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The Superyacht REPORT

TRUTH • OPINION KNOWLEDGE • IDEAS AND EXPERT INDUSTRY ANALYSIS

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ON THE EDGE OF THE WIND

Sailing technology has evolved rapidly in the past decade with advances in materials science, and the increasing power of super-sailing sports like the America's Cup and Volvo Ocean Race. Sailing superyachts have benefited with more advanced materials and faster speeds, but design and safety are still key considerations. **Don Hoyt Gorman** considers the leading edge of the art form.

In the world of superyacht sailing, performance is king, and performance in sailing – which is being led much in the same way automotive technology is being led by highly funded teams chasing world championships and trophies – means greater stiffness, less stretch and a focus on weight in the sails and rig.

Ten years ago, the criteria for an ultra-rigid, lightweight sailing rig had yet to emerge as something that was considered reasonable for superyachts. The focus then was on durability and ease of handling for the crew. However, materials science has come a long way in a decade and today's sailing rigs are fabricated to incredibly high tolerances with carbon fibre, titanium, and other extremely strong materials to provide a balance of strength and durability, as well as the requirement to win races.

The changes on deck and in the rig mean the entire evolution of handling has changed. Yacht sails today can be locked into position rather than relying on their halyards for tension, which contributes to a tremendous increase in rigidity and transfers the force of the wind more completely into the movement of the yacht through the water. Masts and booms can be made of carbon fibre, with deck equipment built to handle forces that far exceed anything a crew could safely handle without mechanical assistance.

As flex has been eliminated on the back of stronger materials, peak loads within the system have escalated. With the higher-tech equipment on board, owners have been bringing in more and more experienced and professional race crews who do what they're trained to: trim sails on much harder than a superyacht sailing crew would otherwise do.

All of this is good news: technical advances mean better performance and, ideally, a better experience for the yacht owner. It has also meant that companies working at the forefront of the technology have had to adapt quickly to the changing requirements of the entire sailing rig system.

Hendrik van der Linde, custom sales director at the British sailing hardware firm Lewmar, has been overseeing a serious investigation into the loads and safety for crew, owners and guests. "The new-material superyacht racing sails from Doyle and North have essentially no stretch; the latest rope fibres also offer no stretch; the boats are bigger; there are more powered winches with bigger furling gear to handle bigger sails," van der Linde said. "There is more club racing with superyachts, with regatta sailors as crew who push the gear to the limit. Over the past few years, the maximum sheeting load on a headsail has increased from 6 to 7.5 tonnes and later to 8 to 10 tonnes. With the latest generation of materials, we are seeing 12 tonnes or more in static loads, with shock loads upwards of 13 to 14 tonnes."

With no stretch in the sailing propulsion system, the bigger shock loads are being transferred through the deck equipment directly into the deck and hull construction. To deal with this, the team at Lewmar has increased the pulling load of the winches and built stronger centre stems and gears.

PHOTOS: LEWMAR

ABOVE: STRATIS SAIL
BELOW: FIBRES IN THE STRATIS PLANT
PHOTOS: DOYLE

With no stretch in the sailing propulsion system, the bigger shock loads are being transferred through the deck equipment directly into the deck and hull construction. To deal with this, the team at Lewmar has increased the pulling load of the winches and built stronger centre stems and gears.

"We calculate for between six and eight turns of line around the winch to create the correct friction between pulling and releasing the load," van der Linde said. "We have a fast first gear with good pull to get the slack out of the system. On blocks and sliders, we calculate sheave diameter so the rope fibres don't chafe and degrade, and we're now using heat-treated materials to get higher breaking loads. We test every product on the rig to 10 per cent over its specified safe working load."

What may have formerly been the most delicate components of the sailing system, the sails themselves, are now, by virtue of their laminate construction with blends of carbon fibre, the least likely parts to break.

