

2021 REGULATIONS

22-30 OCTOBER



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2021 Bridgestone World Solar Challenge Regulations

Introduction and welcome

The biennial World Solar Challenge is owned and managed by the South Australian Tourism Commission; an organisation set up by the Government of South Australia to promote tourism in South Australia. Since 2013, Bridgestone Corporation has been the naming rights sponsor of the event.

The aim of the Bridgestone World Solar Challenge is to stimulate research into, and development of, sustainable road transport. The Bridgestone World Solar Challenge is primarily a design competition. The regulatory philosophy is to provide the parameters on which to base the design, rather than specify exactly how to build a solar car. Science and technology evolve and to encourage the most innovative ideas, event requirements also evolve. Participation in the 2021 Bridgestone World Solar Challenge calls for the design and construction of a solar car within given design parameters and driving the solar car across the continent of Australia in accordance with these regulations.

Each Bridgestone World Solar Challenge is different. Revisions for the 16th edition retain the clear distinction between Challenger and Cruiser Classes: Challenger Class cars will be efficient, and Cruiser Class cars will be efficient and practical.

The major changes for 2021 include:

- Challenger Class solar cars must have three or more wheels
- new ground clearance requirements based on automotive standards
- new turning circle requirements
- solar collectors must have low environmental toxicity
- a standard manikin must fit into each seat
- teams must have the dynamic stability of their solar car certified
- the emergency safe state may not have any voltage or current present outside of energy storage packs or the solar collector
- solar cars must have daytime running lamps
- the registration plate must be mounted at the rear of the solar car
- teams must have their solar cars re-certified after making significant repairs.

The information contained in this document is for the purposes of conducting the 2021 Bridgestone World Solar Challenge and must not be regarded as constituting definitive instructions as to how a solar car should be constructed or operated.

This document is organised as far as practical into the following sections:

- Administration
- Solar car regulations
- Adventure (Darwin and on-road protocols)
- Achievement and celebration.

Additional information or clarification of the intent of regulations is included in italics.

The words WORLD SOLAR CHALLENGE and the SUN, FLAMES, RISING IN SEMI-CIRCLE image are registered trademarks owned by the South Australian Tourism Commission.

1 Administration

1.1 Scope

- 1.1.1 These regulations apply to the 2021 Bridgestone World Solar Challenge (hereinafter called ‘the event’), and comprise participants’ eligibility, pre-event preparation, scrutineering, testing, on-road components and any associated activities published by the event organiser as being part of the event.
- 1.1.2 The event will be conducted under the regulations described in this document (which supersede regulations for any previous edition of the Bridgestone World Solar Challenge) and any amendments, further regulations or Team Notices that may be issued.

1.2 Correspondence

- 1.2.1 All correspondence shall be conducted in English, the official language of the event.

If you are unsure of the meaning of a regulation, ask for clarification by emailing the Participant Liaison Officer at teams@worldsolarchallenge.org

- 1.2.2 Official correspondence must be conducted between the event organiser and the entrant’s nominated representative (the Team Manager) as detailed by the entrant on the entry form. Specific written instruction to include others in team correspondence will be accepted.

1.3 Time zones

- 1.3.1 At the time of the event, Darwin and the Northern Territory observe Australian Central Standard Time (ACST = UTC + 9.5) while Adelaide and South Australia observe Australian Central Daylight Time (ACDT = UTC + 10.5). The event will observe ACST (Darwin time) throughout the journey to Adelaide.
- 1.3.2 After arrival at the finish line, all activities will be conducted in ACDT (Adelaide time).

1.4 Conduct of the event

- 1.4.1 The on-road component of the event is conducted on public roads between Darwin and Adelaide, Australia—a distance of approximately 3020 km. In addition to these event regulations, all activity is conducted under applicable traffic codes, civil laws and regulations.
- 1.4.2 Specific instructions contained in route notes will be considered part of the event regulations.

- 1.4.3 All activities undertaken by a registered entrant, including activities conducted prior to the commencement of the official event period, are governed by statutory regulations, breaches of which may incur event penalties.

1.5 Eligibility

- 1.5.1 Eligible vehicles will be those that meet the design criteria described by these regulations. Participating solar cars must not be used on any public roads during the event period until permission has been granted by the civil authorities and the event organiser. Further information will be included in the Team Manager's Guide.
- 1.5.2 Solar cars must be powered by solar irradiance collected by the solar car. The only other external energy inputs that may be used are:
- the energy in the energy storage system at the start of the event
 - external energy used to recharge Cruiser Class solar cars at designated locations and times.

It is accepted that energy from regenerative braking, road gradients and wind incident on the car while driving may also be used.

1.6 Entrant obligation

- 1.6.1 By applying, entrants declare that they know and understand the regulations of the event and agree that participation will constitute their full acceptance.
- 1.6.2 Each entrant will appoint an individual to act as the 'Team Manager'. The Team Manager will be responsible for regulatory compliance, the actions of team members, and any other individuals associated with the team. Once appointed, the Team Manager may only be replaced with the approval of the event organiser.
- 1.6.3 Entrants are expected to act fairly and in good faith in accordance with the regulations.
- 1.6.4 Penalties (which may include exclusion) will be applied to any team deemed to have departed from the spirit of the event by deliberately acting to gain an unfair advantage over others, or by conduct that could bring the event into disrepute.

1.7 Event organiser

- 1.7.1 The event is owned and managed by the South Australian Tourism Commission (ABN 80 485 623 691), a body corporate pursuant to the *South Australian Tourism Commission Act 1993* (SA) ('the event organiser').

Head Office: GPO Box 1972, Adelaide 5001
Head Office Telephone: +618 8463 4500
Event Telephone: +618 8212 8500
Event E-mail: admin@worldsolarchallenge.org
Web: www.worldsolarchallenge.org

1.8 Event Management Team

1.8.1 The Event Management Team is:

- Hitaf Rasheed, Executive Director Events South Australia
- Chris Selwood AM, Event Director, Bridgestone World Solar Challenge
- Dr Alistair MacDonald, General Manager Adelaide 500 & Bridgestone World Solar Challenge
- Naomi Misajlo, Event Manager, Bridgestone World Solar Challenge
- Clint Hendry, General Manager Commercial Sales
- Andrew Fotheringham, General Manager Marketing & Communications
- such other members the event organiser may appoint.

1.8.2 Scientific Faculty:

- A/Prof Peter Pudney
- Dr David Rand AM FTSE
- Mr Paul Gwan
- Prof John Storey
- Dr David Snowdon
- Dr John Ward
- Mr Bart De Moitié
- Dr Glenn Platt
- such other members the event organiser may appoint.

1.8.3 Operational Advisory Group:

- Bill Muirhead
- Harry McCallum
- Vince Ciccarello
- Daniel Sawyer
- such other members the event organiser may appoint.

1.9 Officials of the event

- 1.9.1 The event will appoint officials who will be responsible for the conduct of the event.
- 1.9.2 During the event, these officials will wear white or red event shirts.
- 1.9.3 A full list of all appointed officials will be published on the event website and distributed to teams via a Team Notice.

1.10 Jury

- 1.10.1 The event organiser will appoint a team of independent jurors to resolve disputes. Jurors will be published within the full list of officials noted in regulation 1.9.
- 1.10.2 The team of appointed jurors is the only authority empowered to determine the interpretation of these regulations.

1.11 Judges of Fact

- 1.11.1 Each official appointed by the event organiser is a Judge of Fact on any event-related activity.
- 1.11.2 Observers appointed by the event are Judges of Fact on all event-related activities.

1.12 Schedule

- 1.12.1 A detailed event schedule including all official functions, promotional activities and public engagement activations will be published on both the event website, team portal and distributed to teams via a 'Team Notice'.
- 1.12.2 All registered teams **must** adhere to the event schedule, attend official functions, media calls, promotional activities and /or public engagement activations with the solar car and/or any other team vehicles or equipment as listed or requested.

Friday 5 June 2020 (World Environment Day)	Event dates announced Volunteer Registrations Open
Friday 19 June 2020	2021 Event Regulations published Applications for Entry Open
Friday 4 September 2020	Early Applications of Entry close
Friday 18 December 2020	Standard Applications for Entry close Volunteer Registrations close
Saturday 5 June 2021	Official Entry list published
Friday 18 June 2021	Group A Documentation submission deadline
Friday 16 July 2021	Group B Documentation submission deadline

Friday 13 August 2021	Group C Documentation submission deadline
Monday 11 October 2021	Group D Documentation submission deadline
Saturday 9 October 2021	Event Headquarters open in Darwin (Hidden Valley Motor Sports Complex)
Saturday 9 October 2021	Official event period commences
Sunday 10 October 2021	Team manager's briefing
Monday 11 October 2021	All teams to be based at Event Headquarters (Hidden Valley Motor Sports Complex)
Saturday 16 October 2021	Static scrutineering & public engagement program commences
Tuesday 19 October 2021	Official Team Welcome function
Tuesday 19 October 2021	All team members are required to be in Darwin and registered
Wednesday 20 October 2021	Chief Minister's VIP Reception (TBC)
Thursday 21 October 2021	Dynamic scrutineering commences
Thursday 21 October 2021	Team briefing
Thursday 21 October 2021	Media briefing
Friday 22 October 2021	Ceremonial Start in Darwin
Tuesday 26 October 2021	Ceremonial Finish Line opens in Adelaide
Wednesday 27 October 2021	Cruiser Class finish
Thursday 28 October 2021	Cruiser Class public judging
Saturday 30 October 2021	Award Ceremony (TBC)
Tuesday 2 November 2021	Pack-down area closes, official event period closes

1.13 Entering the event

Applications for entry are invited from any entrant prepared to meet the standards and obligations of the competition.

- 1.13.1 Applications may be made from the time these regulations are published, until noon Friday 18 December 2020 (ACDT), or such other time as the event organiser may determine.
- 1.13.2 Applications for entry must be made via the official online entry form, available on the Bridgestone World Solar Challenge website (www.worldsolarchallenge.org).
- 1.13.3 Accepted applications for entry will only be considered confirmed upon payment of the application fee.

- 1.13.4 The number of places is limited. Applications received after the limit is reached may be placed on a reserve list.
- 1.13.5 The granting of a place in the event will become void if the entry fees have not been received by the due date.
- 1.13.6 Entrants who do not satisfy the Chief Scrutineer that they will achieve compliance with the regulations (through documentary submission) may fail to qualify for the event and their place may be offered to a team on the reserve list.
- 1.13.7 The event organiser reserves the right to accept or reject any application without explanation.

1.14 Entry fees

- 1.14.1 Entry fees include **Australian tax (GST)** and are based on the class requested on the entry form. For example, if a Challenger Class team fails to qualify and is offered a place in the Adventure Class, no refund of the difference is payable.
- 1.14.2 An application fee of 10% of the total entry fee is payable upon confirmation that the application for entry has been accepted by the event organiser. Payment of this fee will be via credit card as part of the online entry form process. An official tax receipt will be provided via email.
- 1.14.3 The application fee, which forms part of the total entry fee, is non-refundable.

Entrants will be provided with an invoice for the remaining entry fee within one month of receipt of their completed official entry form and application fee. Acceptable methods for payment of entry fees will be detailed in the invoice document.

- 1.14.4 International banking charges are the responsibility of the entrant. Minor adjustment (up to AU\$150) can be settled at registration in Darwin.
- 1.14.5 Applications submitted before 17:00 (ACDT) on Friday 4 September 2020 will be considered an Early Entry and qualify for the Early Entry fee.

Early Entry fees must be paid in full by Monday 2 November 2020. Failure to pay by due date will void the qualification for Early Entry fees and a secondary invoice will be issued for the Standard Entry fee.

