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Welcome!

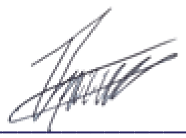
The Ilanga Cup is Southern Africa's first closed track endurance circuit event, which is focused on driving the innovation of renewable and alternative energy. The event takes place annually and has been created for local solar car teams to put their solar vehicles to the test in a controlled environment, designed and focused on measuring the vehicles' performance, efficiency, and durability.

The Ilanga Cup serves as a platform for solar car teams - professionals and amateurs alike - to not only test their solar cars but also learn and improve both team and the vehicle dynamics – doing this in the most efficient way possible. With these opportunities, the aim is to nurture young and upcoming solar car teams and grow existing solar car teams in order to be able to compete in larger-scale events that are internationally recognised such as our very own South African Sasol Solar Challenge.

The event offers three entry classes that allow enthusiasts, pioneers, and professionals to design and build a vehicle solely powered by the sun for competition. These classes are as follows:

- **Challenger Class** is for single-seat solar cars designed to be fast
- **Cruiser Class** is for efficient, practical solar cars with two or more seats
- **Adventure Class** is non-competitive, and is designed purely for hobbyist's or project cars

The information contained in this document is for the purposes of conducting the 2022 Ilanga Cup and must not be regarded as constituting definitive instructions as to how a solar car should be constructed or operated.



Robert Walker

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1. Solar car regulations

1.1 Classes

1.1.1 The 2022 Ilanga Cup will have three classes of solar cars:

- **Challenger class** is for single-seat solar cars designed to be fast
- **Cruiser class** is for efficient, practical solar cars with two or more seats

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- **Adventure class** is non-competitive, and is designed purely for hobbyist's or project cars

1.2 Dimensions

1.2.1 When driving in a straight line, the solar car must fit inside a right rectangular prism 5000 mm long, 2200 mm wide and 1600 mm high, with the base of the prism coincident with the ground. (with the exception of teams entered in the Adventure Class)

1.2.2 The eyes of every occupant must be more than 700 mm above the ground.

1.2.3 The fully laden solar car must be able to drive off a road with a 50mm vertical edge drop without any part of the solar car, other that the tyres, touching the ground.

1.2.4 For compatibility with other International Solarcar Federation (ISF) events, solar cars must include internal space large enough to carry supplementary solar collectors with a total collection area that is half of the maximum allowable area of a main solar collector. Supplementary solar collectors will not be allowed in the 2022 Ilanga Cup; teams do not have to build or carry supplementary solar collectors. (with the exception of teams entered in the Adventure Class)

1.3 Wheels

1.3.1 Challenger, Cruiser and Adventure solar cars must be supported by four wheels: two front wheels and two rear wheels. Points of contact between the tyres and the road must be symmetrical about the longitudinal centreline of the solar car.

1.3.2 For Challenger and Cruiser solar cars, the distance between the front tyre centres and the distance between the rear tyre centres must each be more than half the width of the solar car.

1.4 Solar collector

1.4.1 The primary energy source for a solar car is solar irradiation collected by the solar car.

1.4.2 A standard solar collector uses photovoltaic cells without reflectors or concentrators. Teams wanting to use reflectors, concentrators or some other form of solar collector must send details of the proposed solar collector to the event organiser for approval.

The power generated by a proposed non-standard solar collector should be equivalent to the power generated from a standard solar collector.

1.4.3 If the solar collector comprises photovoltaic cells all the same chemistry, and used without concentrators such as reflectors or lenses, then the total cell area must not exceed the allowable total cell area:

Class PV Cell Chemistry Allowable Total Cell Area (m^2)

Class	PV cell chemistry	Allowable total cell area (m^2)

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Challenger	Si	4.000
	thin film single junction	3.560
	thin film multijunction	3.240
	multijunction	2.640
Cruiser	Si	5.000
	thin film single junction	4.440
	thin film multijunction	4.050
	multijunction	3.300
Adventure	Si	5.000
	thin film single junction	4.440
	thin film multijunction	4.050
	multijunction	3.300

1.4.4 Teams must provide calculations that demonstrate compliance.

1.4.5 Cell area calculations must be based on flat, unconnected cells. For cells used without overlapping, cell area is defined as the projected area of the cell in a direction perpendicular to the plane of the cell. For cells that are overlapped, cell area is defined as the exposed surface area of the cell. Cell area includes active material, busbars, fingers, and connection pads.

Example calculation: The area of a SunPower cell with a width of 125 mm and a diagonal diameter of 160 mm is less than 0.015333 m^2, and so the area of 260 cells is less than 3.9866 m^2 and the area of 326 cells is less than 4.9986 m^2.

1.4.6 Teams wanting to use a mixture of photovoltaic cell chemistries must send details to the organiser for approval. If the areas of the different chemistries are area A_1 of silicon cells, area A_2 of thin film single junction cells, area A_3 of thin film multijunction cells and area A_4 of multijunction cells then the areas must satisfy.

$$A_1 / 4.000 + A_2 / 3.560 + A_3 / 3.240 + A_4 / 2.640 \leq 1$$

for Challenger solar cars, and

$$A_1 / 5.000 + A_2 / 4.440 + A_3 / 4.050 + A_4 / 3.300 \leq 1$$

for Cruiser solar cars, and

$$A_1 / 5.000 + A_2 / 4.440 + A_3 / 4.050 + A_4 / 3.300 \leq 1$$

for Adventure solar cars.

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1.4.7 If the solar collectors comprises photovoltaic cells used with concentrators such as reflectors or lenses then the total aperture area of the solar collector must not exceed the allowable total cell area, by cell chemistry, for non-concentrator photovoltaic solar collectors. Teams wishing to use concentrator photovoltaic solar collectors must contact the event organiser for more information.

1.4.8 All devices used for solar charging must be carried in the solar car. This includes stands, supports, and cables.

1.5 Energy storage

1.5.1 A solar car may store energy. A standard energy storage system uses rechargeable electrochemical cells. Teams wanting to use some other form of energy storage must send details of the proposed energy storage system to the event organiser for approval.

1.5.2 If the energy storage system comprises rechargeable electrochemical cells all with the same chemistry, then the allowable total cell mass for Challenger and Adventure solar cars is:

Electrochemical Cell Chemistry Allowable Total Cell Mass (kg)

Electrochemical cell chemistry	Allowable total cell mass (kg)
Li-S	15.00
Li-ion	20.00
Li-polymer	20.00
$LiFePO_4$	40.00

The allowable total cell mass of rechargeable electrochemical cells is not restricted for Cruiser solar cars. However, the external energy used by a Cruiser class solar car, including the energy stored at the start, will influence the team's score.

