



Energy, Education, Environment

Sunrayce 99 Regulations

Revised January 1999

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Sunrayce 99

Regulations

1. Purpose

The fundamental mission of *Sunrayce*[™] is to promote and celebrate educational excellence. Fueled by the spirit of friendly competition and teamwork, *Sunrayce* champions the creative integration of technical and scientific expertise across a range of exciting disciplines.

Our mission includes

- ◇ The recognition and development of academic programs and institutions which further excellence in science, mathematics, and engineering
- ◇ The support and encouragement of bright young minds to succeed in these fields of study and in subsequent careers
- ◇ the creation of public awareness and enthusiasm, both for education excellence itself, and for the technologies that emerge from that excellence
- ◇ The acknowledgment of the importance of public/private partnerships in the achievement of these goals.

2. Administration

2.1 Application of Regulations - These Regulations will apply to *Sunrayce 99* (the "Event"), which includes the selection of teams, registration of teams, the inspection of solar cars ("Scrutineering"), the qualification of solar cars (the "Qualifier"), the cross-country competition (the "Rayce"), and the awards banquet.

2.2 Supplemental Documents - Additional documents may be distributed to all teams entered in the Event to supplement these Regulations. These documents will clearly state that they are a supplement to the Regulations, and they will have the same force and effect as these Regulations. If there is a conflict between a supplemental document and these Regulations, the document having the later date shall take precedence. Supplemental documents specifically referenced in these Regulations include the *Request for Proposals*, the *Sunrayce 99 Dateline*, *Instructions for Structural Reports*, *Instructions for the Qualifier*, *Instructions for Scrutineering*, and the *Route Book*.

2.3 Acceptance of Regulations - All persons or groups selected to participate in the Event are assumed to know these Regulations. Their participation in the Event will constitute acceptance of them.

2.4 Interpretation of Regulations - All interpretations must be published in the *Sunrayce 99 Dateline* to become official. During the Qualifier and Rayce, all official interpretations will be announced at a Drivers' Meeting and posted at Rayce Headquarters. The only group authorized to interpret the regulations is the Regulations Committee.

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January 1999

- 2.5 Advertising, Promotion, and Publicity** - All advertising, sales promotion, and publicity material produced by the teams or their sponsors concerning or referring to the Event will refer prominently to the Event as *Sunrayce 99*. All teams, by entering the Event, specifically agree to abide by this regulation. By entering the Event, all teams and team members agree to the use of their names and their likeness in any publicity materials (brochures, magazines, videos, photographs, etc.) that may be issued by the Event's sponsors.
- 2.6 Rayce Headquarters** - During Scrutineering, the Qualifier, and the Rayce, a Rayce Headquarters will be established near these activities and will assume the management functions for the Event.
- 2.7 Officials** - A team of Officials to conduct Registration, Scrutineering, the Qualifier, and the Rayce will be selected by *Sunrayce 99* Organizers. Officials having specific duties shall be announced to the teams through the *Sunrayce 99 Dateline* and at the team meetings.
- 2.8 Jury** - A Jury will be formed to judge protests on conformity with these Regulations, team disputes, and penalties. In addition, the Jury is empowered to decide cases not specifically covered by these Regulations. The jury will be available to teams during the Rayce.

3. Entries

- 3.1 Entry Registration** - The Event is open to colleges, universities, trade schools and other post-secondary educational institutions in North America ("Institutions"), and those international educational institutions that are invited by the *Sunrayce 99* Organizers. Each Institution wishing to participate in the Event must submit an entry consisting of an Information Sheet, a signed Participation Agreement, and a signed proposal describing how they will organize and train a team to design, build, and Rayce their solar car. The entry must be signed by an official of the Institution (College Dean or equivalent). An entry from multiple Institutions is permitted, provided the entry is signed by an official from each of the Institutions represented. No Institution may support more than one team's entry. The entries are used to officially register all teams for the Event.
- 3.2 Number of Entries** - There is no limit to the number of Institutions that may submit entries and thus become registered for the Event. However, in the interest of safety, the number of solar cars entered in the Rayce will be limited to 40.
- 3.3 Seeded Entries** - The top three finishers in *Sunrayce 97* will be awarded seeded status in *Sunrayce 99* provided they register for *Sunrayce 99*. These "seeded" teams must still comply with the requirements of these Regulations to ensure their entry in the Rayce. Seeded teams will be given special consideration over all other officially registered teams ("Challengers") during the qualification process.
- 3.4 Teams** - Team members shall be credit-earning undergraduate or graduate students having good academic standing at the sponsoring Institution(s). Each team must have at least four members.
- 3.5 Faculty Advisor** - Each team must have at least one faculty advisor who will provide guidance as needed throughout the solar car design, build and test process. However, the faculty advisor may not perform the role of team leader, as this is a student competition.
- 3.6 Technical Documents** - Technical documents describing the solar car's structure, batteries, and solar cells must be submitted to *Sunrayce 99* Headquarters by January 15, 1999. Early submissions will receive prompt review by Headquarters. Should changes be necessary, amended submissions will be accepted through April 30, 1999. The technical information provided in these documents will not be made public. The information contained in each team's final submission must match the solar car presented at Scrutineering.

3.6.1 Structural Report - Safety is the sponsors' primary concern with regard to the structural development and fabrication of the solar cars. Safety should be the team's primary concern also. All teams are required to document, by calculation or testing, the structural protection provided for the driver with regard to front, rear, rollover, and side impact. A specific case that must be addressed is a frontal collision with another vehicle's bumper. Additionally, the team shall include an analysis of their tires, wheels, steering, braking, and suspension systems. This report must be approved by *Sunrayce 99* Headquarters. Detailed *Instructions for Structural Reports* will be distributed to all registered teams. Specifics within the instructions must be met by the competing teams.

3.6.2 Battery Approval - All storage batteries used in the solar car must be approved by *Sunrayce 99* Headquarters. Each team must provide a copy of the manufacturer's battery specification sheet, the MSDS (Material Safety Data Sheet) obtained from the battery manufacturer, proof of purchase of the batteries, and the following battery information:

Manufacturer's name
Stock number, type, or description
Module voltage (e.g., 6, 12, or 24 V)
Number of modules to be used in the solar car
Manufacturer's specifications, including capacity (kWh), weight (kg), and cost (US\$).