- 1.14.6 The Standard Entry fee will apply to applications received after 17:00 (ACDT) on Friday 4 September 2020 and before 17:00 (ACDT) on Friday 18 December 2020.
- 1.14.7 All entry fees are payable in full by noon (ACDT) Friday 26 February 2021; failure to pay by the due date will void the application. Any refund will be subject to the terms outlined under Regulation 1.16.
- 1.14.8 The entry fees are:

Class	Early Entry fee	Standard Entry fee
Challenger	AU\$13,500	AU\$15,000
Cruiser	AU\$13,500	AU\$15,000
Adventure	AU\$11,500	AU\$12,500

and includes

- Team Entry fee
- Team Member Registration fee of up to twenty (20) team members.
- Twenty (20) Awards Ceremony tickets.

An entry fee of AU\$75 will be levied for each additional team member over and above the already included twenty (20). This fee covers team member registration and an awards ceremony ticket.

- 1.14.9 The event organiser reserves the right to accept late entries. Entry requests granted after the close of entries will attract a 10% late fee.

All enquiries regarding fees or payments should be directed to the Participant Liaison Officer via email teams@worldsolarchallenge.org or phone +61 8 8212 8500 during business hours, 09:00–16:30, Adelaide time, Monday-Friday.

1.15 Other fees

- 1.15.1 A fee (estimated at AU\$130) will be payable to the relevant authority by the owner of each solar car in respect of compulsory third-party bodily injury insurance required by operators of motor vehicles.

1.16 Refunds

- 1.16.1 Refund entitlement is based on date of withdrawal.

Withdrawal date	Refund
Before 18 December 2021	Full refund*
Before 26 February 2021	75% refund
Before 1 June 2021	25% refund
After 13 August 2021	No refund

**The application fee and bank charges are not refundable.*

1.17 Cancellation of the event

- 1.17.1 The event organiser reserves the right to cancel or abandon the event for reasons beyond its reasonable control, including but not limited to acts of God, natural disasters, acts of war, weather, riots and strikes outside its organisation, communicable disease crisis and quarantine restrictions.

1.18 Insurance

- 1.18.1 The event organiser holds an AU\$20,000,000 Public Liability policy (aggregate cap with a sub-limit of AU\$5,000,000 per incident) which covers registered team members for property damage caused by a participating solar car during the event. The cost of this coverage is included as part of the entry fee.
- 1.18.2 The event organiser will facilitate for compulsory third-party bodily injury insurance as required by operators of motor vehicles to operate the solar car on public roads, a fee for which may be payable by the owner of the vehicle (refer Regulation 1.15.1)
- 1.18.3 Cover has been arranged to cover any claims *on the event organiser* (not solar car teams) for damage caused by a participating solar car during the event. This cost is part of the entry fee.
- 1.18.4 Comprehensive insurance for personal effects, tools, equipment, solar cars and other vehicles is the responsibility of the entrant.

Participants are advised that a personal travel insurance policy in respect of theft, loss, sickness and accidents is highly recommended. The Australian Government has [reciprocal health care agreements](#) with some countries, covering limited subsidised health services for medical treatment. The event organiser will ensure that the costs of remote area evacuation and emergency medical treatment are covered in the event of an accident. As this can be tens of thousands of dollars, a Team Member Registration Fee described in Regulation 1.14.8 will be levied on each individual team member travelling from Darwin to Adelaide as part of the event.

1.19 Team members

- 1.19.1 Each team must include (but not be limited to):
- a Team Manager
 - a safety officer, responsible for the safety of the team
 - a battery officer, responsible for the solar car battery
 - an interpreter if the Team Manager is not proficient in English
 - at least three and at most six solar car drivers
 - at least two drivers for each support vehicle (solar car drivers should not drive support cars on the same day as driving the solar car)
 - at least one person with a recognised first aid certificate that is current for the duration of the event

- passengers for Cruiser Class teams.
- 1.19.2 Each team member will be required to register online and be physically present at team registration in Darwin. All team members must be in Darwin and registered by 17:00 on Wednesday 20 October 2021.
- Teams will not be allowed to proceed to dynamic scrutineering until all team members have been registered in Darwin.***
- 1.19.3 A person holding the position of Team Manager, safety officer or battery officer may not hold any other of these roles.
- 1.19.4 A person holding the position of Team Manager, safety officer or battery officer must be seated in the front escort vehicle, solar car or rear escort vehicle during the on-road component of the event while the solar car is in motion on a public road.
- 1.19.5 The person holding the position of safety officer may not be a solar car driver.
- 1.19.6 Each solar car driver must hold an appropriate motor vehicle driver's licence recognised by Australian authorities and valid for the total period of the event.
- Driving licences will be inspected and verified by Australian road transport authorities as part of the scrutineering process. Acceptable driving licences must include a photograph of the holder, the class of vehicle for which the licence applies and the expiry date. If these details are not in English, either the licence must be accompanied by a certified translation, or a valid International Driving Licence is required.*
- 1.19.7 The event organiser is unable to take responsibility for any person under the age of 18.
- An entrant may make a request for a minor to be included in their team provided such request is accompanied by a document giving permission and acknowledging that supervision of the person concerned is the responsibility of the Team Manager, not the event organiser. The document must be signed by both the parent or legal guardian of the proposed participant, and the Team Manager.*

1.20 Team identification

- 1.20.1 Team, Team Manager and solar car details will be taken from the online entry form.
- 1.20.2 Requests to change entry details will only be considered when submitted, by the Team Manager, by email or through the team portal.
- 1.20.3 Once an entry has been accepted, any request to change entry details will be subject to the provisions of Regulation 1.29 and the approval of the event organiser.
- 1.20.4 Each team will be allocated a team number on acceptance of entry.
- 1.20.5 Early Entry applications may make a special request for the use of a team number. Requested numbers should contain two digits.
- 1.20.6 Allocation of any number is at the sole discretion of the event organiser.

1.21 Permits

- 1.21.1 Motor vehicles, including solar cars, entering Australia will require a federal import permit.

Strict conditions are in place for the import of all motor vehicles entering Australia. As experimental vehicles (solar cars) will not have a compliance plate, the event organiser will apply to import the solar car of each team that has met qualification requirements (including the payment of entry fees).

- 1.21.2 Import permit arrangements for other vehicles (including road trailers) are the responsibility of the entrant.

1.22 Freight

- 1.22.1 The entrant is responsible for all freight arrangements.

- 1.22.2 Freight deliveries to the Hidden Valley Motor Sports Complex outside the dates of the event will not be accepted.

Details of all freight, customs and quarantine arrangements will be provided in the Team Manager's Guide.

1.23 Visas

- 1.23.1 Citizens of countries other than Australia or New Zealand need a visa to enter Australia.

Visas are the responsibility of the individuals concerned. Visa requirements are detailed by the Australian [Department of Home Affairs](#). Information on how the event organiser is permitted to support visa applications will be provided in the Team Manager's Guide.

1.24 Vehicle preparation

- 1.24.1 Preparation facilities will be available at the Hidden Valley Motor Sports Complex in accordance with the dates listed in the schedule.

The event organiser is responsible for all operations at the Hidden Valley Motor Sports Complex. Hidden Valley Motor Sports Complex management is unable to assist with early arrivals, pit allocations or freight issues. Detailed arrangements will be published in the Team Manager's Guide and via Team Notices.

1.25 Style Guide

- 1.25.1 The correct title of the event is the *Bridgestone World Solar Challenge*. Entrants and their sponsors **must** use the correct title in all references to the event.
- 1.25.2 The *Official Logo* of the event will be published as an appendix to these regulations. The *Official Logo* will be supported by a style guide that details its conditions of use.
- 1.25.3 Registered entrants and their sponsors wishing to use the *Official Logo* in non-commercial publicity may do so in accordance with the requirements of the style guide.

- 1.25.4 Registered entrants and their sponsors wishing to use the *Official Logo* in a commercial context (i.e. merchandise offered for sale) must seek the written permission of the event organiser.

1.26 Sponsorship obligations

- 1.26.1 It is a condition of participation that the entrant acknowledges event and category sponsors in their own publicity. Failure to do so may result in the team being delisted from event publicity.

1.27 Media and promotional obligations

A promotional schedule will form part of the schedule of activities. The promotional schedule will contain details of official media calls and other promotional activities created for the benefit of the event, the entrants and their sponsors.

*Per Regulation 1.12.2, requests to attend media calls, promotional activities, public appearances etc are **obligatory** for all registered teams.*

- 1.27.1 Notwithstanding the provisions of Regulation 1.27.6, the event organiser will respect the Intellectual Property of the respective owners. Technical details of solar cars will be kept confidential until the start of static scrutineering and commercial in confidence requests and media embargos will be honoured.
- 1.27.2 Registered entrants must notify the event organiser of public or media promotional activities held for or on behalf of their attendance in the event, not less than seven days prior to the activity taking place.
- 1.27.3 Media travelling with or in support of any team must comply with the event media accreditation requirements.
- 1.27.4 Entrants will be held accountable, through the application of event penalties, for the unacceptable actions of media representatives travelling with or in support of their team, whether registered as such or not.

Standard operational procedure of Australian police is to first remove the cause of any problem. Police have advised that, where media vehicles following a team are creating a danger for other road users, they will take the solar car off the road. Teams are advised to reinforce this point to their country's media in their own language.

- 1.27.5 Registered entrants who maintain an internet presence are required to provide a link to the official Bridgestone World Solar Challenge website: www.worldsolarchallenge.org.
- 1.27.6 The creation and use of any sound recordings or still or moving images of the event used for commercial gain or public performance by the entrant or their sponsors are subject to the prior written approval of the event organiser.
- 1.27.7 Non-commercial media content generated by the entrant must reference the event in accordance with the provisions of Regulation 1.25.
- 1.27.8 Teams and or their sponsors shall not engage in any marketing or promotional activity that will materially detract from the value and standing of the event or its sponsors.

1.27.9 Activity by sponsors of teams shall not imply ownership or sponsorship of the event.

1.27.10 Entrants are responsible for the activities of their sponsors.

1.28 Remotely Piloted Aircraft (Drones)

1.28.1 Remotely piloted aircraft (RPA) may only be operated with the approval of the event organiser.

1.28.2 RPA registration and pilot accreditation must be in accordance with [Civil Aviation Safety Authority \(CASA\) regulations](#).

Further information will be provided in the Team Manager's Guide and/or any subsequent Team Notices.

1.29 Compulsory documentation

1.29.1 Except for Group D documents, each team must submit documentation using online forms. All submissions must be made by the dates stated in the event schedule.

The purpose of the documentation is to help teams identify potential compliance issues before the car is shipped to the event.

Group A

- General Specification
- Electrical System Specification
- Solar Collector Specification
- Energy Storage System Specification

Group B

- Battery Incident Plan
- Team Safety Plan
- Team promotional information
- Publication-quality information and photographs of the team and solar car.

Group C

- Logistics schedule
- Travel, arrival and accommodation information.

Group D

Group D documentation must be submitted prior to static scrutineering, as defined in the schedule.

- Final technical documentation that describes the car as built, and highlights any changes since earlier submissions

- Two printed A4 copies of a diagram of the solar car in plan view, with the front of the solar car depicted at the top of the diagram, and clearly showing how emergency isolation is to be activated
- The original signed Roadworthiness Certificate
- A simplified wiring diagram, printed on A4 paper, showing how the main functional blocks (PV array, energy storage packs, electronics modules, etc.) are connected, together with circuit breakers, contactors, and fuses.

The example Solar Wombat electrical diagram, available on the Bridgestone World Solar Challenge team portal, indicates the level of detail required for the simplified wiring diagram.

- 1.29.2 If the Team Manager wants to vary the documentation after the submission deadline, the Team Manager must make the request to the event organiser in writing setting out the proposed variations. If the event organiser accepts the Team Manager's request, the varied document will supersede all previous versions. The event organiser will not be responsible for failure to broadcast or publish any document for publicity because of variations proposed by the Team Manager.

