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The Superyacht REPORT

TRUTH • OPINION KNOWLEDGE • IDEAS AND EXPERT INDUSTRY ANALYSIS

MORE SPEED LESS DRAG

In the quest for sailing performance, the 59.9m ketch *Hetairos* has extended the boundaries of sailing superyacht design and engineering, leading the build team to seek often radical solutions in every area from advanced carbon construction to a retractable hydraulic propulsion system. **Jason Holtom** reports.

Following a brief from a very experienced owner for the fastest world-cruising superyacht at Panamax size, the *Hetairos* design team, led by Erik Wassen from Dykstra & Partners and the build team led by the owner's project manager Jens Cornelsen, researched every detail of the project, paying close attention to weight saving and reduced drag.

"The owner was very keen to try to collect as much information as possible about the possibilities of material usage, innovative structural solutions, rig, keel and system developments," said Wassen, the naval architect on this project. "Between the start of the design contract in 2003 and the start of the build in 2007 we made a number of studies to determine the best beam, the achievable displacement, the keel and rudder retracting systems, the propulsion, the rig layout, the styling and weight studies."

The project was not an easy brief because the owner was very particular in his wish for a classic looking yacht, ketch rigged with very distinct traditional lines. His previous *Hetairos* was a traditional 42.84m ketch built by Abeking & Rasmussen in 1993 in mahogany. Always immaculately prepared, this classic Bruce King design cruised and raced extensively, reaching as far as the Millennium Cup in New Zealand in 2000.

Tradition is, however, only on the surface because under the skin *Hetairos* is a very different yacht, with state-of-the-art pioneering solutions and attention to detail, which, the project team claims, takes the level of customisation of every part to an unheard of degree in the pursuit of performance. For the new 59.9m ketch, the performance had to be hidden away, even to the painted faux-wood effect transom concealing the carbon prepreg laminate underneath.

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THE OYS RETRACTABLE DRIVE PODS ARE 940MM FROM THRUSTER BODY TO THE CENTRE OF THE PROPELLER HUB. THE LEG ITSELF STANDS 720MM FROM THE HULL TO THE CENTRE OF THE HUB. A KORT NOZZLE IMPROVES PROPELLER EFFICIENCY, WHICH ARE ALREADY MORE EFFICIENT THAN SHAFTED PROPELLERS AS THEY ARE NOT AT AN ANGLE. THE CARBON TRAP DOORS OPEN SIDEWAYS TO GIVE LEAST RESISTANCE TO THE WATER FLOW DURING DEPLOYMENT.

Measures were taken to monitor every single item fitted with a strictly controlled weight-saving regime at every point in the build.

Working to the maximum mast height of 62.5m to pass under The Bridge of the Americas to transit the Panama Canal, the hull form was developed by Dykstra & Partners for the maximum waterline length to take the twin-masted sail area. Tank testing was carried out using three 2.5m models at the University of Delft and the rig and sail configuration was assessed in the wind tunnel at the Wolfson Unit, Southampton, UK.

Having successfully raced a Reichel Pugh designed 23.7m fast sled *Black Dragon*, winning the 2005 Maxi Rolex Cup in Sardinia, the owner brought in Reichel Pugh Yacht Design to refine the hull lines with a program of CFD and VPP analysis run in SPLASH and FloSim by Frank DeBord with, tank testing at 1:7.5 scale using a 7.84m model at the US Navy David Taylor Model Basin Carriage No 2 in Maryland, USA.

The towing tank, CFD and wind tunnel data confirmed that the extra waterline length of the plumb bow of the late 19th-century Bristol Channel pilot cutters was the best performing configuration for the maximum possible sail area. This meant the owner could achieve the classic lines he wanted with relatively low freeboard, a seven-metre bowsprit with graceful long counter stern and three raised varnished deckhouses.

Two of the major enemies of sailing speed are weight and drag. In attacking weight, every aspect of the build and fit-out was analysed at the design stage to see what weight-saving solutions could be applied. Baltic Yachts with SP Gurit structural engineering were tasked with building the largest carbon prepreg hull ever built so that *Hetairos* at 230t lightship is less than half the displacement of a similar size yacht built in aluminium. Measures were taken to monitor every single item fitted with a strictly controlled weight-saving regime at every point in the build.

