SCIENCE OPERATIONAL MANUAL

LE COMMANDANT CHARCOT

PONANT

Detail	Revision	Date	Name
DRAFT	0	05/06/2021	Mathieu Petiteau
Update tools & communication Added echo sounder EA440	1	28/08/2021	Mathieu Petiteau
General Update + additionnal equipment	2	26/10/2021	Vladislav Sidorenkov-Duprez

Table of Contents

EXECUTIVE SUMMARY 1

1. SHIP'S DATA 2
   1. GENERAL DATA 2
   2. VESSEL'S GENERAL ARRANGEMENT 3
   3. ICE PERFORMANCE 4
   4. TECHNICAL DETAILS 5
      1. SIDE DOORS – LIFTING MEANS 5
      2. EXTERNAL DECKS 8
      3. COMMUNICATION 9
      4. POWER (Voltage, Frequency, Power) 9
      5. NAVIGATION EQUIPMENT 10
   5. SECONDARY CRAFTS: TENDER BOAT / HELICOPTER / ZODIAC / HOVERCRAFT / SNOWMOBILE / SHERP 12
   6. LIFE ON BOARD 16
2. SHIP OPERATION AND CRUISES 17
   1. Arctic Area 17
   2. Antarctic Area 17
3. SCIENCE FACILITIES 18
   1. OVERVIEW 18
   2. LABORATORIES / SCIENTIFIC ROOMS 19
      1. Laboratory Office / Dry Laboratory 19
      2. Wet Laboratory 20
      3. Science Computer Room 20
   3. UNDERWATER HULL EQUIPMENT 22
      1. Bubble Study 22
      2. Underwater Instruments 22
   4. SEAWATER SAMPLING AND MONITORING 23
   5. RECORDING EQUIPMENT 25
      1. Sound velocity sensor 25
      2. Thermosalinometer 25
      3. Weather Stations 26
      4. Ice-Related Equipment 27
   6. SCIENTIFIC NETWORK 29
      1. Data Network 29
      2. Wheelhouse Science Console 29
   7. FORESEEN EQUIPMENT 30
      1. Laboratory equipment 30
      2. Bottom equipment 30

List of Appendices

APPENDIX 1: General Equipment
APPENDIX 2: Zodiac crane lay out
APPENDIX 3: Communication coverage
APPENDIX 4: Navigation equipment Topology Drawings
APPENDIX 5: Ship DGPS
APPENDIX 6: Lay out laboratory office
APPENDIX 7: Lay out Wet lab
APPENDIX 8: lay out science computer room
APPENDIX 9: Bubble sweepdown report
APPENDIX 10: Echo Sounder Sea trial report
APPENDIX 11: Bottom equipment arrangement
APPENDIX 12: TVO Sub-hull supports
APPENDIX 13: Science Sea water system
APPENDIX 14: SVS Datasheet
APPENDIX 15: EUCAWS - Weather station
APPENDIX 16: E-HMS
APPENDIX 17: SIMS Ice thickness measurement
APPENDIX 18: Topology Drawings - Scientific Equipment
APPENDIX 19: Bathymetric Crane and Winch
APPENDIX 20: European-FerryBox-Network-EuroGOOS
APPENDIX 21: Underwater equipment Datasheets

Table of Illustrations

Figure 1 Le Commandant Charcot SB view 2
Figure 2 Ahead mode in level ice 4
Figure 3 Ahead mode in a ridge 4
Figure 4 Astern mode in level ice 4
Figure 5 Astern mode in a ridge 4
Figure 6 Le Commandant Charcot side view with shell doors 5
Figure 7 Shell doors 5
Figure 8 Zodiac and Tender boarding platform 5
Figure 9 Aft Hangar, 270 m2 and 3.8m high 6
Figure 10 Provision ramp 6
Figure 11 Layout of the wet lab with position of the shell door for direct sea water access 7
Figure 12 Zodiac Crane 17m outreach 7
Figure 13 Promenade deck: on deck 05 all around the vessel giving access the extreme parts of the ship as close as possible to the sea (9.6 m above the water line) 8
Figure 14 Helideck area on deck 06: free access outside helicopter operation timeframe (13.2 m above the water line) 8
Figure 15 Pool deck: deck 09 aft (21.5m above the water line) 8
Figure 16 The main wheelhouse is forward on deck 08 and the secondary wheelhouse is aft on deck 05 for ice navigation and SRtP 10
Figure 17 Sonar Technical Specification 10
Figure 18 Tender PLL1099 approaching the tender platform 12
Figure 19 AS355N 13
Figure 20 SRA650 Figure 21 ZODIAC MARK 5 13
Figure 22 Christy FCW 9204 Duct 14
Figure 23 YAMAHA VIKING PRO II EFI 14
Figure 24 SHERP 15
Figure 25 Underwater pictures taken with the ROV 15
Figure 26 Exemple of Cruises in the Arctic 17
Figure 27 Exemple of Cruises in Antarctica 17
Figure 28 Le Commandant Charcot - science overview 18
Figure 29 Zoom-in on the dedicated offices and laboratories on deck 03 19
Figure 30 Dry Laboratory Layout 19
Figure 31 Wet Laboratory layout 20
Figure 32 Science computer Room 21
Figure 33 Left: CFD visualisation of bubble sweepdown. Right: bubbles recorded at 10 knots under the TVO 22
Figure 34 Left: All transducer boxes have vent and cable pipes foreseen above water level. Right: bottom picture of transducer positions. 22
Figure 35 TVO with orange bladder, black angle indexation and stainless steel extender. 23
Figure 36 Sea Water System dedicated for research 23
Figure 37 Sea water system dedicated for scientific water sampling. 24
Figure 38 Sound Velocity Sensor tank 25
Figure 39 Thermosalinometer datasheet 25
Figure 40 EUCAWS installation and topology 26
Figure 41 E-HMS monitor layout 26
Figure 42 SIMS suspended in front of Le Commandant Charcot 27
Figure 43 Function principle of the SIMS 27
Figure 44 Route optimisation in Ice with Adrena 28
Figure 45 Examples of chart or picture integration in Adrena with real-time monitoring 28
Figure 46 Scientific Data Network 29
Figure 47 Layout of the wheelhouse 29

EXECUTIVE SUMMARY

Le Commandant Charcot is the unique cruise expedition vessel designed for extreme polar conditions that give the rare opportunity to 270 passengers to explore remote polar areas safely while consuming the cleanest energy currently available. It is indeed the first hybrid electric ship running on LNG (Liquid Natural Gas), which is a major innovation marking PONANT's commitment to sustainable tourism.

The ship's navigation area is encompassing very remote areas for which there are no or very little available knowledge. Le Commandant Charcot is then creating an opportunity for scientific studies in the Arctic and Antarctic.

Since the beginning of the project, Ponant has designed the vessel as "a Ship of Opportunity" for the scientific community. It has a dedicated infrastructure for making measurements, experiments and has autonomous data acquisition available for researchers. Le Commandant Charcot offers a unique versatile logistical and technical platform for observation, research and analysis thereby participating in the global effort to study and conserve the poles. It represents a huge opportunity to learn, understand and bear witness. We better protect what we know well.

The Ponant Science Program is managing the equipment, the contacts with researchers and institutions and ensuring coordination onboard. On-shore personnel oversee contacts with the researchers, manage the call to projects and make the feasibility studies in view of the vessel's operational and technical constraints. A scientific committee is acting as a support for the selection of the projects. A science coordinator is present onboard for the maintenance and operation of the different instruments and is in charge of the communication between researchers and crew.

This document is reviewing all the necessary pieces of information for scientists to come onboard Le Commandant Charcot and use the vessel's facilities during the ship's cruises in the Arctic and the Antarctic.

A general description of the vessel and of the operation areas is followed by the listing and description of scientific equipment related to a broad variety of research fields such as oceanography, geology, or marine biology.

1. SHIP'S DATA

In order to have a good understanding of the vessel's capabilities, this chapter summarizes design information, operational data and lists the general equipment installed onboard which could be of interest for research activities.

1. GENERAL DATA

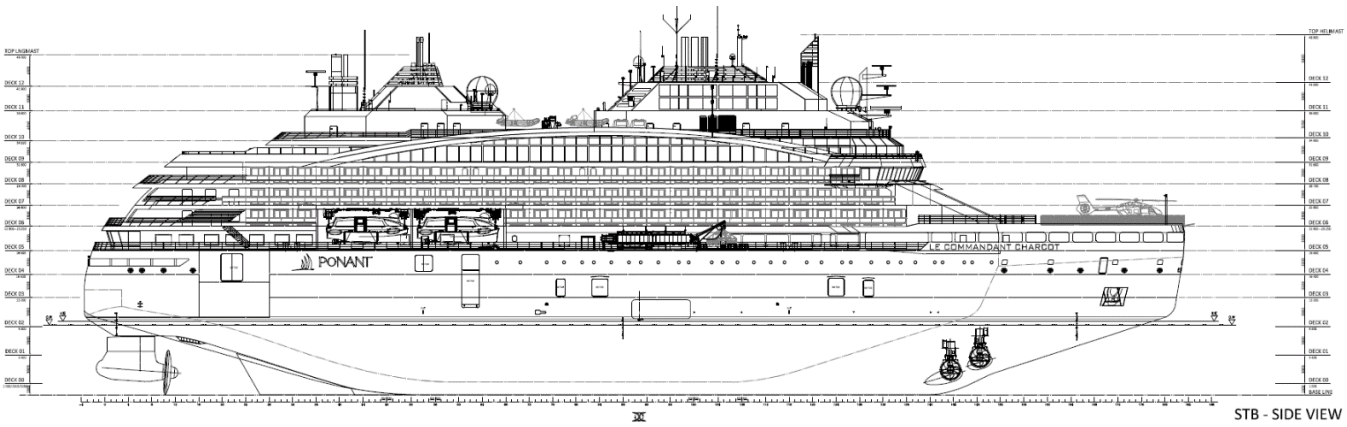


Figure 1 Le Commandant Charcot SB view

NAME:	**LE COMMANDANT CHARCOT**
TYPE:	PASSENGER SHIP
IMO NUMBER:	9846249
PORT OF REGISTRATION:	MATA UTU
OWNER:	PONANT
SHIPYARD:	VARD (NORWAY)
KEEL LAYING:	14 DECEMBER 2018
DELIVERY:	29 JULY 2021
CLASS SOCIETY:	BUREAU VERITAS
CLASS NOTATION:	✠HULL ✠MACH, Unrestricted Navigation, Passenger Ship - SRTP - **DUALFUEL** - POLAR CAT A, ✠AUT-PORT, ✠AUT-UMS, ✠VeriSTAR-HULL, POLAR CLASS 2 (partly: Icebreaker 3 bow; Icebreaker 4 stern), COLD (H -15°C, E -25°C) PMS, INWATERSURVEY, **CLEANSHIP**, BWT, AWT-A/B, COMF-NOISE-1, COMF-VIB-1, ERS-S, HYBRID
LENGTH OVER ALL:	149.9 m
BEAM:	28 m
DRAUGHT	10m
PEOPLE ON BOARD:	270 PASSENGERS + 190 CREW (including 4 Researchers)
NAVIGATION:	INTERNATIONAL – UNLIMITED
TEMPERATURE:	Designed for operation for +35°C / -25°C.
PROPULSION POWER:	2 x ELECTRICAL AZIPODS ABB (2 x 17 MW)
VESSEL SPEED	Maximum speed achievable in open water 18 knots Cruising speed in open water 9 knots Cruising speed in Ice according to Ice concentration and thickness
ELECTRICAL PRODUCTION:	DUAL FUEL WARTSILA ENGINES: 2 x 5335 kW + 4 x 7450 kW
BATTERY	ELECTRIC HYBRID ENERGY STORAGE SYSTEME 4520 KW
FUEL	LNG: 4500 m3 LSMGO: 3600 m3

2. VESSEL'S GENERAL ARRANGEMENT

The Vessel's detailed General Arrangement can be found in Appendix 1. As a summary:

- In decks 0 to 03 & 10 are located the technical Area,

- Deck 04 is the crew accommodation area and including, Aft mooring station, hangar, provision area, mess, crew cabins, heli hangar and forward mooring station.

