1995 FORMULA SAE®

TABLE OF CONTENTS — PAGE NUMBER

1. CONCEPT OF THE COMPETITION

The Formula SAE® competition is for engineering students to conceive, design, fabricate, and compete with small formula-style racing cars. The restrictions on the car frame and engine are limited so that the knowledge, creativity, and imagination of the students are challenged. The cars are built with a team effort over a period of about one year and are taken to a host institution for judging and comparison with approximately 60 other competitors from across the nation. The end result is a great experience for young engineers in a meaningful engineering project as well as the opportunity of working in a dedicated team effort.

For the purpose of this competition, the students are to assume that a manufacturing firm has engaged them to produce a prototype car for evaluation as a production item. The intended sales market is the nonprofessional weekend autocross racer. Therefore, the car must have very high performance in terms of its acceleration, braking, and handling qualities. The car must be low in cost, easy to maintain, and reliable. In addition, the car's marketability is enhanced by other factors such as aesthetics, comfort and use of common parts. The manufacturing firm is planning to produce 1000 cars per year at a cost below $8000. The challenge to the design team is to design and fabricate a prototype car that best meets these goals and intents. Each design will be compared and judged with other competing designs to determine the best overall car.

The cars are judged in three different categories: static inspection and engineering design, solo performance trials, and high performance track endurance. These events are scored to determine how well the car performs. In each event, the manufacturing firm has specified minimum acceptable performance levels that are reflected in the scoring equations. The following points are possible:

75	Presentation
150	Engineering Design
100	Cost Analysis
75	Acceleration
50	Skid-Pad Event
150	Autocross Event
50	Fuel Economy Event
350	Endurance Track Event
1,000	Total Points

YEAR	HOST	WINNER
1994	Formula SAE® Consortium	University of Michigan-Ann Arbor
1993	Chrysler Corporation	Cornell University
1992	Ford Motor Company	Cornell University
1991	General Motors Corporation	Virginia Polytech
1990	Lawrence Institute of Technology	University of Texas-Arlington
1989	University of Texas-San Antonio	University of Texas-Arlington
1988	Lawrence Institute of Technology	Cornell University
1987	University of Texas-Arlington	University of Maryland

YEAR	HOST	WINNER
1986	Lawrence Institute of Technology	University of Texas-Arlington
1985	University of Texas-Austin	University of Texas-Arlington
1984	University of Texas-Austin	University of Texas-Houston
1983	University of Texas-Austin	University of Texas-Arlington
1982	University of Texas-Austin	University of Texas-Austin
1981	University of Texas-Austin	Stevens Institute of Technology

2. ELIGIBILITY

Eligibility is limited to students taking credit toward a degree and that are student members of SAE. In order to maintain the credibility of fair competition at the Formula SAE® competition, the Faculty Advisor must prohibit "ringers". A ringer is someone that has exceptional skills related to the competition (e.g. driver) and is not fully integrated into the normal team activities but attends the competition to help win points.

The car must be conceived, designed, and fabricated by the students without direct involvement from professional engineers, automotive engineers, racers, machinists, or related professionals. The student team may use any literature or knowledge related to car design and information from professionals or from professors as long as the information is given as a discussion of alternatives with their pros and cons. **However, professionals may not make design decisions or drawings and the Faculty Advisor must sign a statement of compliance, as given in the Appendix as A-1, with this restriction. It is the intent of SAE university design competitions to provide direct hands-on experience to the students. Therefore, it is desired that students perform all fabrication tasks whenever possible.** Eligibility is limited to students to insure that this is an engineering competition rather than a race. Winning is more related to engineering professionalism than to who crosses the finish line first.

To avoid the possibility of new students merely bringing last year's car to the competition and therefore missing the engineering experience, cars that have been entered in two or more previous Formula SAE® competitions are prohibited. **Second year cars are allowed, but if a team wants to continue with a car design for more than one year, photographic documentation proving that the car was significantly modified, along with a statement from the Faculty Advisor, is required.** The design judges will deduct design points for the lack of understanding of a design by the team.

The Faculty Advisor must accompany the team to the competition but is not allowed to provide hands-on help to the team or serve as a team member during the actual competition. The Faculty Advisor will serve as a liaison between the team and the officials and will make any communications of protest or complaints to the judges. The Faculty Advisor will oversee the school's responsibilities on and off the track.

3. VEHICLE REGULATIONS

The following mandatory restrictions will be enforced by the judges through inspection. **Noncompliance must be corrected and the car re-inspected before the car is allowed to compete in the performance events.**

3.1 Chassis Rules

3.1.1 Ground Clearance

Ground Clearance must be sufficient to prevent any portion of the car (other than tires) from touching the ground during track events.

3.1.2 Wheels and Tires

The wheels of the car must be 20.32 cm (8 inches) or more in diameter. The tires can be any size or type. Tire or wheel type, compound or size may not be changed after the static judging has begun. Tire warmers are not allowed. No traction enhancers may be applied to the tires after the static judging has begun.

3.1.3 Suspension

The car must be equipped with a fully-operational suspension system with shock absorbers, front and rear, with usable wheel travel of at least 50.8 mm (2 inches) 25.4 mm (1 inch) jounce and 25.4 mm (1 inch) rebound with driver seated. The judges reserve the right to disqualify cars which do not represent a serious attempt at an operational suspension system or which demonstrate unsafe handling.

3.1.4 Steering

The steering system must affect at least two wheels. The steering system must have positive steering stops which prevent the steering linkages from locking up (the inversion of a four-bar linkage at one of the pivots). The stops may be placed on the uprights or on the rack and must prevent the tires from contacting suspension, body, or frame members during the track events. Allowable steering free play will be limited to 15 degrees total measured at the steering wheel.

3.1.5 Brakes

The car must be equipped with a brake system acting upon all four wheels and must be capable of providing four-wheel lockup on dry asphalt at any speed. **A single brake acting on a limited-slip differential is acceptable.** The brake system must be protected with scatter shields from failure of the drivetrain or from minor collisions. The car must be equipped with a brake light clearly visible from the rear. ***Unarmored plastic brake lines are prohibited.***

3.1.6 Jacking Points

A jacking point consisting of a 30.46 cm (12 inches) minimum length of 25.4 mm (1 inch) O.D. exposed tube perpendicular to the longitudinal centerline must be provided at the rear of the car.

3.2 Crash Protection

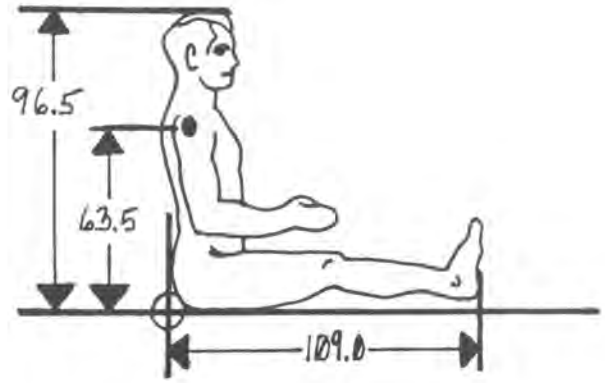
3.2.1 Roll-over Protection

The ***driver's head and hands*** must be protected from contact with the ground in any roll-over attitude. This requires a roll bar near the driver and a forward roll hoop ***within 15.24 cm (6 inches) of the steering wheel. A line from the top of the roll bar to either the forward roll hoop or an equivalent part (SEE NOTE) of the frame forward of the roll hoop must clear by two inches both of the following:***

- The helmet of the tallest seated driver on the team

  and

- The helmet of a seated 95th percentile male (anthropometric data) as shown below. A two dimensional hinged template will be used to ensure compliance to this minimum requirement.



