THE POURQUOI PAS?, AN INNOVATIVE OCEANOGRAPHIC VESSEL

By :

Olivier LEFORT

Pourquoi pas? Project Leader – Ifremer

Marc NOKIN

Implementation Manager for Submersible Devices – Ifremer

I. THE *POURQUOI PAS ?*, THE RESULT OF A PARTNERSHIP BETWEEN THE FRENCH NAVY AND IFREMER

Knowledge of the maritime environment is indispensable for safe navigation in peacetime and is a decisive factor when deploying and conducting naval operations during times of war or emergency.

Today, marine science research centres around three major questions; the sustainable exploitation of the resource, how the climate system works and changes in the coast and its use.

These inherently different aims can often be achieved using similar or identical tools.

This is why the partnership between French civilian research bodies and the French navy goes back a long way. The *Pourquoi pas?* of Captain Charcot was equipped by the French navy. Deployment of the bathyscaph was the work of the Navy for French scientific teams in the 1970s. More recently, this has been replaced by missions lead jointly or with complementary sea-going resources.

1-TWO INITIALLY INDEPENDENT SHIP-BUILDING PROGRAMMES

The French naval high command have been looking to replace the hydrographic vessel "*L'espérance*" and the oceanographic vessel, the "*D'Entrecasteux*" since 1991. Preliminary analytical work began in 1992 and ended in 1994 with a first draught of the requirements. Various solutions were contemplated and investigated with a view to using either one or two vessels (with or without a partnership) in order to meet the exact requirements.

For its part, Ifremer began a fleet renewal scheme in 1985, intended to rationalise the sea-going resources of the *Centre National pour l'Exploitation des Océans* (CNEXO) on one hand and the *Institut Scientifique et Technique des Pêches Maritimes* (ISTPM) on the other hand.

This scheme meant removing many old or unadaptable ships from the fleet and building new ones: *L'Atalante* (1989), *L'Europe* (1993), *Thalassa* (1996). The *Suroît* was refitted in 1999. The final vessel affected by this renewal scheme was the *Nadir.* Preliminary dimensioning studies for its replacement, the Navire d'Exploration Profonde (NEP, deep sea exploration ship), began in 1997.

2-AN UNPRECEDENTED COLLABORATION

Since a partnership between the French navy and Ifremer seemed to be a possibility for these two separate schemes, the ministries of research and of defence asked Ifremer, the French Navy and the SPN (naval programme department of the French ministry of defence) to jointly review the renewal of their maritime resources.

This review showed that, mostly, the requirements of the two organisations could be met with two shared-use ships, benefiting the state through economies of scale, both in terms of investment and operating costs.

The ministries of research and of defence agreed on 17 July 2000 to work in partnership for the shared production and use of two new ships, based on joint-funding.

?? the hydro-oceanographic ship (BHO), a military vessel, operated by the ministry of defence (DGA), with a 5% contribution from Ifremer.

?? The deep-sea exploration vessel (NEP), a civilian ship, operated by Ifremer, with a 45% contribution from the ministry of defence.

This partnership is detailed in an agreement signed by the ministry of defence and Ifremer that was on 12 April 2001.

The BHO, fitted out by the French navy, carries the name the *Beautemps-Beaupré*, an 18th century hydrographer. She conducted her first hydrographic missions in the Arabian Sea at the beginning of 2004. She is a multi-purpose ship, fitted with the latest generation of multi-beam sounders for use in deep and shallow waters, laboratories and impressive scientific equipment. The *Beautemps-Beaupré* is derived directly from the *Thalassa* and is 80 metres long, with a displacement of 3,300 tons. She was built by Alstom Marine and is electrically-powered. Ifremer's 5% contribution to its financing entitles it to ten days' annual use.

The NEP was named the *Pourquoi pas?* as a tribute to Captain Charcot. She is Ifremer's largest ship. She is operated by Ifremer. Built in Saint Nazaire on the *Chantiers de l'Atlantique* site (Alstom Marine), this vessel is responsible for carrying out deep-sea hydrographic or oceanographic missions, providing the sequential deployment of two underwater systems, carrying out seismic studies and deploying SHOM hydrographic motorboats and the Newtsuit recovery system for submarines in difficulty.

