The foil alphabet

This is the English version of a French article, published in October 2014 on the blog "Foilers". This translation would not have been possible without the help of my friend Nicholas Waller, an independent English teacher and translator with a website at http://www.centpourcentanglais.com (traducteur français-anglais et prof d’anglais indépendant).

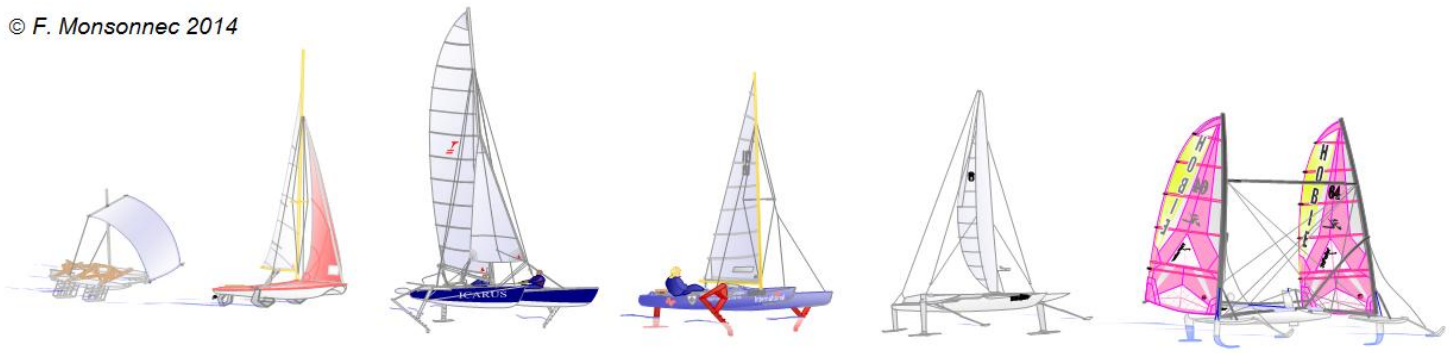
Open your books, no talking.
Repeat after me: C, E, J, L, O, S, T, U, V, Y are the different types of foils that currently exist.
Well done!

In 2008 I wrote an article about the two main families of hydrofoils, “V-foils and T-foils". Since that article, new letters have emerged or come into wider use. It is now time to update the foil alphabet! Especially since it’s always possible for new forms to appear. After a century of development, we are really in the "Age of the Hydrofoil."
You, over there, at the back of the classroom near the radiator, do you want to take off later?
Well, joking aside, I’m playing the professor without being one (or an engineer) and this article certainly contains errors, so all comments are welcome.

For each type of foil, you will find in this article:

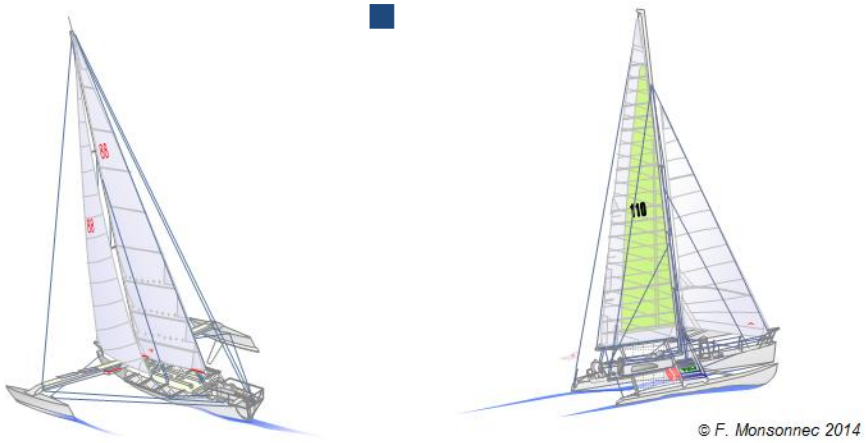
- A little history
- Some examples of boats equipped with that kind of foil (for *hydrofoils*, *foilers* and *foil-assisted multihulls*, see my definitions in the appendices at the end of this article)
- A diagram. I try to show the forces generated: Lift and lateral resistance (resistance to leeway, or lateral plane). I’ve done this for the most logical application (foiler or hydrofoil). For the foilers, I show the extended and retracted position (if retraction is possible). For hydrofoils, I show them in displacement mode and in flight.
- An attempt to explain the operation of lift and lateral plane.
- A list of benefits and disadvantages

It is impossible to cover all the possible configurations and applications, so the list of pros and cons of each type of foil can never be exhaustive. That’s just how it is!



Six hydrofoil boats
Nancy E-foil 1913 – Triplane E-foil 1964 - Icarus V-Foil 1970 - Mayfly V-foil 1971 – Force 8 T-foil 1976 – Trifoiler L-foil 1992

Summary



Two foilers
Paul Ricard V-foil 1979 – Gautier II Y-foil 1981

1 – E-foil!

The term E-foil is a pure invention on my part; in reality it's the ladder foil. I wanted a letter of the alphabet for each type of foil. "E" is the first letter of the word "échelle" (which means ladder in French) and the parallel planes of a ladder foil also look like the bars of a capital E ... kind of. The second explanation works better, because "E for échelle" doesn't hold up in English or Italian.
It seems that the first people to have designed and tested ladder foils were the Meacham brothers. In 1897, they tested a model with five foils. In their patent filed in 1910, they used a controlled T-foil (with a plane which can rotate) surmounted by a second plane. Therefore, this is a ladder foil.