ALL DIMENSIONS IN CM

The roll bar and roll hoop must be a continuous closed section attached securely to the primary structure. As a minimum, the driver's roll bar and roll hoop must be constructed of mild steel (e.g., 1020) tube with 25.4 mm (1 inch) O.D. and 2.36 mm (0.093 inch) nominal wall thickness, or alloy steel (e.g., 4130) with 25.4 mm (1 inch) O.D. and 1.57 mm (0.062 inch) nominal wall thickness. **No composite materials are allowed for the driver roll bar or roll hoop.**

If any other material is used, the team must present documentation of material type (purchase receipt, shipping document of letter of donation); material properties; heat treatment. The team must also submit calculations demonstrating equivalence for energy dissipation, and ultimate and yield strengths in bending, buckling, and tension. The completed Safety Structure Equivalency Form, as given in the Appendix as A-2, must be submitted to the host **no later than February 1, 1995.**

NOTE: A roll hoop is required on all cars for protection of the driver's hands. If a point forward of the roll hoop is used to demonstrate the aforementioned 50.8 mm (2 inch) clearance over a driver's helmet, then it must meet the same material and strength requirements that the roll bar and roll hoop meet, and it must attach to the main vehicle structure. Also, if a point forward of the forwardmost suspension attachment is used to provide the 50.8 mm (2 inch) clearance, the design must be approved by the host.

A 4.76 mm (3/16 inch) inspection hole must be drilled in a non-critical location of the roll bar. The roll bar must be braced in the fore or aft direction with braces on ***the left and right sides within 15.24 cm (6 inches) (measured vertically not parallel to the roll bar)*** of the top of the roll bar at an angle of at least 30 degrees from the vertical.

3.2.2 Side Impact Protection

The driver must be protected from a side collision while seated in the normal driving position. Side impact must meet the requirements listed below.

Tube Frames - A frame member must connect the roll bar and the front roll hoop at a height between 200 and 350 mm (7.87 and 13.78 inches) above the ground with a 77.1 kg (170 pound) driver seated in the normal driving position. At least ***one (1)*** diagonal frame member ***per side*** must connect the upper and lower frame members forward of the roll bar and rearward of the front roll hoop. ***Multiple tubes may form a triangulated structure off of the side of the upper and lower rails to achieve similar side impact protection.*** For the purpose of this rule, a frame member should be 25.4 mm x 1.57 mm (1.00 inch x .062 inch) mild steel tubing or equivalent.

Composite Monocoque - The section properties of the sides of the vehicle must reflect impact considerations. Bodies or skins which are non structural are not adequate to meet the side impact rule. A team may submit a proposed section for approval. The approval process will be based upon the engineering judgement and experience of the technical judge. Submitted information should include: material type(s), cloth weights, resin type, fiber orientation, number or layers, core material, and layup technique.

Metal Monocoque - These structures must meet the same requirements as tube frames and composite monocoque unless exempted through technical review.

Vehicle designs which protect the driver to an equal or greater extent than required will be allowed, provided they have been judged as such in the technical review. The completed Safety Structure Equivalency Form as given in the Appendix as A-2, must be submitted to the host no later than February 1, 1995.

3.2.3 Frontal Impact Protection

The drivers feet must be protected from frontal impact by a 150 mm (5.91 inch) crush zone as defined below. The planes defined below are normal to the fore/aft axis of the car.

3.2.3.1 The rearward plane of the crush zone will begin at the lowest point on the driver's heel or the forward surface of the master cylinder, whichever is further forward. This will be measured with pedals in the furthest forward position.

3.2.3.2 The forward plane of the crush zone is the forward most plane in which:

a) the top of the frame member is at least 100 mm (3.94 inch) above the bottom of the bottom structural member, and

b) the distance between the outer surfaces of the structure is at least 200 mm (7.87 inch).

3.2.3.3 Non-crushable contents (e.g., batteries) may be located between the forward and rearward planes, but their fore/aft thickness will be subtracted from the distance between the planes to determine the thickness of the crush zone.

3.3 Safety Rules

3.3.1 Safety Harnesses

The car must be equipped with a five or six-point safety harness system which is securely attached to the primary structure. ***The harness must meet SFI 16.1 specifications and be labeled as such.*** The system must consist of lap harnesses approximately 76.2 mm (3 inches) wide, shoulder straps approximately 50.8 mm (2 inches) wide, and an anti-submarine strap approximately 50.8 mm (2 inches) wide. The latch must be a metal to metal quick release. There shall be a single release common to all harnesses in the system. Harness to structure attaching hardware must not contact the driver.

The lap harness portion must pass around the pelvic area below the Anterior Superior Iliac Spines ***(Figure I in Appendix as A-3).*** Under no condition may the lap harnesses be worn over the area of the intestines or abdomen. The lap harnesses should come through the seat at the bottom of each side of the seat. The harness should not be routed over the sides of the seat. The lap harness attachments should be spaced no wider than 35.56 cm (14 inches) apart and must achieve a minimum wrap of the pelvic surface of 180 degrees. The seat must be rolled or grommeted or otherwise treated to prevent chafing of the harness.

The shoulder harness straps must be attached to a primary structural member of the car behind and below the driver's head and neck. The shoulder harness to structure attachment(s) must be located above a plane 40 degrees with the horizontal and passing through the shoulder to harness tangency points. The harness system must be worn as tight as possible at all times.

3.3.2 Driver Safety Equipment

The following equipment must be worn at any time a driver is seated in the vehicle and the engine is running or being started:

3.3.2.1 A well-fitting safety helmet with a Snell M85, SA-85, M90 or SA-90 rating.

3.3.2.2 A fire resistant suit that covers the body from the neck down to the ankles and the wrists. The suit shall be manufactured from one or more of the following accepted materials: Nomex, Kynol, FPT, IWS (wool), Fiberglass, Durette, Fypro, PBI and Kevlar. ***By 1996, all driver's suits must meet SFI 3.2A and be labeled as such. (It is recommended that any new suits purchased for the 1995 competition meet this specification.)***

3.3.2.3 Fire resistant gloves which are free of any holes. Leather gloves are not acceptable.

3.3.2.4 Goggles or face shields, made of impact resistant materials.

3.3.2.5 Shoes of durable fire resistant material, and which are free from any holes.

3.3.2.6 Arm restraints must also be installed on the car in a manner such that the driver can release them and exit the vehicle unassisted regardless of the vehicle's position.

3.3.3 Driver Visibility

The car must be equipped with functional rear-view mirrors. The driver must have adequate visibility to the front, rear, and sides. The driver's head must be free to rotate 90 degrees to either side.

3.3.4 Head Restraints

A restraint must be provided on the car to limit rearward motion of the head in the case of an accident. The restraint must be a padded surface with at least 38.1 mm (1.5 inches) of crushable, damped padding located no more than 25.4 mm (1 inch) away from the helmet in the uncompressed state. The head restraint must meet the above requirements for all drivers. It is recommended that the surface be 2.32 dm squared (36 square inches).

