2025

Tasmanian Model Solar Challenge, version 7, August 2025

TMSC Car Kit Instructions

UTAS

TasNetworks

ENGINEERS AUSTRALIA

A Brief Introduction

Thanks to the generous support of Tas Networks, a free entry-level kit of parts is again available to those starting out in the 2025 Model Solar Car Challenge. It provides everything you need to put together a rolling chassis using only basic hand tools. The kit forms the basis of an entry into the Tasmanian competition and should give very good performance if assembled according to these instructions.

The aim of the competition is to design and build a solar powered car to travel around a purpose-built race track in the shortest possible time.

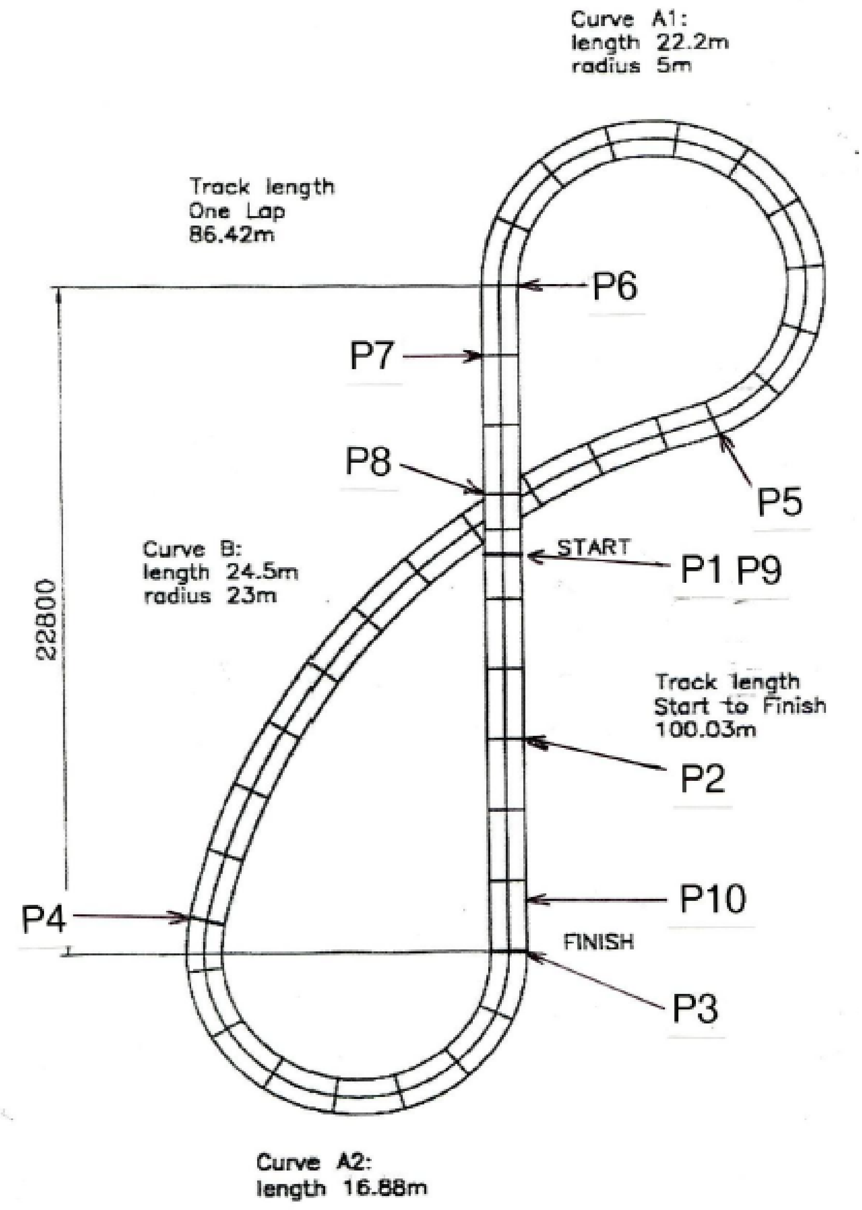


Figure: The main track is a 100m figure-8 and has 2 lanes for cars to race side by side

Participants are free to use any materials and technology but will need to conform to this year's rules and regulations. If you're looking to design the fastest possible car then you'll need to consider all of the physics and engineering at play. We'll cover a few of the basics here but students will need to do some further research if they'd like to delve a little deeper.

Top entries at the Tasmanian event will qualify for the Australian-International Model Solar Challenge finals and be given a chance to race against the fastest cars from around Australia and Taiwan.

Lightweight materials such as balsawood, polystyrene, styrofoam, cardboard, corflute, molded plastic, etc. are usually used for a car body. Teams are also welcome to make modifications to their kit parts or use only certain components in their own custom build.

The kit comes in either a 3 or 4-wheeler version and it's up to you to decide between the two options. 3-wheel cars experience less rolling resistance, tend to weigh less and usually have better drive wheel traction. 4-wheel cars are generally more stable when cornering and so are less likely to come off the track at higher speeds.

An example of something that's been put together using the 4-wheeler kit can be seen below:

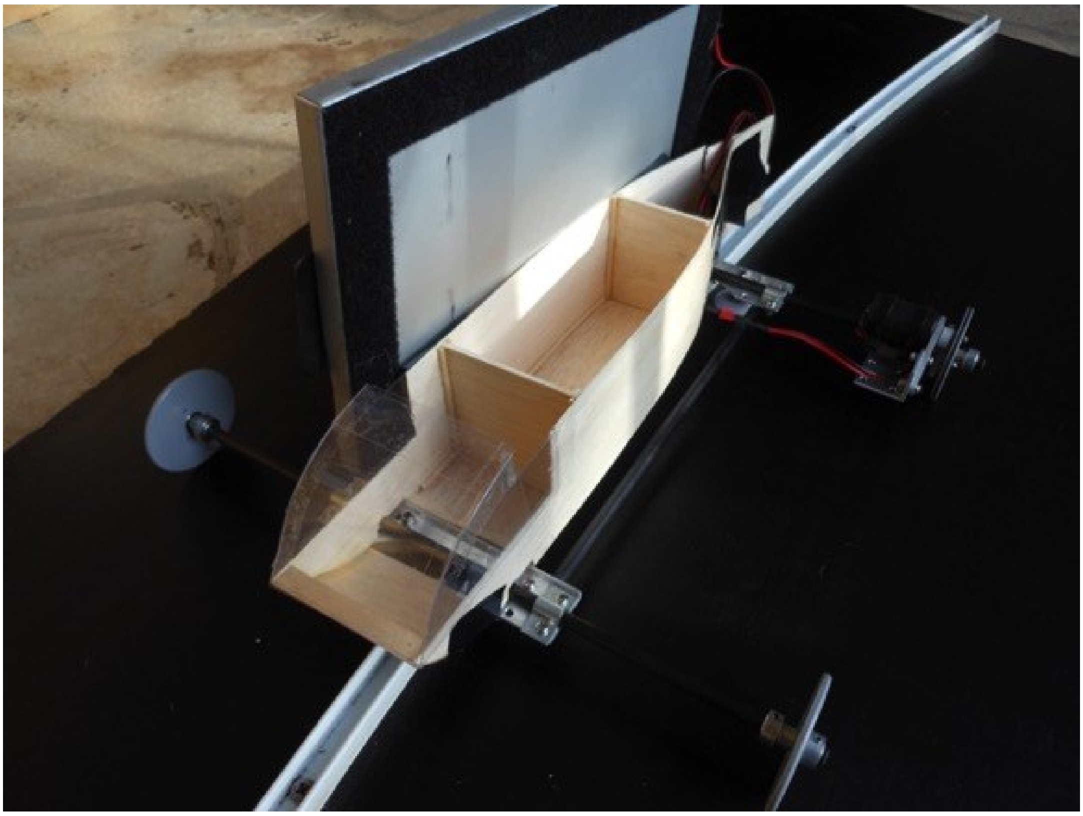


Figure: A 4-wheeler kit with an almost complete body made from Balsawood

A few additional photos plus some of a 3-wheeler can be found here:

www.facebook.com/tassolarchallenge/posts/385247532332267

And here's a short video clip of the 4-wheel car in action:

www.facebook.com/tassolarchallenge/posts/383239595866394

Be aware that these cars were designed and built to comply with either the 2018 or 2019 regulations. You'll need to come up with something different to comply with the rules in 2025.

2025 Rules

The main design specifications for 2025 are:

- The car must be no larger than 500mm long, 150mm high and 320mm wide.
- Cars must include a space to carry 20x ping pong balls.
- A space is also needed to seat a 4.5" wooden manakin driver.
- A minimum area of 150mm x 50mm is required on each side of the car for attaching event stickers.
- Teams can use their own solar panel or one provided at the event. All panel powers will be limited to 5.5W and any panel that weighs less than 240g will need to carry an additional weight to make up the difference.
- Cars must carry an additional 200g when racing with an electronic device that regulates the solar panel output (ie Automax or Picaxe solar panel controller).

Please download this year's full set of car rules at:

www.tassolarchallenge.org/regulations/

Figure: Designs in 2025 will need room to carry 20x ping pong balls

A Few Quick Car Design Tips

Some of the key areas to take into account when designing your car include:

- Weight - lighter cars have less rolling resistance and accelerate faster from the start line.
- Aerodynamics - more streamlined shapes are able to reach higher top speeds.
- Stability and Centre of Gravity - a lower CoG will reduce a car's likelihood of rolling over and coming off the track when cornering.

Check out the Tasmanian website or Facebook page to see many more examples of cars from previous events but remember that these have all been built according to a different set of design specifications.

Some Other Requirements and Information Before Getting Started

This kit will give you a rolling chassis but doesn't include the motor, electronics controller or solar panel. Some further information on these is given below.

Motor

The kit is intended to be used with a Faulhaber 2232 6V DC motor. This has been the top performing option for the last 20 years and you're unlikely to be competitive without one. The motor gets manufactured in Germany but you can source them here in Australia from Scorpio Technology ($133.64 each). They can be found in their solar catalogue here:

static1.squarespace.com/static/556646a4e4b0bda793faf918/t/68706ebfee4a7a40ce02be8e/1752198910782/2025_Solar_Catalogue_Jul25.pdf

Solar Panel

Participants have had to race with a very specific solar panel over the last few years. These were handed out by us at the event and consist of a Scorpio SOLAR26 solar panel mounted to an aluminium tray for protection.

We'll continue to have these available at our event in 2025 but teams are now also permitted to race with their own solar panel. Here we'll list a few of your better options but there will of course be others worth considering. The choice is ultimately up to you. The two most important things to look out for are that your panel should produce more than 5.5W and weigh 240g or less. If it produces less or weighs more then you'll be at a disadvantage.

1) The first option is to buy your own SOLAR26 panel ($117.10 each) from Scorpio Technology:

static1.squarespace.com/static/556646a4e4b0bda793faf918/t/68706ebfee4a7a40ce02be8e/1752198910782/2025_Solar_Catalogue_Jul25.pdf

This will give you the same power, voltage and current as the panels we hand out but allows you to decide on the type of backing, how to wire it up, connectors, etc. Your own panel with a flat aluminium backing will be much more aerodynamic than ours with the folded-up edges. Or no backing at all would mean your panel will only weigh approx 50g. You'd need to be very careful not to damage it in a crash but the advantage is that you can then carry the remaining 240g - 50g = 190g at a much lower point in the car and bring down its centre of gravity. Scorpio Technology test all their stock before shipping so you're guaranteed to be getting a good quality panel.