It thereby meets the scientific requirement of being able to conduct long-term multidisciplinary missions in sensitive areas, such as hydrothermal sources or fault zones. The vessel firstly carries out a medium-scale survey using a towed sonar. Then, during the same mission, a *Nautile* manned submersible device or the *Victor 6000* remote-operated device (ROV) is deployed over a smaller area chosen from within the surveyed area. She is one of the few modern oceanographic vessels capable of carrying out all these operations during the same mission.

The *Pourquoi pas?* was delivered to Ifremer on 5 July 2005. After being fitted out, the ship underwent trials, between the end of August 2005 and April 2006, intended to validate the performance of the scientific equipment and the deployment procedures for the mobile equipment. The trials were carried out by the crew in collaboration with the project team and involved numerous technicians and scientists from Ifremer, the SHOM and Genavir teams. They enabled:

?? Qualification of the scientific equipment

?? Implementation of the IT network and the update of the data acquisition, processing and distributing software

?? Validation of the deployment of the Victor 6000, Penfeld, towed systems, hydrographic motorboats and the Newtsuit system

At the end of April 2006, the vessel began a six-month mission for SHOM (French naval hydrographic and oceanographic department), the Navy (Congas, Mouton) and the scientific community (Vicking, Momareto, etc.).

II. TECHNICAL FEATURES OF THE *Pourquoi pas?*

1-MAIN DIMENSIONS

??	Order date	17 December 2002
??	Delivery	05 July 2005
??	Overall length	107.60 metres
??	Length between perpendiculars	95.42 metres
??	Beam	20 metres
??	Max. draught	6.925 metres
??	Lightship displacement	4,400 tons
??	Deadweight tonnage	2,200 tons
??	Max. displacement	6,600 tons
??	Gross tonnage	7854 UMS
??	Net tonnage	2,356 UMS
??	Max. speed	14.5 knots
??	Transit speed	13.3 knots
??	Economic speed	11.0 knots
??	Range	80 days at 11 knots
??	Classification	BUREAU VERITAS
??	Propulsive power	2 x 1650kW at +/- 150rpm (asynchronous motors, APC)
??	Electrical power output	4 x 1837kVA 50 Hz (4 Wärtsilä diesel 8L20C + Leroy Somer LSA 53 MY alternators)
??	Transverse thrusters	4 x 735kW
??	Rudders	2 x Becker

2-TECHNICAL SPACES

?? Surface area of scientific offices 601m^2 for 40 onboard scientists
?? Surface area of cabins and communal areas 1064m^2
?? Surface area for storage 283m^2
?? Bridge surface area 236m^2

3-ACOUSTIC RESULTS

Radiated noise

The provisional levels of noise radiated in the water were calculated using an internally developed code. This calculates the effect of each source on the overall amount of noise radiated and quantifies the mechanical and acoustic effects.

The database used for these calculations, which has been continuously updated for around fifteen years, includes the following elements:

?? The ship's structure

?? Mechanical and acoustic characteristics of the main sources (i.e. the propulsion engines, electric generators, compressors, chillers, etc.)

?? Characteristics of the engine room and technical offices in which these sources are installed

?? Characteristics of the propellers

?? Acoustic and mechanical transfers in the water

The following sources were taken into account: the 2 propellers, the two propulsion engines, the general air compressor, 3 fully charged electric generators, a starting air compressor, 1 reverse osmosis unit, 1 chiller at full power.

The calculated spectrum of radiated noise, shown below, shows levels that exceed those defined at each extremity.

The provisional levels from the propellers are the causes of this excess. The modelling used is not yet adapted to the optimised propellers. The software is currently being improved.

The measurements of noise radiated in the water show, however, that the results are very conservative and that the actual levels are lower than those defined.

Self noise

Self noise is the sum of all the background noises picked up by the acoustic equipment. These background noises are principally attributable to:

?? Solid-borne noises, or vibrations, transmitted through the structure by the equipment installed in the vessel, such as the electric generators;

?? Hydrodynamic noises from turbulent flows over the gondola pod.