Any portion of the roll bar or bracing which might be contacted by the driver's helmet shall be covered with styrofoam or other energy-absorbing material, minimum of 32 kg/m^3 (2 lbs/ft^3) polystyrene or equivalent, to a minimum thickness of 12.7 mm (0.5 inch).

3.3.5 Floor Closeout

All vehicles must have a floor ***closeout made of one or more*** panels which separate the driver from the pavement. ***If multiple panels are used, gaps between panels are not to exceed 3.18 mm (1/8 inch).*** The closeout must extend from the foot area to the firewall and must protect the legs and torso from track debris.

3.3.6 Steering Wheel

The steering wheel must have a near circular perimeter. "H", "Figure-8", or cutout wheels are not allowed. The steering wheel must be attached to the column with a quick disconnect. The driver must be able to operate the quick disconnect while in the normal driving position with gloves on.

3.3.7 Driver Egress

All drivers must be able to exit to the side of the vehicle in no more than 5 seconds. Egress time begins with the driver in the fully seated position, hands in driving position on the connected steering wheel, wearing the required driver safety equipment. Egress time will stop when the driver has both feet on the pavement.

3.3.8 Roll Over Stability

The track and center of gravity of the car must combine to provide adequate roll-over stability. Roll-over stability will be evaluated using a pass/fail test. The vehicle must not roll when tilted at an angle of 57 degrees in either direction corresponding to 1.5 G's. The tilt test will be conducted with the tallest driver in the normal driving position.

3.3.9 Kill Switch

The car must be equipped with a positive toggle-type kill switch affecting the entire electrical system of the car, located on the (driver's) right side of the vehicle in the proximity of the roll bar at shoulder height. This switch must be within easy reach from outside the car. An additional positive toggle-type kill switch must be located for easy operation by the driver.

The SCCA electrical symbol must be attached near both switches and the "run" and "kill" position must be clearly labelled.

3.3.10 Fire Protection

A firewall must separate the driver compartment and all components of the fuel supply and liquid cooling systems. **The firewall must be a non-permeable surface made from a fire resistant material.** ***Pass throughs for wiring, cables, etc. are allowable if gromets are used to seal the pass throughs. Also, multiple panels may be used to form the firewall but must be sealed at the joints to meet the intent of driver protection.***

The car must be equipped with at least a single 0.91 kg (2 pound) 10BC or 1A10BC fire extinguisher. The hand held extinguisher must be mounted a safe distance from the fuel system and must be easily visible and removable from inside and outside the car, and must be labelled with the SCCA extinguisher symbol. A fire control system may be used if the actuation location meets the intents above. ***Halon systems will not be legal for the 1995 competition and beyond. This ruling is in compliance with an international Halon ban which will be effective one year later. All fire extinguishers must be equipped with a manufacturer installed pressure/charge gauge; the gauge must be readable to the technical inspectors.***

3.4 Powertrain

3.4.1 Engine and Drivetrain

The engine used to power the car may be any four-cycle piston engine with 600 cc displacement per cycle or less. The engine can be modified within the restrictions of the rules. The host will measure or tear down a substantial number of engines to confirm conformance to the rules. The initial measurement will be made externally with a measurement accuracy of one (1) percent. When installed to and coaxially with spark plug hole, the measurement tool has dimensions of 381 mm (15 inches) long and 29.21 mm (1.5 inches) diameter. Teams may choose to design in access space for this tool above each spark plug hole to reduce time should their vehicle be inspected.

The engine and transmission must be sealed to prevent leakage. In addition, a catch can or cans must be employed to retain fluids from any vents for the coolant system and the crankcase. The can must have a volume of ten (10) percent of the fluid being contained or one quart, whichever is greater.

Any transmission and drive train may be used. Exposed high-speed equipment, such as torque converters, clutches, belt drives and clutch drive, must be fitted with scatter shields of at least 12 gauge 2.67 mm mm (0.105 inch) mild steel (or documented equivalent ultimate strength and equivalent safety) to protect drivers, bystanders, fuel lines and safety equipment (such as brake lines) from flying debris in case of failure. Guards for finger protection may be made of lighter material.

3.4.2 Fuel Allowed

During all performance events, the cars must be operated with gasoline (auto gas, aviation fuel, or racing gas) or (M85). No other fuel (such as nitromethane or alcohol) is allowed. Nitrous oxide or other oxidizing agents are not allowed. The M85-fueled cars must use the fuel mixture documented in the supplemental M85 rules. The host will provide fuel for all the teams at the event. (Specifications will be sent to all competitors in mid-December).

The temperature of fuel introduced into the fuel system may not be changed with the intent to improve calculated fuel economy.

No agents other than fuel (gasoline or M85), and air may be induced into the combustion chamber. Non-adherence to this rule will be reason for disqualification. Officials have the right to inspect the oil. Only ambient air may be used to cool an intercooler.

3.4.3 Fuel System

All gasoline fueled cars must be equipped with a fuel tank having a volume of no more than 3.785 liter (1 U.S. gallon). M85 fueled cars must be equipped with a fuel tank having a volume no greater than 5.678 liter (1.5 U.S. gallon). The fuel system must have a provision for emptying the fuel tank for the purpose of measuring the tank volume.

All fuel tanks must have a filler neck of at least 25.4 mm (1 inch) diameter and at least 38.1 mm (1.5 inch) vertical height. The inside of the filler neck must be scribed with a readily visible line for the purpose of filling the tank to a repeatable level. The fuel level scribe line must be located between 12.7 mm and 25.4 mm (0.5 inch and 1 inch) below the top of the filler neck.

The fuel system must be designed such that the spillage during refueling cannot contact the driver position, exhaust system or hot engine parts, or the ignition system. Belly pans must be vented to prevent accumulation of fuel.

The fuel tank and carburetor venting systems must be designed such that fuel cannot spill during hard cornering or acceleration. This is a concern since motorcycle carburetors normally are not designed for lateral accelerations. During the inspection, the car must be capable of being tilted to a 45 degree angle without fuel spilling from the carburetor or full gas tank. All fuel vent lines must be equipped with a check valve to prevent fuel leakage when the tank is inverted. All fuel vent lines must exit outside the bodywork.

High pressure over 103.4 kPa (15 psi) fuel systems must utilize metal braided hose with threaded fittings except where commercial fuel system components are used without modifications. Fuel lines must be securely attached to the vehicle and/or engine. All fuel lines must be protected from possible rotating equipment failure.

In order to prevent hazards in the case of a roll-over or collision, all parts of the fuel storage and supply system, and all parts of the engine air and fuel control systems that affect power (including the throttle or carburetor, but excluding air cleaner systems) must lie within a plane defined by the roll bar and the front and rear of the frame. All fuel tanks must lie within the major structure of the chassis.

3.4.4 Throttle and Intake Restrictor

The car must be equipped with a carburetor or throttle body. The carburetor or throttle body may be of any size or design. The throttle cable must have smooth operation and must not have the possibility of binding or sticking. The throttle actuation system must use two independent springs to close the throttle such that the failure of one spring cannot effect the performance of the other spring. ***Throttle cables must be at least 50.8 mm (2 inches) from any exhaust system component and out of the exhaust stream.*** The use of a push-pull type throttle cable with a throttle pedal that is capable of forcing the throttle closed (e.g. toe strap) is recommended. A positive pedal stop must be incorporated on the throttle pedal to prevent over stressing the throttle cable or actuation system.