More than spars or rigging, which are all about rigidity, sails are designed around stretch rather than ultimate breaking load. Safe working loads might be a third of the breaking load, whereas sails are designed to a maximum elongation. "For a racing sail for a superyacht, we might design to 0.18 or 0.2 of a per cent elongation, whereas on a pure race boat like *Shockwave*, we might be down to 0.1 per cent," said Richard Bouzaid, head designer and director of Doyle Sails. "The highest we'll go even on a cruising specification now is about a 0.28 per cent, the reason being we never want to load the membrane: the fibre should be taking the load, not the glue."

New sailing superyachts will have carbon forestays or carbon V1s about 50mm in diameter. "You look at those and think they're massive, but if you took the carbon strands coming into the head of a sail, there's probably four times as much carbon in there than there is in that solid stay," Bouzaid said. "It's incredibly unusual to break the sail. The break load in the head of a superyacht sail, which might see a maximum of 20 tonnes of load, is

> "We have trolleys to move the sails around, because these things can weigh over a tonne."
> – Richard Bouzaid, head designer and director, Doyle Sails

LOADING TWO 93M MASTS IN NEW ZEALAND
PHOTO: SOUTHERN SPAS

probably upwards of 250 tonnes. So you'll end up with more stretch in the cables and the rig than in the sails themselves, so we end up engineering them to handle that as well."

Doyle Sails has a sail loft with dimensions of 100m long by 37m wide; it is the biggest sail loft floor in the world. "Size has not yet become an issue," Bouzaid said. "The tables we use for making our stratis membranes are 55m, long enough to handle the foot of a reaching gennaker for *Kokomo* – although the yacht never ordered one. We have trolleys to move the sails around, because these things can weigh over a tonne."

With the increase in loads, and the exponential increase in the risk of serious injury associated with it, the latest sailing control systems are being programmed automatically to start to ease off if they exceed limits stipulated by the owner's insurance policy.

The rapid advance in sail technology and the relative ease of ordering a flashy new set of racing sails has led to more than a few problems out on the race course. "A lot of the older boats out there racing were never really engineered for this type of thing, and they have a lot of failures in their blocks and tracks that simply struggle to take these immense loads," Bouzaid said.

Current new-build superyachts are being engineered with the involvement of the sailmaker, rig-maker and mast-maker at a very early stage. "We come together to establish the loads and make sure that all of the hardware will be sufficient to be able to deal with all of it," Bouzaid said. "No one wants breakages or winches that are grunting and can't pull in a sheet under heavy load. When we design a membrane for older superyachts we run through an engineering cycle that gives us a good sense of the size of the membrane their equipment will handle and we can give the client a very good sense of the limitations on its use," Bouzaid said. "We give them the information on what kind of static loads they'll get from the membrane, and we'll evolve the recommendations on things like wind-speed limits they should observe."

Owner and founder of the Superyacht Racing Association Barry Houghton famously won't race his yacht *Salperton* in winds over 30 knots after a main sheet parted during a race several years ago and seriously injured a crewmember. But sail racing by its very nature is a competitive sport and risks are inherent. Racing jibs that have been designed and manufactured by the best sailmakers to a wind-speed tolerance of 15 knots have been known to remain deployed in the heat of racing in 18-knot winds.

The interactive loop between sailmaker, rigging designer and mastmaker is a key one, especially in the latest new builds. The announcement of Royal Huisman's 58m new build during the Monaco Yacht Show is case in point. Huisman's neighbour and partner Rondal is supplying the mast while the 3Di sails are being fabricated by North Sails at their loft in New Zealand.

"She's a very big, powerful sloop and we're continuing to work on the engineering of the whole sailing rig system," said Jens Christensen, vice-president of North Sails. "We're building this new project with the experience of already having delivered our latest 3Di sails to *Hetairos* and *Aglaia,* so this will be a natural progression of what we've been doing," he said. "We've been pushing designers and project managers hard for years to get the

sailmakers in earlier on these major projects to be able to work with them on loads and sheeting positions. We simply say it costs the same upfront to build a sailing rig correctly as it does to build it incorrectly, so why not involve us early and let us help make sure everything works?"

