The Foiling Guide

1. General Introduction

The International Moth has always been an incredible challenge within the sailing world, but with the addition of hydrofoils, the best just got better! It isn't however an unachievable aim to sail and race of these craft. Sufficient practice should permit most people to enjoy this boat.

This guide was written to help those new into foiling a Moth, and possibly those who are already doing it, but would like to be better. It may also be an interesting read to anybody tempted by the class, or who have a general interest in Hydrofoil Moths.

There could be no better early advice within this guide than an email Simon Payne sent out to the mailing list during the early stages of foiling in the UK. Intended for those new to foiling, it still contains points which even the established sailors should consider.

"I've been thinking about the challenge for new starters and I'd like to offer a bit of advice....I know people are expecting some tips on how to sail the foiler. Adam and I will try to write a "beginners guide" to help here but given that you can't build a house without good foundations, first I'm afraid the basics.........

For those waiting for boats/foils you are going to have a great time! Probably the most rewarding sailing you've ever done. But a bit of a heads up .... In case you think differently...it ain't easy and I need to manage your expectations....You need to remember it's a new skill and we all start somewhere on the learning curve. Where you start and how quickly you progress is up to you..

So to be prepared you can start your programme even before you get your boat / foils and here's how:-

1. Get down the gym. You may think you are God's gift to sailing but if you aren't fit (and most of you aren't) you won't do it. More embarrassingly you will probably throw up in the rescue boat which isn't good for the class image. More seriously these are hi performance pieces of kit and you don't want to hurt yourself. If its too much to go to the gym then go running, or sail like hell, but do something.

2. Invest sometime understanding how your boat works. When you are sailing, your boat will be constantly "talking" to you. Sending you little messages that you need to react to.......... or else! If you don't speak the boats language then you wont understand what to do. A good working knowledge will do here.

3. Work at being a better sailor. Race........practice......read......tune...be professional...talk to the good guys. Plan to do well, not just to turn up. It may seem a great idea getting smashed every night but you will think differently the next morning when water is fired up your nose at 20knots! You need to be on top of your game to sail these things.

So sure the control mechanisms can be refined to make life easier, but these boats have already had tons of development. They are already amazingly sophisticated and you won't, absolutely won't design your way around any of the above "basics"

So don't wait until you get your kit ok?"

An appropriate introduction, and one that still too few actually appreciate. This guide should fit into points 2 and 3, hopefully encouraging some better understanding, and prompt some further thinking about what is going on and how to sail these things.

Many people think that foiling is some magical art, and if you just put hydrofoils on, the boat will magically leap up out of the water. If only it was that easy! There are some conditions when the boat does seem to do this, but to do it regularly and as quickly as possible takes a lot of practice, and accurate set-up.

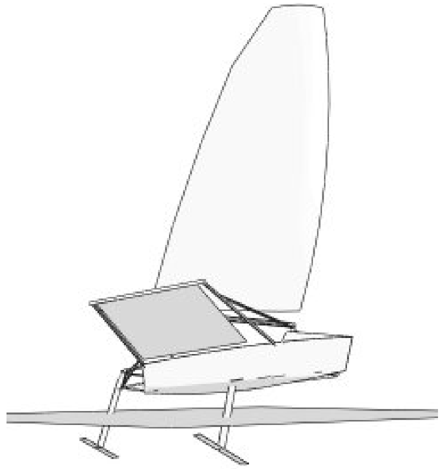
How well, and quickly you can learn to sail a Hydrofoil Moth depends on several factors.

- Understanding of the problem – Hopefully this guide will help in some way.
- Previous Moth experience – It is fair to say that good Moth sailors are able to concentrate just on mastering the hydrofoil element, while those new to the class have to grapple with the instabilities of Moth sailing on top of foil borne flight. This is not as hard as many think though, and with the development of boats, understanding, and more people foiling, it will become easier and easier for those new to the class.
- Personal learning curve – Some people can just do it, and can jump into the boat and sail around happily, others undertake a fair bit of swimming. As a general rule though each new person to the class picks it up quicker than the last.
- Environment – Trying to learn on your own at a tricky venue will be much harder than with other Moths. You do not need to be at a Moth sailing club, but travel to where some others are sailing early on will move you quickly up the learning curve. Don’t hide away at your local club, scaring the rescue crews, join in with other Moths straight away, and learn loads more!

