Seahorse

International Sailing

Issue 463 £5.50 US$8.50

Best in breed…
(and the breed?)

SEPTEMBER 2018
The official magazine of the Royal Ocean Racing Club

ISSN 0143-246X

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No coincidence – Part I

Now into its second decade the Class40 is the strongest offshore fleet in the world. A brilliant concept that proved all the naysayers wrong (when many 'experts' still laughed at the idea of a box rule) – with strong management the fleet has never stopped growing. Tom Humphreys is one of the younger designers who have also found the class offers a rare platform to demonstrate their fundamental grasp of what makes a yacht sail fast

Designing to Class40

The origins of the Class40 date back to 2004, with a growing amount of interest around the 40ft size towards lighter and faster cruising and racing designs capable of crossing oceans and being sailed solo or by a shorthanded crew – very much inspired by the Open-style designs seen in the Imoca and Mini classes. At that time several Open 40 designs had been built along with cruiser-racer designs such as the Jumbo 40. At the request of many in the French marine industry Patrice Carpentier set about, quite brilliantly, drafting a set of rules to encapsulate this growing concept and the Class40 was born.

Since the Class40's major racing debut in the 2006 Route du Rhum the fleet has continued to grow at a steady pace. There are now 155 Class40s on the water and 48 boats are entered for this year's Route du Rhum… which is astounding. While the nucleus of the class remains firmly based in France there are now over 20 nationalities represented and sizeable fleets racing elsewhere, such as here in the UK as well as a growing scene in the States based around the Atlantic Cup.

One of the keys to the success story is the way that Class40 has attracted such a diverse mix of sailors – from the big names and young up-and-coming professionals to enthusiastic and talented amateurs looking for time away from their working lives and to pit themselves in high-level competition against some of the best in the sport.

Each season there is a busy and well co-ordinated race calendar including one transatlantic event and other headliners like the annual Normandy Channel Race. The format is a carefully crafted mix of inshore and offshore racing – which is both another big draw as well as an efficient means of controlling more extreme development. Of course the Rhum remains the jewel in the crown for the class and new designs tend to be concentrated around this event.

So what about the boats? Most early designs tended to be dual-purpose, to cover racing and cruising requirements, as well as being built using cost-effective, production-friendly build processes usually employing vinylester resins plus a gelcoat finish. As a result most of these early designs tended to be heavy and/or short on maximum permitted righting moment. Some of these first designs were as much as a tonne above minimum displacement, but more typically 400-500kg heavy, with some exceptions in the form of the more race-oriented Rogers 40 and the Verdier-designed Tyker 40 series.

This, however, all changed around five years ago, with a flurry of new pure-racing designs hitting the water from several designers, all optimised 100 per cent to the Class40 box rule. This included series designs such as the Mach 40 from Sam Manuard and third-generation offerings

CHRISTOPHE BRESCHI

***Left*: built by Ocean Tec in 2013 Class40 no125 – now renamed *Serenis Consulting* – was the Humphreys office's second Class40 design. Figaro sailor Nicolas Troussel took over the boat in 2015, after which the results really started to flow including two wins in the Grand Prix Guyader and a 1st and 2nd in the complex Normandy Channel Race – testament to the boat's less extreme, all-round design with the ability to perform well in a mix of conditions. Current skipper Jean Galfione has also continued to score well taking a third Grand Prix Guyader win this spring in what is now a seven-year-old design. That said, once power reaching then the later more powerful designs soon slide ahead… no151 (*above*) is the 2017 iteration of designer Sam Manuard's all-conquering Mach40 built by JPS Productions. After years of success in the Mini 6.50 and Class40 Manuard now also at last has his first Imoca – for Armel Tripon**

from Pogo (Finot-Conq) and Akilaria (Lombard) as well as custom designs from Verdier, Ker, Botín and ourselves, with Class40 no125, currently *Serenis Consulting* and skippered by Jean Galfione… a former Olympic pole vault champion!

With this new generation came a big step forward in terms of performance, but most existing boats remained capable of pulling off a big result on their day – something that is an enormous credit to the rulemakers and class managers.

The beauty of the Class40 box lies in its simplicity and the well thought-out base parameters that the rule is built upon.

Class40s are powerful reaching machines. They may only be 40ft but with large square-top mainsails and unlimited reaching and downwind sail area, combined with a righting moment approaching that of a TP52, they are capable of very high average speeds and regular 24-hour runs over 350nm.