2 Solar car regulations

2.1 Classes

- 2.1.1 The 2021 Bridgestone World Solar Challenge will have three classes of solar car:
- **Challenger Class** is for single-seat solar cars designed to be efficient
 - **Cruiser Class** is for efficient, practical solar cars with two or more seats
 - **Adventure Class** is for solar cars designed to participate in previous events but not eligible for Challenger or Cruiser Class. Adventure Class is non-competitive.

2.2 Dimensions

- 2.2.1 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.
- 2.2.2 The eyes of every occupant must be more than 700 mm above the ground.
- 2.2.3 When driving on a flat road, all parts of the fully laden solar car except the tyres, wheels and wheel hubs must be at least 100 mm above the ground (Australian Design Rule 43/04).
- 2.2.4 The fully laden solar car must be able to drive over a road apex formed by a 1:15 incline followed by a 1:15 decline without any part of the solar car other than the tyres touching the road.



The length of the road apex will be greater than the wheelbase of the solar car.

- 2.2.5 The fully laden solar car must have an approach angle of at least 10° and a departure angle of at least 10°.

2.3 Wheels

- 2.3.1 Challenger Class solar cars must be supported by at least three wheels while driving. Cruiser Class solar cars must be supported by at least four wheels while driving.
- 2.3.2 The fully laden solar car should not tip when tilted by 45° about each pair of adjacent tyre contact patches.

The team's certifying engineer must approve the stability and the rollover propensity of the solar car.

2.4 Solar collector

- 2.4.1 A standard solar collector uses silicon 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 no more than the power generated by a standard solar collector. The materials should have low environmental toxicity; this precludes the use of GaAs, CdTe and CuInSe₂. Teams wishing to use non-silicon materials of low environmental toxicity, such as perovskites or organic solar cells, should contact the event organiser. Where the solar collector employs reflectors or concentrators, the allowable aperture of the solar collector should not exceed that of a standard solar collector.

- 2.4.2 For standard solar collectors, the total cell area must not exceed 4.000 m² for Challenger Class teams and 5.000 m² for Cruiser Class teams.
- 2.4.3 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 166 mm is less than 0.0155063 m², and so the area of 257 cells is less than 3.9852 m² and the area of 322 cells is less than 4.9931 m².

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

2.5 Energy storage

- 2.5.1 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.
- 2.5.2 If the energy storage system comprises rechargeable electrochemical cells all with the same chemistry then the allowable total cell mass for Challenger Class and Adventure Class solar cars is:

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 or Adventure Class 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.

- 2.5.3 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.
- 2.5.4 The table below shows the maximum number of cells allowed for Challenger Class solar cars using Li-ion cells with size designator '18650', '20700' or '21700'. For all other cell sizes and types, the cell mass will be deemed to be the maximum cell mass specified in detailed cell model specifications provided by the manufacturer.

Cell size	Number of cells (Challenger Class)
18650	420
20700	315
21700	285

If the manufacturer specifies a nominal cell mass and a tolerance, the maximum cell mass is the nominal cell mass plus the positive tolerance.

- 2.5.5 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 cell model, the Chief Energy Scientist will determine the nominal cell mass for cells of that model.
- 2.5.6 The sum of deemed cell masses (i.e., summed over all cells) must be not more than the allowable total cell mass.
- 2.5.7 The energy storage system must be contained within at most two packs.
- 2.5.8 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.
- 2.5.9 The solar car must automatically prevent electrochemical cells from being operated outside the operating ranges for voltage, current and temperature specified by the manufacturer. Teams must provide endorsement by their certifying engineer that an adequate and effective automatic battery management system has been designed and implemented so that fault conditions will be managed safely.

2.5.10 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.

2.5.11 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 if they are not electrically connected to the solar car, its instrumentation or control systems.

2.5.12 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 2.29).

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

2.5.14 The solar car must be designed so that any liquids or gases from a damaged energy storage pack cannot enter the occupant space.

2.5.15 Energy storage packs must be constructed so that each pack can be sealed using tamper-evident plastic seals, like 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.

2.5.16 Energy storage packs must have a means of being sealed so that no electrical connection can be made to the energy storage system. The seals will be tamper-evident plastic seals, like 3 × 100 mm plastic cable ties.

This regulation allows teams to have the energy storage system impounded inside the solar car. Examples of acceptable sealing mechanisms include:

- disconnecting each energy storage pack from the rest of the solar car and sealing a cover over the power connector on each pack
- removing the energy storage packs from the solar car and sealing them in a box provided by the team.

2.5.17 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.

2.5.18 Any external charging system that is used to recharge the energy storage system 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
- charging must stop automatically when the energy storage system is full or if a fault occurs.

This regulation applies to all charging done in Australia, including in the pits at Hidden Valley Motorsport Complex.

- 2.5.19 Cruiser Class charging will be metered by the event organiser. Cruiser Class 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%, 50 Hz). The ac current draw must not exceed the limit indicated by the SAE J1772 pilot signal generated by the event organiser's Electric Vehicle Supply Equipment (EVSE), which will allow charging rates up to 30 A. The EVSE may disconnect the car if the indicated current limit is exceeded for more than 5 seconds.

When many Cruiser Class cars are charging simultaneously it may be necessary to limit the ac current available to each car to a value less than 30 A. This value could be as low as 6 A. The current limit will be signalled by the event EVSE, using the SAE J1772 signalling protocol. Teams unable to achieve the allowed charge because of current restrictions less than 30 A will be allowed extra charging time to compensate for these restrictions.

2.6 Vehicle identification

- 2.6.1 The solar car must have a unique identifier, which must be permanently attached to a substantial part of the solar car chassis or frame. The identifier must include a manufacturer code, the year of manufacture, and a serial number.

Teams may use a Vehicle Identification Number (VIN) or generate their own identifier, e.g. ABC-2020-01.

- 2.6.2 The solar car must have a space at least 220 mm wide and at least 110 mm high for mounting a rear vehicle registration plate. The registration plate must be mounted with the longest edge parallel to the road and parallel to the vehicle's axles, and with the letters upright. The registration plate must be within 50 mm of the rearmost part of the car. No part of the solar car may be in the region rearward of the registration plate in the range 15° up, 0° down, 45° left and 45° right from all parts of the registration plate.

2.7 Signage

- 2.7.1 Solar cars must incorporate event signage in unbroken rectangular spaces 200 mm high and 500 mm wide on both the left and the right sides of the solar car. Artwork will be available from the Bridgestone World Solar Challenge team portal.

Stickers will be provided to teams requiring the signage. Incorrect use of artwork will result in a sticker of the correct size and with the correct artwork being applied.

- 2.7.2 Teams must display their team number on the left and the right sides of the solar car, in digits that are more than 150 mm high and that are clearly visible against their background.
- 2.7.3 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.

2.7.4 Solar cars must have a front signage area on the solar car body, forward of the windscreen. The front signage area must contain:

- the name of the solar car, or the name of the team, or the number of the solar car, readable at 3 m perpendicular to the centre of the name
- a 150 × 150 mm square event logo.

The entire front signage area must be visible in top view and in front elevation view and must not overlap with the solar collector. Artwork or a sticker for the event logo will be provided by the event organiser.

2.7.5 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.

2.8 Ballast

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

Adventure Class team occupants need not carry ballast and will not be weighed.

2.8.2 Ballast will be supplied by the event organiser in the form of steel shot packed in canvas bags.

The approximate density of the ballast material is 5 kg per litre. Ballast provided by teams will not be accepted.

2.8.3 Challenger and Cruiser Class solar cars must have means of securing ballast within 300 mm of each occupant's hip point.

2.8.4 Ballast bags must be returned to the pack-down area at the end of the event.

2.9 Tracker

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

The tracker box will be 120 mm long, 120 mm wide and 70 mm high. 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 2 kg. It will emit radio frequency energy with no more power than emitted by a mobile phone. The unit will be given to the team for installation during scrutineering.

2.9.2 When the tracker box is installed in the car, it must be possible to construct a right circular cone with its axis perpendicular to the top face of the box and an apex angle of 120°, and with the cone touching each edge of the top face of the box, so that 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. The tracker box may be tilted within the solar car.

Fibreglass and aramid composites, vinyl stickers, paint, clear acrylic and clear polycarbonate are radio transparent if they do not include metal or carbon. Solar cells, carbon fibre composites and metal are not considered radio transparent.



- 2.9.3 The tracker unit must be returned to the event organiser at the end of the event.

2.10 Safety

- 2.10.1 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.
- 2.10.2 Each team must engage a professionally qualified engineer to certify that the solar car is designed and constructed using sound engineering practice, meets the design parameters where stated, maintains stability while driving during testing, and is roadworthy and fit for being driven from Darwin to Adelaide on public roads. The certifying engineer must be qualified to certify vehicles for operation on public roads.

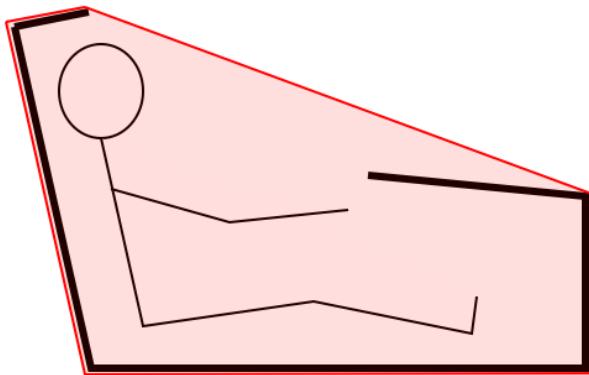
The Roadworthiness Certificate must be signed by a single certifying engineer. However, that engineer may engage other engineers to advise on aspects outside their expertise.

- 2.10.3 Any changes made after certification to items described in the roadworthiness certificate must be re-approved by the team's certifying engineer.
- 2.10.4 All parts of the solar car must be fixed so that they cannot detach while driving. Latched parts such as doors, canopies and top shells must be secured with redundant or two-stage latches.

2.11 Occupant cell

- 2.11.1 Solar car occupants must be enclosed in an occupant cell designed to protect them from injury.
- 2.11.2 Teams must provide documentation that specifies which parts of their solar car constitute the occupant cell.
- 2.11.3 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.
- 2.11.4 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.



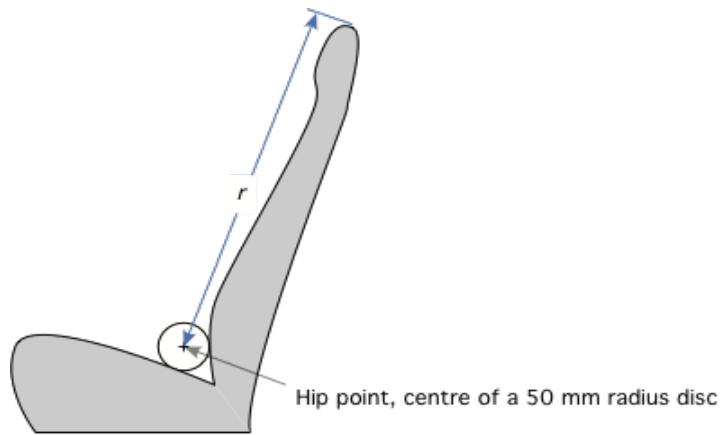
2.11.5 Each team must provide a description of how the occupant cell will protect the occupants from frontal impacts, side impacts and rollover impacts. This description must be endorsed by the team's certifying engineer. For teams wishing to do finite element analysis of the occupant cell, the minimum 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.

Loads are based on the fully laden mass of the solar car. Teams must be able to show that the occupant cell structure will not fail with these test loads, that any deformations will not impinge on the occupants, and that risks of impacts of the occupants with the interior of the car are minimised.