3.6.3 Solar Cell Approval - All solar cells must be approved by *Sunrayce 99* Headquarters. Each team must provide a copy of the manufacturer's solar cell specification sheet, proof of purchase of the solar cells, and the following solar cell information:

Manufacturer's name
Stock number, type, or description
Manufacturer's quote for cell area (cm²), performance, and cost (US\$)
Cell area (cm²) after trimming or cutting for placement on the solar car

3.7 Team Data - Each team must submit team photos and data sheets to *Sunrayce 99* Headquarters by April 30, 1999. The photo and data will be publicly released and used in event brochures. Late submissions will be omitted. Early submissions will not be made public prior to April 30, 1999.

3.7.1 Team Photo - The team photo shall be submitted as a color print measuring approximately 20 by 25 cm. The photo must clearly show the solar car and at least four team members. Team members in the photo must be identified by name and by their Institution when there is more than one Institutional sponsor.

3.7.2 Data Sheet - The data sheet must include solar car weight (with battery but no driver), solar car dimensions, motor type and rating, solar cell type and manufacturer, estimated peak solar array power in both racing and charging configuration (overhead sun, clear sky), battery weight and estimated capacity, chassis description, braking system, and wheel type and size. All specifications must be provided in both metric (SI) and English units. The team leader, crew members, designated drivers, and faculty advisor(s) must also be listed.

3.7.3 Team Data Changes - Teams may change specifications of the solar car and crew up to the scheduled time of Scrutineering, with the exception that solar cell and battery specifications may not change after April 30, 1999 without specific approval from *Sunrayce 99* Headquarters. Any changes submitted after April 30, 1999 may not be timely enough to appear in printed list or brochures.

3.8 Rayce Registration - All people taking part in the Rayce must be registered at Rayce Headquarters. This includes team members, sponsors, officials, guests, and the media. Badges will be issued and used to obtain access to restricted areas. These badges must be visible at all times.

3.8.1 Crew Requirements - All team members involved in the Rayce ("crew") must present themselves at Registration to complete all required forms. A letter from the Institution's Registrar must be presented that verifies that all members of the crew were credit-earning students with good academic standing throughout the 1998-1999 academic year, or graduated from the Institution no earlier than December 1998. Proof of insurance required in the School Participation Agreement must be presented. Team members will be required to complete and sign liability waiver and emergency medical information forms.

3.8.2 Driver Requirements - Only registered solar car drivers will be allowed to drive solar cars in the Rayce. A team shall have a minimum of two (2) drivers available at all times. In addition to meeting the crew requirements, solar car drivers must present a valid driver's license and must supply their own ballast bag and ballast (sand or metal shot only). The official weight of each driver, including driving clothes, helmet, and shoes, will be 80 kg. If the driver weighs less than 80 kg, ballast will be added to make up the difference. If the driver weighs more than 80 kg, no credit will be given.

3.9 Scrutineering - Each team registered for the Rayce must submit their solar car for inspection prior to the Qualifier to verify compliance with these Regulations. In addition, spot checks for regulation compliance may take place during and immediately after the Qualifier and Rayce, and the top five overall finishing cars will be impounded following the Rayce for a final inspection.

3.9.1 Scrutineering Time and Location - Scrutineering for *Sunrayce 99* will be conducted at various locations in the spring of 1999. Exact dates, times, and locations will be announced in advance. A complete road-worthy solar car is required for Scrutineering. Order of inspection will be determined by drawing. Teams that fail to present their solar car at their designated time will drop to the back of the queue, and will risk not having enough time to complete the Scrutineering process.

3.9.2 Scrutineering Format - Scrutineering will involve inspection stations for sizing, body, electrical, and mechanical; plus outdoor dynamic tests to verify handling and braking performance. *Instructions for Scrutineering*, a detailed description of the Scrutineering tests, will be distributed in advance to all registered teams.

3.10 Qualifier - Each team must successfully participate in the Qualifier before they will be allowed to compete in the Rayce. The Qualifier will be held before the Rayce on a closed track. The exact dates, times, and location will be announced in advance.

3.11 The Rayce - A maximum of 40 qualified teams will be permitted to participate in the Rayce, a staged cross-country road race for solar cars. Solar cars must race in the same configuration used at the Qualifier. The Rayce will span ten days from June 20 to June 29: nine days of racing plus a day of rest (and recharge, solar only, on June 25). Each day of racing will cover a course with specific start and finish lines. The team with the shortest cumulative Official Elapsed Time over the entire course will be declared the winner. The Rayce route will be on public highways.

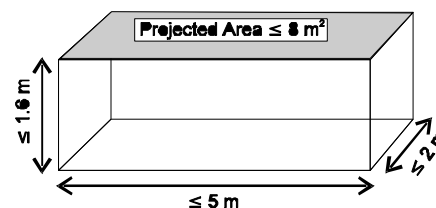
3.12 Safety - Each team is responsible for the road-worthiness of its solar car. Passing Scrutineering or implementing changes suggested in comments on the team's Structural Report does not relieve the team of any liability. All solar cars and support vehicles must be maintained in a safe, road-worthy condition and be operated safely at all times. A team may be disqualified and withdrawn from the Event at any time if it is judged to be operating their solar car in an unsafe manner.

- 3.13 Withdrawals** - Any team wishing to withdraw must notify *Sunrayce 99* Headquarters in writing. If the withdrawal occurs during the Qualifier or Rayce, that team must first notify Rayce Headquarters. All written withdrawals signed by an official of the Institution are final. *Sunrayce 99* Headquarters will withdraw teams that do not meet the technical document deadlines or fail to present a solar car at Scrutineering or the Qualifier.

4. Solar Car Regulations - Electrical

- 4.1 Power** - Global solar radiation received by the solar car without artificial external augmentation is the only source of energy that can be used for propulsion, except for energy stored in the solar car's battery system at the beginning of the first day of racing. Wind energy as well as direct and diffuse radiation are considered forms of global solar radiation. With the exception of the effects of wind on the basic shape of the car, all components used to convert global solar radiation for propulsion shall be considered part of the solar array described below.
- 4.2 Solar Array** - At any given moment, the solar array comprises all components that are involved in the conversion of solar energy for use by the vehicle. In addition to direct energy conversion components (such as photovoltaic cells), the solar array includes any reflective surfaces, refractive lenses, or thermal cooling systems employed to increase power output. Components that carry or process the energy after conversion are not considered part of the solar array, nor are structural members whose sole function is to support the solar array. The entire solar array must fit within an imaginary right rectangular parallelepiped ("box") of limited size whenever the solar array is connected to the solar car's motor or battery. The length of the box may not exceed 5 meters, the width may not exceed 2 meters, and the height may not exceed 1.6 meters. Furthermore, the product of the length and width, less any single rectangular region not occupied by solar array components, may not exceed 8 m^2 .

