Guillaume Verdier, Vincent Lauriot Prévost(VPLP), specialists in Open 60's mono and multihulls look together at a new IMOCA open 60.

Image : Guillaume Verdier

Monohulls Open 60s have been developed under the IMOCA rule (International Monohull Open Classes Association), recognised as an international class by the ISAF in 2001. It was created twelve years ago after the edition of the first Vendée Globe by sailors. This rule was established in the way of safety but remains largely open to architectural design. The rule slowly evolves according to the various experiences, incidents and accidents encountered by the sailors (capsizes, dismasting, structural failures). At first the boats used to be mainly focused on the Single handed races (Around Alone and Vendée-Globe, Rhum) pushing the boats to be designed for the main purpose of downwind sailing, but they now tend to evolve toward crewed race (EDS, Rubicon, Calais Round Britain). We are now placing emphasis on the versatility, and the ability to offer high performances on all points of sail.

We find particularly important, considering the program of such boats, to take a step back on the actual rule, and think about what might go wrong in terms of strength, safety and risk analysis.
We shall try here to develop our vision of a new boat both by looking at the rule implication as well as mixing our mutual IMOCA-monohull and ORMA-multihull experience.

The IMOCA rule is mainly governed by one single aspect : The Safety at sea. It comprises

- Geometric and structural parameters
- Minimum Stability Standards

Basically, for what concerns the geometric and structural parameters, the boat has to fit within:
LOA = 18.28m
Max draft = 4.5 m
Unsinkable
5 watertight bulkheads regularly spaced + crash box
max bow sprit or overboard extension = 1.828m

The stability standards are those really governing the hull dimensions.

The 10 degree rule
The Boat shall not heel by more than 10 degrees in its worth configuration case. Practically, she is under test without sails, the keel being canted at its maximum angle, the water ballast's being filled one after the other one. The logic pushes us to design the boat so that you cant the keel until you reach the 10° limit with empty water ballast. You thus have a full righting moment capability relative to the 10° rule with the keel alone. However further power can be gained by adding water ballast's located in such a way that they don't interfere with the rule. They will bring us the required extra power needed both for upwind and downwind configuration, as well as the required inertia to go through waves and maintain the bow down in upwind sailing configurations.

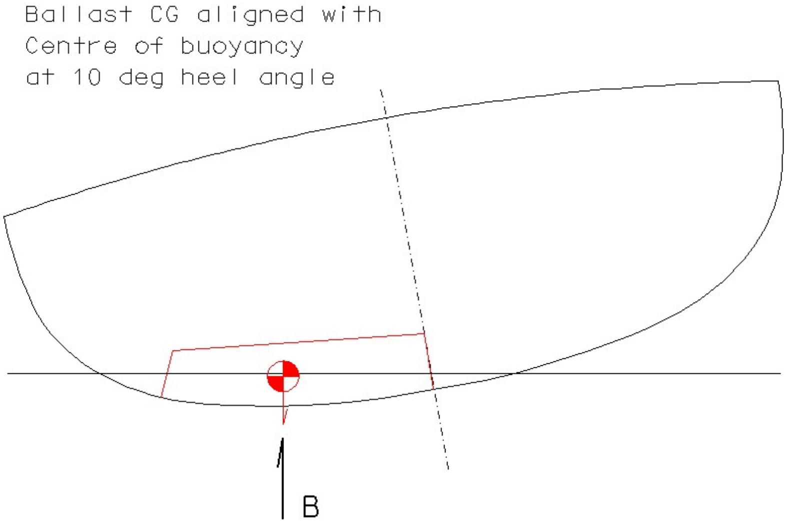

DIAGRAM BOAT HEELED 10 DEG

This 10 deg rule tends to push toward extremely wide U-shaped, thus powerful hulls

The 127.5 degree rule (angle of vanishing stability) and the 5 to 1 ratio for positive stability

This rule stipulates that the boat in a virtual configuration (no sails, no water ballast and the keel in the centre-line axis) shall capsize at a minimum angle of 127.5 degrees. It does not mean that she will really capsize at 127.5 deg, but it is a practical configuration allowing any boats to have their stability checked in an easy 90° test.