I hope this guide helps with the learning process in some way.

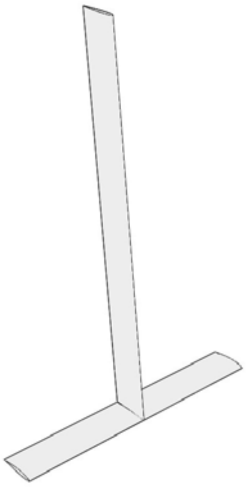
Current Layout

The basic configuration used by most people at the moment is like shown to the right. Other configurations exist and are in development, but have yet to prove as fast and/or manageable as this layout.



The current hydrofoil configurations in use are variations on those from Fastacraft in Perth, Aus. These systems consist of a fully submerged inverted T-foil centreboard, and a T-foil rudder mounted off a gantry to increase foil separation.

Centreboard



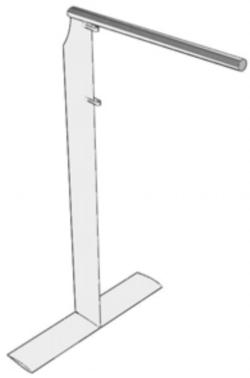
The centreboard is a very short chord parallel sided blade, that is raked forward out of the case, to increase foil spacing and to try and limit air travelling down the blade. At the bottom of the centreboard there is an 850mm span asymmetric foil section that is set at approximately zero degrees to the bottom of the hull.

The current foil section used for the lifting foils is a NACA 63412. The Fastacraft lifting foils have a chord of 120mm, and the Full Force ones 110mm. A variety of spans have now been sailed with. Complete details of the foil sections and sizes currently used are detailed at the end of this section.

Both the centreboard, and rudder hydrofoils have trailing edge flaps to allow the modification of their shape to influence the amount of lift produced. Each one is adjusted in a different way though.

Rudder

The rudder is also a parallel side foil of short chord with an asymmetric foil at the tip. This foil is around 650mm in span, and it set at roughly the same angle of attack as the centreboard.



The trailing edge flap on the rudder is not adjusted as often as the centreboard flap, it is used more as a fine tune control to subtly modify the amount of lift on the rudder foil. This is achieved by the tiller extension connecting to a worm screw within the tiller, which translates the rotational movement of twisting the tiller extension into a linear movement of a small control rod that runs the length of the tiller to a small lever arm, and a vertical pushrod within the rudder that controls the angle of the flap. Twisting the tiller extension one way moves the flap up, and a twist the other moves it down. You just have to remember which way is which on each tack!

Gantry

The set-up angle of the rudder can be adjusted by small adjustments to the rudder gantry, which supports the rudder out to near maximum distance from the transom to increase the foil separation and thus stability.

Wand System & Cable Linkage

The centreboard flap is adjusted by a surface sensing ‘wand’ mounted at the bow. This wand is actually just a batten that is hinged at the bow. Near the pivot, the batten is connected to a control rod of either a cable type or carbon rod. This runs over or through the deck to the head of the centreboard to connect to a lever at the tip of the foil. Within the foil is a pushrod that moves the trailing edge flap. Thus with the whole system linked up the angle of the wand dictates the angle of the trailing edge flap.

With the hull in the water at low speeds, the wand is pushed up and back by the water. Through the action of this wand on the control cable, the pushrod within the centreboard is pushed down, deflecting the flap into a downwards position. With the flap deflected down the section is able to create more lift for its given speed and area, as discussed earlier.

Once the boat if flying the wand will swing forwards so the tip is just touching the water’s surface. The angle change of the wand changes the length of the control cable, and thus the pushrod within the centreboard is not forced down as far and the flap angle is reduced, which in turn reduces the lift produced. To ensure the constant touching of the water surface by the wand, it is forced forwards by a length of elastic.

