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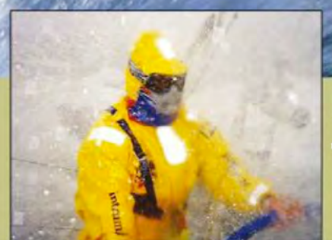

Back where we belong – Richard Mason

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The new *My Song* is the latest in a string of fine yachts of that name – so what comes next is worth a thought… As well as softening the profile and the 'intrusion' of the coachroof, the use of bulwarks gives a very large yacht the hint of a much racier and more nimble boat, with the gently hiked crew floating up above the deck itself… Dwarling! Note the low, single lifelines and the structurally critical midships drain slot cut into the bulwark

Not simple

The superyacht circuit grows with every new season, as do the demands for better sailing performance. Always on top of the aesthetics, for their new 130-footer Reichel/Pugh were inevitably pressed hard to deliver on some rigorous performance targets…

More than three years in the making, the latest Reichel/Pugh-designed Nauta 130 superyacht, built by Baltic Yachts in Finland, is about to make its racing debut at Les Voiles de St Tropez.

The design brief started with a superyacht capable of cruising the world with a well-appointed interior… But high-tech construction was also specified, since from the beginning the yacht was also intended to compete on the Mediterranean and Caribbean superyacht circuits. So great emphasis was placed on performance, plus maximising interior accommodation!

The concept began in 2013 as a 115-footer and by the end of that year had grown to 117ft, then 119, 125 and then 126ft… Preliminary design and engineering began in spring 2014; following an initial CFD study with nine candidate hulls and multiple appendage configurations the team arrived at a final length of 130ft…

Teamwork

Like most contemporary superyacht projects, this commission was a collaboration between different groups. Reichel/Pugh was responsible for the naval architecture, including design of the hull, appendages and sailplan. Nauta Design crafted the exterior and deck styling as well as a luxurious interior. Baltic Yachts were selected for the construction of the yacht early on for their experience with large-scale composites, complex systems and interior craftsmanship. The project was managed by Nigel Ingram of MCM.

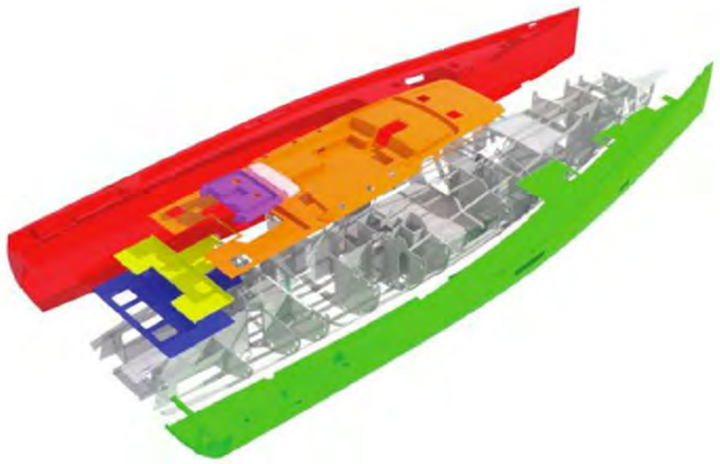
Reichel/Pugh's engineering services were also selected for the yacht based on our prior work, which includes the engineering of WallyCentos *Magic Carpet*[3] and *Galateia*. Having co-located design and engineering teams within the Reichel/Pugh office enabled the team to quickly arrive at solutions that best suit both the engineering requirements and design targets. Reichel/Pugh engineers also worked in collaboration with Gurit to help meet an aggressive build schedule.

Beneath the surface but never far out of sight, underwater appendages are critical to the performance of every sailing craft, large or small. APM of Italy delivered another superb fin, bulb and keel trunk, which was no small task. The rudder and steering system components were manufactured by Isotop Composite in France, using their autoclave to produce a high-aspect rudder that's both stiff and light.

The unique retractable propulsion system was designed from the ground up by Baltic Yachts and Hundested. Noise and vibration specialists Van Cappellen Consultancy were brought in to ensure that some challenging sound targets were met.

Neatly hidden below the deck in many places, Harken hardware was specified throughout with many elements designed to order including custom sheaves, padeyes and of course hydraulics. North Sails provided the sail wardrobe.

Frequent communication between sail, rig and equipment suppliers helped to refine loads, hardware and composite reinforcements; ultimately reducing excess weight without sacrificing performance. ▷



Left: the assembly order with a hull that is split vertically will be familiar to raceboat and multihull builders though still rare in superyachts; but there are big gains to be had in using more time to complete work inside the boat before the parts are joined. *Above*: like an FD's halyard take-up reel but bigger. Onto this 1.6m drum is wound nearly half-a-tonne of furled code zero

Under power

Retractable propulsion systems are not new to Baltic or Reichel/Pugh, with most of our current designs featuring some form of retractable drive to minimise drag under sail. However, for superyachts of this size each system must be custom designed and built. Ample testing must also be carried out on such a highly loaded component.

