FOREWORD

Dear Shell Eco-marathon Participants,

2020 has been a challenging year, but as we move into 2021, we do so with hope. Hope that life will gradually return to normal and that, together, we will emerge stronger. When it comes to Shell Eco-marathon we will draw on our collective spirit of collaboration, innovation, and empathy to get back to our fulsome competition as soon as is safely possible. After all, it is these qualities that have defined Shell Eco-marathon for more than 35 years and I’m confident that they will continue to do so with your involvement.

On that note, I’d like to formally introduce the upcoming Shell Eco-marathon season. 2021 will see us adopt a unique model that combines physical competition elements (where possible), with new and exciting virtual opportunities. All with the continued goal of addressing an age-old problem that, if solved, will have long-lasting benefits for everyone: how to travel as far as possible using as little energy as possible?

The result is that the Shell Eco-marathon 2021 season will have two significant components – track competitions where possible; and a virtual programme which will be centred around a newly created ‘Virtual League’.

We know that the track competitions are the beating heart of Shell Eco-marathon and we will endeavour to get back to the track as soon as it is safe to do so. As the external environment continues to evolve, it is not clear what restrictions there may be, and for which locations in 2021 – and we will need to wait a little longer to see exactly how we will do this in 2021. However, in preparation, the season contains what we are calling new ‘mini Shell Eco-marathon competitions’ - designed to address these challenges. These will be smaller, more accessible events to take place where and when safely possible across the regions, in line with the required global and local health and safety guidelines. As more information becomes available, we will continue to update you on our planning for these events.

Nevertheless, to ensure we continue to provide an engaging and stimulating programme while physical events are less assured, we have created a new virtual programme which is called ‘Virtual League’. The Virtual League will be in addition to the track events and will consist of several optional virtual challenges which all feed into an ongoing league table - designed to recognise and reward your achievements throughout the year. From virtual technical inspection to off-track awards and global energy challenges, it will stretch and strengthen your STEM skills from start to finish. More information on how this will work, and the individual challenges can be found at our new website – www.makethefuture.shell.

While nothing can replace the track, we hope that these virtual components will continue to provide opportunities throughout this season as we navigate these difficult times. Please note that to participate in the virtual or physical competitions teams must register for the 2021 Shell Eco-marathon season by October 14, 2020; and entry to our first virtual competition ‘Pitch the Future’ closes on September 30, 2020 - so I encourage you to register as soon as possible!

To conclude, I hope you’re safe, I hope you’re well, but I also hope you’re excited. The future of Shell Eco-marathon is here, and I know that together we can turn these challenging circumstances into an opportunity to enhance the programme for many years to come.

Kind regards,

Norman Koch
Global General Manager Shell Eco-marathon
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1. **ORGANISATION**

**ABOUT THE RULES**

a) The rules for Shell Eco-marathon 2021 events can be downloaded from the Shell Eco-marathon website. They comprise of:


ii. Chapter II - Rules of the specific location where Shell Eco-marathon on-track events take place.

b) It is the responsibility of participating Teams to read and understand the Official Rules. As some competition components this year are virtual in nature, participants should pay particular attention to our data protection policies (in Article 105 and Article 106), and guidance on protection of their and other people’s intellectual property (in Article 107 and Article 108).

To highlight rule changes and aid the understanding of frequently misunderstood rules:

i. **Red text** indicates a change, addition, or amendment to the previous year’s Official Rules.

ii. **Italic text** is explanation of a rule for better understanding.

c) Links are used throughout this document for navigation.

d) Tech Tips videos have been developed to explain specific rules and illustrate acceptable solutions. Links to these videos will be available from the Shell Eco-marathon participant’s webpage.

e) In this document functions and roles are defined as follows:

i. ‘Organisers’ – the specific Shell company that organises the Shell Eco-marathon event in a region stated in Chapter II, and all persons acting on its behalf.

ii. ‘Team’ – group of individuals with a team name and one vehicle that has been accepted for entry to the Shell Eco-marathon competition.

iii. ‘Participant’ – member of a Team.

iv. ‘Team Manager’ – a Participant that has been appointed on the event registration document as a single focal point for his/her team for the Organisers.

v. ‘Faculty Advisor’ – a professional staff member of the educational institute which the Team represents.

vi. ‘Race Director’ – person appointed by the Organisers, who is responsible for managing and sanctioning all on-track activities.

vii. ‘Track Marshal’ – person appointed by the Race Director to act on his/her behalf, to ensure on-track safety and observe on-track rule compliance.

viii. ‘Technical Director’ – person appointed by the Organisers, who is responsible for managing and ensuring the technical standards and integrity of the Shell Eco-marathon competition.

f) Any decision by the Organisers is final, independent of whether it is explicitly identified in Chapter I or not.

**ARTICLE 1: ACCEPTANCE**

a) Applications to enter the competition must be made via online registration on the Shell Eco-marathon website. The Organisers will review all applications and will select Teams based on the quality of their
proposed entry and historical successes from previous Shell Eco-marathon events. The criteria for the historical successes will include achieving valid runs, completing technical inspection, and demonstrating a readiness to compete upon arrival to the event. In addition, the Organisers reserve the right to invite Teams who represent the spirit of this competition.

b) By fact of their entry, Participants accept all provisions of the Official Rules and agree to abide by all decisions made by the Organisers. The Organisers reserve the right to add, modify or delete any Article of the Official Rules. In such an event, the Teams will be notified. The Organisers are solely empowered to pronounce in cases not provided for in the Official Rules.

c) The Organisers reserve the right to modify, postpone or cancel the competition for any reason including for reasons of force majeure due to, including but not limited to, adverse or extreme weather conditions, the occurrence of a natural disaster, acts of terrorism or safety concerns. No claims for compensation will be accepted.

d) The Participant is aware that photo, audio and video recordings will be made throughout the event and that these recordings may be used commercially for advertisement or promotional purposes.

In the Virtual Programme as defined in Section 6 of the Official Rules, the Participant is aware that by participating in the competition components, they will appear in such photos and videos.

In all other physically held on-track events, the Participant is aware that they may choose not to appear in such photos and videos by requesting so at check-in, following which they will be given an additional unique lanyard. This will be used as a visual indicator to all photographers/videographers on site to that effect.

ARTICLE 2: ENTRIES

TEAM PREPARATION

a) Shell Eco-marathon is an academic educational programme. All Teams wishing to enter must be affiliated with an educational institution and their participation must be endorsed by it. Educational Institutions eligible for Shell Eco-marathon participation are universities, colleges and secondary schools preparing students for higher education degrees, vocational training certificates, professional certificates or official second-level school-leaving examinations. Participants must be at least 16 years of age on the first day of the competition, however 14 and 15-year olds may be allowed if appropriate safety and supervision plans are agreed in advance with the Organiser.

b) A maximum of two vehicles per Educational Institution may be considered for any given Shell Eco-marathon event, if they are distinctly different projects. If more than two Teams from the same institution submit an application for a Shell Eco-marathon event, the Organisers reserve the right to select which Teams will advance based on the acceptance criteria detailed in Article 1a).

c) For each entry, a Team Manager, a Driver and a Faculty Advisor must be designated. A Reserve Driver may also be designated.

d) The Team Manager must be a student member of the Team currently enrolled at the institution. In case all Participants are legal minors, the Faculty Advisor must act as Team Manager.

e) The Team Manager can only be responsible for one vehicle. He/she may also be a Driver or Reserve Driver for that vehicle, but only for that vehicle.

f) The Team Manager is the Team’s sole official liaison with the Organisers. All information will be addressed to him/her. For the purposes of the project, he/she will be responsible for the Team, must speak on behalf of the Team and must be able to understand and speak English.
The eligibility criteria for Drivers are detailed in the relevant section of Chapter II. The Driver and Reserve Driver must be students of the educational institution in question. The Driver and the Reserve Driver for one vehicle cannot be the Driver or Reserve Driver for another vehicle. Both must be able to speak and understand English. Both the Driver and the Reserve Driver must be at least 16 years old.

Each interested Team must apply to compete in the Shell Eco-marathon event closest to their home country. Attendance at another Shell Eco-marathon event outside its home region is subject to decision of the relevant regional organising committee.

Teams are permitted to select names that are appropriate to their research, their school, and Shell Eco-marathon. Names that are offensive or disrespectful to others who may be participating will not be allowed. The Organisers reserve the right to require Teams to change their name.

**ARTICLE 3: TRACK ACCESS CONDITIONS**

During both the practice runs and the competition, all vehicles must comply with the technical and safety rules of the event. Whenever a vehicle enters the track, the vehicle body must be in place and bear all the competition numbers, sponsor stickers and Shell logos required by the Official Rules. Organisers will supply these numbers and logos.

**ARTICLE 4: IDENTIFICATION**

a) Logos, official sponsor stickers and racing numbers must be fixed to the vehicle body in accordance with the diagram provided (see Appendix 1) such that they can be clearly read during any public presentation, in promotional films and on all photographs.

b) Under no circumstances may the Shell logos, the sponsor stickers or racing numbers be modified, either on the vehicle or on any other documentation. It is prohibited to cut the stickers supplied by the Organisers. Their dimensions are as follows:

i. For each side and for the front of the vehicle: A Shell logo, 200 x 215 mm.

ii. For each side and for the front of the vehicle: racing numbers, 200 x 260 mm.

iii. For each side, on the lower part of the body: a sponsor sticker, 770 x 800 mm.

c) A mandatory 100 mm space must be left free on all four sides of the Shell logo, and it should be placed with the base parallel to the ground (not at an angle).

d) Any other sponsor names/logos must be smaller than the Shell logo. Each sponsor sticker must fit within a maximum area of 400 cm² (empty space included).

e) The trademarks or logos of tobacco companies and alcoholic drinks producers are prohibited. Trademarks and logos of other energy companies and direct competitors to event sponsors require the prior written approval of the Organisers. This rule applies to all vehicles and all Participants’ apparel.

f) In the event of a breach of this rule, the Organisers reserve the right to remove any sponsor logos.

g) All vehicles are subject to the Organisers’ approval concerning these provisions.

**ARTICLE 5: COMPLIANCE**

a) Only vehicles that comply with the present Official Rules can participate. No vehicle will be allowed on the track for practice or competition until the Organisers have approved it. The decisions of the Organisers are final in all matters concerning the compliance of vehicle design and construction with the Official Rules.
b) The Organisers reserve the right to rescind vehicle approval upon further or more detailed evaluation. The Organisers must be notified of any modifications to the vehicle after inspection. Non-compliance with this rule will lead to vehicle disqualification.

c) Vehicles complying with all safety rules but not all technical rules will not be allowed to compete. However, they may be allowed on the track for practice or demonstration at the discretion of the Technical Director.

ARTICLE 6: PROTESTS

The Team Manager is the only person authorised to lodge protests. Protests must be brought to the attention of the Technical Director via the results desk. Protests must be lodged within the following times:

a) Vehicles: before track closure on the current day.

b) Team and Driver behaviour: within 30 minutes following the end of the attempt.

c) Results: within 1 hour after the result of an attempt has been posted.

ARTICLE 7: DISPUTES

In the event of any disputes, all decisions made by the Race Director are binding and final.

ARTICLE 8: PENALTIES

a) Non-compliance with the driving rules or safety rules will result in the penalties in Article 8:d). Notwithstanding this, the Organisers reserve the right to make decisions on a case by case basis depending on the severity of the breach.

b) The Organisers may exclude, disqualify or penalise any Participant who has cheated, gained an unfair advantage due to any breach of the Official Rules, hindrance of other Participants, departure from the normal course, or any act or omission capable of misrepresenting performance, especially regarding energy consumption or method of propulsion.

c) During the competition, the Driver or Team Manager must report to the Organisers any movement made or attempted by means other than the vehicle’s own propulsion system. In such an event, the attempt in question will be invalid. If this type of incident is not reported, all the Team’s attempts will be invalidated.

d) The following general penalties apply:

1st infraction: Formal warning.

2nd infraction: Best overall attempt invalidated at the end of the competition.

3rd infraction: Immediate Team disqualification.
2. SAFETY

ARTICLE 9: SAFETY RULES

a) As with any motorsport activity there should be an understanding that certain inherent risks will be present. Recognising and controlling these risks are vital for the well-being of people and local surroundings. Safety is an essential consideration for the Organisers. These Rules are to protect all individuals and surrounding areas and are in no way intended to curtail the spirit of the competition. Any activity deemed unsafe or outside of the spirit of the event will be met with appropriate action by the event Organisers.

b) Therefore, compliance with safe driving and sporting rules, as well as any instructions given by Track Marshals or the Organisers is mandatory for everyone. All Participants must comply with the safety measures and must notify Organisers about any anomalies or incidents. In case of dangerous conditions, leave the area immediately. During the event, the paddock area will be monitored by the Organisers to assist Teams to comply with safe practices.

c) The Race Director is responsible for and has the final authority in determining the safe conditions for track operations regarding weather.

d) Non-compliance with any of these Rules may lead to disqualification from the competition at the sole and absolute discretion of the Organisers.

e) Electrical safety in the paddocks is an especially important topic in Shell Eco-marathon events. Teams must read and comply with the safety concerns in Article 24, Article 57, and their regional Chapter II Rules.

2A – DRIVING RULES

ARTICLE 10: DRIVING KNOWLEDGE AND TEST

a) Only the registered Driver and the Reserve Driver will be authorised to drive the vehicle.

b) Drivers may be questioned about their knowledge of the driving rules during inspection. The Organisers reserve the right to deny track access to Drivers with insufficient knowledge of the Rules.

c) Driving on-track: Drivers must use smooth, safe driving techniques for example thinking ahead, avoiding sudden directional changes, and being fully aware of vehicles around them.

d) Drivers must have a minimum of two hours of driving experience with their vehicle. Drivers will be asked various questions to verify their skill level:

1. Do you have prior experience driving in a Shell Eco-marathon competition?
2. Do you have prior experience driving in a similar mileage competition?
3. Do you have a minimum of 2 hours driving experience in your team vehicle?
4. Have both drivers driven the current vehicle?

Drivers may be required, in the discretion of the Technical Director, to verify their skill level on a test track as part of passing Technical Inspection.

ARTICLE 11: DRIVING UNDER THE INFLUENCE OF ALCOHOL/ILLEGAL SUBSTANCES

a) Driving under the influence of alcohol or illegal substances is forbidden. This applies to all Drivers, Reserve Drivers, and Participants.
b) Procedures for alcohol or substance testing are detailed in Chapter II.

c) Any breach will be penalised in line with Article 8 and the following additional penalties:

   i. Any alcohol or substance related breach of the rules will be treated at least as a ‘2nd infraction’ of the Team, even if no prior violation has occurred.

   ii. In addition, the affected Driver is immediately banned from track access if he/she is under the influence. A Reserve Driver may substitute the Driver if he/she is eligible to drive.

   iii. Any second alcohol and/or substance related infraction will lead to the immediate disqualification of the entire Team.

ARTICLE 12: BRIEFING

The attendance of the daily Drivers’ briefing is mandatory for the Team Manager and all registered Drivers and Reserve Drivers every day. Failure in attending these briefings by the Team Managers and Drivers will disqualify the Team from practicing and/or competing that day.

