
# INTERNATIONAL CONFERENCE

# DESIGN AND OPERATION OF PASSENGER SHIPS

23 - 24 February 2011, London, UK

## PAPERS

THE ROYAL INSTITUTION OF NAVAL ARCHITECTS
10 UPPER BELGRAVE STREET, LONDON, SW1X 8BQ Telephone: +44 (0)20 7235 4622

# LE BOREAL & L'AUSTRAL DESIGN: THE CRUISING YACHT CONCEPT

**B. Leblond**, Ponant Cruises
**G. Scherl**, Fincantieri
**T Tincelin**, Stirling Design International, France

**SUMMARY**

The aim at the heart of the Le Boreal and L'Austral designs was the concept of a cruising yacht. Custom-built at the Fincantieri Shipyard in Ancona, Italy, Le Boreal was delivered to Compagnie du Ponant in April 2010. As the fourth ship of their cruise fleet, she can accommodate 264 passengers in 132 cabins with 95% passenger cabins featuring a private balcony. This paper will present the design process in terms of conceptual design and exterior styling, hydrodynamic and environmental efficiency, as well as the innovative aspects specifically developed for these projects in compliance with rules and regulations.

## 1. INTRODUCTION

### 1.1 PONANT CRUISES PROJECT

For over 20 years now, Compagnie du Ponant has embodied the art of Yacht cruising, combining a sophisticated 'à la française 'lifestyle on board with exploration and discovery to reach secret ports only accessible to small capacity vessels.
Dream locations off the beaten track, new cultures and close encounters with the wonders of Nature – these are the privileges on offer thanks to the small size and technical capabilities of the vessels belonging to Compagnie du Ponant.

### 1.2 MAIN CARACTERISTICS

The main characteristics of these two sisterships are:

- Jauge : 10.900 UMS
- LOA 142.1 m
- B 18.0 m
- T 4.70 m
- Speed 16.8 kn
- Propulsion 2 x 2,2 MW
- Capacity 264 passengers (132 cabins)
- Crew 140 (74 cabins)

## 2. CONCEPTUAL DESIGN & EXTERIOR STYLING

The aim at the heart of the Le Boreal and L'Austral designs was the concept of a cruising yacht. Custom-built at the Fincantieri Shipyard in Ancona, Italy, Le Boreal was delivered to Compagnie du Ponant in April 2010. As the fourth ship of their cruise fleet, she can accommodate 264 passengers in 132 cabins with 95% passenger cabins featuring a private balcony.

Her pure, streamlined silhouette was created by Stirling Design International (SDI) in Nantes, France. Le Boreal has been awarded a Gold Medal by the European Cruiser Association. Le Boréal won the prize in the "Best Newcomer of the year 2010" category, ahead of Seabourn Sojourn which received a silver medal. This prize was given in recognition of her elegance, personality, innovative equipment and the meticulous attention to detail in the design of the ship to fulfill the expectations of her passengers.

### 2.1 THE GENESIS OF THE PROJECT

During 2007, SDI started working on the conceptual design of the vessel on a competition basis. The preliminary design of these newbuildings measured 110-metres long at that time with a unique streamlined silhouettes fitted with large arched windows fore and aft to further enhance their style.

As a former designer at Pinifarina, Joël Bretecher, principal designer at SDI, has always been designing cruise ship with the same meticulous and creative approach than a Ferrari car designer.

After one full year of conceptual design studies, SDI has being awarded the exterior design by Ponant Cruises.

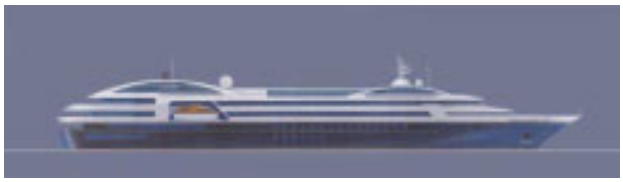

Figure 1: Preliminary studies of ship profile (©SDI 2007).