- 4.2.1 Racing Configuration** - Whenever the solar car is moving under its own power, the solar array must be in its racing configuration. In racing configuration, the box must be defined such that the length and width lie parallel to the ground. Furthermore, all portions of the solar array must remain fixed with respect to the solar car chassis, in the same orientation and configuration used when the solar car was inspected during Scrutineering.



- 4.2.2 Charging Orientation** - Whenever the solar car is stationary, the solar array may be reoriented to maximize solar exposure for charging. No reconfiguration of the solar array is allowed. In charging orientation, the box can have any orientation relative to the ground. However, all portions of the solar array must remain geometrically fixed with respect to the "box", in the same configuration used when the solar array was inspected during Scrutineering.
- 4.2.3 Electrical Connection** - All connections between the solar array and the solar car must be carried by the solar car.
- 4.2.4 Water Spray** - Ambient-temperature water from an external source may be applied to the solar array using hand-pumped sprayers if the water is applied while the solar car is stationary and the application does not present a shock hazard. This is a unique exception to the general requirement that cooling systems must be considered part of the solar array.

4.3 Solar Cell Technology Limitation - If photovoltaic technology is used, only solar cells manufactured in North America and that are available to all registered teams at a price not exceeding US\$10/watt will be allowed. The price limit corresponds to bare cells; teams may pay extra for cutting, tabbing, or lamination of the cells. A cell will be considered manufactured in North America if the crystal growth, junction formation, and metallization are performed within the physical boundaries of North America. Substantial modification of the crystal structure, junction, or metallization constitutes manufacture of a new cell.

4.4 Storage Batteries - All solar cars are allowed to store solar-generated energy in a battery system composed of individual modules having a combined energy capacity of 5 kilowatt-hours (5 kWh) or less. No other energy storage system will be approved. Battery size shall be based on the manufacturer's published specifications submitted by the team for energy capacity based on any single discharge rate from C/3 (3 hours) to C/20 (20 hours) inclusive. Here, the word "module" denotes an individual, self-contained unit (usually thought of as a battery); the term "battery system" denotes the full solar car battery. There is no separate limit applied to system voltage or number of modules. The solar car must travel along the entire Rayce with the same make and number of battery modules that were used at the Qualifier and at the Rayce start. Battery modules may be replaced after the start of the Rayce, however a penalty will be incurred. Replacement battery modules may have been charged by any means prior to installation in the solar car.

4.4.1 Battery Enclosures - All battery modules must be fully contained in enclosures that are electrically isolated from the solar car. The enclosures must be constructed from non-conductive, acid-resistant material. The battery enclosure covers must be constructed from the same material used in the fabrication of the rest of the enclosure. The cover must be firmly secured. The resistance measured between the battery terminals and any portion of the solar car chassis shall be greater than 1 M Ω for applied potentials up to 500 V. The battery enclosures must be secured to the solar car chassis so as to prevent them or the modules within from coming loose in the event of an accident or rollover. Velcro fasteners/straps will not be approved. All sides of each battery enclosure, including top, must be marked using 10-mm-high letters with "Caution: Corrosive Acid" and "High Voltage."

4.4.2 Battery Stacking - Stacking the batteries is discouraged. If it is necessary to stack the batteries, a battery rack must be used. The rack must be made of non-conductive, acid-resistant material that is strong enough to support the weight of the entire battery system. The rack shall meet the same electrical isolation requirements as the battery enclosures.

4.4.3 Battery Ventilation - Battery enclosures must be equipped with a forced ventilation system rated at a minimum of 280 liters per minute. It must operate whenever the battery system is electrically connected to the solar car or to the solar array. Such ventilation systems must exhaust to the exterior of the solar car and must be powered by the battery system.

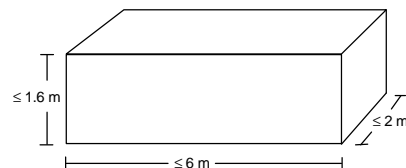
4.5 Battery Technology Limitation - The solar car storage battery may be composed only of rechargeable, commercially produced lead-acid, nickel-cadmium, or nickel-metal hydride modules. Batteries must be available in sufficient quantities to be accessible to all participating teams. The battery modules may not be modified in any manner, including the addition of electrolyte additives; case modification; or plate addition, removal, or modification.

4.6 Main Fuse - A separate fuse (not a circuit breaker) must be placed in series with the battery system and the rating must not exceed 200% of the maximum expected current draw. All low-voltage taps from the battery system must be separately fused. All fuses must be placed first in series with the battery starting at the positive connection.