Over the years the rule text has expanded slightly, adding detail to close off some of the loopholes that inevitably cropped up. However, for the designer there remains plenty of freedom to let the creative juices flow and, while the areas of the rule left to exploit have been getting a little less obvious, a dock-walk at a Class40 event will still reveal significant differences between the latest crop of designs in terms of hull form, deck design and detailing, appendages, rigs, sails and so on. It is also refreshing to see such a range of designers, builders and equipment manufacturers represented within the class.

The key parameters driving the design of a Class40 are rule maximums for length, beam, draft, righting moment (measured at 90° heel), water ballast volume, mast height and upwind sail area, plus rule minimums for displacement, freeboard, deck camber and coachroof volume. There are further simple restrictions on rig and appendage configurations, sail inventory and on the materials and processes used in the build of the boat as well as in the construction of the rig, keel, rudder and other equipment.

The use of carbon, honeycomb cores and pre-preg reinforcements was outlawed at the start and that has not changed. Cost control remains a key driver for the class management. However, early designs apart, all boats are now built using wet-laminated or infused epoxy/E-glass/foam sandwich with a painted (not gelcoat) finish.

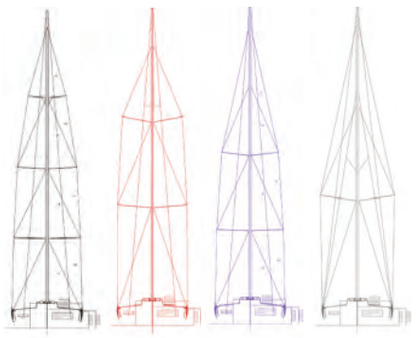
By modern standards these are relatively low-tech materials and the high righting moment and corresponding loads that these boats generate place a lot of emphasis on the structural engineering and build if you are to hit both rule minimum weight and maximum righting moment.

Within a tight box rule, if you're off the money with these targets then you're off the pace from the word go. As a result these are structurally quite complex boats requiring considerable structural detailing and ample use of local reinforcements, to deal with local loads so that the shell laminates can be paired down to a minimum.

Other critical steps in building to weight require the use of thermo-formed, pin-hole foam cores instead of double-cut foam to minimise resin uptake within the core. (This is where heat is used to pre-shape the foam to carefully conform to the three-dimensional shape of the hull and deck moulds. It is more labour intensive, and it comes at a cost, but it can equate to a weight saving of around 150kg with a resin-infused build.)

I'm proud to say that our own design (*Serenis*), along with Marcelo Botín's design *Tales II*, were the first two boats to hit absolute values for minimum displacement and maximum righting moment. No surprise that the structural engineering for ▷

CHRISTOPHE BRESCHI



Owen-Clarke have been prolific Class40 designers – probably their most refined boat to date is no143 *Longbow* (*left*), built by the now defunct Carbon Ocean Yachts in 2015 but so far raced only on the US east coast. The design is biaised towards light to medium conditions but as yet no one really knows how fast she would be up against the European fleet… shame. *Below*: Marc Lombard's scow-influenced 2017 Class40 design *Carac* is no beauty but early problems in light air are being overcome and she is turning into a fierce all-round competitor (more next month). *Above*: the four most popular Class40 rig configurations – with development going loosely *from left*, three and two pairs of conventional spreaders to *right*, low-set single or double spreaders in the search for minimum rig weight and lowest VCG

both these designs was done by the first class team at Pure Design & Engineering in New Zealand. It also required a highly focused effort on our part to design out any redundancy and of course good execution by builders Ocean Tec in Slovenia.

Alongside project manager Andreas Hanakamp we worked hard to simplify systems and instilled stringent detail weight targets that Ocean Tec bought into wholeheartedly, recording the weight of all composite work and components prior to installation. This just left us with the task of calculating what weight needed adding (we had allowed a small margin) and at what vertical position prior to measurement to hit the stability targets bang on.

Most of today's Class40 builds tend to be within 50kg of minimum displacement, while also hitting maximum righting moment within a few kilos (surprisingly a few boats are still being launched that for different reasons are substantially heavier and/or low on max righting moment).