- Decks 05 & 09 are the passenger Public Spaces including for deck 05 the Aft Wheelhouse, the Main Restaurant, the lobby, the Main Lounge and the Theater, the Heli Hangar and is completed by an outside Promenade deck. Deck 09 is including the Pool deck & pool bar & Grill restaurant, the internal pool, the spa, fitness room and observation lounge
- The decks 06 to 08 are filled with passenger cabins except for the Main wheelhouse, forward of deck 08.

The vessel can accommodate 470 persons on board with about 216 crew divided as follows:

Table 1 Crew List

Deck Dpt	28
Engine Dpt	22
Medical Dpt	3
Hotel Dpt	134
Entertainment Dpt	13
General crew	**200**
Naturaliste / Exp Leader	N23/S19
Scientists	4
Helico team	2
TOTAL	**N216/S212**

3. ICE PERFORMANCE

This PC2 Ice class vessel has been designed to safely sail in the Arctic and Antarctic Oceans during their respective summer periods. The Icebreaking hull shape has been designed by AKER ARCTIC.

The vessel can sail until 2.5 m thick compact multi-year level ice of 700 MPa resistance and has two modes of sailing in ice: ahead and astern.

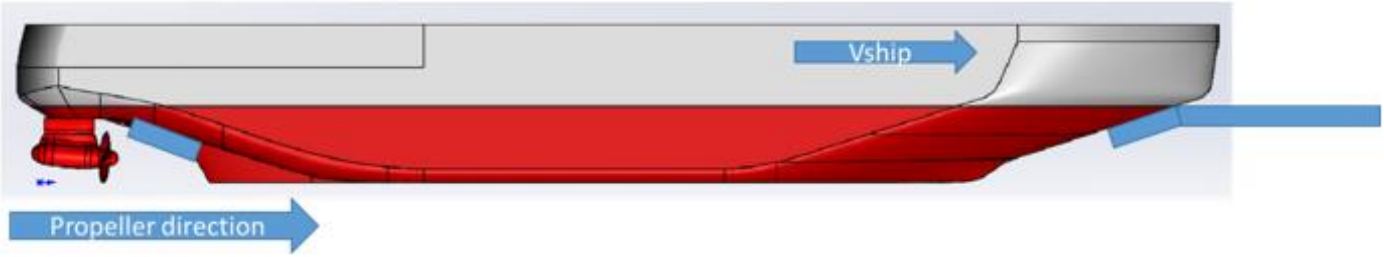


Figure 2 Ahead mode in level ice

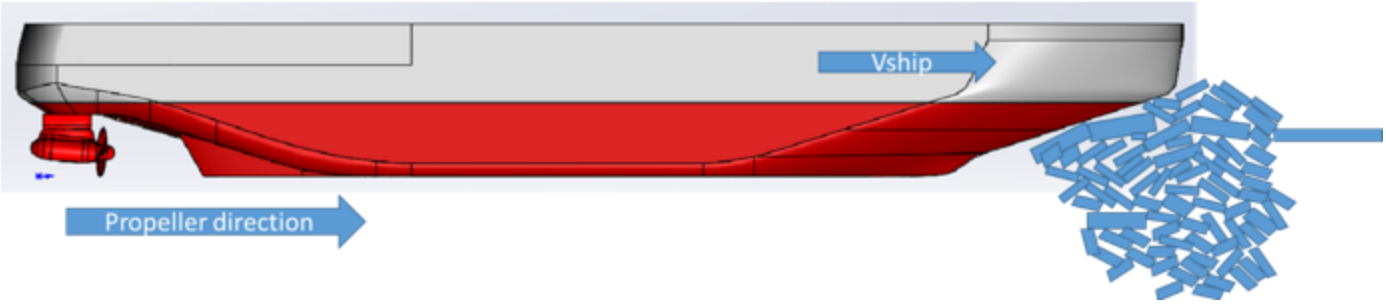


Figure 3 Ahead mode in a ridge

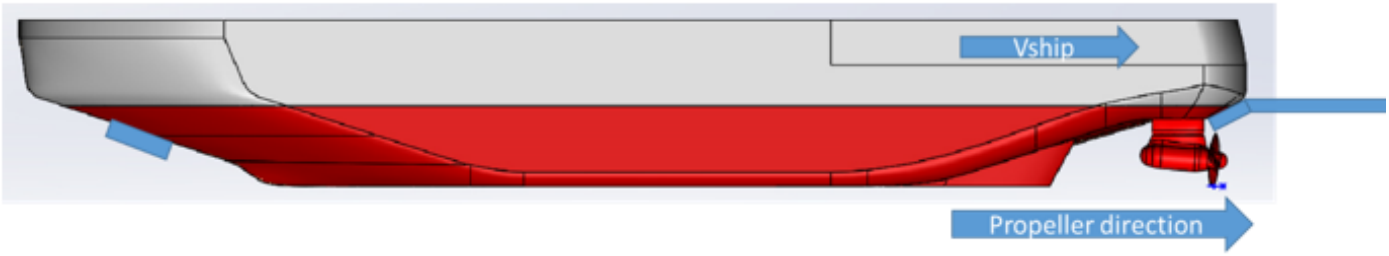


Figure 4 Astern mode in level ice

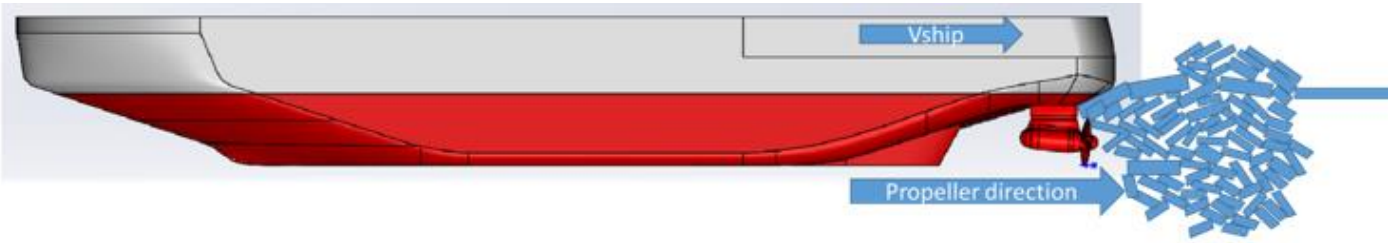


Figure 5 Astern mode in a ridge

Approximate maximum vessel performances in level Ice:

Ice thickness [m]	0	0,5	1	1,5	2	2,5
Speed [kn]	18	16	11	7	4,5	2

Thanks to this dual acting mode, the vessel is able to pass through ice ridges of more than 10m at a continuous slow speed without ramming and so gives this vessel a huge maneuverability in very difficult ice conditions ensuring the safety of the passengers and crew.

4. TECHNICAL DETAILS

1. SIDE DOORS – LIFTING MEANS

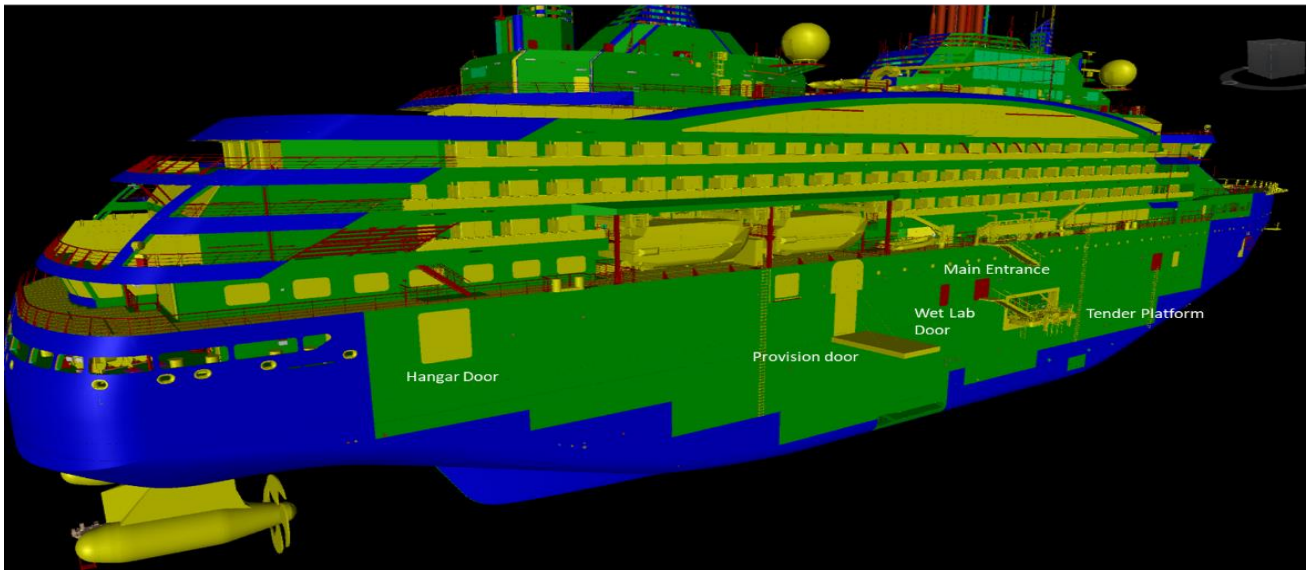


Figure 6 Le Commandant Charcot side view with shell doors

The vessel has several shell doors which can be used for embarkation/disembarkation of people, provisions, equipment, and spare parts. These shell doors are coupled with lifting equipment, which is described below.

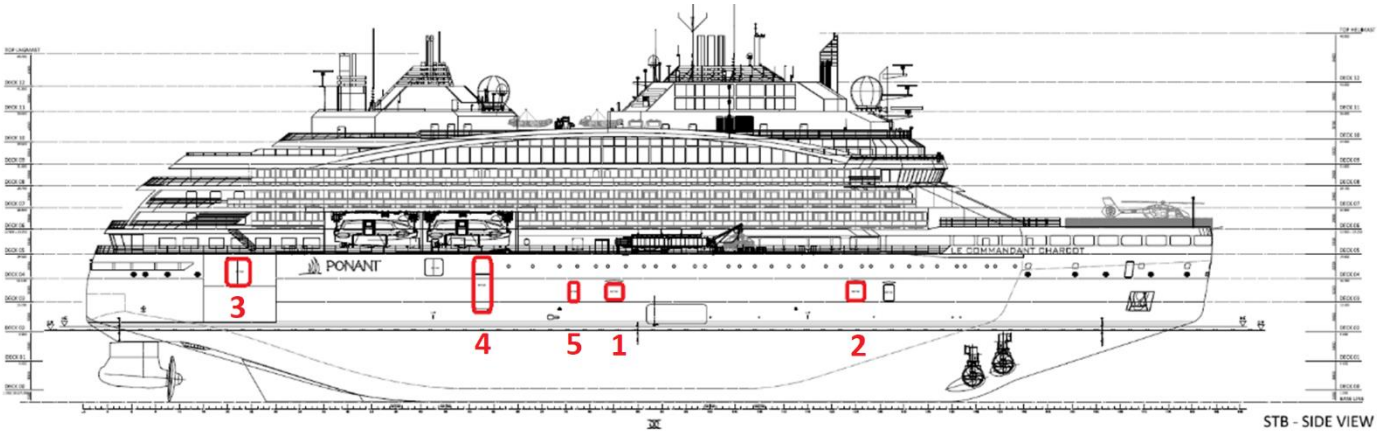


Figure 7 Shell doors

1. **Expedition Side Door** – DECK 3 SB & PS: Clear Opening 2.2 m x 2.4 m. Main Passenger entrance for expedition activities located 3,2 m above the water line: Direct access on Ice or to zodiac and tender operations. A ladder is connected to a tender platform located between 1 m and 0,5 m above water level.

