2010 Formula Student Class 1A Rules

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PART A – ADMINSTRATIVE REGULATIONS

ARTICLE 1: FORMULA STUDENT CLASS 1A OVERVIEW AND COMPETITION - as article 1 from 2010 FSAE Rules except

A1.1 Formula Student Class 1A Objective and Regulations
The Formula Student Class 1A competition embodies the same objectives as The Formula SAE ® Series (see 2010 FSAE Rules A1.1) but it also allows the development of alternatively fuelled vehicles.

A1.1.1 The 2010 FSAE rules must be applied to the design of all aspects of the car unless specific regulation changes are stated in this document

A1.1.2 An overview of the main regulation differences is as follows:

a. Class 1A is open to cars that meet all the normal regulations for Class 1 cars except those that relate to the powertrain. In place of the original rules which allow only a petrol or E85 burning engine to power the vehicle an alternative set of rules for Class 1A will allow a much wider range of fuels, prime movers and hybrid vehicles with more than one form of power. Cars using petrol or E85 that are eligible for either Class 1 or Class 1A may be entered in either (but not both).

b. During the endurance event a much greater proportion of the score will be given over to fuel consumption and instead of measuring fuel consumption in litres the production of CO_2 will be measured in kg. The quantity of CO_2 released to the atmosphere by the consumption of each allowable fuel will be specified in the rules and is intended to represent the UK average number for the type of fuel under consideration.

c. The Sustainability event that will evaluate the embedded CO_2 and energy in the vehicle replaces the cost event.

d. In consideration of the extra powertrain work required for a Class 1(A) car the direction will be given to design judges to increase the weighting of importance placed upon power train aspects of design.

e. Where appropriate Class 1A cars will use a 250 cc spark ignition engine (or 310cc compression ignition engine) in place of the 600 cc unit used in Class 1. This will allow some space and weight for the fitting of hybrid systems if desired, reduce the range issues for some alternative fuels and also allow Class 1A petrol / electric hybrid cars to compete in Formula Hybrid in the US.

f. Allowable Power Sources - The allowable forms of power are specified as Petrol, Diesel, E85, LPG, CNG, Hydrogen, Hydrogen fuel cell or Electric and combinations of these to form a hybrid but the organising committee will consider requests for other fuels to be added to this list.

g. There are significant additional regulations describing and relating to the

powertrain including the requirements for drive-by-wire systems and HV electrical systems. For those teams that choose a hybrid solution, the regulations should in most cases enable them to compete in FSAE's Formula Hybrid event. http://www.formula-hybrid.org/rules.php

A1.2 Vehicle Design Objectives

For the purpose of the Formula Student Class1A competition, teams are to assume that they work for a design firm that is designing, fabricating, testing and demonstrating a prototype vehicle for the non-professional, weekend, competition market.

A1.2.1 The vehicle should adopt alternative powertrain technologies such that it is high performance, whilst the amount of CO_2 it emits is as low as feasibly possible and the CO_2 and energy embedded in the vehicle is minimised. Recyclability must also be considered in the design.

A1.2.2 The vehicle should have high performance in terms of acceleration, braking and handling and be sufficiently durable to successfully complete all the events described in the Formula Student Class 1A Rules and held at the Formula Student competition.

A1.2.2 The vehicle must accommodate drivers whose stature ranges from 5th percentile female to 95th percentile male and must satisfy the requirements of the Formula SAE Rules.

A1.2.3 Additional design factors to be considered include: aesthetics, cost, ergonomics, maintainability, manufacturability and reliability.

A1.2.4 Once the vehicle has been completed and tested, your design firm will attempt to "sell" the design to a "corporation" that is considering the production of a competition vehicle. The challenge to the design team is to develop a prototype car that best meets the Formula Student Class 1A vehicle design goals and which can be profitably marketed.

A1.2.5 Each design will be judged and evaluated against other competing designs to determine the best overall car.

A1.4 Judging Categories

The cars are judged in a series of static and dynamic events including: technical inspection, sustainability, presentation, and engineering design, solo performance trials, and high performance track endurance.

A1.4.1 The dynamic events are scored to determine how well the car performs. Each dynamic event has specified minimum acceptable performance levels that are reflected in the scoring equations.

The following points are possible:

Static Events:

Presentation	75
Engineering Design	150
Sustainability	100

Dynamic Events		
	Acceleration	75
	Skid-Pad	50
	Autocross	150
	Fuel Economy/CO_2 emissions	200
	Endurance	200
Total Points		1,000

ARTICLE 2: THE 2010 FORMULA SAE SERIES – as per 2010 FSAE Rules

ARTICLE 3: FORMULA SAE RULES AND ORGANIZER AUTHORITY – as per 2010 FSAE Rules

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ARTICLE 5: SAFETY OFFICER(S)
Note teams also require a faculty advisor as described in Article 5 of the 2010 FSAE regulations.

A5.1 Requirement for a safety officer

A5.1.1 The intent of the FSAE regulations, when correctly followed is to ensure that wherever possible the cars are fundamentally safe. This is achieved by applying strict regulations relating to the vehicle layout and the design of key components. For the new technologies that are embraced by Class 1A, setting of regulations to ensure complete safety of a wide range of alternative powered vehicles is impossibly difficult. For this reason the safety of Class 1A vehicles must be ensured by a professionally competent person(s) nominated by the Entrant. This competent person(s) will be designated the Safety Officer(s).

A5.2 Requirements of the safety officer

A5.2.1 All entries for Class 1A must be accompanied by a form that specifies one or more person who is responsible for the safety of the car (The Safety Officer or SO). The SO must supply a resume detailing their experience in the field of technology employed by the car. His or her acceptability as an SO needs to be approved by the organisers before the entry is accepted. It is likely that the SO will be a Chartered Engineer or someone of equivalent status.

A5.2.1 The SO must have significant experience of the technology that is being developed and its implementation into vehicles or other safety critical systems. Note: It may be necessary to have more than one person to achieve this requirement.

A5.2.2 The SO must ensure that the students are provided with adequate training such that they are competent to work with the systems on the vehicle.

A5.2.3 The SO(s) must sign the risk assessment document to confirm that the vehicle encompasses good engineering practices.

A5.2.4 The SO(s) should be present at the competition during scrutineering and

whenever the car runs.

A5.3 Unusual aspects of the design

A5.3.1 The SO must ensure that the team discusses any unusual aspects of the design with the rules committee to reduce the risk of exclusion or significant changes being required to pass scrutineering.

ARTICLE 6: VEHICLE ELGIBILITY – as per 2010 FSAE Rules except for the following

A6.9 Second Year Vehicles: Formula Student Class 1A

A6.9.1 Vehicles that have competed during any one (1) previous Formula SAE year may compete provided that they have been substantially modified to meet the Class 1A regulations.

A6.9.2 Penalties for insufficient redesign of cars that were in Class 1A for their first year of competition or insufficient knowledge by the team will be applied during the Design Event. Refer to the Rule C - 5.15 “Penalties for Insufficient Redesign”.

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2010 Formula Student Class 1(A) Rules
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ARTICLE 3: DRIVER'S CELL – as per 2010 FSAE Rules

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B4.5 Firewall

B4.5.1 A firewall must separate the driver compartment from all components of the fuel supply, the engine oil, the liquid cooling systems and any energy storage systems. It must protect the neck of the tallest driver. It must extend sufficiently far upwards and/or rearwards such that any point less than 100 mm (4 ins.) above the bottom of the helmet of the tallest driver shall not be in direct line of sight with any part of the fuel system, the cooling system, the engine oil system or any energy storage system or related components.

B4.5.2 The firewall must be a non-permeable surface made from a *rigid,* fire resistant material.

B4.5.3 Any firewall must seal completely against the passage of fluids, especially at the sides and the floor of the cockpit, i.e. there can be no holes in a firewall through which seat belts pass.

B4.5.4 Pass-throughs for wiring, cables, etc. are allowable if grommets are used to seal the pass-throughs. Also, multiple panels may be used to form the firewall but must be sealed at the joints.

B4.5.2 If the car has HV electric systems then the firewall must be made from or coated in an electrically insulating material.

ARTICLE 5: DRIVERS EQUIPMENT (BELTS AND COCKPIT PADDING) – as per 2010 FSAE Rules

ARTICLE 6: GENERAL CHASSIS RULES – as per 2010 FSAE Rules

ARTICLE 7: BRAKE SYSTEM – as per 2010 FSAE Rules except as follows

B7.1.4 "Brake-by-wire" systems are allowed for regenerative braking as long as at least 50% of the brake travel activates a mechanical hydraulic system which meets the normal FSAE rules when the regenerative braking system is turned off.