2.12 Seats

- 2.12.1 Cruiser Class solar cars must be designed to carry more than one occupant.
- 2.12.2 Each solar car occupant must have a seat that faces forwards. The driver's legs, viewed from above, must be within 10° of the forwards direction.
- 2.12.3 Each seat must have a back, and a head restraint that is 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.

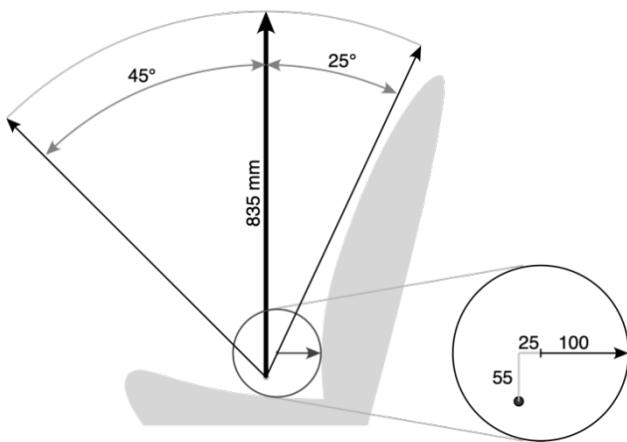


- 2.12.4 Each occupant's heels must be below their hip point.
- 2.12.6 No more than four solar car seats may be occupied while driving.

2.13 Occupant space

- 2.13.1 Occupant space for each seat must comply with Section LK of the Australian National Code of Practice for Light Vehicle Construction and Modification, as shown in the following diagram. The 835 mm radius arm must be able to move 45° forwards, 25° backwards and 7° either side of vertical. 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. No other part of the solar car structure, including the windscreen, may be inside the occupant space.

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.



- 2.13.2 A Bridgestone World Solar Challenge manikin ("PVC Pat") must fit into each seat. Dimensioned drawings of the manikin are available on the Bridgestone World Solar Challenge team portal. The angle between the shoulder, hip and knees must be more than 90°.

2.14 Safety-belts

- 2.14.1 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, SFI 16.6, FIA 8853-2016, FIA 8854/98.

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

- 2.14.2 Safety-belts must be fitted and used according to the manufacturer's instructions, or as approved by the team's certifying engineer.
- 2.14.3 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
 - the location of anchor points must comply with the instructions of the safety-belt manufacturer, or with UNECE Regulation 14 Annex 3.
- 2.14.4 Compliance must be confirmed by the team's certifying engineer.

2.15 Egress

- 2.15.1 Teams must demonstrate that all occupants can exit the solar car in less than 15 seconds, without assistance. Cruiser Class solar cars with more than four seats will be tested with four occupants.
- 2.15.2 Doors and canopies used for egress must be capable of being secured and released from inside the solar car and from outside the solar car.
- 2.15.3 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.
- 2.15.4 Occupants must be able to exit the solar car without assistance.

Teams may not use adhesive tape to secure exits.

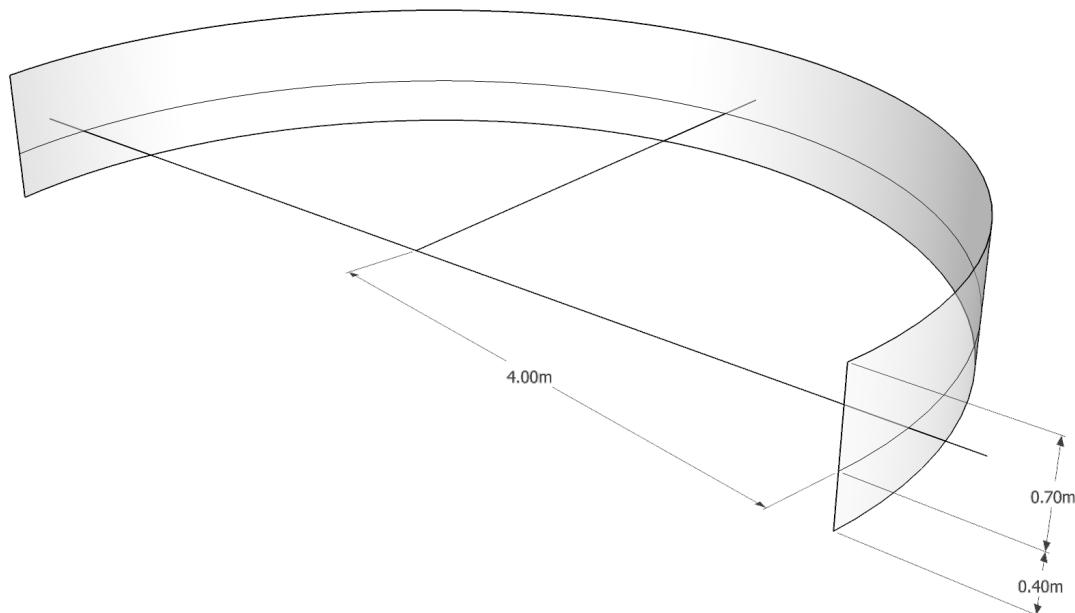
2.16 Cooling and hydration

- 2.16.1 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.
- 2.16.2 Each solar car occupant must have space for at least two litres of drinking water (see Regulation 3.22.3).

2.17 Forward and sideward vision

2.17.1 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.



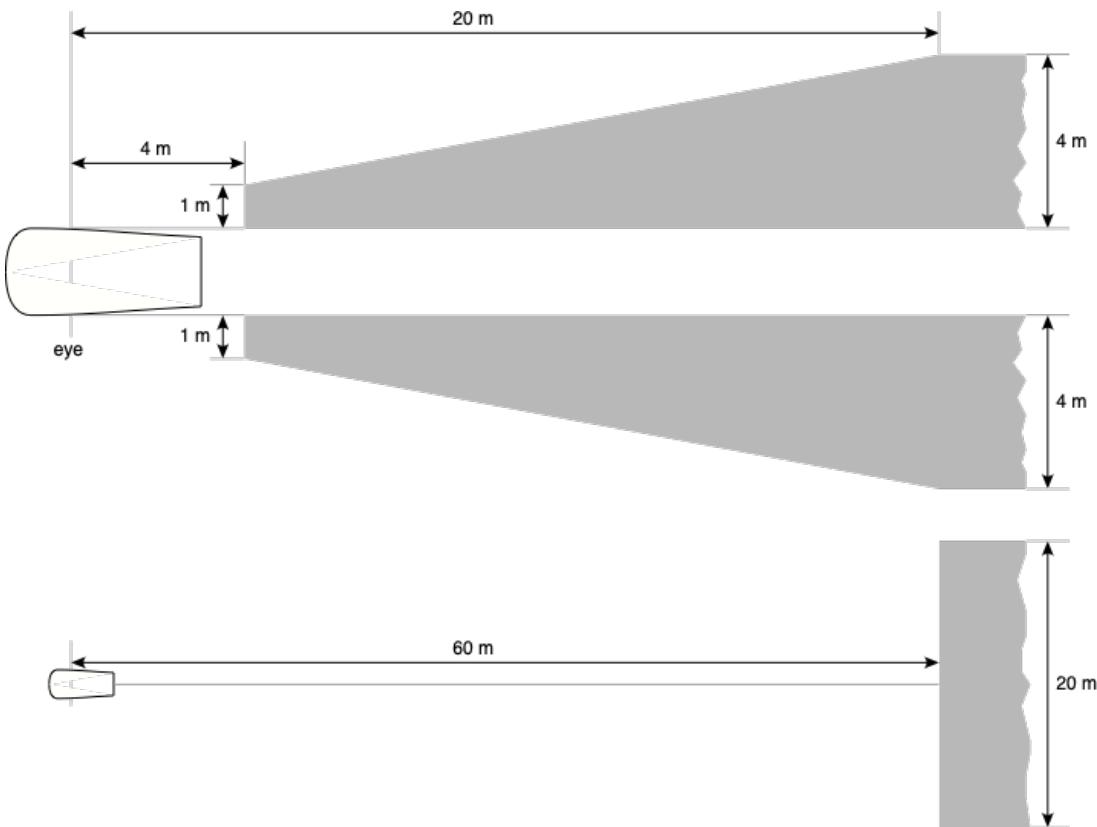
2.17.2 Forward and sideward vision must be achieved without the aid of mirrors, lenses or electronic vision systems.

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

2.17.4 Traffic light colours must be discernible through the windscreen.

2.18 Rear vision

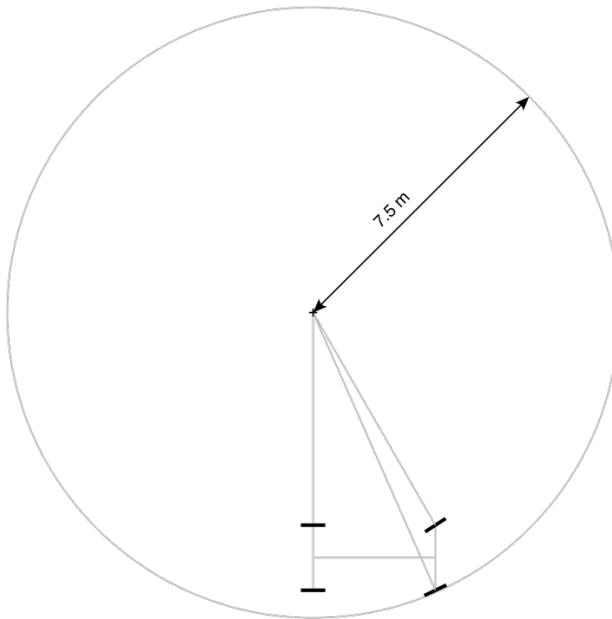
2.18.1 The solar car must have rear vision systems that enable the driver, when seated in the normal driving position with the safety-belt fastened, to see the ground in the shaded areas shown in the diagrams below (UNECE Regulation 46, Section 15).



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

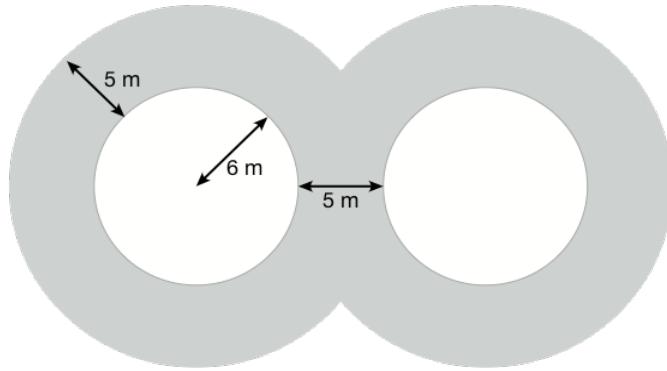
2.19 Steering

- 2.19.1 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.
- 2.19.2 Failure of any non-mechanical component of the steering system must not prevent effective steering of the solar car.
- 2.19.3 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.
- 2.19.4 Rear-wheel steering is not permitted. Specifically, no wheel that is rearward of the centre of mass of the solar car may be steered, either by a mechanism that the driver operates or via a servo motor. This does not preclude suspension designs that are deliberately designed to have built-in bump steer or roll steer.
- 2.19.5 The solar car must be able to turn in each direction within a circle with a radius of 7.5 metres, measured to the extreme outer edge of the tyre track at ground level.

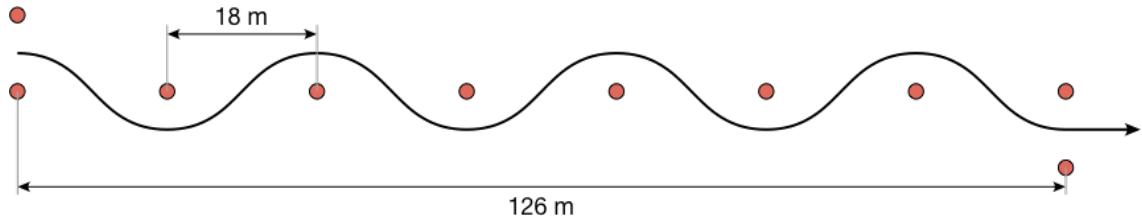


2.20 Stability

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



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



- 2.20.3 The solar car must be stable at all achievable speeds and in crosswinds likely to be encountered. Teams must provide analysis or test results that show that the car will be stable at high speeds and in cross winds. This analysis must be approved by the team's certifying engineer.