2) Kitesite SP60B ($65) and SP60F ($43) solar panels:

www.kitesite.com.au/schools/solarcars/solarpanels.html

These are similar to the panel from Scorpio but cost significantly less. They're marginally heavier but this doesn't matter as long as they're producing more than 5.5W. The SP60B version is the same voltage as the Scorpio panel so your car gearing will remain very similar.

The lower price of the SP60F also makes it worth a look but you may need to adjust your gearing slightly to account for the drop in panel voltage (from 7V down to 6V).

Both Kitesite panels are good quality options and the samples we've tested all measure in at over 5.5W. However they're not all tested by Kitesite so it can't be 100% guaranteed that they'll meet the advertised specifications.

3) Low-cost panels from eBay, aliexpress, Temu, etc. There are heaps to choose from but those with a white backing appear to be your best bet. These are relatively light weight and also use a softer encapsulation to help stop the solar cells from cracking with changes in temperature. Many annoyingly come with a USB port for charging up devices like phones or tablets but a few panels can be found with just the solder tabs. Our pick would probably be this 5V 800mA one from aliexpress:

www.aliexpress.com/item/1005009035448688.html

These are currently selling at a reduced price of $5.89 each and all the samples we've tested so far have been quite good. You would need 2x of these per car so the cost will come to around $20 per panel inclusive of the postage from China. This gives roughly 6x full car panels for the price of 1x from Scorpio. The aliexpress panel will give you a slightly higher voltage (10V instead of 7V) so you'll need to ratio your car gearing accordingly. If you were previously running with a 20-tooth gear on your motor then you would now need something closer to a 20 x (7V/10V) = 14-tooth gear for the same conditions.

Some more information on these panels can be found at the following facebook post:

www.facebook.com/tassolarchallenge/posts/pfbid02rzGdM9cpsEMw1VreL7rkpVgcGNKR1P1gQiuyW95k9es2PLEu1omjdxFJDuTAyLwTl

Electronics Controller

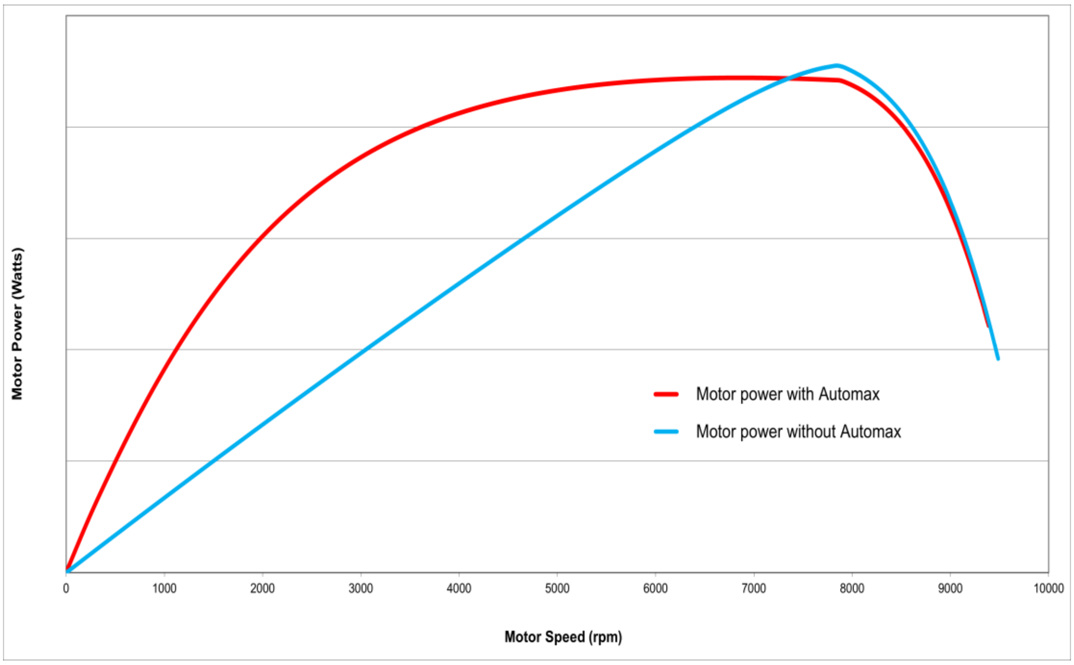


Figure: An electronics controller like the Automax isn't 100% efficient but enables the motor to deliver much more power over a greater range of shaft speeds (ie while the car accelerates from a standstill)

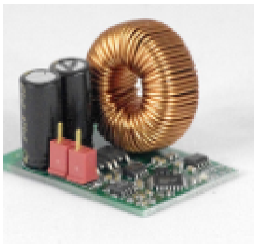
An electronics controller, often referred to as a maximum power point tracker, maximiser, optimiser, or starting-current multiplier, can drastically improve the performance of your model solar car. These give a big increase in motor power across a greater range of operation and are particularly helpful in boosting car acceleration from a standstill. They also don't need you to be as accurate with your top end gearing since there's a much broader power peak.

So using an electronics controller should be a no brainer, right? Not quite. Just to throw a spanner in the works we now require your car to carry an extra 200g if you choose to use one. It will be up to you to investigate whether it's worth the added weight and you'll most likely want to test both options. Teams will be free to choose between the two setups before every race.

We STRONGLY suggest everyone gets a controller even if you don't intend on using one. They make it much easier to get your car going, especially in changing weather conditions. The two options we recommend from Scorpio Technology are:

1. The Automax ($133.73 each). This board comes fully assembled and continually tracks the maximum power point of any connected solar panel.

2. The Picaxe 08M2 Solar Panel Controller ($30.61 each). This board must be self-assembled and soldered together but costs much less. It's a great lower cost alternative and provides students with an additional learning experience in electronics and circuit board assembly. Just be sure to ask Scorpio to send you the pre-programmed Picaxe chip unless you want to modify and upload the programming yourself.



AUTOMAX SOLAR MPPT

Code: AUTOMAX

AutoMax is a computerised Maximum Power Point Tracker.

This unit holds the solar panel's output voltage at its Maximum Power Point voltage regardless of the load conditions. Assembled and tested.

Includes Deans Micro plugs.

$133.73

SOLAR PANEL POWER CONTROLLER (SPPC)

Code: PICSPPC08M

The *PICAXE08M2 SOLAR PANEL POWER CONTROLLER* controls a solar panel's output voltage to its maximum power point voltage irrespective of load. This results in the transfer of all the available solar panel power to the load. Depending on the load characteristics this circuit can provide a significant multiplication of the current available from the solar panel into the load.

For a motor this means increasing its torque, especially useful when a car is accelerating from a standing start. This feature also allows a motor to start and operate at a much lower light intensity than is possible with the motor directly connected to the solar panel.

The unit automatically sets the appropriate control voltage on start up.

While it was specifically designed to operate with a Scorpio No. 26 Solar panel it will operate with any solar panel that has an open circuit voltage between 7.0 volts and 10.0 volts and a short circuit current between 0.1 amp and 1.0 amp.

PLEASE NOTE*: The PICSPPC08M2 is supplied with a blank PICAXE chip, that requires programming. A PICAXE download cable (PICUCAB) is required. Pre-programmed chips are also available on request when ordering.*

$30.61 (1-19); $28.47 (20+)

Figure: Scorpio's two electronic controller recommendations

You'll be fine if you use one of the Scorpio or Kitesite panels but if you decide to use the aliexpress one or something else with an open circuit voltage of over 10V then the Picaxe controller will need a few modifications to make it work. We cover this in a bit more detail in this facebook post:

www.facebook.com/tassolarchallenge/posts/pfbid07Nxw4ardFqPdFdY6nwUF2niGRvfiP7qGVkJGbNACtH9CVZEvJoQwpSH39FmrK4D7l

Scorpio also has some other useful electronic components such as connectors, wiring, heatshrink, switches, etc. as well as tools including side cutter pliers, wire strippers, soldering irons, multimeters, etc. These are generally competitively priced but will also be available from your local electronics supplier like Jaycar.

Kit Components

The following set of components are supplied in the kit. You'll become more familiar with these as you work through the assembly process. Some additional nuts, washers and bolts may be included as spares but we otherwise recommend getting them from somewhere like Nuts and Bolts Tasmania.

- 6mm Carbon Tubes (3x for the 3-wheel kit, 4x for the 4-wheel kit)
- Steel Saddle Brackets (6x for the 3-wheel kit, 9x for the 4-wheel kit)
- Aluminium Frame Brackets (front and rear)
- M3x8mm Bolts (frame assembly)
- M3x25mm Bolts (guide roller assembly)
- M3 Nuts (regular)
- M3 Nuts (Nyloc)
- M3x6mm Washers
- M2 countersunk screws (for attaching motor)
- A selection of 0.5 Mod plastic pinion gears for the motor (12-20 tooth)
- Aluminium Motor Mount Bracket
- 3D Printed Adjustable Motor Mount Plate
- M3 knurled thumb nut or axial thrust bearing (3-wheel kit only)
- M3x12mm Washers (3-wheel kit only)
- Retaining Collars (4x for the 3-wheel kit, 8x for the 4-wheel kit)
- Non drive wheels with bearings (2x for the 3-wheel kit, 3x for the 4-wheel kit)
- 1x Drive wheel with bearings, O-ring tyre and attached 56 tooth spur gear
- 4x Guide rollers with bearings
- 4x Guide roller spacers
- Multi-use tool (Spanner)

Please contact us at the Tasmanian Model Solar Challenge if you need any additional parts and we'll see what we can do to assist.

Assembling the Kit - The Frame

Start by laying out the carbon tubes, saddles, aluminium frame brackets, nyloc nuts, washers and M3x8mm bolts. The frame of the 4-wheel kit uses 8 saddles and 12 bolts, the 3-wheel kit uses 6 saddles and 10 bolts.

Figure: Parts needed to assemble the frame

The tubes come in 2 different types and lengths. The longer sections are a bit under 320mm (the maximum allowable car width) and intended to be used as axles. These are roll-wrapped and you'll notice a hatched pattern on them which helps reduce the risk of splitting when later attaching the wheel collars. The shorter sections are approximately 250mm long and used to connect the front and rear brackets. Fibers only run along the length of these and make them very stiff but more likely to split. Teams are free to design a car with a longer chassis but will need to source some longer tubes of their own. These are available from Scorpio Technology, HobbyKing, Ebay and many other online suppliers. Your local model hobby, kite or archery store may also stock tubes in this size or you can contact us at the TMSC for some possible extras.

The front and rear brackets are identical in the 4-wheel kit. The 3-wheel kit also has the same front bracket but the rear is a bit different. All are made from 12x25x1.6mm aluminium angle, where a small lip has been left to increase bracket strength. Face these lips upward and rotate the front bracket so most of the holes end up behind the axle. This moves the mounting point of the guide rollers behind the wheel centres and will help the car negotiate any misalignments in the race track.

