

SAILSetc Fin Alignment Tool

For 50 to 100 mm wide fins

Introduction

The fin alignment tool is used to check the alignment of the fin with the hull. The "short" kit has two components which are 3D printed in eSun's PLA Plus, a high temperature engineering filament with superior mechanical properties, and nylon fasteners, as shown in Figure 1. The larger part is a "track", and the smaller part is a "boss".

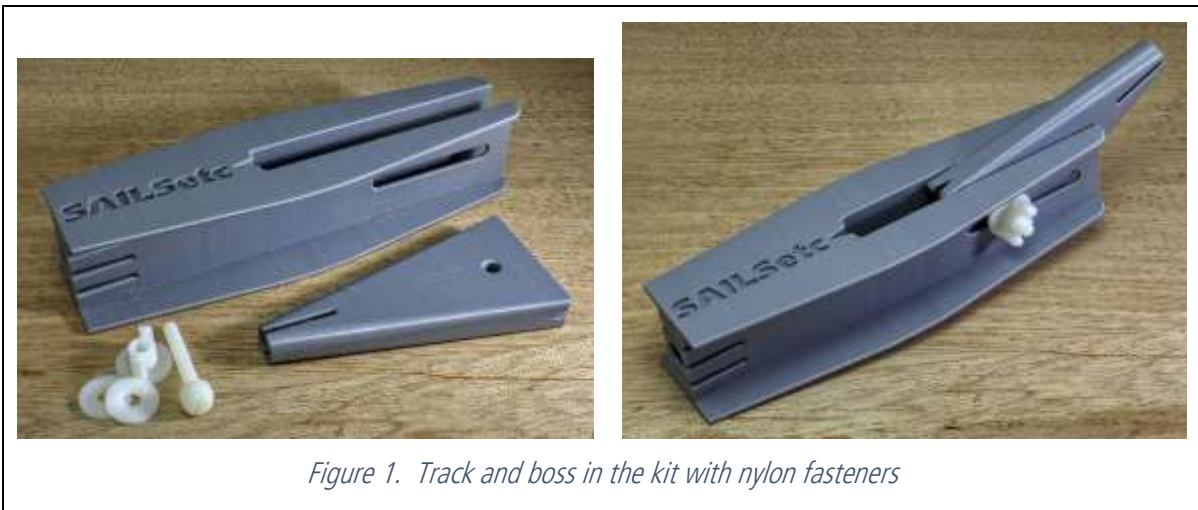


Figure 1. Track and boss in the kit with nylon fasteners

A "full" kit is available which has, in addition, two 11 mm diameter alloy tubes. These are 400 and 500 mm in length to suit an International One Metre, or 500 and 600 mm to suit a Marblehead and Ten Rater.

In use, the tool requires two plumb lines, made from bowsies, light line, and wire from your tool box.

Scope of the tool

The tool works for fins with 50 to 100 mm chord (width) at mid-length of the exposed part of the fin, and up to 15 mm thick.

A fin alignment tool for fins with larger chords and greater thickness is under development.

Preparation for use

The track and boss are supplied in assembled form in the kit. The thumb screw and wing nut should be adjusted initially to provide a firm, but sliding, fit of the boss in the track.

A Preparing the tubes

- A.1 If the “short” kit was purchased, cut two pieces of 11 mm diameter alloy tube (IOM mast tube) to length. 400 and 500 mm suit an IOM, or 500 and 600 mm suit a Marblehead and Ten Rater.
- A.2 Square the ends of the tubes and remove the sharp edges. This is important for both the following step A.3 and particularly for step B.3.
- A.3 Check the straightness of each tube and mark its axis of symmetry. One way to do this is as follows, illustrated in Figure 2. (Note this may not work reliably for groovy section tube.)

Support a steel rule on a flat and smooth surface with one edge uppermost. Place one end of the tube on the rule edge with the tube perpendicular to the rule. If the tube is perfectly straight it will remain stationary when released. If the tube is not straight it will roll until its axis of symmetry is vertical. Mark the upper side of the tube at both ends for reference, preferably with a line that is at least 100 mm long; this is important for step B.2. Do this for both tubes.