ARTICLE 13: ACCESS TO THE TRACK

a) Vehicles must pass a safety inspection prior to accessing the track for practice runs. A safety sticker will be clearly affixed once the vehicle has passed the inspection.

b) For practice runs on both the test track and the competition track, only vehicles with a safety sticker will be allowed on the track.

c) For the competition, only vehicles with safety and technical inspection stickers will be allowed to compete.

d) The Organisers will allow opportunity for Team Managers and Drivers to survey the track before any vehicles are allowed on the track. For further details please refer to Chapter II.

e) After pre-start measurements have been completed, Teams must be ready to start their attempt within two minutes or return to the paddock.

ARTICLE 14: PUSHING THE VEHICLE

At no time on the racetrack are drivers allowed to push their vehicle or have it pushed, including to start the run or to cross the finish line.

ARTICLE 15: RACE DIRECTION

It is forbidden to drive in reverse gear or to drive against the race direction.

ARTICLE 16: RADIO COMMUNICATION

The use of hand-held communications is forbidden in the vehicle. However, the use of a “hands-free” kit is allowed if both hands of the driver remain on the steering system.

ARTICLE 17: OVERTAKING

a) Drivers are required to give clear passage for other vehicles wishing to overtake.

b) Drivers in overtaking vehicles must sound their horn and pass with caution. The Driver of the overtaking vehicle is responsible for the safety of the manoeuvre.

c) Drivers of the vehicles being overtaken must use their mirrors and must not change course suddenly.

d) On the track, overtaking is authorised on both the right and the left, provided the above-mentioned safety rules are followed.
ARTICLE 18: BREAKDOWNS AND OTHER INCIDENTS

a) Intentional stopping on the track is forbidden unless it is required by the competition, e.g. for Urban Concept vehicles, or is needed to prevent a safety incident.

b) The Driver is allowed 30 seconds to attempt to re-start the vehicle from within its driving position.

c) If a vehicle breaks down or is involved in a minor disabling accident on the track, the Driver must immediately make every attempt to drive the vehicle to the side of the track and wait in the vehicle for the Track Marshals to arrive.

d) In an emergency, the Driver must get out of the car and wait in a safe place off the track for the Track Marshals to arrive and recover him/her and the vehicle.

e) It is forbidden to carry out repairs on the track. In the event of a flat tyre, even when near the starting line, a new start will not be granted for the attempt in question.

ARTICLE 19: OFF-TRACK VEHICLE MOVEMENTS

a) All vehicles must be parked inside the designated paddock area or directly in front of it. When off the track, vehicles must be moved without the use of the engine. They must be pushed or pulled by an accompanying Team Member wearing gloves. This also applies to the pit lane and the paddock area. Test-driving in the paddock area is forbidden.

b) Any breaches and any unsafe or unfair behaviour brought to the attention of the Organisers could result in a penalty.

2B – DRIVER AND EQUIPMENT

ARTICLE 20: DRIVER WEIGHT

a) The minimum Driver Weight is:
   - Prototype vehicles - 50.0 kg
   - Urban Concept vehicles - 70.0 kg

b) The Driver Weight is defined as the weight of the person driving the vehicle including full driving gear and communication devices. If the Driver Weight does not meet the minimum weight requirement ballast needs to be fitted to the vehicle. This ballast must be provided by the Team, in form of weightlifting discs or rectangular metal plates. No other form of ballast is permitted. The ballast must be effectively secured to the vehicle to ensure Driver safety in the event of collision or roll-over. For Urban Concept vehicles the ballast must be outside the driver compartment. A seal will be installed around the ballast by a technical inspector and must remain in place during the event. If the seal has been tampered with or removed the vehicle will no longer be valid to compete.

c) If a Team has two drivers and one or both drivers are underweight, the ballast weight will be based on the lightest driver.

d) Drivers (in full driving gear, including communication devices) and their ballast may be weighed before or after each attempt. A weight loss of up to 1 kg during an attempt will be tolerated.

ARTICLE 21: HELMETS

a) For practice and competition, Drivers must wear full-face or three-quarter helmets suitable for motorsport activities. Helmet certification labels must be clearly readable. Helmets worn by all Drivers will be subject
to inspection. Helmets should not have any indentations or cracks and should be in proper working condition as intended by the helmet manufacturer.

b) All helmets must be affixed with a face shield (or visor). The face shield (or visor) must cover from the top of the face down to below the driver’s nose. Tinted face shields or sunglasses to be worn under the face shield are permitted. The helmets must correctly fit the Driver and be secured by a chin strap. Visors should be free from major scratches and have clear visibility.

**ARTICLE 22: DRIVER CLOTHING**

a) All Drivers must wear a one-piece racing suit as the outermost layer of clothing, and the racing suit must be classified as Flame Retardant Clothing (FRC) according to a recognised standard. Drivers are not allowed to wear synthetic clothing underneath the race suit because synthetic material may melt if exposed to flames.

   *Cotton shirt and underwear are recommended.*

b) Socks (made from cotton or FRC material) and shoes are required.

c) Fire retardant gloves are required and must completely cover all fingers.

d) If Drivers wear balaclavas, they are required to be made from FRC material.

e) No bare skin should be visible when the Driver is wearing the racing suit, gloves, socks, shoes and helmet.

**ARTICLE 23: DRIVER COMFORT**

Please note that in the event of hot weather conditions, high temperatures may affect Driver comfort and potentially cause heat stress.

a) It is recommended to properly ventilate the inside of the vehicle to provide cooling to the Driver.

b) It is recommended to provide sufficient drinking liquids to the driver for the duration of an attempt. If fluid containers are provided to the driver(s), these containers must be hands free.

   *Camel-back style or bottles secured inside the driver’s compartment with flexible feed straw are recommended.*

c) It is recommended to equip the vehicle with an effective shield from the sun.

d) For driver comfort, Teams can install fans or air-cooling type systems that are not included in the electrical measurement of the vehicle. Any fans or air-cooling systems must be self-powered by internal batteries.

c – GENERAL SAFETY

**ARTICLE 24: EQUIPMENT AND MATERIALS**

Teams are required to provide and use at the event:

a) Leather, canvas or other cut resistant gloves for general work, including movement of vehicle

b) Chemical resistant gloves for fuel or motor oil handling

c) Safety glasses for all Participants

d) Hearing protection for all Participants

e) Duct tape to secure cords or cables lying on the pit floor

f) Lift stands or appropriate raised platform for vehicle tuning and repairs
g) Tools and materials

h) Effective equipment suitable to mitigate and/or control Lithium-based battery fires must be used during battery charging. The equipment must prevent or contain the spread of fire or battery even during charging. Equipment that may be used includes:

- A battery charging bag that is designed specifically for containment of a Lithium battery fire, or
- A fireproof blanket that can be placed over AND under the lithium battery being charged. The blanket must be big enough to fully cover and contain any potential battery fire.

i) Vehicle Crates and Transportation

- Participants are required to seek early guidance regarding shipment of any Dangerous Goods material from a commercial freight company to obtain the latest shipping legislation.
  
  Commercial transportation regulations have increased significantly in recent years. Teams need to understand the ramifications for non-compliance. Individual Teams are responsible for commercial shipments.

  Shipments made by air freight are the most stringent compared to road freight.

- Dangerous Goods shipping and packing information will be available on the Shell Eco-marathon website, including mandatory declaration form(s), and Shipper contact information for each region.

j) Electrical safety

- All electrical equipment used must be properly fused.
- Electrical cables must be in good condition and appropriate for the equipment it is intended for.
- Teams are only allowed to use a single multi-plug strip with internal overcurrent protection.

2D – ATTENTION

Review all sections of the Official Rules as they contain further safety matters specific to each topic.
3. VEHICLE DESIGN

3A – GENERAL

ARTICLE 25: VEHICLE DESIGN

a) During vehicle design, construction and competition planning, participating Teams must pay attention to all aspects of safety, including the safety of the driver, participants, volunteers and spectators.

i. Prototype vehicles must have three or four running wheels that are in constant contact with the road.

ii. Prototype vehicles must have a minimum crumple zone of 100 mm between the front of the vehicle body and the driver’s feet.

iii. Urban Concept vehicles must have exactly four wheels that are in constant contact with the road.

b) Aerodynamic appendages, which adjust or are prone to changing shape due to wind, are not allowed.

c) Vehicle bodies must not include any external appendages that might be dangerous to participants; this includes pointed parts of the vehicle body. Sharp points must have a radius of 50 mm or greater or covered with foam or a deformable material.

d) Vehicle body panels and windows must be rigid and may not change shape due to wind.

e) The vehicle interior must not contain any objects that might injure the Driver in the event of a collision. Windows must not shatter into sharp shards. Protective film covering the windows is allowed but must not distort the driver’s visibility.

f) The energy compartment (engine/motor/transmission/battery, etc.) should be easy to access for quick inspection.

g) All parts of the drive train, including fuel tank, hydrogen system components, etc. must be within the confines of the body cover.

h) All objects in the vehicle must be securely mounted. Bungee cords or other elastic material are not permitted for securing heavy objects.

i) All vehicles must have a solid floor and frame that prevent any part of the driver’s body from contacting the ground.

j) All vehicles must be fully covered. Open top vehicles are not allowed. Vehicles that look like bicycles, tricycles or wheelchairs are not acceptable.

k) The Organisers will provide all Urban Concept vehicles with a telemetry System and require them to install in their vehicle for competition monitoring and result calculation (see Section 5).

l) The use of asbestos and asbestos-containing materials is forbidden.

ARTICLE 26: CHASSIS/MONOCOQUE SOLIDITY

a) Teams must ensure that the vehicle chassis or monocoque will safely protect the driver’s body, including crumple space in the event of a front, side, or rollover collision.

A monocoque is a construction that supports structural load by using an object’s external skin as opposed to using a frame.
b) The vehicle chassis must be equipped with an effective roll bar that extends 50 mm around the driver’s helmet when seated in normal driving position with the safety belts fastened.

If this position impairs the driver visibility it will be deemed that the roll bar is not adequate. The effectiveness of the roll bar and driver’s visibility will be validated simultaneously, i.e. the driver must not be in such position that he or she must raise their head or torso above the roll bar to pass the visibility test.

ROLL BAR & SAFETY BELTS

c) The roll bar must extend in width beyond the driver’s shoulders when seated in normal driving position with the safety belts fastened.

Teams may use a tubular or panel roll bar. If a tubular roll bar is used, it must be metal. A panel roll bar is the rigid partition separating the cockpit from the energy compartment, and it must be integrated into the vehicle chassis or monocoque.

d) The roll bar must be able to withstand a static load of 700 N applied in a vertical, horizontal, and/or perpendicular direction, without deforming in any direction.

e) If the vehicle must be lifted at a specific place on its body, it should be clearly marked with a rectangular box stating, “LIFT HERE”.

ARTICLE 27: PROPULSION AND ENERGY STORAGE SYSTEM ISOLATION

a) A rigid Bulkhead must safely isolate and seal the vehicle’s propulsion and energy storage systems from the driver’s compartment.

A bulkhead is an upright partition separating the driver’s compartment from the energy compartment. This means engines, fuel cells, fuel tanks, batteries (propulsion or accessory), hydrogen cylinders, supercapacitors, etc. must be placed outside the driver’s compartment behind the bulkhead. The purpose of this bulkhead is that in the event of a fuel leak, fire or battery release incident, it prevents liquids and/or flames from reaching the driver. Avoid having any gaps or holes between the body and the bulkhead. It is recommended to seal gaps with materials such as metal/aluminium sheeting or aluminium tape.

b) The bulkhead must be able to protect the driver from an open flame in the energy compartment.

c) The bulkhead must prevent manual access to the energy compartment by the Driver.

d) If holes are made in the bulkhead to pass through wires or cables it is essential that the wires and cables are protected by a grommet or similar protective material to prevent chafing or damage. All gaps and holes must be filled.

ARTICLE 28: VISIBILITY

a) The Driver must have access to a direct arc of visibility ahead and to 90° on each side of the longitudinal axis of the vehicle. The Driver’s field of vision must be achieved without aid of any optical or electronic devices. Movement of the Driver’s head within the confines of the vehicle body to achieve a complete arc of vision is allowed, but the driver’s helmet must always be 50 mm below the roll bar. The side windows tinting must be light enough to allow the driver to be seen from outside the vehicle.

b) The vehicle must be equipped with a rear-view mirror on each side of the vehicle, each with a minimum surface area of 2,500 mm² (e.g. 50 mm x 50 mm). An electronic device may not replace a rear-view mirror.

c) For Urban Concept vehicles wet weather visibility is also mandatory (see Article 52).
ARTICLE 29: SAFETY BELTS

**ROLL BAR & SAFETY BELTS**

a) The Driver’s seat must be fitted with an effective safety harness with at least five mounting points to maintain the Driver securely in his/her seat. The five independent belts must be firmly attached to the vehicle’s main structure and be fitted into a single buckle, specifically designed for this purpose.

b) The safety harness must prevent any upward or forward motion of the Driver’s torso. Any slack in the harness must be adjusted by using the seat belt length adjuster. The adjustor must be located as close as possible to the connection point. The crotch strap mounting point must be underneath the body, and the topmost straps should be mounted 0° to 10° below the top of the Driver’s shoulder.

c) The safety harness must always be worn tight and fastened to prevent the Driver from having free movement when the vehicle is in motion.

d) Each safety harness mounting point must be able to withstand a 200 N force in any direction.

e) The Urban Concept vehicle safety harness must be specifically manufactured for motorsport use (e.g. certified or compliant with FIA standards).

ARTICLE 30: VEHICLE ACCESS

a) It is imperative for Drivers, fully harnessed, to be able to vacate their vehicles at any time without assistance in less than 10 seconds.

b) Prototype vehicles must be equipped with a sufficiently large opening for the cockpit. The driving position must be designed so that emergency services can easily extract the Driver from his/her vehicle, if necessary.

c) The driver compartment must have a single opening mechanism per door, which must be easily and intuitively operable from both inside and outside the vehicle. The method of opening from the outside must be clearly marked by a red arrow and must not require any tools.

d) It is forbidden to use adhesive tape to close the Driver’s opening from the outside.

ARTICLE 31: HORN

a) Each vehicle must be equipped with an electrically powered horn typically used in current automobiles. Bike or cycling horns are no longer permitted.

b) The horn must be mounted at the front of the vehicle without obstruction.

c) The horn must emit sound greater than 85 dBA when measured 4 meters in front of the operating vehicle. The horn must produce a continuous single tone sound when activated – chirping or siren-like tones are not permitted.

d) The horn must be powered by the vehicle battery. However, the power consumed by the horn does not need to be measured by the Joulemeter (See Article 56:d:v).