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 air flow must pass through the restrictor. ***Any device that has the ability to throttle the engine downstream of the restrictor is prohibited.*** The diameter of the restrictor must be no larger than 20 mm (0.7874 inch) for gasoline-fueled cars and 18 mm (0.7087 inch) for M85-fueled cars. The restrictor must be located to facilitate measurement during the inspection process. If the throttle exit (not venturi) or intake manifold (of a single tube through which all flow passes) has a diameter of equal or smaller than the restrictor, then a restrictor is not required.

Turbochargers or superchargers are allowed if the competition team designs the application. Engines that have been designed for and originally come equipped with a turbocharger are not allowed to compete with the turbo installed. The restrictor must be placed upstream of the compressor but after the carburetor or throttle valve. **Thus, the only sequence allowed is throttle, restrictor, compressor, engine.**

3.4.5 Muffler and Exhaust System

The car must be equipped with a muffler in the exhaust system to reduce the noise to an acceptable level. The noise level will be measured with a sound level meter as the car accelerates at full power along a straight line for a distance of 30.40 m (100 feet). The measurement is made at the midpoint of the run at a distance of 6.1 m (20 feet) from the car, 0.914 m (3 feet) above the ground. The sound level must not exceed 105 dB on the A weighting band at any time during the test. The noise level will be tested prior to the dynamic events and may be repeated during the dynamic events or as requested by the judge of one of the

events. A DNF will be awarded for the runs on which the sound test was failed. The exhaust must be routed so that the driver is not subjected to fumes at any speed considering the draft of the car.

3.5 General

3.5.1 Car Number

Each car will receive a number at the time of its entry in the competition. This number must be displayed in 15.24 cm (6 inch), or larger, characters that are clearly visible from both sides of the car. The top nine numbers are reserved for the top nine finishers from the previous year's competition.

3.5.2 Aerodynamics and Power Ground Effects

The purpose of the following rules is to minimize any likelihood of injury to spectators, officials, driver, etc. in the case of accidental contact with the wings and structure:

3.5.2.1 The wing or wings must be located in plan view within a quadrilateral defined by the outside of the tires on the sides, by a transverse line 457.2 mm (18 inches) in front of the fronts of the front tires, and by a transverse line between the rear of the rear tires. (Or could base this on the wheelbase and track.)

3.5.2.2 Egress from the vehicle within the time set in section 3.3.7 shall not require any movement of the wing or wings or their mountings. The wing or wings must be mounted in such positions, and sturdily enough, that any accident is unlikely to deform the wings or their mountings in such a way to block the drivers egress.

3.5.2.3 All wings: leading edges shall have a minimum radius 12.7 mm (0.5 inch) unless a wing projects in front of the front of the front tires, in which case it must have a minimum radius of 19.05 mm (0.75 inch).

3.5.2.4 All wing edges, end plates and wing accessories must have minimum edge radii of at least 3.175 mm (1/8 inch) e.g., this would mean at least a 6.35 mm (1/4 inch) thick edge.

3.5.2.5 No power device may be used to move or remove air from under the race car except fans designed exclusively for cooling. No power ground effects are allowed.

3.5.3 Modifications

Modifications to the car are not allowed after the inspection and engineering judging except as noted below. This includes modifications that affect the available gear ratios, power transfer system, or safety. The removal of body panels for weight reduction is not allowed. Adjustments (e.g., tire pressure, brake bias, suspension adjustments, and chain or belt tension) are allowed to the car after the start of the performance events. Necessary repairs are allowed under the knowledge of the Faculty Advisor and the car must pass a re-inspection by the inspection judges.

3.5.4 Fasteners

All bolts untilized in the steering, braking, safety harness and suspension systems must meet SAE Grade 5, Metric Grade M 8.8 and/or AN/MS specifications. All critical bolt, nuts, and other fasteners on the steering, braking, safety harness, and suspension must be secured from unintentional loosening. This can be accomplished best with safety wiring or cotter pinning; however, nylon lock nuts, locktight, and other forms deemed appropriate by the judges will be considered. Rod ends on the steering or suspension must be in double shear or captured by having a bolt head or washer larger than the diameter of the spherical bearing. ***Adjustable tie-rod ends must be constrained with a jam nut to prevent loosening.***

3.5.5 Body and Styling

The vehicle must be open-wheeled, open-cockpit and have a formula style body.

3.5.6 Wheelbase and Vehicle Configuration

The car must have a wheel base of at least 1524 mm (60 inches). The wheel base is measured from the center of ground contact of the front and rear tires with the wheels pointed straight. The vehicle must have four wheels that are not in a straight line.

3.5.7 Flags

The flag signals convey the commands described below, and shall be obeyed immediately and without question.

The following is the meaning of each flag:

3.5.7.1 GREEN FLAG (Solid Green)

A race is under way the instant the green flag is displayed. This flag shall normally be in possession of the Starter only, and shall not ordinarily be displayed at the flag stations around the course. When displayed, the green flag indicates that the course is clear.

3.5.7.2 YELLOW FLAG (Solid Yellow)

STANDING YELLOW -- Take care, Danger, Slow Down, NO PASSING FROM THE FLAG until past emergency area.

WAVED -- Great Danger, Slow Down, be prepared to stop -- NO PASSING FROM THE FLAG until past emergency area.

NOTE: A driver may encounter several flags before reaching the emergency area. The requirements are still the same **"SLOW DOWN, NO PASSING"**.

3.5.7.3 BLUE FLAG (Blue with Diagonal Yellow Stripe)

Another competitor is following you very closely or is trying to overtake you. This flag may be displayed standing or waving, depending upon the speed with which you are being overtaken.

3.5.7.4 BLACK FLAG (Solid Black)

CLOSED BLACK FLAG (Furled) -- WARNING -- you are driving in an unsafe or improper manner, if continued, you shall be given the Open Black Flag.

OPEN BLACK FLAG (Standing) -- Complete the lap you are now on, then stop for consultation at the location designated by the Chief Steward or the Supplementary Regulations for that event.

OPEN BLACK FLAG WITH THE WORD **"ALL"** DISPLAYED -- All cars proceed directly to the pits. Restarts are the same as for a red flag.

3.5.7.5 CHECKERED FLAG (Black and White Checks)

You have finished the race (or practice/qualifying session). Continue cautiously to the pits.

3.5.7.6 RED (Solid Red)

Come to an immediate, controlled stop, taking care not to endanger yourself or another car by the manner of stopping. Pull the car to the edge of the track to the extent circumstances permit.

THE RACE HAS BEEN STOPPED.

NOTE: THE RED FLAG CAN ONLY BE ORDERED BY THE CHIEF STEWARD THROUGH RACE CONTROL.

Penalties and Assessed Times or Disqualifications

• Failure to Yield to a Flag	1 minute
• Over Driving (After a Closed Black Flag)	1 minute
• Passing Under the Yellow Flag	2 minutes
• Mechanical Problem (Black Flag with Orange Ball)	Time needed for car inspection by SCCA Tech Inspector

4. COMPETITION

The competition is divided into two categories:

1) STATIC EVENTS: Inspection, design, presentation and cost.

