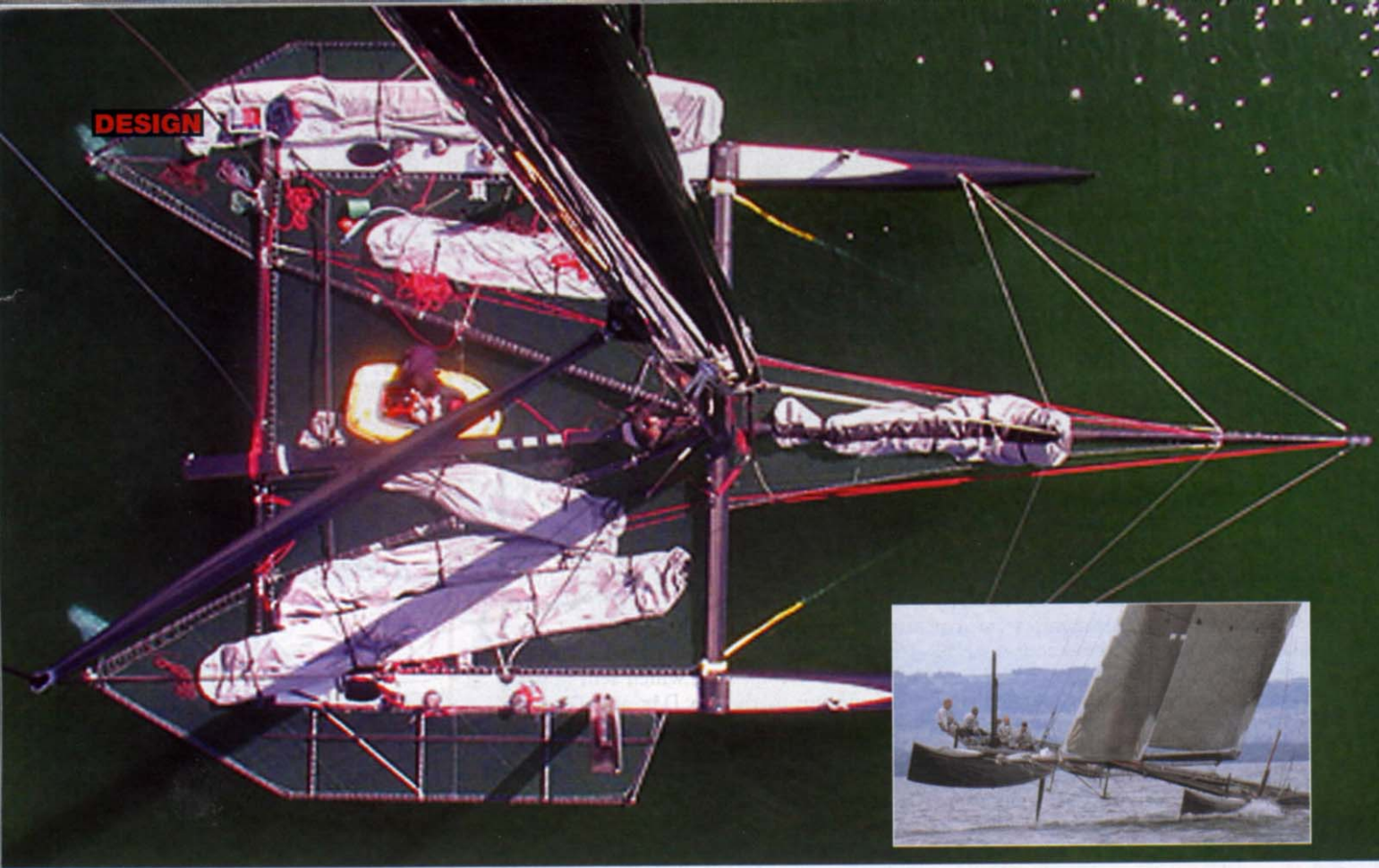


PHILIPPE SCHILLER

Alinghi

birth of a crazy boat

Increasing the 'flight envelope'

When first asked to propose a new multihull for Ernesto Bertarelli, with the Bol d'Or as the target, the first concern of co-designer Jo Richards and myself was how to resolve the wind equation of Lake Leman, where typical winds range around 360 degrees and from 0 to 30 knots...

Our first given was the fact that the best existing boats are now too specialised, the catamarans being fastest in very light air and the trimarans, originally developed from the old Formula 40s, dominant in a breeze. The task: to be able to beat either in their favoured condition.

The concept of the 'drive-train'

We worked first on the 'engine' in close collaboration with Patrick Mazuay, designer at North Sails, using Flow-Membrain, and Alessandro Castelli, using the sail optimisation program SailOpt. The Lake Class box rule limits overall height (24.5m) and length (19.6m), but not sail area.