REDUCING UNDERWATER DRAG

The most obvious target in minimising drag to improve speed was to completely remove the propellers, shafts and P-brackets by fitting a fully retractable propulsion system. Retractable propulsion systems have been installed on a number of high-performance maxi race boats up to 30m, such as *Alfa Romeo II, Wild Oats XI, Highland Fling XI* and *Genuine Risk* – typically with a single-shafted propeller swinging up into a slot or a retractable non-rotating drive leg. Considered adequate as 'get you home after the race' but too much of a compromise on performance and manoeuvrability, these systems were not judged suitable for a world capable cruising superyacht like *Hetairos*.

Fore and aft rotating retractable hydraulic drives were installed on Luca Bassani's 32m Wallygator (*Narrida*) in 1994, where they demonstrated additional manoeuvrability replacing conventional now and stern side thrusters and a main engine.

The design and engineering team for *Hetairos* was looking for considerably more power and flexibility and so opted for side-by-side drives conventionally placed close to where standard shafted propellers would be aft of the keel. This set-up allowed them to save the weight and cost of a stern thruster by configuring the control system to fix one of the retractable propellers fore and aft like a conventional drive, and the other, at 90 degrees on the opposite side to the direction of travel to act as a side thruster. With 257kW available from each drive, *Hetairos*'s captain, Vincent Fauquenoy, said this is a very effective system for manoeuvring in combination with a conventional, albeit custom built for light weight, retractable 128kW Hundested bow thruster.

The first retractable installation planned for *Hetairos* was based on an electrical driven system with ceramic bearings, but the bearings proved to be very susceptible to wear and tear due to difficulties in alignment. In 2009, at a relatively late stage in the build, OYS Thrusters in the UK was approached to develop a hydraulic alternative.

All the hydraulic installation and control systems on *Hetairos*, and on most of the yachts built at Baltic Yachts and the larger yachts at Nautor's Swan, are undertaken by local company Marine & Hydraulics OY (M&H) based in Vantaa, Finland.

Ward Proctor of M&H analysed the power requirement and weight of different propulsion options and found that even though the retractable hydraulic drives themselves weigh more than a conventional drive train, the overall installation of the propulsion system including the four engines on *Hetairos* weighs slightly less without the need for larger main engines, two additional generators and a stern thruster.