Noise from the propeller, although directional, and from the swell can also contribute to inherent noise.

All the measures taken to reach the targets for noise radiated in the water contribute towards a reduction in solid-borne transmission; namely:

?? Double suspension of the electric generators;
?? A new generation of converters used for the propulsion engines;
?? Pumps mounted in "modules", limiting the transmission paths;
?? Systematic decoupling of the pipework;
?? Improvement of the sound proofing in the rooms in which the main sources are found.

The dynamic calculations made on the gondola's structure, fitted beneath the ship's hull, and taking into account the increased mass of water, show very low levels of vibrations and little risk of causing resonance. Moreover, the sounders are uncoupled from the body of the gondola.

The levels of background noise achieved are excellent.

III. A VESSEL OPTIMISED FOR THE DEPLOYMENT OF UNDERWATER SYSTEMS AND VARIOUS EQUIPMENT

1-MISSION SCENARIOS REQ UIRING THE DEPLOYMEN T OF UNDERWATER SYSTEMS

The *Pourquoi pas?* is a ship that is capable to carry out multidisciplinary mission scenarios involving the deployment of various operating systems at sea on a single site. The general philosophy was to offer a flexible structure that could be adapted to future missions and to developments in onboard systems. The requirements were as follows:

?? To successively accommodate and deploy, with a minimum reconfiguration time, two submersible from the *Nautile* or *Victor 6000* class in sea states above 5

?? The ability to carry out coring of up to 30m in length, alternating with the deployment of underwater systems

?? To deploy Ifremer's multi-trace seismic equipment, while anticipating future developments

?? To undertake coastal and deep-sea hydrography missions for SHOM which require three hydrographic motorboats

?? To deploy the French navy's Newtsuit system for assisting military submarines in distress.

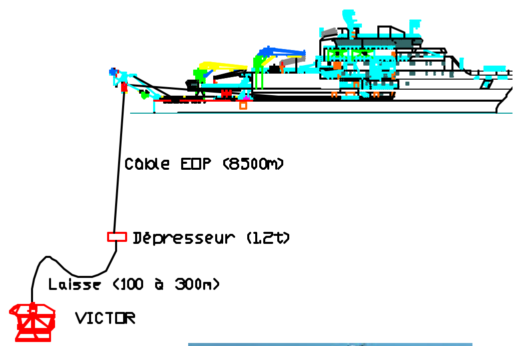
2-SYSTEMS USED

The mobile systems deployed on the vessel fulfil different requirements: autonomous manned submersible, unmanned systems linked by cable to the support vessel (towed or not, heavy or floating in the water) and motorboats

The *Nautile* is an autonomous manned submarine which can accommodate 3 people (pilot, co-pilot and scientist) and is capable of diving to depths of up to 6,000m. The submarine, which is 9m in length and has a mass of 20 tons, can make observation and sampling on a daily cycle (dives during the day, recharge batteries overnight). The *Nautile* support equipment includes six containers for carrying out maintenance at sea and monitoring the dives. The vessel also has to store 40 tonnes of lead shot, which is used during diving and surfacing operations. The full support equipment has a mass of around 100 tons.

The *Victor 6000* is an ROV (Remotely Operated Vehicle) with a mass of 4.6 tonnes, capable of diving to depths of up to 6,000m and performing lengthy operations on the sea floor (observation and sampling). It uses the "depressor" concept, whereby an instrumented weight (1.2t) is inserted between the vessel and the ROV. This concept separates the ROV from the vessel's movements.

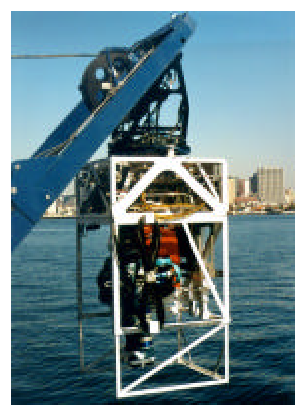
The deep-sea cable is an 8,500m long cable which provides the power supply (20kW) and the transmission of data via fibre-optics.



The tether is around 200m long and is supported by floats along half of its length. Its 'S'-shape disconnects the ROV from heave.