Many of the nuances of the Class40 rule are hidden within that 90° test that is at the heart of the rule. For the test a crane is employed to heel the boat to 90° via a strop attached to the keel bulb, at which point a loadcell is hung from the upper P band at the masthead and securely attached to the dock. When the crane releases the keel the load exerted on the loadcell must not exceed 320kg. This is really an assessment of the boats' vertical centre of gravity (VCG), which of course contributes greatly to both stability and performance.

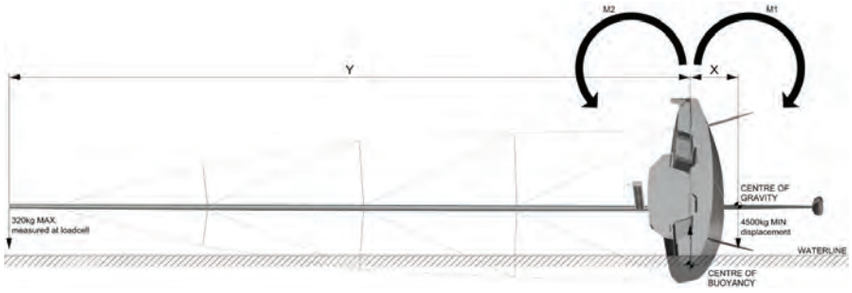
In isolation lowering the VCG offers free performance gains (ie stability increases with no drag penalty). In theory the goal here is to get to the lowest VCG possible within the maximum limit for the 90° test, but with the smallest bulb. A smaller, lower-volume bulb means less drag and provides more scope to centralise mass within the boat to optimise pitch inertia and even perhaps switch from a fabricated keel fin to a heavier, stiffer solid fin which can also be thinner in section and therefore lower drag, particularly useful for reaching and downwind performance.

With the maximum stability imposed at 90° of heel, another interesting point to note is the part that freeboard, deck and hull geometry play. As can be seen in the diagram (*overleaf*) showing a schematic of a Class40 during the 90° test, two moments are in play – one where the weight of the boat, acting through the vertical centre of gravity, is trying to right the yacht about the centre of buoyancy; to the left there is a moment about the centre of buoyancy and the force at the masthead (ie this is what is measured during the test by the loadcell).

However, if you then imagine sliding the centre of buoyancy at 90° heel closer to the keel and away from the masthead (for example, by reducing freeboard) this has the effect of increasing the moment delivered by the same 320kg load measured at the masthead, as the lever between masthead and centre of buoyancy has been increased. As both moments must be equal this requires the centre of gravity to shift to the right by a proportional amount to deliver the same 320kg load at the masthead, meaning a lower VCG can be achieved within the constraints of the rule which would deliver an increase in stability over the sailing heel-angle range.

This highlights the importance of keeping freeboard to the minimum and explains features like the large 150mm deck edge chamfer (the maximum allowed under the rule) and relatively flat deck camber seen on the latest designs.

The deck edge chamfer on its own enables the VCG target to be lowered by around 10mm, due purely to the effect it has on shifting the centre of buoyancy at 90° heel away from the masthead. But it also helps to physically lower the VCG, reducing deck shell area and lowering the height of the hull to deck joint, which is positioned on the bottom edge of the chamfer on our design. This equates to around 0.5 per cent of further free (in terms of drag) righting moment in the 20-30° heel range. In isolation this may not sound like much, but incremental gains all add up. ▷



A few years and 120+ boats… an early Pogo 40 (*far left*) designed by Finot-Conq in 2006. The Pogos enjoyed the lion's share of wins in the first years of the class and also proved popular shorthanded cruising boats (Class40 creator Patrice Carpentier cruised his Pogo extensively on both sides of the Atlantic with his wife Mimi between races). The Owen-Clarke design *Longbow* (*left*) shows how things had moved on by 2015. A simple diagram (*below*) demonstrating why reducing volume at the sheer lowers the measured righting moment allowing a more powerful hull form and/or a larger bulb on the keel

In the early days of the class we had looked at exploiting this loophole more aggressively with a completely cutaway cockpit. However, the rule has been tightened considerably here to avoid designers pushing things too far and to protect the existing fleet. The hull form can play a part in this too and it's easy to imagine how a lower chine with boxier sections could also shift the centre of buoyancy in a similar manner, enabling more stability to be packed on – though this time at the cost of increased wetted area and drag. As usual it remains a juggling act for the designer.

So, while one side of this is to design around the rule to achieve the lowest VCG possible, the other is how to physically achieve this low VCG, while minimising bulb volume and centralising mass about the overall centre of gravity.