90 deg test of Groupe Finot's design-VMI in Les Sables d'Olonnes

This test attests of the real Centre of Gravity position, and a full stability curve is then re-calculated using a stability software. The ratio of positive stability (5 times more area above curve than below) is a representation of the energy needed for the boat to be capsized.

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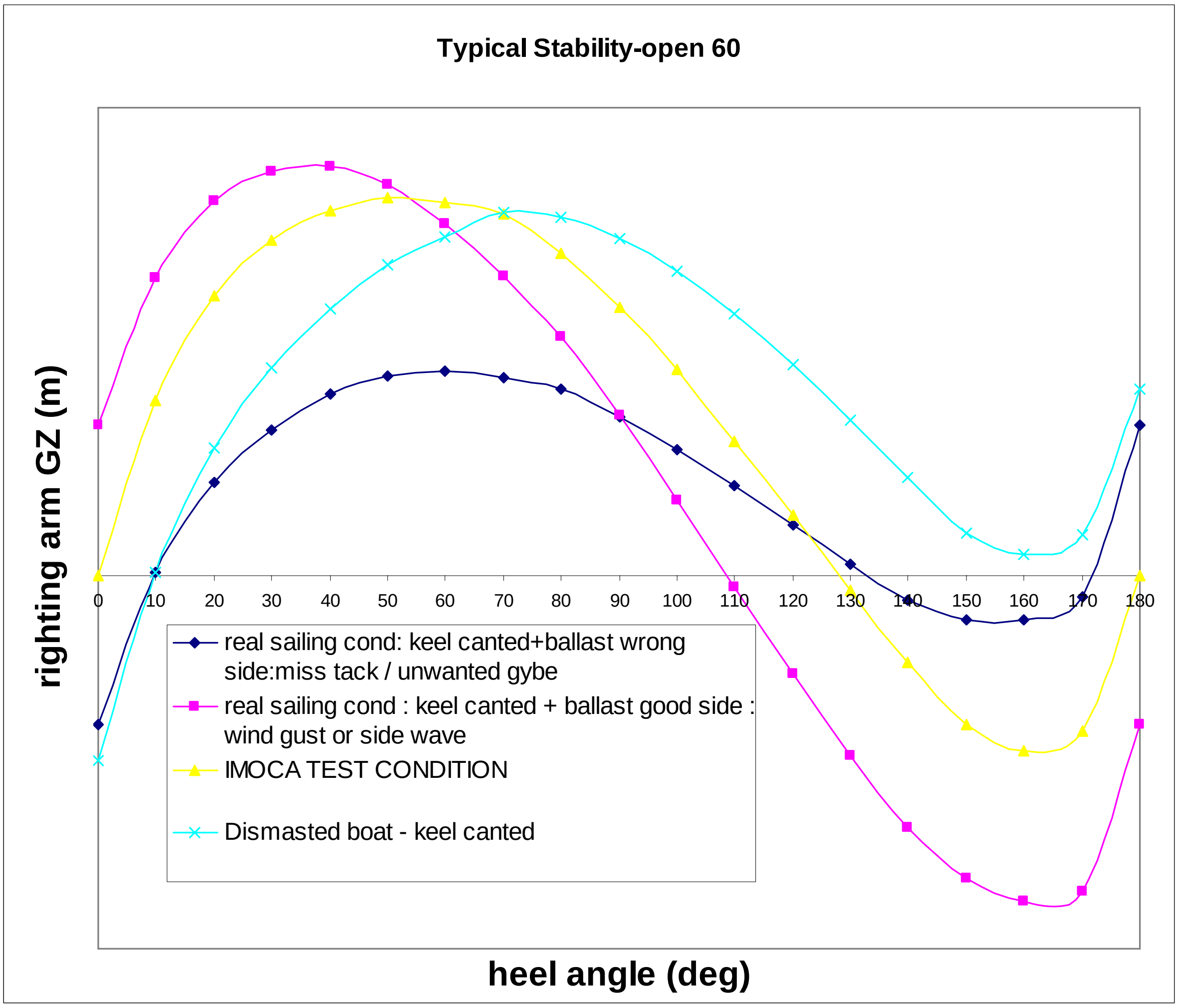