The full support equipment has a mass of around 65 tonnes and comprises four containers, including 1 control container.

The *Newtsuit* system is made up of three sub-assemblies:



?? The *Newtsuit*, a self-propelled diving suit for assisting submarines in distress.

?? *Ulysse*, light support ROV

?? The ventilation system which, once connected, supply fresh air to the submarine and remove contaminated air.

The unit can work at depths of up to 300m. The three sub-assemblies (*Newtsuit*, *Ulysse* and the ventilation shafts) have their own launching and recovery systems (frame incorporating a winch and the launching A-frame).

The hydrographic motorboats, operated by SHOM, for drawing up bathymetric maps in coastal waters.

At 8m long and with a mass of 4.5t, they have specific davits for launching and recovery.

The *Penfeld* is a vehicle for studying the physical properties of sea-floor sediments, up to a depth of 6,000m. This installation, which is heavy in the water, is linked to the support vessel by a steel cable (maximum depth 2,200m) or from aramid fibre for greater depths. Once it is resting on the sea-floor, a 30m instrumented rod is sunk vertically into the sediment.

The full support equipment has a mass of around 30t. Its mass of 6.5t, dimensions (2.2m (L) * 3.9m (L) * 5.2m (H)) and very low centre of gravity lead to significant "swinging arm" type motions during aerial movements.

The multi-trace seismic equipment measures the geometry, the structure and the shape of geological strata by closely observing the transmission delay of acoustic waves generated by a sound source. Future developments in seismic survey equipment have been taken into account on the *Pourquoi pas?* A 4,500m-long streamer for receiving acoustic waves is towed, whilst the sound sources are generated by between 4 and 6 lines of airguns, also towed. In total, the system, fully containerised, may include more than 25 standard 20' containers.

3-DEPLOYMENT PRINCIPLES

The method for deploying the underwater systems has driven the vessel's architecture.

?? The *Nautile* (manned submersible) is only deployed via the stern A-frame, following procedures established since the creation of the submersible. It is towed on the surface for a time before being recovered.

?? The towed systems are, by their very nature, deployed via the stern of the ship, pulled at a speed greater than 2 knots.

?? Systems linked by cable or operating under dynamic positioning conditions (*Victor 6000*, *Newtsuit* or *Penfeld*) are preferably deployed over the side of the vessel, as this reduces the amplitude of the platform's movements. This functionality is made possible by an oceanographic crane dedicated to this task. Launching, recovering and diving operations are therefore made safer by reducing the effects of heave, enabling the operational limits for deployment of the systems to be increased. They can also be launched from the stern of the vessel, but the sea and weather conditions are then more limited. The deployment of these devices lead to a need for a high-performance class II dynamic positioning system for use in stipulated sea states (5 to 6) and wind conditions.

?? The hydrographic launches are deployed at the side of the ship using specific davits. They can also be launched at the stern of the vessel using similar procedures to those for the *Nautile*.

4-THE DESIGN OF THE STERN DECK AND ASSOCIATED AREAS

To meet these requirements, the *Pourquoi pas?* has a large stern deck, 28m long by around 20m wide, that is extended by an enclosed hangar. The quarterdeck and hangar are crossed by two in-built tracks (rails embedded in the deck) which allow the devices to be moved on motorised trolley, from where they are stored in the hangar to where they are manoeuvred.

The vessel has two main handling areas:

- An aft handling area, served by the stern A-frame, which is used to launch any type of device but preferably the *Nautile* and the towed devices.

- A lateral handling area, laid out on the starboard side, for the deployment of systems tethered by cable for dives at a fixed position (*Victor*, *Penfeld*). This area is serviced by the specific oceanographic crane and a lateral telescopic beam. This area is also used to launch the *Newtsuit*.

Combined with the quarterdeck are:

- The hangar, which can house at least two systems for maintenance and their preparation, as well as 5 20' containers. When operating in cold areas, the hanger can be shut using sliding shutters. Specific adaptations for the *Nautile* have been planned (mezzanine deck for access to the upper parts of the submarine, access gangway along front side, etc.).

