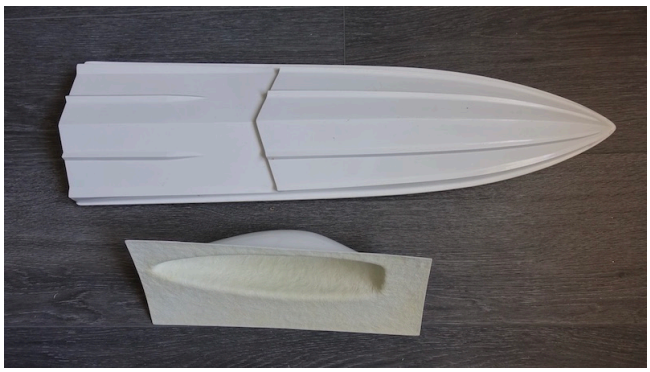
# MTMBC
## Building a Mono 1 race boat on a budget

### Introduction
The number of competitors taking part in the MTMBC Mono 1 championships is low so this article has been written to encourage members to build and race their boats in the championship.
Buying a competitive Ready To Run Mono 1 race boat from the likes of Tenshock, ETTI or Hydro & Marine can be very expensive and they are frequently not available. Even buying a hull and fitting it out with the maker's recommended parts can be similarly expensive with a typical fibre glass hull costing upwards of £120 and the more exotic materials costing much more.
In recent times some club members have raced 'Zoom' boats with fibre glass hulls which are produced in this country. They have been equipped and developed by our members into fast competitive boats ideally suited to the Mono 1 championship. At £29 each for the hulls they are a good quality affordable choice that can be equipped with alternatives to main supplier parts and still be competitive.
So the challenge is to build a Zoom 3 Mono 1 boat that will be competitive and race in the MTMBC Championship for about £200 which is less than half the cost of a commercially available equivalent.

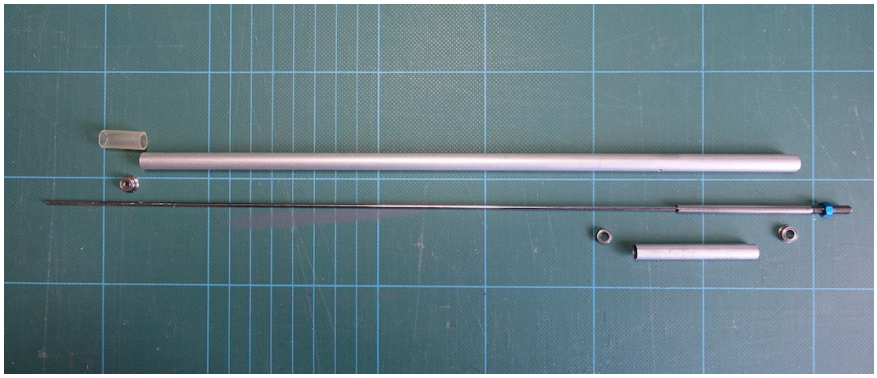
### The hull (comercial)
The Zoom 3 hull is a conventional surface drive single stepped mono, with a large offset superstructure, that is required to make it self right quickly which is an important feature of a good race boat.
If requested a strengthened version of the hull can be supplied for the same price but there is a weight penalty because two layers of fibreglass are used. It is debatable if the advantages of increased strength outweigh the advantage of a lighter and potentially faster boat. For this exercise the strengthened version has been chosen assuming that members who may build one are novices to the class and will probably be involved in some rough & tumble while learning the ropes.



### Building the boat
An assessment of the parts & materials needed to complete the build was undertaken and it included some custom made and some commercially available parts. Please see the parts list at the back of this document for the details. A search of existing stock was undertaken for any suitable materials and the commercial parts were sourced mostly from China.
While they were on the way from China the opportunity was taken to work on the custom built items.