The drive system features a single, four-bladed, forward-facing, controllable pitch propeller to maximise efficiency. When deployed the drive leg can also be rotated through 90° to act as a stern thruster for manoeuvring. When retracted, two doors close to seal the opening with the excess water then being expelled pneumatically.

Grounding

CFD results indicated that significant gains could be made by tapering the keel fin in chord as well as thickness over its full span. Acknowledging the structural challenges we decided to pursue this option, unusual on a boat of this size, providing a more efficient lifting surface and reducing both wetted surface and fin weight.

Reichel/Pugh and APM then worked closely to ensure the tapered keel fin could withstand the same grounding strength criteria with its smaller sections as would be required of a conventional parallel fin. The decision was also made to ensure the yacht could withstand the full grounding and heeling strength cases not just when the keel is fully extended as is common, but also when the keel is in the fully raised position.

For a yacht with a conventional lifting keel fin, the upper sections are kept constant along the span that will be retracted so the lower hull opening can act as a bearing surface for the fin in all positions between fully up and fully down. This effectively separates the grounding reaction forces and in turn reduces the reaction loads. In our case, the keel trunk and internal structure would need to react to the grounding loads solely at the keel head bearings, keeping the loads similarly high in both keel-up and keel-down positions.

APM developed a refined laminate schedule for the carbon keel trunk, adding unidirectional hoop taping at the top to ensure that these conditions are met.

Our engineers also specified additional reinforcement in the deck laminate to support the added load travelling into the deck and designed the keel bulkheads to support the top of the keel trunk transversely. However, the keel bulkheads have large openings to port to allow a continuous interior and, as a result, the starboard side of these bulkheads were engineered to take the upper keel loads acting on their own in both tension and compression. The keel trunk was then bonded in place with large unidirectional tapes connecting the upper portion to the starboard side bulkhead faces, effectively strapping it in place.

The bulwark challenge

The new boat features a raised bulwark around the gunwale; this provides a cleaner profile, giving the coachroof a sleek appearance as it disappears behind the bulwark top, and enables the use of single-wire, half-height lifelines. The bulwark also conceals all manner of hydraulics and line runs.

There is also a long, slender opening in the bulwark at midships, to let water wash away when sailing; however, a consequence of a seemingly simple feature was the need for careful extra engineering of the bulwark laminate around the opening.

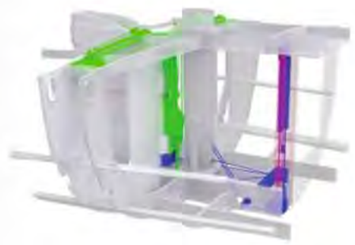
Stiffness of the hull shell is always critical for a sailboat – today more than ever. With increasing performance have come stiffer rigs, able to withstand massive compression loads, sails that hold their shape without yielding, lines that barely stretch and the constant pursuit of more and more righting moment. Longitudinal stiffness is the key to rig tension, keeping headstay sag to a minimum. For this reason, a stiffness target was set based on the global deflection of the yacht (and its correlation with headstay sag).

Finite Element Analysis (FEA) remains a crucial tool for global laminate design, particularly for projects of this size. Our engineers used Altair Hyperworks to model the entire structure and analyse deflections. On a conventional yacht the longitudinal stiffness is often achieved through the use of unidirectional tape banks on the hull bottom and side decks. It is also important to note that buckling stability of these stiffening tapes, and of the deck in general, is a primary concern since the deck is loaded in compression longitudinally under normal sailing conditions.

Due to the sectional geometry of this yacht, the bulwark is the portion of continuous deck furthest from the neutral axis in longitudinal bending and therefore the highest compressive stress for a given section is concentrated in the bulwark top laminate. To make matters more challenging, the 'drainage cutout' is located near midships, where the greatest longitudinal bending moment occurs – meaning the largest compressive loads due to longitudinal bending occur at the point with the least sectional area to resolve them.

It became clear during FE analysis that buckling of the bulwark would be the driving factor to meeting both our strength and stiffness criteria. The bulwark fore and aft of the drainage opening required a number of analysis iterations to find a suitable combination of core density, thickness and laminate stack to support the compressive load and resist buckling. In these regions the bulwark top laminate consists of 6mm skins comprising mainly unidirectional tapes and 50mm Nomex honeycomb core of varying density. The hull strake also utilises unidirectional tapes and 75mm honeycomb core.

Once confident that a light and feasible solution had been identified for the majority of the bulwark laminate, attention turned to the laminate around the opening, which had become the crux of the global stiffness design. As was done for the rest of the bulwark, variables were investigated through FE analysis, including laminate thickness, core thickness and density. The analysis also considered geometric solutions such as the number and location of vertical supports that could be used to stabilise the compression 'plank' forming the top of the opening. Originally, there were no supports for the plank, but early on one pillar was added to stabilise the long unsupported span in terms of buckling.