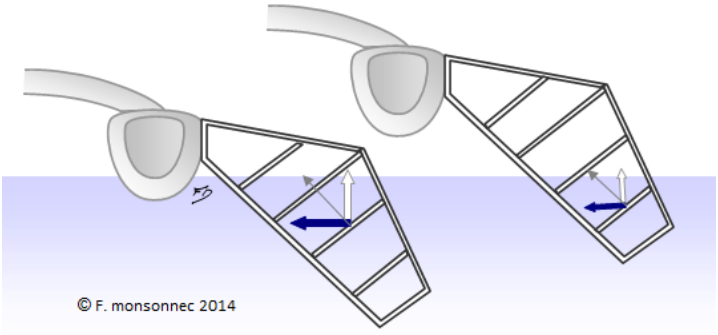
On foilers and foil-assisted multihulls

These foils were not designed for these types of boat, which emerged some years after the hydrofoil boats ("modern hydrofoil boats"). Also, the configurations developed later are more efficient for these types of boat.

On hydrofoils

During the 19th and 20th centuries, this solution was a response to the difficulty of producing thin foils with a high aspect ratio.
► Enrico Forlanini in 1906, Crocco and Ricaldoni in 1907, Peter C. Hewitt in 1907, Alexander Graham Bell and Casey Baldwin in 1913.
Triplane by Roland Tiercelin in 1964 and Williwaw by David Alan Keiper in 1967 used this arrangement and today P28 Gonet & Cie.

E foil - hydrofoil



Lift

The first models had foils arranged in parallel horizontally. Then some prototypes were fitted with inclined foils. Lift is a function of flying height. When we plot the lift curve on a graph, for a ladder foil with horizontal foils, the lift curve has different levels or steps but that's not the case if the foils are inclined.

Lateral resistance

For both the horizontal and inclined ladder foil, the amount of lateral resistance is a function of flying height and the complexity of the structure.

Benefits

- Good strength due to using small parts and structure like a grid.
- The different planes prevent the formation of wing tip vortex, which is the positive side of having nodes at all the junctions!
- E-shaped foils like those of Monitor direct the centre of pressure outwards, hence the use of very short arms, rather than inwards like the V-shaped foils of Hydroptère.

Disadvantages

- Many nodes: high drag
- Difficulty in positioning the various planes perfectly
- Greater risk of picking up seaweed or flotsam

2 - V-foil

Used on foilers and hydrofoils, this kind of foil is rectilinear and inclined most often at 45°. The incidence is rarely variable. The lift is a function of the immersed surface. The V-shape is in fact a combination of two foils. The foil can be twisted to have a variable incidence according to the immersed depth. It is also possible to integrate a trailing edge flap (Cote d'Or, Syz & Co). The first designer to have used this configuration seems to be Robert Row Gilruth, father of the first full-scale “flying” sailing boat.

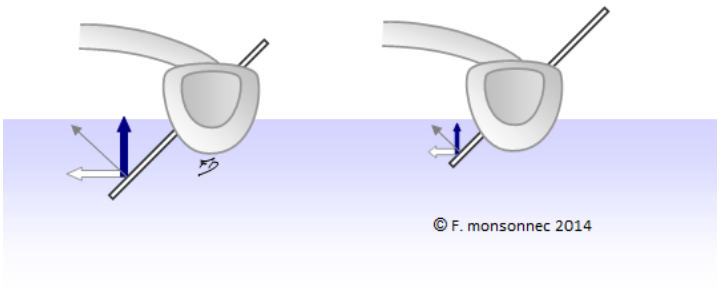
On foilers and foil-assisted multihulls

The lifting power of the foils is smaller than the displacement of the boat, so the foils are immersed most of the time.
► Trimama, Paul Ricard, Ker Cadelac 2

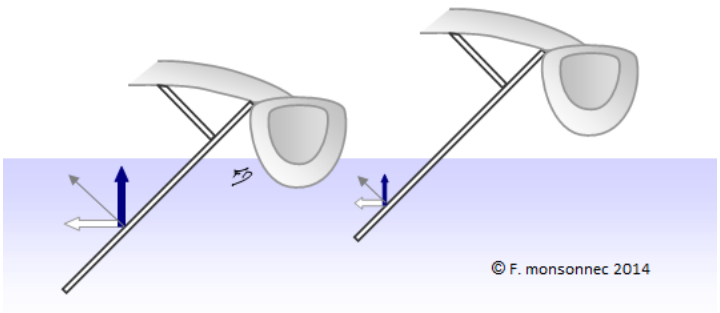
On hydrofoils

The reduction of the wetted surface decreases lift, so this type of arrangement is called "self regulated", even though in reality, self regulation has its limits. The Hydroptère team at one time looked into a rudder foil incidence control using two infrared sensors (see my point of view on this subject in PN 26 and 28 (in French).
► Icarus, Mayfly, Hydroptère

V foil - foiler



V foil - hydrofoil



Lift

Being a function of the projection on the horizontal axis of the immersed surface, it decreases with increased flying height.