ARTICLE 32: NOT USED

ARTICLE 33: DRIVER POSITION

For safety reasons, the head-first driving position is prohibited.
ARTICLE 34: CLUTCH AND TRANSMISSION

a) All vehicle propulsion must be achieved only through the friction between the wheels and the road.

b) All vehicles with internal combustion engines must be equipped with a clutch system.

c) For centrifugal/automatic clutches the starter motor speed must always be below the engagement speed of the clutch.

d) Only Urban Concept ICE vehicles are required to have idling capabilities. This means the vehicle must be able to remain stationary while the engine is running.

e) For manual clutches the starter motor must not be operable with the clutch engaged. An interlock is required to facilitate this functionality.

f) Please refer to Article 64:b) regarding starter motor requirements.

g) Guards for transmission chains and/or belts are mandatory. *This is required to protect driver or technician when working on the car in the event of the chain or belt breaking. It must be made of metal or composite material rigid enough to withstand a break.*

ARTICLE 35: EXHAUST SYSTEM

a) The exhaust gases must be evacuated outside the vehicle body.

b) Exhaust pipes must not extend beyond the rear or the side of the vehicle body.

c) Exhaust pipes must be solid with no signs of fatigue or leaks.

d) Exhaust pipes must be appropriate for high temperatures.

ARTICLE 36: ENVIRONMENTAL CONSIDERATIONS

All vehicles are expected to comply with reasonable environmental conditions including smoke, odour, and sound level emitted.

ARTICLE 37: EMERGENCY SHUT-DOWN

**EMERGENCY SHUTDOWN**

a) The purpose of the emergency shutdown system is to disable the propulsion system of the vehicle. Different types of propulsion systems require different measures to accomplish this.

b) Spark ignition engines (gasoline, ethanol) will require the emergency shutdown mechanism to shut down the ignition. It is not necessary to isolate the accessory battery.

c) Compression ignition engines (diesel) will require the emergency shutdown mechanism to shut off the fuel or air flow. It is not necessary to isolate the accessory battery.

d) For Battery Electric vehicles the emergency shutdown mechanism must provide a physical isolation of the propulsion battery from the vehicle electrical system. The use of a power controller or other logic systems to drive an isolation device is not permitted. If relays are used, the relays must be a normally open contact type. *Care should be taken to ensure that the relay coil power is also removed when the relay coil is open. This may be achieved by using a latching circuit.*

e) For Hydrogen vehicles see Article 65:e).
f) There must be both an internal and an external shutdown mechanism.
   i. The internal emergency shutdown mechanism is for driver operation and may be designed in any effective way.
   ii. The external emergency shutdown mechanism must be at the rear of the vehicle and permanently installed on a non-detachable part of the bodywork.
   iii. A standard sticker (Blue triangle with red electrical arc) provided by the Organiser must be positioned on the vehicle body to indicate clearly the exterior position of the emergency shutdown actuator.

   g) The external emergency shutdown mechanism must be achieved by means of a latching red push button, which can only be re-activated by rotating it. Push/pull levers are not accepted.

   h) In addition to the above devices, all vehicles must be equipped with a “dead man’s safety device” or sometimes referred to as “operator presence control.” The purpose for this device is to ensure that in case the driver becomes incapacitated the vehicle’s propulsion power is automatically disengaged (returns to an idle condition). This device may consist of a spring-loaded hand operated accelerator or foot pedal lever. An electric dead man switch is permissible if the switch is located on the steering wheel. If an electric dead-man switch is used the driver must directly (for example by thumb or index finger) engage the switch continuously while driving.
   i. This device is a separate switch from the required “emergency shut-down” mechanisms identified in Article 37.f).
   ii. If an ICE Prototype vehicle is designed with a WOT (wide open throttle) operation of the dead-man switch must switch off the ignition system.

**ARTICLE 38: ADDITIONAL INSPECTIONS**

a) After passing technical inspection, any alternation must be re-approved by the Organisers.

b) After any significant incident to the vehicle, it must be re-inspected.

c) At any time, the Organisers may perform unannounced inspections on the vehicles.

**3B – PROTOTYPE CLASS**

**ARTICLE 39: DIMENSIONS**

a) The vehicle maximum height must be less than 1000 mm.

b) The vehicle track width must be at least 500 mm, measured between the midpoints where the tyres of the outermost wheels touch the ground.

c) The ratio of height divided by track width must be less than 1.25.

d) The vehicle wheelbase must be at least 1000 mm.

e) The maximum total vehicle width must not exceed 1300 mm.

f) The maximum total length must not exceed 3500 mm.

g) The maximum vehicle weight, without the Driver is 140 kg.

h) None of the body dimensions above must be achieved by design singularities such as ‘stuck-on’ appendages or cut-outs.
ARTICLE 41: TYRES, WHEELS, AXLES AND WHEEL HUBS

a) All types of tyres and wheels are allowed.

b) Any type of wheel rim may be used. Rims must be compatible with the dimensions of the selected tyres to satisfy safety standards.

   Bicycle wheels are not generally designed to support substantial lateral cornering forces, such as may be found in Shell Eco-marathon vehicles at certain speeds.

   The wheel axles must be designed for cantilever loads (like in wheelchairs) rather than for load distributed equally on both sides (like in bicycles).

c) Wheels located inside the vehicle body must be isolated from the Driver by a bulkhead and must not touch the chassis or body.

d) Any handling or manipulation of wheels by the Driver is forbidden from the moment the vehicle is at the starting line until it crosses the finish line.

e) All installations must be carried out in a way that there is no likelihood the wheels will touch other parts of the vehicle (i.e. cables, wires, hoses, and energy compartment components like batteries, etc.). These must be safely mounted/secured so that they cannot interfere with the turning wheel during driving and cause accidents.

ARTICLE 42: TURNING RADIUS AND STEERING

a) Only front wheel steering is permitted. If the Organisers are not satisfied with the effectiveness and/or control of a vehicles steering system, this vehicle will be removed from the competition.

b) The turning radius must be 8 m or less. The turning radius is the distance between the centre of the circle and the external wheel of the vehicle. The external wheel of the vehicle must be able to follow a 90° arc of 8 m radius in both directions. The steering system must be designed to prevent any contact between tyre and body or chassis.

c) Electrically operated indirect steering systems are permitted providing they are operated by a steering wheel or similar (rotary potentiometer), joystick operation is not permitted. If electronic steering systems are used, in the event of system failure, the vehicle must be equipped with manual steering override.

d) The Organisers reserve the right to set up a vehicle handling course to verify the following when the vehicle is in motion: driver skills, turning radius and steering precision. For example, the Organisers will verify that steering is precise, with no play.

ARTICLE 43: BRAKING

BRAKING

a) Vehicles must have two hydraulic braking systems, one per axle. Brakes that act on the tyres are not permitted.

   i. The front brake(s) must have a single foot operated pedal controlling front wheel(s).

   ii. The rear brake(s) must have a single lever action attached to the steering wheel or a single pedal.
iii. For each axle, a maximum of two master cylinders is allowed, but they must act on single hydraulic circuit to ensure a proper balance between right and left wheel. One master cylinder per wheel is not allowed.

iv. It must be possible to activate the two brake systems at the same time without taking either hand off the steering system.

b) The effectiveness of the braking systems will be tested during vehicle inspection. The vehicle will be placed on a 20 percent incline with the driver inside. Each brake system will be activated separately, and each individual brake system must keep the vehicle immobile.

c) During practice or competition runs, the brakes must be protected against any adjustments made by the driver. The effectiveness of the protection will be evaluated during technical inspection and rechecked before entering the track. In addition, vehicles will be checked at the start and/or finish area. Any system that has been compromised will invalidate that run and a penalty may be issued by the Organisers.

3C – URBAN CONCEPT CLASS

ARTICLE 44: DEFINITION

The Urban Concept class offers an opportunity to design and build energy efficient vehicles that are closer in appearance to modern passenger cars. Urban Concept vehicles must comply with the specific Shell Eco-marathon rules for this vehicle class. Vehicles competing in this class will focus on “stop and go” driving.

During practice and competition driving at Shell Eco-marathon events, only the Driver is allowed inside Urban Concept vehicles, regardless of the number of seats installed.

ARTICLE 45: DIMENSIONS

a) The total vehicle height must be between 1000 mm and 1300 mm.

b) The total vehicle width, excluding rear view mirrors, must be between 1200 mm and 1300 mm.

c) The total vehicle length must be between 2200 mm and 3500 mm.

d) The track width must be at least 1000 mm for the front axle and 800 mm for the rear axle, measured between the midpoints where the tyres touch the ground.

e) The wheelbase must be at least 1200 mm.

f) The Driver’s compartment must have a minimum height of 880 mm and a minimum width of 700 mm at the Driver’s shoulders.

g) The vehicle body and chassis ground clearance must be at least 100 mm with the driver (and necessary ballast) in the vehicle.

h) The maximum vehicle weight (excluding the Driver) is 225 kg.

i) All vehicle dimensions must not be achieved by body extensions such as ‘stuck-on’ appendages or cut-outs.

ARTICLE 46: VEHICLE BODY

a) Teams must submit technical drawings, photographs or animations of their entire vehicle design to the Organisers for approval at their earliest opportunity.

b) The vehicle body must cover all mechanical parts when viewed from all sides. The wheels and suspension must be fully covered by the body when seen from above, and the wheels must be covered up to the axle.
centre line when seen from front or rear. The covering for the wheels and suspension must be a rigid, integral part of the vehicle body.

c) Teams may NOT use commercially available vehicle body parts.

d) Driver access must be easy and practical, as found in common passenger cars. All Urban Concept vehicles must have two side doors. Each door opening must have a minimum dimension of 500 x 800 mm.

   *This will be verified with a rectangular template of 500 x 800 mm with 50 mm radius corners*

e) Any access opening mechanisms must be firmly attached to the vehicle body by means of hinges or sliding rails. Adhesive tape, Velcro, or similar materials are not permitted for this purpose.

f) The vehicle must have a fixed roof covering the Driver’s compartment.

g) A windscreen with effective wiper(s) is mandatory. Please refer to Article 52:b) Article 109:b).

h) Space must be available for a rectangular rigid luggage with dimensions of 500 x 400 x 200 mm (L x H x W). This space must be easily accessible from the outside and must include a floor and sidewalls to hold the luggage in place when the vehicle is moving. The luggage must be supplied by the Participant and must be placed in this space during inspection and competition.

i) Vehicle bodies must not include any external appendages that might be dangerous to other Team members; e.g. sharp points must have a radius of 50 mm or greater, alternatively they should be made of foam or similar deformable material.

j) A towing hook or ring is mandatory at the front of the vehicle. It can be rigid or flexible (cable or strap). If it is rigid, it must be placed fully under the body for safety reasons. Alternatively, it may be retractable or removable as in a regular car but should be easily accessible. It must be used to tow the vehicle in case of breakdown on the track. It must have a traction resistance equivalent to the weight of the vehicle and have an opening width of at least 30 mm.

**ARTICLE 47: TURNING RADIUS AND STEERING**

a) Vehicle steering must be achieved by one system operated with both hands using a turning motion. It must be precise, with no play or delay. Steering must be operated predominately through the front wheels.

b) Steering must be achieved using a steering wheel or sections of a wheel with a minimum diameter of 250 mm.

c) Steering bars, tillers, joysticks, indirect or electric systems are not permitted.

d) The turning radius must be 6 m or less. The turning radius is the distance between the centre of the circle and the external wheel of the vehicle. The external wheel of the vehicle must be able to follow a 90° arc of 6 m radius in both directions. The steering system must be designed to prevent any contact between tyre and body or chassis.

e) The Organisers reserve the right to set up a vehicle handling course to verify the following when the vehicle is in motion: driver skills, turning radius and steering precision.

**ARTICLE 48: WHEELS**

a) The rims must be between 15 to 17 inches in diameter.

b) The wheels located inside the vehicle body must be made inaccessible to the Driver by a bulkhead and must not come in contact with the chassis or body. Any handling or manipulation of the wheels is forbidden from the moment the vehicle arrives at the starting line until it crosses the finish line.
ARTICLE 49: TYRES

It is recommended to use flat profile tyres designed for small passenger cars or light trailers, round or triangular profile tyres for mopeds or motorbikes are permitted. Tyres must fit the rims recommended by the manufacturer and have a minimum tread of 1.6 mm. The tyre/rim assembly must have a width equal or greater than 80 mm, measured from tire sidewall to tire sidewall. The width is measured with the tyre fitted on its rim at its rated pressure.

**Caution:**

- The manufacturer’s size indications should not be taken as measure, as the width of the rim directly impacts the width of the rim/tyre assembly.
- Tyres that measure less than 80 mm will not be approved.

ARTICLE 50: LIGHTING

The vehicle must have a functional external lighting system, including:

a) Two front headlights

b) Two front turn indicators

c) Two rear turn indicators

d) Two red brake lights in the rear

e) Two red rear running lights

f) The centre of each headlight unit must be located at an equal distance and at least 300 mm from the centre-line of the vehicle.

g) The mandatory red indicator light for the self-starter operation must be separate from any of the above (see Article 64:c).

h) A Hazard light function must be included in the vehicle system.

ARTICLE 51: BRAKING

**BRAKING**

a) The vehicle must be equipped with a four-disc hydraulic brake system, with a single brake pedal, which has a minimum surface area of 2500 mm². The brake pedal must operate the master cylinders either directly or through a rigid mechanical link. Wires/cables are not allowed. Commercially available brake systems (discs and callipers) with a minimum disc thickness of 3 mm are mandatory. Manufacturer’s documentation is required to demonstrate authenticity. Bicycle brakes are not allowed.

b) The brakes must operate independently on the front and rear axles or in an X pattern (i.e. right front wheel with left rear wheel and left front wheel with right rear wheel).

c) A single master cylinder may be used provided it has a dual circuit. A maximum of two master cylinders is allowed.

d) The effectiveness of the brake system will be tested during vehicle inspection. The vehicle must remain immobile with the Driver inside when it is placed on a 20 percent incline with the main brake in place. Moreover, a dynamic inspection may be performed on the vehicle-handling course.

e) A parking brake function is required to keep the car stationary during technical inspections and fuel measurements. It must provide a brake force of at least 50 N.
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f) Wet weather capability is mandatory (see Article 52:a).