Figure 2. Checking for straightness and identifying the axis of symmetry



Figure 3. Axis of tube symmetry aligned with track vertical plane

B Adding the tubes

- B.1 Take the shorter tube in one hand and the track in the other.
- B.2 Use the reference marks added in the previous step A.3 to orient the axis of symmetry of the tube with the vertical plane of the track, as per Figure 3.
- B.3 Push the tube into the hole of the track.

The hole is designed to be a tight but spring fit onto the tube so it may take some effort to insert. The inner end of the hole is tapered so the end of the tube will self-centre when it is fully pushed home. This 'self-centring' action will only work if the end of the tube has been properly squared off, as in step A.2.

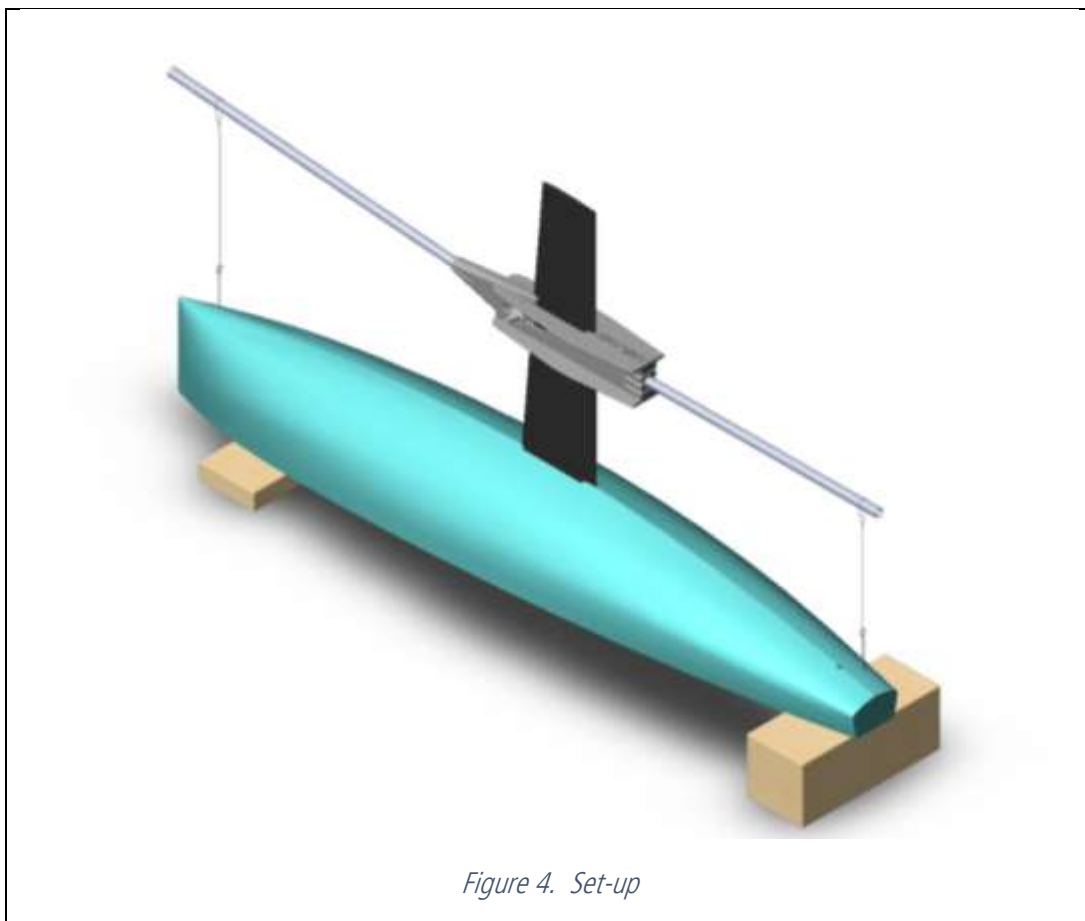
No glue should be used or needed to keep the tube in place (see below if the tube is not a tight fit).