1.5.3 Teams wanting to use other cell chemistries, or a mix of cell chemistries must send details of their proposed energy storage system to the event organiser for approval. The Chief Energy Scientist will determine allowable configurations.

1.5.4 Li-ion cells with size designator '18650' are deemed to have a cell mass of 47.6 g. The maximum number of 18650 cells allowed for Challenger and Adventure solar cars is 420. For all other cell sizes and types, the cell mass will be deemed to be the nominal or maximum cell mass specified in detailed cell model specifications provided by the manufacturer.

1.5.5 Specifications from third party suppliers or found on the internet might not match those endorsed by manufacturers. If the event organiser receives conflicting or unclear specifications of cell mass for a particular cell model, the Chief Energy Scientist will determine the nominal cell mass for cells of that model.

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1.5.6 The sum of nominal cell masses (i.e., summed over all cells) must be not more than the allowable total cell mass.

1.5.7 The energy storage system must be contained within at most two packs.

1.5.8 Electrochemical cells must not, at any time, be operated outside of the operating ranges for voltage, current and temperature specified by the manufacturer. Teams must provide manufacturer's specifications that include:

- minimum operating cell voltage
- maximum operating cell voltage
- maximum discharge current
- maximum charge current
- maximum temperature while discharging
- minimum temperature while charging
- maximum temperature while charging.

1.5.9 Teams must provide documentation that describes how they will monitor their electrochemical cells, and what the team and the solar car will do if any cell goes outside specified operating limits. Teams must obtain endorsement by their certifying engineer that an adequate and effective monitoring regime has been designed and implemented, and fault conditions will be managed safely.

1.5.10 Batteries used only to

- power a real-time clock when the solar car is turned off; or
- retain data when the solar car is turned off; or
- power wireless tyre pressure monitors

are not considered to be part of the energy storage system, provided that the total energy capacity does not exceed 2.0 Wh.

1.5.11 Batteries or cells inside devices such as handheld radios, cameras, mobile telephones or wristwatches that are carried by the driver or passengers are not considered to be part of the energy storage system, provided that they are not electrically connected to the solar car, its instrumentation or control systems.

1.5.12 Capacitors are not considered to be part of the energy storage system if their total energy storage capacity is less than 10.0 Wh. Such capacitors must be automatically discharged to less than 60 V within five seconds of the solar car being placed in safe state (see Regulation 1.29).

An external battery is not necessary to start a solar car. Possible alternatives include:

- *Use a small galvanically isolated dc/dc converter inside an energy storage pack to supply voltage to a remote start switch. You can use a separate switch on the energy storage pack to turn off this dc/dc converter if it is not going to be used for an extended period.*

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- *If the driver can reach the energy storage pack, put the start switch on the energy storage pack.*
- *Use an air switch inside an energy storage pack, with an airline to a remote start button.*

1.5.13 Energy storage packs must be mounted in the solar car so that they will be restrained in a 20g acceleration.

1.5.14 If an energy storage pack is capable of spilling dangerous liquids when damaged then there must be a spill-proof barrier between that energy storage pack and the solar car occupants.

1.5.15 If an energy storage pack is capable of emitting dangerous gases when damaged then the solar car must be designed so that any gases from a damaged pack will be vented to the exterior of the solar car behind any occupant ventilation intake.

1.5.16 Removable energy storage packs enable teams to work on their solar car while their energy storage packs are impounded. If energy storage packs are removable then:

- each energy storage pack must remain in safe state while not connected to the solar car
- each energy storage pack must meet the electrical safety requirements of Section 1.28 while outside of the solar car
- the team must provide a lockable box for storing energy storage packs while they are impounded.

1.5.17 Energy storage packs must be constructed so that each pack can be sealed using tamper-evident plastic seals, similar to 3 × 100 mm plastic cable ties. With seals fitted, it must not be possible to remove any cell from a pack without breaking the seal. Seals will be provided by, and fitted by, the event organiser at scrutineering.

1.5.18 Energy storage packs must be designed and constructed so that scrutineers can verify the cell models being used and the number of cells of each model.

1.5.19 Any charging system that is used to recharge the energy storage system (when allowed) must meet the following requirements:

- the charger must be used with a residual current device
- the charger must be either permanently connected to the energy storage system, or connect to the energy storage system using an appropriate connector
- the output of the charger must be electrically isolated from any ac input
- the charger must stop charging automatically when the energy storage system is full or if a fault occurs.

1.5.20 Cruiser charging will be metered by the organiser. Cruiser solar cars must be equipped with an on-board ac charger with an IEC 62196-2 Type 2 (male) charging inlet and be capable of charging from a single-phase ac supply (230 Vac, +10%, -6%). The ac current draw must not exceed the limit indicated by the SAE J1772 pilot signal generated by the organiser's Electric Vehicle Supply Equipment (EVSE), which will allow charging rates up to 30 A but may reduce the limit to as low

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as 6 A. The EVSE may disconnect the car if the indicated current limit is exceeded for more than 5 seconds.

1.6 Vehicle identification

1.6.1 The solar car must have a unique Vehicle Identification Number (VIN), which must be permanently attached to a substantial part of the solar car chassis or frame.

VINs meeting the requirements of the event can be issued by the International Solarcar Federation.

1.7 Signage

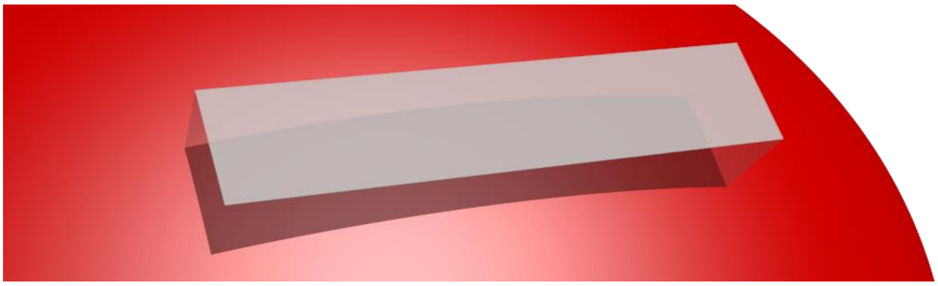
1.7.1 Unbroken rectangular spaces 200 mm high and 500 mm wide must be provided on both the left and the right sides of the solar car for event signage.