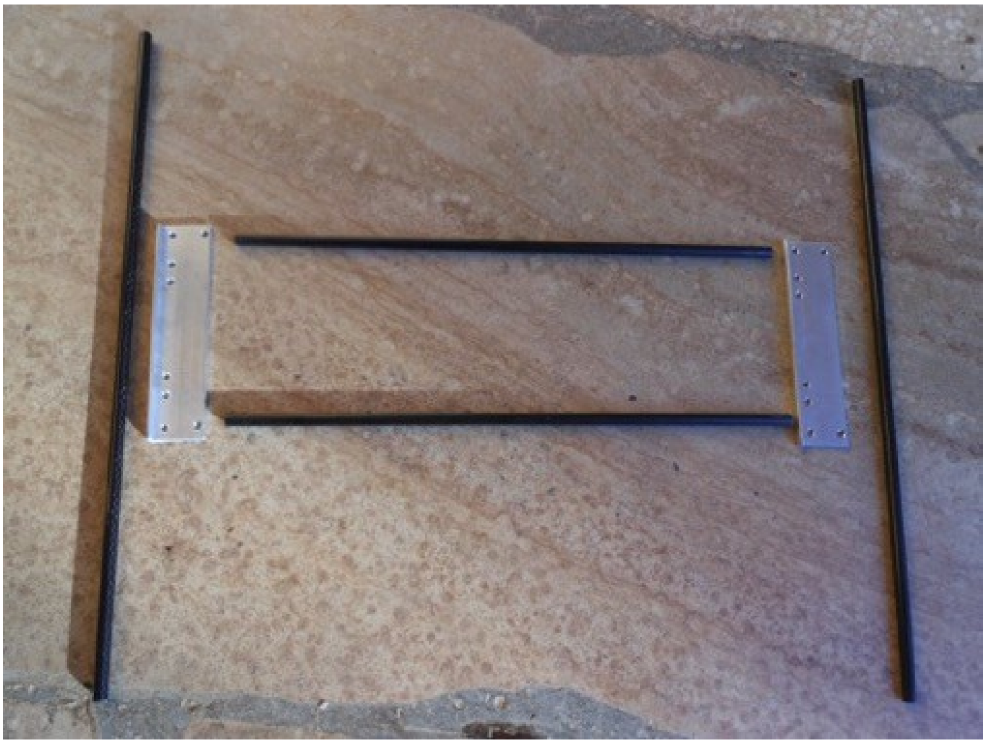


Figure: Frame layout of the 4-wheel kit (front is facing right)

Now start attaching the saddles to the aluminium brackets using the short M3x8mm bolts, washers and domed Nyloc lock nuts as per the upcoming images. Nylocs rather than regular nuts are used here to stop the frame from coming loose over time when racing. Lock nuts can initially be threaded on by hand until you reach the little nylon insert. After this you'll need to use a screwdriver and spanner or pliers to continue tightening.

Figure: The kit may include a Multitool Spanner, 2.5mm Allen Key and mini X-Wrench to assist with assembly

Perhaps the easiest way to get everything together is to forget about the carbon tubes for a second and just concentrate on getting all the saddles in position. If you don't tighten everything together all the way you can then still slide the tubes into place.

Figure: Assembled front bracket (top view)

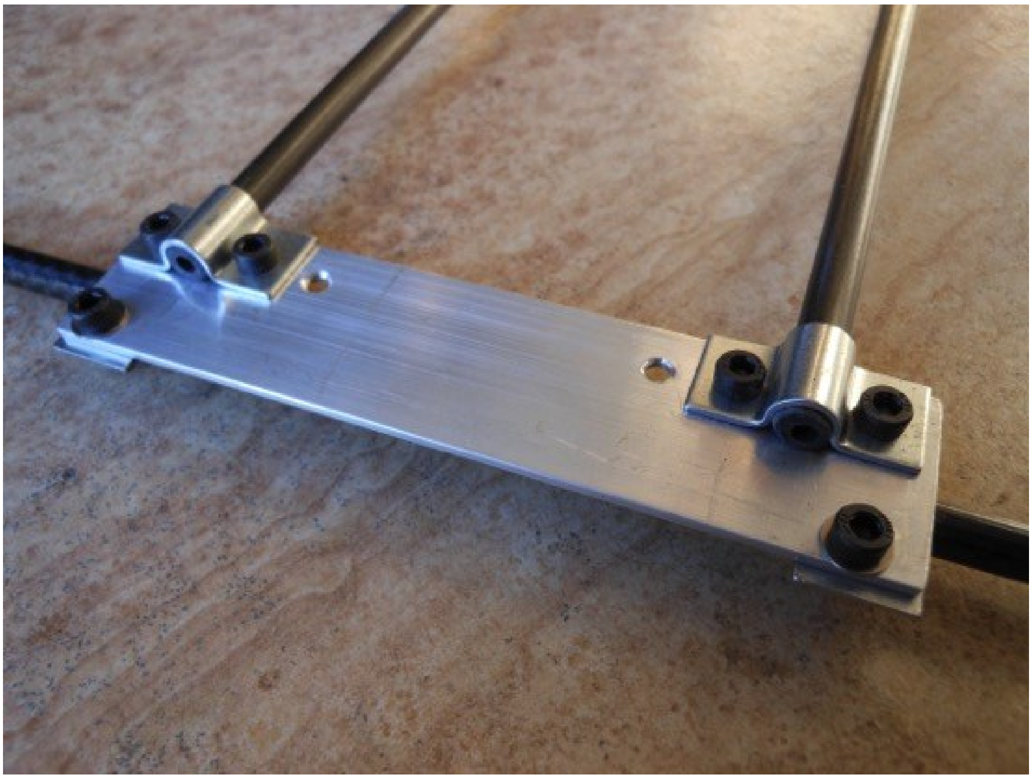


Figure: Assembled front bracket (bottom view)

The top and bottom saddles need to be arranged so they're at right angles to one another. If done correctly you should find that one of the bolts goes though both saddles at the corner where they overlap.

There's no need for a washer where the bolt heads or nuts rest up against the steel saddles but try and use one whenever they're going to be tightened up against the softer aluminium. If you look closely you should be able to see some washers being used on the previous page.

Begin tightening down the saddles with the tubes in place but be careful not to go so far as to start splitting the carbon fibre. Measure, loosen, make adjustments and re-tighten as you go to ensure everything ends up square. The front and rear axles should be parallel to one another (4-wheeler kit) or you'll create extra rolling resistance and energy loss. Make sure there isn't any twist in the frame before doing a final tighten.

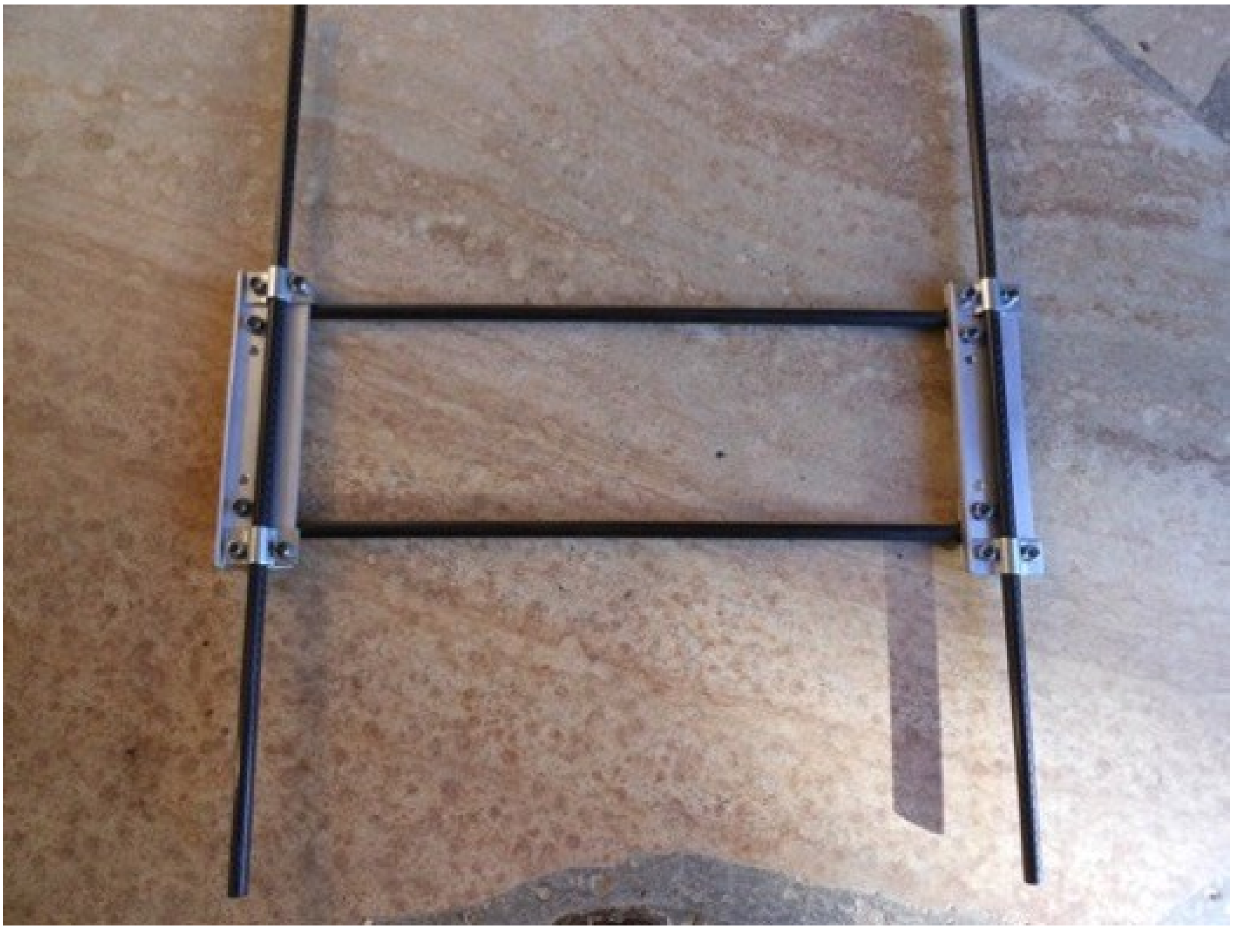


Figure: Assembled 4-wheel frame (top view)

There's a different rear bracket for the 3-wheeler and this can be seen on the following page.

Figure: Rear bracket of the 3-wheeler kit (top view)

Figure: Rear bracket of the 3-wheeler kit (bottom view)

That’s it, the main frame is complete! You can now start designing and building the rest of your car and car body. Just remember to read the regulations carefully to see what’s required in 2025. Some tips and information on body design are covered later in this document.

You’ll need to work out how you’re going to integrate or attach your car body to the frame. You might decide to glue it on permanently or make it removable using tape, rubber bands, cable ties, velcro, nuts and bolts, etc.

You can also go back and modify the frame if you like. We wouldn’t recommend cutting down the front axle for stability reasons but shortening the rear one and bringing the wheels in could be an option for teams working on a 4-wheeler.