Lateral resistance

As with lift, this is a function of projection on an axis, this time the vertical axis and it also decreases with increased flying height.

Benefits

- A tried and tested system
- Foil with a certain amount of self-regulation

Disadvantages

- The centre of lift moves along the hydrofoil with changes in the immersed depth.
- Attaching this kind of foil to a boat designed to fly is not easy, and a support strut is often used.
- On foilers and foil-assisted multihulls, the foil often exits the float near the waterline with a risk of ventilation along the foil.
- They are subject to significant forces and are not always easy to retract.

As with E-shaped foils, the centre of pressure of the foils must pass though the centre of the sail rig, which requires long outrigger arms and also means a loss of balance when sail area is reduced.

■

3 – T-foil

In 1906 the Meacham brothers published an article in which they described the basic principles of a hydrofoil flying on controlled hydrofoils shaped like an inverted letter T. This type of foil was improved in 1950 by Christopher Hook on his boat named Hydrofin (see History of mechanical systems for regulating the incidence of foils on the Foilers blog).

On foilers and foil-assisted multihulls

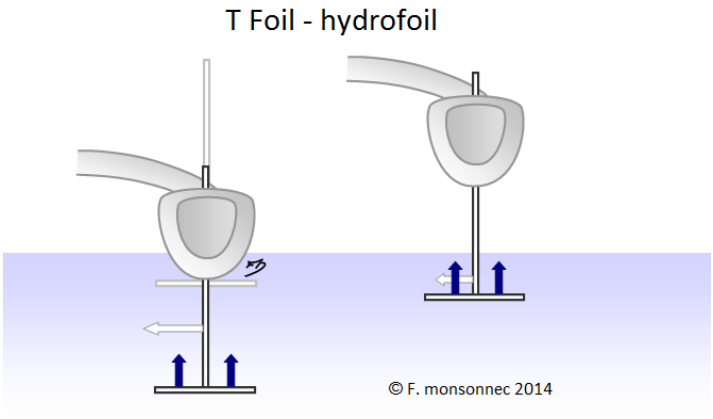
They are rarely used because, unless they are equipped with an automatic control system (which I have never seen on this type of boat), the lift produced by the foils is not self-regulated. Most of the time, the foil surface is low (and therefore so is the lift) and the foil remains immersed all time. Otherwise, the foil could get to the surface and spin out, with all the risks that entails. A V-foil (mounted in a well or case) or more particularly a Y-foil looks like a better solution.

► We / Sebago, F40 Triton, Blue Arrow, VSD 2

On hydrofoils

The above remark is equally valid and even more vital, which is why in this case the T-foils are equipped with a control system in the form of feelers or wands which act on the angle of incidence of the horizontal part, or by movement of a flap.

► Force 8, Phifly, Windrider Rave, Moth hydrofoil, Rich Miller's hydrofoil sailboard (forward foil), AFS 1



Lift

It is related to the surface area and the angle of incidence of the horizontal part. Unlike V-foils on a hydrofoil, the surface area does not vary but the incidence does.

Lateral resistance

This is produced entirely by the surface of the vertical portion, the strut, which decreases with the take-off height.

Benefits

- The centre of lift passes up the axis of the vertical strut, which means a strong structure.
- The hydrofoil is relatively deeply immersed; it is less subject to ventilation and is less affected by the movements of the water surface particles.

Disadvantages

- Need for a control system in the case of a hydrofoil
- Fragility of the control system
- Retraction of the foils may not be obvious
- Drag from the node or joint between the strut and the foil (consider making it a torpedo)

■

4 - Y-foil

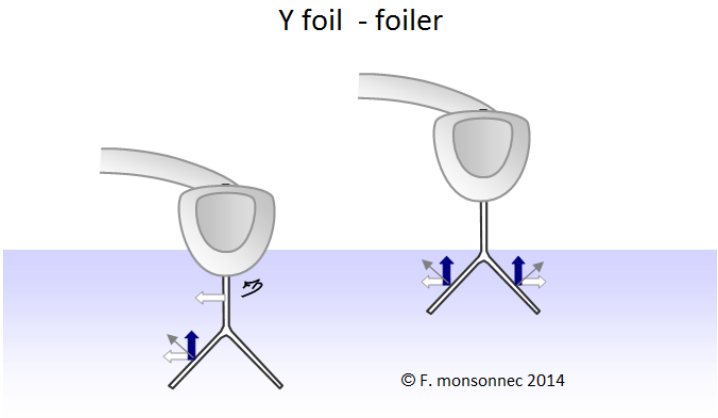
Invented by Sylvestre Langevin, the inverted Y-foil is the "trademark" of his foilers. Others have tried this type of foil, for example Adrian Thompson on the F40 Promocean or the MVP / VLP duo (Marc Van Peteghem & Vincent Lauriot Prévost) on their trimaran Gérard Lambert (but the foils of this boat were designed in conjunction with S Langevin!).