In 2019, at least six cars left the road when hit by strong wind gusts. Wind gusts exceeding 100 km/h are possible. Some of the factors affecting vehicle stability are presented in the informal discussion paper by Prof John Storey, 'Stability Considerations', available on the World Solar Challenge website.

2.21 Brakes

Braking requirements are based on UNECE Regulation 13-H.

- 2.21.1 The braking system must be approved by the team's certifying engineer.
- 2.21.2 The solar car must be equipped with independent service and secondary braking systems, so that if the service system fails the secondary system can still stop the solar car. The service and secondary braking systems must each apply mechanical braking effort to the road wheels.

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. For three-wheel cars with two wheels at the front, secondary braking should act on the two front wheels; for all wheel configurations, secondary braking must be adequate (Regulation 2.21.9) and stable under braking (Regulation 2.21.6).

- 2.21.3 Independent braking systems may share components deemed 'not liable to failure' if 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.
- 2.21.4 Hydraulic brake hoses and lines are regarded as liable to failure.
- 2.21.5 For Challenger and Cruiser Class vehicles, the service braking system must apply mechanical braking effort to all road wheels.
- 2.21.6 Braking must not cause the solar car to yaw. This requirement applies to both the service braking system and the secondary braking system.
- 2.21.7 For solar cars without anti-lock brakes, the front wheels must lock up before the rear wheels.
- 2.21.8 The service 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.

2.21.9 If the service 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.

2.21.10 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 hold the fully laden solar car on a 20% incline or decline.

2.22 Tyres

2.22.1 Tyres must be suitable for highway use and used in accordance with their manufacturer's recommendations always.

2.22.2 Solar cars must be fitted with tyres that are:

- 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 Australian 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 30 April 2019. A positive outcome to the approval process, which may take up to three months, is not guaranteed.

2.22.3 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.

2.22.4 Tyres must be approved by the team's certifying engineer.

2.22.5 Tyres must be free of any apparent defect.

2.23 Driving and reversing

2.23.1 The fully laden solar car must be able to start from rest on a 7% gradient.

2.23.2 The solar car must be able to be driven backwards under its own power with the driver seated in the normal position.

2.24 Lighting

2.24.1 Solar cars must be fitted with:

- two rear stop lamps
- one central stop lamp
- left and right front direction indicator lamps

- left and right-side direction indicator lamps
- left and right rear direction indicator lamps
- two daytime running lamps.

Headlamps and tail lamps are not required, though would increase the practicality score of Cruiser Class solar cars.

- 2.24.2 Stop lamps must emit red light. Direction indicator lamps must emit amber light. Daytime running lamps must emit white light.
- 2.24.3 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 team's certifying engineer.

Lamps approved for motorcycles may not meet these requirements.

- 2.24.4 Solar cars must have the correct type of lamp in each position. 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.

Lamp	UNECE category	SAE/DOT type
Front indicators	1, 1a, 1b	I3, I4, I5
Rear indicators	2a, 2b	I6
Side indicators	5, 6	E2
Stop lamps	S1, S2	S
Central stop lamp	S3	U3
Daytime running lamp	RL	Y2

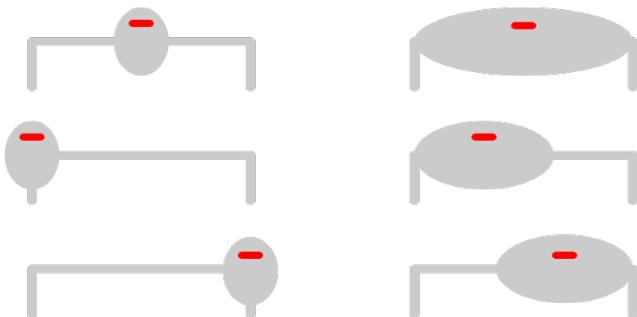
Lamp position and visibility requirements are based on UNECE Regulation 48.

- 2.24.5 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.

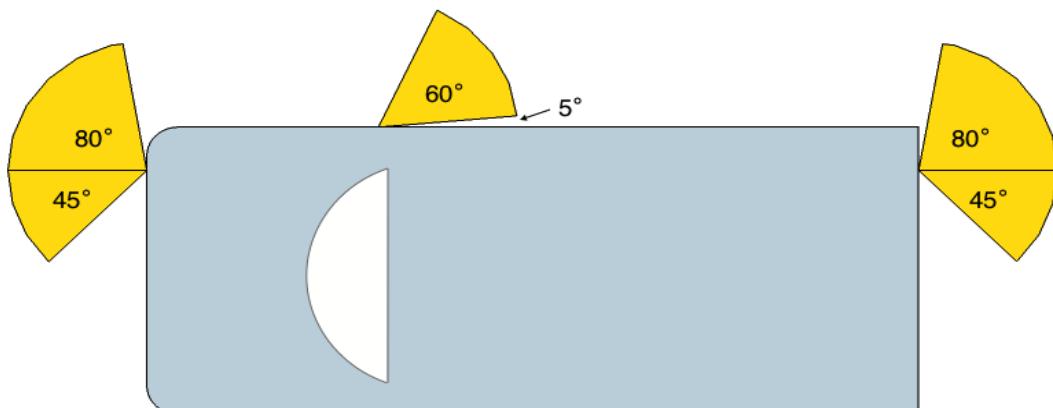
The “apparent surface” of a lamp includes all parts of the lamp surface that emit light and are not obscured by other parts of the light-emitting surface.

- 2.24.6 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 (if the solar car has a rear windscreen), 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.



- 2.24.7 Front and rear direction indicator 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.
- 2.24.8 Side direction indicator lamps must be less than 1800 mm behind the front most part of the solar car and within 400 mm of the extreme outer edge of the solar car on each side.
- 2.24.9 The entire apparent surface of direction indicator lamps must be visible 15° up and 5° down. Minimum horizontal visibility requirements (of the right direction indicator lamps) are shown in the following diagram.



- 2.24.10 Direction indicators must flash at 90 ± 30 flashes per minute.
- 2.24.11 It must be possible to flash the left and right direction indicator lamps simultaneously, as a hazard warning signal.
- 2.24.12 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.
- 2.24.13 Headlamps (if fitted) must be at the front of the solar car 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 500 mm above the ground. The

entire apparent surface must be visible 15° upwards, 10° downwards, 45° outwards and 10° inwards.

2.24.14 The stop lamps must operate whenever driving is possible and the brakes are applied.

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

2.25 Audible warning device

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

2.25.2 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.

2.25.3 The device must emit a continuous and uniform sound. The audible warning device must be capable of operating for 50,000 cycles of on for one second and off for four seconds.

2.26 Instrumentation

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

- the speed of the solar car
- whether the direction indicators are operating
- whether the hazard lights are operating
- energy storage system warnings
- electronic rear vision images (if fitted).

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

2.27 Automatic functions

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

Cruise control must not resume automatically following a brake operation.

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

Automatic driving must not resume automatically.

2.28 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.

- 2.28.1 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.
- 2.28.2 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).
- 2.28.3 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).
- 2.28.4 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 and flimsy, easily displaced covers are unlikely to meet the requirements of supplementary insulation. The front surface of a photovoltaic cell is deemed to be double-insulated if properly encapsulated.

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



- 2.28.6 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 2.28.1). 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.

- 2.28.7 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.

- 2.28.8 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.

- 2.28.9 A system must be implemented to monitor the isolation of the solar car's chassis and body as per Regulations 2.28.7 and 2.28.8. This system may take the form of a permanently connected electronic device or a properly documented procedure of regular manual checks.
- 2.28.10 A fuse or circuit breaker, suitably rated to protect the wiring, must be mounted in or on each energy storage pack. Additionally, the dc interrupting current (i.e., dc breaking current) capacity of the device must be able to interrupt the maximum possible short-circuit current of the battery packs.

A typical solar car might use a 50 A fuse with a 15000 A dc interrupt rating. Fuses and circuit breakers intended for ac use might not meet this requirement. Teams must provide a manufacturer's data sheet clearly showing that the dc specifications of the device are adequate.

2.29 Electrical safe state

- 2.29.1 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.

Safe state is for emergencies and for complete shutdown of the car. In addition to safe state, a solar car may have a "standby" state that provides power to some subsystems outside of the energy storage packs.

An external battery is not necessary to bring the car out of safe state. Possible alternatives include:

- *a switch on the energy storage pack*
- *an air switch inside an energy storage pack, with an airline to a remote start button*
- *a fibre-optic switch.*

When in the safe state:

- every conductor emerging from each energy storage pack must be galvanically isolated from every energy storage cell
- no voltage may be present across any pair of conductors emerging from energy storage packs or the solar collector
- no current may be present through any conductor loop that is external to the energy storage packs or the solar collector.

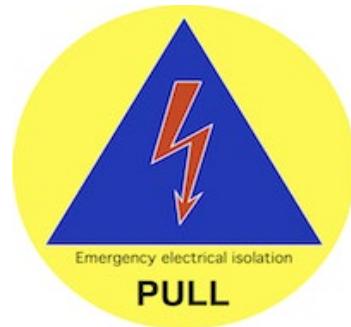
MOSFETS and other semiconductor devices are not considered to offer galvanic isolation.

- 2.29.2 Any conductor that is more than 200 mm from the nearest PV cell is outside of the solar collector.
- 2.29.3 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, power to the loop will be removed, 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 beyond reasonable doubt 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.

- 2.29.4 The driver must be able to place the solar car into safe state with a single simple action while seated in the normal driving position and without releasing the safety-belt. This activation device must be clearly labelled.
- 2.29.5 For emergency use, an activation device that operates with a single simple action that immediately places the solar car into safe state must be provided on the exterior of the car. Multiple activations must not bring the car out of safe state. The activation device must be placed within a yellow disc with a 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 the windscreens, adjacent to the driver egress opening, and not behind the driver.



Both activation mechanisms must be demonstrated at static scrutineering. The scrutineers may invite random members of the public to validate the ease of operation of the external emergency activation device.

3 The Adventure

3.1 Supervision

- 3.1.1 The Clerk of the Course is responsible for supervising on-road activities.
- 3.1.2 During on-road activities, communication with the Clerk of the Course must be made through Mission Control.

3.2 Safety

- 3.2.1 The team safety officer is responsible for the general safety of the team.
- 3.2.2 The team battery officer is responsible for the safe operation of batteries and for supervising response to any battery emergency.
- 3.2.3 Battery incident response kits must be readily available to the solar car and any other vehicle carrying solar car batteries.
- 3.2.4 A team member with a recognised first-aid certificate, current for the duration of the event, must travel in the front or rear escort vehicle.
- 3.2.5 It is the responsibility of each team to ensure that the vehicles under its control are maintained in a safe, roadworthy condition and are operated safely and within the law always.
- 3.2.6 All solar cars and escort vehicles are operated and driven at the team's own risk.
- 3.2.7 The Clerk of the Course may exclude any team from the event at any time if any team member operates a solar car or any other vehicle in an unsafe manner.
- 3.2.8 Teams must look after the health and safety of their team members and observer.

Fatigue and dehydration are serious hazards in this event. This is especially relevant to drivers, particularly those of solar cars.

- 3.2.9 Drivers, team members, officials and observers are to be drug free and maintain a blood alcohol level less than 0.01% whilst engaged in any duties associated with the event.

3.3 Safety-belts

- 3.3.1 The use of safety-belts is mandatory for all occupants of motor vehicles in Australia, including solar cars.