You might even like to change the frame and brackets entirely. Students may like to look at how 3D printing could be used to reduce car weight to make it go faster. Some of the lightest cars we’ve seen at the Australian-International finals have used 3D printed components as part of their design:

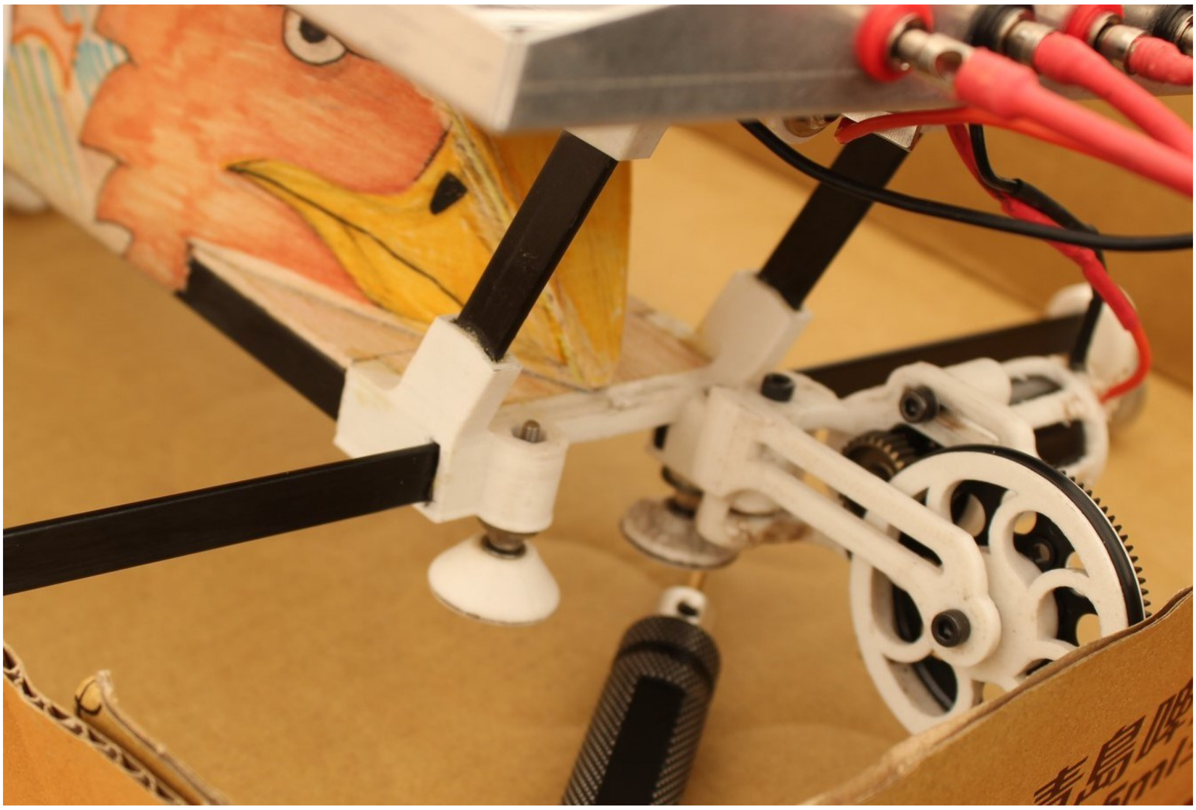


Figure: This car from Taiwan is just one example where 3D printed parts have been used to connect the frame together and give mounting points for the guide rollers

Please continue reading for details on attaching the rest of the running gear like wheels, guide rollers and motor assembly. These are best added at the end of your build once the rest of the car is complete. This not only makes the car easier to work on but also prevents parts from being put under any unnecessary stress during construction. It also helps reduce the chance of accidentally getting any glue on the gears or in your ball bearings!

Assembling the Kit - Wheels, Motor Assembly and Guide Rollers

The wheels, motor assembly and guide rollers can all be added to the car once the frame and body have been completed. There's no real order in which these should be attached so we'll leave this up to you.

Non-drive Wheels

Let's first take a look at the non-drive wheels. These are the same for both the 3 and 4-wheel kits. They don't need tyres and have a hard, smooth outer rim to help reduce rolling resistance and corner drag. Cars normally use tyres to grip the road for cornering but this isn't needed in the model solar challenge since our steering is done by means of a guide rail.

Figure: One of the non-drive wheels fitted between 2 collars

Each of the wheels come sandwiched between two flanged SMF106ZZ bearings. These bearings have an inside diameter of 6mm and slide onto the carbon tube axles. Two aluminium collars are used to lock each wheel into place, simply slide on the first collar, wheel and then second collar. The collars are fixed to the axle by tightening the little grubscrew using a 1.5mm Allen/Hex key.

There's a small lip on either side of the collar. This rests up against the inner race of the bearings and gives the collars some clearance from the outer section that needs to be free to spin.

Figure: The aluminium collars have a small lip on either side for bearing clearance

There's a small air gap inside the wheel, between the two bearings, so be mindful of this when securing the collars. You don't want to press them together too tightly and put unnecessary pressure on the inner race of the bearings. You also don't want the collars too far apart and have the wheels slide side to side along the axle. You might need to fix one in place first and then adjust the other a bit until you get the right spacing and the wheel spins nice and freely.

Brand new bearings come with grease inside to help protect against moisture and reduce wear over thousands of hours of operation. Model solar cars usually only run for 20-30 seconds at a time so we remove this grease to help minimise rolling resistance. Washing out the bearings is done with a dry cleaning fluid like White Spirits which then leaves behind a fine residue that acts as a very low viscosity lubricant. Teams sometimes give the bearings a spray with INOX or WD40 for extra protection but this shouldn't be necessary if stored in a dry room or container.

Drive Wheel and Motor Assembly - 4 Wheel Kit

Attaching the drive wheel and motor assembly is a little more involved. This part is where the 3 and 4-wheel kits differ the most.

First let's take a look at the 4-wheel setup. This requires the Aluminium Motor Mount Bracket, 3D Printed Motor Mount Plate, remaining steel saddle, nuts, washers and bolts.
Use the M3x8mm bolts, washers and nyloc nuts to fix the saddle to the bracket. Fix on the motor plate in a similar manner.

Figure: Motor mount bracket and plate assembly (view 1)

Figure: Motor mount bracket and plate assembly (view 2)

At this point you can then slide the whole assembly onto the axle. You can technically add it to any of the four wheel locations but we suggest putting it on the left hand side of the car. This makes the car drive forwards if the motor is run in its preferred clockwise direction.

In this example we've attached the assembly in the most common position (left rear). Fit the motor in place using the 3 small M2x4mm countersink screws and a small Phillips screwdriver. There are 6 threaded holes in the front face of the Faulhaber motor so you can rotate it around until you're happy with the position of the wiring.

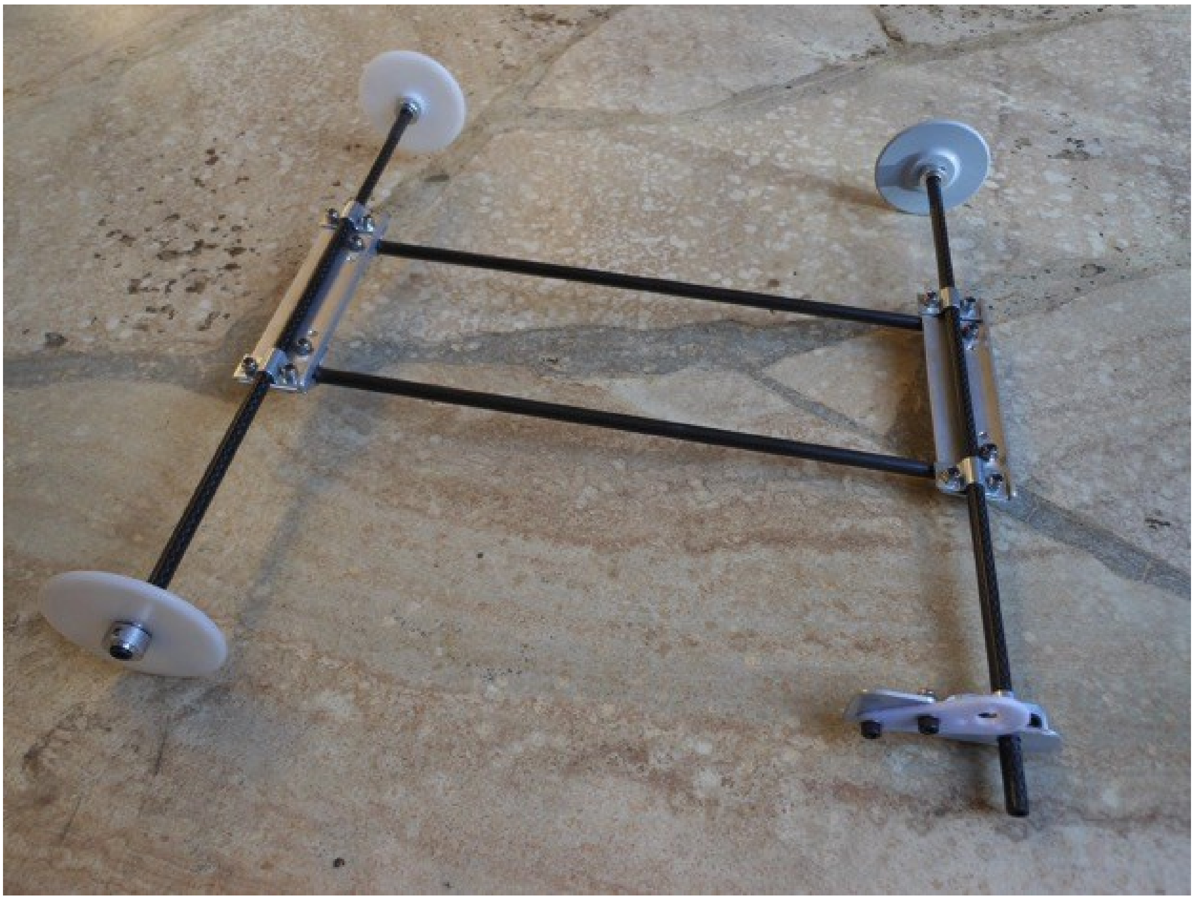


Figure: Motor mount assembly here has been positioned at left rear of the car

The next step is to carefully press the small pinion gear onto the motor shaft. You want as much of the gear on the shaft as possible but not too much so it's rubbing up against the mounting plate.

Now rotate the motor plate out of the way and slide on the first collar, drive wheel, then second collar. The drive wheel has a spur gear attached and also an O-ring tyre to help improve traction. Fix the collars onto the axle using the 1.5mm Allen/Hex key. Again, like with the non-drive wheels, be careful of the spacing between them. With the wheel now locked in place you can go ahead rotate the motor plate back down so the gears become engaged. Fasten it in position once you're happy with the mesh, there should be a very small amount of play between the gears so that the wheel is smooth to turn over.