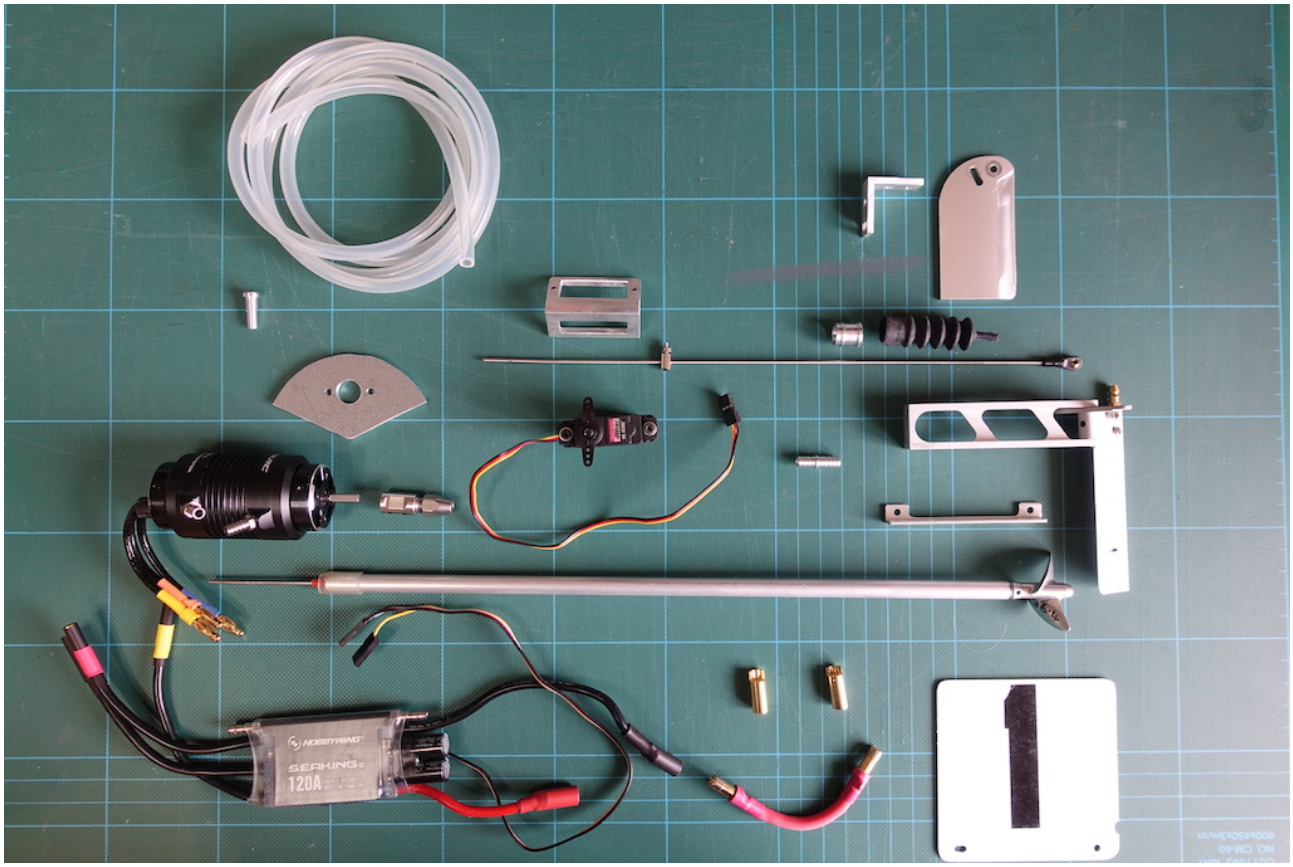
**Note:**- A small lathe has been used to make some of the parts for this boat but in most cases it is not essential and items like cooling water and push rod breakthroughs can be made from suitably sized short pieces of tube glued into place. Where a lathe is essential (prop shaft assembly parts) and members don't have access elsewhere I can offer a free service to turn those parts.

## The prop shaft assembly (partly commercial & custom made)



A straight wire drive was selected as the best way forward but commercially available options are limited and expensive so it was decided to custom build a prop shaft around a Tenshock 2mm to 4mm diameter wire & stub shaft drive shaft available from the manufacturer @ $11.33

Suitable Aluminium tubes and Stainless Steel bearings were ordered from the UK to build a prototype and establish how a drive could be successfully assembled for use in the boat.




## Motor mount (custom)

A motor mount was made for the GoolRC 2968 3,400KV 4 pole motor. A fan shaped crescent of 3.17mm (1/8 inch) thick aluminium plate was cut to the inside 'V' shape of the hull and drilled to accommodate the motor mounting pattern. Prior to assembly holes were drilled along the two edges that sit next to the hull to provide a positive key for a generous glue fillet.

### Coupling (commercial)
4mm to 2mm collet.

### Rudder with water pick up & stand off (commercial)
90mm rudder x 100mm stand off.

### Turn Fin (custom)
The adjustable turn fin bracket was made from aluminium angle and the blade was cut from aluminium sheet, shaped and sharpened. The angle the blade enters the water can be adjusted front to back and from left to right. The design is a copy of an ETTI turn fin.

### ESC (commercial)
A HobbyWing Sea King 120Amp pro is being used in this experiment but the Flycolor 90Amp ESC with BEC for Boat is a suitable, more affordable, alternative.

