Vision

Every custom yacht needs a vision. More than just a design brief, rather a broader and larger statement of the ultimate objective. This was a bolder vision than most...

Baltic 142 DSS

In the depths of winter at Baltic Yachts in Jakobstad, Finland, the finishing touches are being applied to a new 142ft sailing yacht that on New Year's Day was already being hailed as 'the most anticipated superyacht launch of 2019'. The product of tens of thousands of hours of design, engineering and construction, and unfettered free-range thinking, this is a yacht that draws upon a host of innovative technologies and has the potential to redefine the sailing superyacht for years to come.

The owner, a longtime Baltic Yachts client and an experienced yachtsman with several circumnavigations to his credit, had developed a comprehensive set of objectives for the project. He was adamant that he did not want the last or even the best yacht of the previous generation. Bringing decades of sailing experience to bear on the decision-making path, he was prepared to consider every possible option to achieve the yacht that would embody his vision, and beyond.

At its core the yacht is a blue water performance cruiser – aren't they all? But this one would be able to sustain itself independently of the services of the Mediterranean superyacht yards. A yacht equally at home in the Southern Ocean or the lagoons of the South Pacific, all while being sailed by a small crew with the owner living onboard. A yacht that would be able to dry out on its own keel and generate its own electricity without diesel power for ocean passages. A yacht capable of new levels of performance; able to sail in excess of 400nm/day on passage, all while being safe, responsive and supremely comfortable.

The central tenets of this brief are entirely consistent with the experience of the owner, and when written down in black and white may appear quite unremarkable. But they belie the many layers of complexity and technical challenges to be navigated to realise the owner's vision in a yacht of this scale.

Baltic Yachts have a long and illustrious history of delivering 'visions' to discerning clients, and embracing technical challenges is a core part of their DNA. But the Baltic 142 DSS represents more than the odd technical challenge – more a full-scale expedition into the future of the sailing superyacht.

With the brief defined and a diverse spread of novel technologies all under serious consideration, Baltic assembled an experienced team of partners to bring things to reality:

- Farr Yacht Design
- Gordon Kay/Infiniti Yachts
- Lucio Micheletti
- Gurit
- Rondal
- North Sails Italy
- BAR Technologies
- Isotop Composites

In the preliminary stages of the project Farr Yacht Design (FYD) developed a number of candidate appendage configurations that included various canting-keel options (both fixed span and telescopic), fixed-keel options, lift keels and exploration of the viability of a Dynamic Stability System foil. Each of these was developed sufficiently to accurately investigate weight, interior layout implications and comparative performance estimates.

Baltic Yachts and Farr Yacht De naval architects for this highly i new superyacht, have made a si and positive statement by comm using DSS at this size and displ previous larger DSS application been limited to lighter and very powerful 100-foot maxi racers. V with a 9m lateral sliding foil on a this size demands great precisio operating at a very large scale – model maker will understand wh Yachts first trial-fitted a dummy (*left*) before touching the precio thing which took Isotop a year t

As yacht size increases much of the conventional wisdom of canting-keel performance advantage becomes less certain. With limited draft relative to yacht size (even with lifting/telescopic keels), lower ballast ratios and proportionally heavier canting components, the available righting moment boost from the canting keel is less marked than might initially be expected. Lifting or telescoping keels provide a means of increasing the effective righting moment from the ballast package while still permitting reduced draft access to port. Compared with a canting-keel alternative the requirements for the lifting systems are lighter and more compact, having less impact on the interior arrangements.

Over recent years FYD has been researching foil-assisted sailing solutions and sees some significant performance advantages available from the Dynamic Stability Systems (DSS) approach. From a performance perspective the positive feedback loop introduced by DSS offers some significant benefits. The vertical force provided by the foil acts to reduce the effective displacement, while providing dynamic righting moment. As the drag reduces, the speed increases and the foil provides more righting moment. At higher speeds, as the foil begins to approach the free surface, the foil lift begins to reduce, creating a soft, automatic ride-regulation system.

