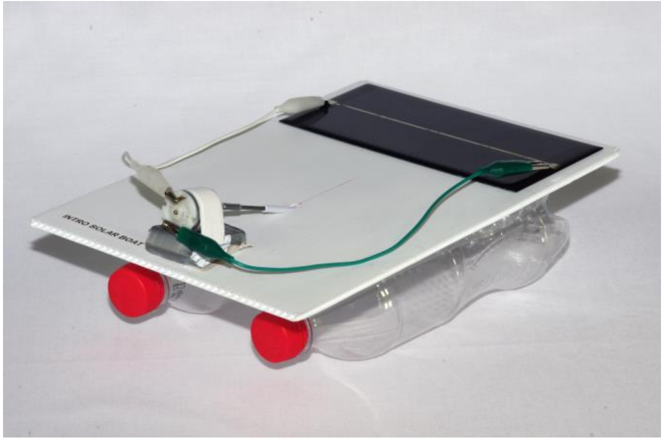
INTRO SOLAR BOAT

CONTENTS:

DESCRIPTION



This kit contains all the components needed to construct a functional solar powered boat propulsion system. This unit includes instructions on how to assemble these components together with suggested ideas for hull construction in order to build a complete basic boat that works.

By building and experimenting with this boat students will gain a significant insight into renewable energy in the form of electricity from solar, basic electricity, motors and energy conversion from solar power to motion of their boat.

SECTION 1. GENERAL AND PLANNING INFORMATION

DESIGN CONSIDERATIONS

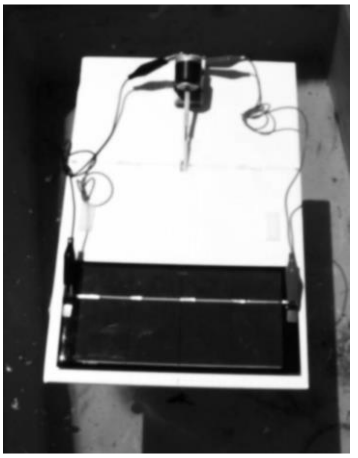
1.1 GENERAL

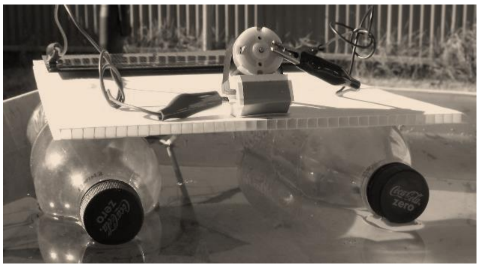
As well as being a fun educational project, students can use the knowledge they have gained and extend it to building a boat capable of participating in the Junior division of the Victorian Model Solar Vehicle Challenge boat competition. For full details of the competition regulations, how to enter, additional resources and help available go to www.modelsolar-vic.net.

A basic boat made from the components supplied in this kit meets most of the requirements of the competition regulations and with a few minor modifications would be accepted to compete. If a truly competitive boat was the aim, upgrading of some components is required. Suggestions for upgrades required are included.

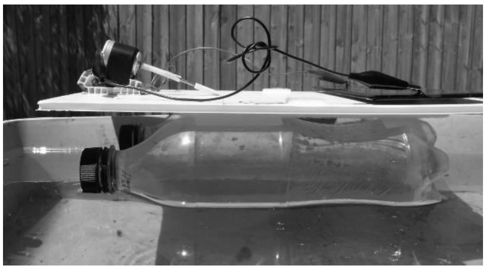
The following are photographs and test results of a boat manufactured using the components supplied in this kit together with a hull consisting of two 600 ml plastic cola bottles.

Note: the boat is floating in a test dish.