3.4 Helmets

- 3.4.1 Each occupant of a solar car must wear an approved motorcycle helmet securely fitted and fastened in accordance with the manufacturer's instructions.

- 3.4.2 Motorcycle helmets must have a mark certifying compliance with either:
- Australian/New Zealand Standard AS/NZS 1698:2006
 - United Nations Economic Commission for Europe Regulation No 22 (UNECE 22.05).
- Half-shell helmets are not permitted.*
- 3.4.3 Helmets must not be modified, have unauthorised attachments, or be used in any way contrary to the manufacturer's instructions.

3.5 Safety equipment

- 3.5.1 Suitable and appropriate safety equipment must be carried always. The minimum safety equipment that must be carried in the rear escort vehicle is:
- a first-aid kit
 - safety glasses and gloves for handling batteries
 - at least two hazard warning cones
 - two **yellow** warning flags, minimum size 300 mm x 300 mm
 - suitable fire extinguishers
 - fire blankets
 - sand (or similar material) for extinguishing fires
 - a spade
 - suitable containers for damaged electrochemical cells
 - safety vests
 - two whistles.

3.6 Support vehicles

- 3.6.1 Each team must supply a front and a rear escort vehicle, a means of transporting the solar car, and sufficient additional vehicles to transport and support the team and its equipment during the event.
- 3.6.2 The minimum requirement for transporting the solar car is a suitable truck or trailer, which must accompany the team throughout the journey.
- Many vehicle rental companies in Australia require the hirer and all drivers to be at least 23 years of age. One-way interstate rentals may not be possible through an airport rental desk and require head office approval. Trailers should be booked early.*
- 3.6.3 Each solar car must, always when in motion on the route, be accompanied by two escort vehicles—one immediately in front of the solar car and one immediately behind the solar car.

- 3.6.4 A minimum of two drivers must be available for every vehicle associated with the team.
- 3.6.5 The rear escort vehicle must not be a bus, truck or large campervan, or be towing a trailer.

If traffic approaching from behind sees a large vehicle with a flashing light, the immediate perception is that that vehicle itself is the hazard, not the solar car it is escorting. This may lead to a member of the public overtaking a large rear escort vehicle only to encounter an unexpected and previously unseen solar car. Large rear escort vehicles make it difficult for vehicles approaching from the rear to see the solar car.

3.7 Escort vehicle signage

- 3.7.1 All team vehicles must carry a sign, visible from 30 m to the rear, stating the name and team number of the team to which they belong.
- 3.7.2 All team vehicles equipped with Citizen's Band (CB) radio must carry a sign, visible from 30 m to the rear, advising the CB channel number in use.
- 3.7.3 A warning sign larger than 900 mm x 300 mm with black lettering on a yellow background, clearly visible from 30 m, must be displayed on the rear of the rear escort vehicle, stating

CAUTION: SOLAR VEHICLE AHEAD

- 3.7.4 No vehicle other than the rear escort vehicle may carry such a sign.
- 3.7.5 Front and rear escort vehicles must be fitted with amber flashing lights visible from all directions at a distance of at least 200 m in daylight. Flashing amber lights must not be obscured by signs or other equipment on the roof of an escort vehicle.

Beacons designed as warning devices for industrial equipment are unlikely to meet the visibility requirement.

3.8 Communication

- 3.8.1 Every solar car must have means of two-way voice radio communication with its rear escort vehicle. Communication must be possible whenever the driver is in the solar car, including when the main energy storage contactors are open and when the car is in safe state.
- 3.8.2 Each team must carry a satellite telephone and notify the event organiser of its number. This notification will be required at registration. An external antenna is usually required when using a satellite telephone in a vehicle.
- 3.8.3 The front and rear escort vehicles (at least) for each solar car must each have an 80-channel UHF CB radio compliant with [Australian regulations](#). Teams must monitor the channel they have been allocated always while on the road, and respond promptly and courteously, in English, to reasonable communications with other road users, teams and officials.

3.9 Heavy vehicles

- 3.9.1 Any team operating or contracting a vehicle over 4.5 tonnes GVM or a passenger vehicle with 12 or more seats must register the full details with the event organiser.
- 3.9.2 Compliance with Australian National Heavy Vehicle regulations concerning driving hours, record keeping and fatigue management is mandatory.

3.10 Preparation and testing

- 3.10.1 The event organiser will provide facilities for team preparation and track testing of solar cars at the Hidden Valley Motor Sports Complex in accordance with the dates listed in the schedule.
- 3.10.2 All participating teams must base themselves, and their solar cars, at the Hidden Valley Motor Sports Complex from Monday 11 October 2021.
- 3.10.3 The event organiser will appoint a paddock manager to supervise the preparation and test facility. The directions of the paddock manager must be followed.
- 3.10.4 Australian workplace standards will apply to all event-related activities in Australia.
- 3.10.5 The Clerk of the Course may impose event penalties for breaches of speed limits or other rules at the Hidden Valley Motor Sports Complex.
- 3.10.6 No test driving is to be conducted in the paddock, car park or access roads.
- 3.10.7 The track must not be accessed without clearance from the track controller.
- 3.10.8 The event organiser will work with the relevant authorities to provide on-road testing facilities. Detailed arrangements will be published in the Team Manager's Guide and/ or via a Team Notice.
- 3.10.9 Any team driving a solar car on a public road without a permit is liable to civil penalties and exclusion from the event.

Teams who make direct contact with Australian road authorities delay this process.

- 3.10.10 The event organiser reserves the right to request a security deposit against damage, rubbish removal or cleaning beyond reasonable expectations.

3.11 Team registration and scrutineering

- 3.11.1 All participants are required to attend with their team to complete the registration process and present their solar car for the scrutineering process. The scrutineering process is divided into static and dynamic operations.
- 3.11.2 Team registration and static scrutineering will take place at the Darwin Convention Centre or such other place as determined by the event organiser at the time and date described in the schedule.

- 3.11.3 Teams must attend registration and static scrutineering with:
- the Team Manager, and an interpreter if required
 - all solar car drivers, with their driving licences
 - any waiver documents required for participants under the age of 18
 - original signed copy of the indemnity form
 - all solar car passengers
 - the team safety officer
 - the team battery officer
 - the solar car, in road-ready condition
 - front and rear escort vehicles, including any trailer that may be attached to the front escort vehicle, in road-ready condition
 - the solar car trailer or solar car transport truck they intend to use in the event
 - tools and personnel required to facilitate inspection of the solar car
 - a list of all vehicles associated with the team, including make, model, colour and registration number
 - Group D compulsory documentation
 - a spare solar car tyre of each type
 - a sample energy storage cell (if cells inside the energy storage packs are not clearly visible)
 - the lockable box in which energy storage packs can be impounded where required.
- 3.11.4 Solar cars must be transported to scrutineering on the solar car trailer or truck that will be used during the event.
- 3.11.5 The Team Manager must attend all registration and scrutineering stations. A Team Manager not proficient in English must provide an interpreter to accompany them always during this process.
- 3.11.6 All team members must complete their online registration by signing in at registration.

3.12 Static scrutineering

- 3.12.1 Static scrutineering will check for compliance with the regulations and will include a regulatory compliance and roadworthiness inspection by the Northern Territory road transport authority.
- 3.12.2 Qualification must be achieved in road-ready condition. ***Teams that do not present at the designated time in road-ready condition may fail to qualify.***

- 3.12.3 Up to seven members of a team (including an interpreter and any team media personnel) may accompany the solar car on the scrutineering floor. Team members may be substituted between inspection stations.
- 3.12.4 Some dismantling (such as removal of the solar collector or top shell) may be required to facilitate inspection of the following components:
- mechanical systems (including seats, tyres, brakes and steering)
 - electrical systems
 - energy storage system.
- 3.12.5 Dismantling and reassembly of the solar car when required to facilitate inspection of the solar car must be conducted (in the sole opinion of the Chief Scrutineer) in a reasonable time.
- 3.12.6 Checks and inspections with the solar car in a road-ready configuration will include, but not be limited to:
- signage
 - dimensions
 - solar collector type and size
 - egress—all solar car drivers and passengers are required
 - vision—all solar car drivers are required
 - lights, indicators and horn
 - electrical compliance.
- 3.12.7 All energy storage devices must be declared at static scrutineering. Failure to declare any energy storage device may lead to disqualification.
- 3.12.8 The mass of each Challenger or Cruiser Class solar car driver or passenger, with helmet, driving clothes and shoes, will be determined at scrutineering. If the mass of a driver or passenger is less than 80 kg, ballast provided by the event organiser will be added to make up the difference. No credit will be given if a driver or passenger weighs more than 80 kg.
- Deliberate consumption of excessive food and drink prior to weigh-in is not in keeping with the spirit of the event and may be hazardous to the health of the individual.*
- Solar car occupants must wear similar clothes (including shoes) while driving as when they weigh in.*
- 3.12.9 Drivers and passengers may be re-weighed at any time during the event. Changes in weight considered unreasonable by the Chief Medical Officer will be referred to the Clerk of the Course.
- 3.12.10 Non-compliance penalties may be imposed at the absolute discretion of the Chief Scrutineer and may include failure to qualify. Penalties will be published.

3.13 Dynamic scrutineering

- 3.13.1 Dynamic scrutineering exercises will test the speed, stability and braking capability of the solar car.
- 3.13.2 Dynamic scrutineering will be held at the Hidden Valley Motor Sports Complex, or such other place as determined by the event organiser, on Thursday 21 October 2021. Attendance of Team Managers and drivers at 07:00 roll call is mandatory.
- 3.13.3 No solar car may be submitted for dynamic scrutineering without having first passed static scrutineering.
- 3.13.4 Solar cars must complete dynamic scrutineering in road-ready condition and with occupants and ballast in place.
- 3.13.5 Cruiser Class solar cars with four or fewer seats must complete dynamic scrutineering with all seats occupied. Cruiser Class solar cars with more than four seats must complete dynamic scrutineering with four seats occupied.
- 3.13.6 No solar car will be given permission to start the event until it has passed dynamic scrutineering. Any solar car failing dynamic scrutineering will only be permitted to re-present at the absolute discretion of the Chief Scrutineer. Dynamic scrutineering will close at 12:30 on Thursday 21 October 2021.

3.14 Modifications or changes after scrutineering

- 3.14.1 Once a solar car and its drivers have passed static scrutineering, no changes to the design or configuration of the solar car (that is, to any items described in the compulsory documentation) or changes to drivers will be permitted.
- 3.14.2 Once a solar car has passed dynamic scrutineering, and until released from the start line, component exchange, modification or repair of the solar car is not permitted without the approval of the Chief Scrutineer.

3.15 Briefings

- 3.15.1 A compulsory briefing for Team Managers and team safety officers will be held in Darwin on Sunday 10 October 2021 at a time and place to be advised. Team managers not proficient in English must request permission to be accompanied by an interpreter.
- 3.15.2 A compulsory safety, procedural and media briefing will be held on Thursday 21 October 2021 at a time and place to be advised. All team members must attend.

3.16 Observers

- 3.16.1 The Clerk of the Course will appoint an observer to travel with each team. Observers may be changed between teams at any time during the event.

3.16.2 The observer's responsibilities are:

- to record the locations and times that teams start and stop
- to record the locations and times of all activities and incidents that may affect the outcome of the event
- to record the number of Cruiser Class occupants travelling between control stops
- to check that ballast is correct for each driver or passenger change
- to be satisfied that the energy storage system cannot be charged or interfered with between sunset and sunrise, except as allowed for Cruiser Class solar cars
- to notify a Red-Shirt or the Clerk of the Course at the earliest opportunity if any breach of regulation is suspected, energy storage cells or modules have been changed or an energy storage system seal broken, or if they have any concerns about the actions of the team.