ARTICLE 52: WET WEATHER RUNNING

a) During weather conditions of light rain/drizzle, the Urban Concept vehicles (only) may be required to drive on the track during competition with approval from the Race Director. Therefore, all Urban Concept vehicles must be adequate for running under such conditions.

b) The vehicle must be equipped with an effective electric windscreen wiper arm assembly typically found in a production car.

c) The operation of the wiper assembly must be activated by an independent switch easily accessible to the driver.

d) The wiper operation must provide the driver a clear view.

e) The vehicle must be adequately ventilated to prevent driver’s compartment from fogging.

f) It is required that the vehicle’s electrical system be suitable for wet weather conditions to prevent malfunction.

g) The effectiveness of the vehicle to run in wet conditions will be evaluated during the initial inspection phase.

h) Tyres must have a minimum tread of 1.6 mm (see Article 49).

i) The vehicle’s brake effectiveness may be re-inspected before and/or after any run.
4. ENERGY SOURCES

4A – GENERAL

ARTICLE 53: ENERGY TYPES

Vehicles may only use one of three energy categories listed below, which each have individual prize categories (See Article 103). As determined by the Organisers based on current location circumstances not all energy types or fuels will be available; Teams will be communicated to which energy types or fuels will be available per event location.

a) Internal Combustion Engine:

i. Shell FuelSave Unleaded 95 (Europe and Asia)/Shell Nitrogen Enriched (US) Gasoline*

ii. Shell FuelSave Diesel (Europe)/Shell Diesel (Asia and US)

iii. Ethanol E100 (Denatured)

* The gasoline and diesel provided by the Organisers during the competition are the Shell fuels prevalent in the local market where the event takes place. For testing and tuning purposes in the Team’s home countries where Shell fuels may not be available it is recommended to use the locally available Unleaded 95 (87 US) or Diesel instead.

b) Battery-Electric

c) Hydrogen Fuel Cell

ARTICLE 54: RESULTS CALCULATIONS

a) All live results displayed during the competition are provisional until verified and published by the Organisers after the completion of the event, usually within three days after the event.

b) For Prototype vehicles, the results will be calculated based on the propulsion energy consumed.

c) For Urban Concept vehicles, the results will be calculated based on the propulsion energy consumed PLUS the electrical energy consumed by the vehicle as measured by a joulemeter.

d) Results for the Internal Combustion Category will be expressed in kilometres per litre (km/l) or miles per gallon (mpg) depending on region (i.e. theoretical distance covered using energy of gasoline equivalent) corrected to a temperature of 15°C on a tank-to-wheel basis.

i. Regardless of the fuel used, for the internal combustion category, the measurement will be determined from this equivalent consumption of gasoline. This calculation will be performed using the net calorific value (NCV), which represents the quantity of energy released per unit mass or volume of fuel during complete combustion yielding steam and carbon dioxide, and the energy consumed from the battery as measured by the joulemeter, corrected to allow for the efficiency of the electricity production process. The inclusion of electrical energy consumed is applicable for Urban Concept vehicles only. (See Article 54:b).

ii. Typical NCV values (mass basis) for different fuels are given in the table below. The NCV values (vol.) at 15°C are calculated on the day of competition by multiplying the actual mass based NCV by the fuel density at 15°C.
### ENERGY TYPE

<table>
<thead>
<tr>
<th>ENERGY TYPE</th>
<th>NCV BY MASS (kJ/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell FuelSave Unleaded 95 (Europe and Asia), Shell Nitrogen Enriched (US) Gasoline</td>
<td>42,900</td>
</tr>
<tr>
<td>Shell FuelSave Diesel (Europe), Shell Diesel (Asia and US)</td>
<td>42,600</td>
</tr>
<tr>
<td>Ethanol E100</td>
<td>26,900</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>119,930</td>
</tr>
</tbody>
</table>

### iii. Example:

1,000 km is covered with one litre of Shell FuelSave Diesel and the total electrical energy consumed is 200 kJ. Given that the general density values of diesel and gasoline are 0.83716 and 0.7646 kg/l @ 15°C respectively, and NCVs as per the table above, then the corresponding gasoline equivalent volumes consumed are:

$$
\text{Diesel: } 1 \times 0.83716 \times 42900 \div (42900 \times 0.7646) = 1.09 \text{ litres gasoline}
$$

$$
\text{Electricity: } 200 \div 0.25 \div 0.75 \div (42900 \times 0.7646) = 0.03 \text{ litres gasoline}
$$

$$
\text{Nett} = 1.09 + 0.03 = 1.12 \text{ litres gasoline}
$$

Where

- $0.25 = \text{efficiency of the engine conversion process}$
- $0.75 = \text{the efficiency of engine driven alternator generated electricity}$

The final fuel consumption result is thus:

$$
\text{Fuel consumption (km/L)} = 1000 \div 1.12 = 892.9 \text{ km/litre gasoline equivalent at a reference temperature of 15°C}
$$

### iv. The results for hybrid vehicles will be expressed based on the primary energy used.

- **e)** Results for Battery Electric vehicles will be expressed in kilometres per kilowatt hour (km/kWh), or miles/kWh depending on region, and will be determined by using a joulemeter supplied by the Organisers.

- **f)** Hydrogen Fuel Cell vehicles will use a flow meter to measure the $H_2$ consumed, and for Urban Concept vehicles, the energy consumed from the starter or accessory battery will be measured by the joulemeter. The results will be calculated using the NCV of $H_2$ listed above and expressed in km/m$^3$ hydrogen.

### ARTICLE 55: FUELS SUPPLY AND HANDLING

- a) Only the fuels listed in Article 53 will be provided to the Participants by the Organisers during the event.

- b) No additives may be added to the fuel. Only the energy derived from the combustion of the fuel in the presence of air alone within the engine system may be used for forward propulsion. No other material that could serve as engine fuel may be used at any time during the event.

- c) Participants handling fuel must wear safety glasses and chemically resistant gloves.

- d) No additives, catalysts, water injection, or fuel treatment devices are allowed.

### ARTICLE 56: JOULEMETERS

- a) Joulemeters will be provided by the Organisers and must be installed on all Urban Concept, prototype battery electric, and selected Prototype ICE and hydrogen vehicles.
b) The Organisers will provide a joulemeter to selected Teams at the event.

c) Joulemeters must be installed inside the engine compartment. Joulemeters mounted outside the vehicle are not allowed.
   
i. For internal combustion vehicles, the joulemeter must be easy to read and reset.

   *Easy to read means someone standing outside the vehicle can easily read the screen of the joulemeter and have access to the on-off switch at the side of the of the joulemeter.*

   ii. For battery electric and hydrogen vehicles, the joulemeter must be positioned so that the display can be easily read and reset from outside the vehicle without the removal of any vehicle body components. It is acceptable to access the joulemeter from outside the vehicle though a hinged door.

   d) Joulemeter placement in vehicle electrical circuit:
      
i. For Urban Concept and non-battery electric Prototypes vehicles, the joulemeter must be installed between the battery and the vehicle electrical system.

   *For ICE vehicles, the starter motor cable must be connected after the joulemeter but before the main vehicle fuse. This placement is to insure the joulemeter measures the starter energy. The starter motor is not required to be fused.*

   ii. For Prototype battery electric vehicles, the joulemeter should be located between the vehicle electrical system and the motor controller.

   iii. For Urban Concept hydrogen vehicles without an accessory battery, the joulemeter must be installed between the external starter battery and the vehicle electrical system. (See Article 65:k)ii)

   iv. For Urban Concept hydrogen vehicles with a supercapacitor a joulemeter must be installed to measure the supercapacitor voltage.

   v. The horn circuit may be powered by a separate circuit connected directly to the battery. (See Article 31:d).

   *This means the horn circuit does not need to pass through the joulemeter (if installed) and the horn energy will not be measured by the joulemeter*

   e) The location and placement of the joulemeter(s) will be verified during technical inspection.

**ARTICLE 57: VEHICLE ELECTRICAL SYSTEMS**

a) For safety reasons, the maximum voltage on board of any vehicle at any point must not exceed 48 Volts nominal or 60 Volts max. (This includes on-board batteries, external batteries, supercapacitors, fuel cell stack, etc.)

**BATTERY SAFETY**

b) For all energy types, only one vehicle battery is allowed.

i. For ICE and hydrogen fuel cell vehicles this is called the accessory battery (see Article 57:h)

ii. For battery electric vehicles this is called the propulsion battery, which means that an accessory battery is not allowed.

*Battery definition: A ‘battery’ is defined as a source of electrical energy, which has exactly two connectors and can be described as a unit. This unit may contain more than one sub-unit. If more*
than one sub-units are used they should be packaged together in a single physical package. The package may be made of any material provided it contains the entire battery.

c) The battery must be installed outside of the Driver’s compartment behind the bulkhead. (See Article 27) Batteries mounted directly under the driver’s seat are not allowed.

d) If Lithium-based batteries are used,

i. Battery Management Systems (BMS) must be tailored to the lithium chemistry to control and protect the battery against risk of fire.
   1. The BMS must provide cell balancing and overvoltage protection during off-track charging.
   2. For battery electric vehicles, the additional requirement of cell level over-discharge, cell level overcurrent and battery over-temperature must be provided as part of the on-vehicle system. The BMS must AUTOMATICALLY isolate the battery, without operator intervention, if a limit or out of range condition is reached on any of the above parameters.

   3. For battery electric vehicles, the on-vehicle BMS must be located in the physical battery package (See Article 57:b)ii above.)

   ii. For all self-built batteries, the following applies (note: a battery with a separately purchased BMS is also considered a self-built battery).

      1. If there are one or more cells or modules, the overcurrent protection value for cells in parallel must be selected such that under normal operating or expected failure conditions, no single cell will be exposed to current beyond its rating.

      2. All cells or modules must be identical in configuration. (i.e. a battery constructed from cells of different capacities is not allowed).

      If the BMS is purchased separate from the battery, ensure it is compatible with battery chemistry. Example: Li-Polymer (LiPo) batteries require a BMS designed for LiPo batteries.

   iii. Charging of batteries must be done with the battery charger purchased together with the battery or a purpose-built charger specifically suited to the given battery chemistry. For self-built batteries, Teams must demonstrate that the charger is suitable and is integrated with the BMS system.

   iv. The maximum capacity of any Lithium-based battery used is 1,000 Wh. For batteries not rated in Wh, the Wh rating is calculated by multiplying the amp-hour rating of the battery by its nominal voltage.

   v. Protection for Lithium-based battery charging, whether in or out of the vehicle must be provided, see Article 24:h)Article 109:h).

   vi. Any Lithium based battery must be equipped with a solid metal containment tray under the battery OR the battery must be enclosed in a battery charging bag. Either the tray or bag must be suitable to prevent the battery, in the event of a battery fire, from burning through the battery mounting or the vehicle body and dropping to the ground or in the engine compartment in the event of a vehicle rollover. Lightweight aluminium, other semi-metallic materials, or non-solid trays are not acceptable as metal containment.

   vii. Power tool or hand-held equipment batteries are not permitted as a battery electric propulsion battery.

   viii. Printed manufacturer’s documentation for lithium-based batteries and the associated battery management system must be available for review during technical inspection (see Article 58:c).
e) All batteries and Supercapacitors must be short circuit protected. Protection may be in the form of a fuse, fusible link, or a current interrupting device (circuit breaker). Automatic reclosing current interrupting devices are not allowed. Short circuit protection devices must be located on the positive conductor and as close as possible, or a maximum 300 mm from the positive terminal of the battery or Supercapacitor. The rating of the short circuit protection device must enable the battery or Supercapacitor to always supply enough short circuit current to open the device. For vehicles with a starter motor, the starter motor cable is NOT required to be protected.

f) For safety reasons, both the positive and negative circuits of the propulsion battery (for battery-electric vehicles) and Supercapacitors must be electrically isolated from the vehicle body, frame, and metal components.

g) All vehicle electrical circuits must be protected against electrical overload. Overload protection may be in the form of fixed current limits within electric controllers or by the insertion of individual circuit fuses.

h) Accessory battery

i) The accessory battery provides all allowed electrical needs such as safety devices (windscreen wipers, lights, hydrogen sensors, hydrogen relays and hydrogen shutdown valve), ignition, fuel injection control, and starter motor.

ii) The accessory battery may also power electrically driven engine components such as engine oil and cooling pumps, electric turbo compounding, electromechanical variable valve timing, compressors/blowers, etc. The use of electric fuel pumps is not allowed.

Only Urban Concept vehicles can utilize electrically driven engine components.

i) The following devices may be powered by batteries other than the vehicle battery provided they use built-in batteries: radio communication system and driver ventilation.

j) All electrical/electronic enclosures purchased or built by the Teams must be made of transparent material or at least have a transparent cover to allow the technical inspectors to view the contents.

k) Electrical wiring must be in good condition, neat, secured and not close to moving parts. All wiring connections and terminations must be visible and easily accessible. Splices are not allowed.

ARTICLE 58: TECHNICAL DOCUMENTATION

TECHNICAL DOCUMENTS

a) Competitors need to provide technical documentation in 2 stages:

i. Prior to the event during the online submittal process (see Article 58:b)
   This documentation serves only to verify that the Teams understand the Rules. Online approval in no way constitutes a pre-approval for the Technical Inspection phase.

ii. At the event (see Article 58:c)
   This should be a precise technical description of the vehicle. During technical inspection, the documentation will be compared against the vehicle. Deviations between the technical documentation and the vehicle will be required to be reconciled prior to passing technical inspection.

b) Technical Documentation – prior to event.

i. Competitors must provide, through the online submittal process, documentation on the vehicle energy supply and propulsion system. It is not necessary to submit detailed component specifications or electrical schematics as part of the online submittal process.
ii. Energy supply block diagram

The online submitted energy supply block diagram and associated text description must contain information describing the energy flow and component function for the vehicle energy systems. Specific items to be included in the block diagram for each energy category are listed below:

- **ICE**: engine, fuel tank, fuel line, injector, pressure relief valves, pressure regulators, pressure gauge, compressed air bottle, vehicle cut-off mechanism
- **H2**: fuel cell, cylinder, solenoid valve, pressure regulator, flow meter, motor controller, motor, supercapacitor, vehicle cut-off mechanism
- **BE**: Motor, battery/BMS, fuse, wiring, e-stop switches, motor controller, vehicle cut-off mechanism

iii. Propulsion system block diagram

The online submitted propulsion system block diagram and associated text description must contain information describing the propulsion mechanism for each energy category below:

- **ICE**: Engine/Motor to road (engine, transmission, clutch, wheel, motor, supercapacitor, motor controller)
- **H2**: Motor to road
- **BE**: Motor to road

c) Technical Documentation – at event (to be reviewed during Technical Inspection)

i. Competitors must have available for inspection with the vehicle printed documentation describing selective technical aspects of the vehicle. The printed documentation must be bound and divided into the following sections. The specific required sections for each energy category are defined below.

**ICE energy category**

- Energy Supply Diagram
- Propulsion System Diagram
- Electrical Schematic
- Hybrid System +
- Battery/BMS ++

**Battery Electric energy category**

- Energy Supply Diagram (Electrical Schematic)
- Propulsion System Diagram
- Battery/BMS
- Motor/Motor Controller

**Hydrogen category**

- Energy Supply Diagram
- Propulsion System Diagram
- Fuel Cell
- Electrical Schematic
- Motor/Motor Controller
ii. The minimal contents of each of the above required sections are defined below.

- **Energy Supply Diagram:** include updated diagrams and associated descriptive text as defined in Article 58:b) above.

- **Electrical Schematic:** provide a vehicle level schematic showing all vehicle wiring and associated components and connections. The schematic should include component values such as voltage levels and fuse ratings. Schematics of components such as the engine management system or fuel cell controller are not required in this section.

- **Hybrid System:** include manufacturers’ component specifications at the lowest level of purchased components. Include diagrams describing the power flow into and out of the hybrid system. Include supercapacitor documentation (see the supercapacitor section below).