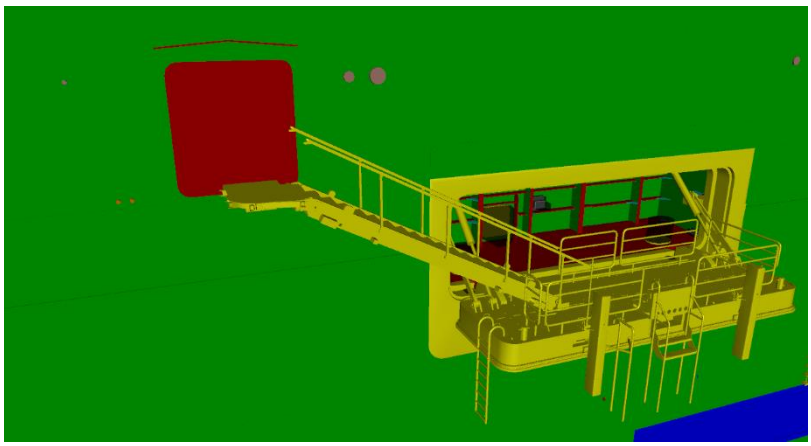


Figure 8 Zodiac and Tender boarding platform

2. **Crew / Luggage Side Doors** – DECK 3 SB & PS (3,2m above the water line): Clear Opening 2.2 m x 2.4 m. Main Crew entrance, luggage, and spare parts transfer. Coupled with a 2-ton SWL and 5-meter reach travelling crane.

3. **Aft Hangar Side Doors** – DECK 4 SB & PS (5,3 m above the water line): Clear Opening 3 m width x 3.7 m height. Hovercraft and SHERP storage and provision access, coupled with a 2-ton SWL and 5-meter reach travelling crane.

Note: This side doors allow a 20 feet container to pass through so that a scientific container can be secured in the hangar. Dedicated on shore lifting device must be arranged to be able to load the container inside the vessel.

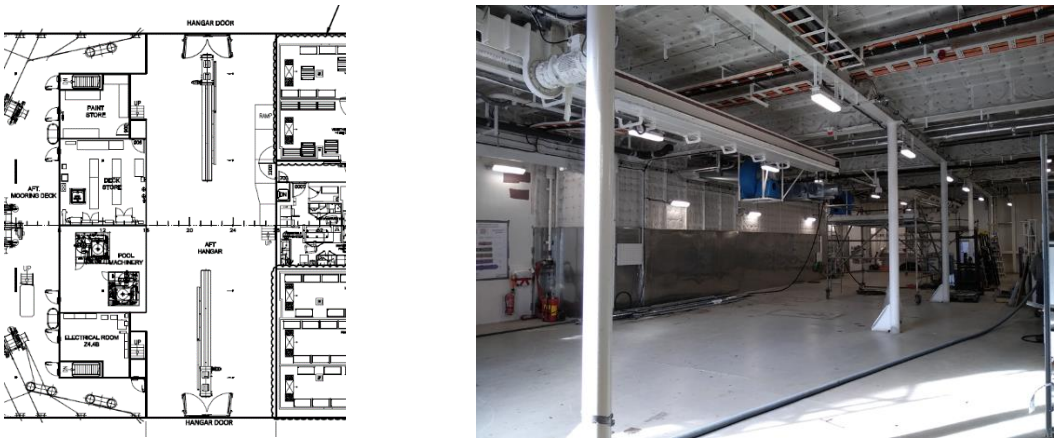


Figure 9 Aft Hangar, 270 m2 and 3.8m high

4. **Provision Side Door** – Deck 3 & 4, SB & PS: Provisions transfer. Consisting of a 5-meter ramp and an elevator reaching decks 3 and 4 with 2-ton SWL

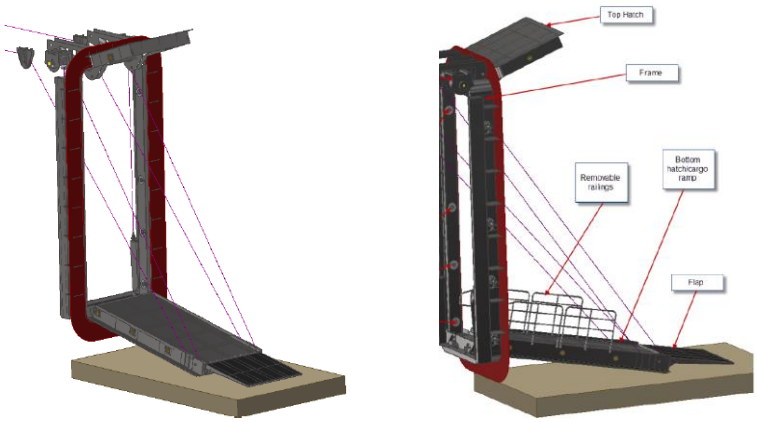


Figure 10 Provision ramp

5. **Wet Lab side door** – Deck 3 (starboard side only. 3,2m above the water line): Clear Opening 1.2 m x 2.4 m. Can be opened at sea. Access to overboard during sailing condition.

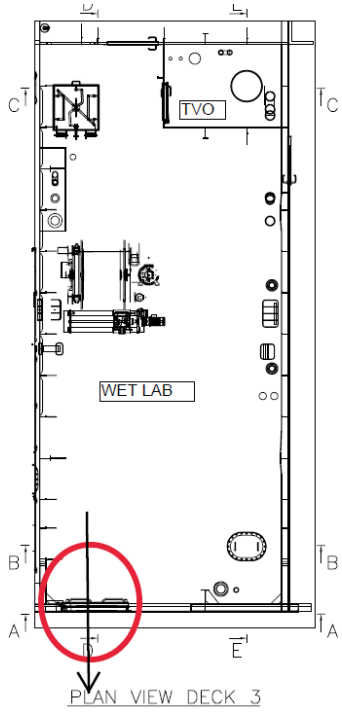


Figure 11 Layout of the wet lab with position of the shell door for direct sea water access

Except for the Wet laboratory side door, all the above doors and cranes are located on Starboard as well as portside, guaranteeing access and loading capacity from both sides.

<u>Other lifting devices:</u>

In order to load equipment on top of the ship, another foldable crane is available on deck 10 with a 2-ton SWL and a reach of 17 m (maximum outreach from ship's side is 8 m). (see APPENDIX 2)

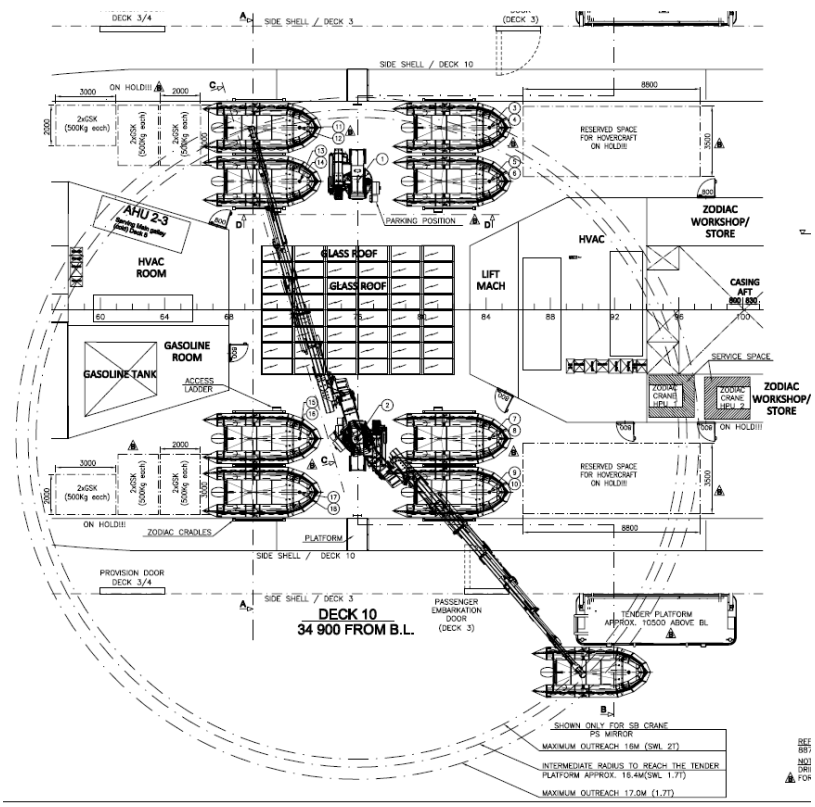


Figure 12 Zodiac Crane 17m outreach

2. EXTERNAL DECKS

Accessible external decks are located on deck 05, deck 06 and deck 09:

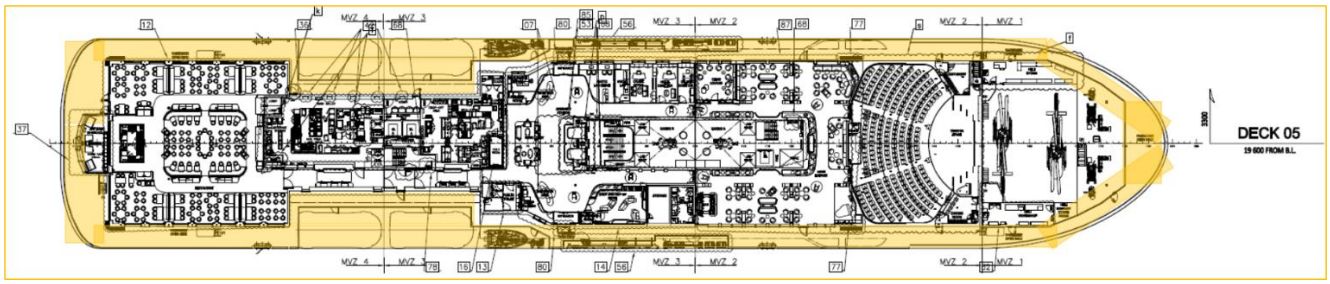


Figure 13 Promenade deck: on deck 05 all around the vessel giving access the extreme parts of the ship as close as possible to the sea (9.6 m above the water line)

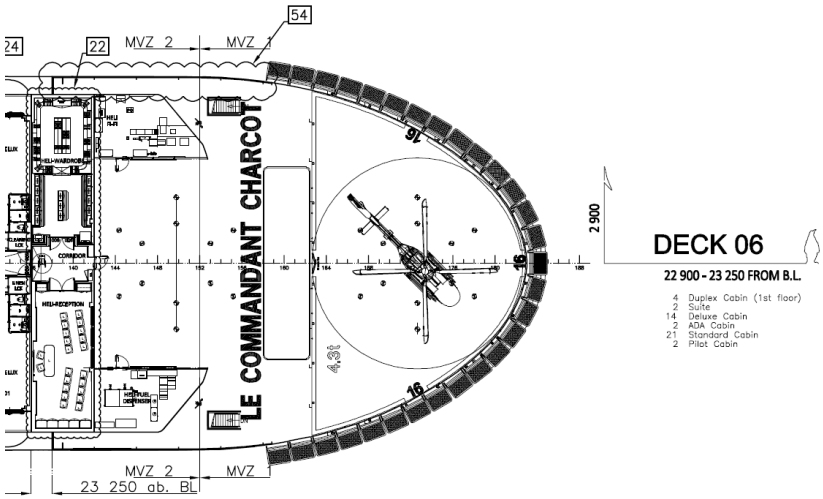


Figure 14 Helideck area on deck 06: free access outside helicopter operation timeframe (13.2 m above the water line)

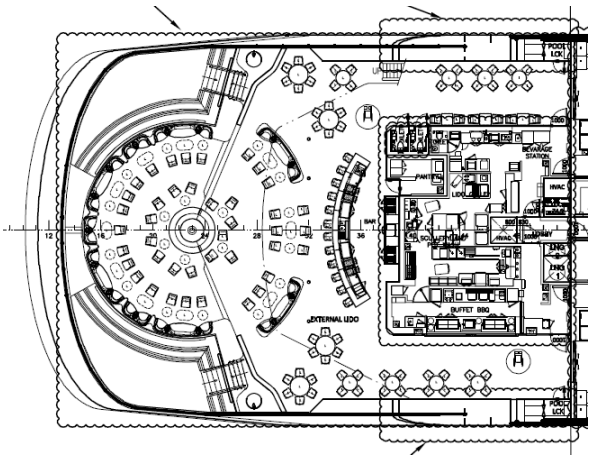


Figure 15 Pool deck: deck 09 aft (21.5m above the water line)

ALL OTHER EXTERNAL DECK ARE FORBIDEN IN NORMAL CONDITION.
(LNG, GAZOLINE and KEROZEN on board)
RESTRICTED SMOKING AREAS WILL BE IDENTIFIED ON EXTERNAL DECK ONLY.
(NO SMOKING POLICY INSIDE THE VESSEL)

3. COMMUNICATION

The vessel is equipped with standard Nautical communication means as well as Iridium Certus Antennas for Internet connection in high latitudes (above 80°N). The below table is summarizing the equipment onboard. All the equipment is certified for operation in cold climate until -25°C at least. In Appendix 3 can be found the coverage of each main network. In addition, hand-held devices for local communication is provided (UHF onboard, VHF for expedition team).