- 4.7 Battery Switch** - The battery system must be equipped with a manually operated, high-current switch to quickly disconnect the battery from the electrical system. This switch must be capable of interrupting the full load current. The switch must be located within easy reach of the driver. The switch must be plainly marked in letters at least 10-mm high as the "Battery Switch" with "ON" and "OFF" designations. These markings must be clearly visible to the driver inside the solar car and to rescue personnel outside the solar car (canopy removed); use two sets of markings if necessary.
- 4.8 Motor Switch** - All solar cars must have a motor switch wired to disconnect all power to the motor from either the battery or the solar array. The switch must be able to interrupt full load current, and it must be separate from the battery switch. It must be within easy reach from the driver's position and clearly marked in letters at least 10-mm high as the "Motor Switch" with "ON" and "OFF" designations. These markings must be clearly visible to the driver inside the solar car and to rescue personnel outside the solar car (canopy removed); use two sets of markings if necessary.
- 4.9 Supplemental Batteries** - Supplemental, replaceable batteries carried in the solar car may be used to power only the following accessories: radios, electronic panel meters, and data telemetry.
- 4.10 Cable Sizing** - All electrical cables must be properly sized to expected system currents.
- 4.11 Electrical Shock Hazards** - All exposed or easily exposed conductors, junction boxes, solar cells, etc., operating at greater than 36 volts must be protected from inadvertent human contact and must be marked "High Voltage" in letters at least 10-mm high.
- 4.12 Lighting** - Solar cars must have front and rear turn indicators and brake lights visible from 30 meters in full sunlight. Automotive-type turn signal and brake light bulbs must be used, and the aperture for these lights shall be at least as large as the diameter of the bulb. Turn signals must be located at the front extremity of the vehicle with a 1.5-meter minimum left to right separation. Turn signals and brake lights must be located at the rear extremity of the vehicle with a 1.5-meter minimum left to right separation. The geometric visibility of each light shall be 45 degrees from center and 15 degrees up and down. Additional brake lights may be centrally located if desired. The brake lights must be red colored. The turn signals must be either red or amber colored.
- 4.13 Horn** - Solar cars must be equipped with a horn that can be heard at a sound power level between 82 and 102 dBA at a distance of 15 meters in front of the solar car. The horn must be permanently mounted, electrically powered, and must be acoustically coupled to the air outside the solar car.
- 4.14 Accelerator** - Accelerator mechanisms on solar cars must be free moving, and when released, must return to the zero current position. If the solar car is equipped with cruise control, it must be designed with an automatic shut-off when the brake is activated.
- 4.15 Control** - acceleration, braking, and steering must be under the sole control of the driver.

5. Solar Car Regulations - Mechanical

5.1 Solar Car Dimensions - The solar car (including solar array) will have the following maximum dimensions when moving under its own power: height=1.6 meters, width=2 meters, length=6 meters. When turning corners, wheels and wheel fairings may exceed these dimensions.



5.2 Tire and Wheel Requirements - The solar car shall have a minimum of 2 front and 2 rear tires in contact with the ground at all times. Minimum separation of the inner edges of the tires must be 15 cm. The wheels shall be designed for the intended application.

5.2.1 Tire ratings - Tires in contact with the ground shall be loaded and inflated within the manufacturer's rating at all times during vehicle operation. Each wheel and tire on a single axle must be rated for the full weight applied to that axle.

5.2.2 Dynamic Stability - All wheels and their suspension will be inspected for safe operation in normal and adverse conditions.

5.3 Driver Cockpit - The driver's cockpit may not subject the driver to excessive strain during normal operation, and must be designed to protect the driver from injury in the event of an accident.

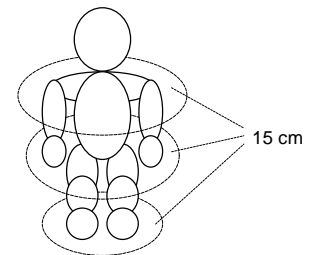
5.3.1 Seating Position - The normal driving position must place the driver's entire head higher than the highest point of his or her legs. No head-first positioning is allowed for the driver.

5.3.2 Belly Pan - The cockpit must be equipped with a full belly pan to isolate the driver from the road. The belly pan must be strong enough to support the full weight of an 80-kg driver.

5.3.3 Roll Cage - All solar cars must be equipped with a roll cage that encompasses the entire driver. The roll cage shall be a fixed, integral part of the solar-car structure. The protection provided for the driver in a collision must be documented in the team's Structural Report. In addition to providing collision and roll-over protection, the roll cage must be designed so as to deflect body/array panels of the car away from the driver in the event of an accident. There must be 5 cm of clearance in all directions between the roll cage and the helmet of the driver seated in the normal driving position. The roll cage must be of steel tubing having a minimum carbon content of 0.18 percent. The roll cage tubing must have a minimum outside diameter of 2.5 cm and minimum wall thickness of 2 mm. Alternate materials which afford equivalent protection for the driver are permitted, provided they are fully documented in the team's Structural Report.

5.3.4 Padding - The roll cage must be padded with energy-absorbing material wherever it may come into contact with the driver's helmet. This energy-absorbing material may be included within the required 5 cm of clearance. In addition, a headrest of at least 2-cm-thick resilient material must be mounted behind the driver's head.

5.3.5 Crush Space - The driver, when seated, must have a minimum of 15 cm of horizontal distance between his or her shoulders, hips, and feet and the car's outer body surface.



5.3.6 Safety Belts - All solar cars must be equipped with a minimum of a five-point lap and shoulder belt (harness system). The use of safety belts is mandatory. The safety belts must be attached securely, as recommended by the manufacturer, to a strong component connected to a main frame member, or to a main frame member itself in the solar car. The harness must be attached with bolts and nuts; bolts threaded into a structural member or "insert" are not allowed. If a hammock-type seat is used, the safety belts must remain functional in the event of a structural failure in the driver's seat. Only commercially manufactured safety belts are allowed. They must bear the manufacturer's emblem, and they must not be modified in any way from the condition in which they were received from the manufacturer.

5.3.7 Fresh Air Circulation - Fresh intake air from vents or wheel openings must be provided for the solar car's driver.

5.3.8 Egress - The driver's cockpit must provide for the driver's unassisted exit within 10 seconds. Driver's doors and/or canopies may not be taped shut at any time.

5.4 Visibility - In the normal driving position with ballast on board, the driver's eyes must be at least 75 cm above the ground.

5.4.1 - Windshield - All solar cars must have a windshield made of shatter-resistant material. The windshield must be free of excessive distortion. This will be tested by having the driver identify 2-cm high letters at a distance of 3 meters through any of the required viewing angles referenced below. Solar cars must have a method to clear at least 0.1 m² of the windshield of rain. The clearing method must be operable at all times and must be in use when it becomes necessary to use the windshield wipers on the team's support vehicles.

5.4.2 Forward Vision - From the normal driving position, the driver must be able to see at all times without artificial assistance: 1) a point on the ground 8 meters in front of the solar car, 2) a minimum of 17 degrees above the horizon on level ground, and 3) a full 100 degrees to either side of center. To provide an "encompassing" roll cage, some elements of the roll cage may obstruct a portion of the forward vision. However, this view must be essentially unobstructed by the solar car structure so the driver can easily see the road and all oncoming traffic.

5.4.3 Rear Vision - All solar cars must be equipped with a rear view mirror that will allow the driver to at all times see a vehicle 15 meters directly behind the solar car and up to 30 degrees off center. Fiber optics and/or electronic rear vision systems are not allowed. The rear view mirror shall use only a single reflection and shall be mounted on the solar car.