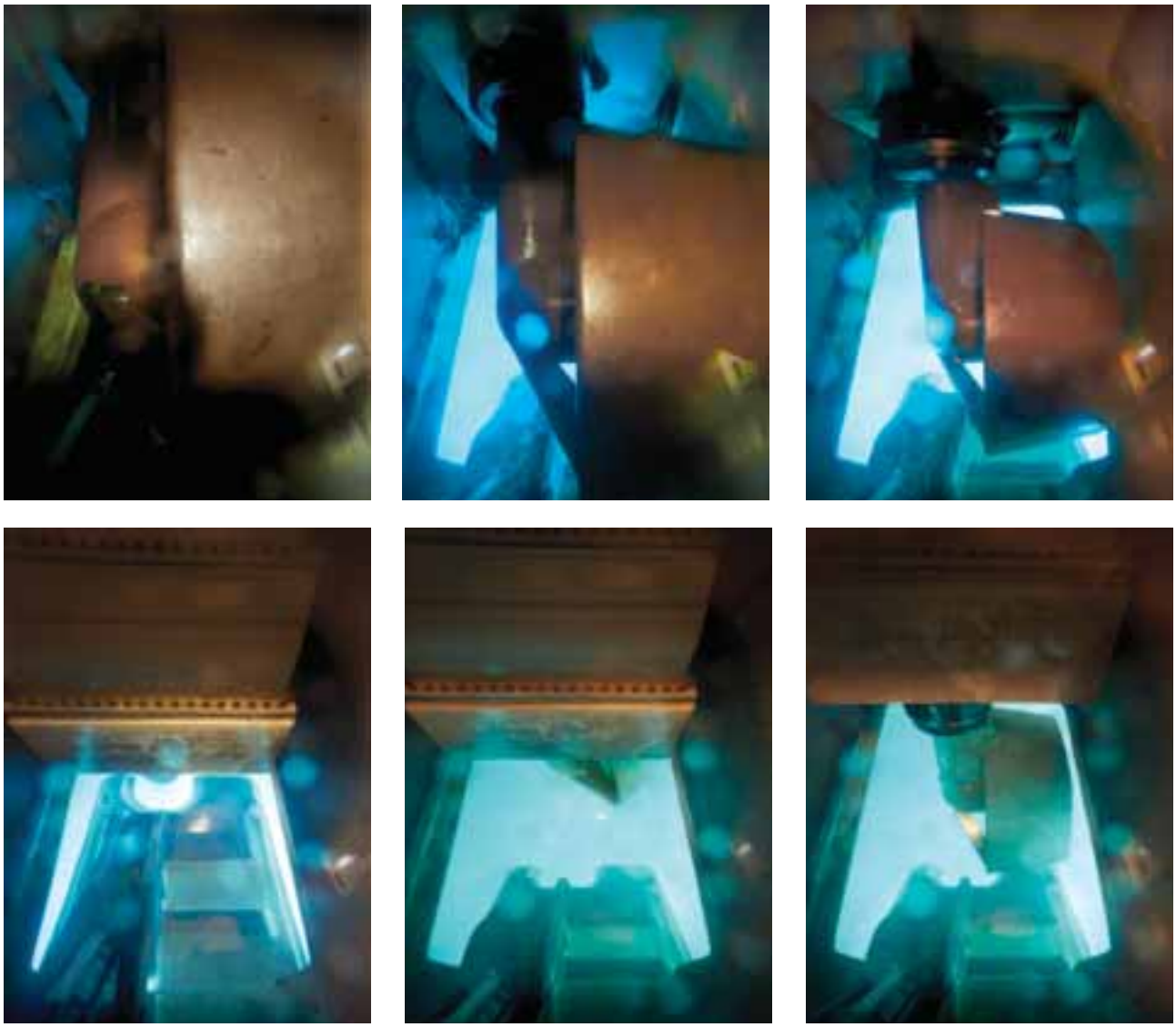
"If you consider the main engines, typically for a yacht of this size they would be two Caterpillar 500kW, with gearbox, shaft, etc., and two Northern Lights at 50kW; add them together with all the accessory equipment, we save approximately 20 per cent of the weight," Proctor explained.

As there was no need for a pair of large marine diesels driving conventional gearboxes and shafts, a unique set-up was developed with four identical high RPM VW V8 marine 257kW engines, each encased in a custom-built carbon sound-proofed enclosure to deliver the hydraulic and electric power to where it is needed. Two engines are dedicated in pairs for each of the two propellers.

PRINCIPAL SPECIFICATIONS

LOA: 66.70m, including bowsprit
LOD: 59.90m
LWL: 49.76m
Beam: 10.54m
Draught: 3.5/6.9m lifting keel
Air draught: 62.5m
Displacement: 230 tonnes
Ballast: 85 tons (26 tonnes fin, 59 tonnes lead bulb)
Internal moveable liquid ballast: 36 tons (20 tonnes seawater, 10.88 tonnes fresh water, fuel)
Carbon spars: Southern Spars
Composite rigging: Future Fibres PBO
Sail plan: 1,695sqm (upwind), 4,564sqm (offwind)
Main sail: 630sqm, mizzen: 515sqm
Gennaker: 2,169sqm
Sails: Moulded North 3Di
Furlers: Reckmann
Hydraulics: Marine & Hydraulics
Retractable rotating drives: OYS Thrusters
Bow thrusters: Hundested 128kW
Keel: APM and Marine & Hydraulics OY
Steering: Edson cables, JP3 bearings, Isotop rudder blade
Engine: 4 x VW 3.5l V8 257kW (350hp)
Tenders: 6.13m custom carbon/ mahogany launch, 5.5m RIB by RWM
Naval architecture: Dykstra & Partners and Reichel Pugh Yacht Design
Interior design: Rhoades Young
Interior fit out: Oldenburger
Hull: carbon prepreg, 80mm Corcell foam core
Deck: carbon prepreg, Nomex honeycomb core
Crew: nine, racing 29
Legal contracts: Ince & Co, Hamburg
Composite engineering: SP Gurit
Class: DNV
Builder: Baltic Yachts 2011
Project manager: Jens Cornelsen