However, while for smaller boats at high speed the foil can be carrying 50 per cent or more of the boat's weight, how well do these advantages translate to a much larger and heavier yacht?

FYD undertook a significant amount of computational simulation to explore the proper sizing, angle of attack and positioning of the foil to verify the validity of the concept at this much greater scale.

The 9m foil's span is largely driven by the beam of the boat and this drives the amount of lift and righting moment that can be generated from the foil. Unlike the existing DSS raceboats, it is anticipated that the effective maximum displacement 'reduction' from the foil would only be in the order of 15-20 per cent (still 40,000kg+) but still sufficient to allow a reasonable boat speed increase.

It is important to remember at this point that one of the primary reasons for considering DSS in this application was for the significant reduction in operating heel angles and the substantial reduction in pitching motions and, as such, these speed improvements are a notable added benefit.

From a risk assessment viewpoint, the DSS systems have been in use for some time and their performance and reliability are established. Real-life testing of the foils and actuation systems has been verified, albeit at smaller scale, and the use of a single sliding foil minimises additional weight and complexity, allowing the foil to be completely retracted into the hull. In conjunction with FYD's development work, the client's team and Baltic Yachts spent extensive time and resources performing due diligence on this decision – sailing on existing yachts with DSS and undertaking additional technical studies before committing to move ahead late in 2016.

With the decision made to pr the DSS foil, the project shifte level, requiring the entire team t detailed understanding of the i of DSS on the design. The pres DSS has a profound effect on architecture of the yacht, influen thing from the hull shape a arrangement to the sizing of package, specification of structu rigging loads, and the sizing of t

Detailed studies of foil shapin tion, tip detailing, actuation s performance and handling wer and the hull shape was carefull in terms of its trim response wit heel in both conventional and D

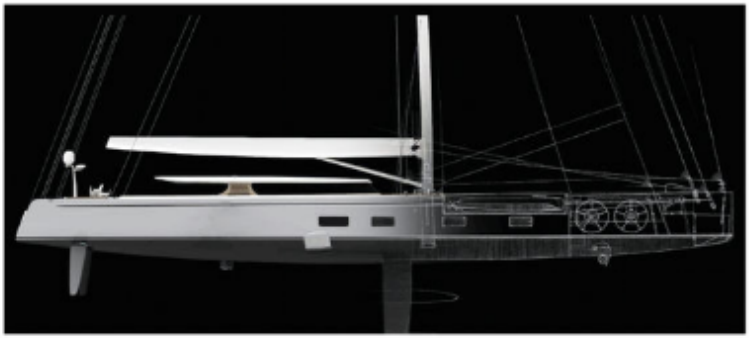
With the position of the foil in terms of the naval architectur neering team within Gurit ther a preliminary structural stud complete yacht, to define the arrangement, typical laminates out an assessment of the glob and strength requirements. It w ical at this stage to invest time loop for the DSS foil and suppo ture, to assess the feasibility posed arrangements and ensur necessary changes were put early in the project as possible.

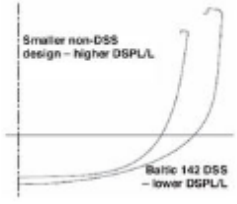
The reduced displacement adoption of DSS allows cre challenges structurally when th question is a cruising yacht, wh a need for a minimum level volume for a comfortable displaced volume is to be reduc compromising the vessel's bea result is a reduction in draught of section.