This success is partially due to the long term cooperation between Ponant Cruises and SDI. SDI focus its activities for shipbuilders and shipowners in the cruising world by promoting new innovative concepts combining cruisers and luxury yachts. Le Levant, commissioned in 1998, was a brilliant illustration of this approach. She is a pure thoroughbred of a yacht and catches the eye with her refined interior design and her elegant silhouette.

On the Austral & Boréal projects, the conceptual and exterior design benefited from detailed 3D modelling work at very preliminary stage. This allowed constant exchange between operational requests from Ponant Cruises, technical and regulatory constraints from the tender shipyards and aesthetical integration of these elements by SDI.

### 2.1 PROJECT DEVELOPMENT

This integrated design approach has been especially beneficial at contract stage. Indeed, at that point the design was fully finalized, and except some latter adjustments (for example extension of the exhaust pipe of the funnel), the basic design has not been significantly modified during the course of the contract.

Figure 2: Le Boréal's final profile (©SDI2009 ).

A close cooperation between the parties has been allowed by 3D format exchange, allowing the shipyard to make use of the 3D model built by SDI. This Rhinoceros model was based on the hull form and the GA of the yard and was imported into the steel hull modeler of the Fincantieri shipyard. This process enhanced the reliability during the life of the project between the model conceived at the design office and the final ship designed and delivered by the Yard.

### 2.1 DETAIL DESIGN

A constant attention has been paid to detail design during the course of the project to achieve on the final ship an intermediate quality standard between a yacht and a cruise ship finish, keeping budget and planning constraints in mind.

Figure 3: Pool and bar area at project stage (©SDI2008 )

Specific technical solutions have been developed among others for:

- The glass arches with grey tinted glass and custom built closed rounded steel profiles for the arches. It should be noted that these arches are not simple portions of a circle but have been designed and built with varying radius and section along the arches.

- The honey comb passenger balconies bulkwards ensure a perfect finish of the bulkward with no steel deformation

- The stainless steel exhaust pipes allow for a proper integration of the relatively large funnel pipes, due to the specific location and geometry the pool deck, smoke annoyance at the stern had to be avoided with increased funnel size in the course of the project.

- The design of the aft platform had been especially studied to offer improved hydrodynamic ship performance by a duct tail effect, offering an increased waterline length. At the same time, this aft platform, typical feature of a private yacht, offer comfortable embarkation capabilities on the tenders and exploration zodiacs.

- Exterior architectural lighting: LED strips have been used to enhance the ship's profile and the geometry of the two arches at night.

Figure 4: Final pool and bar arrangement (©SDI2008 )

## 3. HYDRODYNAMIC PERFORMANCES

### 3.1 HYDRODYNAMIC EFFICIENCY

During the design period, viscous CFD codes have been extensively used for hull and propellers optimization.

As usual, the targets of energy saving and high comfort level were very challenging, and only with the potentiality offered by numerical simulation, it was

possible to match the required results respecting also timeline foreseen for the design process.

The main results achieved are:
- Maximize the performances
- Reduce the time for design development; linked to very short building schedule
- Design cost reduction for competitiveness
- Optimization of the quality and control of the final results step by step

3.1(a) Appendage Optimization

The main steps for appendages optimization are:
- Analysis of the wake field imposed by the hull
- Design of shaft line and flow angle visualization
- Analysis of fully appended hull
- Eventual validation in towing tank

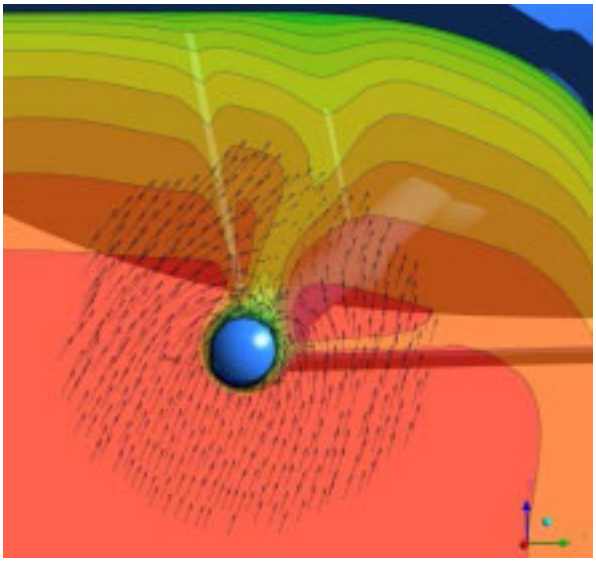

Figure 5: Nominal wake in propeller plane

3.1(b) Propeller Design

After having achieved a proper wake flow, it was possible to optimize the propeller design through the main parameters:

| | |
|---|---|
| Typical clearance | 0,3 D |
| N° of blades | 5/6 |
| Specific load | 700W/m² |

The optimum pitch and RPM was selected at design speed for optimum efficiency and minimum vibration. Different combination of rake and tip geometry were studied, and a propeller with moderate skew was finally selected.

3.1(c) Numerical Codes

Different numerical codes have been used for this project.

The first generation of numerical codes is the lifting line, lifting surface and panel code. The main advantage of these codes is the fact that they are validated by a long experience and are able to give reasonable results about cavitation and pressure pulses in a short amount of time. But these simulations are reliable only in the design condition and are not able to fully describe phenomena linked with viscosity.

To improve the quality of numerical analysis, F/C use RANSE (Reynolds Average Navier-Stokes Equation) a CFD code with a more accurate simulation of viscous phenomena. These codes are able to describe completely the fluid behavior. But these codes are expensive in every aspects, and it is difficult to obtain a solution in wake, even more in presence of cavitation.

The introduction of RANSE code has opened new frontier in propulsion design. The optimized wake helps to totally cancel cavitation on the blade. The new wake design approach allows to obtain very good results in terms of efficiency and comfort. RANSE is definitely a valuable tool to be used in synergy with experience and experiments.

3.1(d) Vibrations

To get an indication of the quality of the ship vibration the van de Kooy criteria can be used [1]. This criterion takes into account the contribution of all the harmonics integrated forces and provides a reliable reference level for a good comfort on board. If the attained value is lower than that indicated by the van de Kooy criteria the ship is expected to achieve a very good comfort with low levels of vibration. For these vessels values ten time less than suggested by van de Kooy have been measured as indicated in Table 1. This means practically total absence of vibration on board.

| | van de Kooy criteria [kN] | Attained value [kN] |
|---|---|---|
| Ship | 28.3 | 2.6 |

Table 1: Tank extrapolated vertical forces

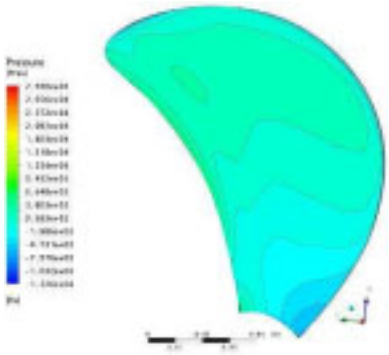

Figure 6: Pressure visualization on a propeller blade

Finally all the theoretical analysis have been tested and confirmed in traditional final towing tank experiments at MARIN.

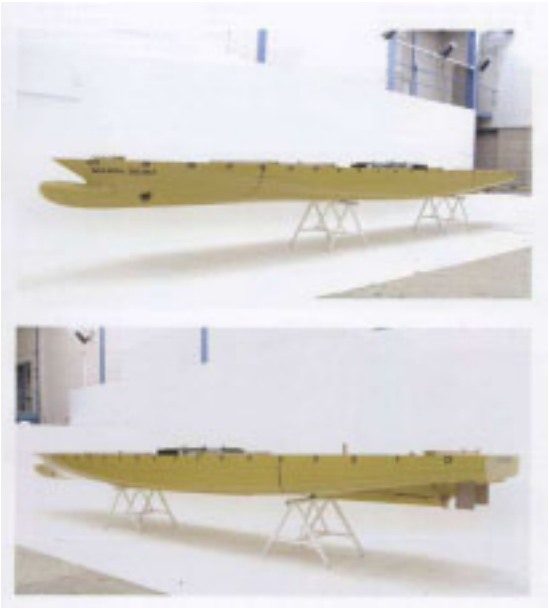

Figure 7: Scale models for towing tank tests

3.2 NOISE & VIBRATIONS

One of the most challenging contractual commitments of the project was represented by the achievement of the BV comfort class certificate.