A significant contributor to this is of course the rig, both in terms of its mass and centre of gravity. While the Class40 rule limits us to standard-modulus carbon fibre construction, a maximum mast height and a cathedral configuration, there are still big opportunities and rewards to be had for ingenuity on the part of the rig designer. Axxon, who are widely represented in the class, have been pushing things particularly hard – first with a two-spreader configuration, with spreaders positioned very low on the mast tube to bring the rig VCG down, and more lately with an aggressive single spreader configuration offering a small overall weight saving but lowering the VCG by a whopping 200mm – at the expense of requiring a little more caution from the crew particularly when flying the big masthead sails.

It's certainly not black and white and the choice in rig direction remains very skipper specific. Our last design remains one of only a few three-spreader rigs in the fleet. A wide array of options were analysed with Southern Spars during the design stage, with the final choice ultimately based around the owner's intentions to compete in the Global Ocean Race, with the three-spreader configuration offering more rig stability under masthead sails, so less to worry about aloft over the course of a long race – albeit at the expense of being a little heavier and with a higher VCG.

Beyond the rig, hitting minimum freeboard and developing a lightweight, low-VCG deck and internal structure, it is also essential that the weight of the systems and other equipment is located as centrally and as low in the boat as possible. Cockpits are being pushed lower to again help from a VCG point of view, which is also a nice safety bonus. Lowering the cockpit also helps to bring the coachroof height down, as the ability to get in and out of the boat easily is linked between the two for obvious reasons. This of course helps further lower the VCG of the deck shell and internal structure in addition to the small windage benefit.

With a relatively large, 115m^2 upwind sail plan and unlimited reaching and downwind sail area, it hasn't taken long for all designers to hit the rule maximum beam and the search for more stability has tended to come in the form of more powerful section shapes as well as increased forebody and bow volume.

Since the undoubted success of the scow form in the Mini 6.50 fleet, the Class40 rulemakers quickly imposed a maximum permissible bow width measured 200mm aft of the forward extremity of the hull, the new rule being cleverly written to preclude the use of full scow bows; but there is still plenty of room to go to extremes as witnessed by the new Lombard Lift 40 design.

Increasing bow volume has the effect of pushing the bow wave further forward relative to that generated by a finer bow. This increases the separation between the bow and stern wave, thus increasing the effective sailing length and reducing wave drag – which is the most significant component of drag at the higher speeds that these boats find themselves at most of the time. In addition, this approach enables form stability to be enhanced in a relatively drag-efficient way, as well as helping to keep the bow up to make it easier to push hard in big breezes.

The trade-off, however, is an increase in spray drag and added resistance in some wave conditions, as well as the higher wetted area and higher prismatic shape being draggier in the light at slower speeds.

While this is usually not a desirable trade for an inshore, windward-leeward oriented design, it is a different story for a power-hungry, shorthanded offshore design. Though this approach is a win-win on paper or when analysed on the computer in calm water for this style of boat, the motions in waves (particularly upwind and close reaching in a big, short sea) must also be analysed carefully. Ultimately the choice on how hard to push bow volume is led by the skipper and crew who will sail the boat and how uncomfortable they are prepared to make things for themselves in these conditions…

Our 2012 design *Serenis* continues to be a consistent performer and has been a regular podium finisher over the past five seasons – further testament to the Class40 rule. She is a little lighter on form stability compared to the latest, super-powerful designs, with a relatively narrow waterline beam and minimal transom immersion, the original client placing more emphasis on VMG performance for a targeted mix of shorthanded and fully crewed events.

This continues to serve the boat extremely well during inshore, coastal and those offshore events featuring a good dose of VMG sailing (particularly upwind) and light to medium air reaching. These conditions are a regular feature of the highly competitive Normandy Channel Race – an event she has a good track record in, having won it in 2015 when skippered by Nicolas Troussel and finishing runner-up last year with her current skipper, Jean Galfione. Sadly alternator issues ended her race early this year.

The Class40 is now at a level of refinement where most of the low-hanging fruit has been thoroughly mopped up. But there are still huge opportunities for incremental gains and we have been working hard to develop our next-generation design which will be introduced shortly after what is certain to be the most hotly contested Route du Rhum in Class40 history.

Next month: Marc Lombard… and when is a scow not a scow? ❑