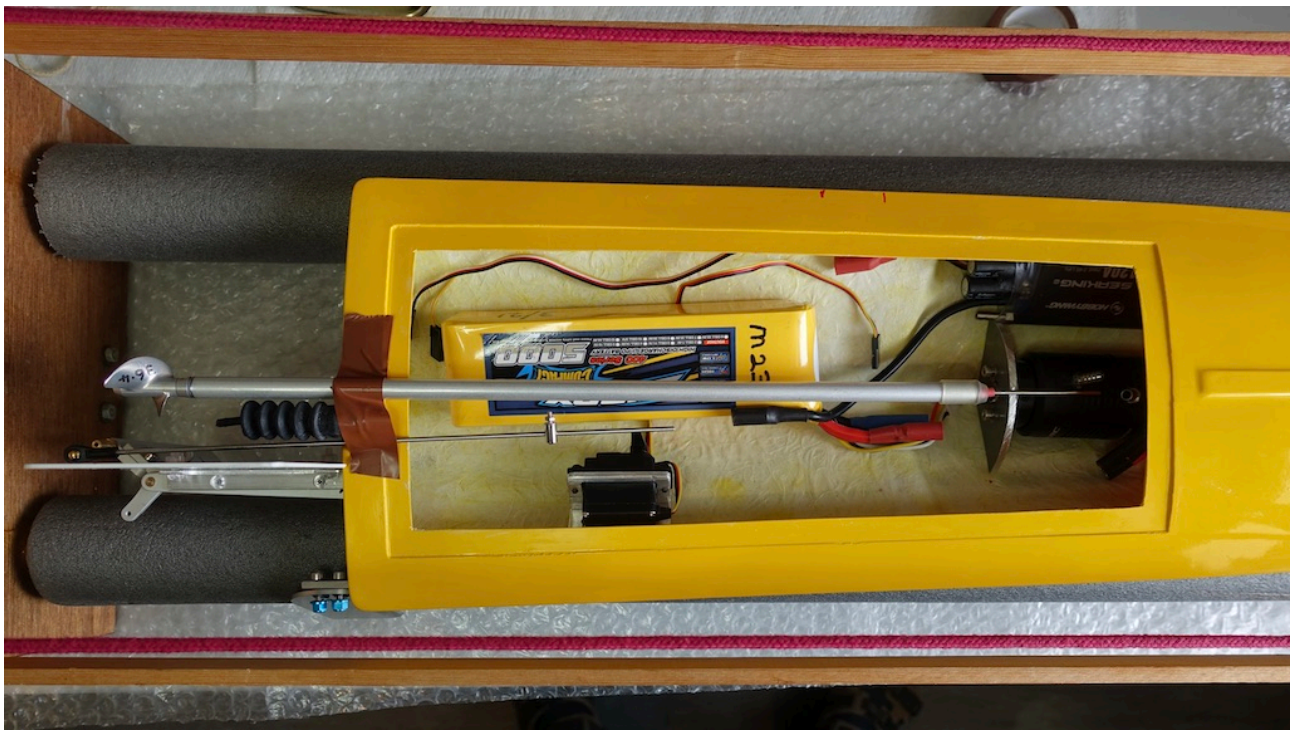
### Safety loop (custom)
Two 5.5mm diameter female connectors were glued into the deck and a loop made from two male connectors and a length of 10 SWG wire.

### Batteries (commercial)
Any 3s 5,000mAh lipo with a 30C rating or higher that will fit in the boat will do the job but experience has shown that Zippy Compacts @ 40C are a good economical option. The batteries have not been included in the cost calculations.

### Rudder servo (commercial) & mount (custom)
A Hitec HS-85MG+ was chosen for the rudder servo and a mount was made from aluminium angle. A push rod breakthrough was turned from aluminium but if you do not have access to a lathe a simpler solution is to use a short length of tube glued in place.

### Cooling water Parts
Cooling tube breakthroughs. If you do not have access to a lathe simply use short lengths of aluminium or brass tube glued in place. The silicone cooling tube is 4mm i.d. and 6mm o.d.