Since the beginning of the project, this target has represented a topic for the Owner to be achieved without any possible compromise.

A good result in terms of noise and vibrations limits starts always from an appropriate layout of passenger spaces on board.

The typical small passenger vessels arrangement, with night area (accommodations) concentrated forward, far from engine room and propeller sources of noise and vibrations, is a good example of such approach.

By the way on Le Boreal, a critical position is represented by the main restaurant, very low and close to the engine room and just above the propellers. This area needed a very special attention to minimize the potential sources of noise (quality of machineries and installation accuracy) and vibrations (pulse pressure and cavitation by the propellers). See table 1 § 3.1 (d).

The results were well over the expectations with the eventual issue of the clean certificate and with complete Owner satisfaction.

## 4. RULES & REGULATIONS

4.1 PROBABILISTIC DAMAGE STABILITY

"Le Boreal" is the first passenger ship classed by B.V. with the application of the probabilistic damage stability criteria. A very good relationship was started between F/C and B.V. since the first stages of project definition, in order to agree on the regulatory criteria.
At that time the applicative guidelines were still under definition at IMO meetings.
In particular the application of some technical solutions that had given good results in previous F/C new buildings of larger size (e.g. safe area for longitudinal pipes and vents routing) were accurately studied and accepted by B.V.

1.2 LOAD LINE AND INTACT STABILITY

Special care has been dedicated to minimize the impact of the Load Line rules. In order to satisfy the requirements of French Flag Administration. special arrangements have been applied to the windows and openings of Main Restaurant (reinforced glasses, storm covers, alarms in wheelhouse for opened doors).
Same conservative approach has been applied in order to maximize the number of balcony cabins on DK.3.

With regards to intact stability criteria, the ship is designed in order to sustain the reduction of stability due to Ice accretion, as required by the Ice Class notation by B.V.

4.2 SAFETY

4.2(a) Accommodation Spaces

| CABINS | Quantity | Berths |
|---|---|---|
| Passenger | 128 | 256 |
| Passenger / Disable | 4 | 8 |
| Total Passenger | 132 | 264 |
| | | |
| Crew / 1 bed | 20 | 20 |
| Crew / 1 bed + 1 hinged bed | 7 | 14 |
| Crew / 2 beds | 31 | 62 |
| Crew / 4 beds | 11 | 44 |
| Officers | 3 | 3 |
| Sen. officers | 3 | 3 |
| Total Crew | 75 | 146 |
| | | |
| TOTAL | | 410 |
| LSA certification | | 400 |

Table 2: Passenger cabin capacity

| PUBLIC SPACES | | OCCUPANCY |
|---|---|---|
| | Deck | MAX CAPACITY |
| Restaurant | 2 | 270 |
| Main lounge | 3 | 110 |
| Main entrance | 3 | 40 |
| Theatre | 4 | 250 |
| Fitness | 5 | 8 |
| Hammam | 5 | 4 |
| Hair dresser's | 5 | 4 |
| Massages | 5 | 2 |
| Casino - Card Room | 5 | 20 |
| Library | 6 | 5 |
| Observation Lounge | 6 | 50 |
| Restaurant "Panoramique" | 6 | 130 |
| Crew Disco | 2 | 20 |

* Contractual occupancy to be used for dimensioning of air conditioning and electrical systems

Table 3: Public space capacity

4.2(a) Assembly Stations

Assembly stations are located :
- Passenger station A – Deck 4 – Main Fire Zone 1, Theatre Area - 264 passengers
- Crew Assembly station – Deck 4 - Main Fire Zone 1 , Stairs – capacity abt. 85 crew