With the increase in loads, and the exponential increase in the risk of serious injury associated with it, the latest sailing control systems are being programmed automatically to start to ease off if they exceed limits stipulated by the owner's insurance policy. Load sensors are built into every component of the sailing rig, including the mast, stays and winches, which all feed into the computerised system that detects and automatically eases when forces meet preset levels. Software developments that have proceeded in parallel with advances in materials science have also enabled designers to model and understand what any given configuration of mast, boom, sail and rigging will do.

Some of the very latest projects in development include masts that are effectively fin rigs with unstayed masts, which would have been impossible to design without the advances in design and modelling software. Rig designers today can come up with virtually any weird or wonderful design they want, and the spar-makers, sailmakers and rigging engineers will be able to make it work. Highly unconventional design possibilities are very much a possibility.

The most iconic sailing rig afloat remains that of the *Maltese Falcon*, which, ironically given the level of technical innovation in her rig, uses simple Dacron sails, provided by Doyle. "They needed something that was durable and highly flexible to work with the in-mast furling system," Bouzaid said.

It isn't just the size and style of the *Maltese Falcon*'s rig that continues to impress; it's the fully integrated sailing management system that was designed to set and strike the entire array of square-rigged sails. Damon Roberts, who led the design and build team for the rig with his previous firm Insensys, is now leading a similar team at Magma

THE MALTESE FALCON
PHOTO: JUSTIN RATCLIFFE

"The hidden design work, detailing and engineering that go into providing all this infrastructure is considerable and it is no surprise that these rigs represent multi-million-dollar investments and can take a couple of years to produce."
– Josh Impey, marketing manager, Southern Spars

Structures building two of the world's largest and most technically complex freestanding, automated 60m+ carbon composite sailing rigs. The company handles all the structural engineering design, prototyping, testing and building of the rigs, as well as commissioning the controls, sails, automation and monitoring systems.

"We're proposing push-button sailing systems as the solution for super-sized

ED DUBOIS' PROJECT 380, A 101M SLOOP, HAS A PROPOSED MAST HEIGHT OF 125M PHOTO: RONDAL

> "Automation in free-standing sailing systems is the only way to make the largest sailing rigs safe, practical and useable. Automation ensures that the boats actually sail rather than motor between destinations."
> – Damon Roberts, Magma Structures

manageable sailing rigs – it makes all the loads and crew numbers practical and manageable," said Roberts. "Automation in free-standing sailing systems is the only way to make the largest sailing rigs safe, practical and useable. Automation ensures that the boats actually sail rather than motor between destinations."

Magma Structures' experience speaks for itself: the *Maltese Falcon* has executed over 11,000 individual sail sets, through storms, gales and calms with no issues and sailed (rather than motored) over 100,000 miles. Magma won't reveal the specific size of the rigs they are working on, but they are expected to be among the largest and most complex afloat. One of the largest proposed rigs ever, Ed Dubois' project 380, a 101m sloop, has a proposed mast height of 125m.

"We're seeing owners contemplate masts over 100m: at the 2012 Monaco Yacht Show, we signed the contract for what will soon be the world's tallest set of masts for a private client's 85m ketch-rigged yacht," reported Josh Impey of Southern Spars. "She'll have two 93m masts – two of the world's tallest rigs on one gigantic yacht. The booms alone are just short of the length of a superyacht, each measuring 23.5m and the longest spreader is over 7m."

While supporting the weight and loads of huge sail areas, the rigs will align exactly with the sail shapes, withstand multi-directional rigging loads and provide the internal motors and hydraulic systems to furl sails, control sail shapes and lock halyards. They will also accommodate navigation and communication electronics, satellite domes, antennas, radars and lighting systems – all of which can demand up to two tonnes of internal cabling. Impey reports that some rigs also include internal venting systems for grey- and black-water tanks, fresh-water washdowns, plus a degree of redundancy and future proofing.

