SAILOR'S PAGE

Foiler for AC-2021

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Background

The idea of stabilising a monohull with canted hydrofoils is more than 100 years old. In 1903 Fredrik Ljungström (most famous among sailors for his furling, airfoil rig) patented hydrofoils for stabilising a monohull yacht. The successful Monitor from 1956 was also a monohull with high-aspect ladder foils on both sides. Some 20 years ago the late Sven-Olof Ridder was working on a concept with an inverted T-foil on a beam on the leeward side to stabilize light-displacement monohulls. When the modified L-foils were successfully used in AC-2012, some of us realized that hydrofoils for a catamaran could be designed much better. William Sunnucks and team installed T-foils, canted 20°, on the outer gunwales on his M-20/Vampire, so the active foil-system on the leeward hull worked as on a foiling Moth. On the water they demonstrated that this worked much better than other foiling catamarans of the same size.

The Defender's and Challenger of Record's concept AC-75 for the America's Cup 2021

The concept-boat, released Nov. 20, 2017, has improved over previous AC-foilers on one point: it has canted T-foils outside the gunwale. This provides for more righting moment, hydrodynamic, and structural efficiency than L-foils inside the gunwale.

But, they rely on ballast in the foils for stability in the harbour and for self-righting! The foils shall be controlled by powerful hydraulics. Standard hydraulic cylinders for the 2 swing-keels will weigh half a ton or so plus hydraulic pumps, valves and other gear. Or maybe they will build the hydraulic cylinders in high-modulus carbon?

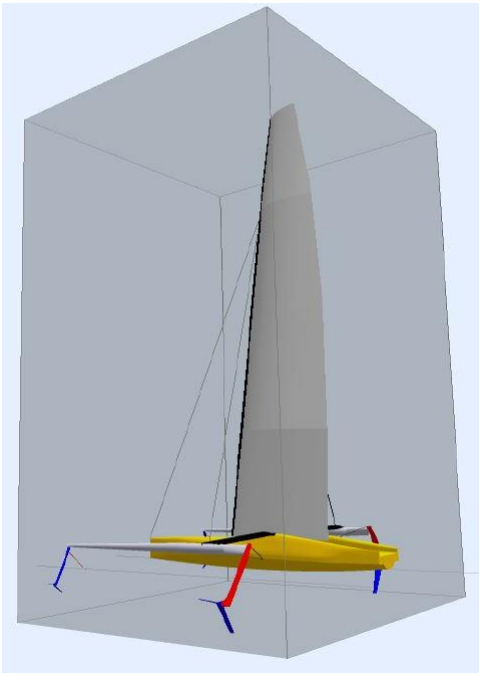
Two reasons for this type of boat are fast tacking and gybing. I estimate the time for lifting a 1.5 ton keel out of water from the sailing position to be half a minute by 4 very powerful grinders. And that is just lifting the 1.5 ton ballast. When lowering the foil, that is lifting the boat, the grinders have to lift the remaining 6 ton of the flying weight! But they will certainly store energy some way so they can tack faster. This is assuming they don't tack too frequently. And the system for that adds more weight.

And of course, the ballast itself contributes to the total weight. If the ballast is to be efficient, it has to be placed in the lower part of the keels, that is, in the water. With 1.5 tonnes in one T-foil they will have to compromise with the hydrodynamic efficiency to obtain a low C.G. Or will they put bulbs on the foils? That will probably be the best choice, but there will be higher drag than without ballast.

Another quite serious issue for the proposed foiler is that the rudder/stabilizer T-foil will be at the hull centreline, while the lifting main-foil is 7.5 m or so outside that centre-line. If the main-foil is controlled, so it flies on constant submergence, a sudden increase in heel, e.g. because of a gust, will cause the hull and hence-the rudder-foil to rise, and in worst case leave the water, so stability and control are lost. Or you will have to use a very deep rudder which will increase the drag.

Configurations with main foils far out on both sides and a central rudder-foil have been successfully used before on e.g. the Hobie Trifoiler and Windrider Rave hydrofoils, but here both the leeward and the windward front-foils are regulated so they keep constant submergence, so the rudder-foil trails safely behind in the water. All successful catamaran-foilers, that retract the windward main-foil, have foils on both rudders, and you can sometimes see the windward rudder-foil leave the water, which works fine, because the leeward rudder-foil is still in the water.