Typical Open 60 IMOCA stability

We find fundamental to take a step outside the rule at this stage and to check for the real stability curve of the boat sailing with wet sails up, fully loaded, keel canted and full water ballast. The dynamic stability of the loaded boat is not part of the rule, but is largely analysed in the office. It is obvious that a boat filled with water with a keel canted at 40 degrees and surfing between 25 to 30 knots down the waves has a huge energy with a poor dynamic stability. We find that small hard chines improve a lot this dynamic stability. We all have experienced the poor dynamic stability of a Laser sailing downwind due to its round bilge. We also see that in bad sailing condition (even sailing slowly) it is preferable that the sailor does not cant the keel at its maximum since the real vanishing stability in case of a huge side wave or gust is low.

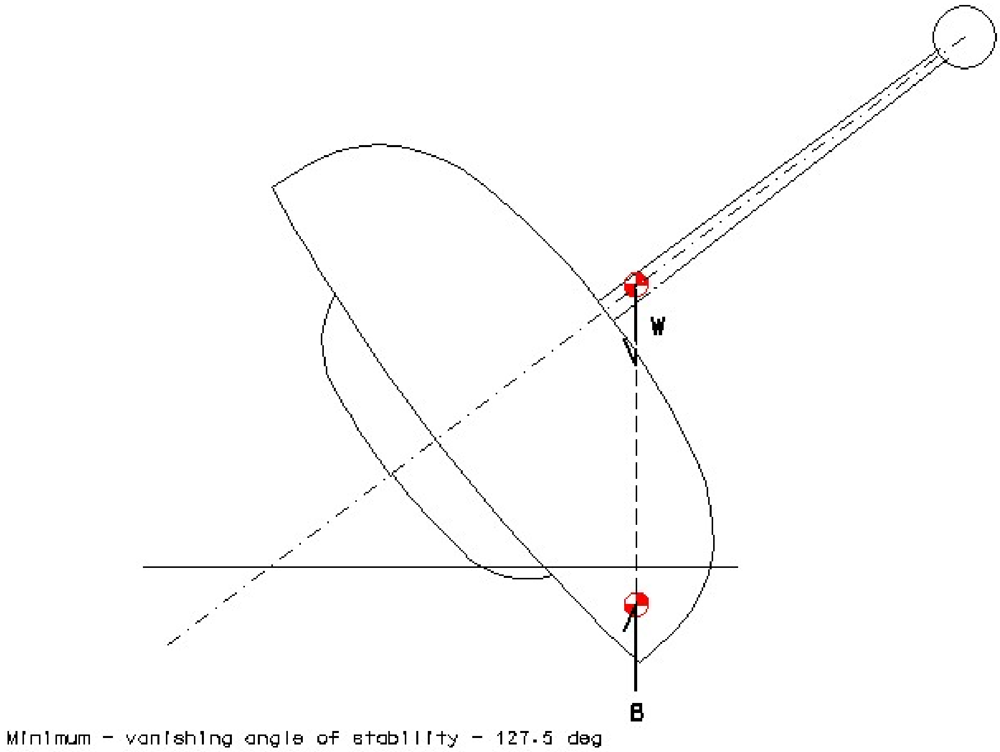


DIAGRAM BOAT HEELED 127.5 DEG

This 127.5 deg rule is important since it counter acts the 10 degree one by the need of higher freeboard and larger deck curvature in case of wide hulls. However excess in deck curvature in the sheer-line region is not always convenient for safe deck manoeuvres, and deck plans, mainly for solo sailing configurations.

The upwind capability

Upwind performance is essential. Even though it only represents 15% of a round the world journey it is essential for being well positioned at the right time in order to catch new meteorological systems. Moreover these boats have to perform for other race programs than a round the world (“The Transat” for instance).

Three main parameters govern the upwind performance:

- The righting moment
- The global balance under power
- The hull shape

The righting moment

Large righting moments induce a large heeling force, thus an important driving force. Relatively U-shaped boats, provided that they heel enough to release their wetted area, provide for light boats the required power. The chine configuration also helps significantly for extra gain in righting moment at equal width.