Overleaf (*page 42*) is sho section of the Baltic 142 comp slightly smaller, non-DSS but performance superyacht. It c that the smaller hull has an section that requires more full its higher displacement:length r

This has a knock-on effect the available space within whic the DSS and its supporting which of course needs to be waterline and any accommodat

A co-ordinated preliminary design of the DSS system was to evaluate both the foil secti feasibility of supporting the bea limited space available. Initi





Left: the midships section of the hull of the Baltic 142 DSS shown with (inside) the hull of a smaller non-DSS design but of relatively heavier displacement. While the hull of the bigger yacht curves up steadily from close to the keel line, the relatively heavier smaller boat carries its fullness out further with a flatter floor to increase immersed volume to support the greater displacement. The knock-on implication for the lighter DSS design is that the shallower angle at the level where the DSS foil exits the hull necessitated some clever engineering to support the foil sufficiently while ensuring easy movement. Top: this graphic nicely illustrates the aft position and pitch of the DSS foil as well as the size of the two carbon under-deck drums on which luff-furled headsails are stored

suggested it was going to be very difficult to support the required foil span within the space available for supporting bearings.

The shallow sloping shape of the hull in way of the foil exit (*see above*) exacerbated this by requiring the outer bearing to be installed a long way inboard to fit within the physical envelope of the hull. With this arrangement the two supporting bearings were too close to one another and needed to be pushed further apart to reduce both the shear force and bending moment in the foil, and the loads in the bearings, which would need to be supported by structure concealed beneath the owner's cabin.

In developing a solution to distance the bearings from one another, Garit engineers collaborated closely with Baltic Yachts to make small adjustments to the accommodation layout and with the Farr office to locally alter the hull shape, developing a subtle blister around the foil exit capable of housing the outer bearing.

Incorporating this discrete blister into the hull shape not only achieved greater bearing separation, and thus more manageable bearing loads, but it also enabled an increase in exposed span by moving the whole assembly slightly further outboard. Further to this, by changing the hull-to-foil interface shape the foil's lift characteristics were also improved.

The end result was not only a more efficient structure, but it also led to added righting moment and an improvement in performance, all confirmed through CFD studies carried out by Farr Yacht Design.

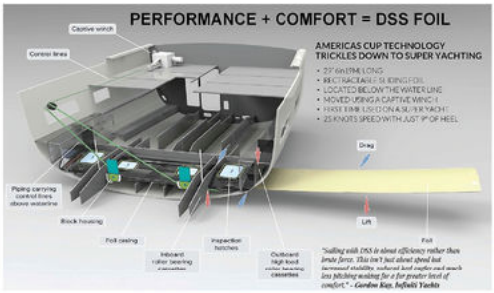
Furthermore, through close collaboration between Garit and Farr, the foil section shape was optimised to minimise the weight of the internal spar while not having a detrimental effect on performance.

The importance of this early work was clearly demonstrable and was also essential when the loads reach this order of magnitude. With a maximum steady state lift of 40 tonnes and an estimated peak dynamic lift of over 60 tonnes, the structure supporting the bearings needed to withstand up to 140 tonnes and 200 tonnes at the inboard and outboard bearings respectively.

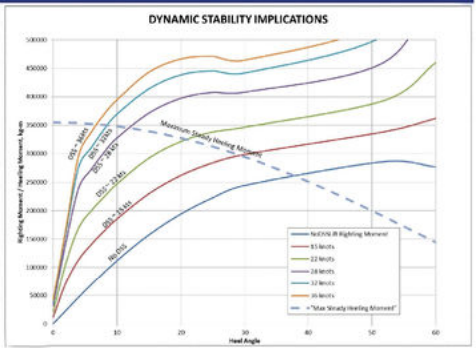
The resulting foil, weighing 1,125kg, with a complex pre-preg carbon lay-up was meticulously constructed over the course of 12 months by Isotop in France, easily the most intricate and complex project the company had undertaken to date.

The carbon inner mandrel, weighing 340kg, was made from six hollow profiles, all made in female moulds and cured in an autoclave. The outer pre-preg laminates, 200 layers in total, which are up to 80.6mm thick at the hull exit, the most highly loaded area, were also optimised in their distribution to ensure failure points are located outside the hull envelope.