Front View



Side View

This boat was tested in the small dish the test results obtained follow:

% Sun	**Static Thrust g**	**Approximate speed m/sec**	**Expected time seconds for 10 m**
15	too low to measure	0.057	175
20	4	0.138	72
40	15	0.166	60
50	20	0.221	45
80	30	0.304	32
90	30	0.304	32

Tests conducted with one Scorpio No. 4 Solar panel with Nominal output in full Sun of 2.0 volts and 0.9 amps (1.8 watts)

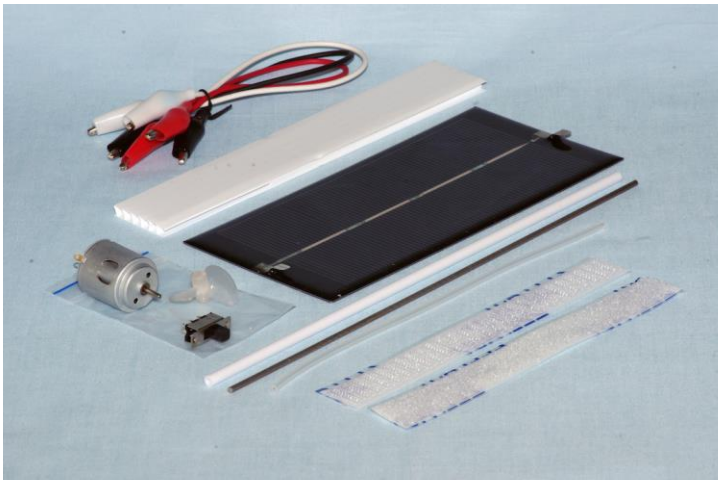
1.2 ITEMS FOR INVESTIGATION

This project provides a number of different aspects of the SOLAR BOAT for investigation. Some ideas are listed below.

- To generate electricity the solar panel needs to be placed in direct sunlight. The amount of sunlight available varies all the time, and will not generate the same power every time. To measure the intensity of the sunlight a Calibrated #10 Solar panel can be used together with a multi-meter.
- Evaluate the suitability of various materials for the platform, such as PVC, acrylic, plywood or balsa wood
- You may wish to incorporate forward / reverse operation, by using a different switch (either our large slide switch or a two way toggle switch can be used).

SECTION 2. COMPONENTS & MATERIAL REQUIRED

2.1 COMPONENTS SUPPLIED



2.2 ADDITIONAL REQUIREMENTS

The following items are required and are available from Scorpio Technology:

- Electric motor mounting clip (EMCL)
- If you wish to carry out additional testing we can provide: other motors, 3 blade propellers, additional No 4 solar panels, tubing 4.5mm ID and propeller shaft bearings.
- If you plan to compete in the solar boat competitions, you will also need to make rods with open loops to follow the guide wire. Our 500mm long 2.5mm dia steel rod is suitable for this (2 required).

The following material is to be supplied by the student / designer:

- Self-adhesive tape – Single-sided
- Self-adhesive tape – Double-sided
- Material for the hull – e.g. 2x600ml cola bottles

2.3 TOOLS REQUIRED

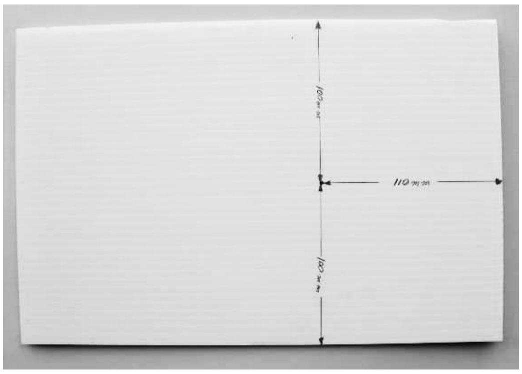
The following tools are required:

- Assorted hand tools
- Soldering equipment and solder
- Scissors
- Pliers
- Knife - “box cutter”
- Ruler and pen

SECTION 3: ASSEMBLY OF THE SOLAR BOAT

3.1 FABRICATION

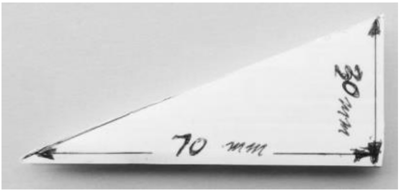
3.1.1. BASE



On the 200mm by 300mm corflute base, mark the position of the propeller shaft hole 110mm from one end and in the center of the sheet.

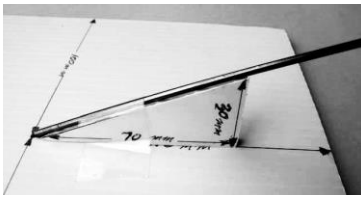
NOTE: The shaft should go through the gap between the reinforcing ribs so it may be necessary to move slightly to one side of the exact center.