Event signage will be provided by the organiser at scrutineering. Artwork and a style guide will be available on request. Incorrect use of artwork will result in a sticker being applied.

1.7.2 Competition numbers must be in an area of at least 200mm x 200mm and be clearly displayed on each side of the solar car. The digits must be more than 150 mm high and clearly visible against their background. These numbers will be provided by the Ilanga Cup.

1.7.3 Event signage and team numbers must be completely visible from 3 m perpendicular to the side of the solar car and at a viewing height of 1.8 m above the ground.

1.7.4 Solar cars must have an unbroken front signage area on the solar car body forward of the windscreen. The projection of a 600 mm × 150 mm rectangle onto the solar car body, perpendicular to the plane of the rectangle (see the diagram below), must fit entirely within the front signage area. The entire front signage area must be visible in plain view and in front elevation view and must not overlap with the solar collector. A 150 × 150 mm event logo must be placed within the projection of the rectangle, with part of the event logo further forward than every part of the solar collector. Artwork or a sticker for the event logo will be provided by the event organiser. The front signage area should also include the name of the team or the name of the car.



1.7.5 The national flag of the country of entry must be displayed on the solar car, adjacent to the windscreen. Minimum size is 70 mm × 40 mm. The flag must not be broken.

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1.8 Ballast

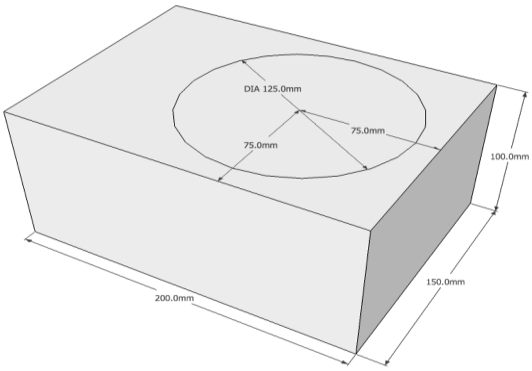
1.8.1 Each solar car occupant will be assigned ballast so that the combined mass of the occupant and their ballast is at least 80 kg.

1.8.2 The solar car must have means of securing each occupant's ballast within 300 mm of their hip point, in a position accessible by the observer.

1.9 Tracker

1.9.1 The solar car must have provision to carry a self-contained tracker provided by the event organiser.

The box will be at most 200 mm long, 150 mm wide and 100 mm high. The upper face of the box will be marked with a circular window with a diameter of 125 mm, as shown in the diagram. The tracker will be self-powered. It will not require any electrical connection from the solar car. The mass of the tracker will not exceed 5 kg. It will emit radio frequency energy with no more power than emitted by a mobile phone. The unit will be installed during scrutineering.



1.9.2 When the tracker box is installed in the car, it must be possible to construct a right circular cone with an apex angle of 120°, and to orient the cone so that the circular window is entirely within the cone, and no ray from the apex and within the cone passes through the ground or through any part of the car that is not radio-transparent at frequencies between 300 and 3000 MHz

1.9.3 The tracker unit will be removed at the conclusion of the event.

1.9.4 This is a standard specification for the trackers used on the Ilanga Cup. Each event/organiser may choose to supply tracking units that are smaller and lighter than this specification. This is at the discretion of each organiser.

1.10 Safety

1.10.1 Teams are responsible for the safety and roadworthiness of their solar cars. Compliance with the regulations and passing scrutineering does not mean that a solar car is safe, roadworthy, and fit for purpose.

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1.10.2 Each team must engage a professionally qualified engineer, responsible for inspecting and certifying that the solar car is designed and constructed using sound engineering practice, meets the design parameters where stated, and is roadworthy and fit for the purpose of being driven on public roads.

1.10.3 The event organisers may, at any stage, remove a solar car from the event if they consider the solar car or the behaviour of the team to be unsafe.

1.11 Occupant cell

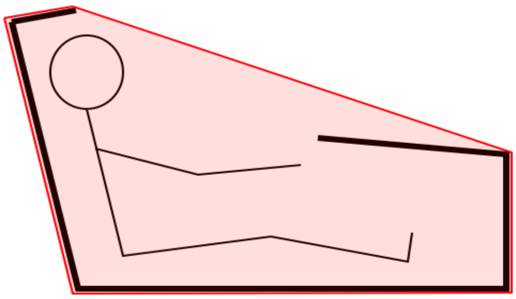
1.11.1 Solar car occupants must be enclosed in an occupant cell designed to protect them from injury.

1.11.2 Teams must provide documentation that specifies which parts of their solar car constitute the occupant cell.

1.11.3 When occupants are seated normally, with safety-belts and helmets on, no part of any occupant or their helmet may intersect with the convex hull of the occupant cell.

1.11.4 No point of any occupant's helmet may lie within 50 mm of the convex hull.

Imagine stretching a rubber skin around the occupant cell; no part of any occupant may touch the skin, and helmets must be more than 50 mm from the skin.



1.11.5 Each team must provide calculations of how the occupant cell will protect the occupants from frontal impacts, side impacts and rollover impacts. This description must be endorsed by the team's certifying engineer and show that the occupant cell will not deform by more than 25 mm and will nor fail at any point when subjected to the following load cases, based on the fully-laden mass of the solar car.

For teams wishing to do finite element analysis of the occupant cell, the minimum test loads are:

- *frontal impact: a 5 g load, opposing the direction of travel, applied to the front of the occupant cell in an area less than 250 mm high and less than 600 mm wide*
- *side impact: a 5 g load into the side of the occupant cell, applied adjacent to the driver's torso in an area less than 250 mm high and less than 600 mm wide*
- *top impact: a load with components 5 g down, 1.5 g sideways and 4 g backwards, applied at each possible area of contact between the occupant cell and the ground when the occupant cell is upside down; the contact area for each test load must have a diameter less than 150 mm.*

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To reduce the risk of injury from impacts, the interior of the occupant cell adjacent to each occupant's pelvis, abdomen, thorax, and shoulder should be covered with energy absorbing material at least 50 mm thick and with a compressive strength of 500–1000 kPa.

1.11.6 The solar car body and occupant cell must be designed so that parts, such as the solar collector, cannot detach and injure occupants.