B.4 Repeat steps B.1 to B.3 for the longer tube and the boss.

If a tube is not a tight fit, increase its diameter. Do this by wrapping one or more pieces of 33 x 100 mm (*) self-adhesive deck patch material, or similar material (**), around the end of the tube. Ensure the reference mark remains visible, and remark as necessary.

(*) When adding a thickening layer of material, it is important not to partially overlap any layer, yet equally important to have complete coverage around the tube. The suggested 33 mm width may need to be adjusted to 32 or 34 mm depending upon the tube diameter.

(**) The spring of the PLA printed part is not as tolerant of an over-size tube as the spring of an ABS or nylon part, for example. Attempting to fit a tube which is significantly over-size will break the part, and it may be that an otherwise loose-fit tube becomes too large when layered with a wrap of self-adhesive deck patch material. In this case, a thinner material would be required. Mylar tape is 0.05 mm thick (SAILSetc product code TM), compared to self-adhesive deck patch which is approximately 0.10 to 0.13 mm thick, and would be recommended for a tube that is only slightly loose.



C Preparing the plumb lines

- C.1 Make two 'lollipops' using 1.2 or 1.5 mm diameter stainless steel wire, aiming for a small round closed eye, perhaps 2 or 3 mm Ø, with a 50 or 75 mm tail. Grind the tail end to a neat point. These are the plumb bobs and are deliberately made light so their weight does not interfere with the setting of the tool in sections E and F.
- C.2 Use a supple and light line – 15 kg breaking strain “soft” Dyneema is an acceptable choice, otherwise a cotton or polyester sewing thread. Make a 20 mm long loop in one end of the line and cut the line 400 mm from the top of the loop. Add a small bowsie (the micro metal SAILSetc product, code 057X, is ideal), pass the end through the eye of the plumb bob, and finish off at the bowsie.
- C.3 Repeat to make a second plumb line.

D Preparing the boat

- D.1 Remove the rudder from the boat.
- D.2 Remove the ballast from the fin.
- D.3 If it is not obvious where the centre of the transom is, find and mark it with a marker pen or on a strip of self-adhesive tape (masking tape is a preferred choice). Use a straight edge bent along the centreline of the hull, but held horizontally in the transverse plane (very important), with one end on the centre of the fin trunking and the edge near the other end on the centre of the rudder tube to give a reasonable guide of the transom centre.
- D.4 If it is not obvious where the centreline of the hull is near the bow, find and mark it with a marker pen or on a strip of self-adhesive tape (masking tape is a preferred choice). A straight edge bent along the centreline of the hull, but held horizontally in the transverse plane (very important) with one end on the centre of the fin trunking and the other one on the centre of the bumper is a reasonable guide.
- D.5 Support the boat upside-down with the fin in place. Lengths of straight timber can be placed on a flat surface to support a flat decked boat. The fin should be approximately vertical – absolute precision is not required at this point, adjustments are made in Section E. The boat needs to be secure and steady in this inverted state to ensure the following steps can be carried out satisfactorily and repeatably.

Procedure for using the fin alignment tool

E Validate symmetry and alignment

- E.1 Measure the fin and mark the mid depth level (mid-way between bottom of hull and top of ballast). Place a horizontal piece of tape on the fin about 20 mm below that point (that is, 20 mm closer to the hull).
- E.2 With the track towards the rear of the boat, place the aperture of the tool over the fin and lower it until the lower edge of the tool is approximately in line with the upper edge of the tape on the fin. Slide the boss along the track until the leading and trailing edges of the fin are a snug fit in the grooves in the two plastic parts of the tool. Tighten the wing nut if necessary.

The forward tube will probably point slightly upwards due to the rake of the fin leading edge. This does not affect the way the tool works.