3.1.2. SHAFT SUPPORT



Mark out and cut a right angle triangle in corflute to the dimensions shown above.

3.1.3. MOUNTING THE STERN TUBE

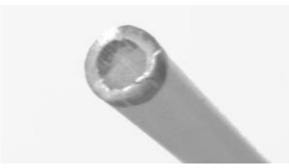


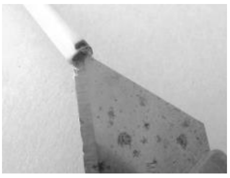
Make the hole for the stern tube and propeller shaft. Using the corflute triangle as a guide push a piece of the 2.5mm diameter steel rod through the corflute and out the other side as shown below. Ensure hole is between the reinforcing ribs of the corflute.

3.1.4. STERN TUBE

Prepare the stern tube: mark the length required - 210mm for this kit. Cut the tube using a suitable knife.

HINT: to minimize squashing of tube place it on a cutting board then roll it under the knife blade keeping moderate pressure on the blade. It will need to be rolled several times (back and forward is ok)

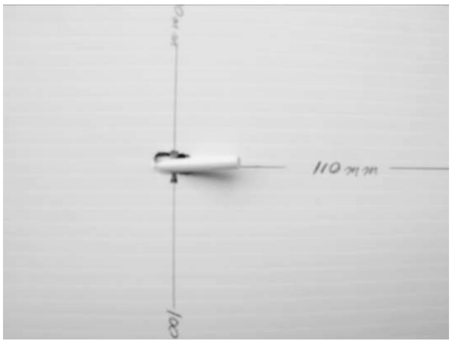




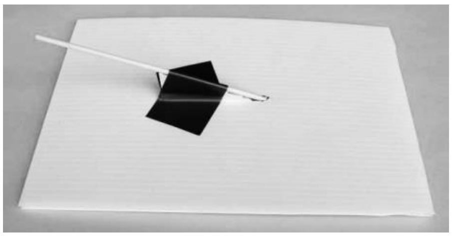
There will be some burrs on the tube end, those on the inside must be removed to allow the shaft to rotate freely.

To remove the burr place the knife blade in the end of the tube and rotate the tube while holding light pressure against the blade.

3.1.5. FIT STERN TUBE TO BASE



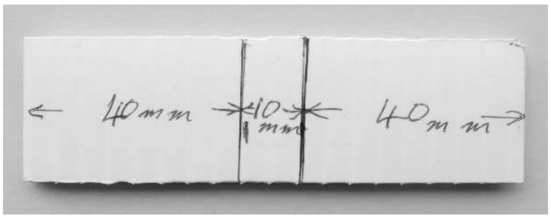
Using small (sharp) scissors carefully elongate the 2.5mm diameter hole to take the diameter plastic stern tube. On the top of the corflute base elongate the hole in the top face only 5mm towards the 110mm end. On the underneath elongate the bottom face only 5mm in the opposite direction. The stern tube should extend 20mm through the base on the top side.



Fit the stern tube through the hole and fix it in place with duct tape at the correct angle with the triangle template used to originally make the hole.

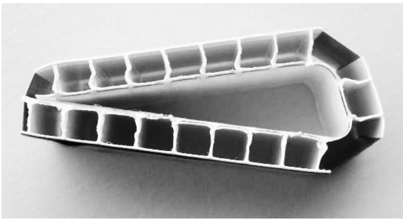
At this stage check that the stern tube is straight by inserting the 2.5mm steel rod (propeller shaft) right through the tube. Holding the base so the stern tube is vertical the steel rod should fall out under its own weight. If the rod does not fall freely investigate and adjust till it will fall freely under its own weight. It is essential that the rod is free or there will be significant friction slowing the rotation of the propeller and hence degrading the boat performance.