The bow mounted wand system does not completely control the ride height but it does enough to allow the helmsman to retain control by doing a few other things. With no automatic control system the boat would continue to ride higher as the speed increased until the foils broke the water’s surface and with much reduced lift the boat would crash back into the water.

Bow of a Prowler Moth showing the ride height adjustment mechanism.

Current Foil Dimensions & Sections

Over the page is a table showing the sizes of the foils used, and the aerofoil sections used up to and during the 2005 season. Both companies listed here are producing new foils for the 06 season, so hopefully the publication of this data is okay. It can be found online and in any dinghy park anyway, but may be of use to an amateur builder out there somewhere.

	Fastacraft	Full Force
Centreboard:		
Section	NACA 66014	NACA 0012
Chord	120 mm	120 mm
Rudder:		
Section	NACA 0012	NACA 0012
Chord	120 mm	120 mm
Centreboard Foil:		
Section	NACA 63412	NACA 63412
Span	850 mm	860 mm
Chord:	120 mm	110 mm
	Kevlar hinged flap	Recessed flap
Rudder Foil:		
Section	NACA 63412	NACA 63412
Span	650 mm	700 mm
Chord	120 mm	110 mm
	Kevlar hinged flap	Recessed flap

<u>Section Terminology:</u>

Aerofoil sections come in a variety of shapes and sizes. Some are classified by their geometric properties, some by their aerodynamic properties and other have just been given names by their designers.

NACA 6 Series Aerofoil Sections

For 6 Series Sections the designation numbers represent the aerofoil aerodynamic properties as shown in the following example,

63412

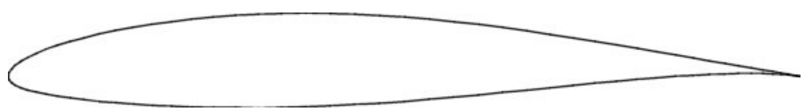
6 -- 6 series designation number.
3 -- location of Cp(min) as 1/10ths chord.
4 -- Ideal (or Design) CL value. (0.4 in this case)
12 -- Max thickness to chord ratio, 1/100ths chord

NACA 4 Series Aerofoil Sections

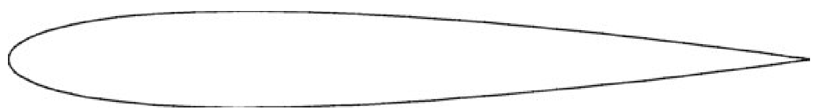
The NACA 4 and 5 Digit aerofoils represent two families of aerofoil section that can be generated by the use of a set of simple polynomial equations. While these sections are slightly out of date in terms of current aircraft usage, they still represent useful sections and are easy to create.

0012

0 – Max camber in % chord
0 – Position of max camber
12 – Max thickness in % of chord



NACA 63412 section, as used for many lifting foils.



NACA 0012 section, often used for vertical sections

Foil Sizes:

The set up of your hydrofoils will vary according to the size of your foils, and this has to be factored into your initial set-up. It is no good setting up the same as someone else if you are running different size foils, the lift of your foils will be different, and thus so will the handling.

John was pretty honest in his answer when asked about the original set up. *"The original foil sizes were a complete guess (gut feel)"*

" originally the flap on the centreboard stopped about 100mm short of the end of the foil but I feel this was no good as the flap was only fighting against the lift still being made by the ends (drag). The next sets I am making now will have 85cm and 65cm."

Table of sizes:

Throughout the 2004 – 2005 period there was refinement in the exact sizes of the foils. With a small rudder foil, when the bow went up, even with the lift reduced with the flap up, there was still a lot of lift produced relative to the small rudder foil. With a bigger foil at the back, there was more restoring moment available, helping the boat feel more stable fore and aft when sailing along.