2) DYNAMIC EVENTS: Acceleration, skid pad, autocross, fuel economy and endurance.

Each of these events is described below in terms of the concept, how the event is conducted, the criteria used in judging, and the formula for scoring.

The host reserves the right to alter the conduct and scoring of the competition based on disruptive weather conditions. A predefined policy for handling such disruptions will be published prior to the 1995 competition.

An individual team member cannot drive in more than three events. If only one 15-mile endurance heat is run, no team member can drive in more than two events and fuel economy does not count as a driving event. Otherwise, fuel economy event is considered a separate event although it is conducted simultaneously with another event. An individual may not drive in both heats of any event. It is the team's option to participate in any event. The team may forfeit their second heat in any performance event. To compete in all events a minimum of 4 drivers is required.

4.1 Inspection

The concept of the inspection is to insure that the safety and design requirements outlined in the rules have been met. For cases in which the rules are not perfectly clear, the intent of the rule must be met. Violation of the intent of the rule is considered a violation of the rule.

Vehicle inspection will be performed at the time specified in the competition schedule. In addition to the general inspection, the following specific tests will be conducted:

- Brake Check
- Sound Level
- Intake Orifice Diameter
- Roll Over Stability (57 degree Tilt Test)
- Fuel Leakage Test (45 degree Tilt Test)

The judges will complete the Safety and Technical Inspection, the Fuel Capacity and Tilt Table Inspection and the Noise Level and Braking Performance Inspection Check-lists in the Appendix as A-4 and A-5. If the judges find any part of the car that does not comply with the rules or is deemed to be a safety concern, then the team must correct the problem and request a reinspection before the car is allowed to compete in any performance event. The inspection judges reserve the right to reinspect any of the specifications (particularly the brakes and muffler) at any time during the competition.

The inspection is not scored for team points; however, the car must pass the inspection and remain in accordance with the rules before it is allowed to compete.

4.2 Cost Event

The concept of the cost event is to obtain an accurate estimate of the cost of the car in limited production. This evaluates not only the actual cost of the car, but also the team's ability to prepare an accurate engineering cost estimate. The car with the lowest corrected cost and the best report will win the event.

Staying within a given budget is critical to the success of any "real life" engineering project (even professional race teams have finite budgets). Designing a great product that is over budget does not translate into a job well done. As such, the cost scoring has been devised to stress this important aspect of engineering and to appropriately reward or penalize teams according to how they manage a budget. (Designing a great mousetrap is not nearly the challenge of designing the best mousetrap for a given amount of money.)

The deadline for submitting cost reports is April 30, 1995. The reports should be mailed to: 1995 Formula SAE®, Educational Relations Department, SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001. It is imperative that the cost judges have the cost reports in enough time for proper evaluation. Teams that submit reports late will be penalized -50 points per day late. Teams that do not submit a cost report will receive -400 points for the Cost Score. The team must present their vehicle at the designated time to the cost judges for review of the cost report.

The cost report review schedule will be posted at the organizational meeting on the first day of the competition. Amendments that reflect any changes made after submission of the cost report must be submitted at registration.

The cost event is judged on the basis of the cost of the car and the quality of the cost report. The cost of the car is determined by the cost of the parts and fabrication for a production rate of 1000 cars per year using established manufacturing practices.

The team will prepare a detailed engineering cost analysis using the guidelines and forms given in the Appendix as A-6 thru A-8. From this analysis, the cost judges will determine if all parts and processes were included in the analysis and if unreasonably low (determine by the experience of the judges) costs were used. In the case of any omission, error, or cost below reasonable estimates are used, then the judges will add a penalty equal to twice the cost error. The competitors price *p18[illegible] will be used to determine the cost score.

For example, if a car has tires listed at $10 whereas other teams list the same or similar tires at $50 (determined by the judges to be reasonable), then the judges add 2 x $40 for each tire to the cost. Errors of costs above reasonable estimates are not penalized further, and the error is not corrected. Cost reports that have not made a serious attempt at an accurate estimate or that claim that their cost is substantially below other similarly-equipped cars will be disqualified as unresponsive and will be scored as unsubmitted.

The score is the sum of the report score and the price score. The report score will be given based upon the quality of the cost report. The range for the report score will be 0-25. The price score will be awarded based upon the following formula:

PRICE SCORE = $75 * (\$8000 - P_{your}) / (\$8000 - P_{min})$ for $P_{your} <= \$8000$

PRICE SCORE = $150 * (\$8000 - P_{your}) / (\$8000 - P_{min})$ for $P_{your} > \$8000$

COST SCORE = Price Score + Report Score

P_{your} is the adjusted cost of your car (with penalties), and P_{min} is the adjusted cost of the lowest cost car (this amount will not be less than $3000). Negative price scores will be given if the cost of the car exceeds the budget limit of $8000; however, the price score will be limited at -300 points.

The cost analysis for the car is based upon the estimated cost for materials, fabrication, and assembly of a car in limited production (1000 cars per year). The engineering cost estimate may have little relationship to the actual money spent for the prototype. The cost analysis should consider fabrication techniques that would be used in production. The actual production technique should be used on the prototype if at all feasible (e.g., cast parts should be cast on the prototype, etc.). Further, the parts used in the cost estimate must be the actual parts used on the prototype and substitution of cheaper parts for the cost analysis is prohibited. For example, if styled wheels costing $150 each are used on the prototype, then substitute wheels costing $50 each cannot be used in the cost analysis.

The cost of the car is itemized into the following subassemblies:

- Engine and Drive Train (including drive axles and bearings)
- Frame and Body (including pedals, shifter, throttle controls and linkages)
- Wheels, Wheel bearings and Tires
- Suspension and shocks
- Brake System
- Instruments, Wiring and Accessories
- Miscellaneous Parts (e.g., seat and harness), Finishing (e.g., painting) and Final Assembly

The cost of fasteners and brackets are included in their respective subassemblies. The costs of the subassemblies include labor as if each sub-assembly were brought from a separate supplier and the car were simply assembled to the finished product.

Parts and materials used in the car are estimated based upon wholesale supplier's quotes (an appendix for cost documentation should be attached) in the quantities stated. If a wholesale price is not available, then sixty (60) percent of retail can be used; however, actual suggested retail cost must be documented since some so-called retail costs actually includes substantial discounts. Costing based upon, and the use of, used parts in production is not permitted.

The time required to machine, paint, fabricate, etc. is costed at $35/hour if it is not explicitly costed from the Operations Cost Table. This rate includes the labor and overhead costs. Overhead includes expendables, capital costs and depreciation of machine equipment. The table given on the next page provides some guidelines to the cost of various operations.

The cost of the engine depends upon the performance rating of the engine and whether it is equipped with an integral transmission. The engine performance rating is based upon the power potential of the manufacturer's specification of the engine without the single carburetor and restrictor modification. The engine is considered low performance if it is capable of producing less than 5 horsepower per 100 cc displacement (industrial engines, etc.). A high performance engine is capable of 5-10 horsepower per 100 cc (normal motorcycle engines with 2-valves per cylinder, etc.).