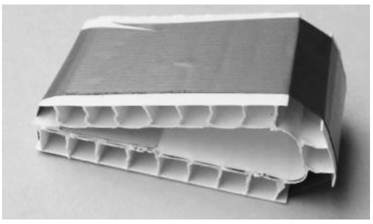
3.1.6. MOTOR MOUNT

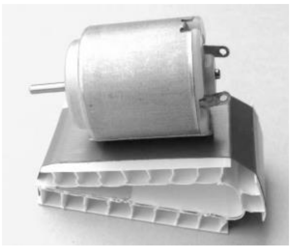


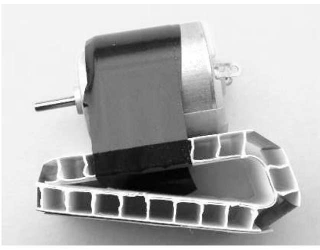
Mark out the motor mount as shown on corflute.

Make two cuts through the top face only 40mm in from each end. Fold over as shown, hold the ends together with double sided tape and apply tape all around the outside.









Hold motor to mount with double sided tape then secure motor by applying tape around the motor and top portion of the motor mount. Apply double sided tape to bottom surface of motor mount.

3.1.7. PROPELLER AND SHAFT

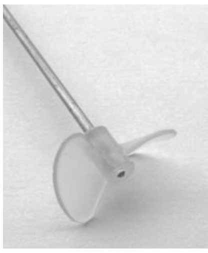
Mark length required. Standard length for this boat is 250mm but you may wish to use a different length if you modify the design. If so, cut to the required length.

Note: the end will be deformed (burred). Remove burrs by filing - Burrs must be removed to allow fitting to propeller and plastic tube used to couple motor to propeller shaft.

Deformed end of cut shaft.

Shaft end after filing

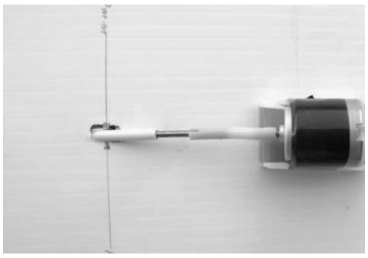
3.1.8. FITTING THE PROPELLER TO SHAFT



Place the propeller on a block of wood shaft hole upwards align shaft with hole and tap shaft end lightly to drive it into the hole in the propeller hub.

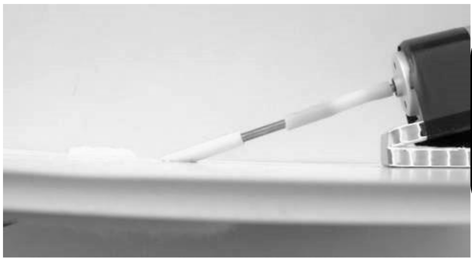
Propeller fitted to shaft.

3.2 MOUNTING THE MOTOR TO THE BASE

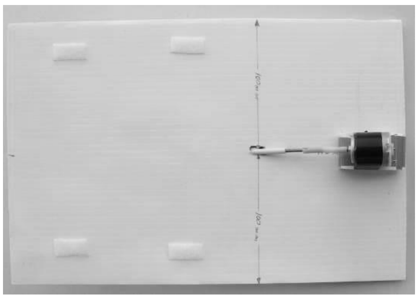


Align motor with propeller shaft and stick motor mount to base with the double sided tape on the motor mount.

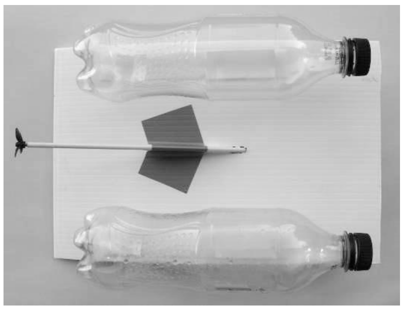
Note: alignment is critical. Misalignment will increase losses and have a detrimental effect on performance.



It is recommended to initially secure the hulls with Velcro so the hull position can be moved fore and aft to adjust the trim of the boat and raise or lower the propeller in the water to obtain the desired position.