ARTICLE 8: POWERTRAIN – as per 2010 FSAE Rules except as follows

B8.1 Engine Limitation

B8.1.1 If a liquid or gaseous fuel burning engine is fitted it must be an Internal Combustion, four-stroke piston engine with a maximum displacement of 250cc for spark ignition engines or 310cc for compression ignition engines.

B8.1.2 The engine can be modified within the restrictions of the rules.

B8.1.3 If more than one engine is used, the total displacement can not exceed the maximum displacement described in B8.11 and the air for all engines must pass through a single air intake restrictor (see B8.6, "Intake System Restrictor.")

B8.1.4 Hybrid powertrains utilizing on-board energy storage are allowed.

B8.1.5 Electric only or hybrid vehicles which use Electric as there prime means of propulsion e.g. electric / hydraulic and series hybrids as well as parallel hybrids are allowed. Note: the price limit of $6,000 for any electric accumulator as per the Formula Hybrid rules will **not** apply in Formula Student.

B8.5 Throttle and Throttle Actuation

B8.5.1 Carburettor/Throttle Body
The car must be equipped with a carburettor or throttle body. The carburettor or throttle body may be of any size or design.

B8.5.2 Throttle Actuation
The use of electronic throttle control (ETC) or "drive-by-wire" is allowed in Class 1A, however strict regulations apply to such systems as described in Article B19.

B8.5.3 Any throttle cable or rod must have smooth operation, and must not have the possibility of binding or sticking.

B8.5.4 When a purely mechanical throttle is used, the throttle actuation system must use at least two (2) return springs located at the throttle body, so that the failure of any component of the throttle system will not prevent the throttle returning to the closed position.

Note: Throttle Position Sensors (TPS) are NOT acceptable as return springs.

B8.5.5 Throttle cables must be at least 50.8 mm (2 inches) from any exhaust system component and out of the exhaust stream.

B8.5.6 A positive pedal stop must be incorporated on the throttle pedal to prevent over stressing the throttle cable or actuation system.

B8.6 Intake System Restrictor

B8.6.1 In order to limit the power capability from the engine, a single circular restrictor must be placed in the intake system between the throttle and the engine and all engine airflow must pass through the restrictor.

B8.6.2 Any device that has the ability to throttle the engine downstream of the restrictor is prohibited.

B8.6.3 The restrictor must have a maximum diameter of:
- Gasoline fueled cars – 12.9 mm (0.508 inch)
- E-85 fueled cars – 12.3 mm (0.483 inch)
- Diesel fueled cars – no inlet restrictor required
- LPG fuelled cars – 13.4 mm (0.527 inch)
- CNG fuelled cars – 13.8 mm (0.543 inch)
- Hydrogen fuelled cars – no inlet restrictor required

B8.6.4 The restrictor must be located to facilitate measurement during the inspection process.

B8.6.5 The circular restricting cross section may NOT be movable or flexible in any way, e.g. the restrictor may not be part of the movable portion of a barrel throttle body.

B8.6.6 If more than one engine is used, the intake air for all engines must pass through the one restrictor.

B8.14 Powertrain System location

B8.14.1 All Power train System components must lie within the surface defined by the top of the roll bar and the outside edge of the four tires. (See 2010 FSAE rules Figure 13).

B8.14.2 Any fuel, compressed gasses, other energy storage media, HV systems and HV wiring must be contained within the primary structure of the frame and when located less than 350mm from the ground must be protected from side or rear impacts with a structure built to Rule B3.24 or B3.31 as applicable.

ARTICLE 9: FUEL AND FUEL SYSTEM – as per 2010 FSAE Rules except as follows

B9.1 Fuel available at the competition

B9.1.1 In addition to the fuel that is available for Class 1, the organisers will seek to secure the supply of appropriate fuels to support Class 1A but this cannot currently be guaranteed.

B9.1.2 Entrants should have a back up plan in mind for fuel supply.

ARTICLE 10: EXHAUST SYSTEM AND NOISE CONTROL – as per 2010 FSAE Rules except

Note: In principle Electric vehicles or vehicles that do not use a combustion engine do not need a noise test. The organisers do however reserve the right to test any vehicle that is deemed to be excessively noisy using an appropriate manner.

B10.2.4 Test Speeds

The test speed for a given engine will be the engine speed that corresponds to an average piston speed of 914.4 m/min (3,000 ft/min) for automotive or motorcycle engines, and 731.5 m/min (2,400 ft/min) for diesel engines and “industrial engines”. The calculated speed will be

rounded to the nearest 500 rpm. The test speeds for typical engines will be published by the organisers.

An “industrial engine” is defined as an engine which, according to the manufacturer’s specifications and without the required restrictor, is not capable of producing more than 5 hp per 100cc. To have an engine classified as “an industrial engine”, approval must be obtained from organisers prior to the Competition.

ARTICLE 11: ELECTRICAL SYSTEM (12V) – as per 2010 FSAE Rules for all low voltage electrical systems (<30V) except

B11.1 There must be a minimum of three shutdown buttons (Master Switches), one on each side of the car just behind the driver’s compartment at approximately the level of the driver’s head, and one on or near the instrument panel easily reachable by the driver.

These buttons, when pushed, must break the flow of current holding the accumulator isolation relays closed, and shut down the engine and any other energy generation systems and disconnect the Low Voltage systems from the LV battery.

If the vehicle has electronic systems normally powered by the LV system, but with internal power backup, then these systems must be fitted with isolation diodes to prevent them from routing power back into a de-energized vehicle.

Once pushed, these buttons must stay in until manually pulled outward to reset the system. The two outer buttons must be red, 60 mm (2.4 inch) diameter (Omron A22E-LP-012 or equivalent) the driver’s shutdown button must be red, with a minimum diameter of 25.4 mm (1 inch).

A HV shutoff which disables the High Voltage must be fitted to allow work to be done on other systems on the vehicle. The HV shutoff must be fitted with a "lockout/tagout" capability to prevent accidental activation of the High Voltage system. The HV shutoff must either interrupt current to the HV isolation relays or directly disconnect the HV circuit. This system must be used whenever work is done on the vehicle.

ARTICLE 12: AERODYNAMIC DEVICES – as per 2010 FSAE Rules

ARTICLE 13: COMPRESSED GAS SYTEMS AND HIGH PRESSURE HYDRAULICS

B13.1 Compressed Gas Cylinders and Lines

B13.1.1 Any system on the vehicle that uses a compressed gas as an actuating medium must comply with the following requirements:

a. Working Gas-The working gas must be nonflammable, e.g. air, nitrogen, carbon dioxide.

b. Cylinder Certification- The gas cylinder/tank must be of proprietary manufacture, designed and built for the pressure being used, certified by an accredited testing laboratory in the country of its origin, and labelled or stamped appropriately.

c. Pressure Regulation-The pressure regulator must be mounted directly onto the gas cylinder/tank.

d. Protection – The gas cylinder/tank and lines must be protected from rollover, collision from any direction, or from damage resulting from the failure of rotating equipment.

e. Cylinder Location- The gas cylinder/tank and the pressure regulator must be located either rearward of the Main Roll Hoop and within the envelope defined by the Main Roll Hoop and the Frame (see B.3.2), or in a structural side-pod that meets the requirements of B.3.24 or B.3.31. It must not be located in the cockpit.

f. Cylinder Mounting- The gas cylinder/tank must be securely mounted to the Frame, engine or transmission.

g. Cylinder Axis- The axis of the gas cylinder/tank must not point at the driver.

h. Insulation- The gas cylinder/tank must be insulated from any heat sources, e.g. the exhaust system.

i. Lines and Fittings- The gas lines and fittings must be appropriate for the maximum possible operating pressure of the system.