Table 2 List of Communication Equipment

ANTENNAS	QUANTITY	DATA	PHONE	TV	DATA / ANTENNA	INFORMATION
VSAT 240 Dual Band C/Ku	2	Y	Y	Y	CIR 12/4 Mbps	TV: Streaming channels only E-mail, data, photo, video
Iridium CERTUS	4	Y	Y	N	700 Kbps x 4	E-mail and data only 2 phone lines per Antenna
Kepler airtime Global Data Service	1	Y	N	N	16GB/day 500GB/month	Polar orbit – store and forward file transfer
FBB 500	2	Y	Y	N	492 Kbps	
Iridium Portable	1	N	Y	N	N/A	
Inmarsat mini-C	2	N	N	N	600 bps	TELEX
EPIRB	2	N/A	N/A	N/A	N/A	Sending ship's position with ship's identification number.
Iridium (SSAS & LRIT)	2	N/A	N/A	N/A	N/A	Working on Iridium network

4. POWER (Voltage, Frequency, Power)

The main electrical system of the ship is an alternating current with insulated neutral, 3 phases, 50Hz. Different Voltage are available: 690V AC, 400V AC, 230V AC and 132V AC receptacles in PAX cabins. Laboratories are fitted with a good amount of power sockets which can be seen further in the document. Several power sockets in both laboratories are fed from Uninterrupted Power System. All foreseen servers and data acquisition equipment are also foreseen to be fed through a dedicated Uninterrupted Power System. The ship has the possibility to connect to the shore power grid where available. Dedicated high power sockets or special connectors can be arranged on a case by case basis upon request.

5. NAVIGATION EQUIPMENT

The operation of the ship can be done from either one of the two separated redundant wheelhouses.

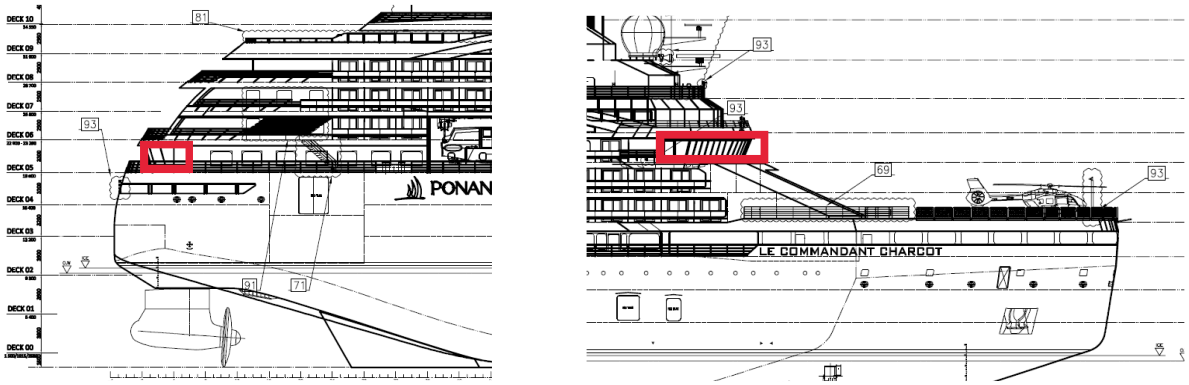


Figure 16 The main wheelhouse is forward on deck 08 and the secondary wheelhouse is aft on deck 05 for ice navigation and SRtP

Main navigation instruments and pieces of equipment are detailed here under and in Appendix 4: Navigation equipment Topology Drawings

1. COMPASS

The regulatory magnetic compass, even though installed on board would be ineffective for the navigation areas of the ship. It is therefore equipped with 2 Gyro Compasses from Raytheon: one STD22 (mechanical gyrocompass) and one STD 30MF (optical gyrocompass). Connection to the scientific network is done in order to record data as well as ship's heading. In addition, a satellite compass JLR-21 is installed for use in high latitudes.

2. GLOBAL POSITIONING SYSTEM

The vessel is fitted with 3 standard ship's DGPS SAAB R5 antennas MGL-5 with datasheets in Appendix 5.

3. SONAR

One Sonar System Farsounder Argos 1000 is used for detecting underwater obstacles until 50 m deep and 1000 m forward.

	Argos 1000
Range	100m, 200m, 500m, 1000m
Field of view	 120° up to 200m range 90° up to 500m range 60° up to 1000m range
Operational Speed	Up to 25 knots

Figure 17 Sonar Technical Specification

4. ICE RADAR

Ice Radar software is supplied by Wärtsilä Valmarine. This software is an add-on to the radar system in order to be able to localize, focus on and monitor ice blocks.

5. OLEX

Bathymetric OLEX system is installed in order to perform measurement and recordings in situ and be able to share those data. This system is useful especially in such places with very little nautical information.

6. MISCELLANEOUS NAUTICAL EQUIPMENT

- Remote control ice projectors: 4 forward and 2 aft (Norselight R60 2000W / 5 nm)
- Remote control thermal camera: VIDEOTEC NXPTZT 1aft and 1 forward (Person detection / recognition / identification: 1140m/280m/142m)
- Echosounder: Skipper GDS 102C
- Speed log SAM 4642

5. SECONDARY CRAFTS: TENDER BOAT / HELICOPTER / ZODIAC / HOVERCRAFT / SNOWMOBILE / SHERP

In order to increase the exploration possibilities of the passengers and the virtual outreach of the ship, it is equipped with secondary crafts, either for passenger experience either for navigation/safety/technical purpose. Depending on the availability and technical feasibility, these secondary crafts are as many ways to dispatch material and researchers further from the ship.

1. Tender boat / Lifeboats

4 tender boats with a capacity of 60 persons are used for transporting passengers, crew members, luggage …, at a speed reaching 10 knots, from the vessel to the shore when the vessel is at anchor.

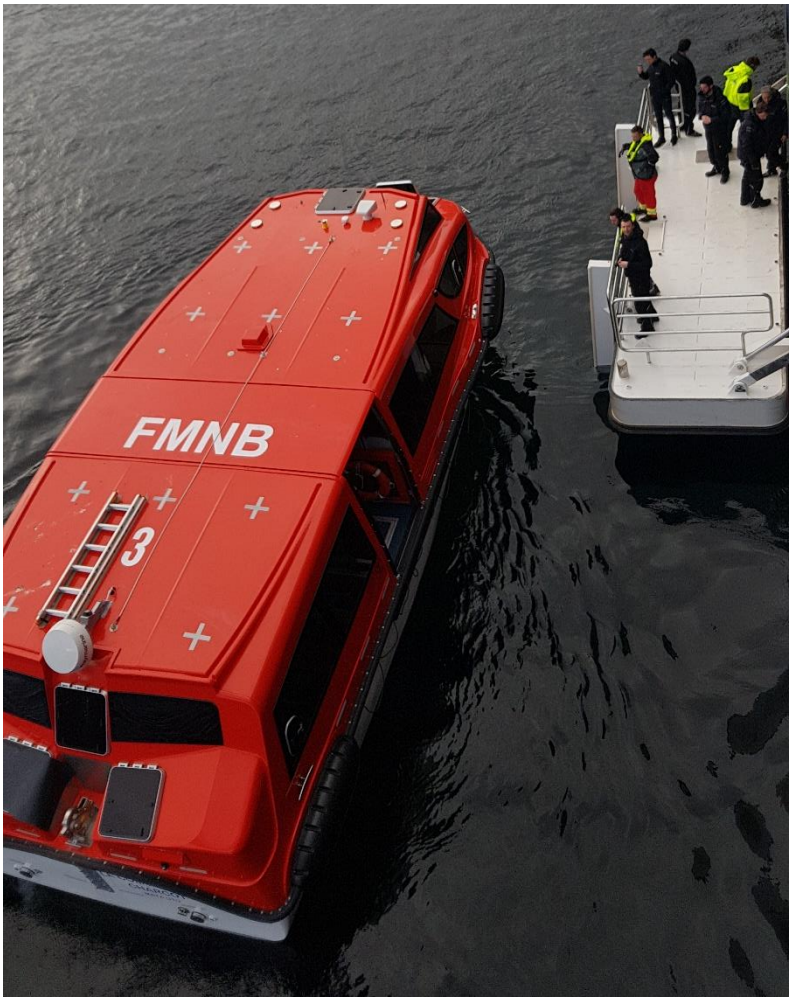


Figure 18 Tender PLL1099 approaching the tender platform

2. Helicopter

One AS355N is permanently located onboard when the vessel is sailing in ice-covered water. The helicopter is used only for navigation and Ice Routing to choose the best available route through the ice and can carry up to 4 people + 1 pilot.

The reach is about 200 Nautical miles and maximum flight duration is 3 hours. Landing on ice may or may not be possible depending on ice thickness, layout, meteorological conditions, and pilot's advice.

The use of helicopter for scientific activities (transport of person or material limited to 800Kg with a range of 10 nm on a sling) should be preliminary addressed to the company to be studied and confirmed if feasible and under which conditions.

A briefing room (Heli-Meeting Room) and a Heli-changing room are available and located on deck 6 close to the helideck.

Figure 19 AS355N

3. Zodiacs

16 Pneumatic crafts are onboard. These zodiacs are used for passenger experience as well as scouting in open water. 14 of them are Zodiac MARK V Heavy Duty with 1 x 70 HP gasoline engine and 2 of them are aluminum-hull SRA650 with 2 x 100 HP engines. The crafts are stored on deck 10 and are launched via the folding crane with a safe working load of 2 t and 17 m of outreach.

Figure 20 SRA650

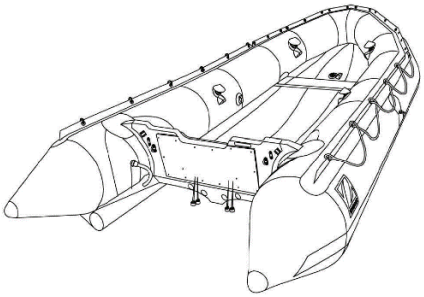


Figure 21 ZODIAC MARK 5

4. Hovercrafts

3 Hovercrafts, model Christy FCW 9204 Duct diesel powered are stored onboard inside aft hangar. They are used for passenger experience and scouting in ice-covered water and disembarkation on shore.

Figure 22 Christy FCW 9204 Duct

The maximum speed is about 70km/h and has a reach of 150km (450km with additional tanks) with 175 HP of installed power. They can carry 10 passengers in addition to the pilot. The operational limits of the hovercrafts are mostly heavy sea, strong winds and uneven ice. Maximum height of obstacles is around 40-50 cm.

5. Snowmobiles

3 snowmobiles with sledges are arranged on board and are usually used for the naturalist scouting and can be used for research activities on ice and ashore.

Figure 23 YAMAHA VIKING PRO II EFI

6. SHERP

One amphibious and all road vehicle SHERP is available for SAR activities and research activities. It can carry up to 5 passengers in addition to the pilot and reach a speed of 40 km/h on land or ice and 6 km/h at sea. The autonomy is approx. 300 km, calculated at 20 km/h on land or ice.

Figure 24 SHERP

7. Underwater ROV

A small underwater ROV (Chasing M2 PRO) can be used to take underwater pictures and recordings of the hull, ice or other scientific experiments.

Figure 25 Underwater pictures taken with the ROV

6. LIFE ON BOARD

Two standard passenger cabins have been dedicated up to 4 scientists: double occupancy with private bathroom and toilet and a balcony.