On foilers and foil-assisted multihulls

This is the "core business" of such foils.
► Gautier II, Gautier III, Ker Cadelac, PiR2, Dupon Duran, Promocean, Flash Harry and Groucho Marx

On hydrofoils

Rich Miller’s hydrofoil sailboard (aft foil)



Lift

These hydrofoils self-regulate by reducing their lift as they approach the surface. The Y-shape allows "soft" regulation. That is not the case with T-foils, which can ventilate and stall. In comparison with T-foils, another interesting point is that the increased angle where each part of the foil meets the vertical strut (greater than 90°) tends to limit the interference between the lift from each half foil and the strut which is also subject to leeway. Depending on the surface area and the angle of incidence, this type of foil allows the crew, at a certain speed, to fly the leeward float above the water with the central hull in contact with the water.

Lateral resistance

Lateral plane is made up of the vertical strut plus a proportion of the angled foils (depending on their angle).

Benefits

- Normally totally immersed (for a foiler), less spin out / ventilation
- Forces produced by the "two foils" are balanced on the strut

Disadvantages

- Retraction of Y-foils is difficult
- When the foils parts are close to the surface, more drag compared to a V-foil

■

5 - L-foil (version 1.0)

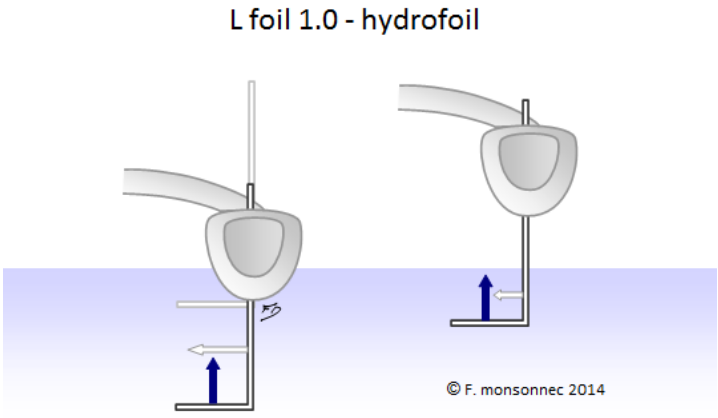
This first version of the L-foil appeared on the first model by Greg Ketterman in 1981 and afterwards on all Trifoilers. This type of foil is an enhancement of the T-foil, as if the foil part had slipped sideways. The modified L-foil becomes more what we call a J-foil.

On foilers and foil-assisted multihulls

Managing the lift generated by this kind of foil requires a control system, so this kind of hydrofoil is not used on foilers or foil-assisted multihulls. Other "letters" like V and C are easier to use.

On hydrofoils

In contrast to T foils, these foils get round the problem of connecting the vertical and horizontal parts. If the connection is a large arc, you lose some lifting surface. If the connection is a node, the drag is higher. The junction between the strut and the foil is a vulnerable area.
► The Trifoilers, Sylphe of Tadeg Normand



Lift

As with the T-foil, each part has its function. The vertical part resists leeway, and the horizontal part provides lift. The junction between the planes may be bigger or smaller. This is a compromise between surface area, resistance and drag.
The surface area does not vary; it’s the angle of incidence which varies, normally by the complete rotation of the foil (both the horizontal and vertical parts).

Lateral resistance

Produced by the vertical portion of the foil, this decreases as the flying height increases.

Benefits

- No connection nodes so less turbulence

Disadvantages

- Bending of the foil due to the fact that the direction of the lift is offset to one side of the vertical part.
- The absence of a node could be considered an advantage, but at the junction between the two planes, the depression value of the vertical part is different to the depression on the horizontal and can generate vortices. The radius of curvature of the foil removes a part of the lift surface. But, according to Greg Ketterman, the effective aspect ratio of the profile would be greater than the aspect ratio of the lift part. The curvature could be an extension of the horizontal portion. However I

think this is valid only if the connection between the vertical and horizontal (or inclined) parts is fairly gradual!

■

6 - U-foil

One might think that the U-foil is two L-foils joined together, but the idea goes back well before the creation of the L-foil! In 1954, Skid, a catamaran designed by Arthur Locke used a foil somewhere between an O and a U. It was an incomplete O or a semi-closed U. In any case, 20 feet long, 12 wide and weighing 710 lb, it flew! Closer to home (at least, closer to my home), Maurice Gahagnon revisited this type of foil on Brest Nautic. This design allows a sturdy foil, easy to attach, but also providing good resistance to leeway.

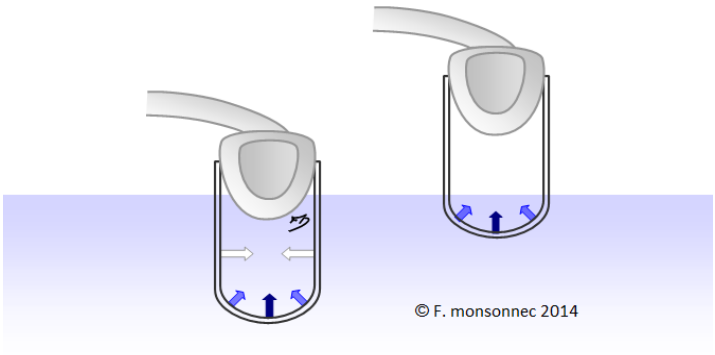
On foilers and foil-assisted multihulls

I've never seen this configuration on this type of boat. The presence of two struts, both generating drag, encourages their use on a flying hydrofoil rather than a foil-stabilised boat.