B13.1.2 Any gas system on the vehicle that is used as a means of propulsion or energy source (eg to charge a battery through a fuel cell) must comply with the following requirements:

a. Working Gas -The working gas may be flammable, but only if it is to be burned or used for the sole means of propulsion of the vehicle.

b. Cylinder Certification- The gas cylinder/tank must be of proprietary manufacture, designed and built for the pressure being used, certified by an accredited testing laboratory in the country of its origin, and labelled or stamped appropriately. The following standard for composite cylinders applies: ISO11439 for hydrogen containers or NGV1 or ECE-R110 for natural gas, methane or similar gases.

c. Pressure Regulation- Where cylinders are interchangeable the pressure regulator must be mounted directly onto the gas cylinder/tank. If the vehicle is to be refuelled with the cylinder onboard the vehicle, the cylinder must be fitted with an internal solenoid, supplied by Dynetek or Teleflex GFI, this must be followed by an excess flow valve prior to fitting of a regulator. The inlet to the solenoid must be directly coupled to a check valve, with a cracking pressure no greater than 1 psi to ensure gas flow may only flow out of the cylinder via the regulator.

d. Protection – The gas cylinder/tank and lines must be protected from rollover, collision from any direction, or from damage resulting from the failure of rotating equipment. It is advised ECE-R110 documents are consulted for recommendations regarding the safe installation of gas systems.

e. Cylinder Location- The gas cylinder/tank and the pressure regulator must be located either rearward of the Main Roll Hoop and within the envelope defined by the Main Roll Hoop and the Frame (see B.3.2), or in a structural side-pod that meets the requirements of B.3.24 or B.3.31. It must not be located in the cockpit.

f. Cylinder Mounting- The gas cylinder/tank must be securely mounted to the Frame, engine or transmission.

g. Cylinder Axis- The axis of the gas cylinder/tank must not point at the driver.

h. Insulation- The gas cylinder/tank must be insulated from any heat sources, e.g. the exhaust system.

i. Lines and Fittings- The gas lines and fittings must be appropriate for the maximum possible operating pressure of the system and must be assembled according to manufacturer's recommendations. As part of the risk assessment for gas systems teams must:

- Provide gas system diagrams.
- Provide details of all components used in the system so that they can be approved by the rules committee. (These can be approved prior to submission of the risk assessment if required)
- Provide details of proof testing for pressurisation of the whole system to working pressure in addition to a leak test on all fittings. (if the testing is not conducted before the risk assessment is complete then this information must be available at scrutineering).

j. The maximum allowable storage pressure is 350 bar.

k. All gas cylinders, regulators, solenoid valves and other equipment exposed to pressurized gas must be appropriately certified for use with the gas being used and the pressure that they are being used at.

l. Where vehicle refuelling is to be carried out onsite the following cylinder connections are to be used:

-350 bar hydrogen: SAE J2600-H35 and ISO 17268

-200 bar CNG: ISO 14469

ARTICLE 14: FASTENERS – as per 2010 FSAE Rules

ARTICLE 15: TRANSPONDERS – as per 2010 FSAE Rules

ARTICLE 16: VEHICLE IDENTIFICATION

B16.1 Car Numbers as per 2010 FSAE regulations except

B16.1.4 The type of primary propulsion system being used by the cars must be clearly obvious to the marshals at the event in order that they can deal efficiently with any problems. This will be done by means of the numbers allocated to the cars which will follow the numbering scheme shown below.

B16.1.5 In front of the number, the power type will be written in letters not less than 15cm high in the same colour as the numbers. e.g.

Numbering System:
Petrol – P-5XX
Diesel – D-5XX
LPG – L-5XX
CNG – C-5XX
E85 – A-5XX

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Hydrogen – H-5XX
Electric – E-5XX

Hybrids must use both of the letters which represent their power type.

ARTICLE 17: EQUIPMENT REQUIREMENTS – as per 2010 FSAE Rules / FS Supps

ARTICLE 18: HIGH VOLTAGE ELECTRICAL SYSTEMS

Note: It is strongly recommended that teams follow recognised standards and guidelines when designing and construction their vehicle. The recommended standards are contained in Appendix C and should be complied with wherever possible. Disregarding these engineering and construction practices can cost a team design points. Where there are differences between these guidelines and the Formula Student Class1A rules, the Formula Student Class1A rules will take precedence.

B18.1 Definition of High voltage system

High Voltage is defined as any system (individually or in series) containing or producing a voltage greater than 30V.
Note: All Teams using HV systems must complete a risk assessment (B20)

B18.2 High-Voltage (HV) Isolation

There must be no connection between the frame of the vehicle (or any other conductive surface that might be inadvertently touched by a crew member or spectator), and any part of any HV circuits. HV and low-voltage circuits must be physically segregated such that:

- They are not run through the same conduit.
- Where both are present within an enclosure, separated by insulating barriers such as Nomex, Formex, or other moisture resistant, UL recognized insulating materials.
- If both are on the same circuit board, they must be on separate, clearly defined areas of the board.

B18.3 Ground Fault Detectors

B18.3.1 All vehicles shall be equipped with an on-board Ground Fault detector. This must be a Bender IR125, IR475LY3 or equivalent if approved by the organisers. The output relay of this device must be wired in series with the shutdown buttons such that a ground fault will cause an immediate shutdown of all electrical systems. The ground fault detector should be accessible, or have a remote LED indicator to show when it has tripped. See the Formula Hybrid website for more information

B18.3.2 Ground Fault Detector Test will be tested during technical inspection, by connecting, a 40,000 Ω resistor between multiple points on the HV circuit and the grounded frame with the HV systems at full charge (See Figure 1). This must cause the Ground Fault detector to trip, and the vehicle electrical systems to shut down within 10 seconds.

B18.3.3 This test may be repeated by the electrical inspectors at any time during the competition.

B18.3.4 Once the Ground fault test has been satisfactorily completed, the scruitineers will seal the High Voltage enclosures. If the seals are broken, the vehicle may not participate in any dynamic events until the Ground Fault test has been satisfactorily re-done. (If a repair is simple, and done in the presence of an Electrical Inspector, the Chief Electrical Inspector may choose to waive the re-testing requirement.)

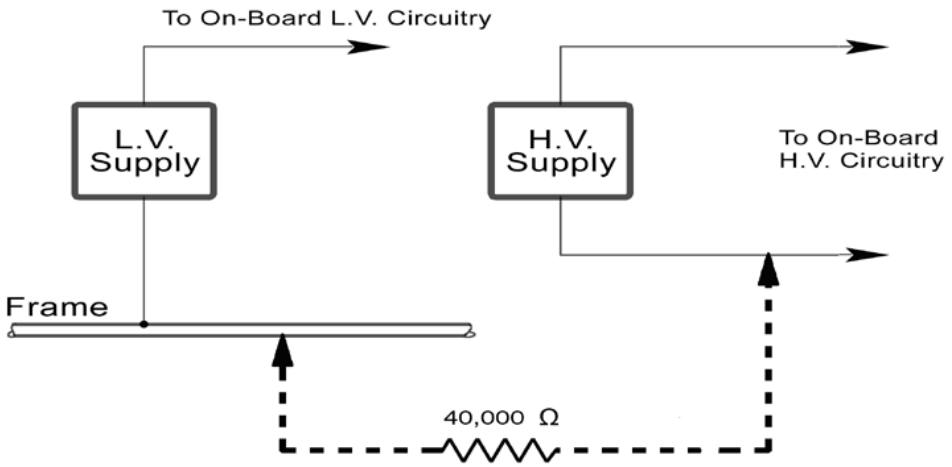

Figure 1 – Ground Fault Test

B18.4 Rain Certification

B18.4.1 All vehicles running HV systems must be rain certified

B18.4.2. To become Rain Certified, a vehicle must first pass the Ground Fault test outlined in B18.3.2. It must then survive a 30 second water spray with all systems energized without tripping the Ground Fault Detector. The water spray will be directed from the top, front and sides of the vehicle. The spray is intended to simulate rain and will typically have drops ranging in size between 0.1 to 5 mm in diameter. A strong stream of water will not be directed at the vehicle.

B18.5 No Exposed HV Connections

B18.5.1 There must be no exposed HV connections.

B18.5.2 Non-conductive covers must prevent inadvertent human contact with any HV. This must include crew members working on or inside the vehicle. Covers must be secure and adequately rigid. Body panels that must be removed to access other components, etc. are not a substitute for enclosing HV connections.

B18.5.3 HV systems and containers must be protected from moisture in the form of rain or puddles for any car that is certified to run rain or wet conditions.

B18.5.4 There will be no HV connections behind the instrument panel or any cockpit switch or control panels.

B18.5.5 All controls, indicators and data acquisition connections must be isolated using optical isolation, transformers or the equivalent.

B18.5.6 Any components (eg. Electronic throttle or regenerative controls) carrying high voltage must be mounted outside the cockpit area. Any mechanical components that connect to these HV components must be either be non-conductive or well-grounded.

B18.6 HV Insulation, Wiring and Conduit

B18.6.1 All insulation materials used in HV systems must be rated for the maximum temperatures expected.

B18.6.2 Insulated wires must be commercially marked with a wire gauge, temperature rating and insulation voltage rating. Where short sections of cable are used, it is allowable to provide to the scrutineers a section of equivalent cable which contains these markings. Other insulation materials must be documented.

B18.6.3 All HV wiring must be done to professional standards with appropriately sized conductors and terminals and with adequate strain relief and protection from loosening due to vibration etc.

B18.6.4 All HV wiring that runs outside of electrical enclosures must be enclosed in orange non-conductive conduit, such as Electri-flex LNMP or equivalent. The conduit must be securely anchored at least at each end, and must be located out of the way of possible snagging or damage.