The scientists will be part of the crew and as such will be able to use crew facilities (Crew fitness room, Crew resting room, crew mess, storage and workshops).

Regarding lunch and dinner, scientists will have access to the crew mess and upon decision with the crew to the passenger's restaurant (compulsory dress code). During the cruise, the mix between passengers and scientists is encouraged.

Scientists will be free to work on their experiments and sampling after a risk analysis performed prior to the cruise or at the beginning of the cruise. Coordination with ship's operation will be performed with the onboard science coordinator from deck department under the responsibility of the Staff Captain. The science coordinator shall always be aware of the ongoing activities and will inform the scientists about ship's operation.

2. ACTIVITIES WITH PASSENGERS

In parallel with their activities, the scientists would be encouraged to share their work with the passengers and give lectures. They can also invite the passengers, if possible, into their daily work.

Depending on the size of the audience, three rooms can be used:

- The Theater (capacity up to 270p) deck 5,
- The Conference room deck 3 (capacity up to 30p),
- The Heli-conference room deck 6 (capacity up to 20p).

All three spaces are fitted with audio-amplification, and large TV screens or projector for presentation support.

2. SHIP OPERATION AND CRUISES

All cruises are built at least two years in advance and can be found directly on the website or on the online brochure. In general, the summer is dedicated to the Arctic and the winter to the Antarctic.

1. Arctic Area

Between April and September, the vessel is sailing in the Arctic Ocean, with cruises starting from Longyearbyen or Reykjavik. Navigation areas are including the East Coast of Greenland, Iceland, North Pole, Svalbard archipelago, North-East passage.

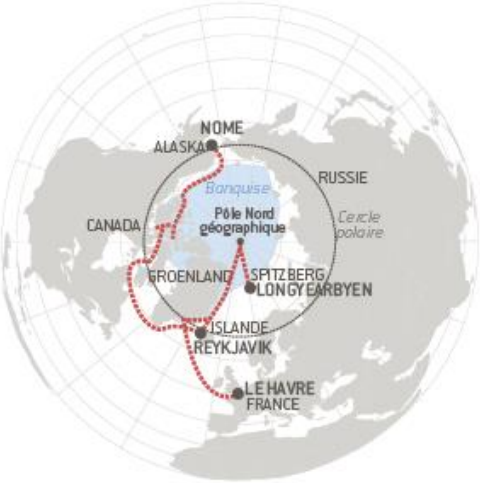


Figure 26 Exemple of Cruises in the Arctic

2. Antarctic Area

Between October and March, the vessel is sailing in Antarctica with cruises starting from Ushuaia, Punta Arenas or Puerto Montt and for some cruises from New Zealand. Navigation Area includes Peter Island, Marguerite Bay, Charcot Island, Wedell Sea, Bellingshausen sea, Ross sea, South Georgia and the South Sandwich Islands.

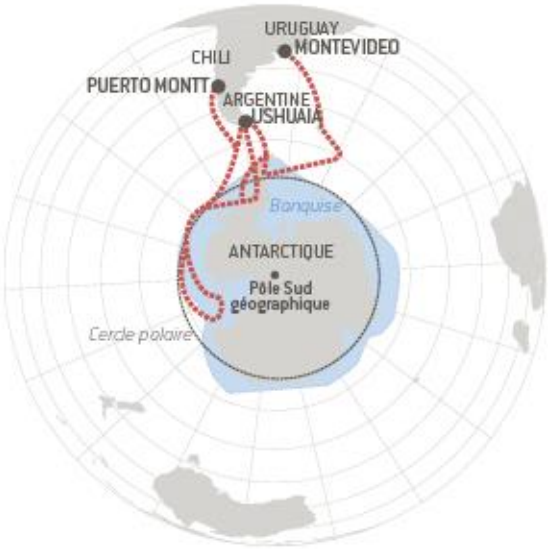


Figure 27 Exemple of Cruises in Antarctica

3. SCIENCE FACILITIES

The below chapter is describing all facilities and equipment related to scientific studies onboard Le Commandant Charcot. It includes the layout of the laboratories, the list of installed instrumentation, equipment and available supplies as well as the definition of the dedicated science network. Finally, the vessel is ready to receive a number of oceanographic systems which are listed but not available yet.

1. OVERVIEW

The below picture is defining all areas of the ship which are related to scientific purposes. Water sampling can be done in the wet lab, whereas the data analysis and office work can be done in the dry lab. Storage space is available in these rooms. In the wet lab, a travocean pipe is allowing the temporary lowering of recording devices brought by science teams. In addition, the hull has the necessary penetrations to permanently install several transducers which are listed further in this chapter. A server room is at the center of the science network and is managing the data of all installed autonomous recording equipment. The science network is reaching all laboratories, the transducer area, main wheelhouse, antenna area and is connected to the ship's network for internet connection. Meteorological sensors are installed onboard for the recording of air, sea, and ice parameters. The data collected through these sensors is available in open databases.

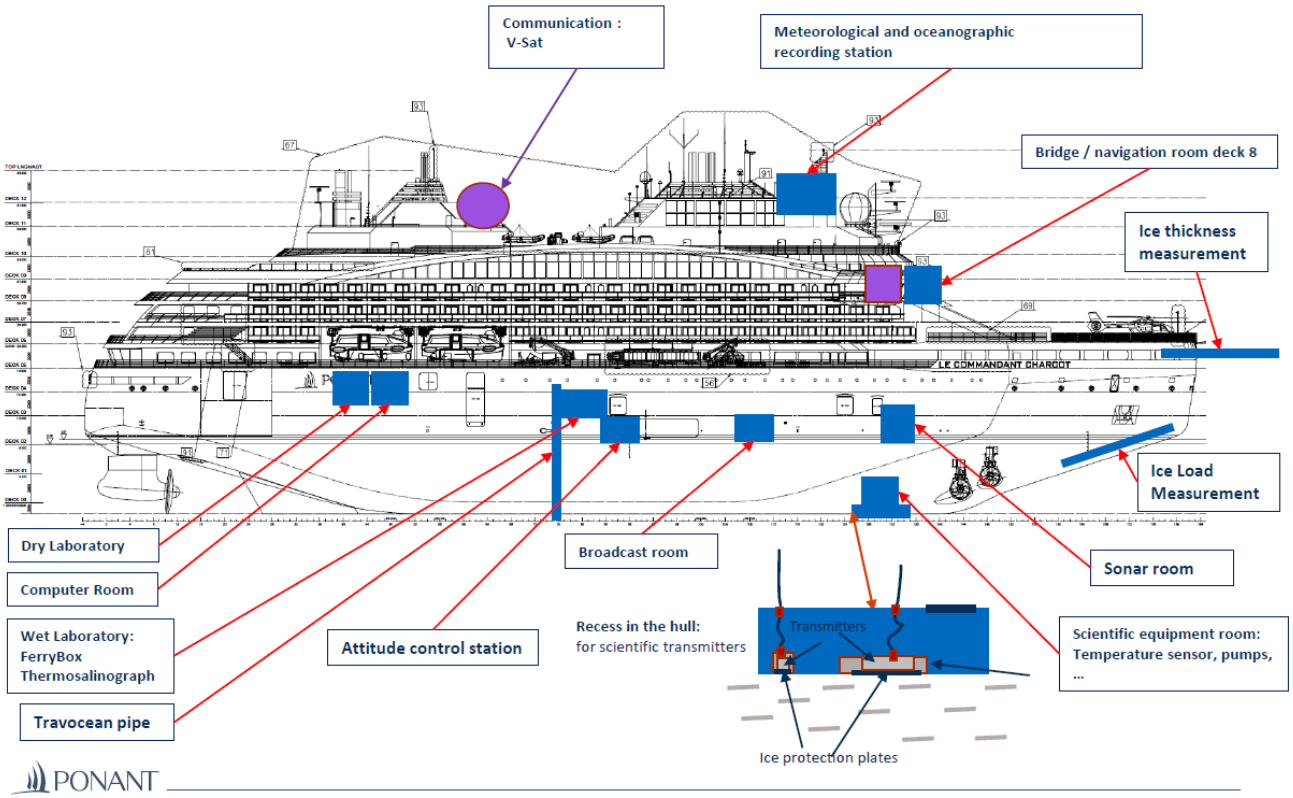


Figure 28 Le Commandant Charcot - science overview

2. LABORATORIES / SCIENTIFIC ROOMS

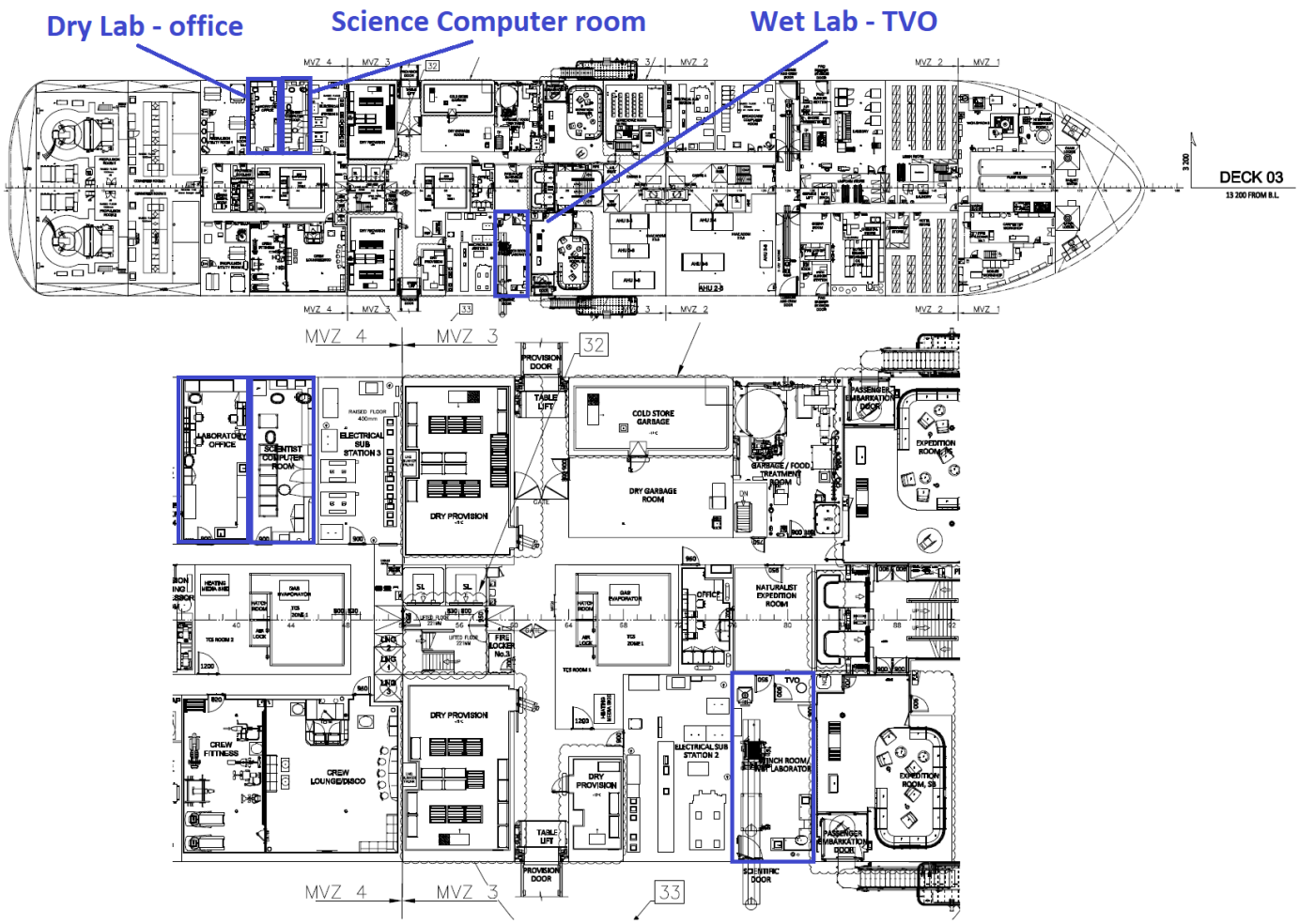


Figure 29 Zoom-in on the dedicated offices and laboratories on deck 03

1. Laboratory Office / Dry Laboratory

This office has an area of 35 m2 including an office area for 3 workstations and a storage area. The other half of the room can be used for water sampling (sea water faucet via peristaltic pump and metal-free piping) and analysis.