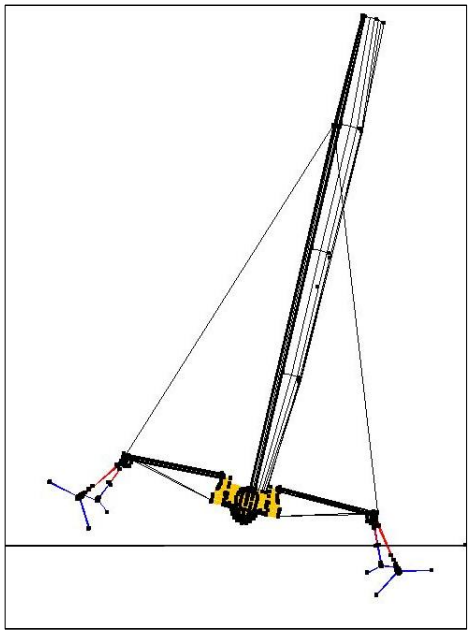
The AC-75 can be righted with the keels, yes. But if you make an ordinary capsize to leeward with the regular sailing configuration, you



need energy (stored or from the grinders) to move the keels, so they can right the boat up. Pretty much as you can do with the unballasted foiler, described below.

An alternative configuration

If the requirements for the new boats are that it shall be possible for the sailing crew to easily right the boat on their own after a capsize, the boats shall be easy to tack or gybe and they shall be faster than non-foiling boats. I suggest this configuration:



This is a monohull foiler with canted T-foils on wide beams. The rear beam is equipped with 40% displacement floats, to provide stability at very low speed. When sailing, the main T-foils are fixed, and in the normal flight-mode the boat is heeled some 10° to 15°, so the windward foil is lifted out of the water. The crew is in the central cockpit when sailing, so no trampolines are required between the hull and the amas.

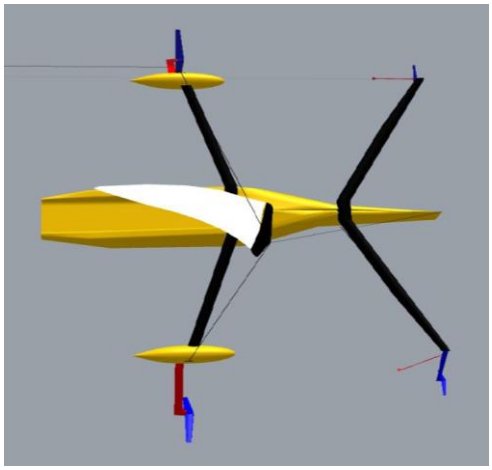
The shroud-base is wide, so a rotating wing-mast with diamond-stays is practical and also allows a light mast. The mast shall have the same volume as one ama.

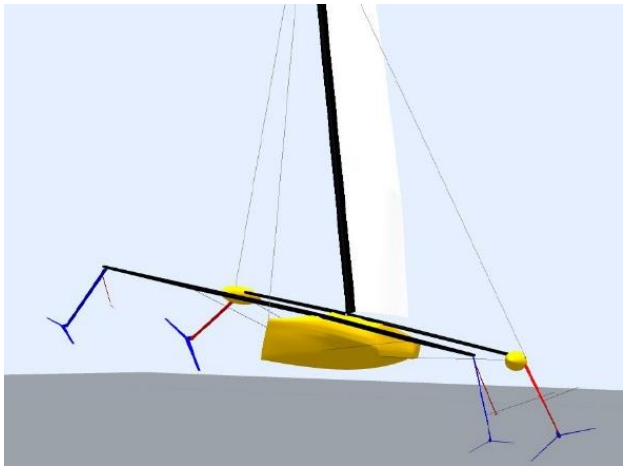
In the pictures the boat has a canard-configuration. The advantage is that the foils can keep submergence in a very stable and simple way: The canard's angle of attack is regulated by a surface-sensor (wand), that keeps the submergence with quite high gain, and then the main-foil trails behind in a very stable manner. By regulating altitude with the smaller foil, the control-forces are smaller than if you control altitude with the main foil, as on most Moth dinghies. The set altitude of the front foil can be adjusted from the cockpit. Eventual flaps on the main-foils are used only for trim. This configuration is used on several human-powered and engine-powered craft, like the Decavitator, my Trampofoil and the Boeing Jetfoil.

The hull is 1m wide in the water-line, but has a cockpit for the crew with 3m beam. The shrouds are adjustable, so the mast can be canted to windward. This can give some increase in speed on a long tack. But for short-tacking the mast may be kept in the central position, which also works quite well.