B18.7 Fusing

All electrical systems (both low and high voltage) must be appropriately fused. Any wiring protected by a fuse must be adequately sized and rated for current equal to the fuse rating (See wire requirements in B18.6)

The continuous current rating of a fuse must not be greater than the continuous current rating of the smallest wire it protects. All fuses must be rated for the highest voltage in the systems they protect. Fuses used for dc must be rated for dc, and must carry a dc rating equal to or greater than the system voltage Appendix A.

If multiple parallel strings of batteries or capacitors are used then each string must be individually fused. If individual fuses are used this will provide a total fusing equal to the number of fuses multiplied by the fuses rating. Any wires conducting the entire pack current must be appropriately sized to this total fusing or an additional fuse used to protect the wiring.

Multiple parallel fuses in a single string are not permitted.
Starter Motor wiring (Battery/Relay/Motor) is not required to be fused.

B18.8 Accumulator Type and Size

B18.8.1 Total accumulator voltage may not exceed 400V.

B18.8.2 Accumulator capacity may not exceed 7,250 Wh for electric only vehicles as specified in B18.8.5.

B18.8.3 For vehicles which are Hybrids or have alternative power sources to the accumulator, the accumulator capacity must not exceed 4,449 Wh as specified in B18.8.5.

B18.8.4 Teams must state, as accurately as possible, their accumulator capacity. Energy accumulators must be of an approved type. Batteries and capacitors are approved accumulators. A team must gain approval for any other types of accumulator.

B18.8.5 The following equations must be used to determine accumulator size Where C, Vnom, Vpeak and Ah are device nameplate values:

:

Batteries**:**

$$Energy(Wh) = (Vnom)(Ah)(0.8)$$

Capacitors

$$Energy(Wh) = \left(\frac{C(Vpeak^2 - V\min^2}{2} \right) * 3600$$

where V*min* is assumed to be 10% of Vpeak.

B18.9 Energy Storage Container Electrical Configuration

B18.9.1 All energy storage must be in closed containers containing normally open isolation relays on both positive and negative sides of the storage device wired in such a way that when an incoming energize signal is interrupted there is no HV connection to the outside of the containers.

B18.9.2 The boxes must also include an appropriately rated fuse or circuit breaker.

B18.9.3 The relays must be rated to interrupt the rated fuse current at the maximum expected voltage.

B18.9.4 Contactors and relays containing mercury are not permitted.

B18.9.5 Multiple energy storage containers connected in parallel or series may be used however the following requirements must be met:

a. There must be a contactor at both the positive and negative terminal of each energy storage container such that no voltage is present outside of any energy storage container once the contactors are de-energised.
b. HV electrical connections between the containers must be protected by non-conductive conduit (See Section B18.6) anchored solidly to the containers.
c. The cables must be contained within the primary structure of the chassis.

B18.9.6 All voltages outside the energy storage container must decay to below 30 V within ten seconds of when the relays are disconnected. For example, filter capacitors must have bleeder resistors across them.

B18.9.7 The power supply for the HV accumulator relays must only be active when the motor safety system has a 12V power supply and all other systems including driver controls are switched to enable them to be activated. Where the motor controller(s) require a 12V power supply this must also be active before the accumulator relays can be powered. The power supply must be configured so that it can be interrupted by any of the 3 master switches, the required interlocks on any of the HV cable connections between the HV accumulator and motor controller(s), the ground fault detector, the brake over-travel switch and the relay power controller (B19.4).
Note: the motor safety system could be a switched controller using a set of relays or an ECU within the motor controller or an ECU external to the motor controller. In each case, this device must receive and interpret all of the signals which determine whether it is safe to activate the accumulator's relays.

B18.9.8 It must only be possible to close the accumulator relays once the HV cables are connected correctly between the accumulator and the motor controller. If the cable is not connected to the motor controller, or a connector on the cable is not connected then an interlock in the power supply to the accumulator relays must be broken.

B18.9.9 There are many conditions which must result in the HV accumulator contactor relays being opened. These conditions must be covered in the risk assessment. For example, for a HV Battery, these conditions include but are not limited to:

a. Over current
b. Cell voltage too high
c. Cell voltage too low
d. Cell temperature too high

B18.9.10 The energy storage containers must have closable access ports allowing a 6" electrical probe to make contact with each extreme of the HV system on the motor controller side of the contactor relays. These will be used to permit testing the isolation stipulated in section B18.3. Optionally, access to the same electrical nodes may be provided at another point.

Note: Standard measurement probes compatible with a Fluke 88V DVM will be used i.e.: Fluke TP220 Industrial Test Probes
http://metersandtools.com/Fluke-88VA-Automotive-Multimeter-Combo-Kit/M/B000WTB67K.htm

B18.9.11 Each energy storage container must have a prominent indicator to warn of HV.

For a capacitor accumulator, each energy storage container must have a prominent indicator, such as an LED that will illuminate whenever that container contains a voltage greater than (at a maximum) 30V. This must be clearly visible in direct sunlight. As an alternative, the accumulator container may contain an "embedded" analog meter clearly visible from the outside.

For a battery accumulator, each energy storage container and each battery pack contained within a container must have a label at least 200 cm^2 with the text "High Voltage ALWAYS ENERGIZED"

B18.10 Energy Storage Container Mechanical Configuration

B18.10.1 The energy storage container and mounting system must be sturdy, considering forces encountered during on-course competition and the possibility of a rollover accident. The mounting system must be designed to withstand forces from a 20g deceleration such that the HV system does not enter the cockpit area. The materials used to construct the container must be electrically insulating, mechanically robust, and ideally transparent to allow easy inspection. Not all of these properties are available in a single material, but the following are required:

- At least one layer of fireproof material between the driver and the energy storage container.
- Mechanically robust, fireproof insulating material (e.g., Nomex) between live electrical parts and any conductive portions of the container.
- Adequate structural robustness for the weight of the accumulator.

B18.10.2 Any energy storage container, HV system wiring and HV system components must be contained within the major structure of the frame and if positioned below 350mm from the ground must be protected from impact by another vehicle by structure meeting FSAE rule B3.24 or B3.31.

B18.10.3 There must be no unintentional electrical conduction paths through any of the walls of the container. (Metal screws, rivets, etc.)

B18.10.4 The container must be prominently labelled with high voltage signs, at least 200 cm^2, with a red (or white on red) lightning bolt. Containers which hold Batteries must be labelled with the text as defined in B18.9.11. Containers which hold capacitors must be labelled with the text —High Voltage or —Danger High Voltage.

B18.10.5 Systems capable of venting H_2 gas (batteries) must have an active ventilation system that is active whenever the system is charging, whether from on-board or off-board sources.

B18.11 Grounding

B18.11.1 All conductive HV electrical cases (for example the motor, motor controller case or heat sinks) must be grounded to a common point on the chassis

B18.11.2 All car components (eg. chassis and suspension) must be electrically connected so that there can be no electrical potential difference between them.

B18.12 Low-Voltage Circuits

B18.12.1 Low-voltage (< 30 V) circuits must be grounded to the frame of the car. (This ensures that, in the event of a fault in the isolation of the HV circuit, no HV will be present between controls or anything else that personnel might touch and the frame.) If the low-voltage circuits are powered by a

battery or other source that is not inherently current limited, proper fusing must be used.

B18.12.2 Low-voltage and HV circuits must be segregated and isolated as described in Section B18.2

B18.12.2 The capacity of the Low Voltage battery need not be included in the overall vehicle accumulator capacity calculations.

B18.13 Charging Equipment

B18.13.1 All charging equipment must be maintained in safe working condition.

B18.13.2 High Voltage chargers and/or power supplies must be marked with appropriate High Voltage stickers.

B18.13.3 If any voltage remains outside the charger after the power is turned off then any open connections must be securely covered.

B18.13.4 All chargers must be UL (Underwriters Laboratories) listed. The vehicle must be de-energized while charging from external sources (as much as possible while still allowing charging), and no other activities (including any mechanical or electrical work) shall be allowed.

B18.13.5 When the on board accumulator is recharging with an off board charger, the chassis of the vehicle and the external charger must share a common earth. This Earth connection must be made before the energy storage unit is allowed to recharge

B18.14 Warning Strobe Light

There must be an amber strobe light compliant with SAE Standard J1318 Class 3 (Federal Signals Renegade®, Star Warning Systems 200Z or equivalent) mounted on the highest point on the roll bar, that will indicate when a vehicle is energized. Energized is defined as any time a High Voltage exists outside the accumulator containers.