- The core-sampler gangway, situated at the front of the stern deck, on the starboard side. It is 40m long and is fitted with booms for deploying the long core-sampler (30m).

- The winch compartment is situated under the rear deck and contains two traction winches and four cable storage reels including a cable for Victor (nominally 8,500m long) and cables for coring or dredging operations. They come out onto the deck via two openings in the deck, one at the front and one at the rear of the stern deck.

- Tweendecks give "surface level" access. They are opened to the outside using watertight doors and are situated around 1m above the water line. They are used for helping with the recovery of systems at sea. One tweendeck is located at the transom, the other on starboard side.

- The scientific control room is the office for real-time monitoring of dives (*Victor 6000* or *Nautile*, for example). The device steering containers can be taken up to this level to improve links between pilots and scientists (directing the dives) and pilots and the bridge (directing the vessel).

From the point of view of the study, the coordination of the rear deck was identified as requiring a specific iterative process that involved the client from the inception of the project to initialise the design, then to assess and approve it. This process is similar to the design cycle for the shipbuilding project but on a smaller scale.

5-MAIN HANDLING EQUIPMENT

The stern A-frame has a clearance of 13m and encompasses the two tracks for carriages.

It has two complete handling systems in order to be able to work with two systems successively (central and starboard sections).

The size of the A-frame has been dictated by the handling of the *Nautile* submarine. It has a 22t capacity, in line with the BUREAU VERITAS ALS standard (required for manoeuvring manned devices). It is moved by four hydraulic cylinders (two cylinders per post) to ensure stand-by redundancy should one of the cylinder fail. The submarine is lifted using a dedicated winch on the port upright of the A-frame, which is fitted with a 100mm-diameter textile hoist line.

The handling of unmanned devices involves the use of two 10t SWL winches, serving the central and starboard sections respectively. These winches can operate in "take up the slack" mode or under constant tension, during the recovery of floating devices. This function allows the cable to be kept under tension to avoid the risk of sudden oscillations in the cable caused by the movements of the vessel. These winches are also fitted with a "shock absorber" function to limit dynamic overtension when lifting (air/water transfer, in particular).

The oceanographic crane is situated on the starboard and is designed for launching and recovering the *Victor 6000* and *Penfeld* devices over the site of the vessel. Its maximum reach is 15m.

It is equipped with a docking head, dampended against pitch and roll, and under which the vehicle is placed during aerial movements. This platform also has a slew ring for correctly positioning the vehicle on the trolley.

The lifting winch, with an 8t SWL, features the "take up the slack" and shock-absorber functions, for lifting the devices in complete safety. This crane can also be used to handle light loads, of around 2t (like a shuttle lift, stations, dinghies, etc.) using a specific winch, fitted with a synthetic hoist line.

The lateral telescopic boom is situated at the exit of the hangar and is principally used to support the deep-sea cables from the winch hold (*Victor*, *Penfeld* or core-sample for example).

It has a 15t on line SWL and extends 4m over the side. It is fitted with different winches for assisting operations: 2t winch, 8t winch and 2t hoist.

6-CONCLUSION

The ship's first year of service has demonstrated its ability to fulfil mission requirements, whilst several underwater systems are successively deployed. Various combinations, such as *Penfeld/Victor*, *Penfeld/Victor* or *Victor/Nautile* have been employed during the test missions, which confirmed the numerous possibilities offered by the ship in terms of onboard facilities.

The ROV/COT test mission, which took place between 6 and 12 January 2006, validated the operational deployment of the *Victor 6000* ROV over the starboard side in rough seas. These sea trials demonstrated the important of launching the devices over the starboard side, using suitable resources such as the oceanographic crane and the lateral telescopic beam. This launching principle makes the handing of devices safer and increases the operational limits for their deployment.

The latest adjustments to the new core-sampling equipment, derived from the *Marion-Dufresne*'s Calypso system, have been carried out over three missions. This system is capable of taking 24m core-samples, with a removal rate above 85% for the majority of core-samples. The system, already operational, shall be used on the Vicking mission.

At the end of these long-term trials, the *Pourquoi pas?* will, from then on, be at the service of the scientific community and the French ministry of defence.