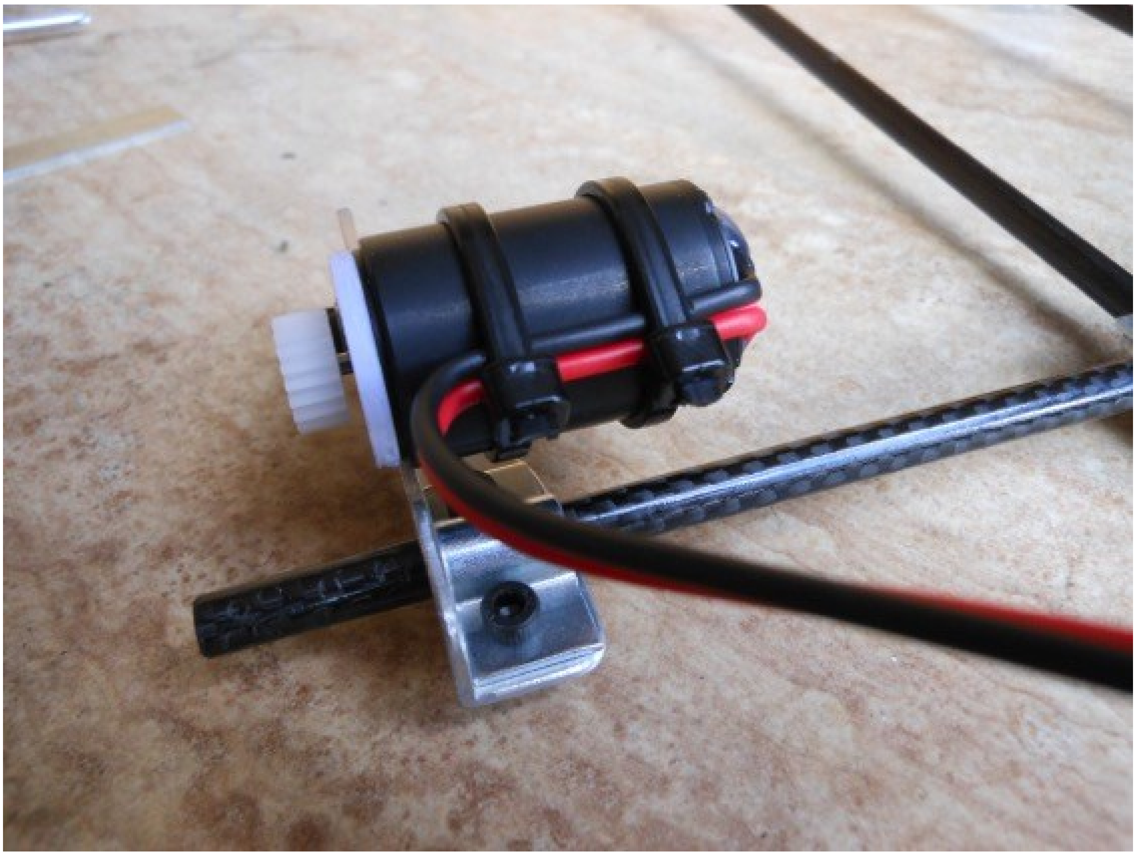


Figure: A small gap should be left between the motor gear and mounting plate

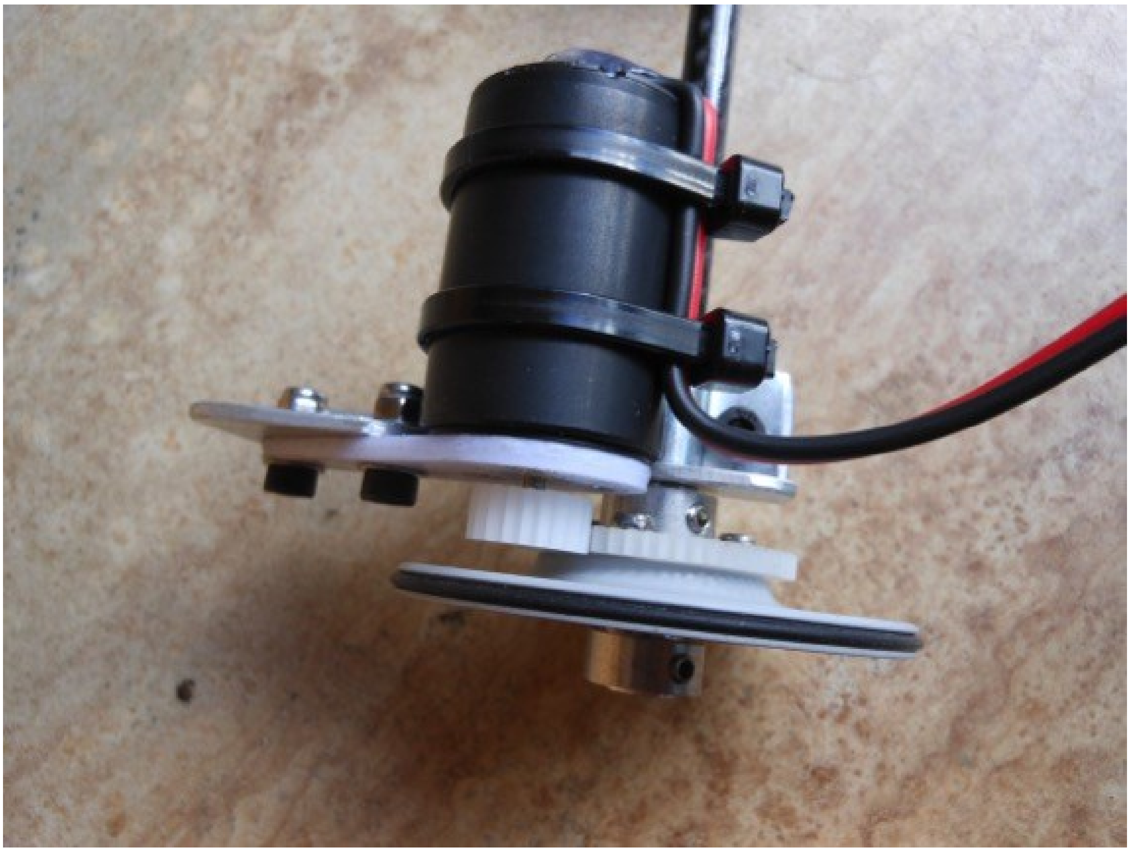


Figure: An example of the completed drive wheel assembly

Figure: The 4-wheel chassis with all wheels and motor fitted

Drive Wheel and Motor Assembly - 3 Wheel Kit

We've already seen that there's a completely different motor bracket for the 3-wheel kit. This comes attached to the rear frame bracket and is designed to be free to swivel from side to side for rear wheel steering. It pivots around a fixed M3x20mm bolt and usually has 2 nuts jammed against one another or a collar with grubscrew to stop the assembly from coming loose.

Either an M3 knurled thumb nut or axial thrust bearing and some M3x12mm washers are used to raise the swivel bracket and ensure the mounting position of the rear wheel matches the height of the front wheels.

Fit the motor to the 3D-printed mounting plate with the small M2x5mm countersunk screws using a small Phillips screwdriver. Remember to first rotate it around until you're happy with how the wiring comes off the motor. Now press the plastic pinion gear onto the motor shaft while being careful to leave a gap to the plate.

There's a 3mm hole in the swivel bracket for attaching the drive wheel. All drive wheels come attached with a default 56-tooth spur gear and you'll then need to switch between different motor gears for different gear ratios. Adjust the slotted motor mount plate until there's a nice mesh between the gears before tightening it in place.

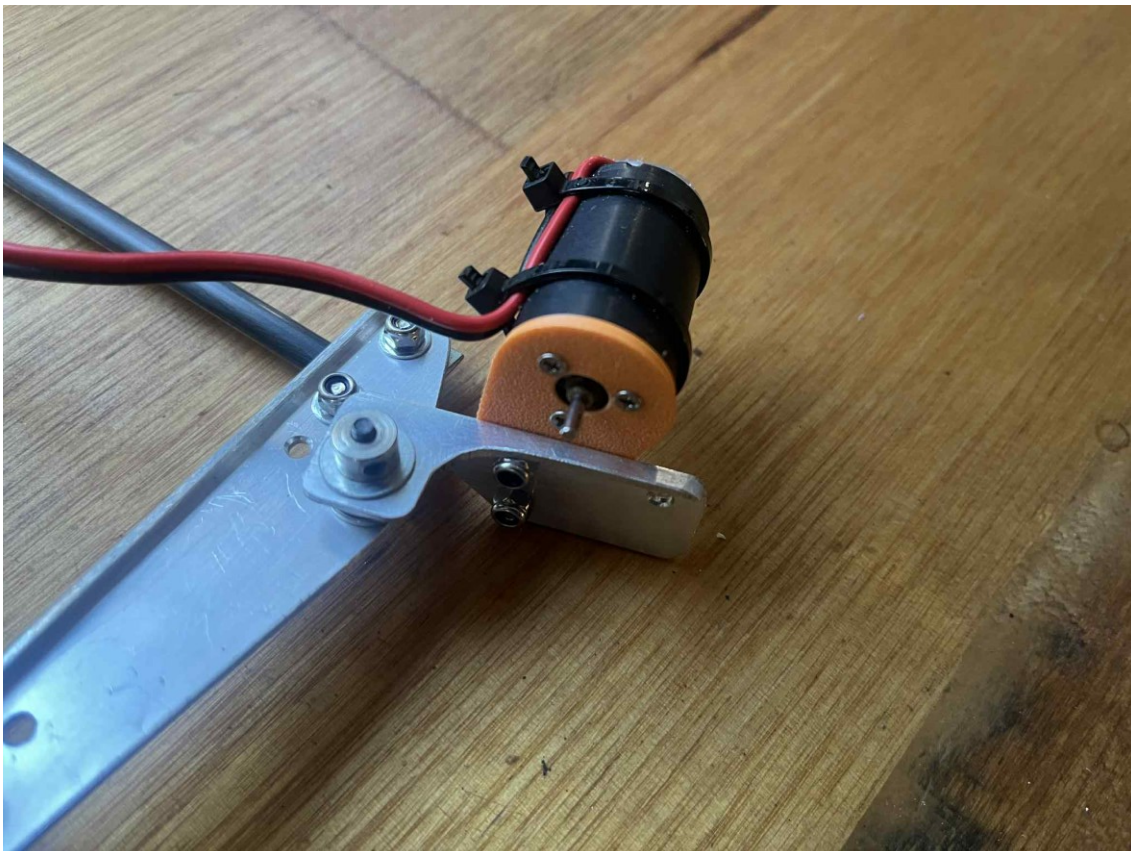


Figure: The 3-wheel swivel bracket with motor attached (top view)