An ultra high performance engine is capable of more than 10 horsepower per 100 cc (new high-tech engines, 3 or 4-valves per cylinder, etc.). The engine is considered to be purchased with all of the required components and systems necessary to run except the carburetor (or fuel injection system), turbo or supercharger if used, the intake manifold, the exhaust manifold, cooling system, and mufflers. These costs must be listed separately in the cost analysis. The following table lists the cost of the engine (without intake and exhaust systems):

RATING	WITHOUT TRANSMISSION	WITH INTEGRAL TRANSMISSION
Low	$0.35/cc	$0.60/cc
High	$0.75/cc	$1.00/cc
Ultra-high	$1.00/cc	$1.25/cc

Engines that come equipped with an integral transmission, differential, and U-jointed axles must estimate the cost of the differential and U-joints separately.

The following table should be used in estimating costs:

OPERATIONS COST TABLE	
Labor	$35.00/hr
Welds	$ 0.14/mm (0.35/inch)
Saw or tubing cuts	$ 0.016/mm (0.40/inch) diameter
Tube bends	$ 0.75/bend
Tube end preparation	$ 0.75/bend
Drilled hole	$ 0.35/hole
Tapping holes	$ 0.35/hole
Sheet metal shearing	$ 0.20/cut
Sheet metal punching	$ 0.20/hole
Sheet metal bends	$ 0.05/bend
Sheet metal stampings	$ 0.008/cm^2 (0.05/sq. inch)
Sand castings	$ 6.61/kg (3.00/pound)
Die castings	$ 8.82/kg (4.00/pound)
Plastic injection molding	$ 6.06/kg (2.75/pound)
Fiberglass (nonstructural)	$ 21.53/m^2 (3.175 mm) (2.00/square foot (1/8 inch)

Costs for composites and structural construction similar to fiberglass should be costed separately with a clear identification of the costs of all material and processes. As a guideline, $88.18/kg ($40/pound) has been suggested for non-graphite composites, and $220.5/kg ($100/pound) could be used for graphite-based composites.

4.3 Presentation Event

The concept of the presentation event is to evaluate the team's ability to make a presentation to the customer. The presentation judges will evaluate the organization, content, and delivery of the technical presentation. The team that makes the best engineering presentation (regardless of the quality of the car) will win the event.

Presentation will be made on the first day of the event. The presentation time will be randomly selected and will be posted in conjunction with the organizational meeting held in the morning. A team will receive zero (0) presentation points if they fail to make their presentation during the allotted period.

One (or more) team member(s) will give the presentation to the judging team. The host will provide details regarding the presentation in the newsletter. The presentation cannot last more than 10 minutes and should not be interrupted by questions. After the presentation, there will be approximately 5 minutes of questions. Only judges are permitted to ask questions. The audience may not ask questions or make any comments or distractions. During the question period, team members are encouraged to answer questions.

The presentation judges will consider the content, organization, and delivery of the presentation and will only evaluate the team's ability to give a technical presentation. The judges will use the judging form given in the Appendix as A-9.

The scoring of the event is based on the average of the two presentation judging forms. There is a maximum of 50 points from the Presentation Judging Form.

PRESENTATION SCORE = 75 * P_{your}/P_{max}

It is intended that the scores will range from near zero (0) to seventy-five (75) to provide good separation.

4.4 Design Event

The concept of the design event is to evaluate the engineering effort that went into the design of the car and how the engineering meets the intent of the market. The car that illustrates the best use of engineering to meet the design goals and the best understanding of the design by the team members will win the design event.

The design event consists of an informal question and answer session between the team and the design judges. The design judges are encouraged to ask penetrating questions relative to the team's understanding and level of analysis of the car. Examples of questions are: stress levels, frame stiffness, Ackerman angles, bump steer, weight distribution, suspension curves, roll centers, rationale for design tradeoffs, etc.

The design judges will evaluate the engineering effort based upon the team's responses to questions and an inspection of the car. The design judges will inspect the car to determine if the design concepts are adequate and appropriate for the application (relative to the objectives set forth in the rules). It is the responsibility of the judges to deduct points on the design judging form as given in the Appendix as A-10 if the team does not understand the engineering and construction of the car.

The design score will then be calculated from the design judging form as follows:

DESIGN SCORE = 150 * P_{your}/P_{max}

The scores should range from zero (0) to one-hundred fifty (150) to provide good separation.

4.5 Acceleration Event

The acceleration event evaluates the car's acceleration in a straight line on flat pavement.

There will be two heats. Each heat must have a different driver and each driver can have two runs. Starting order will be based upon time of arrival to the staging area. Heat 1 and 2 will not be run sequentially, but simultaneously. Heat 1 drivers will have starting priority over heat 2 drivers.

The cars will accelerate from a standing start over a distance of 91.44 m (100 yards) on a flat surface. ***The cars will be staged 30.48 cm (12 inches) behind the starting line.*** A green flag will be used to indicate the approval to begin, however, the timers start only after the front tires cross the start line. There will be no particular order of the cars in each heat. A driver has the option to take a second run immediately after the first.

Special agents that increase traction may not be added to the tires or track surface and "burnouts" are not allowed. Cars that have not run by the end of the event (determined by the host) will receive a DNF.

The acceleration score is based upon the corrected elapsed time. Elapsed time will be measured from the time the car crosses the starting line until it crosses the finish line. A two (2) second penalty will be added for each DOO (including entry and exit gate cones). An OC will result in a DNF for that run.

The score for the acceleration event is spread between zero (0) and seventy-five (75) based upon the elapsed time. The following equation is used to determine the scores for the event:

$$\text{ACCELERATION SCORE} = 75 * \frac{(7.5/T_{your}) - 1}{(7.5/T_{min}) - 1}$$

DNF = zero (0) points. Negative points will not be given for elapsed times greater than 7.5 seconds. T_{min} will be the elapsed time of the fastest car.

4.6 Skid-Pad

The concept of the skid-pad event is to measure the cornering ability of the car on a flat surface while making a constant-radius turn.

Each car may compete in two heats. Each heat must have a different driver and each driver can have two runs. There will be no particular order of the cars in each heat. Immediately following a run, the driver has the option of entering the front of the line to take a second run.

There will be no distinction between heat one (1) and two (2) and there will be no particular starting order. Heat one (1) drivers will have starting priority over heat two (2) drivers. Cars which have not run by the event closing (determined by the host) will receive a DNF for the event.

There will be two circles of 15.24 m (50 feet) diameter in a figure eight pattern. The circle centers will be separated by 18.29 m (60 feet), and a driving path 3.05 m (10 feet) in width will be marked with chalk and pylons. The start/stop line is defined by the centers of the two (2) circles. A lap is defined as traveling around one (1) of the circles from the start/stop line and returning to the start/stop line.

The cars will enter perpendicular to the figure eight and will take one full lap on the right circle to establish the turn. The next lap will be on the right circle and will be timed. Immediately following the second lap, the car will enter the left circle for the third lap. The fourth lap will be on the left circle and will be timed. Immediately upon finishing the fourth lap, the car will exit the track. A driver has the option to take a second run immediately after the first. The car will exit at the intersection moving in the same direction as entered.

Sixteen (16) pylons will be placed around the inside of each circle and sixteen (16) around the outside of each circle. Additional pylons will establish the required entry and exit gates. Also, a cone will be placed in the middle of the exit gate to prevent drivethroughs until the finish lap.