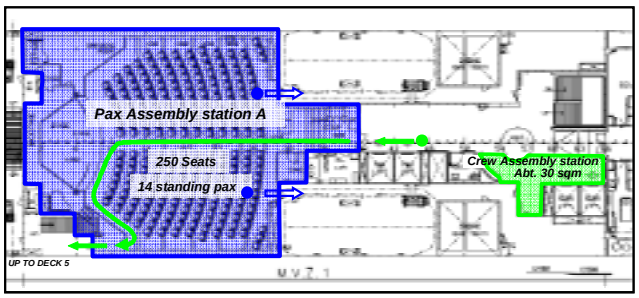


Figure 8:Passenger Assembly station A

On large passenger ships the consistent number of life boat on board imposes a constrain in the general arrangement layout with one deck, usually the promenade deck, occupied along all its length with a continuous row of life boats.

On the contrary on smaller passenger ship the few life boats are all located in one limited area of the ship, creating the necessity to find the safer and most convenient escape course from the other fire zones.
Usually it results in loosing cabins or private balconies, with consequent lose of payload and revenue potential.

On “Le Boreal” a big effort has been dedicated at design stage, in cooperation with Owner and Statutory Bodies, in order to minimize such a negative impact.

A special alternative escape route has been studied for persons evacuation from the forward Main Fire Zone driving them on the uppermost open deck and then to the embarkation area without compromising the passenger cabins quantity and quality and the safety on board.

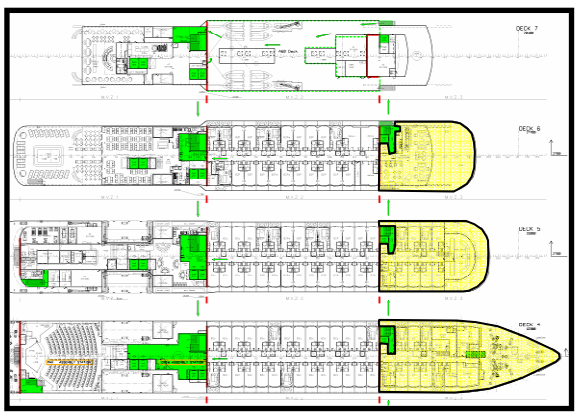

Figure 9: Escape From Accommodation Spaces
Deck 1 to 6, MVZ 3

4.3 FLAG AUTHORITY

“Le Boreal” is the first ship worldwide to comply with the regulations recently issued by the French flag Administration for passengers with movement difficulties.

It’s a well known fact that pioneering the application of brand new issued regulations, never tested and tuned previously on real buildings, could have the dramatic impact of a tropical storm.

In particular on small ships the spaces are very reduced and unforeseen requests of increasing stair width, or reducing deck slopes, or adding platforms and lifts could have a significant impact on the commercial result of the vessel.

A very carefully design process in cooperation with Owner and Administration has been carried out in order to minimize impacts and to find equivalent technical solutions satisfactory for all parties involved in the respect of the inspiring principles of the rules.

## 5. ENVIRONMENTAL IMPACT

Reducing its impact on the environment is a priority for Compagnie du Ponant from the thoughtfully selected itineraries, to using eco-friendly tinless hull coatings, to respecting local people, and raising awareness among passengers and crew. It is a tradition that Le Boréal and L’Austral will take forward as both will be eligible for the “Green Ship” label.
Compagnie du Ponant is a member of the Charte Bleue d’Armateurs de France, requiring ship owners to protect marine and coastal environments. It also belongs to the IAATO (International Association of Antarctic Tour Operators) and rigorously applies the regulations and advice for preserving the environment through responsible behaviour.

5.1 POWER GENERATION

The power generation is based on 4 Wartsila engines 8L20 for a total 6400 kW at 100% MCR and 1000 rpm.

The Marine Environment Protection Committee (MEPC) of IMO (International Maritime Organisation) will implement in July 2011 a new regulation, which will ban the use and carriage of heavy and intermediate fuel oils in Antarctic waters.

However, the two new yachts of Compagnie du Ponant, Le Boréal (launching May 2010) and L’Austral (launching May 2011) are equipped with diesel engines using MDO (Marine Diesel Oil) with low sulphur content. This diesel oil is permissible for navigation in Antarctic waters.