On hydrofoils

It’s odd that such a small number of designers have tried this system, which is however well suited to amateurs.
► Skid; on the float of the proa The Ugly Ducking designed by the Danish Leif Wagner Smitt in 1980; model boat by Greg Ketterman in 1981 (a U but with some angles!), Brest Nautic; different versions of Loisirs 3000; without forgetting Gurval Lego’s work on the "Curved Foil" on his Dafoilboard. This is an "open U" or "rounded V" and our friend Gurval seems happy with the first tests.

U foil - hydrofoil



Lift

As for the T-foil, the lift surface does not change, and this foil must be fitted with some sort of control.

Lateral resistance

Same observations as for the T-foil; it is related to the immersed depth of the foil

Benefits

- The port and starboard foils may be produced from a single mold (mould)
- The maximum angle of incidence is in the middle of the foil and decreases gradually as one approaches the vertical parts. Near the surface there is no lift and therefore no spin out.
- There are no wingtip problems (vortices).
- High strength

Disadvantages

- Large wetted surface
- It's essential to have a lift control system for the complete foil. A control flap is not possible (unless there's a flat region in the middle of the foil)

■

7 – O-foil

Quite similar to the U-foil, this shape was used by Loic and Gilles Durand on their tripod O PAF. Shaped like an "O" and made of carbon fibre, these O-foils were controlled for depth through sensors attached to the end of the floats.

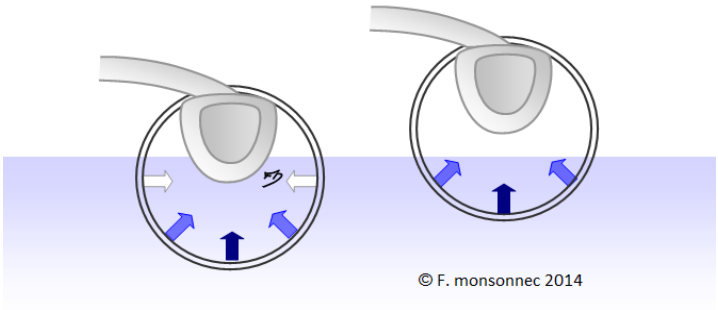
On foilers and foil-assisted multihulls

As with U-foils, they are not used on boats of this type

On hydrofoils

► As noted above, this type of shape was certainly used on O PAF, and on the Hydrocat designed by Patrick Cudmore.

O foil - hydrofoil



Lift

As the O-foil rises in the water, its lift decreases, either through the operation of a control system or because the lift surface decreases. Lift does not decrease in a linear fashion as for V-foils, and this point, I think, makes it necessary to have a mechanical control. You cannot count solely on the reduction in lift surface.
For example, if the foil at rest is immersed down to half the diameter of the circle (so the waterline is at the axis), a take-off of an inch or so will significantly decrease the lateral plane but will only slightly decrease the lift which is more related to the lower part of the circle / foil.

If my analysis is correct, when the waterline reaches a point represented by the intersection of a line passing through the centre of the "O" with a line at 45° relative to the horizontal, thereafter the lift will decrease more quickly than resistance to leeway.

Lateral resistance

See above

Benefits

- According Gilles and Loic Durand, the "O" shape makes it easy to build. The basic shape was obtained on a plaster mold (mould). The foils were then machined on a lathe. Their very sturdy shape made it possible to build thin (9 mm) but rugged foils.

Disadvantages

- Awkward and bulky
- Non-linear decrease of lift force and leeway resistance
- Difficult to retract the foil

■

8 - C-foil

Initially mainly used instead of V-foils on foil-assisted multihulls, the C-foil was proposed by Bernard Smith in 1972 in his patent 3631 828. I do not know if he had the opportunity to try them. In the late 70s, Derek Kelsall made molds for curved foils and used this type of foil on Bits and Pieces, a boat made from pieces of Tornado and tested at Brest in 1980. John Shuttleworth, who worked with Derek, also designed this type of foil.

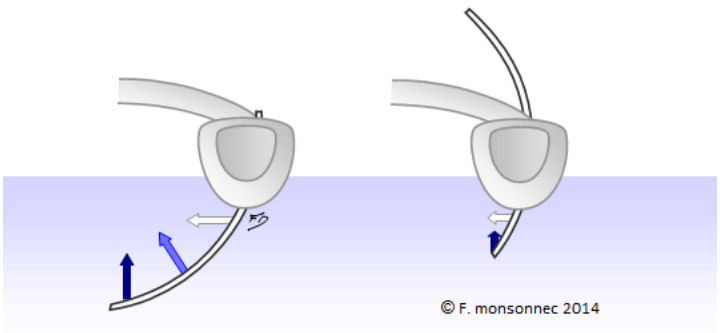
On foilers and foil-assisted multihulls

This is an excellent solution, which has greatly improved the performance of this type of boat, which hitherto were mostly equipped with foils at 45° (V-foils).
► Orma 60', Mod 70, BMW Oracle in the 33rd America's Cup

On hydrofoils

This type of foil does not allow easy control of lift. That's why the teams who initially chose the C form changed their configuration (if they could) for L or J-foils.
► Enya 3, Raphael Censier (A-class cat)

C foil - foiler



Lift

It is a function of the immersed depth of the foil and therefore the immersed surface but it does not vary in a linear fashion. The deeper the hydrofoil is immersed, the more the end of the foil approaches the horizontal, which increases the amount of lift.