LEFT: THE ANGLED WATERTIGHT BOX, FAR LEFT, CONTAINS ONE OF THE RETRACTABLE SWINGING THRUSTERS.
BELOW: THE ENGINE ROOM RUNS EITHER SIDE OF THE KEEL, WITH EACH STAGGERED PAIR OF VW V8 275KW ENGINES ENCASED IN CUSTOM-MADE SOUND-PROOF BOXES (BEING INSPECTED BY THE CAPTAIN, LEFT).



PHOTOGRAPHIC SEQUENCE OF A THRUSTER BEING DEPLOYED (CLOCKWISE FROM TOP LEFT). THE MAIN CARBON HATCH WITH TITANIUM HYDRAULIC RAMS OPENS SIDEWAYS TO REDUCE RESISTANCE AS THE THRUSTERS CAN BE DEPLOYED WHILST THE BOAT IS SAILING. ONCE DEPLOYED, THE MAIN HATCH RETRACTS FLUSH TO THE HULL TO MINIMISE DRAG. WHEN FULLY RETRACTED, A SMALL CIRCULAR SECONDARY HATCH COVERS THE HOLE WHERE THE LEG WOULD BE IF DEPLOYED.

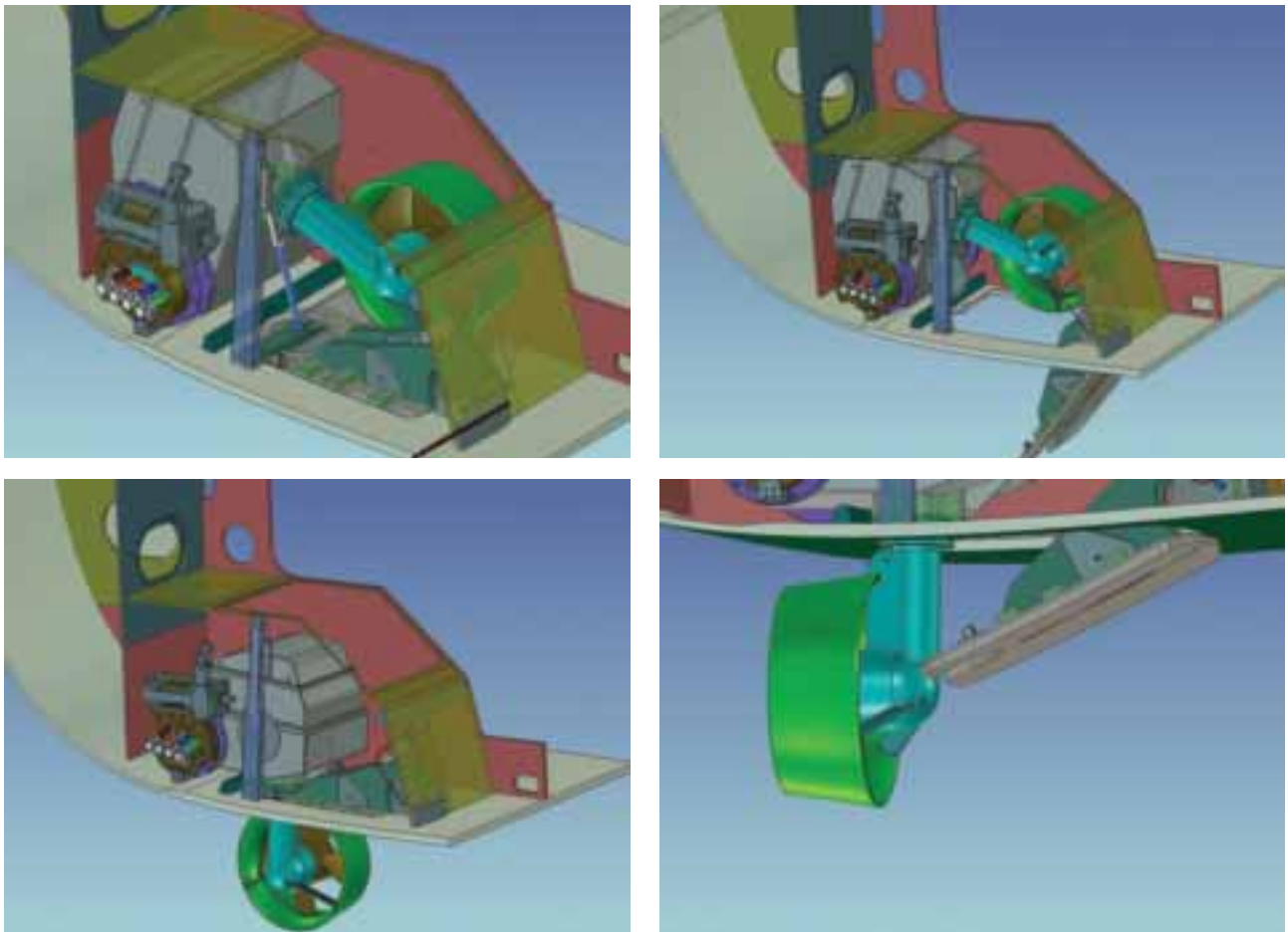
In addition to the direct supply to the drives, all four VW engines have an additional pump feeding into the hydraulic supply to operate all the sailing systems, bow thrusters, lifting keel, lifting rudder, anchor windlass and hatches. In addition, each engine has an output of 80kW for hotel supply.