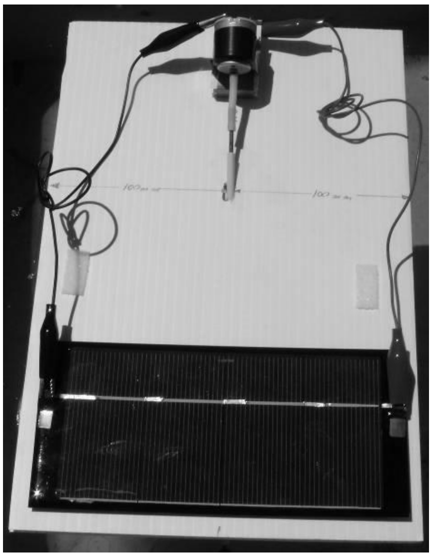


Top view



Under side view showing the bottle hulls in place.

SECTION 4. WIRING UP THE SOLAR BOAT



Secure the solar panel to the base with Velcro (a small area of Velcro about 6mm square at each end is sufficient). Attach clip leads to panel and motor.

To test, expose the solar panel to direct Sunlight, motor should run in Sun levels above 20%.

If the motor is rotating in the wrong direction swap the clip leads at the motor to the opposite terminals.

SECTION 5. TESTING THE SOLAR BOAT

SUNLIGHT versus ARTIFICIAL LIGHT

For testing your boat a good substitute for sunlight is a powerful halogen lamp. Mains powered halogen flood lamps are readily available from lighting shops or hardware suppliers.

A 500 watt lamp directly facing the panel and about 300mm away, will produce a light level equivalent to about 50% Sun. CAUTION: the lamp puts out more heat than the sun, so to avoid panel damage only illuminate the panel for about 40 seconds – then allow the panel to cool down.

A safer option is a low voltage 100 watt handheld halogen spotlight. This type of lamp is available from automotive accessory stores and is usually 12 volt rated. You will need a suitable battery or power supply. This lamp is suitable to demonstrate power generation (with the vehicle held in the air) but is not sufficient to run a vehicle.

NOTE: In the classroom, the light may appear very bright to our eyes, but the boat does not run as the light level is far too low for the solar panel to produce useful quantities of power. Fluorescent lights are a poor substitute for Sunlight, as the frequency of light they produce is very different from the sun. Incandescent lamps are much better, however remember that full sunlight is around 1000 Watts per square metre. In a typical room at home you might have 500 Watts of light in a room of 15 square metres, this is only about 3% of the energy provided by full Sunlight, so it is no wonder solar panels do not work well inside.

SECTION 6. FURTHER WORK

6.1 BASIC UPGRADE AND EXPERIMENTING

The following are some ideas that you may wish to test out:

- Change propellers from the 2 blade to the 3 blade to suit Sun level and panel wiring configuration
- Add a second solar panel
- Wire the Panels in series or parallel
- Angle panels towards the Sun
- Add basic on / off switch

- Fit motor mount clip to allow easy changing of motors for trials of different motors

6.2 ADDITIONAL UPGRADE TO COMPETITIVE STATUS

- Use 350 sq cm lightweight panel
- Improve hull hydrodynamics
- Change shaft angle (reduce)
- Better propellers
- Stern tube with bearings
- Add guides
- Fit switch with off /series /parallel (DPTT center off)
- Upgrade motor

SECTION 7· THEORY

7.1 HOW THE SOLAR PANEL WORKS

Silicon solar cells (photovoltaic cells) generate electricity when exposed to sunlight, but a halogen lamp can also be used. These cells can be likened to a generator using sunlight as fuel. The electricity generated from the photovoltaic cells can be used immediately or stored in a rechargeable battery.

7.1.1. The Solar Cell

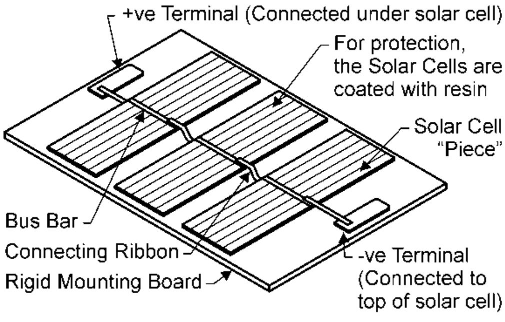
Solar cells are silicon based and typically in the order of 0.3mm thick. They are a glass like material, which is very brittle. Consequently they must be mounted in a way that offers protection.