5.5 Fasteners - All fasteners must be of suitable type, strength, and durability for their application, with the following minimum requirements:

5.5.1 Bolts - Bolts used in the steering, braking, suspension, seat mounts, safety harness, drive train, and battery box systems must at minimum meet SAE grade 5, metric grade M 8.8 and/or AN/MS specifications. Bolts must be of the correct length, and extend at least two threads beyond the nut. Bolts in tension must not have shaved or cut heads.

5.5.2 Securing of Bolts - The bolts described above must be secured from unintentional loosening by safety wire or cotter pins. In difficult areas only, Inspectors may allow nylon lock nuts, Loctite, or other means deemed appropriate. Excessive use of Loctite is not permitted. Lockwashers should not be used in critical areas. If lockwashers are supplied by the manufacturer (such as brake/suspension assemblies), Loctite, or something similar, should also be used.

5.5.3 Hose Clamps - Hose clamps must not be used to secure any structural or critical members of the car. Their use to secure ducting or wire cables is allowable.

5.6 Covers and Shields - All moving parts must be suitably covered to prevent accidental human contact when the solar car is fully assembled. All steering linkage must be shielded from contact by the driver.

5.7 Steering Stops - The steering system must include steering stops to prevent dangerous or damaging steering travel during evasive maneuvers or when a wheel strikes a roadway obstruction.

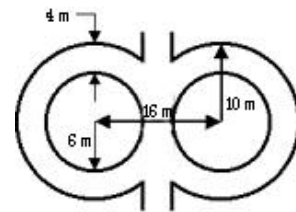
5.8 Clearance- Interference or rubbing of the wheels with the solar car's body, wheelwell, or structure at full steering lock or suspension travel is not permitted. Movement of rod-end bearings may not be obstructed in any axis throughout the full travel of suspension and steering. Other moving parts, such as the motor shaft, must not contact stationary parts except through properly designed bearings.

5.9 Ballast Carrier - If any solar-car drivers on a team require ballast to increase their weight to 80 kg, that team's solar car must have provisions for carrying and securing the bag(s) containing ballast. The ballast must be contained in such a way that it cannot come loose in the event of an accident or rollover. The ballast bag and its identification markings must be visually accessible during driver changes.

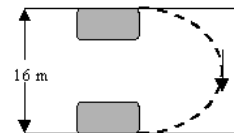
5.10 Brakes - Solar cars must have a balanced, dual braking system so that if one system should fail, the solar car can still be stopped. The two systems must be operationally independent and may be either front/rear or redundant front or redundant rear (one sided systems left or right are not permitted). Hydraulic systems must have separate master cylinders. Regenerative brakes may not be considered as one of the braking systems.

5.11 Braking Performance - Solar cars must be able to stop from speeds of 50 kph or greater with an average deceleration on level pavement exceeding 17 kph per second. The time interval over which the deceleration is averaged shall be from the first indication that the driver should stop until the solar car comes to a complete halt. When braking, the solar car must not veer excessively to the left or right, or exhibit structural instability.

5.12 Handling Performance - Solar cars must be able to negotiate a figure-8 course with a 4-meter-wide-lane without knocking over any of the cones or exhibiting signs of structural instability in less than 11 seconds per side.



5.13 Turning Radius - Solar cars must be able to make a U-turn in either direction, without backing up, such that all wheels remain within a 16-meter-wide lane.



5.14 Graphics - Solar cars must prominently display their assigned number, Institution name, and the Event logo such that they are clearly visible from a roadside vantage point. Additional graphics related to the team's Institution(s) or sponsors are permitted, provided they are neither offensive nor disruptive.

5.14.1 Solar Car Numbers - Each team registered for the Event will have a unique number approved by *Sunrayce 99* Headquarters (positive integer, 3 digits maximum). Teams that participated in *Sunrayce 97* and registered on time for *Sunrayce 99* have the right to retain the number they used in *Sunrayce 97*. This number must be clearly displayed on both sides of the solar car. Each number must have a minimum of 5 cm of unobstructed background color on all sides. These colors can be black on white, white on black, or another high-contrast color approved by *Sunrayce 99* Headquarters. The numerals themselves must be a minimum of 25 cm high, 12 cm wide (except the numeral one), and have a minimum brush stroke of 4 cm. Numbers containing more than one digit must have a minimum of 2.5 cm spacing between them.

5.14.2 Institution Name - The name of the Institution(s) sponsoring the team must be displayed on the solar car. The use of abbreviations or initials must be approved by *Sunrayce 99* Headquarters. The Institution's name shall be as large or larger than any team sponsor's logo or name.

5.14.3 Event Logo - The Event logo must be applied on both sides of the solar car. The logo will be provided by *Sunrayce 99* Headquarters and will measure no more than 22 cm in height by 32 cm in width. The logo must be mounted with 5 cm of unobstructed background color on all sides.