ARTICLE 19: VEHICLE CONTROL SYSTEMS

B19.1 Drive by Wire systems - Drive-by-wire systems which control the power delivered to the wheels electronically will be allowed in Class 1A. The functioning of such systems must be covered by a risk assessment (B20) Note: Front wheel steer-by-wire systems will not be allowed as per rule B3.2.4.

B19.2 At least three mechanical actions are required to make the car move under its own power

For example on an electrically (or hybrid electric) powered car there might be the normal electrical master switch, a secondary ignition switch and the throttle pedal. The secondary ignition switch should latch off whenever the master switch is turned off.

B19.3 Two independent systems to shut off power

B19.3.1 There must be at least two completely independent systems to shut off power due to the throttle pedal being released or the brake pedal pushed.

(This is the equivalent of the current two throttle return springs rule as described in the FSAE rules). The functioning of these systems must be covered by a risk assessment (B20).

B19.3.2 The two systems must not share any components (such as sensors, actuators or electronic control boxes).

B19.3.3 The two systems must be independently demonstrated to the scrutineers before the car will be allowed to run (the Entrant must determine a method to perform this test).

B19.3.4 Any sensors included in these systems must have separate power and ground wiring.

B19.3.5 Where these systems rely on electrical sensors, these systems must be able to detect open circuit and short circuit faults on any signal wires or sensors such that any fault condition results in all power being turned off being shutdown.

B19.3.6 The above regulations are in addition to the brake over travel switch is still required for Class 1A cars and this must shut off all power.

B19.4 Actuator / Relay Power Controller / Datalogger

B.19.4.1 It is expected that a simple controller which will monitor control signals for faults and provide a method of logging electrical power used will be made available to teams at minimum cost, however it is possible that teams will be required to fulfil these requirements. Details any device or whether teams have to provide this will be displayed on the Formula Student website as soon as possible.
Note: this device in no way diminishes the team's responsibility to ensure that their own control systems function correctly and safely.

B19.4.2 Power to the drive by wire throttle controller, the HV contactor relays or any other drive by wire device must pass through a simple electronic controller.

B19.4.3 The controller will monitor the control sensors and will remove power to the drive by wire device in the event of a sensor failure.

B19.4.4 The controller sensors will be considered to have failed when they achieve an open circuit or short circuit condition which generates a signal outside of the normal operating range (typically < 0.5V or > 4.5V)

B19.4.5 It is intended that this device will log HV electrical current and voltage, however it may be necessary for teams to provide this information

B19.5 Maximum Electrical Power

B19.5.1 The maximum electrical power measured at the HV DC cables must not exceed 75kW at any time.

ARTICLE 20: REQUIREMENTS OF THE RISK ASSESSMENT

B20.1 Submission of a risk assessment - The Entrant will be required to

submit a risk assessment for the car covering all elements of technology that fall outside the normal FS regulations. This document must be signed by the safety officer. This risk assessment should be submitted at the same time as the SEF report. For each technology the organisers will supply a list of minimum areas to be covered in this risk assessment. A Risk assessment template will be provided on the Formula Student website.

B20.2 **Unusual aspects of design** - It is the responsibility of all entrants to discuss unusual aspects of the vehicle's design with the rules committee well in advance of the event to ensure that there are no significant problems at scrutineering.

B20.3 **Risk Assessment content** - Where appropriate, the following items must be included in the risk assessment:

a. Information on any changes to materials used (e.g. sealing devices) because alternate fuels are to be used.
b. Information on any system used which is allowed for Class 1A but not under FSAE rules (e.g. any system between the driver and supply or absorption of energy at the wheels, drive/brake by wire, etc.)
c. FMEA study to be conducted on any drive/brake by wire systems to ensure where practical all failure scenarios have been evaluated and accounted for
d. Where software is used this should be verified to comply with MISRA Guidelines published by MIRA [http://www.misra.org.uk/] or similar approved guidelines must be followed
e. Strategy and detail of short circuit protection and specific cooling systems (e.g. for electric batteries).
f. Appropriate emergency equipment (e.g. fire extinguishers)
g. Storage & Transportation of fuels.
h. Means of discharge of remaining fuel (included stored electricity for capacitors)
i. Procedures for working on systems outside of FSAE rules (e.g. HV electrical systems, hydrogen, etc) where appropriate
j. Training to be conducted with students for working on systems outside of FSAE rules (e.g. HV systems, etc) where appropriate.
k. An outline of the overall vehicle design covering in particular the powertrain systems that are being used.
l. Teams will be required to have a schematic of the high voltage system which clearly indicates the wire size/rating, fuse rating, enclosures, and the location of any isolation between the HV and LV systems of the car.
m. A detailed electrical schematic of the internal circuit of a major component in the HV system (e.g., a motor controller) is required if the circuit is designed by a team but is not required for purchased components.

2010 Formula Student Class 1(A) Rules
PART C – STATIC EVENT REGULATIONS

ARTICLE 1: STATIC EVENTS AND MAXIMUM SCORES

The maximum possible scores in the static events are:

Technical Inspection	No Points
Sustainability	100 Points
Presentation	75 Points
Design	150 Points
Total	325 Points

ARTICLE 2: TECHNICAL INSPECTION – as per 2010 FSAE Rules

ARTICLE 3: SUSTAINABILITY EVENT (REPLACES FSAE COST AND MANUFACTURING EVENT)

C3.1 Sustainability Event Objective and Rules

C3.1.1 The objectives of the sustainability event are:

a. To teach the participants that environmental impact is a significant factor that must be considered in any engineering exercise, particularly at the design stage. For the 2010 event the metrics used for assessing environmental impact are restricted to embodied energy and CO_2 in the materials used to manufacture the vehicle.
b. For teams to make trade off decisions between the performance advantage and environmental impact of each part and assembly.
c. To gain experience with creating and maintaining a Bill of Material (BOM).
d. For the participants to learn and understand the principles of Eco-Design.

C3.1.2 The objectives of the sustainability event rules are:

a. To provide a logical, simple and time-efficient rule set enabling students to achieve the event's objectives.
b. To improve fairness by providing consistent guidelines independent of teams' geographical location by using standardized material ecodata tables.
c. To require the minimal burden of supporting documentation such as material suppliers environmental data sheets. However, in some cases there may be unusual materials used in components such as batteries, ultra-capacitors, fuel cells and composites that are not covered in the standard tables. In this case participants are encouraged to source the relevant embodied energy and CO_2 information directly from the suppliers wherever possible and forward it to Formula Student Rules Committee for approval and inclusion in the materials database.

C3.2 Event Requirements

The event is comprised of three (3) parts:

C3.2.1 The preparation and submission of a report (the "Sustainability Report"),

which is to be sent to the Sustainability Judges prior to the competition. See C3.6.

C3.2.2 A discussion at the Competition with the Sustainability Judges around the team's vehicle. See C3.17. This evaluates not only the environmental impact of the car, but also the team's ability to prepare accurate impact estimates and assessments as part of the design process. Teams will be expected to demonstrate that they have performed trade-off analysis when selecting materials.

C3.2.3 A "real case" scenario where students will have to respond to a challenge related to the environmental impact of the student vehicle.

C3.3 Definitions

The following definitions will apply throughout the Sustainability Event rules:

C3.3.1 Adjusted Impact – The final score for the vehicle including penalties.

C3.3.2 Bill of Material – A hierarchical list of all parts of the vehicle. A BOM lists every item that is on the vehicle but also shows the relationships between these items, for example showing the parts that make up an assembly. An Impact Bill of Material (IBOM) is a standard BOM that includes embodied energy and CO_2 information for the materials that go into manufacturing the vehicle, a measure of the environmental impact of the components.

C3.3.3 Ecodata – Data relating to the properties of a material which have an impact upon the surrounding environment during its production, use and disposal, such as embodied energy/CO_2, toxicity, biodegradeable, renewable etc.

C3.3.4 Eco-Design – The process by which items are designed for minimum environmental impact by careful consideration of form and materials selection.

C3.3.5 Environmental Impact – For the purposes of the Class 1A Sustainability Event the environmental impact for each item is simply the mass of the constituent materials that make up that item multiplied by the unit energy and CO_2 values for those materials from the Sustainability Materials List.

C3.3.6 Initial Environmental Impact – The environmental impact of the vehicle submitted for initial judging in the Sustainability Report.

C3.3.7 Purchased Parts – Also called bought in parts; where possible, for commonly used parts such as tyres, these items are listed in the Sustainability Materials List in a near as-installed condition. In some cases purchased parts may still require additional processing before they can be assembled to the car, which may affect the final mass in the IBOM.

C3.3.8 Quantity – The amount of the item.

C3.3.9 Raw Materials – Materials used for manufacturing parts, such as aluminium, steel and rubber.