Foil Sizes: Original Fastacraft

Main foil
Span: 900 mm
Chord: 120 mm
Area: 0.108m^

Rudder Foil
Span: 520 mm
Chord: 120 mm
Area: 0.0624m^2

Ratio: 58% (Too small)

Foil Sizes: Garda Top 3

Main foil
Span: 850 mm
Chord: 120 mm
Area: 0.1m^2

Rudder Foil
Span: 650 mm
Chord: 120 mm
Area: 0.078m^

Ratio: Rudder foil should be 75 – 80% of Main foil

The fleet levelled out with a rudder foil ~ 75% - 80% of the size of the main foil.

These modifications were only done by sailors who'd amassed a lot of 'air time', and thus understood the feelings and feedback. Most people should concentrate on time on the water before playing with foil configurations too much. Learning how much you can do with body weight and how much can be done by the system, is an important skill.

Note – the data presented here is of the fastest set-ups in 2005, already new foils are being used in 2006 with further performance improvements reported, but the basic sizes, and ratios have not changed much. For the latest info consult the builders & designers direct. This guide cannot hope to stay up to date with every foil generation.

3. Foil Set-up & Tuning

Foil set-up is a critical part of mastering foiling. This section is concerned with those things you can do on the shore prior to going sailing. The set-up of the conventional 'Fastacraft style' system is what will be considered here.

If your foil setup is not right, the boat will be hard to control and as a result will be off the pace. Most people would agree with this, but do not put much effort into measuring and the full understanding of what is happening.

For some their boats are set-up correctly straight out of the box, others need to undertake more of an initial set-up. Some need to fine tune for their weight and sailing style, but all should understand and appreciate the nuances of foil trim.

Few people really know what angles they are using and how their set-ups compare to others so it is probably worth us all taking the time to measure our foil angles, and try to understand the implications of the data. Setting up the different systems is very similar, it is just the finer details that are different.

The fundamental measurements that we are interested in are:

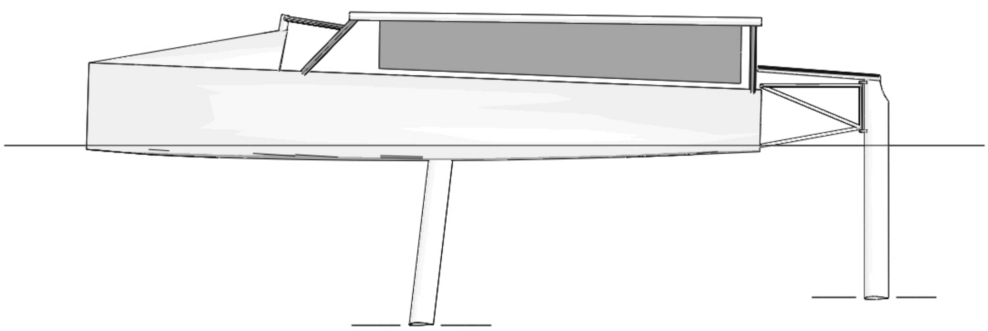
- Centreboard foil angle relative to the hull
- Foil angles relative to each other

Also under your control during the set-up of your foils are:

- Flap angle to boat flying height relationship – Centreboard lift
- Wand length
- Elastic tension

3.1 Centreboard Foil Angle.

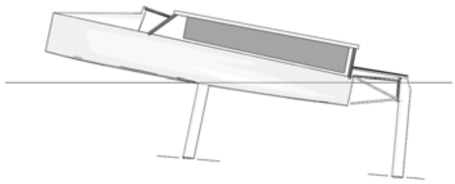
Your designer/ builder will have joined the centreboard lifting foil to the vertical centreboard section at a specific angle. What we are interested in is not the angle of the vertical section, but the angle of the lifting section relative to the hull. As the main lift producing foil, the angle this foil takes to the water flow is very important.



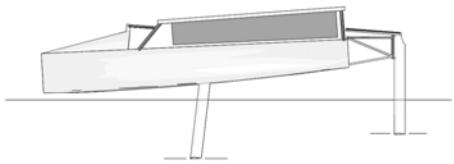
The general set-up being run at the moment is with centreline of the lifting foil parallel to the hull when it is set up with equal bow and transom immersion. (Roughly parallel to the bottom of the hull in the area of the centreboard case.)