- **Battery/BMS:** (For Lithium-based batteries only) Provide battery/BMS manufacturer component specifications at the lowest level of purchased components. At minimum, the battery documentation should include cell chemistry, cell electrical characteristics, cell series or parallel configurations, battery voltage, and current ratings. The BMS data MUST include:
  1. Cell over-voltage and under-voltage protection limits
  2. Battery over-current limit (not required for accessory battery)
  3. Operation of cell balancing (how and when)
  4. Battery over-temperature limit (not required for accessory battery)
  5. How the BMS will protect the battery when an over-voltage, under-voltage, over-current or over-temperature condition is reached, i.e. how will the BMS protect or isolate the battery, in the case of Battery Electric Vehicles, when these limits are reached?

- **Motor/Motor Controller:** Provide motor/motor controller manufacturers component specifications at the lowest level of purchased components. For Battery Electric Vehicles, include design documentation on the purpose-built motor controller. The documentation may contain control flow diagrams, motor controller and sub-component schematics and PC board layouts if PC boards were used. Also, include software documentation if software was written as part of the motor controller development.

- **Fuel Cell:** Provide fuel cell manufacturers component specifications at the lowest level of purchased components. This should also include the surface area of the fuel cells, rated power and voltage.

- **Supercapacitors:** Provide supercapacitor manufacturers component specifications at the lowest level of purchased components. At a minimum, include supercapacitor system rated voltage and maximum current.
4B – INTERNAL COMBUSTION ENGINES

ARTICLE 59: PROPULSION
The type and design of the internal combustion engines are not restricted; however, they must run only on the fuel provided by the Organisers and must not consume any engine oil (2 stroke engines are not allowed).

ARTICLE 60: OTHER ON-BOARD ENERGY SOURCES
a) For all fuel categories stored pneumatic energy not replaced during the competition by the engine may only be used for the fuel injection system. Fuel pumps are permitted for all fuels provided they are mechanically driven by the engine only.

   Electric fuel pumps are prohibited.

b) It is permitted to pressurise the liquid fuel tanks, to feed the engine, only under the following conditions:
   i. Pressurisation is done by means of a translucent compressed air bottle fitted with a safety valve set to 5 bars maximum – or the lower operation pressure of the vehicle system. This safety valve must be located between the pressure regulator and the pressurised air bottle.
   ii. The pressurisation is done in the starting area by means of an air pump.
   iii. The Driver must not modify the pressure during the competition.

c) Auxiliary energy sources (chemical, latent energy from phase changes, etc.) are not permitted.

d) For Urban Concept vehicles engine temperature can be regulated with a pressurized pure water or commercially available coolant in a cooling system powered by an electrical pump.

e) For Prototype vehicles, if the engine temperature is regulated with water, the said regulation should be limited to the use of pure, un-pressurised water as coolant and a mechanical water pump.

f) The external regulation temperature of the engine by external heating devices is limited to 100°C.

g) The use of vacuum from air intake cannot be used for auxiliary equipment such as clutches.

ARTICLE 61: FUEL TANKS (ICE VEHICLES)
a) The vehicle must be equipped with only one of the following approved fuel tanks supplied by the Organisers:

   Tank capacities: Prototype: 30, 100 or 250 cc
                    Urban Concept: 30, 100, 250 or 350 cc

b) Only tanks bearing a clearly visible stamp proving its “APAVE” certification compliance can be used for pressurised systems.

   APAVE tests fuel tanks and certifies their ability to withstand a pressure of five bar.

c) The fuel tank must be mounted in an accessible and zero-degree vertical position which allows in-situ filling with a burette of approximately 1 metre height.

d) The fuel tank must be mounted in a way that its top is at least 50 mm below the roll bar and far from any moving parts, batteries, heat and ignition sources.

e) The fuel tank cap, whether it is leak proof or not (drilled), must be in place during the competition. For diesel engines, a small (<3 mm) hole must be drilled in the centre of the cap to allow air to enter the tank, hence allow fuel out.
f) Fuel return lines must be fed into the fuel feed line below the fuel tank. For diesel engines, the return line can be fitted to the fuel cap only if the engine was originally equipped with a manual priming pump and this return line and the pump have not been modified.

g) Teams must equip their vehicle with clear fuel lines which are not prone to expansion when pressurised (max. internal diameter 8 mm).

h) For all pressurised fuel systems, the hoses connecting the pressure bottle to the fuel tank cap must be flexible (do not need to be Rilsan/Nylon type) to allow easy connection and to prevent side loading to the tank necks.

ARTICLE 62: FUEL SYSTEM

a) Participants must provide a description and a precise technical drawing of the fuel supply system from tank to engine.

b) This system must be designed that it can be completely drained and refilled before the competition.

c) The fuel line between the tank and the engine must not include any additional components, for example filters. A second valve directly at the bottom of the fuel tank is tolerated.

d) For diesel engines, a cut-off solenoid valve is required. (See Article 37:c)

e) Engines with carburettors are prohibited (Fuel injection is mandatory).

f) The air intake manifolds must not contain any fuel (or be able to accumulate any fuel) or blow-by gas when the vehicle is on the starting line prior to departure. Air filters are not allowed in the intake system. Blow-by gas must not be recycled during the competition but must be collected in a specific canister for environmental protection.

   Blow-by gas: gas inside the engine (oil vapours, unburnt fuel, or gas in the combustion chamber that has not been evacuated in the exhaust). This gas is usually recovered at the intake manifold. This is known as blow-by gas re-circulation.

g) The fuel system must be easily accessible for inspection and measurements.

h) It must be possible to set the fuel supply system to atmospheric pressure for measurement of the fuel level. The pressurisation system must be equipped with a pressure gauge and normal running pressure must be clearly marked on the gauge.

i) The standard fuel consumption measurement method for liquid fuels is by volumetric replacement of the fuel consumed with a temperature corrected volume of the fuel.

j) The fuel consumption of all ICE vehicles that have achieved more than 1500 km/l (3,528 mpg) will be measured gravimetrically. At the start, the Technical Team will fill the fuel system, and the entire fuel system (including tank, injector, pipes, injector) will be weighed on a precision balance. All the components must be compact and easily detachable for weighing purposes. After completion of a successful run, the entire fuel system will be removed and weighed again on the same balance. This handling of the fuel system and transportation to the weighing room must be performed by a competent Team Member who has a valid access pass. The handling of the fuel system will be supervised by a Technical Team Member who will also perform the weighing, which must be witnessed by a Participant.

k) Fuel is a volatile product. Therefore, it is not allowed to artificially increase the fuel system temperature, which would lead to the formation of vapour locks. Conversely, cooling or refrigeration of the fuel below ambient temperature is also prohibited.
ARTICLE 63: VEHICLES USING HYBRID TECHNOLOGY

a) A Supercapacitor is the only allowed energy storage device for hybrid vehicles. Mechanical or hydraulic energy storage is not permitted. The use of any battery in the hybrid propulsion system is forbidden.

b) This capacitor must be the only source of stored energy for the electric motor driving the vehicle.

c) Two connectors must be installed safely outside the vehicle to allow the voltage measurement on the starting line. These must be labelled “Supercapacitor Voltage”.

d) The state of charge of the Supercapacitor will be checked before and after each run by measuring its voltage. The voltage registered after the run must be at least equal to the voltage registered before the run. In the event of the contrary, the Supercapacitor must be recharged by running the engine until its voltage is equal to the voltage registered before the run. The time required to recharge the Supercapacitor by running the engine after the competition is added to the recorded time of the relevant run.

e) The electric circuitry must be correctly fused to prevent overloading any of its parts. The fuse needs to be clearly labelled in the technical drawings and easily accessible for Technical Inspection (see Article 57:g).

ARTICLE 64: STARTER

a) An electric starter must be used during the competition. Manual hand starting is prohibited.

b) It must be clearly established that the starter is never capable of providing any forward propulsion to the vehicle.

c) For Prototype vehicles only a clearly visible red indicator light called the starter light, equivalent in its luminescence to a 21 W light bulb, must be installed on the rear of the vehicle and must be clearly visible from both sides of the track to signal any operation of the starter motor.

d) If Track Marshals report the repeated or intensive use of the electric starter by a Team, the Organisers reserve the right to order an immediate inspection of the vehicle. If any non-compliance is observed, the Team will be penalised accordingly.

e) At the start, the starter and the starter light must be extinguished by the time the rear wheel of the vehicle crosses the start line. Failing to comply will invalidate the run and count towards the maximum number of attempts.

4C – ELECTRIC PROPULSION

ARTICLE 65: FUEL CELL POWERED VEHICLES

Hydrogen safety

a) Fuel system

i. Participants must provide a description and a process flow diagram of the fuel supply system.

ii. The fuel system must be easily accessible for inspection and measurements.

iii. The fuel cell must run by itself. The electricity needed for temperature regulation, fan, compressor, electronic management system for the fuel cell and the electric motor must be supplied by the fuel cell and not by the accessory battery.

iv. The hydrogen system must be designed as follows:
v. The flow meter must be fixed at the inlet of the fuel cell. Both must be at the same pressure.

b) Hydrogen cylinders

i. Fuel cell-powered vehicle must use a compressed hydrogen cylinder, referred to hereafter as a cylinder, as provided by the Organisers during the entire event. Only one cylinder may be fitted to a vehicle.

ii. Cartridges and other means of hydrogen storage are not permitted.

iii. For Prototypes vehicles, the following cylinders will be provided:

Europe: B04 cylinder, 0.4 litre of hydrogen at 200 bar
(60 mm/320 mm) 1.4 kg

Americas: Exchange cylinder ~ 152 bar
5.3” X 17.1” (135 mm x 434 mm), 8.6 lbs. (3.9 kg)

Asia: Catalina MD cylinder, 2.9 litre of hydrogen @139 bar
(111 mm x 424 mm), 2.4 kg

iv. For Urban Concept vehicles, the following cylinders will be provided:

Europe: B1 cylinder, 1 litre of hydrogen at 200 bar
(100 mm x 350 mm) 2.57 kg
and
B04 cylinder, 0.4 litre of hydrogen at 200 bar
(60 mm/320 mm) 1.4 kg

Americas: Exchange cylinder ~ 152 bar
5.3” X 17.1” (135 mm x 434 mm), 8.6 lbs. (3.9 kg)

Asia: Catalina MD cylinder, 2.9 litre of hydrogen @139 bar
(111 mm x 424 mm), 2.4 kg

v. All cylinders must be installed on the vehicle under the supervision of the Technical Team. Participants are not allowed to keep any cylinders in their possession overnight. Upon arrival at the circuit, Team Managers must contact the Technical Team, who will organise all relevant logistics.

vi. The cylinder must be installed securely in the vehicle to minimise movement and stress on pipework when the vehicle is moving.

c) Ventilation

The vehicle body must allow for ventilation at the highest point of the fuel cell compartment, providing an orifice with a minimum opening of 500 mm². Another 500 mm² opening must be provided at the highest point of the driver compartment.

d) Hydrogen detector

i. A hydrogen sensor must be installed in the fuel cell compartment, near the main ventilation orifice mentioned above. This hydrogen sensor must drive the emergency shutdown valve and relay mentioned below. The trip level of the hydrogen sensor must be tuned to 2.5% of the LEL (Lower Explosive Limit) of hydrogen, i.e. 1% of hydrogen in air. A test will be carried out during the technical inspection.

For commercial Fuel Cells with integrated H₂ detector it is still required to fit a H₂ sensor as described above.
ii. The reset of the hydrogen detector, i.e., the hydrogen sensor and its electronics, must be done manually via a switch located in the fuel cell compartment. This switch must not be accessible by the Driver from the cockpit.

e) Emergency shutdown valve and relay

i. The hydrogen supply circuit must be equipped with a solenoid emergency shutdown valve. This valve must be normally closed in the absence of electricity.

ii. The power supply to the motor must be automatically cut off at the same time as the above emergency shutdown valve is activated. This is to be achieved by a suitable fail-safe relay.

iii. This valve and relay must be activated by any of the following three scenarios:

1. Through hydrogen detection as explained above

2. Through the emergency push-button located on the outside of the vehicle. The emergency shutdown sticker provided by the Organisers must be positioned on the vehicle body to clearly indicate the place of this emergency push-button. (See Article 37.f).

3. Through another emergency push-button, accessible by the Driver in driving position

iv. In case of activation by one of these three scenarios, the valve and relay must act simultaneously.

v. These three scenarios will be tested during Technical Inspection and before each attempt.

f) Pipes and connections of the hydrogen circuit

i. In all cases, piping and connectors of the hydrogen circuit must be designed for hydrogen use. The Team Manager must be able to present during the technical inspection the technical data sheets from the manufacturer of these piping and connectors to show that they are suitable for hydrogen use.

   The use of PTFE pipes is recommended. PU tubing should not be used as this tends to leak.

ii. If the pressure in the hydrogen circuit is higher than 1.5 bar absolute (= 0.5 bar above atmospheric pressure) piping must be made of steel and connectors must be screw/compression type.

iii. If the pressure in the hydrogen circuit is lower than 1.5 bar absolute (= 0.5 bar above atmospheric pressure) flexible piping and unscrewed connectors are accepted.

iv. PTFE (Teflon) sealing tape must not be used because it can damage the flow meter. In any case Participants are responsible for damage to the flow meter due to wrong connections.

v. H2 piping and equipment must be protected from overpressure at 90% or lower of their maximum pressure rating.

   In case of the use of pressure relief valves, they must be vented outside through the top section of the vehicle. The exhaust tubing must be well secured to the vehicle.

g) Purge pipe

If a purge pipe is needed, its end must be located outside the vehicle.

h) Measurements and Equivalencies

i. The consumption of hydrogen is measured by an embedded flow meter. The flow meter will be checked/calibrated by the Organisers before Technical Inspection.

ii. Only flow meters specified by the Organisers are permitted. For Urban Concept cars at regional events, refer to Article 70.
iii. The volume of hydrogen consumed is posted in normal litres. The display of the flow meter must be easy to read from outside the vehicle, when the vehicle body is closed. It must be inaccessible by the Driver in normal driving position.

iv. The serial number on the hydrogen flow meter must not be covered or removed.

i) Oxygen and air reserves

Oxygen for the fuel cell’s operation must be from the surrounding air, not from oxygen tanks or compressed air reserves.

j) Supercapacitors

i. If an embedded electric storage device is part of the powertrain, it must be of capacitor type, referred to hereafter as ‘Supercapacitor’. Other types of embedded electric storage device (Pb, NiMh, etc. batteries) are forbidden.

ii. The state of charge of the Supercapacitor will be checked before and after each run by measuring the Supercapacitor voltage. Two measurement points (Supercapacitor voltage + and - a labelled “Supercapacitor voltage”) must be installed outside the vehicle to allow the voltage measurement on the starting line.

iii. The voltage registered after the run must be at least equal to the voltage registered before the run. In the event of the contrary, the Supercapacitor must be re-charged by running the fuel cell until their voltage is equal to the voltage registered before the run. The additional time required to recharge the Supercapacitor by running the fuel cell after the competition is added to the recorded time of the relevant run.

iv. The maximum Supercapacitor voltage must not exceed that referenced in Article 57:a).

k) Fuel cell starter battery

i. Accessory battery

If the accessory battery can be electrically isolated from the fuel cell output, the accessory battery can be used to start the fuel cell. The battery is considered electrically isolated when energy from the accessory battery cannot contribute to vehicle propulsion.

ii. External battery

If the accessory battery cannot be isolated from the fuel cell output, an external battery must be used on the starting line to start the fuel cell system.