Figure 30 Dry Laboratory Layout

In this room, the below list of equipment is arranged:

- 3 Working stations: fitted with 220 v sockets (normal and UPS), science LAN sockets, ship's LAN sockets,
- 2 Corian working benches with 2 sinks: hot water and cold water taps, compressed air connection, sea water tap, distilled water tap,
- 1 Telephone on the ship's network,

- Lockers, Shelves.

Complete layout of the room can be found in Appendix 6.

2. Wet Laboratory

The wet laboratory is 47 m2 and is dedicated to water sampling and experiments needing direct access to water or ice through the shell door.

Figure 31 Wet Laboratory layout

In this room, the below list of equipment is arranged:

- Working bench: 2 sinks, hot water and cold water taps, compressed air connection, sea water tap, distilled water tap,
- Power Socket 220 V IP 44, science LAN sockets, ship's LAN sockets,
- 1 Telephone on ship's network,
- Side doors 1,2m wide, 2 m height which can be opened at sea,
- Dedicated local air conditioning unit.

Complete layout of the room can be found in Appendix 7.

3. Science Computer Room

In order to manage the dedicated science LAN and the real-time recording sensors, a server room has been designed. Completion of the network is foreseen in April 2023.

Figure 32 Science computer Room

In this room, the below list of equipment is arranged:

- 1 working bench: fitted with 220 V sockets (normal and UPS), science LAN sockets, Ship's LAN sockets,
- Lockers, Shelves,
- 1 Telephone on ship's network,
- 1 SCU (self-contained unit: Emergency air conditioning unit),
- 1 FCU (Fan coil unit - Air conditioning unit).

Complete layout of the room can be found in Appendix 8.

3. UNDERWATER HULL EQUIPMENT

1. Bubble Study

The vessel's hull shaped being that of an icebreaker, a CFD study have been made to analyze the bubble sweepdown on this particular hull in order to evaluate the possibility to install oceanographic transducers. The study was done at 10 knots and 12 knots.

Results show that bubbles are led to the bottom, avoiding the Center Line but are present under most of the transducer positions at these speeds. In addition, tests have been made during sea trials to estimate the critical speed where bubbles are starting to interact with echo-sounders. CFD report can be found in Appendix 9 and sea trial report in Appendix 10.

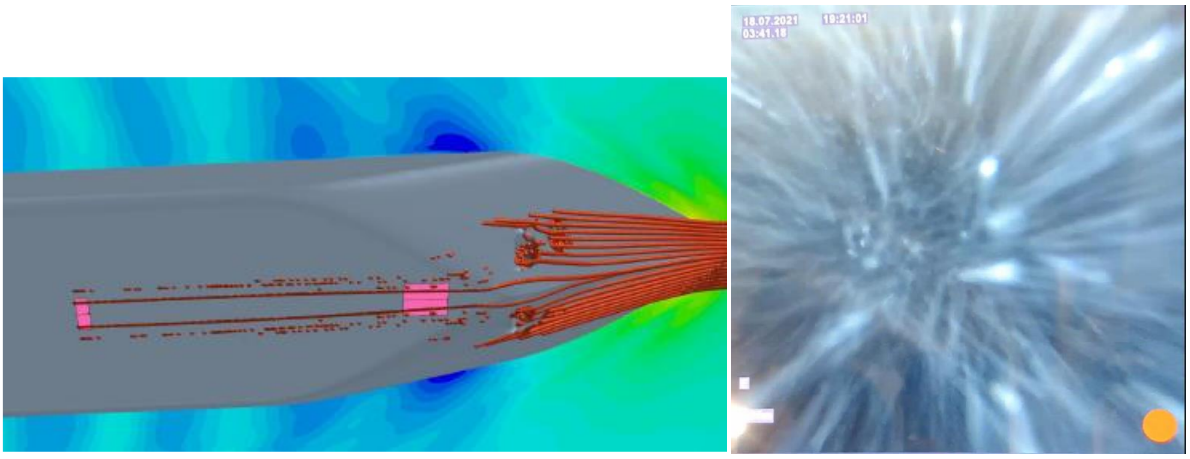


Figure 33 Left: CFD visualisation of bubble sweepdown. Right: bubbles recorded at 10 knots under the TVO

2. Underwater Instruments

1. Hull bottom Layout

Drawing in Appendix 11 represents the layout of the hull's bottom for the permanent installation of several transducers which are listed further in the document. All transducer positions are for now protected by Ice-protective plates.

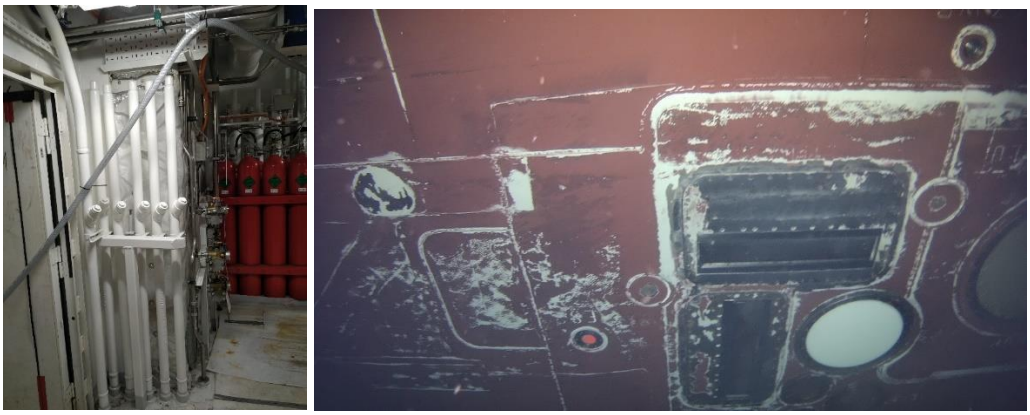


Figure 34 Left: All transducer boxes have vent and cable pipes foreseen above water level. Right: bottom picture of transducer positions.

2. TVO

A Travocean (TVO) pipe is available for installation of temporary sensors (transducers, camera, hydrophone). It includes one extender and angle indexation (see Appendix 12).

Figure 35 TVO with orange bladder, black angle indexation and stainless steel extender.

3. Echo-Sounder

Kongsberg EA440 single beam echo sounder for shallow and medium depth has been installed in addition to the navigation echo-sounders. The 38 kHz transducer with 9° beam option has been selected. The visualization of the depth is made in the wheelhouse.

4. SEAWATER SAMPLING AND MONITORING

The vessel is equipped with specific piping and equipment allowing to take direct clean sea water samples as well as monitoring sea water parameters. The below *Figure 36 Sea Water System dedicated for research*, is showing the principle of the ship's installation. From a penetration in the hull, it is possible to take samples either through a peristaltic pump for micro-organisms (via metal-free pipes), either through a centrifugal pump for sea water monitoring (see Figure 37 Sea water system dedicated for scientific water samplin).

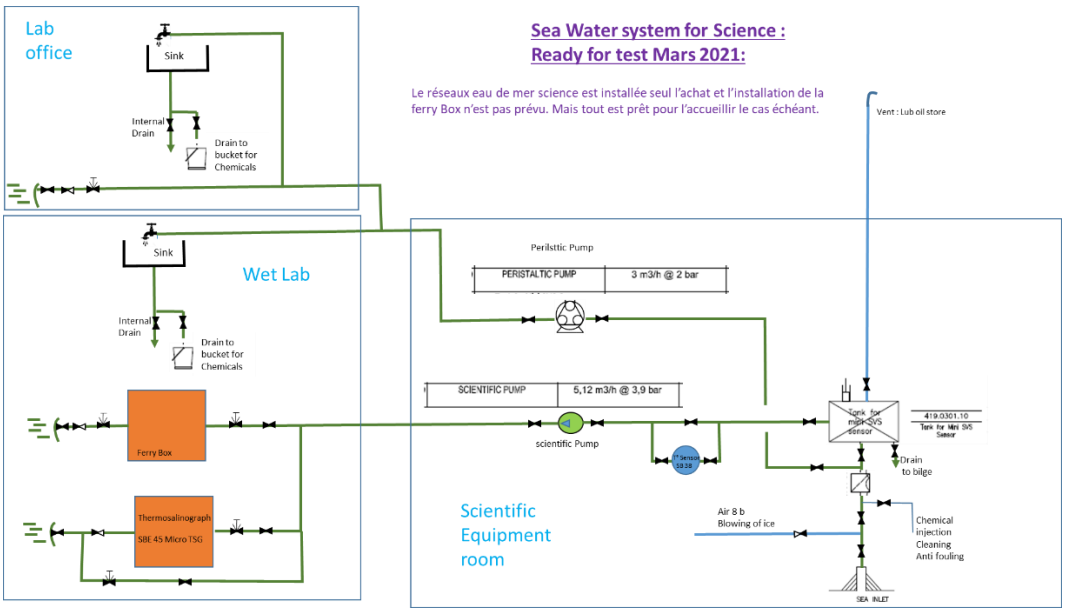


Figure 36 Sea Water System dedicated for research

Drawing in Appendix 13 is showing the piping installation as well as the installed and foreseen testing and monitoring equipment. Dedicated lines for in-flow measurements are installed for a thermosalinograph, celerimeter (minSVS) and a ferry box (not installed yet). The piping has been foreseen with connections for chemical cleaning of the pipes.

SFI	DESCRIPTION	CAPACITY	TYPE	SUPPLIER
419.0101.10	**SCIENTIFIC PUMP**	5,12 m3/h @ 3,9 bar	CENTRIFUGAL W/EL.MOTOR	Allweiler
419.0201.10	**PERISTALTIC PUMP**	3 m3/h @ 2 bar	CENTRIFUGAL W/EL.MOTOR	Allweiler
419.0301.10	**Tank for Mini SVS Sensor**			VARD

COMPONENT

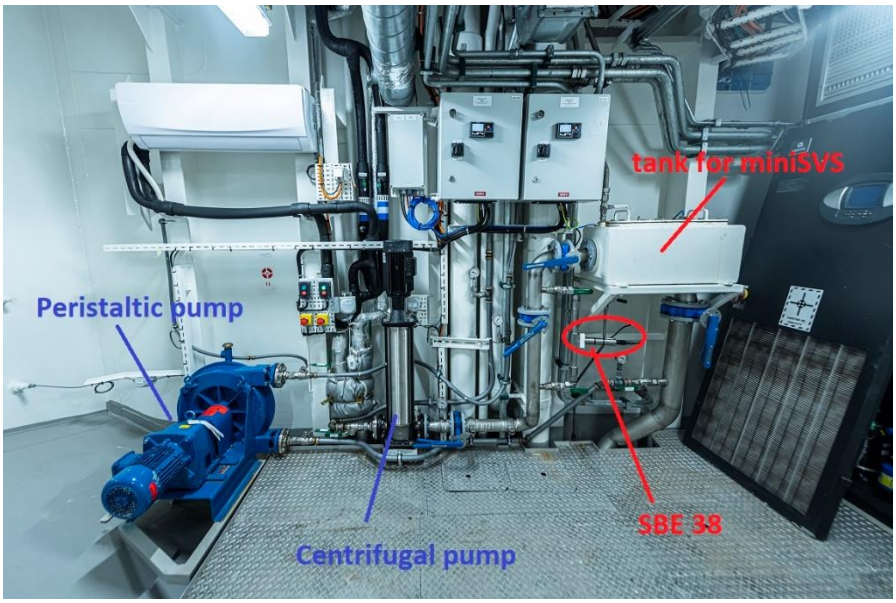


Figure 37 Sea water system dedicated for scientific water sampling.

5. RECORDING EQUIPMENT

In addition to inviting scientist to come onboard, the vessel has been equipped with continuous recording equipment. This equipment is managed by the onboard scientific coordinator.