In all, M&H's piping contractor, GS Hydro, installed over 250m of high-pressure titanium hydraulic piping. All four engines also have alternators supplying 80kW each to the electrical generation for hotel supply. "The four engines will be more demanding to maintain due to the higher revving engines," Wassen explained. "In volume, the requirements are not much bigger than a conventional drive system and the hydraulic supply gives greater flexibility in location. In safety terms, the system is good, because you have double back-up with two engines to each shaft when just one is sufficient to propel the yacht at six knots."

Proctor said the loss of efficiency due to the conversion steps from mechanical power to hydraulic and back to mechanical is about 18 per cent and so you might need a bit more installed power to compensate. However, this loss is more than made up by the gain in propeller efficiency by between 5and 10 per cent as they are fenced by a Kort nozzle and run in a vertical plane parallel to the water surface rather than a shafted propeller running down at a five- or six-degree angle.

"We selected ducted thrusters to obtain enough bollard pull and to reduce the noise and vibration issues with the limited clearance between hull and propeller," Wassen said. "There is still optimisation to do on the propeller design to reduce some cavitation noise, but typically the system is less noisy than expected."

The thrusters are installed in watertight carbon boxes with two inspection windows, and swing rather



3D RENDERINGS BY BALTIC YACHTS SHOWING THE DEPLOYMENT OF THE DRIVE PODS. TOP LEFT: NOTE SMALL CIRCULAR HATCH WITH TITANIUM RAM (BLUE) USED TO CLOSE THE HOLE LEFT BY THE POD WHEN FULLY RETRACTED. WHEN DEPLOYED, THE PROPELLERS RUN AT RIGHT ANGLES TO THE WATERFLOW FOR MAXIMUM EFFICIENCY.

MARINE & HYDRAULICS OY

The company was founded by South African Ward Proctor, an aeronautical engineer by training, on the recommendation of Richard Hein, whom he had worked with on the first series of Oceanco hulls built in South Africa before production moved to Holland. Hein suggested Proctor moved to Finland to work on the first Swan over 30m in 1995. He was supposed to be in Finland for just two years, and now some 16 years later M&H undertakes most of the custom hydraulic installations on Baltic Yachts and the larger Swans by Nautor and other yards.

than lift vertically because of the limited height in the engine room under the main salon. The drive pod leg length is 940mm from thruster body to the centre of propeller hub, the leg itself stands 720mm out from the hull to the centre of the hub.