Lift isn't the only load case that needed careful consideration. Risk of impact with or fouling by a UFO is a scenario that cannot be ignored and such load cases would also be significant and potentially quite different in nature. So the challenge was to ▷



DYNAMIC STABILITY IMPLICATIONS



design a structure that could not only withstand the vertical bearing reactions, but also the horizonal reactions generated through off-design load cases, which were of a similar magnitude, while all being able to be assembled in a practical sequence… and all fully concealed behind the panelling and furniture of the owner's cabin.

More knock-on

The traditional standard static righting moment-based methods for sizing rig and equipment design loads needed to be revisited in the context of this boat's dynamic, speed-dependent righting moment, including an assessment of real-life operational constraints (something typically reserved for multihulls) to avoid the over-specification of equipment.

This is the sort of challenge Baltic Yachts thrive upon. As a company steeped in innovation, this now gave them, despite a few headaches, a clear reference point for their objective to be the natural home for projects where the vision exceeds the norm.

And Roland Kasslin, head of design and engineering at Baltic, had a vision of his own: to take something inherently complicated and make it as simple as possible for the end user, something that has been at the core of DSS yachts previously developed by Infiniti/DSS. It was at this stage that Baltic brought Infiniti into the team.

Gurit was responsible for the overall engineering of the yacht with BAR Technologies consulting on foil-actuation systems and bearing design. Using the experience of Hugh Welbourn, inventor of DSS, throughout the process often helped find the simple answer to the complex question. Undoubtedly the experience of the triumvirate of Welbourn, Gurit and Isotop, who have now produced over 60 DSS foils together, paid dividends.

In simple terms the DSS foil employed is a transverse foil not dissimilar to that used on the Infiniti 36s, the retrofitted Reichel/Pugh 60 *Wild Joe* and R/P 100 *Wild Oats*, but the loads were now at an altogether different level. The balance between how much righting moment was wanted, how much could be coped with and how much was actually needed was a loop that produced much debate.

In the end it was decided to 'cap' righting moment at 400 tonne-metres. More was possible, but the increased loads would make the rig less efficient as it is the rig that bears most of the brunt. This yacht was not meant to be a monster, but an efficient, easy to sail, comfortable and fast blue water cruiser…

Ultimately, a similar solution was used to drive the DSS foil to the one used on *Wild Joe*. Bearing in mind that the foil alone weighs 1,125kg and servicing is something that should be done when the yacht is out of commission for general maintenance, Gurit stuck to a few simple drivers.

The foil would be driven by line, recessed in the bottom of the foil and powered by a Harken captive winch developed for the task. Limiting the line pull to 20,000kg, as you only want to move the foil either to retract it, because you are not travelling fast enough, or tacking and gybing, allows this 'low-tech' approach. (20,000kg is the load needed to move the foil prior to gybing when sailing at 22kt. This could have been made higher, but this did not fit the philosophy of the yacht and it will usually be possible to slow down to 22kt to gybe the foil).

Solid bearings were selected in place of the titanium rollers on *Wild Joe* for their reliability and with a minimal loss of pulling efficiency. A series of simple mechanical stops ensure the foil sits on the bearings as designed.

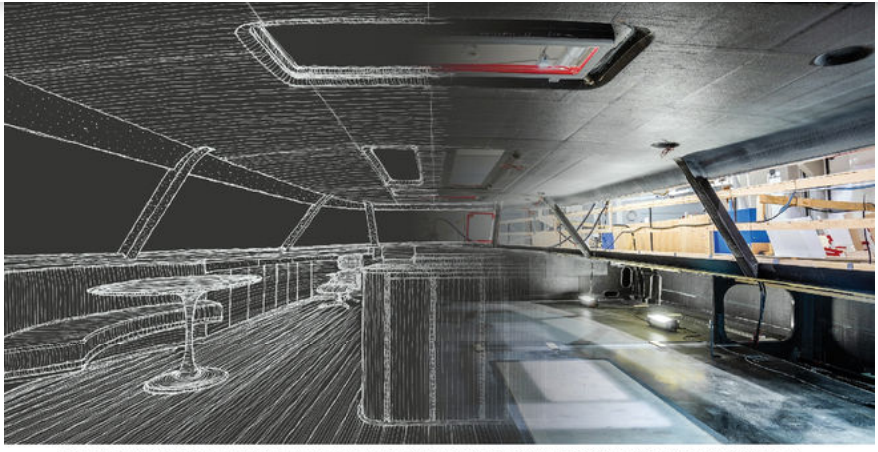
Technically Baltic have done an impeccable job of delivering a DSS package that completely meets the brief. Of course, compared with some of the very advanced propulsion and charging systems onboard it looks positively stone-age, but the benefits of DSS are about keeping it simple and making each yacht even more of a pleasure to sail.