3.16.3 Observers are not permitted to interpret regulations or to give advice or directions to teams. Advice or directions from observers do not supersede regulations or directions from Red-Shirts. The only exception is if an observer asks a team to stop because they feel unsafe—the team must stop.

3.16.4 Each team's responsibilities to the observer are:

- to assist the observer in their duties always
- to provide reasonable food for the observer at least three times a day, and such drinking water as the observer may require
- if requested by the observer, to send for assistance from the event organiser or transmit information to Mission Control
- to provide a proper seat in the rear escort vehicle
- to provide space for the observer's luggage in the rear escort vehicle
- to not make any demands of the observer to assist team operations.

3.16.5 Each team must allocate the front passenger seat of the rear escort vehicle to the observer. This includes fair and reasonable space with, for example, the foot well not being filled with computer equipment such that the passenger space is restricted.

3.17 Start line and grid

3.17.1 The ceremonial start of the event will be held in State Square, Darwin, from 09:45 on Friday 22 October 2021, or such other place and time as the event organiser may direct. Detailed procedural instructions will be issued in Darwin via a Team Notice.

3.17.2 Starting position will be determined by class and performance during dynamic scrutineering.

- 3.17.3 All solar cars must be in their starting grid position by the appointed time for final inspections. Any solar car not present will have their starting position amended.
- 3.17.4 Teams must not work on their solar cars on the start grid.
- 3.17.5 Two team members must stay with the solar car on the start grid to assist officials with final inspections.
- 3.17.6 Front and rear escort vehicles must be in their designated places by 09:15.
- 3.17.7 Escort vehicles must be in position with the solar car before entering public roads. Solar cars which have left the start line and whose escort vehicles are not able or not ready to merge will be directed to return to the start area.

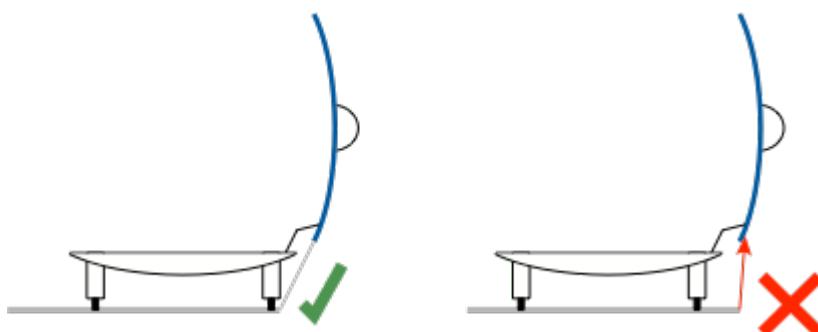
Team managers should recognise that it is not a realistic expectation for escort vehicle crew members to witness the start and re-join their vehicles to make a timely departure.

3.18 Energy collection and storage

- 3.18.1 Charging the energy storage system or powering the solar car from an unauthorised source will lead to exclusion from the event.
- 3.18.2 External devices intended to increase the irradiance on the solar collector or increase the efficiency of the solar collector must not be used at any time.

Spraying of water from external sources is not allowed.

Ground sheets must not be placed in any position where it is possible to draw a straight line from any part of the ground sheet to any part of the solar collector.



- 3.18.3 From the official start of the on-road component of the event until finish or withdrawal, the energy storage system must never be removed from the observer's control.
- 3.18.4 Damaged energy storage cells may be bypassed, but must not be removed from the energy storage system unless it would be unsafe to leave them in. Cells removed must be replaced by ballast with mass greater than the mass of the removed cells.
- 3.18.5 If a solar car is unable to continue because too many energy storage cells have been damaged, the team may, with the event organiser's permission, replace cells and continue. The final ranking of the team will be based on the distance achieved before replacing cells.

3.19 Route

- 3.19.1 The event course will be the major highways between Darwin, Northern Territory, and Adelaide, South Australia—approximately 3020 km.
- 3.19.2 One printed copy of the official route notes will be provided to each registered team. Additional copies will be available for download from the Bridgestone World Solar Challenge website from September 2021.
- 3.19.3 Mandatory control stops will be established along the route. The locations of the control stops will be published in the official route notes.
- 3.19.4 Any detour signs erected by the civil authorities must be observed and the correct route re-joined at the first opportunity.
- 3.19.5 The event organiser may change the course at any time.

3.20 Timing

- 3.20.1 The official start time on Day 1 will be 10:00 for all teams.
- 3.20.2 The official start time each day after Day 1 is 08:00. The official finish time each day is 17:00.
- 3.20.3 A time penalty of one minute will be imposed for each minute taken past the official finish time, up to and including 10 minutes past the official finish time. Beyond 10 minutes, each additional minute will attract a penalty of two minutes. Time penalties incurred in this manner will determine an adjustment of the official start time the following day.

Example: If a team finishes at 17:07 on Day 2, the official start time for Day 3 will be adjusted to 08:07. If a team finishes at 17:13 on Day 2, the official start time for Day 3 will be adjusted by $1 \times 10 + 2 \times 3$ minutes to 08:16.

- 3.20.4 A solar car starting before its official start time will be subject to a penalty of 2 minutes for each offending minute.

3.21 Tracking

- 3.21.1 Each solar car must carry a data logging and tracking device provided by the event organiser. The specifications of the tracking device are described in Regulation 2.9.
- 3.21.2 Information concerning progress and operation of solar cars may be published during the event.
- 3.21.3 Satellite tracking data will not be accepted as basis for inter-team protests.

3.22 Solar car drivers and passengers

- 3.22.1 Only registered solar car drivers may drive the solar car during event hours.

- 3.22.2 When driving, ballast must be carried in accordance with the provisions of Regulation 2.8.
- 3.22.3 Each solar car driver and passenger must have at least two litres of water whenever they start their stint.
- 3.22.4 Solar car drivers must change at Adelaide River, about 115km south of Darwin, at a location to be specified in the Route Notes.
- 3.22.5 Solar car drivers who will drive the solar car for more than one hour in a day must not drive a support car within two hours of driving the solar car.

3.23 Driving conduct

- 3.23.1 Each team must ensure that all vehicles associated with their attendance at the event are driven in a careful and courteous manner always.
- 3.23.2 Overtaking must be done in a safe manner and take in to account prevailing conditions.

A team seeking to overtake another team should communicate with the other team via radio, and both teams should maintain communication throughout the manoeuvre.
- 3.23.3 The organiser reserves the right to determine if any individual is acting de facto as a part of a team.
- 3.23.4 The front and rear escort vehicles must have their amber flashing lights operating whenever they are escorting the solar car. Support vehicles must not have amber flashing lights operating if they are not (directly) escorting the solar car.
- 3.23.5 Except when pushing a disabled solar car to a place of safety, solar cars must not be pushed along the road. Push starting the solar car is not allowed.
- 3.23.6 Whilst travelling on the open road, the front escort vehicle must be within 500 m of the solar car. The solar car must be allowed a safe stopping distance appropriate to the speed and conditions prevailing.
- 3.23.7 Whilst travelling on the open road, the rear escort vehicle must be within 5 seconds of the solar car and must always maintain a safe stopping distance appropriate to the speed and conditions prevailing.
- 3.23.8 Solar cars must not be driven on any public road between sunset and sunrise.
- 3.23.9 Teams must comply with all requirements imposed by road traffic authorities, police, or event officials.
- 3.23.10 Solar cars, escort vehicles and other team vehicles may be subject to scrutineering at any time during the event to ensure compliance with the regulations.

3.24 Stopping

- 3.24.1 No team vehicle may stop on the road except in an emergency or when required by traffic conditions.

Stopping on the road so that you can lift your car off the road is dangerous and will attract a penalty determined by the Clerk of the Course.

- 3.24.2 When stopped adjacent to a road, all wheels of all vehicles must be clear of the road.
- 3.24.3 Wherever possible, vehicles must be parked, and all team activity must occur, at least 10 m from the edge of the road.
- 3.24.4 Where any activity takes place less than 2 m from the road, two team members must be positioned in a place of safety to warn approaching traffic using yellow flags, and to warn the team of approaching traffic using a whistle.
- 3.24.5 If a solar car has suffered damage to any component certified by the team's certifying engineer, other than tyres, then the team may repair their solar car but may not resume driving until:
- the team's certifying engineer has recertified the repaired car
 - the team has submitted the new certification to the Clerk of the Course
 - the Clerk of the Course has approved the resumption of driving.
- 3.24.6 If a solar car rolls onto its side or roof then the team must withdraw immediately.
- 3.24.7 Teams wanting to repair their solar car or escort vehicles may, after obtaining approval from the Clerk of the Course, mark the road at the location where they stopped and trailer their solar car to a suitable place for making repairs, then return to the location where they stopped and continue driving.

3.25 Obstructing other road users

- 3.25.1 Vehicles associated with a team must not obstruct other road users, including other teams. Infringement of this regulation will incur a penalty for each incident.
- 3.25.2 To avoid obstructing other road users, each driver of a team vehicle other than the solar car and front and rear escort vehicles must leave at least 200 metres of space in front of their vehicle so that other road users can overtake and occupy the space in front of them. If it is safe to do so and will help clear traffic building up behind a vehicle, drivers of team support vehicles should pull off the road to allow other road users to pass.

3.26 Control stops

- 3.26.1 Solar cars must stop for 30 minutes at designated control stops along the route. The locations of the control stops will be specified in the official route notes provided by the event organiser.

- 3.26.2 All vehicles must obey control stop speed limits.
- 3.26.3 Teams must obey all directions given by the control stop manager.
- 2.26.4 Teams must park in the spaces designated by control stop officials. Teams may not modify the parking space in any way. Ground sheets may not be used. No team members other than arriving occupants may touch the solar car once it is in the parking space.
- 2.64.4 Occupants must get out of the solar car without assistance from other team members. Occupants must remove their ballast from their solar car.
- 3.26.4 Once all occupants are out of the car, the arriving driver, alone, may reconfigure the car for charging before control stop timing commences.
- 3.26.5 Control stop timing commences when the arriving driver activates the control stop timing system.
- 3.26.6 No team member may touch the solar car for 25 minutes. The solar car may reconfigure itself.
- 3.26.7 After 25 minutes, the departing driver, alone, may reconfigure the car for driving. The driver and any passengers may get into the car and prepare for departure. No other team member may touch the car.
- 3.26.8 The solar car may depart once 30 minutes have elapsed. The solar car must not depart until ballast and drinking water are in place, seat belts are fastened, helmets are secured, and the solar car is ready for the road.

The control stop manager may reset the remaining time to 30 minutes if team members interfere with the solar car during the 30-minute control stop period.

3.27 Overnight stops

- 3.27.1 An overnight stop commences when the team stops driving for the day and finishes when the team starts driving the next day.
- 3.27.2 The selection (and any cost) of overnight stop locations is the responsibility of each team.
- 3.27.3 At overnight stops, the solar car and all other vehicles must be parked in such a manner that they, and all team activities, are conducted at least 10 metres from the edge of any road.
- 3.27.4 If a team's overnight camp is not immediately adjacent to the road, a marker cone must be placed on the roadside adjacent to the point the team exited the official route.
- 3.27.5 The observer, with the Team Manager, must place a mark on the road to indicate the position at which the solar car stopped. The mark will be the starting line for the following morning.
- 3.27.6 The solar car must be driven, pushed by hand or carried by hand between the stopping location and its solar charging location.

- 3.27.7 There are no restrictions on the number of team members used to reconfigure the solar collector for charging at overnight stops.
- 3.27.8 The energy storage packs of Challenger Class solar cars will be disconnected and sealed 15 minutes after sunset each day. The energy storage packs of Cruiser Class solar cars will be disconnected and sealed:
- 15 minutes after sunset if the car is not at the end of a stage, or
 - 15 minutes after the end of external charging at stage ends.
- 3.27.10 Energy storage packs will be unsealed 15 minutes before sunrise.