1. As soon as the vehicle starts to move, this battery must be unplugged.

2. Two connectors must be installed outside the vehicle to allow a quick connection and fuel cell system start on the starting line. These external connectors must be securely fastened to the vehicle.

iii. As mentioned in Article 57:h)i , it is mandatory to power the hydrogen detector using the accessory battery. This battery must also power the emergency shutdown valve, relay and lighting system for Urban Concept vehicles.

l) Electrical circuit/Electronics

i. All wiring associated with the accessory battery circuit must be clearly distinguishable from the propulsion system by physical isolation or the use of different wire colours.

ii. A fuse must be installed on the positive terminal of the fuel cell stack. Its melting current (expressed in Amps) must be less than the active area (expressed in square centimetres) of one cell of the stack. For instance, if the active surface of one cell of a 20-cell stack is 60 cm², the melting current of the fuse must not exceed 60 A.
iii. If a Supercapacitor is used in the circuit, a fuse must be installed on the positive terminal of the Supercapacitor pack. The fuse rating must be less than or equal to the maximum usable power divided by the rated voltage.

m) Other equipment
Compressors, fans and coolers for the fuel cell system must be powered by the fuel cell or Supercapacitor, not by the accessory battery.

ARTICLE 66: NOT USED

ARTICLE 67: BATTERY ELECTRIC VEHICLES
a) The drive train in the Battery Electric category is restricted to a maximum of one electric storage device, and up to two electric motors, with associated control units. The electric motors may be purchased, purchased-and-modified, or purpose-built. The motor controller MUST be purpose-built for the Shell Eco-marathon. Modifications to purchased motor controllers or the use of purchased motor controller evaluation kits are not acceptable. Motor controllers built from sub-components such as single-board computers, power stages, etc. are encouraged. If a motor controller is built incorporating one or more single printed circuit boards (PCBs), the text “SEM” must be included in the mask of the PCB etching. If the motor controller includes controlling software, the software must be developed or integrated for the Shell Eco-marathon.

b) Only Lithium-based batteries are permitted as electric storage devices.

c) The vehicle must be equipped with an onboard Battery Management System (BMS) to control and protect the battery against risk of fire as defined in Article 57:d|Article 109:d).

   Any BMS for propulsion batteries must provide an AUTOMATIC isolation of this battery in the event of any measured parameters getting out of their designed range.

d) The Lithium-based battery and any accessory circuits are subject to the maximum voltage defined in Article 57:a).

e) Participants are required to present a printed copy of their electrical schematics at Technical Inspection. (See Article 58:c)

f) The vehicle battery must be placed outside the Driver’s compartment behind the bulkhead and securely mounted. Bungee cords or other elastic materials are not permitted for securing the battery. See Article 25:h).

g) All electrical circuits must be protected as defined in Article 57:g).

h) All “Battery Electric” vehicles which complete a successful run will be classified in descending order of fuel economy, expressed in distance/kWh, where distance is either miles or km depending on the region.
5. ON-VEHICLE TELEMETRY EQUIPMENT

ARTICLE 68: GENERAL

TELEMETRY

a) For selected events, all Urban Concept vehicles must install the telemetry system provided by the Organiser for the duration of the event. This telemetry system is composed of an onboard computer (consisting of an antenna pod and a backbone), a dedicated battery system and cables, and one or more energy measurement sensors, dependent on the vehicle’s energy type.

b) The use of telemetry equipment is limited to selected events.

c) All Urban Concept ICE vehicles that use a sparkplug must use a resistive type.

d) Teams are responsible for ensuring their vehicle electrical system is compatible with on-vehicle telemetry equipment. While there is no direct electrical connection between the telemetry equipment and vehicle electrical system, vehicle electrical noise may interfere with the operation of the telemetry equipment. Organisers will work with Teams to mitigate vehicle electrical system noise impacting the operation of the telemetry equipment, but if not resolved, Teams may not be allowed to compete in the Shell Eco-marathon World Championship.

ARTICLE 69: ONBOARD COMPUTER

a) Mounting location must be approved by the Organiser and instructions will be provided.

b) The onboard computer will be powered by a dedicated battery system provided by the Organisers. The dedicated battery system must remain isolated from the vehicle electrical system. Teams are responsible for charging the telemetry battery provided.

c) The external antenna pod must be mounted on the outside of vehicles that has an unobstructed view of the sky and its LED’s must be visible from the side of the vehicle. The mounting of this antenna requires a 32 mm diameter hole in the body of the vehicle.

ARTICLE 70: HYDROGEN FLOW METER

a) All Urban Concept Hydrogen vehicles must be fitted with the hydrogen flowmeter which is provided by the event Organisers. The onboard computer will be connected to the flowmeter via a one-meter cable.

b) The hydrogen flowmeter is a Vögtlin Redy smart series Hi performance GSM:B9TA:BN00 calibrated for Shell Eco-marathon.

ARTICLE 71: LIQUID FLOWMETER

a) All Urban Concept Internal Combustion Engine vehicles must be fitted with the liquid flowmeter, which is provided by the event Organiser. The liquid flowmeter will be connected to the onboard computer backbone via a one-meter cable.

b) The liquid flowmeter is a Max Machinery Model P001 specially modified for the Shell Eco-marathon. The liquid flowmeter must be installed below the fuel injector by the Teams prior to Technical Inspection.
ARTICLE 72: JOULEMETERS

a) Joulemeters will be used to measure the vehicle electrical energy and will be installed in all Urban Concept vehicles, see Article 56. In Urban Concept vehicles, the Joulemeter will be connected to the onboard computer backbone via a 1-meter cable.
6. GLOBAL VIRTUAL PROGRAMME

Following a 2020 season marked by a necessary transition to a virtual programme, Shell Eco-marathon 2021 will adopt a hybrid model that combines physical competition elements, where possible, with new and exciting virtual formats. Just as a hybrid vehicle can achieve greater energy efficiency by combining the advantages of its distinct types of energy, this blend of physical and virtual competitions will ensure that students have even more opportunities to participate in Shell Eco-marathon and be recognised for their talent and hard work.

ARTICLE 90: GENERAL

a) The 2021 Shell Eco-marathon season will include a Global Virtual Programme, with a dedicated Global Virtual League designed to recognise and reward the achievements of students and Teams throughout this season – independent from any on-track competitions that may take place in 2021. The Global Virtual League will consist of up to five (5) component competitions which will take place throughout the season. All Shell Eco-marathon Teams are eligible to participate in any or all component competitions, and Teams will be awarded points for their performance in the respective challenges according to the table below. Competition dates for the separate component competitions will be announced on the Shell Eco-marathon website. For more information please visit www.makethefuture.shell.


ii. Autonomous Programming Competition - The Autonomous Programming Competition is a completely virtual competition. It has been developed in partnership with Southwest Research Institute. The competition requires Teams to improve the performance of control software for a baseline autonomous vehicle. The Rules and Terms and Conditions of participation will be published in due course at www.makethefuture.shell.

iii. Virtual Technical Inspection (See Section 6A) Note: Participation in the Virtual Technical Inspection component is a pre-requisite for application to an on-track competition in 2021.

iv. Off-Track Awards (See Section 6B)

v. Bonus Challenges – During the 2021 Shell Eco-marathon Season there will be one or more ad-hoc virtual challenges for Teams to participate in. These challenges may require Teams to submit photo/video content, or take part in tasks related to Shell Eco-marathon. The Rules and Terms and Conditions of participation will be published in due course at www.makethefuture.shell.

b) Teams wishing to participate in any Virtual League component competition, must register their Team at the Shell Eco-marathon website as part of Phase 1 registration. Participation in any of the component competitions is voluntary.

ARTICLE 91: VIRTUAL LEAGUE POINTS AND WINNERS

a) The winner of the Shell Eco-marathon Global Virtual League will be determined by points. Teams will accumulate points for each of the league component competitions. There will be one global league table (leader board). The team with the highest number of points at the end of the season in Spring 2021 will be the winner of the Global Virtual League.
b) Points available for each component competition are as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Global Virtual League Points awarded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitch the Future</td>
<td>50 points for regional winners of each challenge</td>
</tr>
<tr>
<td></td>
<td>Additional 100 points for each global challenge winner</td>
</tr>
<tr>
<td></td>
<td>Multiple challenge participations allowed</td>
</tr>
<tr>
<td>Autonomous Programming</td>
<td>150 points for the global winner</td>
</tr>
<tr>
<td>Competition</td>
<td>100 points for the global runner-up</td>
</tr>
<tr>
<td></td>
<td>50 points for the global third place</td>
</tr>
<tr>
<td>Virtual Technical Inspection</td>
<td>Virtual Technical Inspection Score (max. 1000)</td>
</tr>
<tr>
<td>Off-Track Awards</td>
<td>200 points for each regional winner</td>
</tr>
<tr>
<td></td>
<td>100 points for each regional runner-up</td>
</tr>
<tr>
<td></td>
<td>Multiple award entries allowed</td>
</tr>
<tr>
<td>Bonus Challenges</td>
<td>50 points for each regional challenge winner</td>
</tr>
</tbody>
</table>

c) Each Team’s league points and standing will be updated periodically and can be viewed through the Shell Eco-marathon website.

d) For prize money amounts associated with the Global Virtual League and the Component Competition winners please refer to Section 7. The prize money will be awarded in Addition to the Global Virtual League Points.

**6A – VIRTUAL TECHNICAL INSPECTION**

**ARTICLE 92: DEFINITION**

a) A virtual technical inspection will be used to support different components of the 2021 Shell Eco-marathon season. The virtual technical inspection will be based on a subset of the rules and regulations as defined in this document. Any Virtual Technical Inspection is intended for Teams to demonstrate their compliance with the current rules and regulations. All virtual technical inspections will be performed by Shell Eco-marathon Subject Matter Experts. All decisions are final.

b) A virtual technical inspection will be used in the following scenarios:

i. Scenario 1: As its own competition with awarded prizes,

ii. Scenario 2: As a part of the Virtual League Competition,

iii. Scenario 3: For any off-track event, participation in the Virtual Technical Inspection is mandatory. If there are more applications than physical team slots available, the Virtual Technical Inspection results will be used as part of the Team selection criteria.

c) A key factor are the Safety elements of a Team’s vehicle. Teams must understand that participating in the Virtual Technical Inspection does not constitute or imply that any vehicle is deemed valid or safe enough to operate on any road or track for testing or competition purposes.
ARTICLE 93: VIDEO

a) The Team must provide an English narrated video as part of the Virtual Technical Inspection. The maximum time allowed for the video is seven (7) minutes. Videos longer than seven minutes will not be reviewed. Videos should be shot in landscape format with a minimum resolution of 720p and in MPEG-4 format. Videos shot in segments must be edited together into a single presentation. Continuous narration is not required, and teams may also wish to consider adding voice-over or subtitles as necessary.

b) The video must contain only real vehicle or parts of this vehicle, no virtual element will be accepted.

c) The video must contain all the elements as outlined in the Virtual Technical Inspection Checklist for the vehicle type as shown in Appendix 2.

i. The checklist identifies specific points which must be highlighted in a Team’s video. Teams can find full requirements for each checklist item detailed in its associated Article reference.

ii. Prior to presenting evidence for each checklist item, Teams must reference (either visually or verbally), the relevant checklist section that will next be presented. For example, if a Team is going to present on checklist items in Brakes Section, they must first visually/verbally signpost that the next section of the video concerns items in the Brakes Section.

iii. Driving of the vehicle must not be demonstrated.

d) The video must be filmed in compliance with all relevant COVID-19 controls required at the shot location at that time. Participants in any video must be demonstrating compliance with these controls at all times. Failure to follow the local COVID-19 rules could result in being disqualified from the Competition. The Organisers have final say over validity/acceptability of any video.

e) These COVID-19 controls could include but are not limited to hygiene, public behaviour code, body temperature monitoring, social distancing, restrictions on the meeting/gathering size and protocols, wearing masks. Teams will be held solely liable for any related risks.

ARTICLE 94: DOCUMENTATION

a) The Team must provide documentation as described below.

b) The documentation must be in PDF format, either A4 or US Letter page size and using minimum font-size of 9 points. In case of non-compliance the documentation will not be reviewed.

c) All vehicle types:

   i) Vehicle dimensions as per Article 39 for Prototype and Article 45 for Urban Concept.

   ii) Braking system description (two (2) pages max), including diagram and drawing or picture.

   iii) Vehicle level electrical schematic (all energy types). The electrical schematic must use standard automotive electrical symbols and be a maximum of two (2) pages.

d) ICE: Energy supply diagram (1 page), if hybrid add description in 1 additional page.

e) Hydrogen: Energy supply diagram (1 page) and fuel cell description in 1 additional page.

f) Battery Electric: Energy supply diagram (1 page) and purpose-built motor controller schematic and functional description in a maximum of 2 additional pages.

ARTICLE 95: INTERVIEW

a) At the Organisers’ discretion, a web interview with the Team may be requested.
b) The purpose of the interview is to answer any questions the inspector may have regarding the review of the submitted video and/or documentation, or to decide between tied teams.

c) The web interview, if held, will be for a period of 15 minutes or less.

ARTICLE 96: SCORING

a) Scoring will consist of a numerical value.

b) The numerical value, or scoring, for the virtual inspection is a summation of points gained for each individual check point item.

c) Each check point can gain between 0 and 3 points as described below.

- 0 - Is not shown in the video or does not comply with the Rules and Regulations.
- 1 - Partially complies with the Rules and Regulations.
- 2 - Mostly complies with the Rules and Regulations.
- 3 - Fully complies with the Rules and Regulations.

d) The Virtual Technical Inspection Score will be calculated as follows: The sum of the points from each individual check divided by the total possible points that vehicle could achieve times 1000, rounded to the nearest full point.

  Note 1: for example, if an ICE prototype received 110 points out of the total possible points of 123, the VTI Score rating would be 894 \((\frac{110}{123} \times 1000 = 894.3 \text{ or } 894 \text{ rounded to the nearest point})\)

  Note 2: The total possible points will vary between energy types, vehicle options (i.e. lead acid battery or Li-ion battery), and vehicle category (Prototype or Urban Concept).

6B – VIRTUAL OFF-TRACK AWARDS

Applications for Virtual Off-track Awards must be related to the Team’s Shell Eco-marathon project. Previous award winners cannot re-apply using the same vehicle design, innovation, communications or safety campaign. Submission must be clearly different from previous winning applications. Applications must include the Team race number on the cover.

Applications for all Virtual Off-track Awards must be made in the English language.

For the Shell Eco-marathon Virtual Off-track Awards, the required documents must be uploaded to the Shell Eco-marathon website. Please refer to the Shell Eco-marathon website for the applicable submission deadline.