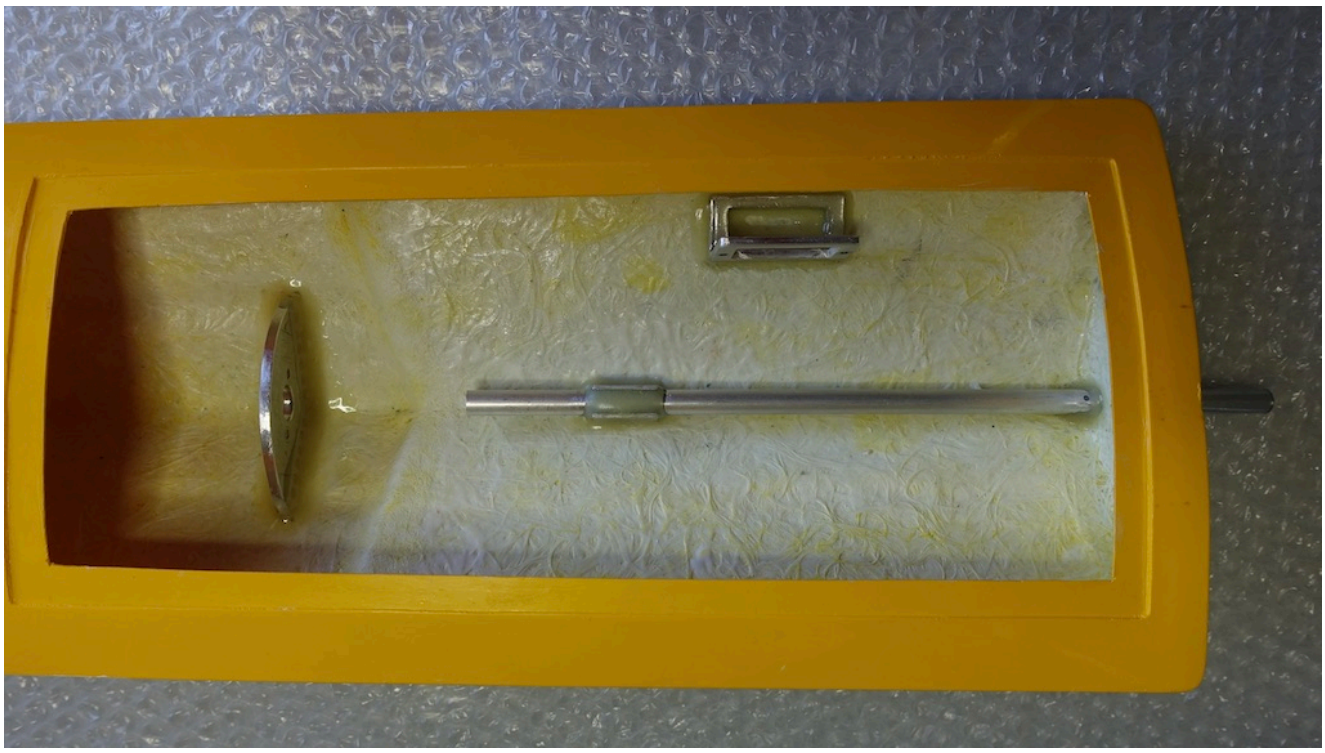
### Getting the balance point right
The large hatch provides good access to the inside of the hull which is spacious and uncluttered. So plenty of space for internal components and options for how they are laid out to achieve the desired balance point. For the boat to perform well it is important to have the balance point correct so where in the hull the main parts sit will determine the balance point. If this is wrong to start with it may be necessary to add weight to correct it which will have a detrimental effect on the performance. The maker recommends 180mm from the transom but we have boats in the club which run well at 200mm. It is clearly not critical and for this boat we will aim at 190mm.
All the main parts were gathered together and positioned in the bare hull approximately where they are expected to be fitted. Not forgetting the hatch cover. Any that couldn't be positioned easily, like the prop shaft were simply taped to the deck or hull in an approximate position. With all components in roughly the right place the balance was tested on a loop of string. This was a good time to decide exactly where the motor, batteries and ESC are going to be fitted as these heavier components have the most effect on the balance.

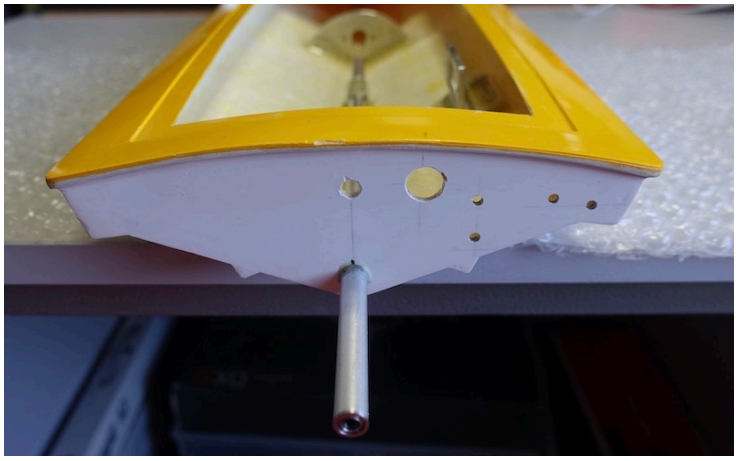


The parts were adjusted to achieve the desired balance point. Once positions were established the prop shaft and tube were marked up in preparation for cutting to length. The positions of the motor mount and servo mount were marked in preparation for fixing later.