The Balance

Experience and 3D balance calculations show that the key to perform well upwind is the helm balance. The trick is to maintain this balance for various reef and sail configurations. We thus privilege high aspect ratio sails with a shorter bordure. It leads us to a mast step located quite aft on the boat. The forestay tension is essential to help the fore sails to be well shaped. Moving the main forestay slightly aft of the bow allows higher forestay tension thus diminishing the sag. This comes from our multihull experience. It also makes a higher aspect ratio foresail. This way the rig significantly improves effectiveness by increasing a global lift to drag ratio.

The canted keel induces a serious unbalance. Its drag makes the boat weather helm and can partly be compensated by an asymmetric leeward daggerboard drag. The asymmetric daggerboard should ideally be located quite Aft. to compensate for the loss of side force due to the canted keel. On previous generation boats the asymmetric daggerboards were located much forward as they are today. It had the advantage to guide the nose of the boat though waves but the huge disadvantage to create weather helm boats not capable to fully use the main sail power. The forestay was slacker, and its foresails had poor upwind performance.

Even though we try to make the keel surface as little as possible to privilegiate the efficient vertical daggerboard, we do not consider the fin as a simple “bulb carrier”. When canted, its contribution to the side force ranges between 30 to 40% of its global surface, and the keel profiles have to be well adapted.

The hull shape

The heeled boat has to have very smooth waterline entries at the bow with minimum pressure variation and deformation of the water stream. The problem of wide hulls is mainly due to off-centred heeled waterlines making a reduced angle of attack on the fin keel (less effective). The width of the boat is thus a question of compromise.

We also pay much attention to the water entries relative to bow waves, trying to ease the boat when facing each wave in order to limit large longitudinal decelerations. Finally the slamming, directly dependant on the hull cross sections in the forward part of the boat makes the sailing very exhausting both for the man and the structure (more than 10 G can be observed at mast head).

The reaching performance

As we bear away, the lateral righting moment is reinforced by the longitudinal one allowing more power. Again a fast boat shall be the one capable to use this power.
Extra driving force produces a pitching moment which is counter balanced both by the dynamic lifted nose, together with extra water ballast near the aft.

This problem is obvious on multihulls which have to counter-act nose diving by having hull shapes such as the new Yves Parlier's Cat or the actual trimarans which are lifting their bows by the way of foils.
On monohulls, the lift is partly provided by the hull section shape. Many believe that a large amount of rocker in the stern region will help lifting the nose up. It actually does, but this downward suction of the stern has to be paid in terms of extra drag...

The weight of the boat is a predominant factor for downwind performance, both in terms of drag as for steering ease. The helmsman or "clever autopilots" have to be able to play easily with the waves to gain speed.

As in multihulls, daggerboards are raked since when lifted up, going off the wind, their lateral centre of effort moves forward, preserving a good balance of the boat. This balance optimisation is essential for the auto-pilots work, thus minimising energy. The range of fuel used over a Vendée period can vary between 250 to 500 litres...