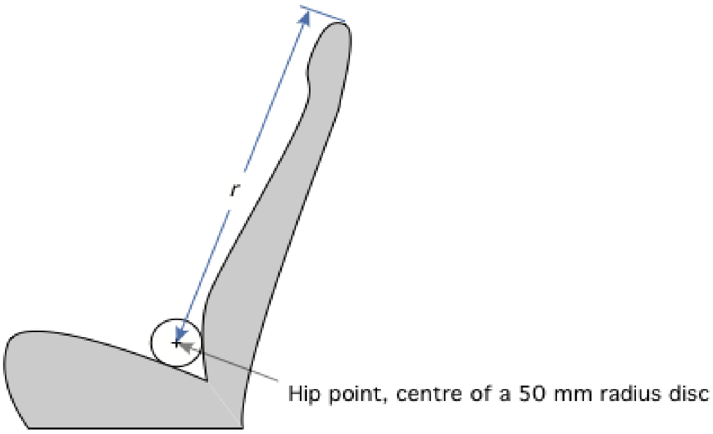
1.12 Seats

1.12.1 Cruiser solar cars must be designed to carry more than one occupant.

1.12.2 Adventure solar cars may be designed to carry any number of occupants.

1.12.3 Each solar car occupant must have a seat that faces forward at an angle less than 10°, about a vertical axis, from the forward direction of travel.

1.12.4 Each seat must have a back and a head restraint. Each head restraint must be entirely behind the occupant's head. The distance from the hip point to the top of the head restraint must be at least 800 mm for front seats and at least 750 mm for rear seats (UNECE Regulations 17 and 25). The hip point may be approximated as shown in the diagram below.



1.12.5 Each occupant's heels must be below their hip point.

1.12.6 The angle between each occupant's shoulders, hips and knees must be more than 90°.

1.12.7 No more than the solar car driver seat may be occupied while driving.

1.13 Occupant space

1.13.1 Occupant space for each seat must comply with Act 93 of 1996: National Road Traffic Act. As shown in the following diagram, the 835mm radius arm must be able to move 45° forwards, 25° backwards and 7° either side of vertical. The solar car structure, including the windscreen, must lie wholly outside the occupant space. The steering wheel, mirrors, seat backs and head restraints may be inside the occupant space but must be designed to minimise the risk of injury in a crash.

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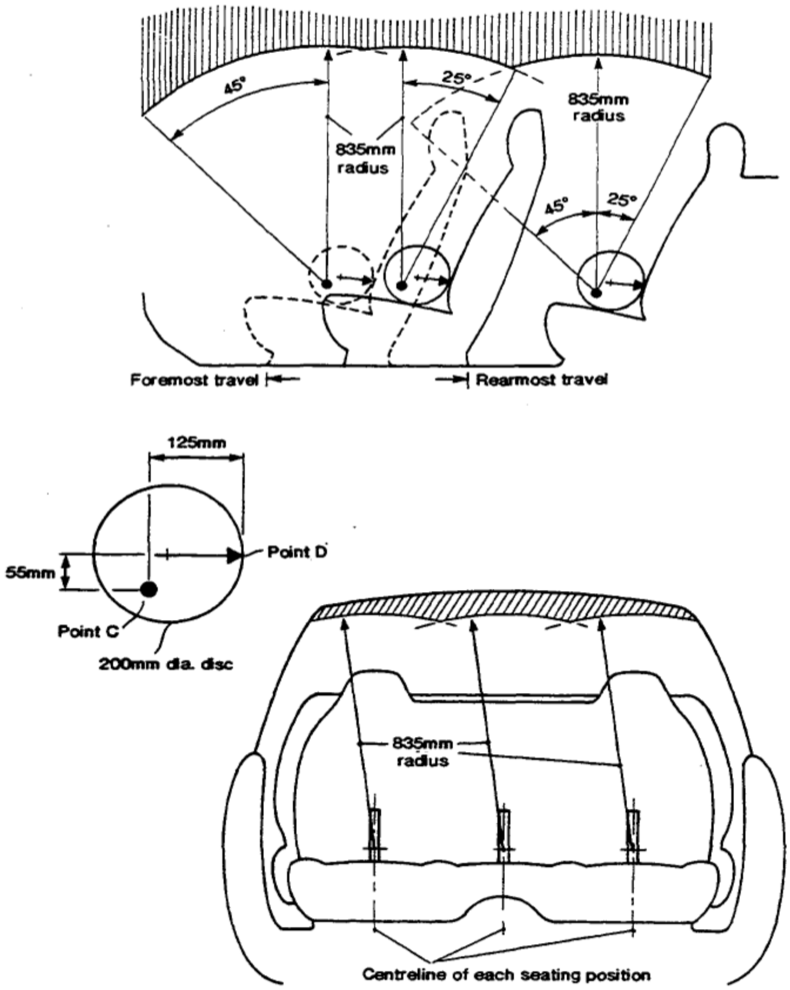
This minimum occupant space requirement is based on a 50-percentile male and does not allow for a helmet. Taller team members may need more occupant space.



1.14 Safety-belts

1.14.1 Safety-belts must be fitted for each seating position. Safety-belts must be compliant with at least one of the following standards: UNECE Regulation 16, US FMVSS 571.209, SFI 16.1, SFI 16.5, FAI 8853/98, FAI 8854/98.

The occupant cell will provide the greatest protection when occupants are secured into the cell with four-point or five-point harnesses.

1.14.2 Safety-belts must be fitted and used according to the manufacturer's instructions.

1.14.3 Safety-belt anchorages must meet the intent of UNECE Regulation 14. In particular:

- upper anchorages for each seat must withstand a force of 13.5 kN applied to the upper safety-belt straps
- lower anchorages for each seat must withstand a force of 13.5 kN applied to the lower safety-belt straps

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- the location of anchor points must comply with the instructions of the safety-belt manufacturer, or with UNECE Regulation 14 Annex 3.

1.14.4 Compliance must be confirmed by the team's certifying engineer.

1.15 Egress

1.15.1 Teams must demonstrate that all occupants can exit the solar car in less than 15 seconds, without assistance. Cruiser and Adventure solar cars with more than four seats will be tested with four occupants.

1.15.2 Doors and canopies must be capable of being secured and released from inside the solar car and from outside the solar car.

1.15.3 Emergency openings, and the methods of opening, must be clearly indicated on the exterior of the solar car, and be visible to an emergency services first responder.

1.15.4 Except in an emergency, occupants must exit the solar car without assistance during the event.

1.16 Cooling and hydration

1.16.1 Each solar car occupant must be provided with ventilation or cooling sufficient to ensure that they will not overheat. The team must describe the system and have it approved by their certifying engineer.

1.16.2 Each solar car occupant must have at least two litres of drinking water in the solar car at the beginning of the day and when departing each control stop.

