



2016 Regulations for: Student Designed Car

Section 9 Car Specifications

The Event will be held on the weekend of the 15th and 16th of October, 2016 at the Scienceworks museum in Spotswood in Melbourne.

Additional information will be published on the web site
www.modelsolaraustralia.org

Section 9 (this document) covers the car specifications.
Sections 1 to 8 (a separate document) cover the administration of the event.
N.B. All nine sections must be read as a single document.
This document supersedes all previous versions.

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9 CAR SPECIFICATION

9.1 Synopsis

The following is intended to be used as a quick reference guide only. It contains all the important basics, but does not cover all of the specification details. **YOU MUST REFER TO THE COMPLETE REGULATIONS FOR FULL DETAILS.** Always remember that car design and construction has to be the work of student team members and only team members are to undertake the operation and any repairs on cars; penalties for adult input will apply. See Administration Sections **§1.3** and **§3.2**

- **Maximum Body Dimensions:** 550mm long, 320mm wide, 180mm high and less than 190 mm from centre line of guide rail at all times.
- **Wheels:** minimum width 1mm or 0.6mm radius at contact point with track.
- **Guiding:** must be on the outside of the guide rail. The guide rail is nominally 16 mm wide 14 mm high.
- **Bumper Bar:** the section of the car that initially impacts the stopping block must have at least a 500mm² flat area to minimise damage to the stopping blocks.
- **Side Panels:** one each side, minimum 100mm long by 50mm high.
- **Cargo:** when racing, the car must carry one empty, undeformed 2000ml Tetra™ Rex gable top carton (aka a Berri Australian Grown 2 Litre juice container) at all times.
- **Structural Integrity:** the car will be stopped by coming into contact with a polystyrene block of approximately 400gm in weight.
- **Solar Array:** must be fully and quickly removable from the car, with a maximum power of 10 watts, silicon technology only and no devices mounted on the array. A single switch may be allowed (see §9.9).
- **Wiring:** all wiring and electronics must be visible, otherwise a circuit diagram is required.
- **ON/OFF Switch:** a commercially-produced switch that is easily visible to the starter is required, with the **ON** and **OFF** positions clearly marked. The switch will only be allowed on the solar array if all the cells are always connected in series.
- **Energy Storage:** is not allowed, except for capacitors up to 0.2 farad, provided they are discharged immediately prior to the start of the race.
- **Electronics:** If used, the total required minimum weight of the solar array, its support structure + ballast will be calculated using the formula as detailed below in “**Ballast**”.
- **Array Power:** the maximum power allowed is 10 watts at 25 degrees Centigrade; panels producing greater than 10 watts will be masked by scrutineers to produce less than 10 watts.
- **Ballast:** If the solar array and its support structure weigh less than the total minimum required by the appropriate formula below, additional weight in the form of ballast will need to be securely attached to the array, in order to bring the weight up to the required minimum.

With Electronics: Total Weight = $250 \times P - 900$ [grams].

Without Electronics: Total weight = $150 \times P - 650$ [grams].

Where **P** = array power in watts.

- **Poster:** An A2 sized poster, laminated or contact covered, detailing the teams efforts must be presented to AIMSCSDC officials prior to scrutineering on the first day of the event, (see §3.4).
- **Interview:** All team members are required to attend a team interview session during the event, (see §3.5).

9.2 Test Criteria

All references to car behaviour and measurements will be based upon the assumption that the car is on a flat, straight section of the track and in full racing configuration.

9.3 No Commercially-Built Cars

Cars must not use any part of the chassis or body of any commercially available model car. Any car found to be so will be immediately disqualified from the Races.

9.4 Size Limit

Maximum car size allowed is 550mm long, 180mm high and 320mm wide. At no time may any part of the car extend sideways more than 190mm from the centre of the guide rail. The size is measured by the smallest rectangular box that is required to contain the car when sitting on the track.

9.5 Source of Power

Only commercially available, silicon photovoltaic cells are allowed. All energy used on board the car during the course of a Race must be supplied by the array and collected during the course of that Race.