Rig and rigging

A yacht such as this, with a limitless cruising ground, meant a great deal of thought was required on how to ensure the boat 'works'. Modern superyachts often now have an 'owner mode' and a 'delivery mode', the transition from regatta to delivery mode involving substantial changes to the rigging set-up and sailplan.

Processes like this can take several days and, with the brief that the yacht would need to be capable of handling all types of use, and transition from calm to storm, without a shore crew to make the alterations in the comfort of the marina, plenty of thought went into the sailplan and rig geometry.

The final rig features a square-top mainsail, allowing for a shorter mast which in turn lowers the centre of gravity without compromising sail area. However, the requirements for minimum headstay sag from both the J1 and the self-tacking staysail meant that due consideration needed to be made to ensure these were not compromised.



The new Baltic 142 DSS is a fully fitted luxury ocean-cruising yacht but you do not have to dig far below the surface to find evidence that its builders are using all their composites expertise to create structures that would not look out of place on a large racing yacht; and among the superyacht fleet that's how it may yet be seen, the polars topping out at 31.1kt downwind in 30kt and 14.09kt upwind

The resultant rig geometry had twin masthead runners and lower and upper deflectors which, on the face of it, sounds complex and hardly easy sailing. However, the rig is set up so that with one reef in the main both runners are tensioned and the option to deflect the runner remains, but only the deflector needs to be released prior to a tack or gybe.

If absolute minimum (ie racing) sag is not required, then there is no need to use the deflector and the rig sets up nicely with the twin runners snugged back – meaning that, other than the lower deflector, nothing need be touched when tacking with the self-tacker, and only the J1 sheets controlled by Rondal captives otherwise. The lower deflector of course presents an obstacle… at least on paper.

By running individual cylinders for each deflector and having a long tail for the lower deflector, there are effectively two modes. For a regatta or day sail, the lower deflector is controlled entirely by the cylinder and the runners move fore and aft from tack to tack as with a conventional yacht. However, when sailing offshore and shorthanded, when one is moving from full main to three reefs and back again and wishes to be able to have both runners set aft and for minimal line movements when tacking or gybing, there is another mode. This brings the lower deflector to the primary winch by the helmsman, so that with a long tail it is a simple process to fully release the lower deflector when tacking or gybing in heavy air and reefed.

This might seem convoluted, but having a yacht of this ilk that can comfortably change from full main to third reef and back again, with minimal change or alarm for the crew is, if not unique, then certainly unusual. In reality the system is simple to use, simple to access and for the crew simple to manage. An essential part of the brief.

Rondal and Carbo-Link were integral in this process, as well as the additional due diligence from Gurit to ensure it was not a fool's errand in trying to make the rig perform as required, but in a way the crew could manage with as little stress as possible.

Sails

The larger the yacht the fewer the sails you have to play with and this yacht plans to sail everywhere, so intelligent choices had to be made.

A preliminary 'sea trial' proposal that includes passing the three great capes to port focuses the mind and the decision-making process. Working closely with North Sails, once again the client was prepared to leave conventional wisdom on the shelf and examine all the options open to him. Unconstrained by rules or regulations, various options for flying sails were considered, including a Quad headsail.