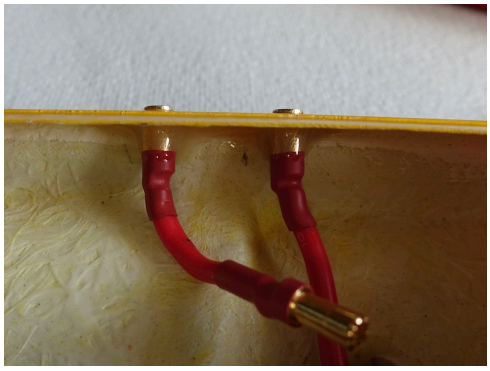
## Initial assembly

It is good practice to keep all parts clean and dust free and to abrade mating surfaces before gluing to provide a good key for the adhesive. Remove any mould release agent from the hull with a solvent. It is also advisable to ‘dry’ assemble all parts to check that they fit correctly and that the final positioning is correct before gluing in place.
Everything was removed from the boat and the prop shaft tube, prop shaft and motor mount prepared for fixing in place.
Fixing the drive line components accurately is important so it is worth taking care to make sure it is right. The peak of the step, the peak of the transom, and the bottom of the boss of the propellor, all need to be in line. The drive line parts minus the prop shaft tube were assembled. That is, motor onto mount, coupling connecting motor shaft to prop shaft and locking nut on the end of the shaft. A spacer with the same diameter as the propellor boss replaced the actual propellor. An estimate of where the hole in the transom needed to be in order for the correct alignment to be achieved was made and a hole the size of the prop shaft diameter (4mm) drilled in the transom. The drive line without the prop shaft tube was assembled in the boat. The boat was placed on a flat surface and weighted to hold the stern down with the peak of the step and transom in contact with the surface. The hull was checked to make sure it was level left to right and the position of the prop boss determined in relation to the flat surface. The boss spacer was high and so it was necessary to file the hole in the transom to establish the correct alignment for the shaft. Once this was done the hole in the transom was drilled to suit the outside diameter of the prop shaft tube. The prop shaft tube was then added to the assembly and the whole thing re-installed in the hull and the alignment checked again before final preparations for gluing it in place. The complete drive line assembly was glued in place and left to thoroughly harden. When properly set a prop shaft tube support was glued in place and allowed to set. Then the motor, coupling and prop shaft were all removed and a generous fillet of glue applied to all the joints, with a large fillet on both sides of the motor mount.





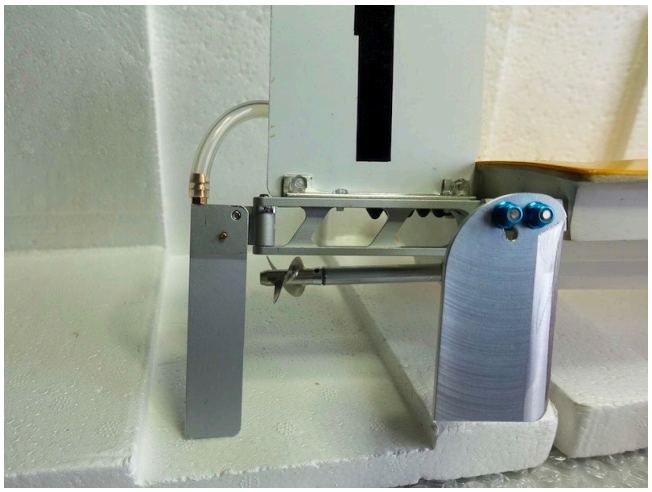
Once the glue was set the transom was drilled for mounting the rudder stand off, turn fin bracket, control rod break through and cooling water break through. The servo mount was then carefully positioned in relation to the break through and rudder arm before gluing in place.
When soldering connectors to electrical parts it is best initially to leave the wires long enough to allow some movement of battery & ESC. This applies to cooling tubes as well. When permanent positions have been established in testing the wires can be shortened to reduce weight & electrical resistance and the cooling tubing shortened to reduce weight.
All break through parts were then glued in place along with the sockets for the safety loop. Wires connecting to the battery plug and ESC plug were soldered to the sockets before gluing them in place through the deck from the inside. A generous fillet of glue was applied under the deck to provide support where the sockets break through because of the pressure that is applied when the safety loop is inserted.