9.6 Solar Array and Support Structure

The solar cells connected together to provide the power which drives the car will be referred to as the array. The complete unit on which the photovoltaic cells (the array) are mounted is the array support structure. The thickness of the array and its support structure must not exceed 30 mm when placed on a flat surface. The structure must be strong enough to survive intact the necessary handling by the scrutineers and officials. The organizers will accept no responsibility for any damage to the solar cells, or the solar array.

Please Note: Wherever the term *array* is used from this point on in this document, it refers to the photovoltaic cell array and its support structure.

9.7 Array Structure Removal

The array and any included ballast (if required), must be easily and quickly removable (less than 1 minute) from the car for power testing and car inspection. Inspection may be required before and/or after each race. When the array and any included ballast are removed, the car must still be capable of free and stable movement.

9.8 Solar Array Wiring

All wiring on the solar array must be visible; if this is not possible, a wiring diagram must be provided upon request. The array must be presented for scrutineering with a pair of wires (minimum 200mm long) marked **+ve** and **-ve** for connection to the alligator clips on the power measuring equipment.

Teams using arrays of their own construction or modified commercial arrays must provide a wiring diagram which includes the number of cells in each series connected circuit. Where the array has multiple individual circuits to allow for both series and parallel connection, teams must supply pairs of connections as described above for each circuit section of the array. The power of each circuit section will be measured and the individual power values recorded, then added together to obtain the power used for ballasting calculations. All wiring must be carried out with standard copper or tinned copper conductors.

9.9 No Devices on the Array

All mechanical, electrical or electronic devices including the ON/OFF switch and any devices for changing the panel voltage or array configuration must be separate from the array. A plug, socket or terminal block to allow connection of the array wiring to the car wiring is allowed.

An exception will be granted for cars using an array permanently wired in series where a single ON/OFF switch will be allowed.

9.10 Power Measurement

The power delivered by the solar array will be assessed at nominal AM 1.5 conditions by the scrutineers using a light box. This power figure will be used for ballast calculations.

Ballast requirements will be determined by the highest power reading obtained from the array during the course of the event. If, upon retesting, a panel returns a power greater than 0.2 watts higher than any previous test, that panel will be re-ballasted to that new higher power.

See **§9.28** for more details.

9.11 Power Limit

Arrays must register a total power of less than 10 watts at nominal AM1.5 conditions. Any array recording a power above 10 watts will have tape applied by the scrutineers to cover a portion of each cell in the array, in order to reduce the power to below this 10 watt limit.

See **§9.28** for more details

9.12 Array Weight

This competition is intended to test car design and construction, not who can source the best solar array. This regulation takes the array power and use of electronics systems out of the equation, thus making it a fair competition for all participants.

If the array weighs less than the required minimum, ballast must be securely attached to it in order to bring the weight up to this required minimum.

The minimum required combined weight of the solar array and ballast:

for cars using electronics systems will be calculated using the formula

$$W_{\text{total}} = 250 \times P_{\text{standardised}} - 900$$

for cars not using electronics systems will be calculated using the formula

$$W_{\text{total}} = 150 \times P_{\text{standardised}} - 650$$

In both formulas where

W_{total} = total weight of Solar array and ballast in grams and

$P_{\text{standardised}}$ = Standardised Panel Power in Watts.

The Committee will provide scales to determine array and ballast weights, measured accurate to $\pm 5\text{gm}$.

9.13 Use of Electronic Devices

Teams may at any time elect to use electronic circuitry for solar panel regulation or motor control. Additional ballast will be required if operating with an electronic control system (see §9.12).

9.14 Ballast

Any additional weight required by §9.12 to bring the weight of the array up to the required minimum is defined as ballast and must be securely attached to the array. The requirement of “securely attached to the array” is that the ballast and array can be handled as a single unit once detached from the vehicle. The ballast does not need to be mounted on the array, although it is an option, it must be sufficiently connected so that combined ballast and array may be removed from the vehicle as one. The secure attachment may be as simple as a suitably strong flexible tether such as insulated wire, fishing line or standard twine that is secured to both array and ballast weights. The intention of this requirement is to ensure that it is easy to perform a clear, unambiguous and obvious identification of what is the ballast and to ensure that ballast weights do not become detached and / or adrift during the course of racing hence becoming a hazard to other vehicles, competitors or spectators.