A single solar cell, when exposed to sunlight generates electricity at a voltage of just over 0.5 volts and a current which varies with the area of the cell and the light intensity. The power generated by the cell at 25 Degrees Centigrade when exposed to light having the same frequency spectrum as the Sun with an energy density of 1000 watts per square metre is its rated power.

Typically high quality cells have a conversion efficiency of around 20%, that is they produce electrical energy equal to 20% of the light power falling on them.

The front side of the cell exposed to the sunlight is negative (-ve) and the underside is positive (+ve).

As the cell temperature increases the power produced falls, predominantly due to dropping voltage. As a rule of thumb power falls by about 0.45% per Degree C increase in cell temperature.



Construction of a "hobby" solar panel - 1.5 volts

ILLUSTRATION ONLY

7.1.2. The Solar Panel

The solar cells are manufactured in different sizes. Standard sizes include 100 x 100mm, 125 x 125mm and 156 x 156mm. For hobby purposes, they are far too large, with too many amperes.

Depending on the Amps required, the cells are cut to the required sizes and connected in series, to give the required voltage. Thus, for example, if three (3) cells 100 x 100 mm are connected in series you will have 1.5 Volts and about 2.8 amps.

Excellent in depth technical information on solar cells and panels can be found at http:www.pveducation.org/

7.2 SPEED AND ACCELERATION.

Did you know that you can calculate your boat's speed?

You need to know the distance over which your boat will travel. Time the duration it takes from start to finish with a stopwatch. You can use the following method to calculate how many Kilometres per hour (km/h) your boat averages. For example if your boat is travelling over 20 metres and it takes 5 seconds to cover the distance:

1. Divide 1000 metres (the length of one kilometre) by the length of your course (in this example 20 metres). **1000/20 = 50**
2. Multiply the time taken by your boat to complete the race (in this example 5 seconds), by the result from the previous calculation. **5 x 50 = 250 seconds**
3. This is the time it would take to travel one Kilometre
4. Work out how many seconds there are in an hour. **60 x 60 =3600 seconds**
5. To calculate the average speed in Kilometres per hour, simply divide the seconds in an hour (3600 seconds) by the time it takes to travel one kilometre (in this example 250 seconds). **3600/250 = 14.4 Kilometres per hour**

This is the average speed obtained over the distance. Remember your boat is not moving at all at the start. This means it must be going much faster (than the average speed) by the end of travel. How fast is your boat going at the end of travel?

First you must find the acceleration of your boat. Acceleration is a measure of how fast your boat's speed is increasing. Acceleration is measured in metres per second squared (m/s^2). Another term that will also be used in the calculation is velocity. Velocity is a measurement of speed. Velocity is measured in metres per second (m/s).

6. To find this, a formula is used and it assumes that the acceleration is constant (ie. the acceleration is the same throughout the travel).

Distance traveled = boat's starting speed + ½ x acceleration x time taken²
To find the acceleration for our example:

20 metres = 0 + ½ x acceleration x 5^2

20 = ½ x acceleration x 25

20/25 = ½ acceleration

0.8 = ½ acceleration

0.8 x 2 = acceleration

Therefore **Acceleration = 1.6 metres per second squared (1.6m/s^2)**

7. To find the velocity of the boat at the end of travel another formula is used.

Velocity = the starting speed of the vehicle + acceleration x time taken

Velocity = 0 + 1.6 x 5

Velocity = 8 metres per second (8 m/s)

8. To calculate final speed, multiply the velocity by the number of seconds in an hour.

8 x 3600 = 28,800 metres or 28.8 Km per hour.

Can you spot the relationship between the average speed and the maximum speed of a boat that starts from a stationary position? What is it, how can this be explained?

Note: Time and distance used in this example are made up values, to show how these calculations work. Your vehicle may achieve better speeds than given in the example.