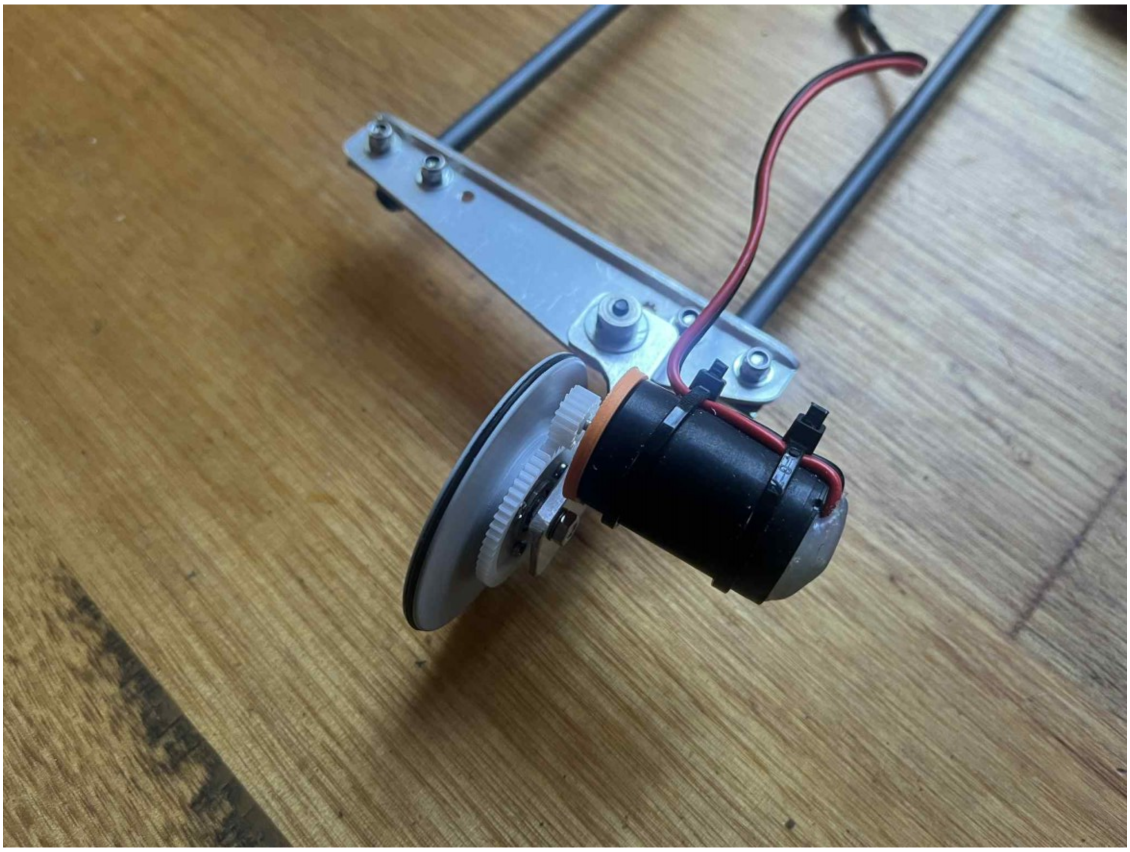


Figure: The 3-wheel rear assembly with motor and wheel attached (top view)

All regular drive wheels come with an O-ring tyre. These are especially important at higher sun levels as they help reduce the amount of wheelslip at the start of a race. Drive wheels without a tyre do have less rolling resistance, and can potentially improve car performance in overcast conditions, but this is only an option we sometimes offer the top teams heading off to the national finals.

An example of the final 3-wheeler setup can be seen below but please note that this image is of an older version kit with a slightly different rear bracket and drive wheel.

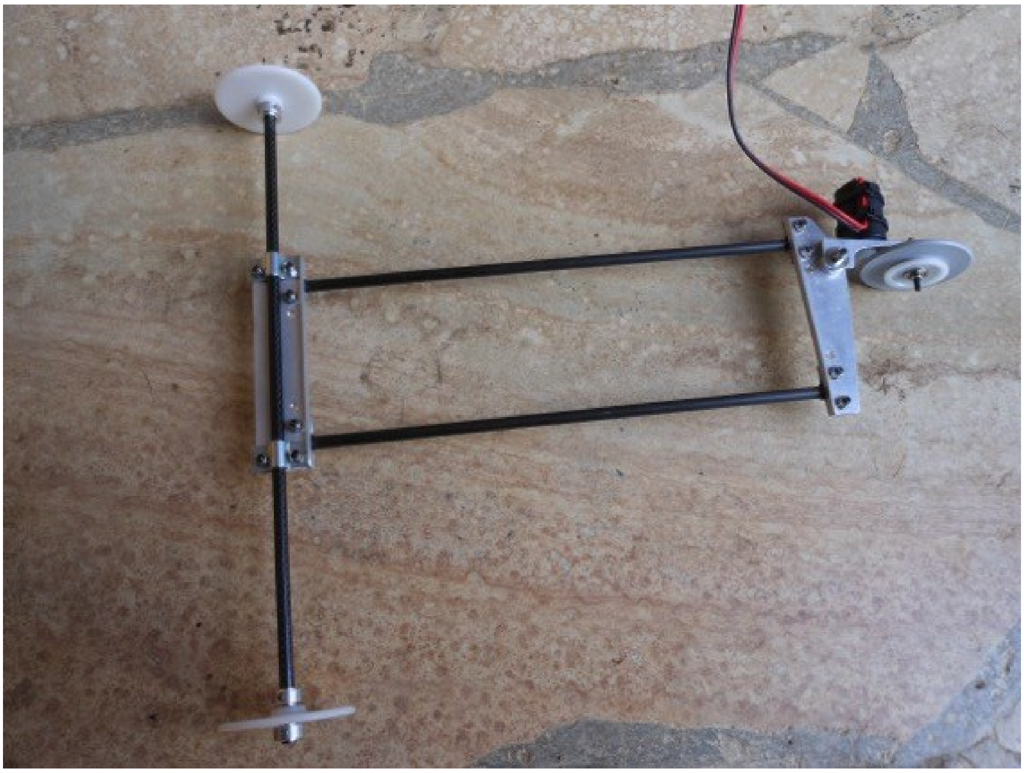


Figure: The 3-wheel chassis with all wheels and motor fitted

Guide Rollers

The last components to add are the guide rollers. A model solar car needs these to follow the guide rail and keep it on the track. It's a bit like a giant scalextric slot car but there's a rail instead of a groove.

To stop the car from spinning out we need some rollers at both the front and back and these are bolted to the frame using the remaining holes in the aluminium brackets. The mounting points have been positioned behind the axle and wheels when possible. This helps reduce the risk of catching them on any track misalignments.

The rollers themselves consist of a flanged F623ZZ bearing that's been glued into a thicker 25mm diameter wheel. This allows the head of the M3 bolt to be recessed up within the roller and gives a lower point of engagement with the guide rail.

The rollers are lowered to the track using aluminium spacers. This will get them much closer to where they need to be. Add extra nuts and washers to make any final height adjustments. An example is given in the image on the next page.

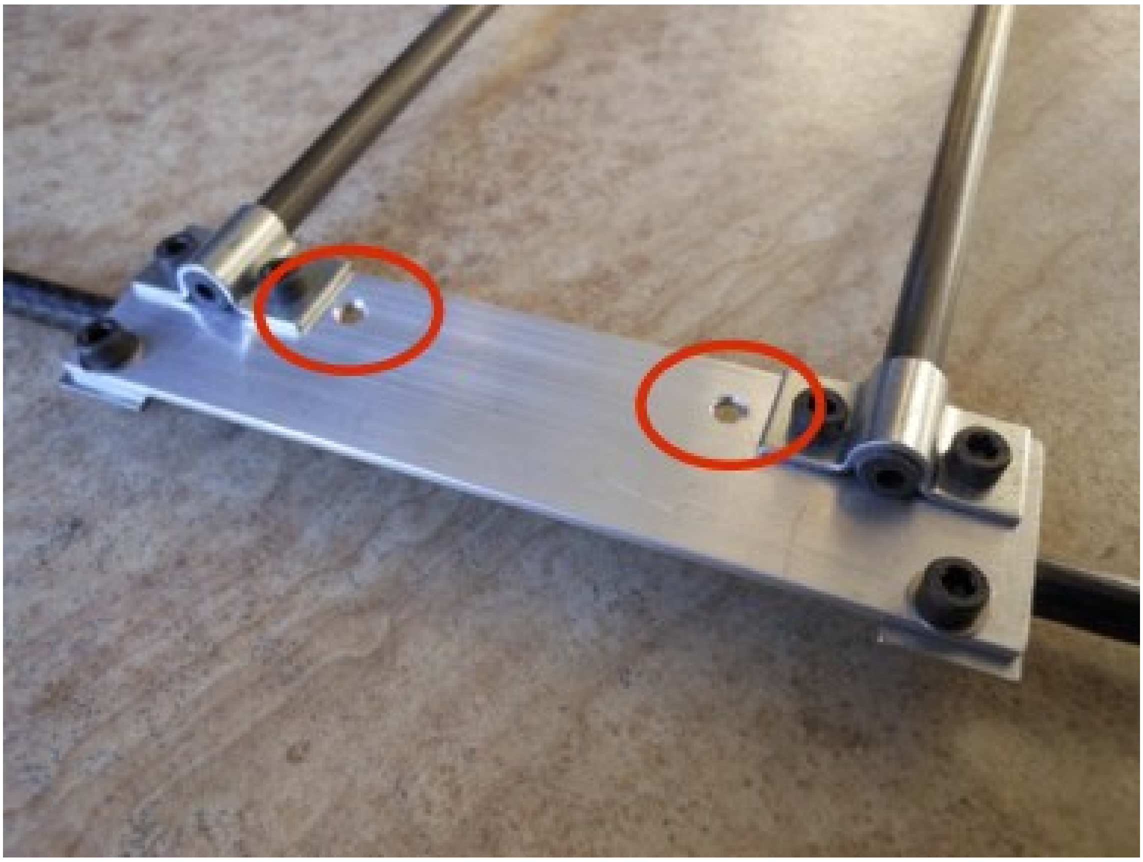


Figure: The guide rollers are mounted to the holes in the frame brackets from underneath

Figure: Each roller has a nut tightened against the bearing followed by a washer and aluminium spacer. This bolt goes through the mounting holes the front and rear brackets.

The kit should already come set up with the guide roller assembly but, if not, use an M3x25mm bolt, slip on the roller and tighten a regular nut against the bearing. Then slide on a washer before adding the spacer to help spread the load from the steel nut against the softer aluminium. Fix in place to the frame with a washer and nyloc nut.