Lateral resistance

It increases sharply as the foil starts to enter the water. As the foil enters the water more deeply, after a certain depth, the amount of lateral plane increases only slowly.

Benefits

- The foil exits the float much lower, nearer the keel line of the float than with the V-foil. This feature delays the start of ventilation.
- Changes to the immersed depth have a "double" effect on lift (see lift, above).

Disadvantages

- C-foils are vertically unstable (on a hydrofoil boat). When the float takes off, the lift decreases only slightly; there is very little inbuilt regulation of the lift and therefore a high risk of stall which explains why C-foils are mainly confined to foil-assisted multihulls.
- The molds are considerably more complex than for straight foils.
- The well or case in which the foil is mounted will be complex

The lift control of these foils, the bottom part of which resembles an L-foil when completely immersed, is difficult to manage. It can be done:

1. By altering the immersed depth
2. With a modification of the angle of the foil relative to the vertical axis
3. On small boats by changing the attitude of the platform
4. By adjusting of the incidence of a rudder foil.

■

9 – J-foil

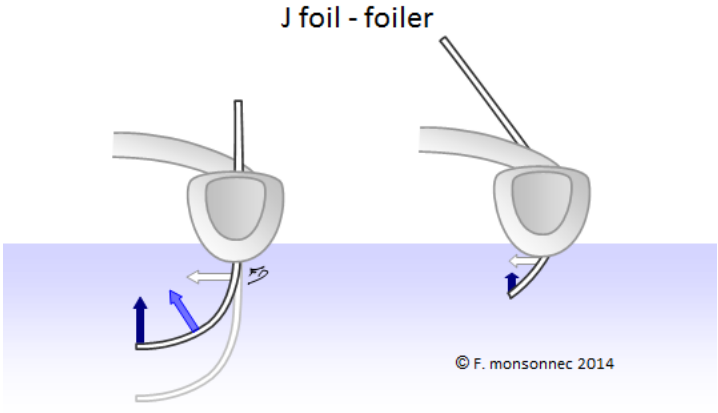
It is a development of a C-foil crossed with an L-foil! The upper part of the foil is vertical. Compared with the L-foil, the fact of having a lower part which is not rectilinear but curved allows the foil to be withdrawn from the top, a point which can comply with some racing rules and also, of course, gives some control of the lift.

On foilers and foil-assisted multihulls

They might have a place here, but the need for a complex system of retraction is a brake on the development of such foils.

On hydrofoils

They appeared on the AC45 before being replaced with S-foils.
► AC45



Lift

The whole curved part, which is the first part of the foil to enter the water, is like a C-foil. Thereafter, only the amount of lateral plane varies with a deeper position.

Lateral resistance

It increases strongly as a function of the insertion of the upper part of the foil. After a certain depth, the lateral plane increases but not the lift (unless you also change the angle of the whole foil!).

Benefits

- The foil exits the float much lower, near the keel line of the float, which delays the start of ventilation
- Controlling the lateral plane and the lift surface is easier than with a C-foil.
- As the foil goes into the water, the first part of its descent regulates the lift by increasing the surface projected onto the horizontal axis. Once the curved part has all entered the water, it is the lateral plane that increases.
- The maximum lift is still available when the foil is partially retracted (as opposed to the C-foil which gets more and more "vertical" during the retraction).

Disadvantages

- Managing the lateral plane and the lift is simpler than with a C-foil but it is arbitrary, with changes to lift during the first part of insertion of the foil and changes to lateral plane only after that.
- J-foils are also unstable vertically and they are more appropriate for use on a foiler.

■

10 - L-foil (version 2.0)

This updated version of the L-foil, with the two parts at an angle which almost forms a "V", has only recently appeared. For me, it combines the good points of different foil types as follows:

V for control by decreasing the wetted surface,
L for the separation into the lift element and the lateral plane element,
C for the shape of the lateral plane portion, which is usually slightly curved,

J for the scalability of the position of the different parts.
But it is indeed an L-shaped foil, with an angle between the lift element and the lateral plane element of less than 90°, and which has a curved upper portion.
This foil is also called the "UptiP" and was invented (I think) by Melvin and Morelli for the TNZ team.

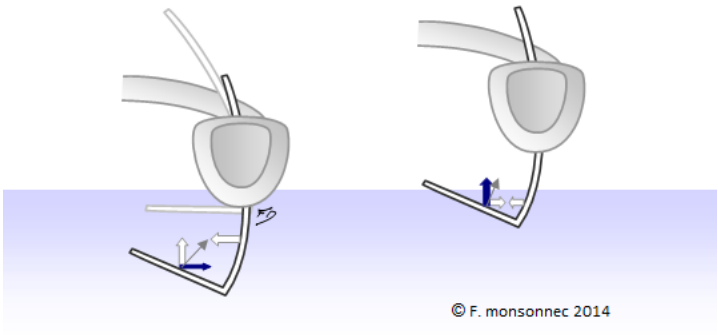
On foilers and foil-assisted multihulls

This type of foil was developed for hydrofoils; boats whose primary purpose is to fly. They are too specialised in favour of flight to be much use for other types of boat.