Readers of this fine periodical will no doubt be familiar with the recent history of the four-sided wonder sail, but for those who are not, it is along these lines: the Quad was part and parcel of the J-Class fleet both in its original guise and in the millennial revival until more effective methods of sailing upwind on the modern J-Class were proven. However, as an all-round reaching sail, considerable time was spent in the Auckland wind tunnel with Doyle Sails testing Quad sails that Hugh Welbourn had developed with Richard Bouzaid of Doyle and David Le Pelley of the University of Auckland.

Results were sufficient to bear further examination and, cutting a long story short, the ill-fated Team Russia fitted Quad sails to their VO70, developed with North Sails, that outperformed the polars by up to 20 per cent. The outside world saw this as the last throw of the dice, those who sailed on the boat knew better. IRC in their wisdom banned it, which probably means it's pretty good, but ORC allowed it and the first two Infiniti 36s used North-built Quad sails to good effect, particularly when neither yacht was built to race (or rate).

With beam becoming relatively smaller as yachts get longer, unless you build an aircraft carrier, the ability to reduce the 'return' section, or the draggy bit, of a big reaching sail is very desirable. Coupled with limited roach to ensure a reliable furl, this was something that required consideration. After only mild resistance all parties agreed to examine the option and once the issue of having two sheets to manage was resolved, the decision was made to build a Quad.

Coupled with a powerful A3, the entire 3Di-built North package was now complete… albeit with the addition of a Cuben J5 for when things get intense.

Systems

The flying sails on this yacht are stored below deck on large custom carbon drums. The drums were developed and manufactured by Baltic Yachts with input from Future Fibres, Gurit and North.

This is the third yacht from Baltic to feature this breakthrough in superyacht sail handling. The 2.1m-diameter drums are driven by a dedicated hydraulic motor, ensuring that the flying sails are stored and deployed as efficiently as possible. The use of these drums frees up significant storage space below and allows the sails to be stored in a manner that extends their life. All that said, the additional complexity of managing the large furled 'cables', and the drum diameters that they are able to be stored around, gave the team at Baltic plenty to think about.

The moveable cabin-top is a masterpiece of engineering due to the demand of the client to reduce both overall freeboard height and cabin-top height. Thereby all framing is engineered and integrated inside the cabin-top panel itself. This is made extra complex since the cabin-top comprises almost 5m of unsupported overhang.

This is a signature feature of the yacht, delivering an indoor/outdoor experience previously only found on big catamarans. However, unlike some of the smaller examples of this indoor/outdoor feature this is a blue water vessel and so structurally it was an extremely complex area to engineer. The end result is a sleek, low-windage and stylish cabin-top… but, as is so often the case, the real challenges are invisible.

The long-stroke (3.8m-6.5m) lifting keel with trim tab and optimised keel trunk was engineered by Gurit and made at Baltic. This was another 'interesting' area since the brief from the owner was that the yacht must be able to dry out, resting on its keel. The carbon keel trunk features 180 layers of carbon and is around 30 per cent lighter than any conventional off-the-shelf solution.

There are two large custom deck hatches for storing a 7.2m guest tender and a 4.5m crew tender under deck. Integrating a 7.2m tender into a yacht of this size in such a way that it remains invisible and yet has minimal impact on the interior volume was not easy!

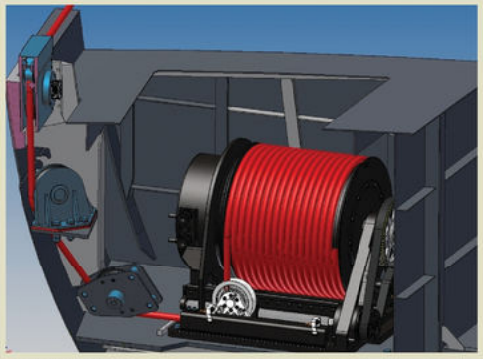
Propulsion

The Baltic 142 DSS also breaks new ground for the company with her diesel-electric propulsion system, which reduces fossil fuel consumption and is considerably quieter than conventional systems. The twin 210kWh custom-built diesel-electric generators comprise a 6.7-litre Cummins engine with a Visedo in-line generator, and a Baltic optimised sound shield, charging a 200kWh high duty HVDC lithium battery bank delivered by Akasol.