Figure: Roller with nut tightened against bearing followed by a washer and Aluminium spacer

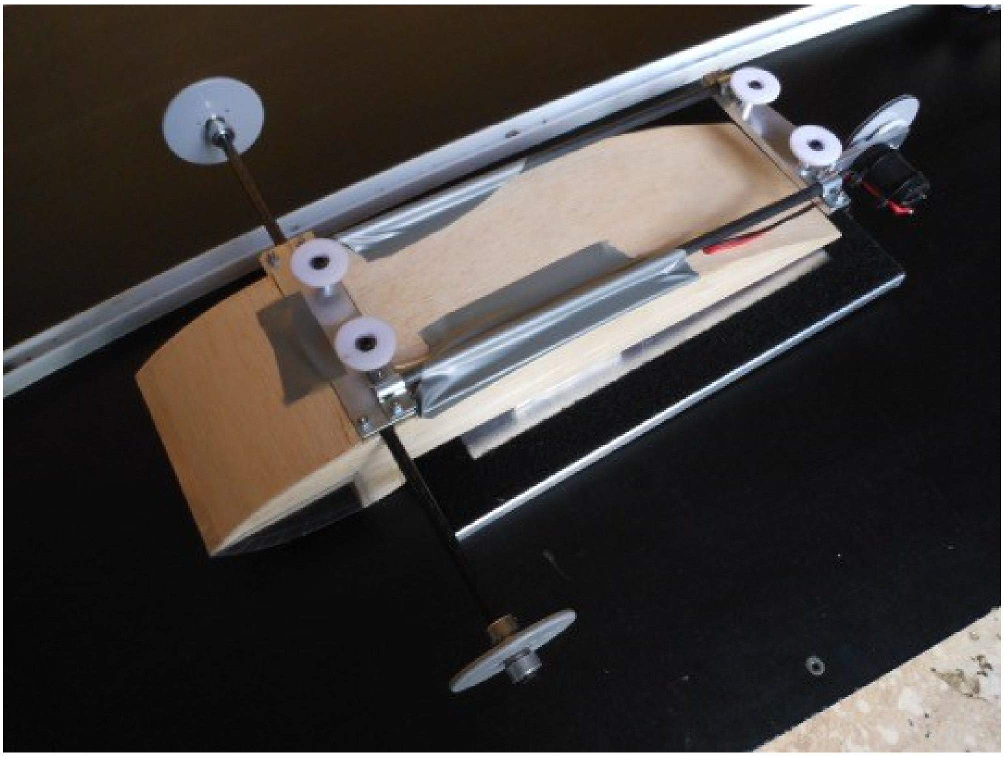


Figure: The 4x guide rollers fitted to the underside of the 3-wheeler frame

The height you need the rollers to be above the track surface will be pretty close if you attach them with the spacers we provide in the kits. A gap of about 3mm is a good starting point but you can still make minor adjustments by adding or removing washers or nuts. If set too low you'll risk scraping the rollers along the track but if too high the car will be more likely to disengage when cornering.

That's all there is to it! You should now have a car that's almost ready to go, just sort out your electronics and you'll be set to start doing a bit of testing.

Gearing

Older kits from 2019-2022 were originally designed to use one of 3 different gear ratios for varying weather conditions. They had either a 56, 64 or 72 tooth spur gear fixed to the drive wheel. The 56 and 72 tooth gears combined with a 20-tooth gear on the motor to give speed reductions of either 1:2.8 or 1:3.6 while the 64 tooth option combined with a 12 tooth gear on the motor to give a reduction of 1:5.33.

Newer kits from 2023-2025 now only come with a 56T spur gear but we instead include a selection of motor gears ranging from 20 teeth down to 14 teeth, sometimes even 12 or 10 teeth. If you're using a 7V Scorpio SOLAR26 or Kitesite SP60B solar panel then an 18 or 20-tooth motor gear will be a good starting point. These gears are best suited for racing in full sun but will still give reasonable performance in more overcast conditions when used with an Automax or Picaxe. Gears with fewer teeth will perform slightly better at lower light levels and it'll be up to you to test what works best in different conditions.

Figure: New kits come with a 20T, 18T, 16T, 14T and sometimes even 12T and 10T gears

The plastic gears need to be pushed onto the motor shaft. They've been used by many top Tasmanian teams but you need be very careful not to put excessive load on the motor shaft as this can start to loosen it. If this happens then you can still save the motor but only if you clamp the tip of the motor shaft in a vise and use a flat-bladed screwdriver to lever the brass bush/collar back along the shaft.

A safer way of making adjustments is by using metal gears that are fixed to the motor shaft using a small grubscrew. Scorpio Technology has a range of such brass pinions from 11T up to 20T and schools are free to purchase them to use with both our 3 and 4-wheel kits. These are however very expensive (approx. $25 each) so we're currently investigating some other options for considerably less.

Figure: Scorpio stock a number of different brass motor gears that you can upgrade to

Please contact us if you're looking for some alternate gears or your motor shaft has started coming loose (can slide in/out) so we can give you a few more details to help fix the issue.

Simulator

Testing your car on the actual race track is the best way to determine the optimum gear ratio for different weather conditions but you can already get yourself in the right ballpark by doing some calculations or using our MS Excel-based solar car simulator. This is can be downloaded from the following link:

www.tassolarchallenge.org/tmsc-kits/

The simulator uses dynamometer data from a 7V Scorpio SOLAR26 solar panel and you can have a play around with numerous parameters including what gear ratio might work best at different light levels. If your car is using a different voltage solar panel then you can still use the simulator but will need to ratio the gearing to suit your setup. In other words, if the simulator says a 20-tooth gear will give the best result then this would equate to around a (7V/10V) x 20T = 14 tooth gear for a 10V aliexpress panel at the same solar intensity.

Car Electronics and Wiring

With the chassis of the car now sorted we can shift our focus to the electrical system. Teams will need to wire up their motor, ON/OFF switch and connectors as well as solder together the electronics board if using the Picaxe 08M2 controller. You'll also need to wire up the solar panel if you're going to race with your own.

A Quick Word on Electronics Units

It's strongly advised that all teams give themselves the option of using either an Automax or Picaxe08M2 electronics unit. These improve the overall performance by getting the most power out of the solar panel at all times. This results in better car acceleration and superior performance across many different light conditions without having to constantly change gear ratios.

You do not need to carry a 200g weight penalty if you choose to race without such a board but you'll need to be very good at selecting and changing gear ratios to suit the weather. If you get it wrong then the performance can be much worse so we recommend all teams have one to fall back on.

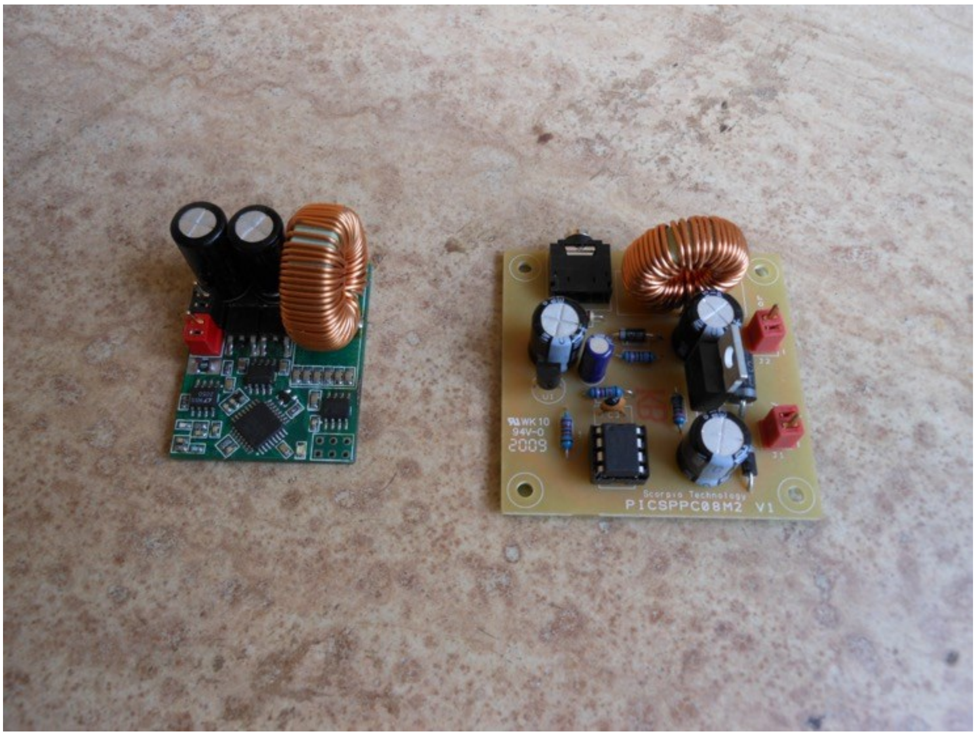


Figure: The Automax (left) and Picaxe08M2 (right) side by side

The Automax should, in theory, be slightly more efficient overall but real-world tests have shown there to be very little difference between the two. Some more information on this can be found at the following facebook post:

http://www.facebook.com/tassolarchallenge/posts/pfbid0KWWRpDhSg3z4fCq5KbGPkQv1iZxUivaXCXB6Ya2bqAMStimnsyf1fnSLhsGjNrpKl

The main advantage of the Automax is that it continuously tracks the maximum power point of the solar panel and so better deals with it moving around due to changes in panel temperature or shading. The Picaxe simply estimates this point on each start up by measuring the open circuit voltage of the panel. This estimate normally gives very good results but teams need to make sure there's no accidental shading of the solar panel when turning the car on.

Overview of Car Wiring

The overall wiring of a model solar car is in fact quite simple but don't stress out too much if you're having a few problems with it. Soldering does take a bit of practice to master. We'd like you to have a go but please get in touch if you're having any issues. We want to see all cars performing at their best!

A basic car wiring example is given below with one of our competition panels, a switch, Automax and motor. If you're putting together your own panel then it will likely be similar but you're free to use any type of backing, wiring and connector you like. Please note that the on/off switch is not allowed to be permanently attached to the panel.

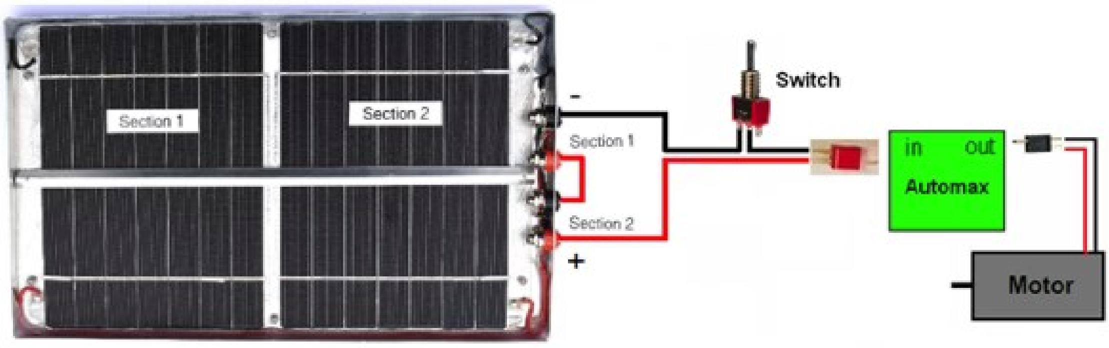


Figure: A typical wiring diagram of a model solar car

4mm banana plugs are needed to connect our solar panels, as per section 6.5 in the regulations, and we supply the small link joining the 2 sections in series at Tasmanian events. You don't need to use banana sockets on your own solar panel and can use a different type of connector altogether. Deans or micro deans are a good option if they're the original brand name ones but the low-cost imitations can sometimes be a bit problematic. We'd otherwise recommend having a look at a JST-type connector.

Both the Automax and Picaxe08M2 circuit boards come with imitation micro deans connectors so you can't really avoid using them here unless you substitute in some replacements. One of these attaches to the motor wiring while the other to the wiring from the on/off switch. These are generally fine but we have seen cases where the connection isn't great and cuts in/out so keep an eye on this.

The male pin on the micro deans connector should be connected to the negative terminal of the motor to make it spin in the direction intended for this kit. Connecting it to the positive terminal will instead make the motor spin in the opposite direction and cause the car to run backwards.