By submitting a Virtual Off-track Award entry, the Team agrees for the Organisers to publish their entry as deemed necessary to recognise the achievement and provide coaching to other Teams.

ARTICLE 97: COMMUNICATIONS AWARD

a) Objective

Communications and promotional activity are crucial in driving interest in Shell Eco-marathon teams and their activities; and potentially in driving sponsorship opportunities. This award provides the opportunity to reward the most impactful and successful integrated communications campaign - showing the efforts to promote the Team ahead of a potential Shell Eco-marathon competition in 2021. The winner will be the Team that demonstrates the best and most effective communication and promotional activities on their Shell Eco-marathon project.
b) Overview

An integrated Communications campaign, using different media channels and engagement activities, is integral for students to promote their Teams ahead of Shell Eco-marathon. Participating Teams are required to create, run and evaluate a communications plan with various activities to show the Team’s trajectory ahead of the competition.

When preparing the campaign, Teams are encouraged to use a wide range of media channels, from traditional media (press, radio and TV), to online tools (websites, blogs) or social media networks (Facebook, Twitter, YouTube, Instagram etc.).

The winner will be judged on the quality and creativity of the content, the volume of activity as well as the impact (potential reach) of the campaign (i.e. media impressions; website visits; YouTube video views; Facebook likes; event attendance, etc.).

As we evaluate the Team’s trajectory before Shell Eco-marathon, the application should indicate when the campaign is launched and run and should include planned activities after the submission deadline.

Remember that engaging with Shell Eco-marathon online and on social media channels can also be an important part of the campaign. Teams applying to the Communications Award are invited to join the regional Shell Eco-marathon Facebook groups, follow the Shell Eco-marathon accounts on Twitter and Instagram, and use the #ShellEcoMarathon hashtag whenever possible.

Teams must note that the effectiveness of the Communications campaign will be judged on activities related to Shell Eco-marathon only. This includes, for instance, the unveiling of your vehicle, press conferences, photos or videos of the Team and the car, or any social media activity. Participation in other competitions without a clear reference to Shell Eco-marathon will not be taken into consideration.

c) How to participate

Participation in this competition is voluntary. Teams interested in applying to the Off-Track Communications Award must apply via the Shell Eco-marathon website. This application must consist of one (1) document (.pdf format) that should be simple and straightforward, and should contain:

i. Communications Plan: A short summary (no more than 500 words) indicating the main idea, objectives, strategy and timeline of the Communications Campaign.

ii. Impact Analysis: A summary report (no more than 500 words) evaluating the success of the Communications Campaign compared with its objectives. Teams should also submit the main results (numbers) gathered throughout the campaign (e.g. event attendees, media impressions; video views; social media likes and shares; re-Tweets; etc.).

iii. Campaign portfolio: Teams should collate and share all (or the best) examples of their campaign. This includes, for instance: press clips; event photos and footage; posters and brochures; creative infographics; websites links; social media channels (Facebook, Twitter, Instagram, YouTube, Tumblr, Vimeo, TikTok etc.); blog posts; screen shots of social media posts; links to YouTube, Vimeo or Instagram, etc.

ARTICLE 98: VEHICLE DESIGN AWARD

a) Objective

This prize recognises innovative design research and execution and will be awarded to the Team, which presents the most original and coherent vehicle in terms of aesthetics, ergonomics, technical feasibility, choice of materials and circular economy thinking. Each of these five criteria will be considered in a final decision. Due to their non-comparable designs there will be one award each for the Prototype and Urban Concept categories.
b) Overview

Teams are required to describe their design approach, the basis for their research, factors which make this design special and issues and solutions encountered during the vehicle production process. Photographs, drawings and / or animations must be included to illustrate the process.

c) How to participate

Application for this award is voluntary. Teams interested in winning the Vehicle Design Award must submit a summary in .pdf format which does not exceed 1,500 words plus photographs, drawings or animations. This document must contain as a minimum the following information:

i. Description of the original design idea the Team wanted to develop and why

ii. Seven images of the vehicle (photographs or drawings) which represent the car, such as:
- 3/4 front perspective view
- 3/4 rear perspective view
- Direct Front view
- Direct Rear view
- Side view
- Top view
- Cockpit view

iii. A brief project timeline and overview of the team structure and work allocation

iv. When was this vehicle registered for the first time for Shell Eco-marathon?

v. What are the new developments this year (if registered before)?

vi. Details about research and tests done to prove the vehicle’s energy-efficiency

vii. Details about vehicle safety and driver ergonomics aspects

viii. Details about the materials used and how well they can be recycled

ix. The weight of the car and details on how the Team managed weight reduction

ARTICLE 99: TECHNICAL INNOVATION AWARD SPONSORED BY SOUTHWEST RESEARCH INSTITUTE

a) Objective

This award is presented to the Team which demonstrates outstanding technical ingenuity along with optimal use of new materials, components, methodology and inventions in their drive train, chassis, body, instrumentation and tyres.

b) Overview

Teams will be required to explain their innovative concept, its features and its benefits, how it relates to the Shell Eco-marathon competition and the potential it has for ‘real world’ application. Submissions that provide in-depth information on a specific innovation are preferred over those that give a general overview of multiple innovations to the project vehicle.

Teams are strongly encouraged to consider all intellectual property developed in conjunction with the Shell Eco-marathon programme as valuable assets and seek professional advice about its protections through patents or trademarks before publishing.
How to participate

Application for this award is voluntary. Teams interested in winning the Technical Innovation Award must apply with a submission in .pdf format which is not to exceed 1,500 words plus photographs, drawings or animations as applicable. As part of the submission, Teams must include an Executive Summary that answers the following questions, at minimum:

i. Describe the innovation.

ii. What makes the innovation unique/novel?

iii. Is the concept relevant to real world applications? If so, how?

The Executive Summary should be included at the beginning of the submission.

ARTICLE 100: SIMULATE TO INNOVATE AWARD BY ALTAIR

a) Objective

This award recognizes the use of CAE (computer aided engineering) simulation and optimization in vehicle design and is presented to Teams which demonstrate outstanding improvement in the design of any vehicle system or component that was achieved by using CAE.

b) Overview

Teams will be required to explain their virtual approaches, the methods they applied and the benefits they targeted and finally achieved.

c) How to participate

Application for this award is voluntary. Teams interested in winning the Simulate to Innovate Award by Altair must apply in .pdf format which is not to exceed 2,000 words plus screenshots, graphs, or animations as applicable.

i. Report must include at least one example of how simulation driven design methods were used for the design of any vehicle system or component. The report should show the steps followed and results obtained from the software that was used

ii. Information and details must be provided in the report on how the simulation helped to improve the initial design. This includes the description of initial as well as the improved design. Images or animations should be used where beneficial to demonstrate how CAE software was used to verify performance in virtual tests.

iii. Improvements in design may include weight savings by using structural optimisation software, reduced drag by using CFD simulation, higher safety by using crash analysis or higher vehicle efficiency by optimised motor design or control strategies. The virtual analysis and optimisation of manufacturing processes like for 3D printing can be included as well.

The award is neutral to any state to the art software used for the virtual development.

Note: Altair will support Teams by providing free Altair software, virtual learning sessions and a dedicated active support forum. Altair will provide free access to their software as well as a dedicated active support forum. Teams are able to request sponsorship by filling out the sponsorship form on www.altairuniversity.com/sponsorship-competitions and for any questions please contact altairuniversity@altair.com.

Throughout the year Teams will be invited to a number of learning courses hosted by Altair providing further information and guidance on how to use Altair software and how to apply it on typical design challenges during a vehicle development process as well as Virtual...
Learning Sessions held in conjunction with Shell Eco-marathon. Further details for which will be shared throughout the year.

Shell International Limited (SIL) does not endorse the products offered by any other company. Students and other readers should be aware that if they contact another company directly, they will be subject to the data privacy policies and processes of that company and that their information is not protected by

**ARTICLE 101: SAFETY AWARD**

a) Objective

This award aims to highlight the importance of safety in the Shell Eco-marathon programme and encourages all participating Teams to actively implement safe practices in their daily activities. It challenges all Teams to review their ways of working including but not limited to training, management and inspection of tools and equipment, assessment and management of PPE requirement, and to review their procedures in order to identify areas where safety standards can be improved.

b) Overview

To be eligible for the award, the Team must demonstrate excellent understanding of safe design concepts and safe manufacturing processes. Furthermore, the Team must be able to demonstrate safe working practices as well as an overall proactive approach to their own and other people’s safety in their home workshop and/or at live event – in paddocks and on the track. In their submission, the Team will also explain changes they have implemented to achieve higher standards of safety.

c) How to participate

Application for this award is voluntary. Teams interested in winning the Safety Award must apply in .pdf format which is not to exceed 1,500 words plus supporting videos, photographs, documents, and drawings, which are encouraged.

**ARTICLE 102: DATA AND TELEMETRY AWARD**

a) Objective

This prize recognizes the conceptual design of how to use vehicle data real-time, or close to real-time, to improve the Team’s result in the Mileage Challenge. The award is open to both Prototype and Urban Concept Teams. The referenced vehicle data can be from the existing Shell telemetry system for Urban Concept vehicles (as described in Section 5). Additional data points that are not currently available through the Shell telemetry system may also be considered. Answers to the following questions will be used in judging the submissions.

- What data will you use from the existing telemetry system or what data would you need that isn’t already available?
- How will your Team use the data? That is, what will you do with it, point analysis, simulation, etc.?
- What data is communicated between the Team and driver, and how? What method of receiving the data by the driver will be used? Display, phone, radio, etc.
- What will the driver do with the data?
- What is the expected outcome from the use of the data? How much of an improvement do you expect and why?

b) Overview
Teams must answer the questions listed in Article 102:a) and explain how expected outcomes relate to the Shell Eco-marathon competition. Submissions that provide in-depth information on a specific use-case are preferred over those that give a general overview of preferred data points.

c) How to participate

Application for this award is voluntary. Teams wishing to participate must submit design documentation in a PDF format. Design documentation should consist of a summary, design basis, any analysis, communication strategy, and other words clearly describing the Team’s approach. The design documentation must not exceed 1,500 words. Graphs and tables are not included in the word count.
7. AWARDS AND PRIZES

ARTICLE 103: ON-TRACK AWARD OVERVIEW AND PRIZES

On-Track awards will be detailed in the Chapter II rules for the respective event.

ARTICLE 104: VIRTUAL LEAGUE AWARD OVERVIEW AND PRIZES

a) Overall Virtual League Winner

The winning Virtual League Team will be determined on the total number of accumulated points as defined in Article 91. There will be one global winner with prize money for first (1\textsuperscript{st}) through sixth (6\textsuperscript{th}) place as follows.

<table>
<thead>
<tr>
<th>Virtual League</th>
<th>Prize</th>
</tr>
</thead>
<tbody>
<tr>
<td>1\textsuperscript{st} Place (most points overall)</td>
<td>$3,000</td>
</tr>
<tr>
<td>2\textsuperscript{nd} Place</td>
<td>$2,000</td>
</tr>
<tr>
<td>3\textsuperscript{rd} Place</td>
<td>$1,500</td>
</tr>
<tr>
<td>4\textsuperscript{th} Place</td>
<td>$1,000</td>
</tr>
<tr>
<td>5\textsuperscript{th} Place</td>
<td>$750</td>
</tr>
<tr>
<td>6\textsuperscript{th} Place</td>
<td>$500</td>
</tr>
</tbody>
</table>

b) Pitch the Future Competition

For each of the four mini-Challenges there will be one regional winner. Those winners will go through to a live pitch and present to a jury which will determine the final global winner for each of the four mini-Challenges. Prize money will be awarded for the regional and global winners.

<table>
<thead>
<tr>
<th>Pitch the Future</th>
<th>Prize</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional winner of mini-Challenge</td>
<td>$750</td>
</tr>
<tr>
<td>Global winner of global mini-Challenge</td>
<td>Addtl. $750</td>
</tr>
</tbody>
</table>

c) Autonomous Programming Competition

There will be one global winner for the Autonomous Programming Competition with prize money for first (1\textsuperscript{st}) through third (3\textsuperscript{rd}) place as follows.

<table>
<thead>
<tr>
<th>Autonomous Programming Competition</th>
<th>Prize</th>
</tr>
</thead>
<tbody>
<tr>
<td>1\textsuperscript{st} Place</td>
<td>$1,500</td>
</tr>
<tr>
<td>2\textsuperscript{nd} Place</td>
<td>$1,000</td>
</tr>
<tr>
<td>3\textsuperscript{rd} Place</td>
<td>$500</td>
</tr>
</tbody>
</table>

d) Virtual Technical Inspection Competition

There will be one Virtual Technical Inspection winner for both Prototype and Urban Concept vehicle categories...
for each of the three regions. Prize money for the regional first (1st) through third (3rd) place are as follows.

<table>
<thead>
<tr>
<th>Virtual Technical Inspection</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Place [most points overall]</td>
<td>$1,500</td>
</tr>
<tr>
<td>2nd Place</td>
<td>$1,000</td>
</tr>
<tr>
<td>3rd Place</td>
<td>$500</td>
</tr>
</tbody>
</table>

e) Off-Track Awards

There will be one winner and a runner-up for each Off-track award. Separate awards will be given for each of the three regions. Prizes for the regional Off-Track Award winner and runner-up are as follows.

<table>
<thead>
<tr>
<th>Off Track Awards</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Winner</td>
<td>$1,500</td>
</tr>
<tr>
<td>Runner-up</td>
<td>$750</td>
</tr>
</tbody>
</table>

f) Bonus Challenges

There will be no prize money for Bonus Challenge, but points will be awarded to the winning team for the Global Virtual League according to Article 91.
8. MISCELLANEOUS

ARTICLE 105: PERSONAL DATA
Terms as set out in the MaketheFuture privacy policy governs and covers the Organiser’s use of any personal data collected as part of the Competition and on the Shell Eco-marathon registration platforms.

The personal information collected is for the purpose of facilitating your participation in the Competition.

ARTICLE 106: PHOTOGRAPHY AND VIDEOGRAPHY RIGHTS
During the Competition, photographs and film will be made by, or on behalf of, the Organiser. Participants may be featured in these photographs and film. The usage and storage of these materials are governed by the terms set out Article 1d) in these Official Rules and in the Terms and Conditions for each competition component as signed by Participants.

ARTICLE 107: INTELLECTUAL PROPERTY
Any work performed in the Competition may result in the creation of valuable intellectual property. Teams are encouraged to consider all intellectual property created during the Shell Eco-marathon programme as valuable assets, and to seek professional advice for the protection of their intellectual property. Material uploaded will share your inventions and methods with the world, so you might be advised to make it clear that this is your intellectual property.