The HVDC battery bank also delivers power to other equipment including the bowthruster, the rotating stern drive leg, captive and deck winches and the DSS system drive. To make such a demanding system feasible the system operates at 700 volts so that equipment can be run electrically rather than indirectly via hydraulics.

The battery bank and the two generators can deliver 420kW, enough to propel the yacht at full power and run all domestic functions as well as sail handling simultaneously. With this huge battery bank the yacht can be used without the need to run the generators at night. While underway the yacht could also run for several hours at half-speed on battery power only.

Contributors:
Gordon Kay – Infiniti Yachts
Sören Jansson – Baltic Yachts
Simon Everest – Gurit
Ken Read – North Sails
Britt Ward – Farr Yacht Design
Bill Faude – Harken
James Wilkinson – Carbo-Link
Dominique Pedron – Isotop ❑



HELD CAPTIVE – Bas Peute, Rondal

Development work on our new Rondal electric captive winch started a decade ago. An aluminium chassis for a standard eight-tonne hydraulic winch was converted to accommodate an electric motor.

Electric motors have become increasingly efficient in recent years, allowing hydraulic motors to steadily be replaced by all-electric power units.

In addition, new techniques enable electrical engineers to peak-shave the power requirements of a yacht.

A hydraulic system needed to be set up to deliver the maximum peak power requirements at all times, even if this is a situation the yacht will rarely, if ever, see. By contrast, the electrical set-up could now be configured for average power requirements because peak demands can always be met from a battery bank or additional genset.

The heart of the E-captive winch is a 700V DC motor, managed by an inverter/motor controller. Like braking with an electric or hybrid car, the Rondal E-captive winch will regenerate power once paying out under load. This regenerated power will be fed back to the yacht.

Baltic Yachts and the team on the Baltic 142 challenged Rondal even further and for weight-saving purposes the aluminium chassis was replaced by a full carbon solution. Based on the proven captive winch layout, this includes base plates, bulkheads and even the drum is now manufactured out of carbon.

The E-captive winches on the Baltic 142 vary in size from 8 to 12 to 18 tonnes' pulling load. Max holding loads are the pulling load multiplied by 1.5. The E-captive winch range has now been completed with a 6-tonne and new 24-tonne unit…

In the cases when there is zero load applied to the rope during paying-out (for example, a slack mainsheet or slack headsail sheets), a captive winch will only ever function reliably when there is a good feeder arrangement installed.

The Baltic 142 features electric-powered Rondal feeders again in a carbon housing. These feeders pull the rope out of the bilge or locker with up to 100kg of force and deliver them to the winch with the correct alignment. The feeders are programmed to start a split second after the winch and spin fractionally slower than the main drum in order to avoid a slack line on the drum.

Rondal were also responsible for the carbon-fibre spars. Here again the Rondal and Baltic Yachts teams were constantly challenging one another to evolve the best possible rig solution for the biggest ever DSS-stabilised yacht.

The rig is supported by Carbo-Link elliptical continuous carbon standing rigging, the elliptical shape being specifically tailored to reduce vibration, and a performance running rigging package manufactured by Offshore Rigging.

The Baltic 142 also features a Rondal 'style-to-order' performance furling boom, carefully shaped in co-operation with the owner's personal design team, Micheletti and Partners. This furling boom is equipped with our latest performance outhaul system engineered specifically to deliver accurate foot tension in all reefed positions. This was achieved by developing a device on the boom that locks onto a 'knob' in the leech of the sail, whether at full hoist or in a reefed position.

The luff of the sail is also connected to a detachable cunningham, again whether at full hoist or in a reefed position, to ensure full control of luff and foot tension at all times. The performance boom offers not only better sail shape – and therefore performance – but also takes the load off the mandrel. With today's much stiffer and more powerful sail technologies, removing the load from the mandrel means significantly less wear and tear.