1.17 Forward and sideward vision

1.17.1 Each driver, when seated in the normal driving position with safety-belt and helmet on, must be able to identify 75 mm high letters at every point of forward travel that is:

- 4m from the driver's eyes, and
- between 0.4m below eye level and 0.7m above eye level, and
- between 100° left and 100° right of the direction of travel.

1.17.2 Forward and sideward vision must be achieved without the aid of mirrors, lenses, or electronic vision systems.

1.17.3 The windscreen that is used for forward and sidewards vision must have an optical transmittance more than 75%.

1.17.4 Motorsport flag signal colours must be discernible through the windscreen.

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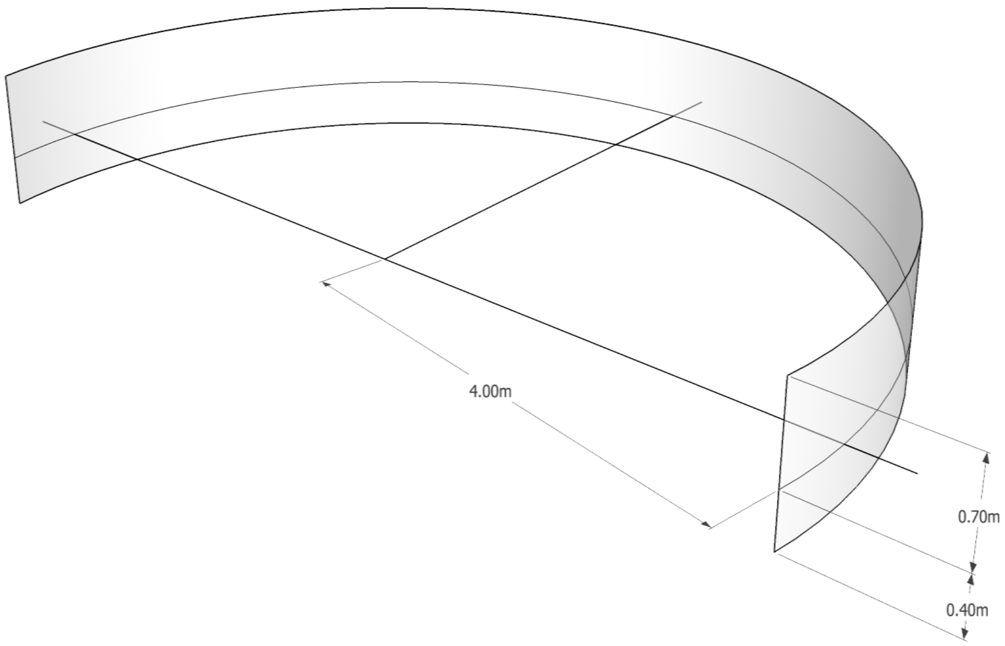
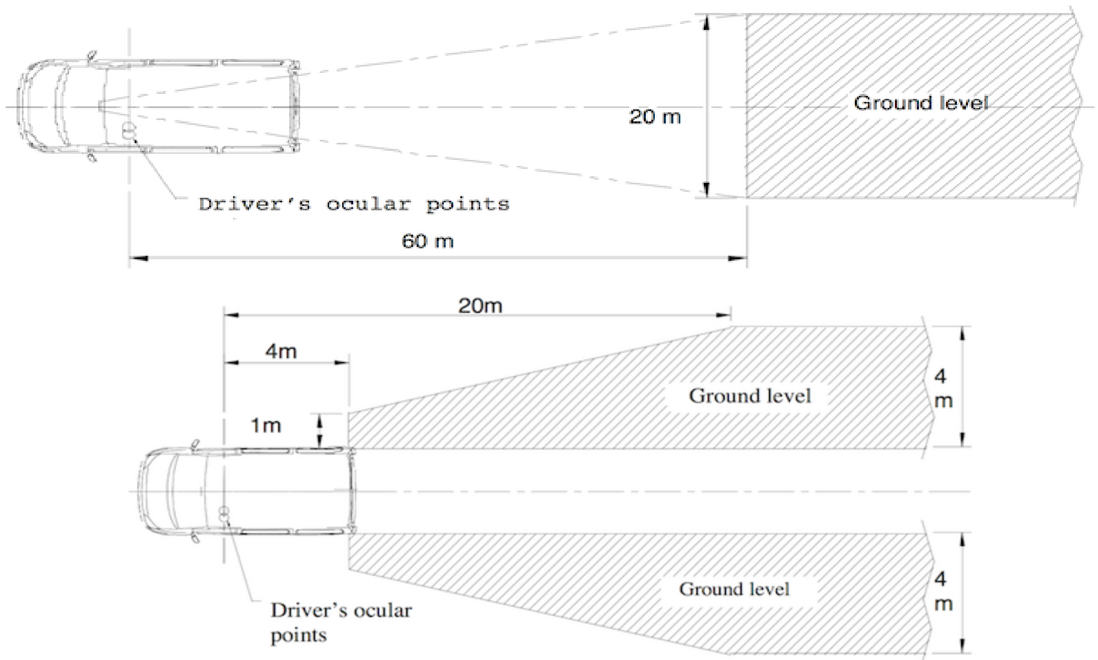


1.18 Rear vision

1.18.1 The solar car must have rear vision systems that enable the driver, when seated in the normal driving position with the safety-belt fastened, to see the ground in the shaded areas shown in the diagrams below (UNECE Regulation 46, Section 15).



1.18.2 Rear vision systems may be electronic, mirrors, or both. Rear vision systems must operate whenever the solar car is in motion under its own power or about to be driven. Rear vision

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images must be oriented so that objects on the right of the solar car are on the right of the image.

1.19 Steering

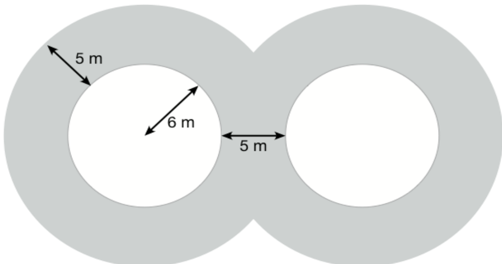
1.19.1 Steering must be controlled by a steering wheel designed so that it cannot catch on clothing while driving or when the driver exits the solar car.

1.19.2 Failure of any non-mechanical component of the steering system must not prevent effective steering of the solar car.

