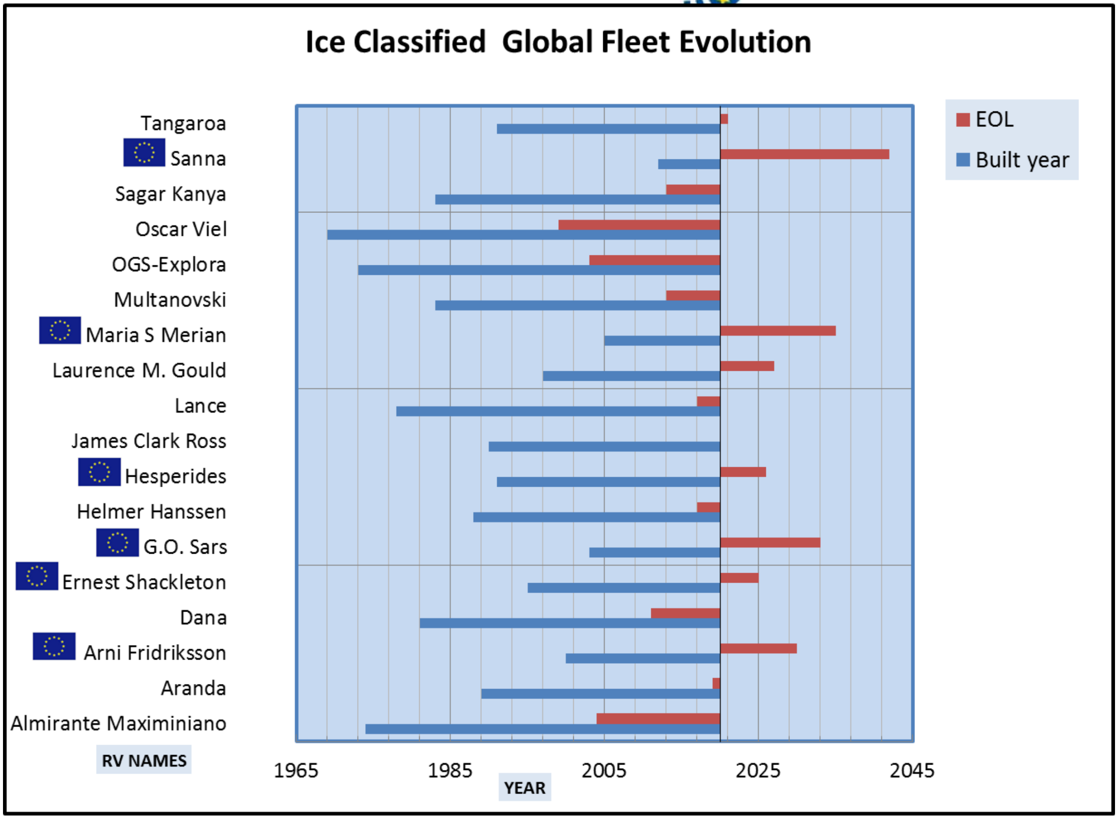


Figure3: Age evolution of the Ice Classified RV

The European Polar Board (EPB) mission is to be the voice of European polar research and to facilitate scientific cooperation in Europe. EPB aids in the development of common scientific programs, optimizing the use of European infrastructure and in representation of polar issues within European research framework programs such as the Horizon 2020. The mission, scientific priorities and infrastructure projects of the EPB are to:

- identify future scientific areas and strategic priorities of polar science within Europe,
- coordinate scientific agenda setting and represent it in European Policy Formulation,
- represent European Polar Research in the global context, and
- Develop or support concepts for joint use of polar infrastructure.