- E.3 Most likely the trailing edge of the fin will not be perfectly vertical so the lower edge of the tool will not be perfectly in line with the upper edge of the tape. Remove the tape and re-position so it does line up with the lower edge of the tool.
- E.4 Add a plumb line to the outer end of each tube by placing the loops over the tubes. Move the loops so that one plumb bob hangs down at the transom (or the rudder trunking itself) and the other near the bow. Adjust the bowsies so that the lower tip of each bob is a small distance above the hull.
- E.5 Adjust the transverse attitude of the boat until the aft plumb bob points to the centre of the transom (or the rudder trunking). It may be necessary to add progressively thicker wedges under the supporting timbers to achieve this. Allow time for the plumb line to settle and get the point of the plumb bob pointing at the target centre.
- E.6 The forward plumb bob will also be pointing somewhere near the centreline of the boat at the bow. Record this position by adding a strip of masking tape across the bow and marking it.
- E.7 There may be some slight asymmetry in the tool so, as a check for this, carefully remove the tool from the fin, rotate it 180 degrees round the axis of the tubes (keeping the track aft and the boss forward) and replace it in line with the tape on the fin. Repeat steps E.4 to E.6. If the forward plumb bob still points at the mark near the centreline of the boat made in step E.6, the tool is symmetrical. Proceed to step E.8.
- E.8 If the forward plumb bob does not point to the E.6 mark as before there is some asymmetry in the tool. There are two methods of proceeding.
 - (a) Disassemble the tool and re-check for bend in the tubes. Reassemble and repeat and make small rotational adjustments of one tube until the forward plumb bob points to the same E.6 mark each time.

It may help to scribe index marks on pieces of self-adhesive material added to one side or other of the tubes where they emerge from the printed parts.

 - (b) Take readings as described below but use the average of the values found with the tool in the two attitudes.

F Check fin alignment

- F.1 Assuming step E.7 has been carried out and the plumb bob remains pointing to the same off-centre mark, measure the distance from the mark to the centreline which we will call X . Carefully note to which side of the centreline the measurement has been taken and recall that the boat is upside down while doing this.
- F.2 Measure the distance between the two plumb lines which we will call Y .

The angular misalignment is $(X/Y) \times 57.3$ degrees (Note † at end)

For an IOM where Y may be around 850 mm, a value of $X = 5$ mm indicates a misalignment of about 0.3 degrees. This is sufficient for a good helmsman to be very aware that the boat is not sailing equally well on each tack. For reasonable balance it is essential to reduce this to below 0.1 degree, that is, X less than 1.5 mm for an IOM.

F.3 Remove the tool from the boat and remove the fin from its trunking. Measure the chord width of the part of the fin that fits inside the trunking which we will call Z .

F.4 To align the fin with the hull it will be necessary to remove some thickness of material from one side of the leading edge of the fin in the trunking and add the same thickness to the other side of the leading edge of the fin inside the trunking. That thickness t is given by:

$$t = Z \times (X/Y)$$

F.5 For the IOM example above, where the chord width of the fin inside the trunking is 85 mm, t is found to be 0.5 mm. There are two methods of proceeding.

(a) Carefully check, and check again, which side of the fin you will need to remove material to bring it into alignment.

Remove t . Use coarse abrasive paper wrapped tightly on a flat solid piece of timber or plastic to abrade the fin taking care to protect yourself from dust particles and the working part of the fin from damage. If you have a Vernier gauge, measure the thickness of the fin before you start work and use the tool to check progress.

Add t . Use thin mylar tape (SAILSetc product code TM, one layer is 0.05 mm thick) or self-adhesive deck patch material (one layer is about 0.1 mm thick) to add thickness where required. (Thick mylar tape, SAILSetc product code TTM-12, 0.1 mm thick, or glass-epoxy self-adhesive batten material is recommended for thicknesses greater than 0.1 mm, SAILSetc product code BM-T is 0.2 mm thick, and BM-M is 0.3 mm thick.) This can be replaced with something more permanent later if required.

(b) An alternative to removing the full thickness t from one side of the leading edge of the fin inside the fin trunking and adding it to the other side of the leading edge is to remove $0.5 t$ from the leading edge and $0.5 t$ from the other side at the trailing edge. In this case $0.5 t$ is added on the opposite side at the leading and trailing edges.