6. Racing Regulations

- 6.1 Traffic Laws** - During the course of the Rayce, all state and local traffic laws must be obeyed, with the exception of those that are uniquely inapplicable to solar-car caravans. Solar cars must observe a maximum speed limit of 55 m.p.h.
- 6.2 Team Uniforms** - On racing days from 6:00 a.m. to 9:00 p.m. team members shall wear uniforms representing their Institution(s). The only information or graphics approved to appear on the front of the team uniform (jacket, shirt, hat, or other wearable) shall be the School name/log, Team name/logo, Car name/number, and Sunrayce logo. Team sponsors may also be displayed, but only on the back of the team uniform shirt or jacket. If team sponsors are displayed, then the event sponsor must also appear in a similar manner on the back of the team uniform. Artwork for the Sunrayce logo and for the event sponsors may be obtained from Sunrayce 99 Headquarters.
- 6.3 Rayce Time** - Official clock time for each day of the Rayce will be based on the local time at that day's start line, as displayed by the Timing Officials. The same official time ("Rayce Time") will remain in effect for the entire day (until midnight), even though that day's route may cross into a different time zone.
- 6.4 Drivers** - Only a single person, the authorized driver, may ride in the solar car.
- 6.4.1 Driver Helmets** - Drivers must wear a helmet in the solar car. The helmet must have a minimum ASTM F-08.53 (F1447-1998 or F1447-1997a), CSPC (16 CFR Part 1203) or Snell B90 (bicycle-type) rating.
- 6.4.2 Driver Shoes** - Drivers must wear closed-toed tennis or better shoes in the solar car. Sandals are not permitted.
- 6.4.3 Driver Ballast** - Drivers and ballast will be identified with unique identification tags. The ballast carried by the solar car must match the driver in the solar car at all times.
- 6.5 Drivers' Meeting** - A Drivers' Meeting will be held each Rayce morning. Attendance at this meeting is required. Due to limited space, attendance is limited to two members per team. All official statements, including starting order, rule interpretations, and Rayce-route revisions, are made at this time.
- 6.6 Starting Line** - The solar cars will be released from the official starting line at 60-second intervals beginning at 10:00 a.m. All solar cars must report to their starting position by 9:45 a.m. Each team's lead and chase vehicles must merge with their solar car after it leaves the starting line. The movement of all vehicles in the start-line area is under the control of the Start-Line Officials.
- 6.6.1 Starting Order** - The starting order for the first day of the Rayce will be determined at the Qualifier. On all other days, the order is based on the solar cars' Official Elapsed Time of the previous day, from shortest to longest. In case of a tie on any day, the first of the two teams to cross the previous day's finish line will precede the other in the starting line-up.
- 6.6.2 Teams Not Ready** - If a team's solar car, lead, and chase vehicles are not in their assigned starting positions at 9:45 a.m., the Start-Line Officials may, at their discretion, move all of the following cars up one slot, and the tardy team must move to the end of the starting queue.

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- 6.6.3 Delayed Start** - The start of the Rayce may be delayed if inclement weather or other hazardous conditions appear likely to pose a threat to the solar cars or their drivers.
- 6.7 Rayce Route** - A *Sunrayce 99 Route Book* will be distributed to each team that qualifies for the Rayce. The *Route Book* will contain information to direct the team along the official route. It will specify days, dates, distances, directions, route numbers, maps, and points of reference. For a team to receive official time, they must follow the official Rayce Route.
- 6.7.1 Route Revisions** - *Sunrayce 99* Headquarters will make every effort to be as accurate as possible in the *Route Book*, but due to unforeseen events it may be necessary to detour. When advance warning is available, Rayce Headquarters will correct the official route accordingly and provide revisions to the *Route Book* to all teams registered for the Rayce, or provide written revisions at the morning Drivers' Meeting.
- 6.7.2 Teams Departing from the Rayce Route** - Any team leaving the Rayce Route must rejoin the route at the same intersection where they left the route, or they will receive no credit for distance driven beyond the point where they departed from the route.
- 6.7.3 Checkpoints** - Checkpoints will be established each day at the discretion of Rayce Headquarters to ensure the solar cars are following the Rayce Route. It is not necessary to stop at the checkpoints. Failure to pass a checkpoint station will result in no credit for distance driven beyond that point.
- 6.7.4 Pit Stops** - A Pit Stop is a mandatory stop during the Rayce day. Each day, one Pit Stop may be designated and detailed in the *Route Book*. These Pit Stops are for 15 minutes and are mandatory for all solar cars reaching the Pit Stop before 3:00 p.m. Failure to stop for the required time will result in no credit for distance driven beyond that point. After 3:00 p.m., teams are not required to stop. Within the Pit Stop area, the movement of all team vehicles shall be under the control of Pit Stop Officials. Solar charging of solar car batteries and solar car maintenance are allowed during the 15-minute Pit Stop. However, teams must not interfere with or block any other team's passage through the Pit Stop. Teams unable to leave the Pit Stop area after 15 minutes must move their solar car and support vehicles to an open area designated by the Pit Stop Officials.
- 6.8 Support Vehicles** - All vehicles and trailers associated with a team (including friends and family), other than the solar car itself, are support vehicles. These vehicles must be registered with Rayce Headquarters. If support vehicles authorized by Sunrayce Headquarters are supplied to all teams entered in the Rayce, then each team shall use the vehicle supplied in accordance with the terms of the agreement under which the vehicle is provided.
- 6.8.1 Support Vehicle Graphics** - All support vehicles, including trailers, must be marked with the team's solar car number (at least 15-cm tall) on both sides and the rear. The name of the team's sponsoring Institution(s) must also be displayed prominently on each vehicle. Additional graphics are permitted provided they are neither offensive nor disruptive.
- 6.8.2 Lead Vehicle** - Each team must provide a support vehicle meeting US Federal Motor Vehicle Safety Standards to alert oncoming traffic to the presence of the solar car. This "lead" vehicle must travel within 500 meters ahead of the solar car, with its headlights on and with roof-mounted flashing amber lights. The lead vehicle may not tow a trailer. The lead vehicle must display the team's solar car number on its front windshield (at least 15-cm tall), in addition to both sides and the rear. The lead vehicle shall not be larger in height or length than a standard 15-passenger, full-size van.