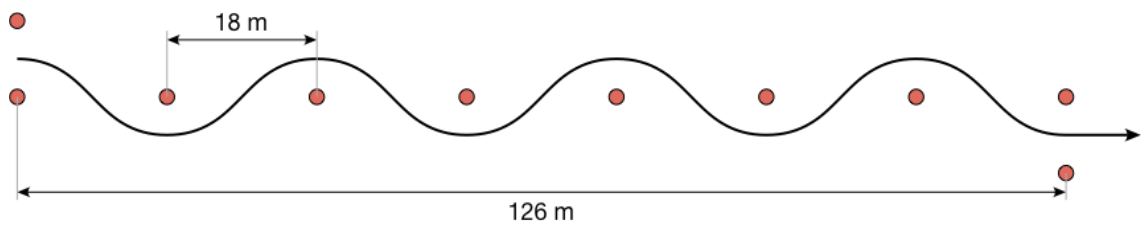
1.19.3 Steering shafts must be designed to reduce the risk of injury to the driver in a crash. A collapsible boss is an acceptable method to reduce steering wheel impacts.

1.20 Stability

1.20.1 Solar cars must be able to negotiate a Figure-8 course in less than 9 seconds per side and less than 18 seconds overall.



1.20.2 Solar cars must be able to negotiate a slalom course in less than 11.5 seconds.



1.20.3 The solar car must be stable at all achievable speeds and in crosswinds.

Wind gusts exceeding 100 km/h are possible.

1.21 Brakes

Braking requirements are based on UNECE Regulation 13-H.

1.21.1 The braking system must be approved by the team's certifying engineer.

1.21.2 The solar car must be equipped with independent primary and secondary braking systems, so that if the primary system fails the secondary system can still stop the solar car. The primary and secondary braking systems must each apply mechanical braking effort to the road wheels.

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Conventional cars have a brake pedal that operates two hydraulic master cylinders or one dual-chamber master cylinder. Each master cylinder operates callipers on a pair of wheels: either the front pair and the rear pair, or diagonal pairs. These arrangements meet the requirements for independent service and secondary braking systems—the service system is all four wheels, and the secondary system is one pair of wheels.

1.21.3 Independent braking systems may share components deemed 'not liable to failure' provided that they are amply dimensioned and readily accessible for maintenance. Components 'not liable to failure' are:

- a brake pedal and its bearing
- hydraulic cylinders and their pistons
- hydraulic control valves
- brake cylinders and their pistons
- brake lever and cam assemblies.

1.21.4 Hydraulic brake hoses and lines are regarded as liable to failure.

1.21.5 For Challenger, Cruiser and Adventure class vehicles, the primary braking system must apply mechanical braking effort to all road wheels.

1.21.6 Braking must not cause the solar car to yaw. This requirement applies to both the primary braking system and the secondary braking system.

1.21.7 For solar cars without anti-lock brakes, the front wheels must lock up before the rear wheels.

1.21.8 The primary braking system must be able to stop the fully laden solar car within distance

$$0.1\,v + 0.0060\,v^2$$

metres from any speed v, in km/h, that the solar car can achieve.

1.21.9 If the primary braking system fails, the secondary braking system must be able stop the fully laden solar car within distance

$$0.1\,v + 0.0158\,v^2$$

metres from any speed v, in km/h, that the solar car can achieve.

1.21.10 Solar cars must be equipped with a parking brake that can be operated by the driver from the normal driving position. The parking brake must be capable of holding the fully laden solar car on a 20% incline or decline.

1.22 Tyres

1.22.1 Tyres must be suitable for highway use and used in accordance with their manufacturer's recommendations at all times.

1.22.2 Solar cars must be fitted with tyres that are:

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- compliant with UNECE Regulation 30, UNECE Regulation 75 or US FMVSS 571.109, as indicated by an E or DOT approval marking on the tyre; or
- otherwise approved by the event organiser.

Experimental or prototype tyres must be approved by the South African road traffic authorities. The event organiser will administer this process, which requires the tyre manufacturer to submit a sample tyre and written technical specifications to the event organiser's office not later than 31 March 2022. A positive outcome to the approval process, which may take up to three months, is not guaranteed.

1.22.3 The speed rating of the tyres must be more than the maximum speed of the solar car. The load rating of each tyre must be more than the maximum static load imposed on it by the fully laden solar car.

1.22.4 Tyres must be approved by the certifying engineer.

1.22.5 Tyres must be free of any apparent defect.

1.23 Reversing

1.23.1 Solar cars must be able to be driven backwards under their own power with the driver seated in the normal position.

1.24 Lighting

1.24.1 Solar cars must be fitted with:

- two rear stop lamps
- one central stop lamp
- two daytime running lamps

Daytime running lamps and tail lamps are compulsory for all competing solar cars.

1.24.2 Stop lamps must emit red light. Direction indicator lamps must emit amber light. Daytime running lamps must emit white light.

1.24.3 Lamps must be compliant with UNECE Regulations 6, 7 and 87, or the SAE/DOT equivalents. Teams must demonstrate compliance by either:

- the presence of compliance markings on the lamps, or
- detailed documentation that demonstrates compliance with the photometric requirements of the UNECE or SAE/DOT regulations, confirmed by the certifying engineer.

Lamps approved for motorcycles may not meet these requirements.

1.24.4 Solar cars must have the correct type of lamp in each position. For example, side marker lamps may not be used as stop lamps. Lamps must be mounted with the correct orientation so that the photometric requirements of UNECE Regulations 6, 7 and 87, or the SAE/DOT equivalents, are met.

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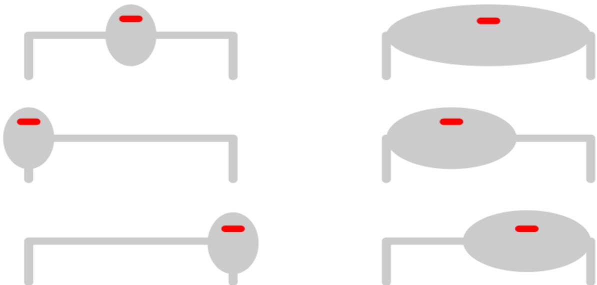
Lamp	UNECE category	SAE/DOT type
Stop lamps	S1, S2	S
Central stop lamp	S3	U3
Daytime running lamp	RL	Y2

Lamp position and visibility requirements are based on UNECE Regulation 48.

1.24.5 Rear stop lamps must be within 400 mm of the extreme outer edge of the solar car on each side, at least 600 mm apart (at least 400 mm apart if the solar car is less than 1300 mm wide), and at least 350 mm above the ground. The entire apparent surface must be visible 15° up, 5° down and 45° to the left and right.