C3.3.10 Sustainability Materials List – Lists the mass-based embodied energy and CO_2 values for raw materials used to manufacture parts built by the teams, bought-in components where data is available and a class of residual material to cover bought-in components that cannot be easily accounted for due to a lack of material composition data The residual material is also used for calculating penalties.

C3.3.11 Sustainability Report – All materials submitted for judging.

C3.3.12 Sustainability Score – Refers to the total number of points out of 100 earned in the Sustainability Event.

C3.3.13 Unit – Is the measurement system used to define the quantity of a parameter. For example millimetres and kilograms are units.

C3.4 General Requirements:
The Sustainability Report must:

C3.4.1 Use the standardized Sustainability Materials List for raw materials.

C3.4.2 List every part on the prototype vehicle. This includes any equipment fitted on the vehicle at any time during the competition. The only exceptions are that, per C3.17.3 “Sustainability Report Exempt Items” of the Rules.

C3.4.3 Be based on the calculated environmental impact of materials used in the construction of the car. The impacts shall be calculated as defined in these rules.

C3.4.4 Exclude tooling, R & D and capital (e.g. moulds, jigs, plant, machinery, hand tools and power tools).

Note: There is no maximum environmental impact value.

C3.5 Scoring

The points for the Sustainability Event will be broken down as follows:

30x $\frac{kg_{min}}{kg_{your}}$ 30x $\frac{MJ_{min}}{MJ_{your}}$	60	Lowest energy/CO_2 - each of the participating schools will be ranked by total adjusted embodied energy and CO_2 from the IBOM and given 0-30 points for CO_2 and energy respectively, based on the formulae on the left.
	20	The Sustainability Report – written, professional presentation of embodied energy and CO_2 data. The report score will be given based on the quality of the report, its accuracy and thoroughness. The range for the report score is 0 –20 points.
	20	Event Day/Materials Selection - The teams must be prepared to discuss in detail the reasoning behind their materials selection and how they balanced technical performance against ecological impact.
Total	100 Points	

Where:
$kg(or\ MJ)_{your}$ is the adjusted CO_2/energy value of your car (with penalties).
$kg(or\ MJ)_{min}$ is the adjusted value of the car with the lowest embodied CO_2/energy (with penalties).

C3.6 Sustainability Report

C3.6.1 The Sustainability Report consists of a full vehicle IBOM with environmental impact data derived from the Sustainability Materials List and supporting documentation where appropriate. The Sustainability Report must be submitted in Excel spreadsheet (.xls only) format and must be identified as follows:

Carnumber_schoolname_competitioncode_SR.xls using the assigned car number, the complete school name and the competition code for the UK event (FS).

Example: 500_University of FSAE_FS_SR.xls.

C3.6.2 Sustainability Report Identification

The front page of the Sustainability Report must include the following:

a. University name.
b. Competition Name.
c. Vehicle Number.

C3.6.3 The Sustainability Report must consist of the following:

a. A Cover sheet.
b. An Environmental Impact Summary sheet listing each section's and the total vehicle's embodied energy and CO_2.

c. Nine (9) commodity report sections on separate worksheets with the parts placed in the sections as specified in Appendix D.

C3.6.4 Sustainability Report Template
The sustainability report must be constructed using the IBOM template provided for download on the Formula Student website. It is only permitted to enter data for vehicle components, it is not permitted to modify the sheet calculations which provide the sub-section and overall totals.

C3.7 Impact Bill of Materials (IBOM)
The IBOM is a parts list for every vehicle part. It also shows the relationships between the items.

C3.7.1 The following terminology will be used when referring to the IBOM.

a. The overall vehicle is broken down into nine (9) Systems which are defined in Appendix D.
b. Systems are made up of Assemblies.
c. Assemblies are made up of Parts.
d. Parts consist of materials.

C3.7.2 An example IBOM structure is shown below:

- Engine & Drivetrain……..…… System
  - Engine…… .....……... Assembly
  - Differential…… ….....…… Assembly
    - Housing…… ……..…… Part
      - Aluminium…… ….....…… Material
      - Needle Bearing…… ……..…… Material
      - M6x1.25 Grade 8.8…… .....…… Fastener
    - Internals…….. .....…… Part
    - End Cap…….....…… Part

The IBOM must follow the format given above. There must be no other IBOM levels added or any removed. Deviations from the structure published will be penalized per C3.14.

Note: Manufacturing processes are currently not considered for the Sustainability Report.

C3.8 The Sustainability Materials List
C3.8.1 All environmental impact figures in the Sustainability Report come from the standardized Sustainability Materials List. This list has been compiled to represent the average embodied energy and CO_2 values for raw materials and a limited number of bought-in components used in the manufacture of the vehicle.

C3.8.2 It should be noted that the ecodata provided is not precise in the same sense as other technical material properties such as stiffness and strength. Eco data is by its nature both regional and subject to variation over time as technology for material extraction and processing evolves. The figures quoted are the mean of available data where the max-min

may be a variation of +- 25%

C3.8.3 Requests to alter the embodied energy and CO_2 values of materials in the list because of changing technologies and processes will not be approved. The list is intended to provide a fair, unchanging (within a given competition year) environmental impact for materials and to reduce regional variations that may help or hurt certain teams. All teams must use the embodied energy and CO_2 values given in the list. If a team wishes to use any materials not included in the list an "Add Material Request" must be submitted to the Formula Student Rules Committee, see C3.10.

C3.8.4 The list represents embodied energy and CO_2 based on material mass.

Note: For bought-in items, such as tyres, the data is still presented on a unit-mass basis, not per component.

Note: To simplify the process of assessing the environmental impact of the vehicle it may be assumed that an IC engine/gearbox assembly is made of 25% aluminium and 75% steel by mass. Any team that wishes to individually assess the actual mass and material of the individual engine/gearbox components may do so.

C3.9 Make Versus Buy

Every part on an individual car can be classified as "made" or "bought". This designation does refer to whether a team actually purchased or fabricated a part.

C3.9.1 Made (or manufactured) parts must be assessed as if the company manufacturing the vehicle was going to make the part internally by purchasing and processing raw materials and into a finished product. Note, raw material left over from the manufacturing process, e.g. machining swarf, is not accounted for in the Sustainability Report, it is assumed that this material is collected and recycled.

C3.9.2 Bought parts must be assessed by determining the proportions of principal materials that make up the part and applying the appropriate figures from the Sustainability Materials List. It is assumed that these parts would be received by the vehicle manufacturer in a relatively finished state. Where the component supplier is able to provide documented evidence of embodied energy and CO_2 for the product used by the vehicle constructor these figures may be used. Copies of the supplier documentation must be included in the Sustainability Report and submitted to Formula Student Rules Committee for approval prior to the event.

C3.10 Add Material Request

C3.10.1 The Sustainability Materials List is intended to include all materials needed by the teams to accurately reflect the construction of their vehicle. However, it will be necessary to add materials to the list to suit individual team requirements. To do this an "Add Material Request" must be submitted to the Rules Committee at fsrules@imeche.org. After review the material will be added to the list with the next list update. The list will

be updated throughout the competition year as required.

Note: Since all teams work off the same list once a team requests an item or material be added to the list all teams will see the addition. Any team using the newly added item will use the same CO_2 and energy figures. The identity of the school that made the request will not be published.

C3.11 Report Submission and Deadline

C3.11.1 The Sustainability Report must be submitted in the designated format.

C3.11.2 Submission Deadline – The submission requirements and deadline will be released on the Formula Student website.

C3.12 Late Submission of the Sustainability Report

It is imperative that the Sustainability Judges have the Sustainability Reports in enough time for proper evaluation. Teams that submit reports late will be penalized 10 points per day late, with a maximum penalty of 80 points. Teams that do not submit a Sustainability Report will receive negative 100 points for the Sustainability Event. Penalties will be applied based on official upload date and time.

C3.13 Sustainability Report Judging and Penalties Process

C3.13.1 The following procedure will be used in determining penalties:

a. Penalty A based on IBOM accuracy will be calculated first using procedure C3.14.

b. Penalty B based on mass accuracy will then be calculated using procedure C3.15.

C3.13.2 Both of the two penalties will be applied against the Sustainability score

a. Penalty A expressed in points will be deducted from the Accuracy score
b. Penalty B expressed in MJ & kg will be added to the Initial Environmental Impact score

C3.13.3 If no additional points remain to be deducted from the Accuracy score the team will score zero for that part of the Sustainability Event.

C3.13.4 Any error that results in a team over-reporting the mass of components in their Sustainability Report will not be further penalized. For example, when the Sustainability Report is prepared the mass of the brake discs has not yet been determined. The team conservatively estimates the disc mass at 1kg each. The final mass is 0.8kg, the team's disc mass is higher than necessary but no further penalty is applied.