On hydrofoils

They are well and truly established. Devised for the AC72, used on the C-Class and the Flying Phantom, they will certainly spread. But don't forget that they are not a universal panacea - they were developed to get round a racing rule.
► Some versions of the AC72, the C-Class , the Flying Phantom, the GC32, and on the Fire Arrow model boat.

L foil 2.0 - hydrofoil



Lift

This depends on the size of the foil /lift element. The lift is greatest when the bottom part of the foil is only slightly lowered because then it is not tilted far from the horizontal. When the foil is fully down the tip may be near the surface, so lift drops off.
Flight in any case means that less of the part below the float, which is part of the control system, is available. In fact, we are getting close to a V-foil. However, instead of a V-foil made up of two rectilinear foils (one in each float), each foil is like a V-foil and we have two little V foils made up of the flat element and the curved element. If you squint a little, these two Vs form a "W" (V V)!
The lift surface remains almost constant with elevation (up to a certain point) but the amount of lateral plane decreases, and leeway increases. This causes a decrease in both the angle of incidence and the lift. The tip of the foil can emerge above the surface of the water, but these are not the ideal operating conditions. The best performance is obtained with the hull above the waves and the wing submerged below the surface.
This system seems to offer the chance to dispense with control systems, but in realityit's not enough and the crew applies control either through the depth of the lifting part of the foil, the position of the crew (in small boats), the full incidence of the lift part (Flying Phantom and Oracle) or a rudder with a T-foil. And of course, any combination of the above!

Lateral resistance

This mainly depends on the immersed depth of the curved portion.

Benefits

- Permits some degree of self-regulation without the use of a sensor, a thing which is not possible with T, L or O foils.
- May get round some racing rules.

Disadvantages

- Control is not as simple as with a mechanical control system or with a "pure" V.
- These foils are complex to manage and to manufacture (both the foil and its well or case).

■

11 - S-foil

The S-foil comes in two flavours: It can be a simple foil without an additional lift part, or it can be an L-foil that looks as if it got caught in a door before full polymerisation of the structure!
Unless I am mistaken, it was first developed for Alinghi 5, but this prototype wasn't satisfactory, perhaps due to the lack of development time. It is true that the goal was not to fly but to relieve some of the weight.
It is now possible to combine an L-foil with this sort of vertical component. Surprisingly, although the principle is more that of an L-foil, this foil takes its name from the shape of the bent part.

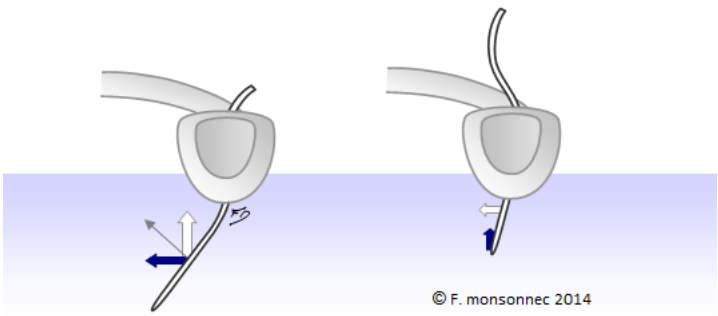
On foilers and foil-assisted multihulls

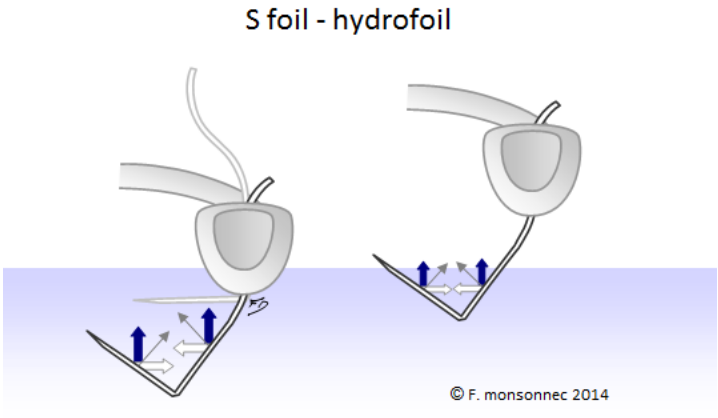
Without an additional lift part, it allows scalability of the lift according to the depth of the foil. However this type of foil is complicated and it seems better for inshore / coastal boats.
► Alinghi 5

On hydrofoils

Used by Team Groupama on their C-Class, these foils showed their potential during the Little America's Cup
► Groupama C-Class, one version of Enya 3

S foil - foiler





Lift

The principle is similar to that of version 2.0 of the L-foil, except that the S-shaped section lets you adjust the angle of the lift part.
When the lift part is fully down, the tip can come close to the surface, which means that the lift decreases.

Lateral resistance

This is a function of the immersed depth of the foil and the flying height of the boat (if it's a boat that flies).

Benefits

- Same benefits as with version 2.0 of the L-foil: permits some level of self-regulation without the use of a sensor, a thing which is not possible with T, L or O foils.

Disadvantages

- Control is not as simple as with a mechanical control system or with a "pure" V-foil.
- These foils are very complex to produce.