4.8 ANNEXES

4.8.1 Technical Information on Heavy Icebreakers PRV

	Ship Name	Dimensions			People		Labs		Cargo		A-Frames	Cranes	Winches (Scientific, Others)	Moon-pool	Broad-band	DP
		Length	Draft	GRT	Crew	Scientifics+ Technicians	Area Wetlab (m2)	Area Drylab (m2)	Capacity Dry Cargo Area (m3)	Capacity cargo container (nº)	No. Capacity	Crane	No/Type/length (m)		yes	DPS1
Full range icebreakers	Agulhas II,	134	7,7	12897	45	100	8 fix labs; 6 Lab Cont - 800 m2		4000	40 TEU	2)	35 T, 3 of 10 T	CTD/6000/	Open		DPS1
	Akademic Federov	141	8,5	12660	80	160			8595					yes ?		
	Akademik Tryoshnikov	134	8,5	12711	60	80										
	Almirante Irizar	121	9,5	14899	135	45			1800							
	Amundsen	98	7,2	5911	30/40	43			190	7 TEU	2)		5	yes	yes	DPS1
	Araon	110	9,9	6970	25	60	yes	yes	15 TEU	31 TEU	2)	25T;10T; 3T	2		yes	DPS2
	Aurora Australis	95	7,8	6574	24	116		8 fix Labs	1700	18 TEU	0	3 Cra.; 25/321; 7/13 & 2 T	2) Oceanograhic/6000		yes	no
	Healy	128	8,9	16000	12+63	50	36	14,2	567		2) Aft & starboard		3) 2-Ocean/ Elect-mec 10000 (3/8"); 12000 (0,332"); 14000(1/4")	no		
	Louis S. St-Laurent	120	9,9	11345	42	57	80	100 ?	8 TEU		3)	1-12 T; 2-8 T		yes		
	Nathaniel B. Palmer	94	6,8	6900	27	39				20 TEU	3) 20 T	1-2T, 1 -10T, 1-23T	Mech./Coax./Cond. EM; 10000;10000;10000	yes		
	Oden	108	7-8,5	9438	23	50	92		4000	12 TEU	2) Aft 20 T		CTD/6000	yes		
	Polarstern	118	11,2	12640	29	55	177	182	8 TEU	54 TEU	1)	1-15T; 1-25T	11		yes	DPS1
	Shirase II	138	7,35	4028	179	80										
	Xue Long	167	9	14997	34	128	500				1)					

4.8.2 Technical information on Ice Classified PRV

	Ship Name	Dimensions			People		Labs		Cargo		A-Frames	Cranes	Winches (Scientific, Others)	Moon-pool	Broad-band	DP
		Length	Draft	GRT	Crew	Scientifics+ Technicians	Area Wetlab (m2)	Area Drylab (m2)	Capacity Dry Cargo Area (m3)	Capacity cargo container (nº)	No Capacity	Crane	No/Type/length (m)		Broad band	DP
RV's Ice classifed	Almirante Maximiniano	93,4	6,59	3865	76	30	40	150					2) Geol/Oce 10000;8000		yes	DPS1
	Aranda	59,2	4,6	1734	12	27	67	43	2TEU	1TEU	2) 10T/1,5T	Aft:3 T/	5) Electr/Mec 700;4000	no	yes	no
	Arni Fridriksson	69,9	6,8	2233	16	16	45	16	0 ??				3) CTD/Hydr/Zoopk	no	yes	no
	Dana	78	6,1	2545	28	10	52	118	550			Fish. Gears 2) 30 T; 3) 25T	CTD/Hydr/Fib op 1800;2500; 4000	no	yes	no
	Ernest ShackleT	80	6,15	1800	25	45	45	45	3000	4 TEU	0	Stern 10 T/Rov 5 t/10M Cargo 30 T-20m			yes	DPS1
	G.O. Sars	77,5	5,8	1408	19	13	8	18			0	Stern 24 T	CTD/Hydr/Dee/ Sei/ Corer /multi 75kN;30 kN, 75kN;	2 Dropkeels		
	Helmert Hanssen	64	5,95	2052	11	29	30	50	500			4T-14 m, 2T-9 m	4) Ctd/Hydr/Dreg/Traw 4000;3000;3500;2400		yes	
	Hesperides	82,5	4,42	2827	55	35	72	195	393							
	James Clark Ross	99	6,3	5732	26	50	23,5	44	1500	5 TEU	2) Aft 20 T; Midship 30 T	20T/20m	2) Hydr/Con 9000;8000	no	yes	yes
	Lance	60,8	6,5	1334	13	25	25	46	615	1 TEU	1T /4,2 m	10 T-9m	3) Mec/Cond/Tra 6000;5000;1000			
	Laurence M. Gould	70,2	5,49	2996	16	28	39,5	33	20-30 TEU	5 TEU	3) Stern 10T,Start 5T;	13,5T; 3,5T; 0,5T	4) Elec-mec/Cond/Coax 10000;9000;7300	yes	yes	no ??
	Maria S Merian	95	6,5	1345	23	23	120	270	7 TEU	14TEU	200 kN	7 cranes. 3 50kN; 2 15 kN; 1 200 kN,	6) fib op/mech/ elc		yes	DPS1
	Multanovski	72	4,5	1754	30	36	12	16				5T7 9m	7) Mec/Cond 8000;6000			
	OGS-Explora	73	4,8	1408	17	12	60	116	500			Stern 1T/Mid 8T	1		yes	no
	Oscar Viel	90	6,06	6500												
	Sagar Kanya	100	5,6	4209	42+18	31	80,9	38	450	2 TEU	20 T	1	4) Mec/Cond 1000;6000		yes	DPS1
	Sanna	33,2	3,5	450	6	10				1 TEU+ 2-10 feet	1) 4 T		all of 2000	no	no	no
	Tangaroa	70	7	2291	18	26	27	>100	615	6 TEU	2) 10T-6m/8,5T 6m	Stern 2T; Mid 15T	6) 2Acu/Hydr/Deep/Ctd/Ca 1200;2000;10000;8000;3000		yes	DPS2