The elapsed time for the right and left circle will be averaged together after the following penalties have been assessed:

- A penalty of 0.1 second will be added to the time for every cone that is knocked down or out (including gate cones).

- A DNF will be awarded for an off course. Cars that spin-out can continue as long as they have not gone off course.

The skid-pad score is computed from the lowest average elapsed time for a single run after penalties times have been added. Estimates of lateral G's are based upon a diameter of 8.534 m (28 feet).

The score for the skid-pad event is based upon the run with the lowest elapsed time for the two (2) timed laps. The following equation is used to determine the scores for the skid-pad event:

$$\text{SKID-PAD SCORE} = 50 * \frac{(6.5/T_{your})^2 - 1}{(6.5/T_{min})^2 - 1}$$

Negative points will not be given for elapsed times greater than 6.5 seconds. T_{min} will be the elapsed time of the fastest car.

4.7 Autocross Event

The concept of the autocross event is to evaluate the car's maneuverability and handling qualities on a tight course without the hindrance of competing cars. The autocross course will combine the performance features of acceleration, braking, and cornering into one event.

There will be two Autocross-style heats, with each heat having a different driver. There will be no particular order of the cars to run each heat but a driver has the option to take a second run immediately after the first. Three (3) timed laps will be run (weather and time permitting) by each driver and the best lap time will stand as the time for that heat. The host will determine the allowable windows for each heat and retains the right to adjust for weather or technical delays. Cars that have not run by the end of the heat will be disqualified for that heat.

The following specifications will suggest the maximum speeds that will be encountered on the course. Average speeds should be 40.2 km/hr (25 mph) to 48.3 km/hr (30 mph).

Straights: No longer than 60.96 m (200 feet) with hairpins at both ends (or) no longer than 45.72 m (150 feet) with wide turns on the ends.

Constant Turns: 22.86 m (75 feet) to 45.72 m (150 feet) diameter.

Hairpin Turns: Minimum of 7.315 m (24 feet) OD.

Slaloms: Cones in a straight line with 7.62 m (25 feet) to 12.19 m (40 feet) spacing.

Miscellaneous: Chicanes, multiple turns, decreasing radius turns, etc. The minimum track width will be 3.66 m (12 feet).

The length of each run will be approximately 0.805 km (1/2 mile) and the driver will complete a specified number of runs. The time required to complete each run will be recorded and the time of the best run will be used to determine the score.

The cars are judged on elapsed time plus penalties. The following penalties will be added to the elapsed time:

- Two (2) seconds per DOO
- For an OC, the driver must re-enter the track at or prior to the missed gate or a 20 second penalty will be assessed.

Penalties will not be assessed for accident avoidance or other reasons deemed sufficient by the track official.

If a car stalls and cannot restart itself, then the track workers will attempt to push start the car at their discretion. Cars deemed disabled will be cleared from the track by the track workers. At that time, two (2) team members may retrieve the car to the paddock. The track workers will signal for more team members as required.

Elapsed time plus penalties will equal corrected elapsed time. The host will determine a maximum allowable course time bases upon a 32.19 km/hr (20 mph) average speed. Cars which are unable to complete a run in less time than the maximum allowable time will receive zero (0) points.

The following equation is used to determine the autocross score:

$$\text{AUTOCROSS SCORE} = \frac{(T_{max}/T_{your}) - 1}{(T_{max}/T_{min}) - 1} * 150$$

T_{max} will be equal to the maximum allowable time determined by the host. T_{min} will be the lowest corrected elapsed time recorded for any competitor in either heat. T_{your} will be the lowest corrected elapsed time of either heat for the team being scored.

4.8 Endurance Track and Fuel Economy Event

The following are general guidelines for conducting the endurance and fuel economy events. The host reserves the right to establish procedures specific to the conduct of the event at the location. All such procedures will be made known to the teams through newsletters.

The Endurance Event is designed to evaluate the overall performance of the car and to test the car's reliability. The event is designed to allow minor repairs to be made to the car. However, time required for repairs (while the car is scheduled to be on the track) will be counted as elapsed time.

The car's fuel economy will be measured in conjunction with the endurance event. The fuel economy under racing conditions is important in most forms of racing and also shows how well the car has been tuned for the competition. This is a compromise event because the fuel economy score and endurance score will be calculated from the same heat.

Course speeds can be estimated by the following course specifications. Average speed should be 48.28 km/hr (30 mph) to 56.33 km/hr (35 mph) with top speeds of approximately 65 mph.

Straights:	No longer than 76.2 m (250 feet) with hairpins at both ends (or) no longer than 60.96 m (200 feet) with wide turns on the ends. There will be passing zones at several locations.
Constant Turns:	30.48 m (100 feet) to 53.34 m (175 feet) diameter.
Hairpin Turns:	Minimum of 9.14 m (30 feet) OD.
Slaloms:	Cones in a straight line with 9.14 m (30 feet) to 15.25 m (50 feet) spacing.
Miscellaneous:	Chicanes, multiple turns, decreasing radius turns, etc. The minimum track width will be 4.57 m (15 feet).

The standard format will be two 24.14 km (15 mile) heats. In the event that weather or facility size precludes the running of two 24.14 km (15 mile) heats, then, one 24.14 km (15 mile) heat will be run with one driver change. Two 12.07 km (7.5 mile) heats each with driver changes will NOT be an acceptable replacement as this significantly reduces the demanding nature of the continuous 24.14 km (15 mile) run. In the event that only one 24.14 km (15 mile) heat is run, only two drivers (not four) will be able to compete in the endurance event.

Each heat will consist of the following:

- The fuel tank will be filled to the mark.
- Elapsed time will begin as defined in the judging section. Driver A will drive 12.07 km (7.5 miles), and elapsed time will stop when the car finishes the course.
- Driver A will proceed directly to the fueling station. The tank will be filled to refill mark and the amount will be recorded. When the fueling is complete, the time of day will be written on a sticker and affixed to the car. Two team members may now enter the fueling area and retrieve car.
- When the car and Driver B arrive at the course staging area (all repairs complete) a second time will be recorded on the sticker. In order to penalize those vehicles which require significant (over 5 minutes) repairs, all time in excess of 5 minutes will be added to the elapsed track time.

- Elapsed time will continue when the car enters the course. Driver B will drive 12.07 km (7.5 miles), and elapsed time will stop when the car finishes.

- Driver B will proceed directly to the fueling station. The tank will be filled to refill mark and the amount will be recorded.

Cars will be allowed to enter the track based upon the current level of traffic on the course. Priority for entering the course will be as follows:

- **The restart queue.** The restart queue consists of all cars which are restarting due to repairs. Priority in the restart queue will be determined on a first come first serve basis. All cars in the restart queue will be restarted prior to starting those in the start queue. A good faith effort will be made to restart cars ASAP, however, track congestion may delay the restart. ABSOLUTELY NO WORK MAY BE DONE ON A CAR WHILE THEY ARE IN THE QUEUE.

- **The Driver B start queue.** This queue consists of cars which are proceeding from the refueling and the driver change. These cars are not being penalized because they have already checked in, and their pit stop clock has stopped. NO WORK MAY BE DONE ON CARS WHILE THEY ARE IN THE QUEUE.