12 – Summary table

Simplified to the extreme, here (as I see it) are the types of foil which can be used for "foiler" or "hydrofoil" applications:

Type	V	T	Y	L	U	O	C	J	S
Foiler	✓	- (1)	✓	-	-	-	✓	✓	✓(2)
Hydrofoil	✓	✓	-	✓	✓	✓	-	✓	✓

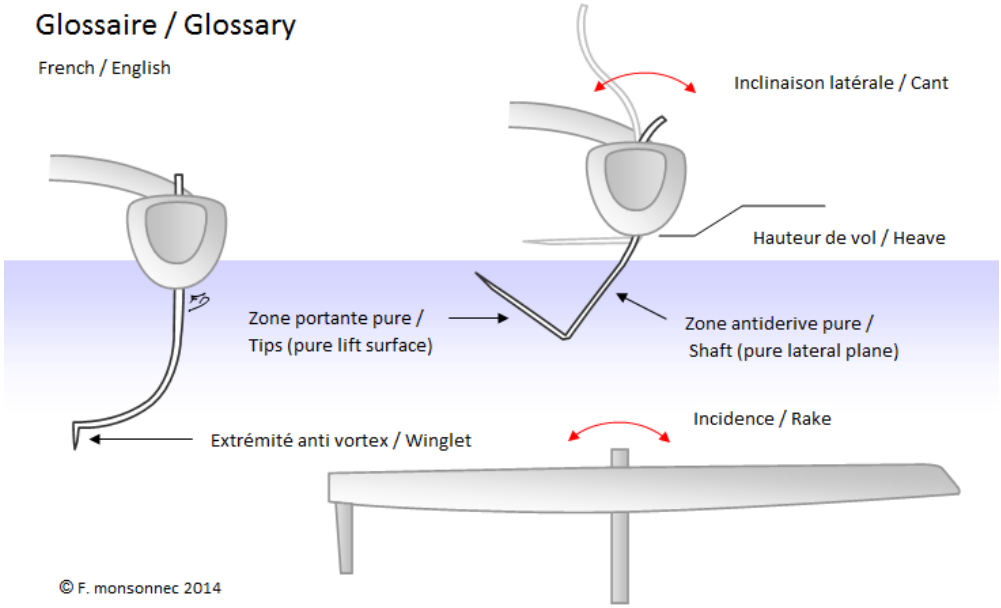
1. Possible, but not the most logical form!
2. Without a pure lift part for a foiler

Without looking at specific examples, and assuming that "control" is not just a manual setting of the angle of incidence or the effect of tilting the platform, but a genuine measurement and adjustment system (sensor and flap rotation for example), is a control system needed (Y) or not (N) on a boat whose aim is to fly?

Type	V	T	Y	L 1.0	L 2.0	U	O	C	J	S
Control	N	Y	Y ~ (1)	Y	N (2)	Y	Y	N (3)	N (3)	N

1. Theoretically should behave like a V but never used for this type of boat
2. As noted above, they approximate to a V-foil
3. Testing of such foils has shown they are too unstable for these applications

13 - Glossary



14 - But also

Z

We now hear rumours of a Z-foil. In the absence of precise information, I have not tried to include it in this summary. Maybe the Z-foil is a member of the L-foil family, with more or less modification?

Δ Elongated Delta

Xavier pointed out to me a video in which we see a unique configuration. I find it hard to make out, but I think I can see a pyramid with the lift part at the base. If this is the case, it

seems strange - relatively strong as far as the foil itself goes, but less so in terms of its attachment to the boat. Perhaps it's useful to have inclined struts, depending on their profile? The designer, Seb Schmidt, is hardly a novice since he has worked on numerous flying projects such as the P28.

■

15 - Conclusion

Questions or comments?

Well, I have probably forgotten a boat, an advantage or a disadvantage, or got some perspective totally wrong. That's why you're there, so please let me have your comments. OK, class, you can close your books now and I hope you have a good break!

Thanks

Thank you to my great friends Gérard Delerm and Daniel Charles for checking the original article in French. And again, to Nicholas Waller for his help for this English version.

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16 - Definitions

Hydrofoils

On this type of sailing boat (also known as a "hydroptère » in France), the foils are designed to lift the boat right off the surface so that only its foils are in the water. You can usually distinguish hydrofoils from foilers by the number of foils. The foilers, and foil-assisted multihulls, are usually equipped with two foils (one on each float) but hydrofoils have three. The third is fixed, usually, at the base of rudder and adjusts the flying height as on an airplane.

Foilers

Foil-stabilised sailing boats or "foilers" can't take off from the water and fly on their foils. They use foils to maintain stability while decreasing the wetted surface by reducing the size of the floats. In this category there are some pure foilers that can't sail at all without their hydrofoils, for example Paul Ricard, Charles Heidsieck IV, and Ker Cadelac II. There are also hybrid foilers that can sail without their foils but with a significant loss of stability and performance, for example Sylvestre Langevin's foilers with Y-foils. These hybrid or mixed foilers are halfway between foilers and foil-assisted multihulls.

Foil-assisted multihulls

These multihulls are a cross between standard trimarans and foilers. They take advantage of the lift produced by the foils to reduce their wetted surface, change the trim of the boat and thus improve their performance. Therefore, they can sail without foils but with a loss of efficiency.

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