4.8.3 Equipment information on Heavy Icebreakers PRV

	Ship Name	Acoustics		Geophysics		Coring			Seismic			Sampling			Water column			
		Multibeam	Parametric	Grav.	Magne.	Gravity	Piston	Multi	Navigation	Streamer	Air Guns	Nets	Multinets	Dredge	CTD	Radiom.	LADCP	ADCP
Full range icebreakers	Agulhas II,	no	no	no	no	yes	yes		no	no	no				yes			
	Akademik Federov																	
	Akademik Tryoshnikov	EM3020																
	Almirante Irizar																	
	Amundsen	EM302		yes				yes	no	no	no	yes	yes	yes	yes	yes		yes
	Araon	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
	Aurora Australis	yes	no	no	no	no	no	no	no	no	no	yes			yes		yes	yes
	Healy	EM122	chirp, 3,5 kHz	yes		yes	yes	yes							yes	yes		yes
	Louis S. St-Laurent	no	no	no	no				yes	yes	yes				yes			
	Nathaniel B. Palmer	EM120	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
	Oden	EM122	SBP120		no	yes	yes	yes	yes	yes	yes	yes			yes			
	Polarstern	Hydrosweep DS II	Parasound DS III	KSS31		yes	yes	yes	no	yes	yes	yes	yes	yes	yes		yes	yes
	Shirase II																	
	Xue Long					yes ?	yes ?								yes			yes

4.8.4 Equipment information on Ice Classified PRV

	Ship Name	Acoustics		Geophysics		Coring			Seismic			Sampling			Water column			
		Multibeam	Parametric	Grav.	Magne.	Gravity	Piston	Multi	Navigation	Streamer	Air Guns	Nets	Multinets	Dredge	CTD	Radiom.	LADCP	ADCP
RV's Ice classified	Almirante Maximiniano	no	no	no	no				no	no	no							yes
	Aranda	no	no	no	no	yes	yes	yes	no	no	no	yes	yes	yes	yes	yes		yes
	Arni Fridriksson	EM300													yes			yes
	Dana	no	no	no	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes			
	Ernest Shackleton	EM12	no		no													
	G.O. Sars	EM300/EM1002	TOPAS PS 18	no	no	yes	yes	yes	yes	HIGH RES.	yes	yes	yes	yes	yes	yes	yes	yes
	Helmert Hanssen	EM300	SBP			yes		yes				yes			yes			yes
	Hesperides	EM120/1002S/	TOPAS PS 18	yes	yes	yes	yes		yes	HIGH RES.	yes	yes	yes	yes	yes	yes	yes	yes
	James Clark Ross	no	SBP, 3,5 kHz	yes	no				yes	yes	yes	yes		yes	yes	yes		yes
	Lance	no					can operate		no	no	no				yes			yes
	Laurence M. Gould	**no ?**	SBP:3,5 kHz	no	no	yes	yes	yes	no	no	no			yes	yes	yes		yes
	Maria S Merian	EM120/EM1002	TOPAS PS 18			yes	yes	yes				yes	yes	yes	yes	yes	yes	yes
	Multanovski																	
	OGS-Explora	SEBAT 8150/8111	CHIRP 6600	yes	yes	yes	yes	yes	yes	yes	yes				yes	yes		yes
	Oscar Viel	no																
	Sagar Kanya	SB3012	GEOACOUSTIC		yes	yes	yes	yes	no	no	no	yes	yes		yes	yes		yes
	Sanna	no	no	no	no				no	no	no	yes	yes	yes	yes			yes ?
	Tangaroa	EM302	SBP: 3,5 kHz	yes	yes				yes	HIGH RES.	yes	yes	yes	yes	yes	yes		yes