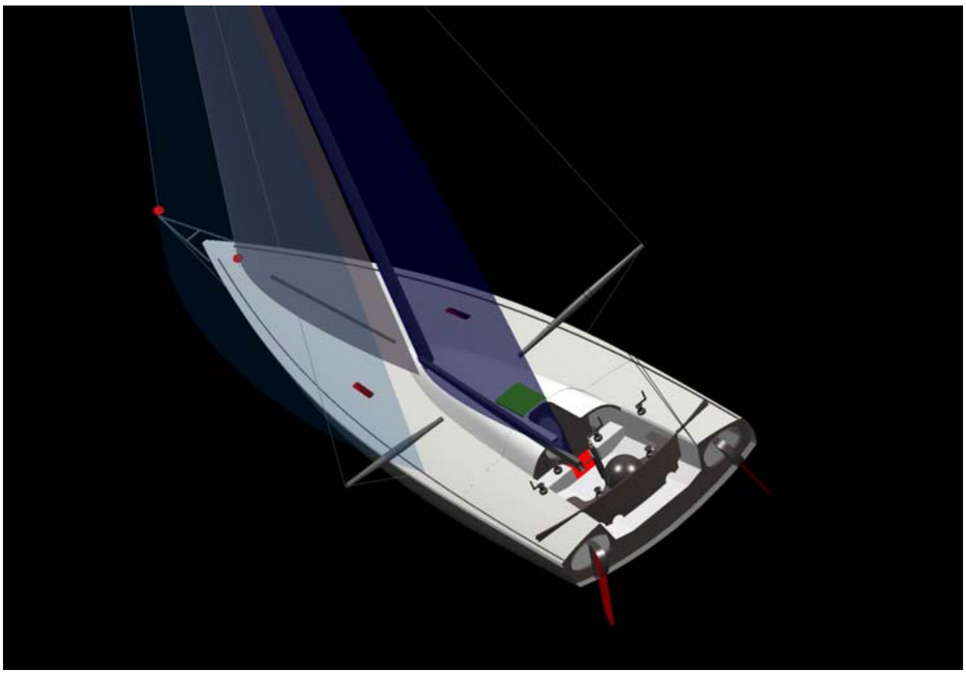
The rig located quite aft on the boat together with some rake provides a better weight distribution on the boat as well as allowing better fore sail arrangements with large gennakers and good sheeting angle. The reduced boom length is more easily sheeted in for the required leech tension. It also gives a bit of slope to the gennaker luff thus creating an upward lift component in the bow region.

The manoeuvres

Such boats have to remain simple and light to ease the sailor's life.
The complexity of mechanical systems makes it risky in terms of reliability for a single man over a 100 days period. Too many mechanical systems require permanent attention for a solo sailor who has to fine-tune it instead of concentrating on the chart table. Already the classic boats have two daggerboards, one canting keel, different water ballasts, plus sometimes a rotating mast on top of the usual manoeuvres.

We also try to have the deck layouts easily compatible and well adapted for solo and crewed races.
The protection of the sailor from wind and waves comes trough a large intermediate protected zone in between the open deck and the interior where the skipper can either work or rest.

Lifting rudders such as the ones developed on PRB and VMI (together with Pascal Conq at Groupe Finot's office) are essential. The probability to break a classic rudder stock due to floating objects is too high. In any case the problem is complex since an accidental rudder release can also be catastrophic.



Images : Guillaume Verdier

The structure

The structure (as the rest of the platform) is entirely modelled with a parametric system, capable to instantaneously calculate the weight of the boat, its centre of gravity, as well as providing the support for ply-to-ply finite element analysis.
The parametric tool allows for any change, thus allowing quick optimisation and iterations.
The technology of such boats allow to play with any type of material. Amongst the carbon qualities, we either use stiff high modulus fibres (less strong) or very strong carbon fibers with a lower rigidity, usually used where compression is critical. For instance on a appendages, both fibre qualities are used.

Rigidity is a key factor to these boat which require a stiff forestay configuration, and a stiff keel system attachment.
The weak point is always near by the cockpit zone creating a sudden break of inertia. We play with fibre orientation and unidirectional fibre concentration to contour these open zones. A regular framing will minimise the loss of rigidity together with providing a crack stopper in case of accident.

The main loads: mast compression, longitudinal and lateral keel efforts, shroud tension, daggerboards, are all concentrated in a close vicinity, allowing a nice weight optimisation and a refined finite element mesh of this area.

In the bow region, we have always believed in the advantage of limited but strong area capable to resist slamming. The seven open 60s which I worked on together with Pascal Conq had this particularity which became gradually optimised. If you compare the weight of a sandwich panel with thick skins, core density around 140 kg/m3 plus the core glue films, you end up with heavier panels per square meter as the extra thin single skin ones (about 5 mm thick) associated to thin ribs to stiffen it.

In conclusion we try to improve the ease of handling of these boats which have to have the ability to be high performer on all points of sail. It should come from a good balance of hydrodynamic and aerodynamic forces privileging high aspect ratio, a hull shape dynamically stable with fine water entries but soon capable to provide lift, a reliable and sound structural configuration, and finally an easy and protected cockpit.