Note: The penalty system is intended to reward accuracy and minimize workload at the competition for students and judges.

Note: Any instance where a team's score benefits by an intentional or unintentional error on the part of the students will be corrected on a case

by case basis.

Note: Only four slick tyres must be included in the IBOM

C3.14 Penalty Method A – Fixed Point Penalty

C3.14.1 From the Bill of Material, the Sustainability Judges will determine if all parts have been included in the analysis. In the case of any omission or error the judges will add a penalty proportional to the IBOM level of the error. The following standard points deductions will apply:

a. Missing/inaccurate material, fastener……..…. 1 pt.
b. Missing/inaccurate part……..... 2 pt.
c. Missing/inaccurate assembly…….. 3 pt.

Note: Each of the penalties listed above supersedes the previous penalty. If a 3 point deduction is given for a missing assembly the missing parts are ignored for Method A. Method B would also include the environmental impact of the missing parts in the calculation.

C3.14.2 Differences other than those listed above will be deducted at the discretion of the Sustainability Judges.
Examples of errors leading to points deductions:

a. Upright shown in IBOM as aluminium but actual part is steel.....1 pt.
b. 5 taper-roller bearings listed, 6 used.....2 pt.
c. Pneumatic shifter not included on IBOM.....3 pt.

C3.15 Penalty Method B – Adjusted Impact Penalty

C3.15.1 The penalty will be calculated using the mass of the vehicle as measured at technical inspection, after passing scrutineering, with no fuel or water (assuming the car requires water). Drivetrain lubricating oil, hydraulic oil such as brake fluid, damper oil etc does not need to be drained and must be accounted for in the IBOM.

C3.15.2 If the IBOM total mass is higher than that measured at technical inspection the IBOM figure is used unchanged.

C3.15.3 If the IBOM total mass is lower than that measured, the difference will be added to the IBOM value and the residual material category from the Sustainability Materials List will be used to establish appropriate energy and CO_2 penalty values.

C3.15.4 It is anticipated that the team may have to make use of the residual material category to account for some bought-in components where the material composition cannot be accurately determined. At the event the Sustainability Judges will continue to use the residual material ecodata when calculating mass-based penalties.

C3.16 Penalty Calculation Example

C3.16.1 For example the pneumatic shifter was inadvertently left off the Sustainability Report. As this is an assembly the standard error is 3 points off the accuracy score.

C3.16.2 The car is weighed at technical inspection at 200kg, but the IBOM total mass is 195kg.. Consequently the 5kg difference between IBOM and measured mass is added to the total impact using energy and CO_2 values from the residual material ecodata.

C3.17 Discussion at the Competition

C3.17.1 At this discussion, the Sustainability Judges will:

a. Review whether the specification of the vehicle in the Sustainability Report accurately reflects the vehicle brought to the Competition.
b. Assess penalties for missing or incorrect information in the Sustainability Report compared to the vehicle presented at inspection.
c. Challenge the team to explain their design methodology in the context of the Sustainability Event.

C3.17.2 The team must present their vehicle at the designated time to the Sustainability Judges for review of the Sustainability Report. Teams that miss their Sustainability Event appointment will potentially lose all Sustainability points for that day. The schedule for these appointments will be in the registration packets and/or posted on the website.

C3.17.3 Sustainability Report Exempt Items
The Sustainability Report will account for all parts fitted to the car. The IBOM must be an accurate reflection of the car in a ready-to-run condition, with three exceptions:

a. Plumbed-in fire extinguisher system
b. Cooling system water (if utilised)
c. Fuel

Note: On-board fire extinguisher systems do not have to be removed for vehicle weighing at technical inspection. Teams are expected to provide an accurate mass for the extinguisher system, to be subtracted from the overall vehicle mass. If the Sustainability Judges consider the declared mass to be inaccurate teams may be requested to remove the system from the car for independent weighing

Note: Data logging equipment and systems are to be included in the IBOM. A category is given in the Sustainability Materials List to cover small bought-in electrical items, such as hand-held GPS receivers and sensors, which cannot easily be taken apart for constituent part weighing.

Note: Any fuel on board at technical inspection weighing will be counted towards the overall vehicle mass and impact score.

C3.18 Unit Systems

The 'currency' of the Sustainability Report will be referred to as megajoules (MJ) of energy and kilograms (kg) of CO_2.

C3.18.1 The Sustainability Materials List is presented using metric units.

C3.18.2 The comment section for each IBOM item may, at the student's discretion, refer to the specific part by actual local designation. For example a 6.35mm bolt is assessed but the comments would say "¼ inch A-arm bolt".

C3.18.3 Because the Sustainability Report reflects an environmental impact for 1000 units per year all materials and components are assumed to be available for the necessary volume without embodied energy or CO_2 penalty.

C3.19 Examples

An example IBOM will be posted to the Formula Student website. This must be used as the master template, with all example data removed before submission.

ARTICLE 4: PRESENTATION EVENT – as per 2010 FSAE Rules

ARTICLE 5: DESIGN EVENT – as per 2010 FSAE Rules

2010 Formula Student Class 1(A) Rules
PART D – DYNAMIC EVENT REGULATIONS

ARTICLE 1: DYNAMIC EVENTS AND MAXIMUM SCORES – as per 2010 FSAE Rules except

The maximum scores in the dynamic events are:

Acceleration	75 points
Skid Pad	50 points
Autocross	150 points
Fuel Economy / CO_2 emissions	200 points
Endurance	200 points
Total	675 points

ARTICLE 2: WEATHER CONDITIONS – as per 2010 FSAE Rules

ARTICLE 3: RUNNING IN RAIN – as per 2010 FSAE Rules

ARTICLE 4: DRIVER LIMITATIONS – as per 2010 FSAE Rules

ARTICLE 5: ACCELERATION EVENT – as per 2010 FSAE Rules

ARTICLE 6: SKID-PAD EVENT – as per 2010 FSAE Rules

ARTICLE 7: AUTOCROSS EVENT (known and SPRINT EVENT in UK Motorsport) – as per 2010 FSAE Rules

ARTICLE 8: ENDURANCE AND FUEL ECONOMY – as per 2010 FSAE Rules except for the following

D8.4 Endurance Objective—200 points

The Endurance Event is designed to evaluate the overall performance of the car and to test the car's durability and reliability.

D8.5 Fuel Economy / CO_2 Emissions —200 points

D8.5.1 For Class 1A the fuel consumption of the cars during the endurance event will be measured and this number will be converted to a figure representing CO_2 released to the atmosphere. The winner of the fuel economy / CO_2 emissions event will be the car that released the least CO_2.

D8.9 Endurance Fuel Fill

D8.9.1 For liquid filled vehicles, before entering the event each vehicle's fuel tank must be filled to the fuel level line (see Rule B – 9.6.6, "Fuel Level Line") at the fuelling station. During fuelling, once filled to the scribe line, no shaking or tilting of the tank or fuel system (incl. entire vehicle) is allowed.

D8.9.2 For electric powered or electric hybrid vehicles, the energy used during the endurance event will be measured by determining the state of charge of the battery before and after the event. Alternative methods may be developed by measuring the electrical current and voltage directly

D8.9.3 Competitors will be asked to make a battery or at a minimum battery characteristics available shortly before the event for determination by the organisers of its fully charged capacity.

D8.9.4 Series hybrid electric cars such as those powered by hydrogen fuel cells will also need to demonstrate that the on board battery is charged to the same state at the end of the event as at the beginning or separately account for the electrical energy used.

D8.18 Endurance Scoring

D8.18.1 The score for the Endurance Event is the sum of the Endurance Time Score and the Endurance Finish Score.

D8.18.2 The Endurance Time Score is based on the team's time for the event, including penalties, compared to the fastest team.

D8.18.3 A car will also receive an Endurance Finish Score of fifty (50) points if the team's time for the event, including penalties, is less than or equal to the maximum allotted time.

D8.19 Endurance Scoring Formula

D8.19.1 The times for the endurance event will be based upon the sum of the times of each driver in the heat plus penalties.

D8.19.2 The following equation is used to determine the time scores for the event:
If **Tyour** is < or = to **Tmax** :

$$\text{ENDURANCE SCORE} = 150 \times \frac{(Tmax/Tyour) - 1}{(Tmax/Tmin) - 1} + 50$$

If **Tyour** > **Tmax**: ENDURANCE SCORE = 0 (ZERO)

Tmin will be the lowest corrected time of the fastest team of the event.

Tyour will be the combined corrected times of both of your team's drivers in the heat.

Tmax *will be 1.45 times Tmin*.