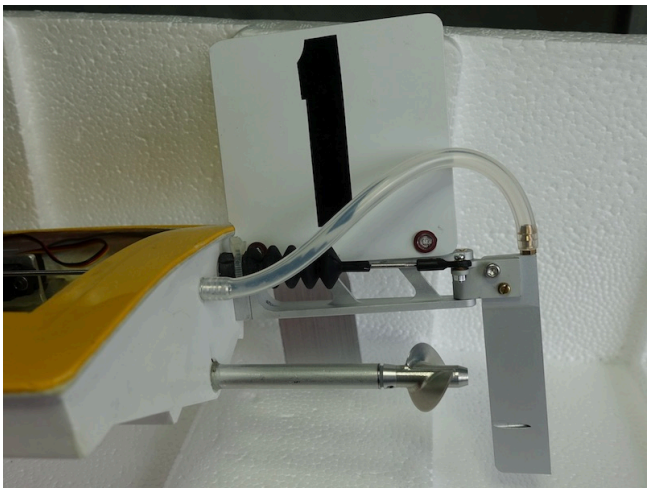


## Assembly

The hull was thoroughly cleaned inside & out with warm water and washing up liquid and allowed to dry before assembly could begin.
After all the preparation assembly started with adding buoyancy to the bow section of the hull and the hatch cover/superstructure. The radio receiver, ESC and motor were all

connected and tested on the bench to make sure everything worked OK and that the motor rotated in the right direction.
The drive line was then installed followed by the rudder and turn fin assemblies. The rudder and push rod assemblies were installed and connected to the rudder arm. The water cooling circuit was installed connecting to the ESC & motor cooling jacket before exiting the hull.



The ESC electrical connections were made and it was secured in place with Velcro. ESC & servo connections were made to the Rx which was secured in place with Velcro.
Securing the battery is a two stage process. The first is to position the battery as far left in the hull as possible and hold it there along its length. A length of aluminium angle was fixed in place for this. A temporary battery clamp, again of aluminium, secured the front end of the battery. This clamp is initially held in place with Velcro to allow backward and forward adjustment until testing has determined its permanent position. At that stage the Velcro will be replaced with a screw fixing allowing the clamp to be swivelled to one side for battery installation and then turned back again to hold the battery securely. There are various other ways that could be employed to hold the battery but this works well.

### Confirmation of racing weight & balance point

With the boat ready to race it was weighed on kitchen scales. At 1,402grams it is a little heavy but this will come down by about 50grams with weight saving activities like shortening wires and trimming any unnecessary materials have been done.
A loop of string was used to check the balance point which is 190mm from the transom as planned.

### Self righting test

The boat was prepared as if for racing and tested by inverting it in water and making sure the self righting action was positive and quick.

### Radio range test

The range test facility on the Tx was used to check that the radio equipment was working satisfactorily at the required distance.

### Fail safe test

With the boat motor running the Tx power was switched off to simulate a signal failure. As expected the motor was shut down soon after the signal was lost.

### Testing at the lake

It would be highly unusual for a boat to perform well on a maiden voyage. Even bought RTR or ARTR models still need some tweaks in order to make them suitable for racing.
So here we go !!!!!!

## Set Up and Testing

### Initial adjustments

The ESC remained on its default settings and was calibrated to the Rx.
The rudder was set vertical and at 90 degrees to the planing surface.
The turn fin was also set vertical and at 90 degrees to the planing surface.

### Cooling circuit
The cooling system was flushed through from the rudder forward to clear any debris and make sure there were no leaks.

### Self righting
The self righting tests were repeated at the lake.

### Maiden voyage
The first run was 2 to 3 minutes long starting slowly and advancing the throttle to run quickly while keeping the boat stable. The cooling water flow was checked during this phase and it was noticed that flow was reduced in right turns. This reduction in flow was not significant and evidently the water pick up on the left of the rudder was being slightly shaded from the water by the blade in right turns.
There was also a tendency for the boat to spin out if the right hand turns were too tight and at high speed.

### Temperatures
The boat was returned to shore and the temperatures of battery, ESC and motor were checked and found to be satisfactory.