"The hidden design work, detailing and engineering that go into providing all this infrastructure is considerable and it is no surprise that these rigs represent multi-million-dollar investments and can take a couple of years to produce," Impey said.

The complete spar package for the 85m ketch has now left the factory in New Zealand and is being shipped to meet the boat. The use of such volumes of carbon fibre makes Southern Spars Custom Projects facility the largest importer of carbon fibre in New Zealand.

Many of the advances in sailing are down to the manufacturing process becoming more sophisticated, explained Andy Claughton, the recently installed technical director at Ben Ainslie Racing who used to be with the Wolfson Unit in Southampton. "We now have an additive engineering process, which is chipping away at the weight of components," he said. "There's a constant passing of the baton between an improved process, which then leads to an improved design paradigm. When the process improves again, you have to re-cast how you design parts."

Claughton, who is heading the entire technology team to bring the America's Cup back to the UK, insists that the wing-sail technology as it currently exists on the America's Cup boats will not make the transition to superyachts. "The practicalities of trying to reef the wingsail and its handleability and how delicate it is make it completely unsuitable for use on yachts," he said. The sails don't stow away, which is their key problem: they're perfect for racing, he said, but you can't actually get rid of all the sail area – you don't want to sit at anchor or try to cruise calmly through an anchorage with one of these.

takes somebody to leave their lunch wrapper in the laminate of a mast …" he trailed off at the thought.

As much as mast-makers may couch their advances in having learned harsh lessons, Claughton said the real advances are coming from increased quality control in manufacturing. "The latest lamination techniques are coming from the wind turbine blade sector where they've implemented fabrication assistance," he explained. "All of the plies will be pre-cut and there will be a laser outline of where the ply has to go. If you have a bunch of guys in overalls applying it they know exactly where to

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Superyachts don't spend a lot of time on the points of sailing for which wing sails are designed, and as soon as there's a breeze on, sailing superyachts trim to maintain a heel angle rather than to achieve full potential power. "As soon as you're not hard on the wind and you're not looking for maximum power, any benefits of the wing sail start to melt away," Claughton said.

On the subject of the advances in materials science, Claughton said the key thing is quality control. "One thing about these advanced carbon structures is that they look great in the drawing but they're actually assembled from hundreds of layers of carbon, and one misstep in that stack leaves you with a defect that could halve the strength of the parts," he explained. "If you mill something out of a solid billet of aluminium, you've got the properties right through the thickness. But it only put it and they know the number that they're seeing projected on to the inside of the mould matches with the ply they're about to apply."

Claughton remains impressed with the DynaRig concept, not because it's aerodynamically efficient, but because of its simple useability. "On some of the big schooners, it's a real trial to get all the sails up and go for a sail, whereas on the *Maltese Falcon*, it only takes one guy to press the buttons and you're off," he said.

Claughton said there is a fundamental contradiction of innovation versus aesthetic that pervades the sailing yacht population. "Sailors are all in favour of innovation, but they actually are quite leery of their boat looking a bit different, so the conservatism inherent in the sailing community holds it back." He said he has an appreciation for Damon Roberts and Ian Howlett's Aero-Rig, which they pioneered when they ran the company Carbospars. "It's super. It looks a bit odd and because you don't make many of them, they're expensive, but if I was designing a superyacht, I'd be very tempted by the Aero-Rig."

What unites the thinking of Claughton and the technicians and salespeople at the leading sail lofts, mast-makers and rig specialists is the level of precision and accuracy their jobs have ascended to. This is superyacht sailing today: a craft, still truly an art in its execution, but also very much a technological pursuit, and at its heart a science.

Sailing is a simple pleasure, something when experienced at its best – with nothing but the heave of the swell and the balance of the rig against a warm wind – provides us with a sense of ease and adventure. What lies beneath the parts of the rig that propel us is a universe of thought, experimentation, trial, error and enormous endeavour striving to achieve something safe, sublime and fundamentally good. Appreciating the world within may just enhance the wonder of the whole thing. ■

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WITH SUBJECT: ON THE EDGE OF THE WIND