Traditionally, perhaps out of habit, we would first design the platform, then the rig, then the sails. Here we reversed the process, first setting out the sailplan, without considering rig, beams or hulls at all. We focused on deciding the best 'powerplant' for our racetrack: the Leman lake.

Thus we chose a rig with one extra foresail (four in place of three), a 'smaller' mainsail and progressively overlapping foresails. Previously we thought we couldn't have overlaps with a rotating mast on a multihull, as the diamonds foul the genoa leach. But now we chose our ideal 'small tube' with no consideration of making it stand up.

What kind of platform?

In parallel, we ran computer tests between optimum tri and cat platforms, fitting each with our new specific 'engine' and racing them on a virtual lake.

The result was to open new doors to us. First, in light air, the difference in wetted area favours the tri – but only if it is sailing on the central hull only, which is practically unachievable. As it heels, the tri goes through an increase in wetted surface until flying on the leeward hull.

Meantime, the wetted area of the cat only decreases with heeling (figure 1). This, combined with the cat's weight advantage of 400kg (about 33 per cent – our weight targets were 1,200kg for the cat and 1,600kg for the tri) means the tri has no chance of being faster in light airs.

But how to compensate for the cat's lack of righting moment in a breeze? Ballast and racks, of course – old solutions but good ones. With 320 litres of water in the windward hull and six crew on racks, we achieve the same righting moment as the tri, with one huge advantage: this extra weight is moveable. Moreover, the cat flies on one hull at 3.5 degrees of heel where the tri needs at least 10 degrees to lift the centre hull.

At the beauty contest for Ernesto's new commission we thus opted for a cat, while our rivals Van Peteghem & Lauriot-Prévost proposed a cute trimaran and Gino Morelli, a mad but impressive cat with a double rig, as on Pete Goss's giant machine.

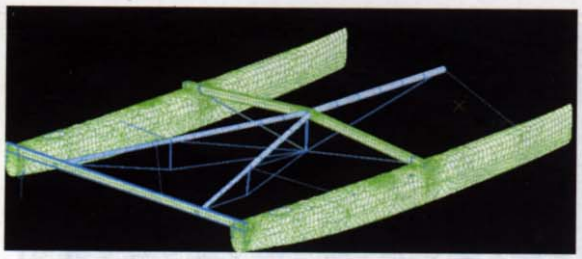
Jo and I received the order on 20 November 1999, meaning we now had six months to design and build this complex monster.

The boat 'is' the structure

These boats are now so complex, and the loads so high, that structural aspects take on a particularly high importance: imagine that on such a 1.2 ton boat you can reach 23.7 tons of mast compression – levels seen on an IACC design weighing over 24 tons. Also, one cable in the substructure is sized at 56 tons – it is amazing that such light boats can produce such enormous loads.

The mast

A designer normally decides the mast chord because 'it seems to be alright like this', and then we pass the task to the structural engineers. We forget that by proceeding in this way mast-column stiffness becomes closely dependent on the chosen combination of scantling and shape. We elected to leave Giovanni Belgrano and Luke McEwen, from SP Technologies, completely free in the choice of mast chord length, and awaited the lightest cocktail for our predetermined stiffness.



Far left: the 'below-deck' cable and beam truss structure is clearly visible in these two pictures, tying in the torsional loads that cause conventional cats to twist under sailing loads. *Left*: an FEA grid of the new boat. Within four weeks of launching *Alinghi* won this year's breezy Bol d'Or by some 17 minutes...

The platform

Particular attention was focused on the detailed engineering, because no metal chainplates or turnbuckles were used. The PBO rigging was all attached to the structure by lacing, exactly like the bamboo sky-scraper-scaffoldings of Hong Kong: very light, but needing great care to assemble.

Safety levels

We have talked about a 'flight envelope', as used in aircraft terminology, but this is now also true in our case. Consequently the *Alinghi* crew carries a User Manual on board, defining the acceptable range for each element of the boat: a maximum speed for the daggerboards, how to fix an emergency sheet safely, and so on.

Appendages

Analysing the various dynamic inputs into the boat upwind, and playing with our different foresail combinations, we encountered some difficulties with the displacement of the centre of effort. Thus, in moving from the G3 Solent to the G0 maxi genoa, the jib tack is moved forward by some five metres.

Working with Jo Richards and aerodynamicist Remi Laval-Jeantet, we decided upon a strange but optimal configuration with enormous rudder blades, small daggerboards but with a very high-aspect ratio – and inclining foils to provide lift, plus small canards set well forward. The large rudders are welcome anyway for better control in the transition between upwind and downwind sailing, while bearing away – always scary in such a boat.

Conclusion

After six months of designing and building our team is completely exhausted, but deeply happy to see the superbly refined product we have jointly achieved. The boat is unbelievably fast and extremely light, flying a hull in just four knots of wind. Its sailing performance is also very 'healthy' in behavioural terms, as much as we can talk about healthy behaviour in a 1,350kg boat with almost 300sq m of upwind sail. 'Crazy boats,' as Jo Richards mutters...