F.6 After the correction work has been carried out, replace the fin in the hull and repeat steps E.1 to F.5 until the mark at the bow coincides with the hull centreline.

G Check the transverse verticality of the mast

Before replacing any added self-adhesive material on the fin with something more permanent, you should consider carrying out another test at this stage.

Symmetrical balance of the boat when sailing to windward also depends on verticality of the hull and, more importantly, the transverse verticality of the mast. Note the transverse verticality of the fin itself is usually guaranteed by virtue of the narrow hulls and heavy ballasts used on the type of boats for which this tool will be used.

The transverse verticality of the mast depends, according to how the boat is built, on the alignment of the mast trunking and/or the length/tension of the shrouds. As the transverse alignment of the fin in the hull may have been altered (unless the alternative method in step F.5(b) has been used) it is as well to check this.

If the mast is not supported laterally by a mast ram, strut or deck fitting of any sort above the heel, float the boat with the rig and all rc equipment on board in its normal place. Sheet the

booms to the centreline. Arrange for a plumb line to hang from the mast at a convenient point where it can hang freely, and adjust the shrouds until the mast is vertical. Repeat for each rig.

If the mast does have lateral support provided by a mast ram, strut or deck fitting of any sort above the heel, proceed as follows:

- G.1 With the boat afloat with all rc equipment on board in its normal place, test the mast verticality by placing a 1 metre length of straight mast tube in the boat, supported through the mast trunking and mast ram. Ensure the mast heel is firmly held in the centre of the mast trunking by adding self adhesive tape around the heel until it is a snug fit.
- G.2 Attach a plumb line at the top of the tube and observe where the pointer settles. Usually it is more convenient to have the plumb line aft of the mast.
- When afloat the boat will usually roll for an annoyingly long time after release causing the plumb bob to do the same. The plumb bob can be helped to settle by immersing it in a cut-down paper cup filled with water, damping down its motion.
- G.3 Sight the alignment of the plumb line from the stern and, if the mast tube is not vertical, measure or estimate the offset of the pointer, distance X .
- G.4 Find the distance from the plumb bob pointer to the plumb line attachment on the mast tube and call that Y .
- G.5 As with the alignment of the fin with the centreline of the hull, find the lateral misalignment of the mast.

The angular misalignment is $(X/Y) \times 57.3$ degrees (Note † below)

- G.6 Remove the fin from the hull and measure the vertical height of the fin inside the fin trunking. Call that Z .
- G.7 Correcting the lateral alignment of the fin requires moving the head of the fin laterally by distance t :

$$t = Z \times (X/Y)$$

For example, Y might be 850 mm, X 5 mm, and Z 100 mm. The angular misalignment is approximately 0.3 degrees, and $t = 0.6$ mm.

Depending on the internal size of the fin box, this may be possible to achieve by simply packing the top of the fin on one side and adjusting the position of the hole in the fin box for the fin attachment screw to accommodate that change. As in step F.5, use Mylar tape, self-adhesive deck patch, or glass-epoxy self-adhesive batten material.

- G.8 Carefully check, and re-check, the direction of this adjustment. If the mast inclines to **starboard**, then the fin and ballast need to be more inclined to **port**, the head of the fin needs to move to **starboard**, and packing needs to be added to the **port** side of the fin head. And vice versa. Use of a sketch will probably help.

If the fin box is a close fit to the head of the fin, it will be necessary to remove some thickness of material from one side of the top edge of the fin head in the trunking and add the same thickness to the other side of the top edge of the fin head inside the trunking.

G.9 As before, when the change has been made, re-test the boat to check that the change has been correctly made.

The mast is now vertical and the fin is aligned correctly with the hull centreline. Two major steps affecting symmetrical balance have been achieved leaving you able to concentrate on the refinements that affect performance.

Note †

This is the useful approximation where, for a small angle μ , $\sin(\mu) = \tan(\mu) = \mu$ in radians.

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