The "apparent surface" of a lamp includes all parts of the lamp surface that emit light and are not obscured by other parts of the light-emitting surface.

1.24.6 A central stop lamp is required. Viewed from behind the solar car, the lateral position of the lamp must coincide with the visual centre of the solar car (see the examples in the following diagram). The lamp must be higher than a point 150 mm below the rear windscreen or canopy, and the bottom of the lamp must be higher than the top of the rear stop lamps. The entire apparent surface must be visible 10° up, 5° down and 10° to the left and right.



1.24.7 Daytime running lamps must be mounted at the front of the solar car, at least 600 mm apart (at least 400 mm apart if the solar car is less than 1300 mm wide), and at least 250 mm above the ground. The entire apparent surface must be visible 10° upwards, 10° downwards, 20° outwards and 20° inwards.

1.24.8 The stop lamps must operate whenever driving is possible and

1.24.9 The daytime running lamps must operate whenever driving is possible.

1.25 Audible warning device

1.25.1 An audible warning device complying with the intent of UNECE Regulation 28 must be fitted to the solar car.

1.25.2 Sound pressure level must be more than L_A = 105 dB measured 2 m from the horn.

The horn should be mounted so that solar car occupants are not subjected to excessive sound pressure levels.

1.25.3 The device must emit a continuous and uniform sound.

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1.26 Instrumentation

1.26.1 The following information must always be provided to the driver while driving:

- the speed of the solar car
- energy storage system warnings
- electronic rear vision images (if fitted).

1.26.2 This instrumentation must be powered from the energy storage system, and not from separate batteries.

1.27 Automatic functions

1.27.1 Any cruise control function must automatically deactivate when the brake is operated, or the car is turned off.

1.27.2 Any automatic driving function must immediately deactivate on manual input or when the car is turned off.

1.28 Electrical safety

Electrical safety requirements are based on Section 5 of UNECE Regulation 100. The term 'high voltage' means more than 60 V dc or more than 30 V rms ac.

1.28.1 Protection against direct contact with high-voltage parts, including conductors, must be achieved using double insulation, enclosures, or barriers. It must not be possible to remove protection without the use of tools.

1.28.2 Protection against direct contact with high-voltage parts inside the driver, passenger and luggage compartments must be designed to exclude objects larger than 1 mm diameter (Ingress Protection rating IPXXD).

1.28.3 Protection against direct contact with high-voltage parts inside areas other than the driver, passenger and luggage compartments must be designed to exclude fingers (Ingress Protection rating IPXXB).

1.28.4 Double insulation must meet the AS 3001/IEEE 100 definition: comprising both basic insulation and independent supplementary insulation that provides protection equivalent to that of the basic insulation. A single layer of reinforced insulation is also acceptable if it provides protection equivalent to double insulation.

Electrical tape wrapped around an insulated wire is not acceptable – anything damaging the electrical tape is likely to damage the insulation too. The front surface of a photovoltaic cell is deemed to be double insulated if properly encapsulated.

1.28.5 High-voltage energy storage packs must be marked with the high-voltage symbol shown in the following diagram.

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1.28.6 The high-voltage symbol must also be visible on any enclosure or barrier that can be accessed without using tools, if removing the enclosure or barrier exposes high-voltage parts.

Example: A motor controller contains high voltage parts, so these parts must be protected by an enclosure or barrier that requires tools to remove (Regulation 1.28.1). If it is possible to access the motor controller enclosure without using tools (e.g., by opening the boot or tilting the solar collector) then the motor controller enclosure must have a high-voltage symbol on it.

1.28.7 The resistance between any exposed conductive part and each terminal of the energy storage system must exceed 100 *V* ohms, where *V* is the nominal voltage of the energy storage system.

This is equivalent to a maximum leakage current of 10 mA.

1.28.8 The resistance between any exposed conductive part and each terminal of every solar cell must exceed 100 *V* ohms, where *V* is the maximum circuit voltage of the solar collector.

1.28.9 Exposed carbon fibre is considered to be an exposed conductive part and so must be isolated from the energy storage system and from the solar collector.

1.28.10 Each energy storage pack must be protected by a fuse or circuit-breaker rated to interrupt the short-circuit fault current of the pack. This fuse or circuit-breaker must be mounted in or on the energy storage pack.

1.29 Electrical safe state

1.29.1 The solar car must have a ‘safe state’ which, in an emergency, minimises the risk of electrical fire and electric shock to occupants, team members, emergency response personnel, and bystanders. When in the safe state:

- there must not be a high voltage across any pair of conductors emerging from the energy storage packs or from the solar collector.
- every conductor emerging from each energy storage pack must be galvanically isolated from every energy storage cell
- voltage exceeding 15 V must not be present across any pair of conductors emerging from energy storage packs or the solar collector, and no pair of conductors shall be capable of delivering more than 50 mA.

1.29.2 Any conductor that is more than 200 mm from the nearest PV cell or from an associated electronics module such as a maximum power point tracker is considered to be outside of the solar collector.

1.29.3 All mechanisms for placing the solar car into safe state and maintaining safe state must be fail-safe; if an electrical activation mechanism fails, the solar car must automatically and immediately place itself into safe state and must remain in safe state indefinitely.

A simple design might use normally open contactors in the energy storage packs, and have these contactors energised via a series loop of mechanical switches, all of which must be closed for normal solar car operation. If the loop breaks or any switch opens, the contactors will open, and the vehicle will enter safe state.

Teams using other mechanisms, such as those incorporating solid state switches (which can fail closed) or software (which can fail in many ways), must be able to demonstrate that the probability of the mechanism failing to place the car into safe state is less than that of a system with normally-open contactors and normally-closed switches.

1.29.4 The driver must be able to place the solar car into safe state while seated in the normal driving position and without releasing the safety-belt.

1.29.5 For emergency use, an activation device that immediately places the solar car into safe state must be provided on the exterior of the car. The activation device must be placed within a yellow disc with a minimum diameter of 180 mm. Also, in the yellow disk must be a blue equilateral triangle (minimum side length 150 mm) that contains a red flash, with the legend Emergency Electrical Isolation. In addition, there must be a clear instruction on how to operate the device (e.g., PULL or PRESS). The yellow isolation disc and the activation mechanism must be clearly visible to an emergency services first responder approaching the driver and must be within 100 mm of the base of that part of the windscreen used to meet the forward vision requirement, and adjacent to the driver egress opening.

2. Cruiser class

2.1.1 The goal for Cruiser teams is to design and build a practical solar car and transport people for the duration of the event on Red Star Raceway. Cruiser teams will be scored on energy efficiency, practicality, and distance.