Uninterrupted flow over the hull is maintained by carbon trap doors that hinge sideways not fore and aft. "This method of opening produces the least drag whilst the opening and closing procedure is underway, presenting the least area to the natural flow of water across the hull so the thrusters can be deployed and retracted whilst still sailing," said Ian Crowden of OYS Thrusters.

"In practical terms a captain is not going to want to heave to or stop in order to start or stop motoring," Crowden explained. "As you can imagine, this always brings with it the challenge of ensuring the complete system can withstand significant loads at all points of the raise and lower cycle. The units are designed to raise and lower at any speed up to a maximum of 15 knots, at which point we would prefer the sheets to be eased before any buttons are pushed."

Reducing weight at every opportunity was a challenge for the OYS team. Through extensive use of FEA programs, it was able to provide the lightest possible solution in more traditional materials, before assessing and exploring the benefits of more exotic materials such as titanium. One example is the main casting used in the actual drive legs, originally designed to be either aluminium or aluminium bronze (AB2). These were eventually modified to be centrifugally cast in titanium using a specialist foundry in Belgium, which represented a significant cost, but was of great benefit in drastically reducing not only the weight of this very large component but also the structure and mechanism required to raise and lower it. Full functional and positional testing including full pressure testing was carried out on site at OYS in the UK. In addition to this, further tests were carried out at the Bosch Rexroth facility in Helsinki.

There is no additional safety or impact implication for such a system. The keel is forward of the drives when deployed, with the propellers themselves actually quite close to the hull. A collision with an underwater

OYS THRUSTERS

Ian Crowden, head of the OYS Thrusters division has over 20 years' experience in hydraulics, having started with Richfield Bow Thrusters and worked with Camper & Nicholsons Yachts. The thrusters range caters for yachts from 30-150m with power ranging from 20-900hp (15-671kW) in both electric and hydraulic variants. OYS has pioneered new low drag, highly manoeuvrable propulsion systems on vessels from 16-66m providing power from 48-460hp (35-350kW). OYS is responsible for the first ever joystick controlled 360-degree rotating sail drive, installed in 2010 on a 16m vessel. As well as adding rotation elements to many traditional drives, OYS is leading the way in fully retractable drive systems. Particularly suitable for sailing vessels, this technology allows for all underwater drive appendages to be retracted into the hull vastly reducing drag and allowing a significant increase in sailing performance.

object would most likely result in propeller damage much the same as with any conventional drive. In the rare case of forward impact, the drive legs would swivel up into the watertight compartment inside the hull. In the worst-case scenario of significant impact the OYS leg can be removed and a new one refitted with the vessel afloat. Having a spare lower pod means this changeover can be carried out within a day or two with the assistance of divers.

Throughout the eight-year project, the owner, a mechanical engineer by training, enjoyed the challenge of working at the cutting edge of the industry, pushing for the very best solutions and actively involved in every critical stage of the process as important decisions on cost and time were required. Making custom parts in titanium is very expensive, for instance, with the material cost about 10 times as much as steel. The owner's view was that if they could make significant weight savings in important areas to improve righting moment then it was worthwhile.

The owner was realistic in giving the project team sufficient time and resources to investigate every avenue. Virtually every item on board has been custom built or customised. Dick Young, who designed the interior, said that just about the only standard off-the-shelf item he has seen on the yacht are the light fittings in the engine room. Such a high degree of customisation inevitably requires the time to design, test, evaluate, design and test again before manufacture, with the inevitable setbacks that can occur along the way. This has implications on time and cost due to the level of perfection required by the owner.

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Project manager Cornelsen, who had already worked on three previous yachts with the owner, drove a tight project, maintaining the difficult balance in some areas on a contract price and others on time and cost so that it did not end up an open-ended budget.

The performance of *Hetairos*, taking line honours in both the 2011 Transatlantic Superyacht Race and 2012 RORC Caribbean 600 Race, has already shown that she is the fastest sailing superyacht today. Visionary ideas and innovative solutions were expected by the owner, who accepted nothing less than perfection and who was ready to break the rules and extend the boundaries of sailing. The result is one of the most remarkable sailing superyachts ever built. ■

Images: Peter Neumann/YPS

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