3.29 Trailering

The term ‘trailering’ applies to any means of transport used to carry the solar car.

- 3.29.1 Teams unable to maintain a minimum speed of 60 km/h on the open road or unable to drive to the next control stop before it closes must stop and transport their solar car forward to the next open control stop to get further instructions from the Clerk of the Course.
- 3.29.2 The solar car must be in safe state always while being transported.

3.30 Withdrawal

- 3.30.1 A team may withdraw by forwarding a completed withdrawal form (available from the observer) to the Clerk of the Course. The solar car may be transported to Adelaide to take part in the displays and the awards ceremony.

3.31 Penalties

- 3.31.1 The Clerk of the Course may impose demerit points on any team that breaches a regulation. Demerit points will be published.
- 3.31.2 Each demerit point given to a Challenger Class team will also incur a time penalty of 30 minutes, to be served at a control stop nominated by the Clerk of the Course. All Challenger Class time penalties must be served before arriving at the finish line.
- 3.31.3 Each demerit point given to a Cruiser Class team will reduce the team’s final score by 1%.
- 3.31.4 A team accruing three or more demerit points will be excluded from the remainder of the event.
- 3.31.5 The Clerk of the Course may impose operational restrictions (such as speed restrictions) on any team.

- 3.31.6 At any time during the event, the Clerk of the Course may issue a penalty of one demerit point in response to any of the following behaviours noted by an observer or reported by an official:
- obstructing other road users
 - stopping on the road (other than when required by traffic conditions)
 - poor safety protocols (e.g., safety flags, whistles etc.)
 - overnight activities too close to the road
 - driving without both front and rear escort vehicles
 - escort vehicles driving without visible flashing lights
 - driving without effective rear vision.
- 3.31.7 The Clerk of the Course will determine penalties for offences including:
- slipstreaming or pressure wave pushing
 - failure to follow the route instructions
 - failure to observe a request by police or event officials
 - wilful damage or interference to property
 - failure to stop at a designated control stop
 - exceeding any posted speed limit
 - driving at less than 50 km/h in areas with a speed limit of 100 km/h or greater, when not constrained by traffic
 - driving without adequate visibility, due to smoke, dust or rain.
- 3.31.8 The Clerk of the Course may exclude any team from the event for wilful disregard of any regulation or of the spirit of the event. These offences include but are not limited to:
- misrepresentation
 - wilful obstruction, or aggressive or unsafe driving
 - replacement of energy storage cells
 - charging of the energy storage system from any unapproved source
 - driving the solar car without a rear escort vehicle
 - accumulation of three or more demerit points.

3.32 Protests and appeals

- 3.32.1 A Team Manager may appeal any decision of the Chief Scrutineer to the Jury by lodging a written Notice of Appeal with the Clerk of the Course within one hour of the notification

of the decision. The Notice of Appeal must detail the grounds for the appeal. An appeal fee of AU\$500 will apply.

- 3.32.2 A Team Manager may lodge a written protest with the Clerk of the Course. Protests must be lodged before 18:00 on the day of the incident giving rise thereto. Protests will not be accepted after 18:00 ACST on the final Saturday of the event. The protest shall specify the details of the incident and a protest fee of AU\$200 will apply.
- 3.32.3 A Team Manager may appeal any decision of the Clerk of the Course to the Jury by lodging a written Notice of Appeal with the Clerk of the Course within one hour of the notification of the decision. The Notice of Appeal must detail the grounds for the appeal. An appeal fee of AU\$500 will apply.
- 3.32.4 Protest/appeal fees will be returned if the protest/appeal is upheld.
- 3.32.5 The Chief Steward may convene a tribunal to consider any protest or appeal requiring final resolution. The tribunal may take advice from any party about the incident giving rise to the decision being appealed. The decision of the tribunal is final and binding.
- 3.32.6 The decision of the tribunal must be conveyed to the Team Manager lodging the appeal within one hour of reaching the decision and confirmed in writing within 12 hours to all parties to the appeal including the Clerk of Course.

4 Achievement and Celebration

4.1 Event results

- 4.1.1 Results published throughout the duration of the event are provisional. Results will not be final until after the determination of any outstanding protests and appeals.

4.2 Completing the course

- 4.2.1 To complete the course, the solar car must reach the finish line by the designated route, in accordance with the regulations.
- 4.2.2 A marshalling point will be established a few kilometres before the finish line. The finish time for the journey will be determined at the marshalling point.
- 4.2.3 The solar car must drive to the finish line, escorted by vehicles provided by the organiser. Other team vehicles will be directed to a long-term parking location.

4.3 Challenger Class

- 4.3.1 The goal for the Challenger Class is to be the first to arrive at the Adelaide marshalling point, in accordance with the regulations.
- 4.3.2 An urban area reference point will be established at the start of the Adelaide urban area. The location will be published in the official route notes. If team A can keep up with traffic and is overtaken by team B after the urban area reference point, the arrival time of team B at the marshalling point will be adjusted to be one minute behind the arrival time of team A. If team A is overtaken by team B and team A is unable to keep up with traffic at any point after the urban area reference point, the arrival time of team B will not be adjusted.
- 4.3.3 Any unserved time penalties must be served at the marshalling point.
- 4.3.4 The Challenger Cup will be awarded to the Challenger Class team that completes the route with the earliest finish time (arrival time at the Adelaide marshalling point plus any unserved penalty time).
- 4.3.5 Challenger Class teams that complete the route will be ranked by finish time (arrival time at the Adelaide marshalling point plus any unserved penalty time).
- 4.3.6 Challenger Class teams that do not complete the route will be ranked behind Challenger Class teams that complete the route. They will be ranked by the number of control stops completed before trailering, and within these groups by arrival time at the last control stop completed before trailering plus unserved time penalties accrued at any time during the event.

4.4 Cruiser Class

- 4.4.1 The goal for Cruiser Class teams is to design and build a practical solar car and transport people from Darwin to Adelaide according to a given schedule. Cruiser Class teams will be scored on energy efficiency and practicality.
- 4.4.2 Cruiser Class teams must arrive at key staging locations prior to the following target arrival times:

Staging location	Target arrival time	Latest arrival time
Tennant Creek	Saturday, 15:30	Saturday, 17:00
Coober Pedy	Monday, 16:30	Monday, 17:00
Adelaide	Wednesday, 11:30	Wednesday, 14:00

The average on-road speed required to meet these target times is about 75 km/h.

- 4.4.3 Teams arriving at a staging location after the specified latest arrival time will be deemed to have not completed the stage.
- 4.4.4 Teams arriving at a staging location after the specified target arrival time but before the latest arrival time will have their score reduced by 1 percent for each minute late.
- Example: If a team is 7 minutes late at Tennant Creek and 9 minutes late at Adelaide then their score will be multiplied by $0.99^{(7+9)} = 0.851$.*
- 4.4.5 Cruiser Class teams will spend Monday night at Tennant Creek and Wednesday night at Coober Pedy. Solar car drivers must clock in, but a 30-minute control stop is not required for Cruiser Class teams at these locations.
- 4.4.6 Cruiser Class solar cars may be recharged from Electric Vehicle Supply Equipment (EVSE) provided by the organiser at Tennant Creek and Coober Pedy, between sunset and 23:00. 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 Class teams spends charging from external sources will be published, along with the energy used, and will be considered by the practicality Judges.
- 4.4.7 Each Cruiser Class 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-km distance travelled
- 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 staging locations, in minutes
- d is the number of demerit points received by the team.

4.4.8 The Cruiser Cup will be awarded to the Cruiser Class team that completes all stages with the highest score.

4.4.9 Cruiser Class teams will be ranked in the following groups:

- teams that complete the entire route to Adelaide, ranked by score
- remaining teams that complete the entire route to Coober Pedy, ranked by score
- remaining teams that complete the entire route to Tennant Creek, ranked by score
- all remaining teams, unranked.

4.4.10 Cruiser Class teams arriving at the Adelaide marshalling point before 10:00 on day 6 will not have their arrival time recognised. No Cruiser Class team will be allowed to proceed to the finish line until after 10:00 on day 6.

4.4.11 The progressive score of a Cruiser Class team at each control stop will be calculated by

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

where

- D is the person-km distance achieved between Darwin 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 staging locations, in minutes
- d is the number of demerit points received by the team.

4.4.12 Nominal external energy use of a Cruiser Class solar car will be calculated as $E_0 + E_1 + E_2$, where E_0 is the nominal energy capacity of the energy storage system, E_1 is the recharge energy measured at Tennant Creek and E_2 is the recharge energy measured at Coober Pedy. 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 LiFePO₄ cells.

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

4.4.14 Person-km distance for a leg between consecutive control stops is the minimum number of occupants in the car during the leg, multiplied by the leg distance.

4.4.15 The practicality score for a Cruiser Class 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.

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-km distance score.

- 4.4.16 Cruiser Class teams must prepare a 3-minute video and a brochure that describes their car, how it will be used, and how it addresses sustainability, mobility and energy resilience. The video and the car will be presented to the Judges in Adelaide. Teams must allow Judges to get into their car to test the space and comfort.

4.5 Adventure Class

- 4.5.1 Adventure Class is non-competitive.

- 4.5.2 The progress of Adventure class solar cars will be controlled by the Clerk of the Course.

Adventure Class solar cars will be allowed to drive to the finish line only after the first four Challenger Class solar cars have done so.

- 4.5.3 Teams in Adventure Class will not be ranked by performance.

4.6 Awards

- 4.6.1 An awards ceremony will be held in Adelaide on the evening of Saturday 30 October 2021 (exact date, time, and location to be confirmed).

- 4.6.2 Entry to the awards ceremony is by ticket only.

Tickets for registered team members are included in the team entry fee and pro-rata team member registration fee outlined in Regulation 1.14. Additional tickets (subject to the capacity of the venue) for friends, family, sponsors, and public may be purchased. Further details will be provided in the Team Manager's Guide and/ or via Team Notice.

- 4.6.3 The winner of the Challenger Class will receive the Challenger Cup; the winner of the Cruiser Class will receive the Cruiser Cup.

- 4.6.4 Additional awards may be presented.
- 4.6.5 The event organiser reserves the right not to present an award in any given category.
- 4.6.6 Each team will receive a participation award.
- 4.6.7 All winning teams must make themselves available for an official media call if required.

4.7 Pack-down facilities

- 4.7.1 Open-air facilities will be made available for repacking solar cars for shipment. All vehicles, containers and equipment must be removed by close of business Tuesday 2 November 2021. Any remaining items will be removed for storage at the entrant's expense.

Glossary

ACDT	Australian Central Daylight Time (UTC + 10.5 hours).
ACST	Australian Central Standard Time (UTC + 9.5 hours).
AS/NZS	Australian Standard / New Zealand Standard.
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. The certifying engineer must be qualified to certify vehicles for operation on public roads.
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.
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.
EVSE	Electric Vehicle Supply Equipment.
FMVSS	United States Federal Motor Vehicle Safety Standards.
GST	Australian Goods and Services Tax.
high voltage	More than 60 V dc or more than 30 V rms ac.
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 an event occurred (e.g. whether a team obstructed traffic).
Juror	A person appointed by the event to resolve disputes.
Mission Control	The event organiser's operations centre.

participant	A person who has registered to participate in the event as a member of a team.
PV	Photovoltaic.
Red-Shirt	A senior event official (wearing a red shirt) responsible for overseeing the conduct of the event.
Regulations	2021 Bridgestone World Solar Challenge Regulations
road-ready	Ready to drive on the road.
scrutineering	The process of checking the solar car and other team vehicles for compliance with the regulations.
SAE	Society of Automotive Engineers.
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 Australian two-way radio operating on the Citizens Band.
UNECE	United Nations Economic Commission for Europe, responsible for <u>regulations for motor vehicles</u> .
UTC	Coordinated Universal Time.
VIN	Vehicle Identification Number.