Sebastien Schmidt

ALINGHI – Structural design

The platform structure and rig of *Alinghi* were heavily influenced by the overlapping headsails sailplan, and a decision was taken early on to accept significant structural difficulties and risk to achieve the highest power-to-weight ratio.

The unusual 'star-shaped' configuration is a development of the space-frame structure of the earlier Lake Leman catamaran *Ylliam* (originally *Khamsin*). *Ylliam* was designed by Jo Richards and engineered by SP Technologies, and in four years has twice been the winner of the Bol d'Or. It was the first boat sporting a full carbon truss/tie rod structure on the centreline, looking somewhat like one side of a mast. This takes the place of a trimaran's main hull, to carry the very high fore-and-aft loads generated by the forestay, mast and mainsheet, but with only a fraction of the weight and drag of the trimaran's extra hull. *Ylliam* was some 600kg lighter than the lightest trimarans on the lake when she was launched.

On *Alinghi* the concept was taken an important step further. *Ylliam*'s aft longitudinal spar, which carries the mainsheet loads, was divided into two separate members, meeting at the mast step and spaced about 4m apart at the stern. Thus a 'Y' shape is formed by the two aft spars and the bowsprit. This completely solves the Achilles' heel of catamarans, which is torsional deformation of the platform. By careful optimisation of the aft diagonal tubes and their associated tie-rods underneath, platform twist was reduced to a third of that seen with the 1996 layout of *Ylliam*.

Alinghi's windward hull trims down by less than one degree compared to the leeward hull at maximum load. Thus the windward hull lifts out parallel to the water, getting rid of its drag earlier. The impulse from a gust or change of sail trim is also transmitted directly into forward thrust, as less energy is wasted in distorting the hull platform.

A consequence of the stiffer platform is that acceleration and dynamic shock loading are increased. Obsessive weight saving is the best way to reduce forces under these loading conditions, and it also means less drag. Attention to detail kept the overall weight down to 1,350kg ready to sail, with the hull shells weighing in at just 114kg each. The boom was under 25kg, compared with 60kg on previous designs.

Finite element analysis and a specially written truss-analysis program were used to calculate the loads on every structural member and optimise their stretch behaviour under all conceivable loading conditions. As some of these loads reach 40 tons, it is important they are known accurately, so nothing is under-strength or overweight.

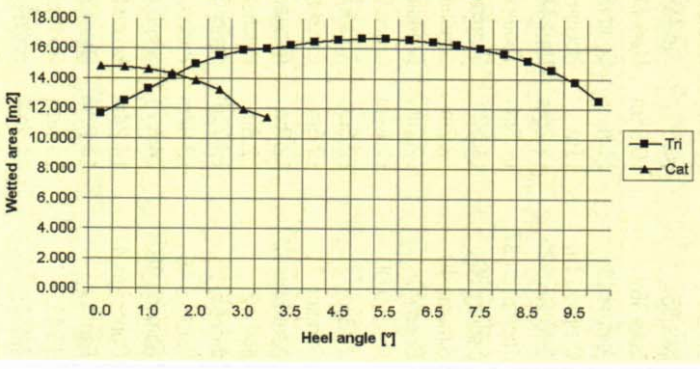
Alinghi also benefited greatly from the developments in materials, construction and engineering technology accessible with a high budget. The most suitable fibre stiffness was chosen for each area depending on whether stiffness or strength was the critical factor, with no cost compromise.

Significant aerodynamic gains were made with the mast compared to standard solutions. A much finer thickness-to-chord ratio section was used, requiring less rotation to fair into the mainsail, cutting down on drag. The overlapping headsails meant the diamond layout for the rigging, so successful on *Ylliam*, could not be used. The current layout, involving a lower shroud and free-swinging diamonds is very demanding on the sailors for adjustment but has less windage and weight, and most importantly allows the headsails to be sheeted very close to the mast. Time constraints were the limiting factor on the rig design, and further development is planned in this area to extract the full potential.

We would like to think the structural layout used on *Alinghi* is not just for a 'crazy boat', for the Bol d'Or, but a similar concept would outperform the current state-of-the-art 60ft grand prix trimarans. ❑

Luke McEwen, SP Technologies

Figure 1. Wetted area comparison between tri and cat while heeling



ALINGHI

Hull length	12.5m
Overall length	19.6m
Mast height	24.5m
Sailing weight	1,350kg
Mainsail	124m²
Mast	14m²
Solent	42m²
Medium genoa	95m²
Maxi genoa	155m²
Gennaker	222m²
Design	Jo Richards & Sebastien Schmidt
Aero/hydrodynamics	Rémi Laval-Jeantet
Structural engineering	Giovanni Belgrano & Luke McEwen, SP Technologies
Build	Decision SA shipyard, Morges
Mast	Espace Composite, France
Rigging	Future Fibres
Carbon tubes	Compotech