When presenting the vehicle for scrutineering teams are expected to have the correct amount of ballast, or at least sufficient ballast weights to assemble the correct amount of ballast. It is expected that the ballast will be securely attached to the panel after the panel power testing stage and before the vehicle is presented for final weighing during scrutineering.

Ballast will not be provided by the scrutineers. All Ballast weights must also be suitably contained to prevent possible detachment as specified above.

Note: Any item or material used as ballast must not perform any function on the car when racing other than acting as the ballast.

Cars will be inspected and check-weighed before and/or after each race, to ensure they are correctly ballasted during racing.

It is the responsibility of the team to ensure the car races with the correct amount of ballast on board.

If a car races with less than the required ballast, it will forfeit that race.

A repeat offence will result in exclusion from the event.

Note: There has been some confusion in the past about ballast. The ballast applies only to the solar array and the quantity of ballast required is dependent upon array power and weight. This includes the weight of the chosen “secure attachment” mechanism employed. Car body and chassis weight are not included or considered in any way in the ballasting requirements.

9.15 No Energy Storage Systems

No energy storage system which assists in the performance of the car, whether electrical, mechanical or chemical, will be permitted. Capacitors of less than 0.2F and inductors are allowed as part of the electrical system. Capacitors above 0.047F must be discharged immediately before the race.

9.16 ON/OFF Switch

Each car must be fitted with a commercially produced 'ON/OFF' switch, the ON and OFF positions must be clearly marked and the switch must be in a location easily visible by the official starter when the car is on the start line. **Note:** The starter is on the left-hand side, so typically, the switch would be mounted on the left-hand side, or on the top.

9.17 Car Wiring

Where possible, all electrical wiring in the car must be reasonably visible and traceable. Teams will be required to explain any wiring going into sealed body areas. A simple block wiring diagram must be provided upon request if this condition is not met.

9.18 Motors

There is no restriction to the type, size, or number of motors that may be fitted to the car. However, the motor manufacturer and/or part number must be made available to the scrutineer for database information upon request.

9.19 Wheels

To reduce damage to the track, knife-edge wheels are not allowed. Each wheel must be at least 1mm wide, or have a radius of 0.6mm on the running surface.

9.20 Steering

Each car must incorporate a means of steering around the track. The guide rails (as described in §5.4 of the administration document) are approximately 16mm wide and 14mm high. The steering mechanism must be designed to operate on the outside of the guide rail.

9.21 Cargo

The car must at all times when racing carry one empty, undeformed 2000 ml Tetra™ Rex gable top carton (aka a Berri Australian Grown 2 Litre juice container) with minimum dimensions 100mm x 100mm square on the base and 260mm high.

9.22 Body/Chassis

The structure of the car must have a body, chassis or frame with enough strength to allow free and stable movement with the ballast and array removed.

In addition, the section of the car body that initially impacts the stopping blocks, the Bumper Bar, must have a flat initial contact surface area of at least 500mm² with the block in order to minimise damage to these stopping blocks. The bumper bar must be able to withstand the impact without permanent deformation or permanent displacement after multiple impacts. The bumper bar supports should at no stage come into contact with or cause damage to the stopping block.

9.23 Side Panels

The car must have two side panels capable of retaining their shape at all times, for attaching numbers and sponsors' logos. These must be easily seen by spectators while the car is racing. They will be located one on each side of the car. Each side panel must be capable of supporting a sticker 100mm long and 50mm high. The permitted curvature of the side panels is 20mm vertically and 15mm horizontally.

9.24 Solar Array Cover

All teams should provide a suitable opaque cover, which will completely shade the active area of their array for use at the starting position. The use of the cover is to assist the officials to detect and eliminate any hidden, illegal energy storage devices. The cover must be a flat sheet of rigid material capable of supporting sponsors' logos. The use of flexible items such as clothing, towels or similar is not permitted.

9.25 Non Conformance

If a car fails to conform to the requirements detailed in any section of the regulations, it must be modified in order to conform, or penalties may be imposed. Penalties will normally be in the form of the requirement to carry additional weight. Minor non-conformances will typically attract a 50gm penalty weight, with this increasing to 200gm for more significant breaches of the regulations. The magnitude of the penalty will be determined by the Chief Scrutineer, in conjunction with the Scrutineering Team. In the event that the scrutineers believe the non-conformance gives the car a significant advantage unlikely to be negated by the carrying of additional weight, the car will be excluded from the event. Penalty decisions will be final and not open to appeal.