### Leaks
There was a small amount of water in the bottom of the hull indicating a slight leak somewhere.

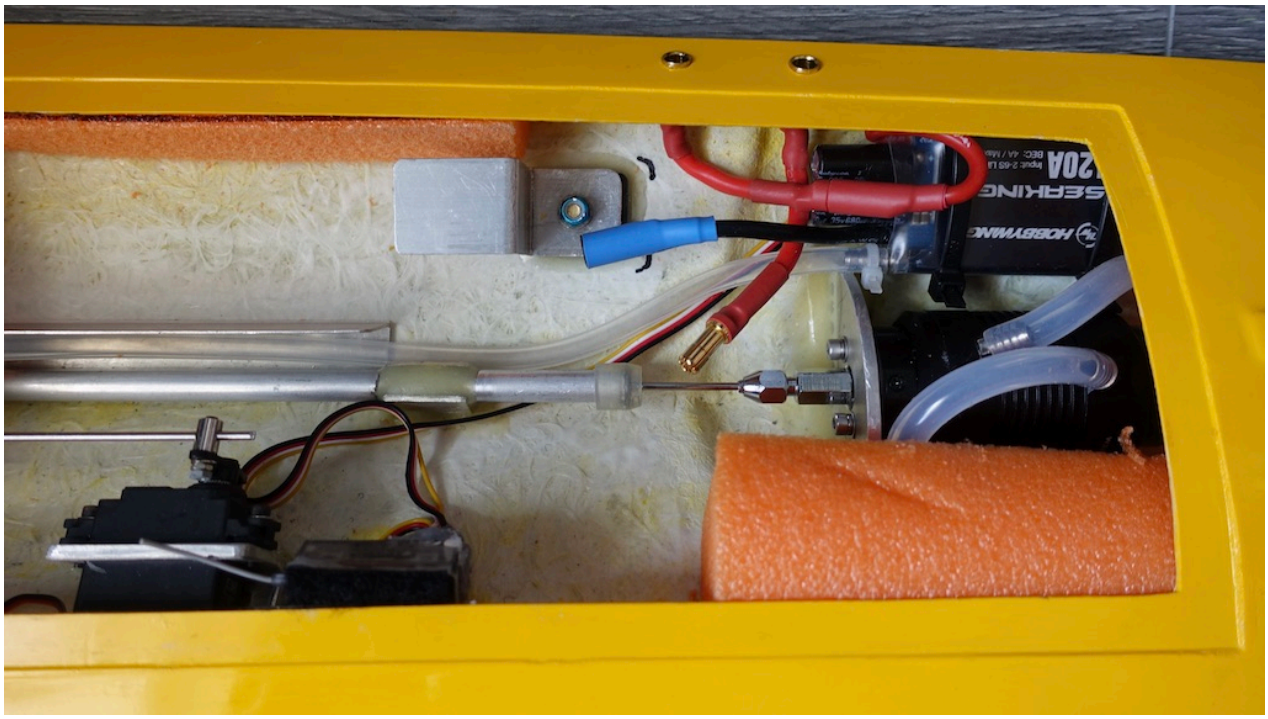
### Second run
The turn fin was angled to the left about 10 degrees to help stop the boat spinning coming out of the turns.
The boat was run longer this time and much closer to race speed. The turn fin adjustment had done the trick to overcome the spinning tendency but it did cause some rocking instability on the straights. This run was completed at near race speed for about 5 minutes. Again temperatures were checked and found to be OK.
So after the first outing there were a number of things to be addressed and tweaks that could be made.

### The leak
The prop shaft was removed from the boat which was taped up as if to race. A length of tube was connected to the prop shaft tube and the boat submerged while blowing down the tube to pressurise the hull. The leak was obvious immediately as air bubbles were released from around the turn fin mounting bolts. These had not been sealed because the turn fin would need adjustment as part of the set up. The screws were sealed with Blu-Tac which should seal and still allow adjustments.

### Cooling system tweaks
The rudder blade was replaced with a similar one but with the water pick up on the right. Fortunately there was a suitable blade available in stock. This change was not strictly necessary but it is preferable to have the cooling operating at 100% all the time.
Sections of the water cooling silicone tube were also replaced. Where the existing tube was required to bend sharply it was inclined to kink so to ensure there was no reduction in diameter and subsequent resistance to flow these sections were replaced with tube having a thicker wall.

## Fixings

Permanent fixing arrangements were made for the battery and ESC. The ESC was raised slightly from the bottom of the hull to help keep it clear of any water slopping around in the bottom of the boat.



## Reducing weight

The ESC/motor wires and the ESC/battery connecting wires were shortened as were the cooling water tubes.

The boat was then re-weighed and it had increased slightly to 1,418 grams. This increase was mostly the battery clamp fixings and the heavier cooling water tubing.

## Sealing the Rx

Once the final connections to the Rx had been made it was sealed with tape and silicone sealant designed for electronics. Enclosing in a Helium party balloon is a more affordable way to waterproof the Rx.

## Tweaks for racing

A balance between the turn fin position to stop spinning out and the tendency for it to cause instability will be found during further testing.

A timed run will be made to ensure the batteries will provide power for the full 6 minutes and 8 seconds of a race. Short of the race time would indicate a smaller propeller is needed. Longer than the race time would indicate a larger propeller and potentially increased speed.