Far left: in green are the component parts for the hydraulic headsail sheet controls (*below*). The three cylinders for the rig controls are shown in blue and pink. *Left*: the retractable propulsion system allows the drive to be rotated 90° for manoeuvring, then sealed and drained once raised. The business end (*below*)

A second pillar was then also added to further reduce the free span and thereby reduce the laminate requirements. As it turned out, each pillar was able to serve a dual purpose and support a padeye on the bulwark top. The final result for the top plank was 48 unidirectional tapes, interleaved with 21 biaxial plies to form 24mm skins over 50mm high-density foam core.

The specification of the laminate for the bulwark opening was a complicated challenge, but through meticulous investigation the engineers were able to find a light and stable laminate solution!

Wind on

Perhaps the most innovative feature of this yacht is its unique sail storage system. The yacht's code zero is 55m along the luff and weighs some 400kg – the fact that these types of sails are stored furled also means it does not fold easily. This prompted us to seek a better storage system.

The result is a (very) large drum mounted transversely in the forepeak to 'store' the sail. The sail is then raised through a large deck hatch as it unwinds from the storage drum, like unwinding a garden hose off a reel. The drum is motorised and the power-management configured so that at all times the rotation can be accurately controlled when hoisting the sail, preventing the drum from free-wheeling too fast. Lowering the sail through the hatch and winding back onto the drum is equally straightforward.

A long transition

Like many of our latest superyachts, this is a true hybrid vessel. It is intended to race at the top level for a week, then days later be converted for luxurious blue-water cruising.

Sounds simple? This conversion process, with the need to load and unload many tons of equipment and sails, change the rigging configuration and generally prepare the boat for a different purpose, in reality usually takes weeks rather than days, so any time saving measure is very desirable.

Installing or removing the bowsprit is a common task when preparing for the next trip, so to allow quick installation and removal the bobstay is secured in the stem with a custom lock, rather than a conventional pin. This allows the bobstay to be pre-tensioned or released quickly using a halyard. Another feature of the system is the use of tack line locks for racing. The bowsprit contains two halyard-style locks to secure one end of each 2:1 tack line as close to the sprit end as possible to minimise stretch. Final tension is then set using rams located in the bow of the boat, connected to the other end of the tack line.

Trim on

To optimise performance the boat's race crew requested transverse jib tracks. This meant a need for more control lines on the jib lead to provide sheeting control inboard and outboard, as well as up and down. On a raceboat, where transverse tracks are common, there is plenty of room below deck to accommodate the line runs, purchases or hydraulics required to run these systems. However, on a yacht where such a high premium is placed on interior volume, there was not much room left to incorporate these functions.

Thanks to a creative arrangement by the Baltic engineers, the two large rams needed for efficient and precise sail control – under extremely high loads – were mounted directly onto the forward face of the keel trunk. This allowed the system to fit within a 600mm x 600mm footprint (along with the full hull-deck span) while maintaining complete functionality.

Spar control

Similar to the jib system, the three rams responsible for control lines coming from the mast needed to be adjacent, vertical and on centreline. There is a lower backstay deflector ram which uses a 1:3 reverse purchase to allow sufficient adjustment length with a limited ram stroke. There is also a ram for the upper deflector, which uses a 1:2 reverse purchase for the same reason. Finally, there is a third cylinder which runs 1:1 to the mainsail cunningham but which can also be used to adjust the mast heel position fore and aft. Vertical stiffeners were added alongside the rams and their associated turning sheaves to resolve the compressive loadings independently from the bulkhead itself, minimising the total structural weight in this area of the boat.

Build

The construction process for this yacht was unique, involving multiple joins on the hull and deck. Many builders these days are investigating new construction methods to speed up internal structure and systems installation by providing good access to the hull as late in the process as possible. Convention dictates the hull and deck are built as separate, single parts; but there is then a limited time when the internal structure, systems and interior can be installed before the deck must be bonded in place.

For this yacht the port and starboard halves of the yacht were laminated as complete 'vertical' components – as was once popular for raceboat builds and is still found in the construction of large multihulls. This meant that one whole side of the yacht was built at once; hull, deck and bulwark in a single mould. The coachroof and a sizeable portion of the aft deck were built separately in parallel.

This arrangement made the lamination easier for Baltic and enabled internal structure to be added quickly to each half of the hull prior to joining the hull and foredeck along the centreline. Once the halves were joined there was still direct access through the coachroof and aft deck opening to add large items like the keel bulkheads, keel trunk, mainsheet structure and a majority of the engine room equipment and systems.

At the same time the coachroof could be prepped and painted, then bonded onto the yacht at a much later stage.

This process worked quite well, but required a significant amount of engineering upfront to produce the hull, deck and bulwark laminates simultaneously.

Summary

This has been an amazingly rewarding build for the Reichel/Pugh team. It required a significant amount of work and there were challenges along the way but, utilising the combined expertise of all parties, in July the team launched a fine example of what the state-of-the-art luxury – performance – superyacht looks like.

David Oliver, Reichel/Pugh, San Diego ❑