- 6.8.3 Chase Vehicle** - Each team must provide a support vehicle meeting US Federal Motor Vehicle Safety Standards to protect the solar car from the rear. This "chase" vehicle must follow directly behind the solar car, with roof-mounted, flashing amber lights. The chase vehicle may not tow a trailer. A sign provided by *Sunrayce 99* Headquarters must appear on the rear of the chase vehicle to warn overtaking traffic of the solar car. The chase vehicle shall not be larger in height or length than a standard 15-passenger, full-size van.
- 6.8.4 Scout Vehicle** - A "scout" or any other vehicle (other than "lead" or "chase") is not allowed on the Rayce Route.
- 6.8.5 Radios** - The chase vehicle must be in two-way radio communication with the solar car at all times. All two-way radio channels must be registered with *Sunrayce 99* Headquarters. All teams must also have a separately monitored CB radio in the chase vehicle tuned to a designated channel to communicate with other nearby teams and Officials.
- 6.8.6 Other Support Vehicles** - All other support vehicles (except the lead and chase) must not travel on the Rayce Route during racing hours. The only exception is to assist the team with a repair, accident, or to trailer the solar car. A suggested alternate route will be identified in the *Route Book*.
- 6.9 Passing on Two-Lane Roads** - Because the Rayce Route will include two-lane roads, there will be times when solar cars and their lead and chase vehicles will need to pull over while being overtaken. Teams need not disrupt their own progress to permit other vehicles to pass when they themselves are trapped behind other traffic.
- 6.9.1 Passing Traffic** - When six or more vehicles are lined up behind a team's chase vehicle, the team must pull over as soon as safely possible to allow the traffic to pass.
- 6.9.2 Passing Teams** - In the event that one team is overtaken by another, the overtaking team can signal their intention to pass by flashing the headlights of their lead vehicle between high and low beam. The overtaking team must also attempt to make CB radio contact with the team being passed to coordinate the pass. Once the overtaking team has signaled their intention to pass, the team being passed must facilitate the pass at the first available safe opportunity, either by slowing down by at least 5 mph (8 kph) in a zone where passing is permitted and feasible, or by pulling completely out of the traffic lane.
- 6.10 Drafting** - Drafting by a solar car is prohibited. A solar car will be considered to be drafting if it continuously follows behind another vehicle at less than a three-second interval. The only exception to this is in congested traffic at speeds of 25 mph (40 kph) or less.
- 6.11 Pushing** - Except for the following situations, solar cars may not be pushed or pulled from the time they are moved into their starting position for the daily start until they reach the finish line later that day. In no case shall regenerative braking be engaged while pushing or pulling the solar car.
- 6.11.1 Pit Stop** - Solar cars may be pushed within the confined area of the Pit Stop.
- 6.11.2 Emergency** - In an emergency or breakdown situation, the solar car must be removed from the road. In this circumstance the car may be pushed or lifted off the roadway. The solar car may then be pushed or lifted back onto the roadway at the same location where it left the roadway.
- 6.11.3 Weather** - The solar car may be pushed onto and off of a trailer to protect it from the weather, provided the solar car is moved back to its original location after it is unloaded from the trailer.

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- 6.11.4 Trailering** - Should it become necessary to load the solar car onto a trailer for transport to the finish line, it may be pushed onto the trailer.
- 6.12 Accidents and Reinspection** - All accidents involving either solar cars or support vehicles must be reported immediately to Rayce Headquarters. In the case of an accident involving personal injury, notification of the appropriate emergency medical services and public safety officials shall take priority. If a solar car is involved in an accident resulting in structural damage, it must be checked by an Inspector to understand the cause of the accident and to verify structural integrity before racing is resumed. The Inspector may require repairs prior to resuming the Rayce.
- 6.13 Timing** - Timing and distance determinations for the Event will be the responsibility of *Sunrayce 99* Timing Officials. No other timing or distance information will be recognized by Rayce Headquarters.
- 6.13.1 Official Start Time** - Each team will be assigned a start time each day, which will be distributed to the teams at the morning Driver's Meeting. If the start of the Rayce is delayed, then all assigned start times for that day will be adjusted accordingly. If the team leaves the starting line at their assigned time, then that becomes their Official Start Time for that day. If the team leaves before their assigned time because they were moved forward in the queue by the Start Line Officials, then the team's Official Start Time is their actual start time. If the team leaves after their assigned time because they weren't ready, then the team's Official Start Time is still their assigned time.
- 6.13.2 Racing Hours** - All teams have 8 hours to reach the daily finish line. Teams that have not reached the finish line must stop promptly 8 hours after their Official Start Time. Assuming 40 cars start at one-minute intervals beginning at 10:00 a.m., the first car will have until 6:00 p.m. to reach the finish line and the last car will have until 6:39 p.m. The hours of the last day of racing may be modified by Sunrayce Headquarters.
- 6.13.3 Teams Completing the Day's Route** - Teams completing the day's route within their 8-hour allotment will have their Daily Elapsed Time based on the actual time that elapsed from their Official Start Time until the team's solar car crosses the official finish line for that day.
- 6.13.4 Teams Not Completing the Day's Route** - Teams that do not complete the day's entire route within their 8-hour allotment will have their Daily Elapsed Time calculated based on their distance traveled along the route. After noting and recording the time and route distance covered, the team may load their solar car onto a trailer for transport to the finish line. Battery charging from the solar array while trailering is allowed. Teams not completing the day's route will have their Daily Elapsed Time calculated as the allowed driving time for the day (normally 8 hours) plus 1.5 minutes per mile of distance not covered on that day's official route (1.5 minutes/mile = .93 minutes/kilometer).
- Example (based on 8-hour day and 30 miles not completed):
Daily Elapsed Time = 8 hours + (1.5 minutes/mile × 30 miles) = 8 hours, 45 minutes
- 6.13.5 Teams Off Course** - If a team departs from the Rayce Route but then returns properly to the route and continues, their Daily Elapsed Time will be determined in the normal manner; no credit will be given for the time the team was off-course.
- 6.13.6 Pit Stop Credit** - All teams that reach the Pit Stop before 3:00 p.m. and wait the required time will receive a 15-minute Pit Stop Credit.

6.13.7 Official Elapsed Time - Each team's Official Elapsed Time for each day will be that team's Daily Elapsed Time minus their Pit Stop Credit (if any) plus any penalties for that day plus any protest filing fees for that day. Note that protest filing fees are counted against the day on which the protest is filed, whereas penalties are counted against the day on which the infraction occurred. Thus, the Official Elapsed Time for a given day is not final until after the end of the Rayce.

Official Elapsed Time = Daily Elapsed Time - Pit Stop Credit + Penalties + Protest Filing Fees

6.14 Overnight Stops - Once a team's solar car arrives in the vicinity of the finish line each day, the movement of that team's vehicles shall be under the control of Finish Line Officials. Specific areas will be designated for solar charging, Impound, support vehicle parking, Rayce Headquarters, and food service. These areas will become the staging area for the start of racing the following morning. Solar cars may be pushed within and between these areas, but regenerative braking may not be used during such times.

6.14.1 Support Vehicle Parking - All support vehicles must be parked only in designated areas. Support vehicles will not be allowed into the charging areas.

6.14.2 Impound - The Impound is a designated area (building, tent, etc.) where all solar cars are secured under the direction of Event Security. The solar car must be complete with no parts missing when placed in Impound. There will be no maintenance allowed on the solar cars while impounded and no team members are allowed in the Impound area except for placement and removal of their solar car. All solar cars must be impounded by 9:00 p.m. each Rayce day. Teams are responsible for delivering their solar car to the Impound entrance early enough to ensure that it is impounded before this deadline. Teams may start removing their solar cars from Impound beginning at 6:00 a.m. the next day.