D8.19.3 If, in the opinion of the officials, course conditions change significantly during the running of the event then they may, at their sole discretion, set Tmax to a higher value.

D8.20 Fuel Economy / CO_2 emissions

The Fuel Economy score is based on the average kg CO_2 per kilometer obtained during the endurance heat.

Teams are advised that the fuel economy score is based only on the distance cars run on the course during the endurance event. Although the starting line, exit line and the driver change zone increase the actual distance a car must drive during the event, those distances are not factored into the fuel economy calculations. Additionally fuel consumption adjustments will not be made for engine running in the entry/exit lines, during driver change, in the penalty box or for any on-course incidents.

D8.21 CO_2 Conversion Factors

The mass of CO_2 released to the atmosphere will be assessed by using the conversion factors below from quantity of fuel used to CO_2 released. The factors are intended to represent the average UK supply of the appropriate commodity and the organisers will not take account of where the actual fuel used came from.

Unleaded petrol – 2.3 kg of CO_2 per litre
Diesel – 2.63 kg of CO_2 per litre
Electric – 0.65 kg of CO_2 per kWh
E85 – 1.64 kg of CO_2 per litre
LPG – 1.60 kg of CO_2 per litre
CNG – 2.90 kg of CO_2 per kg
Hydrogen – 7.90 kg of CO_2 per kg

Note: the Electric energy value includes the anticipated charging losses if the pack is charged over 2hours.

D8.22 Fuel Economy / CO_2 Emissions Scoring Formula

D8.22.1 If CO2your is less than CO2max then the following equation will be used to determine the fuel economy/CO2 emissions score:

$$\text{FUEL ECONOMY SCORE} = 200 \times \left(\frac{(CO2\max - CO2your)}{(CO2\max - CO2\min)} \right)$$

If Vyour is greater than Vmax then the following equation will be used to determine a negative fuel economy score:

$$\text{FUEL ECONOMY SCORE} = -100 \times \left(\frac{(CO2your / CO2\max) - 1}{0.33} \right)^{1.5}$$

Where:
CO2max is the mass of CO_2 that is emitted to atmosphere and is equivalent to consumption of petrol at 14.82 liters/ 100 km. Note - For an Endurance Event distance of exactly 22 km, CO2max is 7.5kg
CO2min is the smallest volume of fuel used by any competitor
CO2your is the volume of fuel used by the team being scored

D8.22.2 Vehicles where CO_2 emissions exceed CO2max by 33% will score negative one hundred (-100) points.

D8.22.3 Vehicles whose corrected time exceeds 1.45 times the corrected time of the fastest team, will receive zero (0) points for fuel economy.

D8.22.4 For shortened courses, CO2min will be the low value per heat.

D8.22.5 Fuel economy scores can range from negative one hundred (-100) to positive two hundred (200) points.

D8.22.6 The minimum combined score for the endurance and fuel economy event will be zero (0) points.

ARTICLE 9: FLAGS – as per 2010 FSAE Rules

ARTICLE 10: RULES OF CONDUCT – as per 2010 FSAE Rules

ARTICLE 11: GENERAL RULES – as per 2010 FSAE Rules

ARTICLE 12: PROTESTS – as per 2010 FSAE Rules

ARTICLE 13: PIT RULES – as per 2010 FSAE Rules

ARTICLE 14: DRIVING RULES – as per 2010 FSAE Rules

ARTICLE 15: DEFINITIONS – as per 2010 FSAE Rules

Appendix A - Wire Current Capacity (DC)

Wire AN gauge Copper	Wire Area (Thousands of circular Mils)	Max. Fuse Continuous Rating
24		5
22		7
20		10
18		14
16		20
14		28
12		40
10		55
8		80
6		105
4		140
3		165
2		190
1		220
0		260
2/0		300
3/0		350
4/0		405
	250	455
	300	505

Appendix B - Required Equipment

Fire Extinguishers
Minimum Requirements
Each team must have at least two (2) 2.3 kg (5 lb.) dry chemical (Min. 3-A:40-B:C) Fire extinguishers
Extinguishers of larger capacity (higher numerical ratings) are acceptable.
All extinguishers must be equipped with a manufacturer installed pressure/charge gauge.
Special Requirements
Teams must identify any fire hazards specific to their vehicle's components and if fire extinguisher/fire extinguisher material other than those required in section 3.4.11.2 (A) are needed to suppress such fires, then at least two (2) additional extinguishers/material (at least 5 lb or equivalent) of the required type must be procured and accompany the car at all times.
Chemical Spill Absorbent
Teams must have chemical spill absorbent at hand, appropriate to their specific risks. This material must be presented at technical inspection.
Cable Cutters
Insulated cable cutters. These must be capable of cutting live HV cables in the event of a serious malfunction. Following is the list of approved cable cutters.
• Bahco 2520s
• Knipex 95 17 500
• Knipex 95 27 600
• Willi Hahn Corp (Wiha) 119 50
• Willi Hahn Corp (Wiha) 408 00
Any other cutters must be approved by the organisers in advance.
Insulated Gloves
Insulated gloves, rated for at least the voltage in the HV system, with protective overgloves.
Safety Glasses
Safety glasses must be worn as specified in section 0
MSDS Sheets
Materials Safety Data Sheets (MSDS) for the accumulator.
Additional
Any special safety equipment called for in the MSDS, for example correct gloves recommended for handling any electrolyte material in the accumulator.

Appendix C - Recommended Standards

- SAE Standard J1673 - "High Voltage Automotive Assembly Wiring Design"
- ISO_6469-part 1 : Electric road vehicles — Safety specifications: On board electrical storage
- ISO_6469-part 2 : Electric road vehicles — Functional safety means and protection against failures
- ISO_6469-part 3 : Electric road vehicles — Safety specifications: Protection of persons against electric hazards
- SAE J2344 : Guidelines for electric vehicle safety
- IEC 61508: Functional safety of electrical/electronic/programmable electronic safety-related systems (FOTA were proposing this for future F1 KERS)

Appendix D – Organised List of Systems and Assemblies

The 2010 Formula Student Class 1A Sustainability Report must follow the organized list of systems and assemblies/parts outlined below. Any questions as to the correct location of the specific items must be submitted to the rules committee by June 1, 2010.

1) Brake System – BR

Brake Fluid
Brake Master Cylinder
Fasteners
Brake Lines
Brake Discs
Brake Pads
Balance Bar
Callipers
Proportioning Valve

2) IC Engine and Drivetrain – EN

Air Filter
Axles
Carburettor
Chain / Belt
Coolant Lines
CV Joints/U Joints
Differential
Differential Bearings
Differential Mounts
Engine
Engine Mounts
Engine/Diff Oil
Exhaust Manifold
Fuel Filter
Fuel Injectors
Fuel Lines/Rails
Fuel Pressure Reg.
Fuel Pump
Fuel Tank
Fuel Vent/Check Valve
Hose Clamps
Ignition Coil / Wires
Intake Manifold
Muffler
Oil Cooler
Overflow Bottles
Radiator
Radiator Fans
Restrictor
Shields

Sprocket/Pulleys
Throttle Body
Turbo/Super Charger
Mechanical Accumulator (Flywheel/hydraulic)

3) Frame & Body – FR

Aerodynamic Wing (if used)
Body Attachments
Body Material
Clutch
Floor Pan
Frame / Frame Tubes
Mounts Integral to Frame
Pedals
Shifter
Shifter Cable/Linkage
Throttle Controls

4) Electrical – EL

Energy Storage (Battery/Capacitor)
Brake Light
Bulbs
Dash Panel
ECM/Engine Electronics
Fuses
Indicator Lights
Kill Switch
Oil Pressure Gage/Light
Relays
Solenoids
Starter Button
Tachometer
Water Temperature Gage
Wire Harness/Connectors

5) Miscellaneous, Finish and Assembly – MS

Driver's Harness
Fire Wall
Headrest / Restraints
Mirrors
Paint – Body
Paint – Frame
Seats
Shields

6) Steering System – ST

Steering Rack
Steering Shaft
Steering Wheel
Steering Wheel Quick Release
Tie Rods

7) Suspension System – SU

Bell Cranks
Front A/Arms or Equivalent
Front Uprights
Pushrods/Pullrods
Rear A/Arms or Equivalent
Rear Uprights
Rod Ends
Shocks
Front Springs
Suspension Mechanism

8) Wheels, Wheel Bearings and Tyres – WT

Front Hubs
Lug Nuts
Rear Hubs
Tires
Valve Stems
Wheel Bearings
Wheel Studs
Wheel Weights
Wheels

9) Electrical Drivetrain – ED

Fuel Cell
Accumulator (Battery/Capacitor)
Electric Motor(s)
Power Controller
HV Harness