There have been cases where the terminals of Faulhaber motors have accidentally broken loose or ripped out. To minimise the risk of this happening it's recommended that the wiring is cable tied or taped to the motor as shown on the previous page. Some hot glue over the terminals is also an extra precaution after completing your soldering.

Figure: A Faulhaber motor with wiring and micro deans connector attached

A simple toggle switch is available from Scorpio or you can grab one from any local electronics store like Jaycar. A switch usually comes with 3 or 6 terminals (2 independent rows of 3) and will connect the centre terminal with one side or the other depending on the toggle position.

Be sure to insulate the underside of the Automax or Picaxe unit if they're going to be resting on or up against something conductive. You don't want it accidentally shorting out and damaging the circuitry. Some gaffa or duct tape will work just fine.

Heatshrink tubing is a neat way to further secure and insulate any solder joints at the plugs or switch. Scorpio stock some of this or you can get lengths of various diameters for a few dollars at Jaycar.

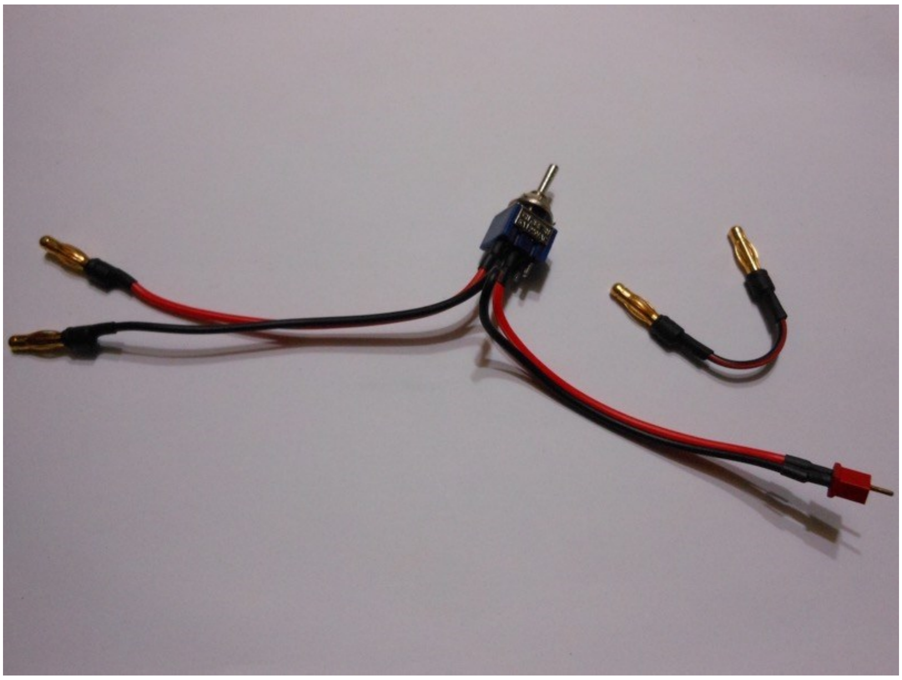


Figure: A wiring harness that will work with our event panels using banana plugs

Try and avoid any excess car wiring. Having cables bunched up and much longer than required not only creates a mess but adds unnecessary weight and increases wiring resistance. It's also a good idea to use red (+ve) and black (-ve) wiring for circuit polarity to make things easier to follow.

Assembling and Setting Up the Picaxe08M2

The Automax is good to go straight out of the box but teams will need to assemble and solder together the Picaxe08M2 themselves. This includes the printed circuit board, components and some detailed instructions on how to put it all together.

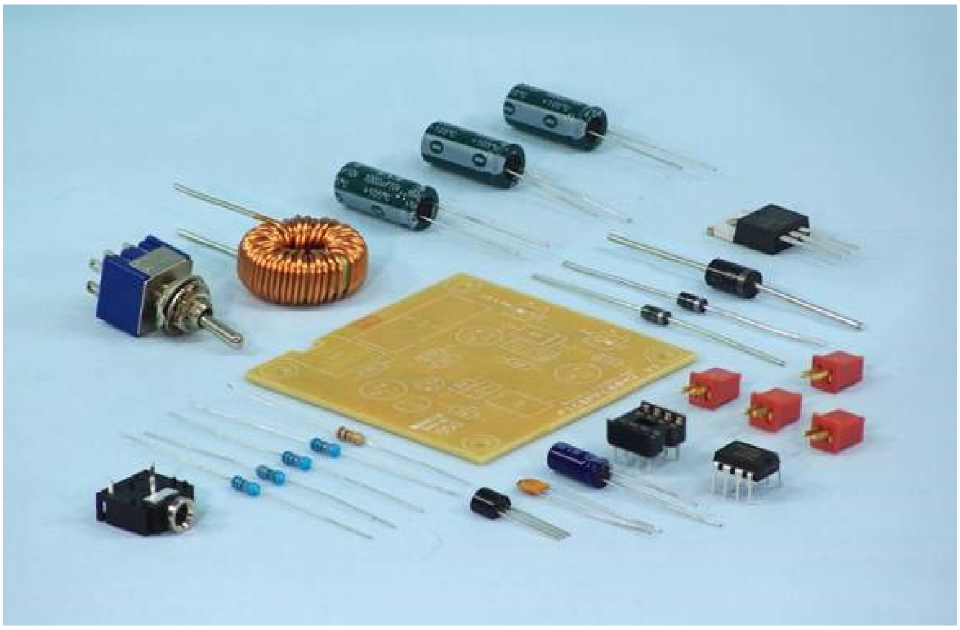


Figure: The unassembled Picaxe08M2 out of the packet

You'll need a soldering iron, solder and some side cutter pliers to snip back the component legs after soldering. Many high schools will already have these tools available but those that don't can source them from either Scorpio or their local electronics store. Please contact us if you'd like some further advice on what to get.

If you've never done any PCB soldering before then you might like to check out a YouTube video or two before getting started.

Please remember that if you're going to use a solar panel that's over 10V then you'll need to modify some of the Picaxe parts as follows:

www.facebook.com/tassolarchallenge/posts/pfbid07Nxw4ardFqPdFdY6nwUF2niGRvfiP7qGVkJGbNACtH9CVZEvJoQwpSH39FmrK4D7l

Solar Panel Wiring Configuration

You can find some information on how to wire up your own solar panel in either series or parallel (or both) in a pdf file at the following link:

www.tassolarchallenge.org/tmsc-kits/

This is aimed more for the boats as there's also some propeller data included but all of the panels we recommended on page 5 can be wired up in a similar way. You'll only need to run them in series for most of the time in the car event but the parallel option may come in handy at very low sun levels.

Car Body Design and Final Considerations

We've so far only really covered chassis assembly and looked at the electrical system. If executed well this will give you the foundation of a competitive car. Designing and building the rest is completely up to you.

Not only should you try and keep your design as light and streamlined as possible but you should also think about your centre of gravity and weight distribution. The placement of the solar panel and any extra weight you need to carry in the car will affect its stability and drive wheel traction. Please see the 2025 regulations for all your design requirements for this year. The size and weight of our solar panels are specified there if you're not going to make up and race with your own.

Common materials to use for the body include balsawood, corflute, various types of styrofoam and vacuum moulded plastic, just to name a few. You can also use recycled goods such as plastic packaging, cardboard, polystyrene, etc. Keep in mind that anything used should be or made water resistant if possible. You don't really want the car soaking up any water if it happens to rain during an event.

3D-printed body parts are also a real option these days. Printing out an entire body/shell may even be possible on a large enough printer but likely to be quite heavy unless the wall thickness is kept very thin. Consider researching and testing some different ideas before settling on the final design and materials.

Looking at Newton's Second Law (F = ma) we know that a lighter car will take less time to accelerate from the start line. Less mass also reduces rolling resistance, both in a straight line and around the track corners. All else being equal, a car is typically half a second slower for every extra 100gm it has to carry in a 1-lap race. This equates to several metres at the finish line at higher sun levels. This has even more of an impact in overcast weather where every extra 100gm can easily make a difference of more than 1 second.

Most of the total drag on a model solar car travelling at top speed is made up of air resistance. This makes streamlining critical when attempting to reach the fastest speed possible. There are two areas that teams can influence when designing their car aerodynamics. These are

1) the frontal/cross-sectional area and
2) the coefficient of drag

Both variables can be seen in the drag equation below:

$$F_D = C_D A \frac{\rho V^2}{2}$$

where
F_D is the drag force
C_D is the drag coefficient
A is the reference area
ρ is the density of the fluid
V is the flow velocity relative to the object

The 2025 regulations require cars to have space for 20x ping pong balls and these are allowed to be arranged in any way. Participants should therefore look at designs that keep down the cross-sectional area as much as possible. Cars that are much higher or wider than required will experience more air drag and end up having a slower top speed.

Body shape and the resulting coefficient of drag is even more important as illustrated below:

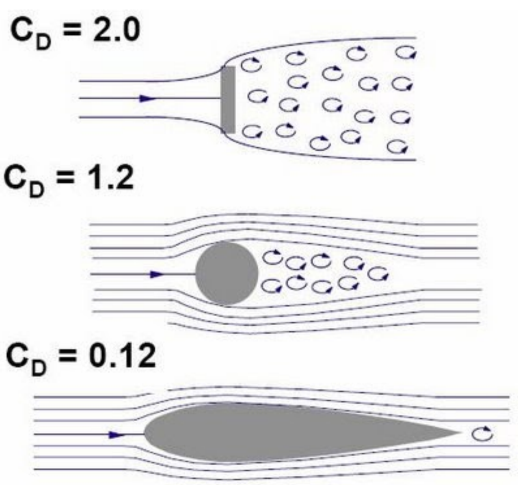


Figure: Typical drag coefficients and flow around a flat plate, circle and symmetric airfoil

All three of these objects have the same frontal area but experience a completely different flow when pushing through the air, the less turbulence the better. The coefficient of drag is given alongside each shape where the flat plate has almost 17 times more drag than the airfoil!

Because model solar cars also have other things like the solar panel and outlying wheels, guide rollers, motor, etc. all affecting air flow you'll find that the difference between a square box and airfoil-type car body won't be quite as extreme as above but it's still significant. All else being equal, the difference between poor and excellent streamlining can quite easily produce more than a 10m variation at the finish line of a 1-lap race.

Summing Up and Further Help

The main purpose of this file has been to provide assembly instructions for the 2025 TMSC car kit. Some other information has been included to hopefully help you design and finish your car for race day.

Some of the simplest cars with bodies made from cardboard and sticky tape can be put together in just a few hours. More complex designs can easily take over 10 hours, even 100 hours if starting from complete scratch, drawing up CAD designs, making up custom parts, moulding carbon fibre, etc.

For further information and more in-depth details on car design, solar panels, motors, gearing, etc. please head on over to the Tasmanian or Victorian state websites or facebook pages. There's plenty of pics of cars from previous years and a lot of other good stuff hidden away that may assist you. Ian Gardner's Design Guide pdf offers a comprehensive read for those that want to get their teeth stuck into some of the more technical aspects.

Or feel free to contact us at the TMSC. We're more than happy to answer any questions about the rules, kits or to assist with anything else. We can often even send someone along to your school if you need a bit of extra help getting started.

Good luck with your car and we look forward to seeing you on race day in Term 4!