The electric propulsion is based on two asynchronous electric motors 2300 kW MCR each, supplied by ABB.

The control system is based on PWM (pulse width modulation) technology. PWM advantage stays in the reduction of the power dissipated by the limiting circuit compared to the analogically controlled thiristors.

Into a semiconductor, the dissipated power, is determined by the product of electrical current by the difference in potential at its extremities.

The PWM is modulated into two different conditions: either total current conduction at almost zero difference in potential or zero conduction at max potential difference, minimizing in both cases the dissipated power.

### 5.2 ENERGY SAVING

Particular attention has been paid to the Energy Saving requirements with the installation of fan coils unit in the passenger cabins in order to warrant the maximum comfort combined with the maximum flexibility and operational cost savings during the life of the ship.

Many are the advantages connected to this solution. In particular the noise reduction and the space saved in the routing of refrigerated liquid pipes instead of treated air ducts and the possibility to save energy with a more accurate control of the plant.

### 5.3 SHIP OPERATION

The Dynamic positioning system installed on board controlled by joystick and interfaced with GPS, will help to maintain the position in restricted areas like fjords or protected bays during naturalistic excursions avoiding the need of anchoring. The system is based on the coordinated action of propulsion, independent flapped rudders and bow tunnel thrusters.

The system results to be very useful during exploration activities based on quick tendering operations (few hours ashore on Zodiacs) in particular in areas like Antarctica where weather can suddenly change and oblige to an immediate repositioning in sheltered areas.

In addition, Farsounder 3D sonar system allows a 3D view of seabed, as well as a simultaneous view of different depths. Through this system, we can detect icebergs and ice packs and thus avoiding to hit them and damage these ecosystems.

Finally, installation of external electric connections allows to connect the vessel to power ashore and to stop the generators during calls to have zero direct carbon emission.

### 5.4 CLEAN SHIP

Le Boreal is conceived to mix the exclusive yacht like atmosphere with cruising to destinations and explorations routes unfamiliar to traditional big ships.

Bringing in mind this priority, the project team has operated since the beginning in the respect of the constrains imposed by the antipollution rules of the more protected areas :

- USCG Alaska Rules 33CFR 159.309 “Limitations on discharge of treated sewage or grey water”

- MEPC 159(55) “Revised guidelines on implementation of effluent standards and performance tests for sewage treatment plants”, la MARPOL 1973/78 Annex I-VI.

The unit is fitted with an AWTP (Advanced Water Treatment Plant) for the treatment of all the effluent waters on board and possible recovery as technical water.

Further, the retention capacity of treated gray water is in the range of one week, giving the maximum flexibility when mooring in harbour or cruising along the shore in the full respect of ambient.

## 5. CONCLUSIONS

The development of a custom cruising yacht concept is challenging design and construction process. Within limited main dimensions, budget and time compared to the largest cruise ships benefiting from inherent economy of scale, the luxury end of the cruise ship market requires mid size vessels with the most advanced level of comfort, performance and aesthetical integration of these technical challenges.

Technical, operational and aesthetical requirements are to meet the same regulatory constraints than larger ships. Specific innovative solutions have been developed for l’Austral and Le Boréal with a constant effort to meet the luxury market requirements.

## 6. REFERENCES

1. GIANPIERO LAVINI, LORENZO PEDONE, DAVIDE HARPO GENUZIO, ‘Application of fully viscous CFD codes in the design of non cavitating propellers for passenger vessels’, *First International Symposium on Marine Propulsors smp’09, Trondheim, Norway*, June 2009.

## 7. AUTHORS BIOGRAPHY

**Bertrand Leblond** is the Technical Manager of Ponant Cruises.

**Gianni Scherl** is in charge for Fincantieri Shipyard for the basic design activities relevant to small cruise ships. In the past he collected experiences in all main activities of shipbuilding and design process

**Thibaut Tincelin** holds the current position of principal designer and Managing Director of Stirling Design International. His previous experience includes position

of naval architect at the project department of STX Europe.

Figure 10: Greetings from Antarctica !