1. Sound velocity sensor

On the seawater system a Mini SVS Celerimeter from Valeport (see Appendix 14 and Figure 38 Sound Velocity Sensor tank) is fitted. Data is acquired in the science computer room via Valeport dedicated software.

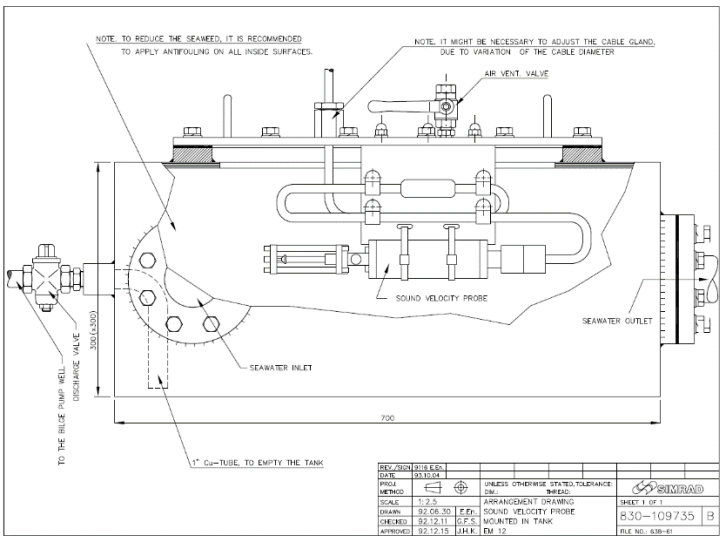
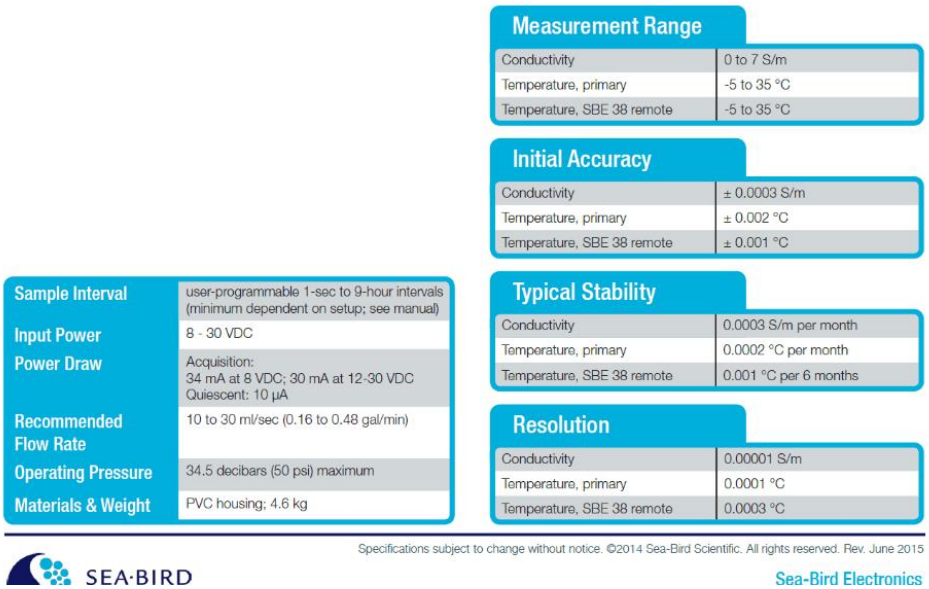


Figure 38 Sound Velocity Sensor tank

2. Thermosalinometer

A thermosalinometer Sea bird SBE 45 connected to a temperature sensor SBE 38 is installed in the wet lab. Data acquisition is made through SODA software developed by the French Institute IRD. Automatic data transmission to shore is implemented. Daily sea water sampling is organized for data verification and sensor drifting analysis.



Measurement Range	
Conductivity	0 to 7 S/m
Temperature, primary	-5 to 35 °C
Temperature, SBE 38 remote	-5 to 35 °C

Initial Accuracy	
Conductivity	± 0.0003 S/m
Temperature, primary	± 0.002 °C
Temperature, SBE 38 remote	± 0.001 °C

Typical Stability	
Conductivity	0.0003 S/m per month
Temperature, primary	0.0002 °C per month
Temperature, SBE 38 remote	0.001 °C per 6 months

Resolution	
Conductivity	0.00001 S/m
Temperature, primary	0.0001 °C
Temperature, SBE 38 remote	0.0003 °C

Sample Interval	user-programmable 1-sec to 9-hour intervals (minimum dependent on setup; see manual)
Input Power	8 - 30 VDC
Power Draw	Acquisition: 34 mA at 8 VDC; 30 mA at 12-30 VDC Quiescent: 10 µA
Recommended Flow Rate	10 to 30 ml/sec (0.16 to 0.48 gal/min)
Operating Pressure	34.5 decibars (50 psi) maximum
Materials & Weight	PVC housing; 4.6 kg

Specifications subject to change without notice. ©2014 Sea-Bird Scientific. All rights reserved. Rev. June 2015

SEA·BIRD

Sea-Bird Electronics

Figure 39 Thermosalinometer datasheet

3. Weather Stations

4. EUCAWS METEO France

An EUCAWS (Shipborne European Common Automatic Weather Station) from French Weather Forecast company METEO FRANCE is installed. Presentation of the equipment and the project can be found in Appendix 15. The equipment is working in complete autonomy and data is accessible at below link:

http://esurfmar.meteo.fr/cgi-bin/meteo/display_vos_ext.cgi?callchx=MBBJ7YM

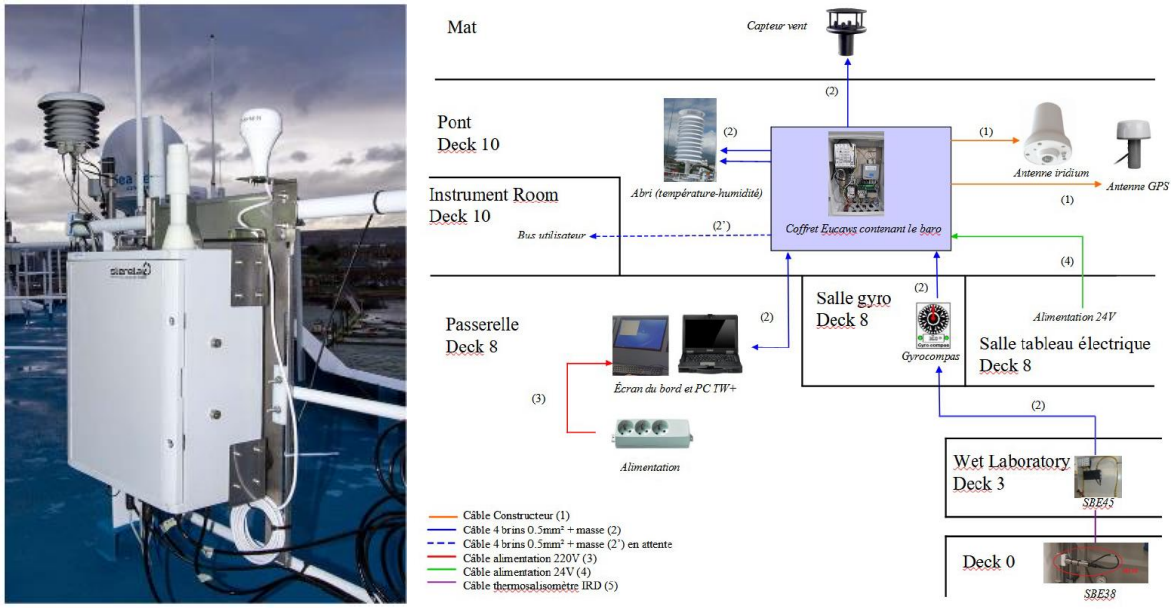


Figure 40 EUCAWS installation and topology

5. EHMS – Environment and Helideck Monitoring System

The system has been installed for the monitoring of weather and ship's movements for helicopter operation. Data is shown in the wheelhouse, in wet lab and other passenger areas and can be stored for further analysis. The data is also broadcasted on the ship's network. Detailed information is available in Appendix 16.

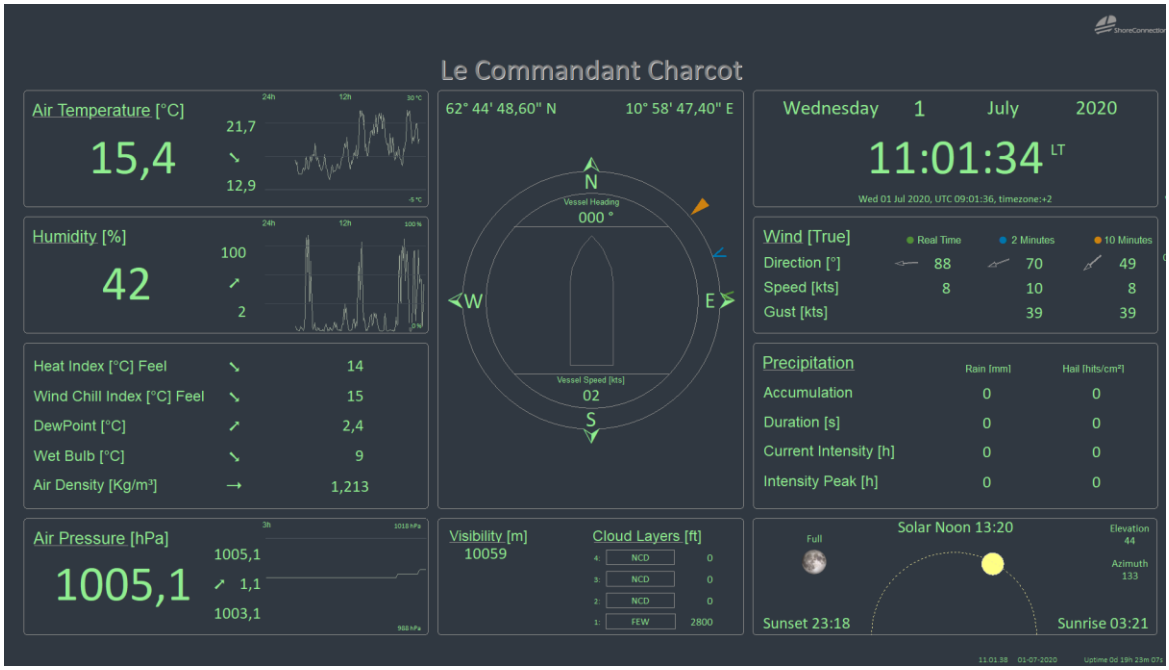


Figure 41 E-HMS monitor layout

4. Ice-Related Equipment

1. ICE THICKNESS MEASURMENT

The below systems have been studied and are planned to be installed

1. EM and Acoustic doppler Ice thickness measurement (SIMS, developed by C. Haas)

An electromagnetic sensor coupled with an acoustic doppler is suspended 6-8m in front of the ship allowing to measure the ice thickness. The acoustic transducer is measuring the distance to the top of the ice. The electromagnetic transducer is measuring the distance to the water level. A substraction is giving the ice thickness. Note: a zero-setting of the electromagnetic sensor is required, as the result is depending on the sea water salinity.

The snow thickness availability is currently under study but the strength of ice cannot be measured. The equipment is provided by ANE and documentation can be found in Appendix 17.