## What next

Tuning a race boat is an on-going activity and future opportunities will be taken to make the boat lighter and to improve the handling.

After further testing the boat will be raced in the championship so look out for the yellow peril.

## Competition & Improvements

### More testing

The boat was run on the oval race course to establish if it was fast enough to compete and if it could run for the full 6minutes and 8 seconds race time. This was also an opportunity to look at the spinning out problem with a view to resolving the issue. The boat ran for well over the race time at a respectable pace. Fortunately spinning out did not re-occur and this was probably because the replaced rudder was 5mm wider than the original providing more resistance to sideways movement in the corners and subsequently reducing the tendency to spin out.

### More tweaks

The turn fin was reset to vertical and another run established that the handling was still good. Adjustments of rudder movement were made on the Tx to suit the drivers preferences. i.e. The end point adjustment was reduced to provide just enough movement of the rudder to allow a wide 90 degree sweep of the buoys and the trim was set to allow a slight drift to the left when the stick was in the neutral or straight ahead position.

### MTMBC Mono1 Championship Round 5

The best measure of a boats performance is to enter a competitive race because water conditions differ significantly between running the boat round an empty course and running in the wake and chop caused by other boats. These conditions effect the stability and power demand on the batteries so it is the only way to be sure the boat is competitive. It can also help to determine if there are any opportunities for improving performance.
The boat was entered into Round 5 of the MTMBC Mono 1 F/E championships and it came away with a best two of three race score of 58 laps and 19 seconds which was good enough to win Round 5 and demonstrate its competitiveness.

### Going faster

The % battery usage was measured after each race and all three race packs used between 50% and 60% of the total available battery capacity. This indicated there was much more power available which could be used to improve performance. The next test run was made with a 37mm diameter propeller instead of 36mm which increased the speed of the boat, so providing the boat is stable in race conditions, it should be faster and even more competitive.

### Conclusion

Building, setting up, testing and eventually racing this boat has been an interesting, enjoyable and ultimately rewarding experience. It has demonstrated that a competitive boat can be built for racing at the club for much less than half the cost of buying a commercial equivalent.
I hope it has offered some encouragement to members and that we will see more competitors joining the fast & exciting Mono 1 racing here at MTMBC.

If you have any questions please contact me by e-mail or telephone and I will do what I can to answer them.

**Hope to see you lake side**
**Dave Parker**

## Costings

VAT and postage has been excluded from most of the items purchased. Batteries have been excluded because these would be required for any boat that may be bought. The cost has been approximate £172.

# MTMBC Mono 1 Zoom 3

| Charateristic | June 2022 | Comment | Cost |
|---|---|---|---|
| Racing weight | 1,418 grams | A little heavy for a racing boat | |
| C of G | Between 180 & 200 mm from the transom | Try 190mm & confirm @ testing | |
| Motor Mount | 3.17mm Aluminium | Custom made from stock | £0 |
| Motor | 2968 3400KV 4 pole brushless with water cooling jacket | Gool RC From RC Fun Plus store @ Ali-express | £27.15 |
| Coupling | Collet 4mm to 2mm | Tilkiea store @ Ali-express | £7.43 |
| Prop shaft | 2mm wire drive 4mm stub shaft threaded M4. Tube ends 50 mm from transom. | Custom designed & made using Tenshock shaft | £13.07 + $11.33 ( £9 ) |
| ESC | 90A water cooled ESC with BEC | Flycolor from Tilkiea store @ Ali-express | £30.58 |
| Battery | 3 Cell Lipo 11.1V 5,000mAh 40C | Zippy Compact from Hobby King (Not included in costs) | £31.19 each |
| Battery fixings | Aluminium angle | From stock | £0 |
| Propeller | 36 mm Dia x 1.4 pitch | Tenshock CNC Aluminium | $16 (£13.50) |
| Rudder & stand off | 100mm stand off with 90mm long blade | Tilkiea store @ Ali-express | £12.80 |
| Rudder servo | Metal geared, ball raced, small servo | Hi-tec HS85MG Mighty Micro | £23 |
| Turn Fin | Aluminium fin and adjustable bracket | Custom made from stock | £0 |
| Push rod & breakthrough | 2mm rod. Ball link and stopper | Rod from stock, bellows & stopper from Sussex Model Centre | £3.24 |
| Cooling water break through | Aluminium tube | From stock | £0 |
| Cooling water exit | Aluminium tube | From stock | £0 |
| Cooling water tube | Silicone 4mm id 6mm od & 4mm id 7mm od | Ebay | £3.04 |
| Race No. bracket | Aluminium angle | Custom made from stock | £0 |