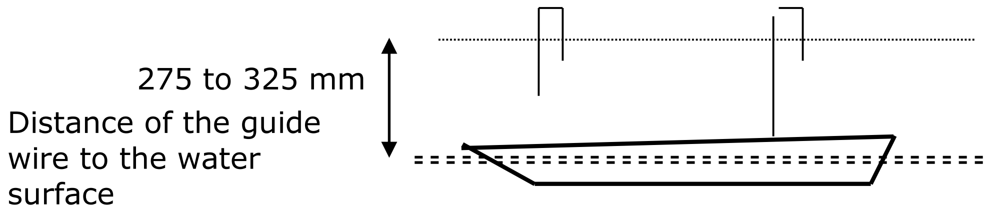
SECTION 8· TECHNICAL SECTION OF 2013 REGULATIONS

The following section is a part of the Victorian Solar boat regulations in 2013, and is included as an example. If you intend to compete, you must check your state's current regulations.

8.1 BOAT SPECIFICATIONS COMMON TO BOTH DIVISIONS.

To be eligible to compete boats must conform to all specifications. The following list details the specifications which are common to both the Junior and Advanced division. The additional specifications which apply to one division only are detailed in 8.1.

9. The maximum boat length including any front and rear projections, shall be 550 mm to ensure that the boat fits behind the starting line. (see Fig.1)
10. The boat width (including the cells) must be no greater than 300mm at the widest point.
11. To enable boats to steer a straight line, they should be fitted with rods with open loops through which the guide line will run. This line will be located as near as possible to 300mm + or – 25 mm above the water. Other designs than the one shown may be used.



12. Both divisions' boats may be powered only by commercial silicon cells with a maximum active area of 350 square cm. Panels must be securely attached, so that they cannot fall into the water.
13. A functioning on/off switch must be installed between the solar panel and the motor.
14. No commercially available boat hulls or kits may be used. Entrants are to design and construct their own boats in the year of the race. Hulls unaltered from previous state or national competitions are not eligible. Boats re-entered with very substantial modifications must have alterations documented to the satisfaction of the race coordinator.
15. Multiple boats entered by one school/group cannot be of an identical hull design – eg each entry from a school would not be allowed to use a hull vacuum formed using the same mould or made of fiberglass from 1 mould. Advanced students using vacuum formed or other moulded hulls must have designed and substantially made them themselves.
16. No batteries or energy storage devices are allowed. However capacitors are allowed as part of an electronics system in the advanced division.
17. Each boat must have the school and boat name clearly visible to the starter and judges. Teams will be provided with a "flag" with the boat's number and name this flag is to be affixed to the rear guide wire.
18. Propulsion: there is no restriction on the use of underwater propellers, air propellers, paddle wheels, oars etc.
19. A poster is required for teams to be eligible for prizes. See 4
20. It is strongly recommended that the boat should have a bow section with a minimum radius of 25 mm. This is to ensure they do not become lodged in the 10 mm square mesh of the starting gate.

8.2 BOAT SPECIFICATIONS SPECIFIC TO A DIVISION

As well as conforming to the boat specifications common to both divisions detailed in 8.0, all competing boats must additionally conform to the specifications applicable to their division as detailed below in 8.1.1 for the Junior Division and 8.1.2 for the Advanced Division.

8.2.1. Junior Division

21. Only one hobby type motor commercially available within Australia with a maximum recommended retail price of $ 5.00 is permitted. Motors from scrapped equipment such as VCR's etc. are not permitted as we cannot verify their performance. Boats using such motors will be required to compete in the advanced division.
22. Only hulls made from either recycled packaging (such as plastic drink bottles or cans etc.), polystyrene foam, cardboard or balsa wood (appropriately waterproofed) may be used. Moulded hulls, eg. vacuum formed plastic and fiberglass hulls are not allowed in this division.
23. Maximum cost of the whole boat must be $50.00 not counting the solar panels.
24. Boats using in water propellers must use direct drive between motor and propeller, gearboxes or other methods of changing the propeller speed relative to the motors rotor speed are not permitted in this division.
25. Boats built by primary students which do not meet these restrictions will be required to compete in the advanced division.

8.2.2. Advanced Division

1. Any type or number of motors may be used.
2. Gearboxes or any type of speed varying system may be used between the motor and propeller.
3. Any materials including vacuum formed plastic, fiberglass or carbon fiber hulls can be used.
4. Electronics and capacitors may be used, but if the total capacitance on board the boat exceeds 15,000 uF all capacitors will be discharged at the start line.