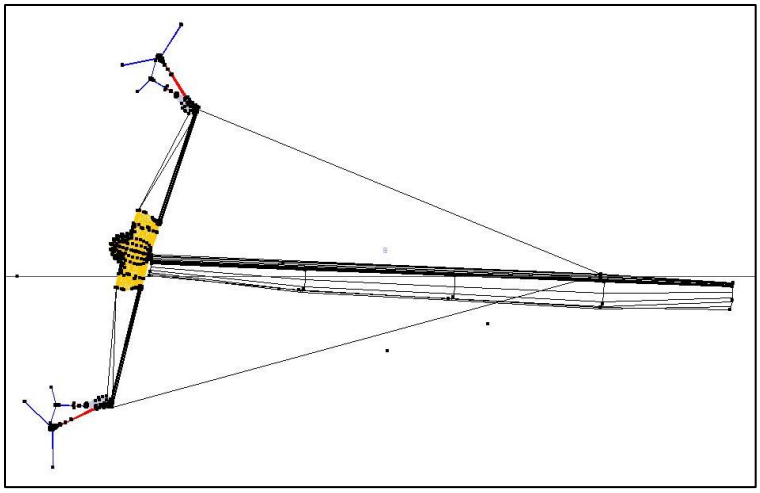
With 5 ton total flying weight including crew and 200 sq.m. sail the boat will have higher dimensionless sail-area/weight ratio than the AC-50. The righting-moment lever /displ.^1/3 is 70 % higher than for the AC-50. The main-hull will fly in 22 knots apparent wind. With low-volume amas, no trampolines and airfoil-section beam the aerodynamic drag will be low. Provided that the sail can be trimmed with optimum twist and camber, this boat has the potential to be faster than the AC-50.

You can do foiling tacks with the foils in their regular position, but when entering the tack you trim the altitude a little higher on the leeward front-foil just before letting the windward foils enter the water.

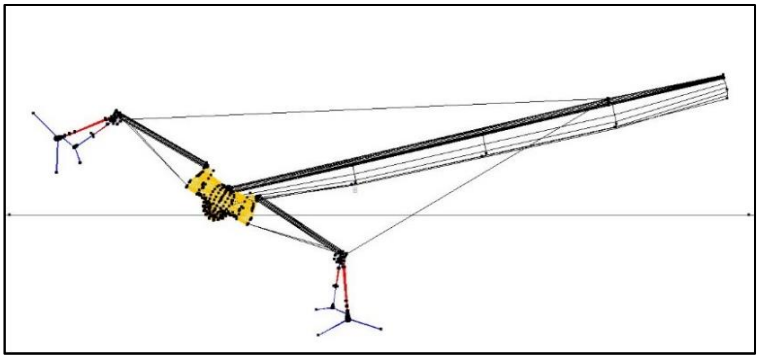




With only 40 % displacement in each ama and about the same in the mast, the stable floating position after a capsize will be on the side, as below.



By adjusting the shrouds with the winch intended for that in the cockpit, the submerged ama is moved, so it lifts the rig



out of the water:

The foils will be so light that the crew can retract them manually. Then the draft is 0.5 m, so the boat can be moored on shallow water. There have also been developed several systems to fold the beams on trimarans. If necessary one of them can be applied.

This proposed boat can sail more efficiently than the AC-75 without any reconfiguring of appendages or movement of ballast in tacks or gybes. The only system for handling the boat besides normal trimming of the sail is the winch for the adjustable shrouds. This is certainly easier than handling the 2 swing-keels of the AC-75.

This was one possible configuration for an efficient and practical course-racing boat and there are certainly others that may work as well or even better.

The new class-rule for America's Cup 2021

It has been announced that there will be a box-rule. But there is a serious risk, that the parameters will be adapted to the concept-boat of November 2017. If there e.g. is a minimum weight, there may not be so much advantage to make more efficient configurations.

The design-element of the Cup would be more interesting if the teams were able to develop more efficient, reliable and less complicated boats than the ballasted twin swing-keel foiler of November 2017.

If the development work in the America's Cup shall be meaningful, the class-rule shall be as open as possible. Such a rule shall only require reasonable safety and practical characteristics.

I suggest something like this:

1) The boat, ready to sail, shall fit inside a box, say 75 x 75 x 110 feet.

2) The onboard sailing crew shall be able to right the boat after a capsize in less than 10 minutes without any outside assistance.

3) If any system for storing energy shall be allowed, the energy of that system must be higher at the finish than before the start.

4) The sailing crew shall be able to haul down the sail(s) in 10 minutes on the water, so the remaining parts of the rig has a maximum projected area less than 500 square-feet.

5) There may also be a rule specifying that the boat shall be able to be dismantled for transportation in some specified time, say 12 hours.