Figure 42 SIMS suspended in front of Le Commandant Charcot

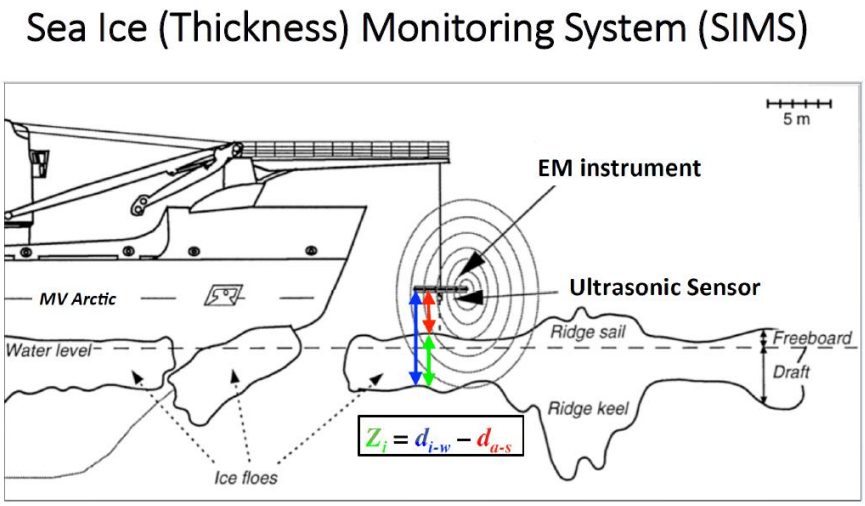


Figure 43 Function principle of the SIMS

2.Ice Load Monitoring System project

With load sensors arranged on the vessel, the hull's response to surrounding Ice condition can be monitored and lead to defining the type of Ice encountered (strength and thickness).

2. ICE ROUTING SOFTWARE

In order to reduce as much as possible the fuel consumption and keep the cruise schedule, it is necessary to predict the encountered ice thickness and to set the best possible route. The ice Routing software is an innovating navigation tool under joint development by Adrena and Ponant.

Ice charts, satellite pictures, vessel's planned waypoints, time constraints and vessel performances in ice are used as an input and the software calculates the less consuming route.

Ice thickness measurement, vessel's speed, power consumption, fuel ROB will be indicated in real time.

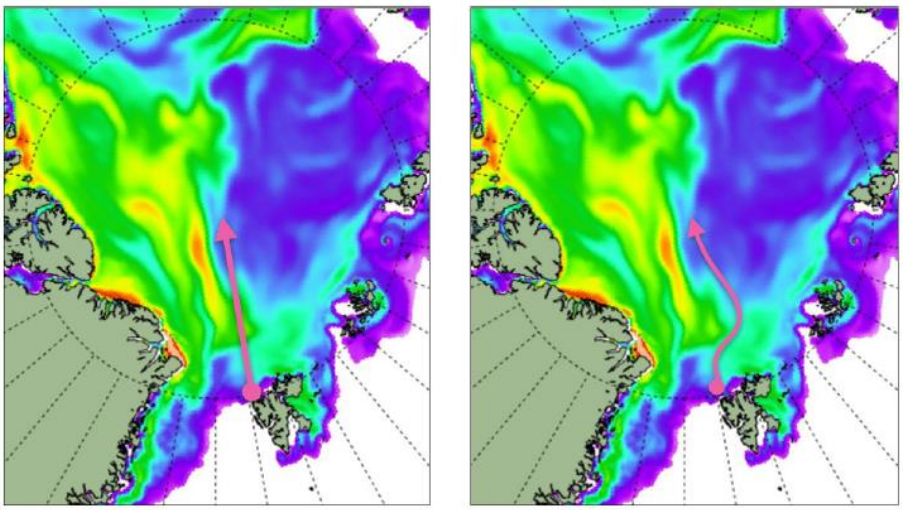


Figure 44 Route optimisation in Ice with Adrena

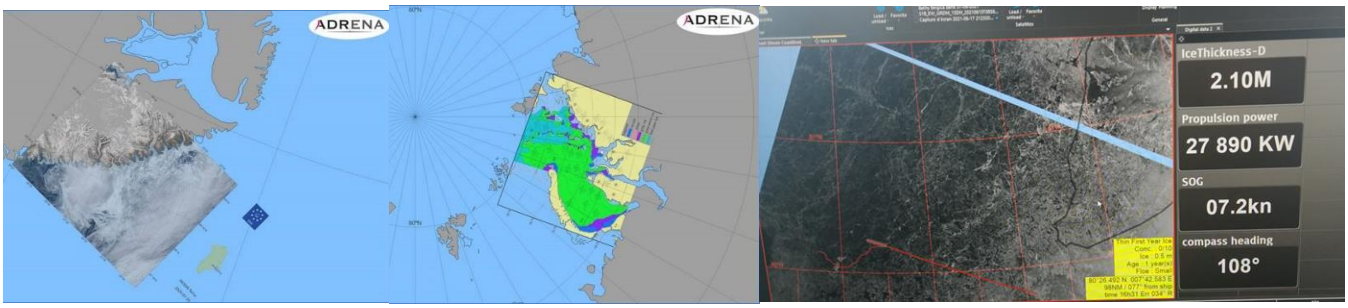


Figure 45 Examples of chart or picture integration in Adrena with real-time monitoring

6. SCIENTIFIC NETWORK

A dedicated LAN for science is installed on board. Topology drawing can be found in Appendix 18. The network is connecting the two Laboratories, the measuring and monitoring equipment, the engine control room, the science computer room, the sonar room (access to bottom instruments), instrument room on deck 10 (access to antennas), broadcast room (access to internet and ship's network) and a dedicated console in the wheelhouse.

1. Data Network

Detailed data network can be found in Appendix 18 and the philosophy can be found below in Figure 46 Scientific Data Network.

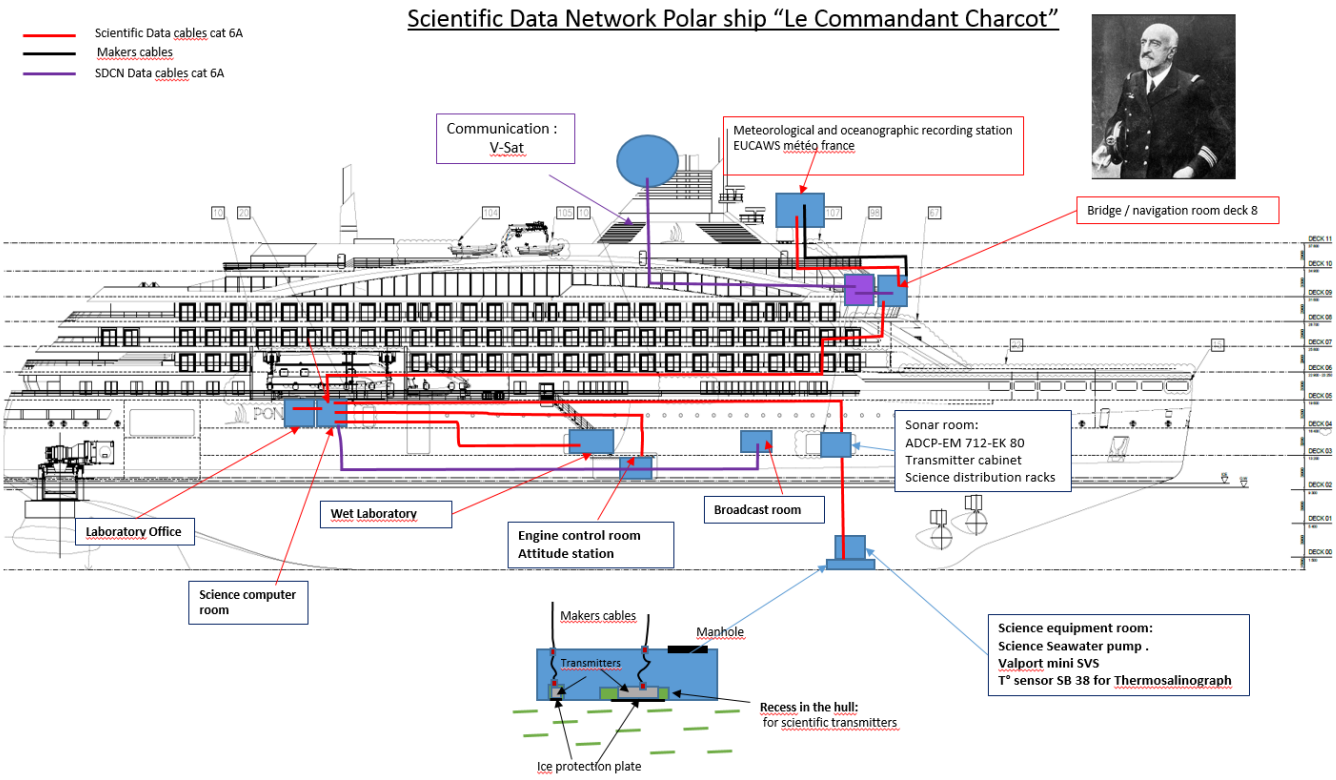


Figure 46 Scientific Data Network

2. Wheelhouse Science Console

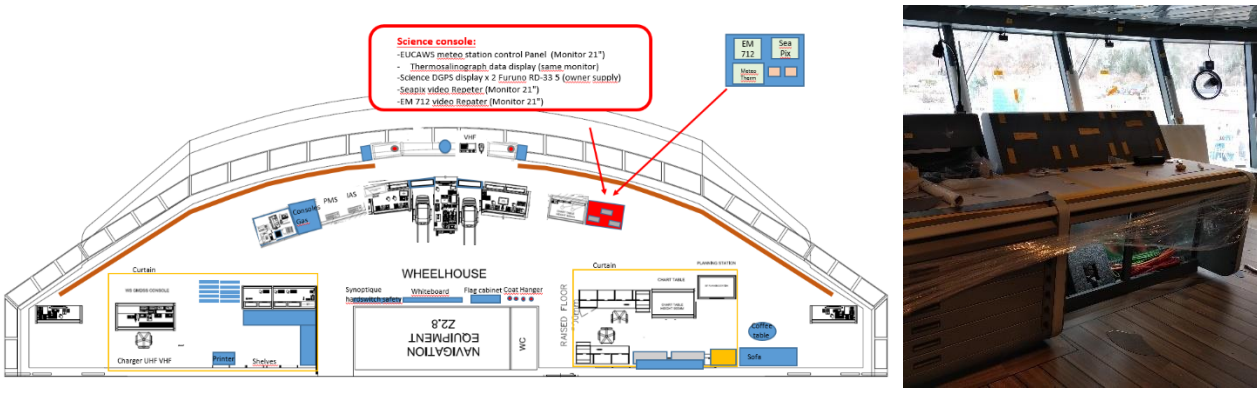


Figure 47 Layout of the wheelhouse

This scientific console is a dedicated working space fitted with three integrated screens and a worktable. It allows remote monitoring of bottom transducers and can centralize visualization of measurements for crew and passengers.

7. FORESEEN EQUIPMENT

The Ponant Science Program is inviting researchers from a lot of different domains and the scientific facilities onboard can be improved on a yearly basis in order to allow on board a bigger variety of experiments. The type of instrument and equipment which will be installed is depending on the needs of the researchers contacted within the program. This chapter is listing foreseen equipment and instrumentation.

1. Laboratory equipment

For water sampling and analysis related to chemical or biological parameters or the study of microbiology, the below instruments can be arranged:

Dry laboratory

- 2 Hoods (over pressure & exhaust),
- 1 Fridge freezer (-20°C),
- 1 Emergency shower and eyes wash,
- Microscopes, Epifluorescence Microscope,
- Glassware,
- Protective equipment,

Wet laboratory

- Winch and crane for bathymetry. Cable length to be defined. (see APPENDIX 19)
- Ferry box with CO2, O2, Nitrate sensors, (see APPENDIX 20)
- Cryogenic fridge (-80°C),
- Chemical cabinet,
- Steaming oven (etuve), oven (autoclave),
- 1 Emergency shower and eyes wash.

Office equipment

- 1 Tracer Printer,
- Server + KVM + screens for centralization of instrument acquisition in science computer room,

2. Bottom equipment

Hull penetrations have been done to accept the below list of equipment for which the datasheets can be found in Appendix 21. Cabling pre-installation is also already provided.

- EM 712 multibeam echosounder,
- SIMRAD EK80 wide-band echosounder with 6 transducers,
- Ocean Observer III 38kHz ADCP (planned for April 2023),
- An iXBlue Seapix Volumetric 3D Sonar,
- MRU (Hydrins), GPS (2 GPS Ashtech HDS800 and 1 CNAV3050), and other support equipment for operation of sounders (planned for April 2023).
- ROV REVOLUTION de Deep Trekker (planned for April 2023).

Hope to see you onboard soon!