Insufficient angle and you will never have enough lift to get out of the water, too much, and you'll be sailing downwind at speed with the boat in a bow down attitude as you trim the bow down to reduce the angle of attack.

The diagram opposite shows the case where the main foil is actually angled down slightly. With the flap deflected down, and due to the camber in the section the foil can still create lift when angled down, but a considerable bow up attitude would be required to get this at the right angle to produce sufficient lift. You'd have considerable transom drag in trying though, and foiling would be unlikely, or need plenty of wind.



The next diagram shows the case where the main foil is positioned at a greater angle of attack, and so creates a lot of lift. This is likely to lift off quite easily but likely to create too much as even with the flap all the way up the foil would still be producing lift in the normal trim mode. To reduce the amount of lift the boat would have to be trimmed quite nose down, and balanced by raking the rudder underneath as well. At speed this is not a very desirable boat attitude! The likely situation with this set-up is that you'd foil early, but crash back down very quick as it would be very hard to reduce the lift. This set-up is also likely to be slow in the displacement condition.



These are extreme cases, and assume everything else is correct, but possibly explains the current set-up.

The centreboard fit in the case is crucial, as any play there will affect the foil angle.

Measurement:

There are a number of ways to set up the foil so it is level with the hull:

Spirit level: With the low rocker profile of the modern hulls the portion of hull at the centreboard case can often be considered level relative to the line of equal bow and transom immersion. A spirit level can be held on the hull, and then level with the chord line of the centreboard lifting foil.

The hull can also be chocked up in the air with the boa and transom at the same height.

Fastacraft provide a template with their foils to fit over the centreboard foil to position the flap in the design section position. The straight edge parallel to the section can be used as a guide.

Full Force foils can be lined up with the outer portion of the foil due to the way the flap is not quite full span.

3.2 Rudder Foil Angle

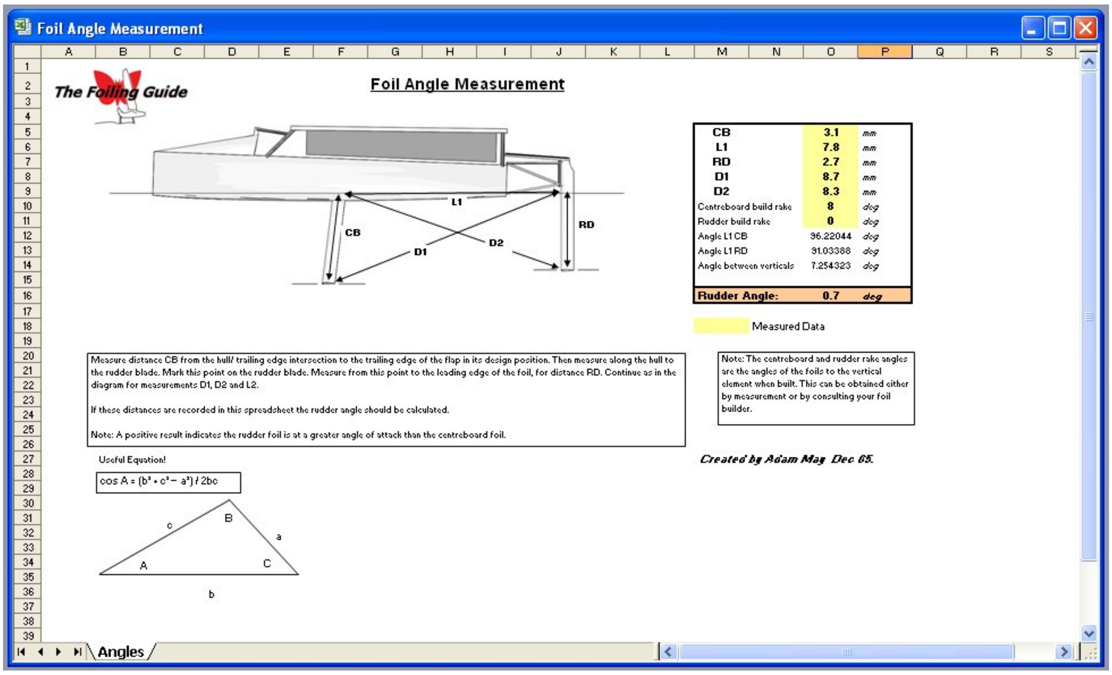
One of the most crucial set up items is the relative angle of centreboard foil and rudder foil. Once the boat is up in the air, this is the dominant angle to be concern with, as it is all about the relationship of the two foils going through the water.