2.1.2 Cruiser solar cars may be recharged from Electric Vehicle Supply Equipment (EVSE) provided by the organiser between prescribed times only (Not Applicable during the 8 hour Challenge). No other charging from external sources is allowed. The external energy used to recharge the solar car will be measured by the organisers. The time each Cruiser teams spends charging from

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external sources will be published, along with the energy used, and will be considered by the practicality judges.

2.1.3 Each Cruiser solar car completing at least the first stage will be given a final score calculated by

$S = D / E \times P \times 0.99^{(l + d)}$

where

- *D* is the person-laps travelled (<Laps travelled> x <number of people>)
- *E* is the nominal external energy use of the solar car, in kilowatt-hours
- *P* is the practicality score of the solar car, between 0 and 1
- *l* is the total lateness at each day, in minutes (in excess of 10)
- *d* is the number of demerit points received by the team.

2.1.4 The Cruiser Cup will be awarded to the Cruiser team that completes the longest distance together with the highest score.

2.1.5 The progressive score of a Cruiser team at the end of the event will be calculated by

$S = D / E \times 0.99^{(l + d)}$

where

- *D* is the person-laps travelled between day start and the control stop
- *E* is the nominal external energy use of the solar car, in kilowatt-hours, prior to arriving at the control stop
- *l* is the total lateness at the day end, in minutes (minus the 10 minutes grace, excluding the last day, where there is no grace)
- *d* is the number of demerit points received by the team.

2.1.6 Nominal external energy use of a Cruiser solar car will be calculated as E0 + Σ En, where E0 is the nominal energy capacity of the energy storage system, En is the sum of all recharge energy measured at each of the charging points provided by the organisers. The nominal energy capacity of a rechargeable electrochemical battery is the sum of the nominal cell masses in kilograms multiplied by:

- 330 Wh kg^{-1} for Li-S cells
- 250 Wh kg^{-1} for Li-ion cells
- 250 Wh kg^{-1} for Li-polymer cells
- 125 Wh kg^{-1} for $LiFePO_4$ cells.

2.1.7 The nominal energy capacity of other types of energy storage system will be determined by the Chief Energy Scientist.

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2.1.8 Person-laps is the sum of the distances travelled by drivers and passengers in the solar car. Person-laps will be counted for each seat that is occupied for a complete lap on the tracks.

2.1.9 The practicality score for a Cruiser team will be determined by a panel of judges appointed by the organiser. Each judge will allocate a single score, between 0 and 100%, to each team. The final practicality score for a team will be the arithmetic mean of the individual judge's scores. Judges will be asked to consider:

- design innovation
- environmental impact
- ease of access and egress
- occupant space and comfort
- ease of operation (driving and charging)
- versatility
- style and desirability
- suitability for the declared purpose
- advanced safety considerations

Judges will not be told how much weight to place on each of these criteria.

The number of seats will not contribute to the practicality score, because the benefits of more seats should be reflected in the person-laps score.

2.1.10 Cruiser teams must prepare a brochure that describes their car, how it will be used, and how it will interact with a smart grid. Teams must also give a 3-minute presentation about their car to the judges after the conclusion of the event before the awards ceremony takes place and allow judges to get into their car to test the space and comfort.

3. Adventure class

3.1.1 Adventure class is non-competitive with fewer restrictive regulations resulting in the opportunity to build a vehicle different to other class vehicles, in turn gives way to innovation and design opportunities.

3.1.2 Teams in Adventure class will not be ranked by performance.

3.1.3 Adventure class vehicles must pay close attention to the technical regulations and build a vehicle according to the guidelines provided above. The most important aspect of designing and building the vehicle should always be focused on safety in all aspects.

3.1.4 Pay special attention to sections with "(with the exception of teams entered in the Adventure Class)" at the end. These notes indicate that the specific regulation does not apply to Adventure Class entrants. All other regulations without this note should take into consideration.

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Glossary

Battery	Electrochemical cells wired in series or parallel and housed in a single container.
CB	Citizen's Band radio.
Certifying Engineer	A professional engineer engaged by a team to report on compliance with regulations and roadworthiness requirements.
Clerk of the Course	The person responsible for coordinating Dynamic Scrutineering and the on-road portion of the event.
DOT	United States Department of Transport.
DST	South African Department of Science and Technology.
Energy Storage Pack	A self-contained box containing components of the energy storage system, such as electrochemical cells and a battery management system.
Energy Storage System	The solar car subsystem used to store energy. It is typically a rechargeable electrochemical battery, but other types of energy storage system are possible.
Entrant	The legal entity that completes the Participation Agreement and requests a place in the event for one or more teams. An entrant is typically a registered institution, organisation, or commercial entity.
Event Name	The official name of the event is the "Ilanga Cup".
BWSC	Bridgestone World Solar Challenge.
EVSE	Electric Vehicle Supply Equipment.
FAI	Federation Internationale de l'Automobile.
FMVSS	United States Federal Motor Vehicle Safety Standards.
High Voltage	More than 60 V dc or more than 30 V rms ac.
ISF	International Solarcar Federation.
Judge	A person invited to make subjective comment on Cruiser Class attributes.
Judge of Fact	A person recognised by the organiser as able to determine whether a particular event occurred (e.g. whether a team obstructed traffic).
Participant	A person who has registered to participate in the event as a member of a team.
PV	Photovoltaic.

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Road-Ready	Ready to drive on the road.
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Official Instagram	https://www.instagram.com/ilangacup/
Official Facebook	https://www.facebook.com/IlangaCupZA
Official Twitter	https://twitter.com/EnduranceChall1
Official Time	South African Standard Time GTM +2. This is given on the South African telephone number 1026.
Scrutineering	The process of checking the solar car and other team vehicles for compliance with the regulations.
SFI	The SFI Foundation issues standards for motor sports equipment.
Solar Collector	The solar car subsystem used to collect solar energy. It is typically an array of photovoltaic cells, with or without concentrators or reflectors, but other types of solar collector are possible.
Steward	An event official responsible for ensuring regulations are applied correctly and fairly.
Team	A group of people registered by the entrant to participate in the event. An entrant may have more than one team participating in the event.
Team Manager	The person in charge of, and responsible for, the actions of a team.
UHF	Ultra-High Frequency. Commonly refers to South African two-way radio.
UNECE	United Nations Economic Commission for Europe, responsible for regulations for motor vehicles.
UTC	Coordinated Universal Time.
VIN	Vehicle Identification Number.

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