6.14.3 Accommodations and Lodging - All teams are responsible for team accommodations and food during the Rayce. Food concessions will be available at each overnight stop. Provisions will be made for camping at or near most overnight stops. Teams are responsible for their own reservations.

6.14.4 Charging Area - A charging area will be provided for the teams. Internal combustion generators will not be permitted within the charging area.

6.15 Observers - Trained Observers, selected and sponsored by *Sunrayce 99* Headquarters, will travel with each team to alert the Inspectors to possible infractions of these Regulations, and to help teams deal with unforeseen events. The Observer has the authority to warn teams when they believe that a rule infraction is imminent. Observers may not interpret these Regulations or give advice on Rayce strategy. Observers will be rotated in their team assignments at least daily.

6.15.1 Observer Accommodation - Teams must allow the Observer the seat of his or her choice behind the driver in the chase vehicle. The Observer must be able to see the solar car and read the chase vehicle's speedometer from this location, and must also be able to determine, at least periodically, how many vehicles are following behind the team.

6.15.2 Observer Record of Performance - The details of the activities of a team will be recorded in a log book carried by the Observer. The team leader will be permitted to review the book each day; however, failure to do so does not make any record invalid. The records kept by the Observer include the Official Start Time, stopping times (including Pit Stop), the distances traveled, and any apparent rule infractions either by their assigned team or by any other team.

6.15.3 Observer Access for Inspection - Observers will be assigned to keep each solar car in sight from the start line to the finish line each day. The Observers shall witness any and all work done on the solar cars during this period. The Observers must be allowed access to the solar cars for inspection of ballast during all driver changes.

6.16 Penalties - Any team failing to comply with these Regulations during Scrutineering, the Qualifier, or the Rayce will be penalized. Penalties range from official warnings to disqualification from the Event. It is the responsibility of the Chief Inspector, with input from the other Inspectors and the Observers, to determine whether an infraction occurred, the severity of the incident, and the appropriate penalty. All time penalties will be submitted by the Chief Inspector to Rayce Headquarters for subsequent posting. Disqualification of a team from the Event requires concurrence of the Director.

6.16.1 Posting of Penalties - Except for the last day, all time penalties will be posted at Rayce Headquarters by 8:00 a.m. the following morning and penalized time will be added to the Official Elapsed Time of the day the penalized incident occurred. On the last day of racing, time penalties will be posted no later than 30 minutes after the finish of the Rayce.

6.16.2 Conduct - Penalties, including disqualification from the Event, may be imposed for improper conduct or the use of alcohol or illegal substances. Improper conduct may include, but is not limited to, improper language, unsportsmanlike conduct, unsafe behavior, or cheating.

6.16.3 Non-Solar Charging of Batteries - After the start of the Rayce until the official finish, teams will be disqualified from the Event for charging their solar car's storage batteries from any source of energy other than the solar car's solar array.

6.16.4 Replacement of Batteries - Decisions to exchange all or part of a battery must be communicated formally to the team's Observer or an Inspector. The penalty will be computed as follows:

Time penalty (minutes) = $480 \times (n+S)/N$, where:

n	=	number of replacement modules
S	=	sum of all modules previously replaced
N	=	total number of modules in solar car battery pack

6.16.5 Disturbing Official Battery Seals - Solar-car batteries will be marked with an official seal. Disturbing these seals in a manner that prevents proper identification by Inspectors will be penalized as though all of the battery modules affected had been replaced.

6.16.6 Traffic Violations - Any solar car committing a traffic violation will be penalized up to 15 minutes for each violation. Any solar car driver who commits three traffic violations over the course of the Rayce will be individually disqualified from the Event.

6.16.7 Failure to Allow Other Traffic to Pass - Any team failing to properly facilitate passing by traffic or other teams will be penalized up to 15 minutes for each offense.

6.16.8 Drafting - A penalty of up to 1 minute will be assessed for each minute that a solar car drafts behind another vehicle.

6.16.9 Pushing - A penalty of up to 30 minutes will be assessed each time it is necessary for a team to push or pull their solar car in order to advance along the Rayce Route. Teams pushing or pulling their solar car along the Rayce Route for more than 15 seconds (except as in 6.11.2) will be assessed a time penalty up to that which would have the same effect on their Official Elapsed Time as if the team had made no further progress beyond that point on that day.

- 6.16.10 Improper Ballast** - A penalty of up to 60 minutes will be assessed each time a team operates their solar car with ballast that does not match the solar car driver.
- 6.16.11 Failure to Impound** - A penalty of up to 3 minutes will be assessed for every minute between 9:00 p.m. and 6:00 a.m. that a solar car is not in Impound.
- 6.16.12 Unauthorized Vehicle on Rayce Route** - A penalty of up to 10 minutes will be assessed to a team each time an unauthorized support vehicle associated with that team drives on the Rayce Route without justification.
- 6.16.13 Exceeding Size Specifications** - Oversized solar arrays will be penalized up to 10 minutes per day per excess centimeter in each dimension beyond the allowed size specification. Oversized solar cars will be penalized up to 5 minutes per day per excess centimeter in each dimension. If both the array and car are oversized, both penalties will be applied.
- 6.17 Protests** - Any team desiring to file a protest must do so by submitting an official protest form to Rayce Headquarters. Protests may be filed for any reason, including disputing a penalty levied against any team, correcting timing errors, or protesting the actions of another team. A "filing fee" of 10 minutes will be assessed against the team's Official Elapsed Time for the day on which the protest is filed. All protests will be heard by the Jury.
- 6.17.1 Protest Judgments** - The decision of the Jury is final and no further appeals are allowed. The Jury will notify Rayce Headquarters of their decision, and Rayce Headquarters will then inform the affected teams. The Jury may refund some or all of the filing fee, which will be credited to the day the filing fee was assessed.
- 6.17.2 Opportunity to Be Heard** - Protests will normally be heard by the jury at the earliest possible jury sitting. It may be necessary in some instances for the jury to postpone the hearing on a protest.
- 6.17.3 Time Limit** - Except for the last day, all protests against penalties must be filed by 8:30 p.m. the day the penalty is posted. Protests that do not directly relate to a penalty must be filed by 8:30 p.m. on the day after the offense occurred. On the last day of racing, protests for any purpose must be filed within 60 minutes after the finish of the Rayce.