The current foil sets operate best with the two foils at about the same angle or the rudder a few degrees angled down relative to the centreboard. Everyone's sailing style and weights are different so an element of fine tuning is required after the initial set up, and the range of differences is still being investigated and will be posted once confirmed.

Differences in foil sizes will also have a considerable impact, so if you are running a different size, take into account the potential difference in lift produced.

Measurement:

A spreadsheet has been created that allows a few key foil measurements to be taken, and from these the relative angle between the centreboard and rudder foils is calculated. *[There should be a link to this from the UK website]*



Roll the boat over, and put the foils into their sailing positions.

1. Find out or measure that angle your centreboard foil is mounted on to your vertical centreboard section is. [This is required within the calculation later, as the angle difference of the two vertical sections is worked out first then the angle difference between lifting sections worked out from that.] If you were interested in comparing like for like with somebody else using the same foils this is less critical as you can still do a comparison. 7 / 8 degrees from the right angle is typical.

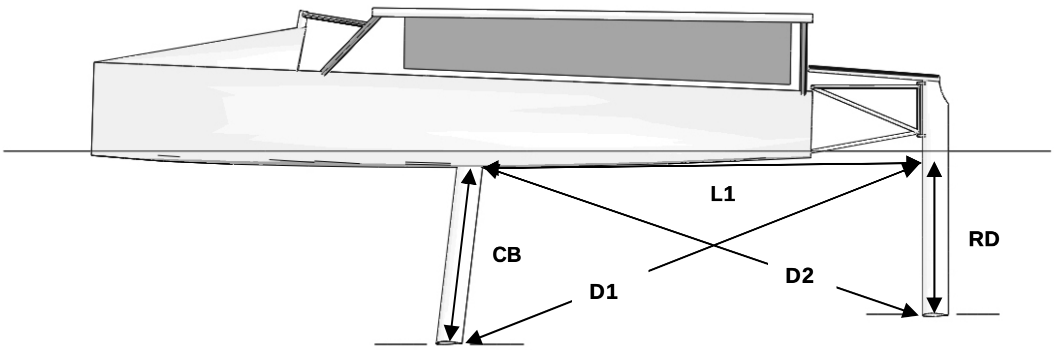
2. Measure the distances L1, CB,RD, D1 and D2 shown in the diagram over the page. Measure distance CB from the hull/ trailing edge intersection to a point on the trailing edge of the foil just above the flap. Mark this point on the foil. Then measure along the hull to the rudder blade. Mark this point on the rudder blade. Measure from this point to the leading edge of the foil at the tip, for distance RD. Measure from the mark on the centreboard trailing edge just above the flap, to the mark near the top of the rudder on the leading edge for D1. Finally measure from the intersection point

of the centreboard trailing edge and the hull, to the tip of the rudder at the leading edge for D2.

3. Input these figures into the spreadsheet.

Note: A positive result indicates the rudder foil is at a greater angle of attack than the centreboard foil.

A figure of between 0 and -2 would be within the ballpark of current known fast set-ups.



Fine Tuning:

Early on some people ran different ‘packer’ sizes under the bottom gantry leg to vary the angle of the rudder and this was changed with wind strength on the day. As everyone has learnt to sail the boats better though, once good standard settings have been found they are not adjusted.

Modern adjustable gantries only facilitate the quicker acquisition of a fast setting, and the ability to do very small adjustments when fine tuning, they are not adjusted regularly. The beginner without a fully adjustable gantry should not worry though. You can achieve similar results with thin packers under the bottom leg of the gantry, it is just a bit fiddly and takes a bit longer.

[Wand and cable section still to come to complete this section]