9.26 Structural Integrity

The car must be constructed in such a way that normal handling and the stopping procedure of hitting a polystyrene block of nominal weight 400gm will not cause damage. No responsibility will be accepted by AIMSCSDC organisers for any damage the car incurs, no matter how it occurs. **Note:** The polystyrene block will be provided by the event organisers and placed in position on the track by an appointed AIMSC Official.

9.27 Autonomous Operation

After the race has started, the car must operate totally autonomously for the duration of that race. This means team members, or any other person must not provide an input of any type to the car during the course of a race. (This of course means the use of any form of remote control, or even the operation of a mechanical switch during a race is prohibited.)

9.28 Detailed Explanation of Regulation Requirements

9.28.1 Power Measurement

The power delivered by the solar array will be assessed at nominal AM 1.5, as described in §9.29.1, conditions by the scrutineers using a light box. This power figure will be used for ballast calculations.

Solar arrays or any portion of the array which required testing must produce no more than 25 volts open circuit, or 2.0 amps short circuit and no less than 3 volts open circuit, or 0.3 amps short circuit when tested, otherwise they will be assigned the power as computed by:

$$\text{Power [watts]} = (\text{open circuit voltage}) \times (\text{short circuit amps}) \times 0.8$$

Curved, stepped or multi-planed arrays must be able to be re-configured so that when placed on the flat light box measuring surface, no part of any cell is more than 30mm away from that surface. The scrutineers will calculate a maximum power value for non-conforming panels.

As the power output of a silicon solar cell is affected by temperature, the scrutineers will scan all arrays with a non-contact thermometer immediately after power testing. The array temperature recorded will then be used to standardise the power output to the power expected at a temperature of 25 degrees Celsius using the following formula.

$$P_{\text{standardised}} = P_{\text{measured}} + P_{\text{measured}} \times 0.004 \times (T - 25)$$

Where **P** = power in watts and **T** = maximum panel temperature in degrees Celsius.

Any ballast required will then be calculated using this standardised power value.

Ballast requirements will be determined by the highest standardised power value obtained from array testing during the course of the event. If, upon retesting, a panel returns a power greater than 0.2 watts higher than any previous test, that panel will be re-ballasted to that new, higher power.

Arrays with a Fill Factor, as described in §9.29.2, of below 0.65 will be tested under conditions specified by the chief scrutineer. Artificial manipulation of Fill Factor is prohibited and will result in disqualification of the team involved.

9.28.2 Power Limit

Arrays must register a total corrected power of less than 10 watts at nominal AM1.5 conditions. Any array recording a power above 10 watts will have tape applied by the scrutineers, covering a portion of each cell in the array. Tape will be applied in integral widths of 19mm ± 1mm until the power is below 10 watts. Fine tuning of final power will not be allowed. Removal of this tape, except by the scrutineers, is prohibited. Racing without the appropriate tape in place will result in forfeiture of the race and depending upon the circumstances, disqualification.

If an array has any part of the active surfaces of the cells covered in any way that effects its power, the scrutineers must be satisfied that this covering is secure and cannot be removed during the course of the event. The scrutineers may require any such covering to be removed and replaced with the official masking material used at scrutineering.

Please Note: The array will be tested as received at scrutineering and no further changes to any covering material will be allowed.

9.29 Definition of Terms.

Terms have been used in these regulations which may not be familiar to competitors. These are: related to air mass, specifically AM1.5, which is commonly used by manufacturers to test panel output under **Standard Test Conditions** and with a measured **Fill Factor**.

9.29.1 Standard Test Conditions ("STC")

The testing conditions to measure photovoltaic cells or the module's nominal output power. Irradiance level is $1,000 \text{ W/m}^2$, with the reference air mass 1.5 solar spectral irradiance distribution and cell or module junction temperature of 25°C . (<http://www.ia-pvps.org/pv/glossary.htm>)

9.29.2 Fill Factor

The fill factor is the ratio of area under the Voltage vs Current curve as a fraction of the area under the rectangle, bounded by the extrapolated lines for Short Circuit Current and Open Circuit Voltage.,