ARTICLE 108: THIRD PARTY’S INTELLECTUAL PROPERTY
By entering, each Team warrants and represents that its vehicle and/or its design is original and does not infringe, defame or otherwise violate the rights and/or property of any third party; does not violate any laws or regulations; and does not utilise, use or infringe the property of any third party including the property and rights of another team without express written permission to do so. Each team further warrants that the possession, exploitation, use or distribution by that team of any intellectual property including without limitation patents, copyrights, designs, trade or service marks, whether registered or not, shall not infringe or misappropriate the intellectual property right of any third party. Each Team shall indemnify the Organiser and its parent, affiliate and subsidiary companies against any costs, loss or damage suffered or incurred by the Organiser and its parent, affiliate and subsidiary companies as a result of any claim that the use by a team thereof infringes the intellectual property right of any third party.
APPENDIX 1: IDENTIFICATION OF VEHICLES

### URBANCONCEPT

**FRONT View**
- Race no.
- Front number plate
- Shell logo

**SIDE View**
- Shell logo
- Partner strip R and L side
- Race no. side plate

### PROTOTYPE

**FRONT View**
- Race no.
- Front number plate
- Shell logo

**SIDE View**
- Shell logo
- Partner strip R and L side
- Race no. side plate

---

<table>
<thead>
<tr>
<th>IDENTIFICATION</th>
<th>POSITION</th>
<th>FORMAT</th>
<th>NUMBER</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell Pecten</td>
<td>Right side</td>
<td>215mm x 200mm</td>
<td>3</td>
<td>Mandatory</td>
</tr>
<tr>
<td></td>
<td>Left side</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Front of vehicle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Race number plate</td>
<td>Right side</td>
<td>200mm x 260mm</td>
<td>3</td>
<td>Mandatory</td>
</tr>
<tr>
<td></td>
<td>Left side</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Front of vehicle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partner strip</td>
<td>Right side</td>
<td>770mm x 80mm</td>
<td>2</td>
<td>Mandatory</td>
</tr>
<tr>
<td></td>
<td>Left side</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency sticker</td>
<td>On exterior position of the shutdown actuator</td>
<td>120mm x 105mm</td>
<td>2</td>
<td>Mandatory</td>
</tr>
</tbody>
</table>
# APPENDIX 2: VIRTUAL TECHNICAL INSPECTION CHECKLIST

## Prototype

<table>
<thead>
<tr>
<th>Article</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Station 1</strong></td>
<td><strong>Driver’s Control</strong></td>
</tr>
<tr>
<td>21 a</td>
<td>Appropriate motorsports helmet(s)</td>
</tr>
<tr>
<td>22 a, c</td>
<td>Racing suit(s) / Gloves</td>
</tr>
<tr>
<td><strong>Station 2</strong></td>
<td><strong>Vehicle dimensions</strong></td>
</tr>
<tr>
<td>39 a</td>
<td>Height &lt; 1000 mm</td>
</tr>
<tr>
<td>39 e</td>
<td>Width &lt; 1300 mm</td>
</tr>
<tr>
<td>39 f</td>
<td>Length &lt; 3500 mm</td>
</tr>
<tr>
<td>39 b</td>
<td>Track width &gt; 500 mm</td>
</tr>
<tr>
<td>39 d</td>
<td>Wheelbase &gt; 1000 mm</td>
</tr>
<tr>
<td><strong>Station 3</strong></td>
<td><strong>Seat Belts &amp; Roll bar</strong></td>
</tr>
<tr>
<td>29 a-b</td>
<td>Safety Belts ≥ 5 mounting points</td>
</tr>
<tr>
<td>29 c-d</td>
<td>Safety Belts - chassis fixing</td>
</tr>
<tr>
<td>29 b</td>
<td>Crotch strap under body</td>
</tr>
<tr>
<td>26 a</td>
<td>Crumple space-protect from front/side impact</td>
</tr>
<tr>
<td>26 b</td>
<td>Roll bar 50 mm &gt; driver's head</td>
</tr>
<tr>
<td>26 c</td>
<td>Roll bar width &gt; shoulders</td>
</tr>
<tr>
<td><strong>Station 4</strong></td>
<td><strong>Brakes</strong></td>
</tr>
<tr>
<td>94 c</td>
<td>Uploaded documentation</td>
</tr>
<tr>
<td>43 a</td>
<td>1 Hydraulic brake system 1 front &amp; 1 rear</td>
</tr>
<tr>
<td>43 a</td>
<td>1 single hydraulic circuit per axle</td>
</tr>
<tr>
<td>43 a</td>
<td>Foot operated front brake by single pedal</td>
</tr>
<tr>
<td>43 a</td>
<td>Rear brake by single lever or pedal</td>
</tr>
<tr>
<td>43 a</td>
<td>All wheels have brakes</td>
</tr>
<tr>
<td>43 a</td>
<td>Ergonomy (both hands on steering mech.)</td>
</tr>
<tr>
<td><strong>Station 5</strong></td>
<td><strong>Not Used</strong></td>
</tr>
<tr>
<td><strong>Station 6</strong></td>
<td><strong>Exit</strong></td>
</tr>
<tr>
<td>30 a-d</td>
<td>Driver exit &lt; 10 seconds</td>
</tr>
<tr>
<td>Station 7</td>
<td>Mechanical Vehicle Design</td>
</tr>
<tr>
<td>----------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>25 k</td>
<td>Fully closed body</td>
</tr>
<tr>
<td>25 a ii</td>
<td>Front Crumple Zone ≥ 100 mm</td>
</tr>
<tr>
<td>25 j</td>
<td>Solid floor &amp; frame</td>
</tr>
<tr>
<td>27 a d</td>
<td>Bulkhead rigid &amp; fire resistant</td>
</tr>
<tr>
<td>25 g, 27 b</td>
<td>Bulkhead isolates energy/driver compartment</td>
</tr>
<tr>
<td>34 g</td>
<td>Chain/belt guard</td>
</tr>
<tr>
<td>25 a i, 25 a iii</td>
<td>Running wheels (Pr:3/4)</td>
</tr>
<tr>
<td></td>
<td>IF ICE (Y/N)</td>
</tr>
<tr>
<td>35 a, b</td>
<td>Exhaust system evacuates outside</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Station 8</th>
<th>Electrical Vehicle Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>58 c, 94 f</td>
<td>Uploaded documentation</td>
</tr>
<tr>
<td>57 e</td>
<td>Elec system has proper fuse protection</td>
</tr>
<tr>
<td></td>
<td>Battery</td>
</tr>
<tr>
<td>57 b</td>
<td>Only one Battery, single physical package</td>
</tr>
<tr>
<td>57 a</td>
<td>Max 48 V nominal (60 V Peak)</td>
</tr>
<tr>
<td>57 c</td>
<td>Batt mount firm, behind b/head, not under seat</td>
</tr>
<tr>
<td>57 d</td>
<td>IF Lithium battery</td>
</tr>
<tr>
<td>57 d iv</td>
<td>Capacity &lt; 1000 Wh</td>
</tr>
<tr>
<td>63</td>
<td>If Hybrid / H2 with energy store</td>
</tr>
<tr>
<td>57 j</td>
<td>Supercapacitor (SC) for energy storage</td>
</tr>
<tr>
<td>63 c</td>
<td>External connectors</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Station 9</th>
<th>Energy Verification ICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>94 c d</td>
<td>Uploaded documentation</td>
</tr>
<tr>
<td>61 a c d</td>
<td>Fuel Tank Position</td>
</tr>
<tr>
<td>60 b i</td>
<td>Safety valve location (between reg and tank)</td>
</tr>
<tr>
<td>61 g</td>
<td>Translucent hoses</td>
</tr>
<tr>
<td>62 c</td>
<td>Nothing in the fuel line (no filters, etc)</td>
</tr>
<tr>
<td>62 e</td>
<td>Fuel injection only</td>
</tr>
<tr>
<td>64 a</td>
<td>Electric Starter</td>
</tr>
<tr>
<td>37</td>
<td>Emergency Shutdown</td>
</tr>
<tr>
<td>37 f</td>
<td>Internal/External Estop Switch</td>
</tr>
<tr>
<td>Station 10</td>
<td>Energy Verification H2</td>
</tr>
<tr>
<td>------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>94 c e</td>
<td>Uploaded documentation</td>
</tr>
<tr>
<td>65 a iv</td>
<td>Correct system design</td>
</tr>
<tr>
<td>65 d</td>
<td>Hydrogen sensor at highest point</td>
</tr>
<tr>
<td>65 c</td>
<td>2 ventilation holes 5 cm²</td>
</tr>
<tr>
<td>37</td>
<td>Emergency Shutdown</td>
</tr>
<tr>
<td>37 f</td>
<td>Internal/External Estop Switch</td>
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<thead>
<tr>
<th>Station 11</th>
<th>Energy Verification BEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>94 c f</td>
<td>Uploaded documentation</td>
</tr>
<tr>
<td>57 d</td>
<td>Li-Ion Battery System</td>
</tr>
<tr>
<td>57 b</td>
<td>Only two terminals</td>
</tr>
<tr>
<td>57d i</td>
<td>In-vehicle Battery Management System</td>
</tr>
<tr>
<td>67 a</td>
<td>Motor/Controller System</td>
</tr>
<tr>
<td>67 a</td>
<td>Purpose built motor controller</td>
</tr>
<tr>
<td>37</td>
<td>Emergency Shutdown</td>
</tr>
<tr>
<td>37 f</td>
<td>Internal/External Estop Switch</td>
</tr>
<tr>
<td>Article</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>Station 1</strong></td>
<td><strong>Driver’s Control</strong></td>
</tr>
<tr>
<td>21 a</td>
<td>Appropriate motorsports helmet(s)</td>
</tr>
<tr>
<td>22 a, c</td>
<td>Racing suit(s) / Gloves</td>
</tr>
<tr>
<td><strong>Station 2</strong></td>
<td><strong>Vehicle dimensions</strong></td>
</tr>
<tr>
<td>45 a</td>
<td>Height 1000 - 1300 mm</td>
</tr>
<tr>
<td>45 b</td>
<td>Width 1200 - 1300 mm</td>
</tr>
<tr>
<td>45 c</td>
<td>Length 2200 - 3500 mm</td>
</tr>
<tr>
<td>45 d</td>
<td>Track width &gt;1000 mm (front)</td>
</tr>
<tr>
<td>45 d</td>
<td>Track width &gt; 800 mm (rear)</td>
</tr>
<tr>
<td>45 e</td>
<td>Wheelbase &gt; 1200 mm</td>
</tr>
<tr>
<td>46 d</td>
<td>Two Doors - Min 500 x 800 mm</td>
</tr>
<tr>
<td><strong>Station 3</strong></td>
<td><strong>Seat Belts &amp; Roll bar</strong></td>
</tr>
<tr>
<td>29 a-b</td>
<td>Safety Belts ≥ 5 mounting points</td>
</tr>
<tr>
<td>29 c-d</td>
<td>Safety Belts - chassis fixing</td>
</tr>
<tr>
<td>29 b</td>
<td>Crotch strap under body</td>
</tr>
<tr>
<td>26 b</td>
<td>Roll bar 50 mm &gt; driver’s head</td>
</tr>
<tr>
<td>26 c</td>
<td>Roll bar width &gt; shoulders</td>
</tr>
<tr>
<td><strong>Station 4</strong></td>
<td><strong>Brakes</strong></td>
</tr>
<tr>
<td>94 c</td>
<td>Brake documentation</td>
</tr>
<tr>
<td>42 d</td>
<td>Ergonomy (both hands on steering mech.)</td>
</tr>
<tr>
<td>51 a</td>
<td>4 disc hydraulic brake</td>
</tr>
<tr>
<td>51 c</td>
<td>One dual master cylinder or 2 master cyls</td>
</tr>
<tr>
<td><strong>Station 5</strong></td>
<td><strong>Visibility</strong></td>
</tr>
<tr>
<td>52, 28 a</td>
<td>Windscreen &amp; wiper / Tint-driver must be seen</td>
</tr>
<tr>
<td><strong>Station 6</strong></td>
<td><strong>Exit</strong></td>
</tr>
<tr>
<td>30 a-d</td>
<td>Driver exit &lt; 10 seconds</td>
</tr>
<tr>
<td><strong>Station 7</strong></td>
<td><strong>Mechanical Vehicle Design</strong></td>
</tr>
<tr>
<td>25 k</td>
<td>Fully closed body</td>
</tr>
<tr>
<td>25 j</td>
<td>Solid floor &amp; frame</td>
</tr>
<tr>
<td>25 c, 46 i</td>
<td>No external appendages or sharp edges</td>
</tr>
<tr>
<td>46 b</td>
<td>Wheel covers integral with body</td>
</tr>
<tr>
<td>30 c</td>
<td>Internal/ext’l opening mech effective/intuitive</td>
</tr>
<tr>
<td>27 a-d</td>
<td>Bulkhead rigid &amp; fire resistant</td>
</tr>
<tr>
<td>25 g, 27 b</td>
<td>Bulkhead isolates energy/driver compartment</td>
</tr>
<tr>
<td>34 g</td>
<td>Chain/belt guard</td>
</tr>
<tr>
<td>25 a i, 25 a iii</td>
<td>Running wheels (Pr:3/4, UC:4)</td>
</tr>
<tr>
<td>46 h</td>
<td>Luggage compartment (and luggage)</td>
</tr>
<tr>
<td>46 j</td>
<td>Towing hook or ring</td>
</tr>
<tr>
<td>50 b</td>
<td>2 front turn indicators</td>
</tr>
<tr>
<td>Station 8</td>
<td>Electrical Vehicle Design</td>
</tr>
<tr>
<td>----------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>50 a</td>
<td>2 front headlights</td>
</tr>
<tr>
<td>50 c</td>
<td>2 rear turn indicators</td>
</tr>
<tr>
<td>50 d</td>
<td>2 red rear brake light</td>
</tr>
<tr>
<td>50 e</td>
<td>2 red rear lights</td>
</tr>
<tr>
<td>50 h</td>
<td>Hazard Lights</td>
</tr>
<tr>
<td>IF ICE (Y/N)</td>
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<td>35 a, b</td>
<td>Exhaust system evacuates outside</td>
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<td>57 a</td>
<td>Max 48 V nominal (60 V Peak)</td>
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<td>Batt mount firm, behind b/head, not under seat</td>
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<td>61 a, c, d</td>
<td>Fuel Tank Position</td>
</tr>
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<td>Safety valve location (between reg and tank)</td>
</tr>
<tr>
<td>61 g</td>
<td>Translucent hoses</td>
</tr>
<tr>
<td>62 c</td>
<td>Nothing in the fuel line (no filters, etc)</td>
</tr>
<tr>
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</tr>
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</tr>
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<tbody>
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<tr>
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<th>Energy Verification H2</th>
</tr>
</thead>
<tbody>
<tr>
<td>65 a, iv</td>
<td>Correct system design</td>
</tr>
<tr>
<td>65 d</td>
<td>Hydrogen sensor at highest point</td>
</tr>
<tr>
<td>65 c</td>
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<tbody>
<tr>
<td>57 d</td>
<td>Li-ion Battery System</td>
</tr>
<tr>
<td>57 b</td>
<td>Only two terminals</td>
</tr>
<tr>
<td>57d</td>
<td>In-vehicle Battery Management System</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>67a</td>
<td>Motor/Controller System</td>
</tr>
<tr>
<td>67a</td>
<td>Purpose built motor controller</td>
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<tr>
<td>37f</td>
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