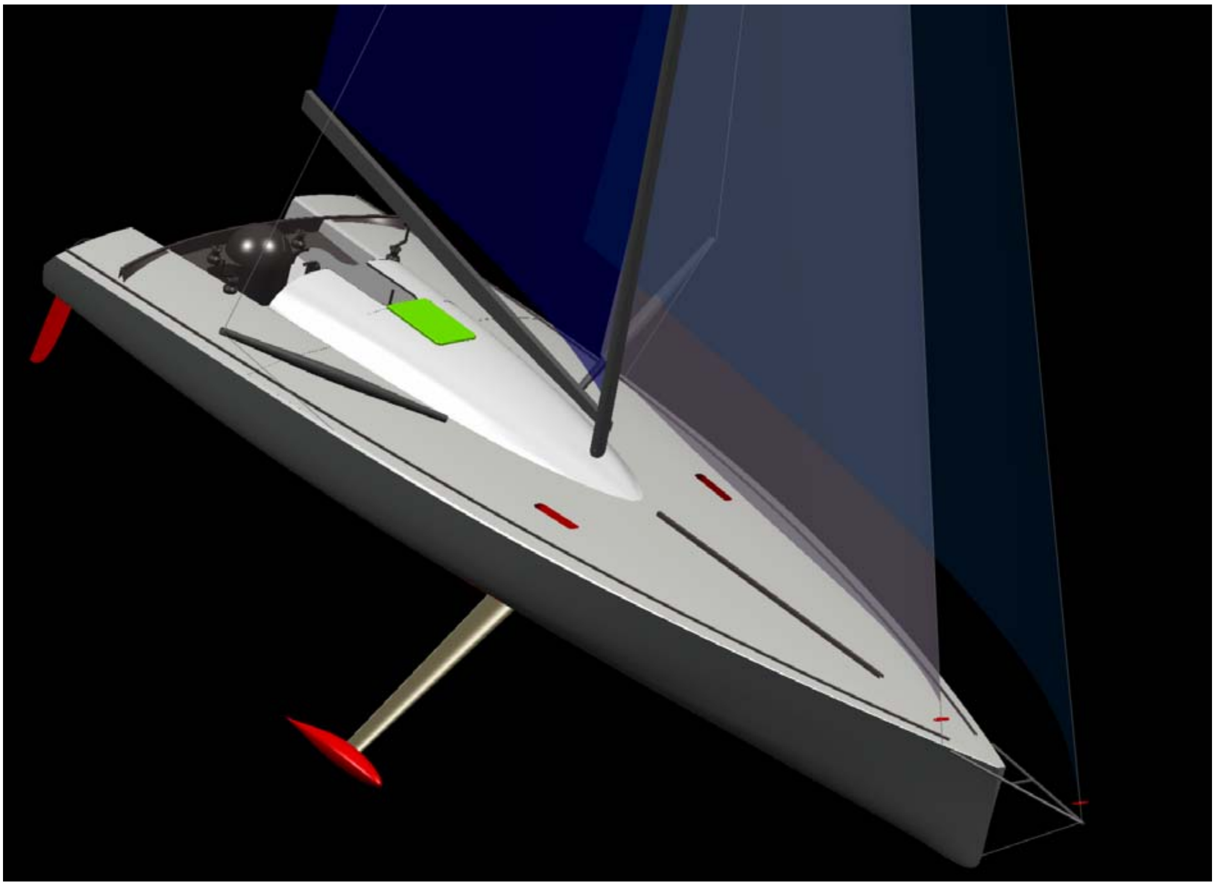


Image: Guillaume Verdier

Guillaume Verdier has been working at Groupe Finot on seven open 60, still being in charge together with Pascal Conq of PRB (V.Riou), VMI (S.Josse), an THEMENOS (D.Wavre). He also is co-architect (together with Romaric Neyhousser and Loic Goepfert) of Yves Parlier recent stepped hull Médiatis-Région-Aquitaine - hydraplaneur.

Site: http://www.naval-architect.net

Vincent Lauriot-Prévost from MVP-VLP office has designed most of the recent successful modern multihulls - ORMA generation.

Site: http://www.mvpvlp.com