- **The Driver A start queue.** The order of the start queue will be posted at least 1/2 hour prior to the event at the operations center. Teams are responsible for arriving at the staging area prior to their start. The stager will sequence the competitors. The results of the maneuverability event will be used to order starts such that the track should contain cars of similar performance potential in order to minimize passing.

- **The postponed start queue.** The postponed start queue consists of all cars unable to get to the start queue in sequence. Priority will be determined on a first come first served basis. Note that there is no penalty for running out of the start sequence, but there will most likely be additional traffic on the track which will cause lost time.

- Time spent in the queue does not count.

The maximum number of cars on the track will be determined based on course layout. It is anticipated that the maximum number of cars would be six (6), with an average of four (4) to allow rapid restarts.

The number of laps on each course may be reduced to ensure completion of the event given existing or foreseeable weather conditions. The course will be no longer than 12.07 km (7.5 miles). If conditions (facilities and number of competitors) are such that it is not possible to conduct two 24.14 km (15 mile) heats, then there will be only one 24.14 km (15 mile) heat.

If a car experiences a breakdown, or is unable to maintain a minimum average speed of 40.23 km/hr (25 mph), then it must exit immediately for repairs and restart as prescribed above. Partial laps are not counted. If the car stalls and must be push-started, then the track workers will attempt a push-start, at their discretion or push the car clear of the track. At that time, two team members may retrieve the car and prepare it for restart under the rules above.

Vehicles must power down after leaving the course and be pushed into and out of the fueling area.

Fuel pumps will be turned on and fuel valves will be opened to insure complete refueling.

Two warmup laps may be provided to drivers A and B prior to the start of each heat, or may be eliminated by the host at its discretion.

The scores for the endurance event will be based on the sum of the following 4 items and will be referred to as the total corrected elapsed time:

- Elapsed time for Driver A
- Course to Course pit time in excess of 5 minutes
- Elapsed time for Driver B
- Penalties assessed

Elapsed time for Driver A will begin when the driver enters the track or 1 minute after permission to enter the track is given, whichever is earlier. Elapsed time for Driver B will begin when the driver enters the track. Elapsed time for each driver will end when the car completes the required number of laps. Course to course pit time will commence when the refueling is complete and a time tag is placed on the car. The pit time will end when the car presents itself to the start queue.

A car must complete each heat (e.g. total corrected elapsed time) within a 60 minute window. The window will begin with the start of elapsed time for Driver A. The window will be adjusted if the host shortens the course length, based on the twenty 40.23 km/hr (25 mph) minimum speed plus five (5) minute pit time plus twenty (20) minute repair time. If it is not possible for a car to complete the heat within the time window, the Chief Course Judge has the authority to pull the car from the heat in the interest of completing the event.

The following penalties will be assessed:

- Any aggressive driving behavior (such as forcing another car off the track, refusal to allow passing, or close driving that would cause the likelihood of car contact) will result in a black flag for that driver. When a driver receives a black flag signal, he must proceed to the penalty box to listen to a reprimand for his driving behavior. The amount of time spent in the penalty box will vary from zero to four minutes depending upon the severity of the offense.
- two (2) seconds per DOO
- For an OC, the driver must reenter the track at or prior to the missed gate or a twenty (20) second penalty will be assessed.
- The Chief Course Judge may disqualify a driver in the interest of safety if the driver is inexperienced or too aggressive, resulting in a DNF.

Penalties will not be assessed for accidental avoidance or other reason deemed sufficient by the track official.

Further driving rules and the meaning of flags are discussed in the Driving Rules section.

The score for the Endurance Track Event is the sum of the endurance time score and the endurance finish score. The endurance score is the sum of the time and finish score. The time score is calculated using the formula below. A car will receive an endurance score of fifty (50) if it completes the entire endurance event within the allotted window. The following equation is used to determine the scores for the event:

$$\textbf{ENDURANCE TIME SCORE} = 300 * \frac{(T_{max}/T_{your}) - 1}{(T_{max}/T_{min}) - 1} + 50$$

T_{max} will equal forty-one (41) minutes if the total heat distance is 24.14 km (15 miles). T_{max} will be decreased in proportion to the total track length if the track is shortened, track length 40.23 km/hr (25 mph) + 5 minutes. T_{min} will be the lowest total corrected elapsed time recorded for any competitor in either heat. T_{your} is the total corrected elapsed time.

The fuel economy score is based on the average mile per gallon fuel economy obtained from both drivers of the endurance heat. Fuel economy will be calculated for both heats.

The volume of M85 fuel will be divided by a 1.75 correction factor to determine the gasoline equivalent volume. This correction factor is equal to the ratio of energy (lower heating value) per unit volume of gasoline to M85.

Fuel economy scores can range from zero (0) to fifty (50). The following equation will be used to determine the fuel economy score:

$$\textbf{FUEL ECONOMY SCORE} = \frac{(V_{max}/V_{your}) - 1}{(V_{max}/V_{min}) - 1} * 50$$

V_{max} will be set equal to 3.79 liters (1 gallon) and will be adjusted to represent 3.19 km/liter (7.5 mpg) if the course is shortened. V_{min} will be the smallest volume of fuel used by any competitor for the two heats.

For shortened courses, V_{min} will be the low value per heat. In any case, the Fuel Economy and the Endurance score will be taken from the heat which yields the highest combined score.

The host reserves the right to impound any competitor immediately after the event to check engine displacement (method to be determined by the host) and restrictor size.

4.9 Rules of Conduct

The Formula SAE® event is a design engineering competition that requires performance demonstration of vehicles and is **NOT** a race. Engineering ethics will apply. In all events, violation of the intent of the rule will be considered a violation of the rule. Any perceived loopholes or potential problems should be identified in writing to the host. The host will then clarify the matter and advise all participants.

4.9.1 General Rules

During the competition, alcoholic beverages are not allowed on any of the event location property.

Disruptive parties at the motel should be prevented by the Faculty Advisor.

Cleanup of trash and debris is the responsibility of the teams.

Personal cars and trailers must be parked in designated areas only. Only **FSAE** competition vehicles will be allowed in the track areas.

Any problems that arise during the competition will be resolved through the Operations Center and the decision will be final. All protests must be in writing and will be subject to a twenty (20) point protest bond. If the protest is denied, this amount will be deducted from the final score; if upheld no points will be deducted. Protests must be filed within one hour after scores are posted.

It is the responsibility of teams to be in the right place at the right time. If a car is not ready to compete at the scheduled time, then the team forfeits the run of the event and will not be offered a late make-up. The driver for an event will be disqualified if he doesn't attend the driver meeting for the event.

4.9.2 Pit Rules

When the car is driven anywhere but the practice area or the competition tracks, the car must be driven at a walking pace. Whenever at all possible, a team member must walk beside the car at a normal walking pace. Cars with wings are required to have two team members walking on either side of the vehicle whenever the vehicle is in motion. During the performance events when the excitement is high, it is particularly important that the car be driven at a very slow pace in the pits; the walking rule will be enforced and point penalties will be assessed for violations of this rule.

Smoking is prohibited in all competition areas. The team's work area should be some defined area and should be kept uncluttered. At the end of the day, each team will clean all debris from their area and help with maintaining a clean paddock. Each team will be required to bring an extra fire extinguisher to keep in the pit area.

All refueling must be conducted by race officials.

4.9.3 Driving Rules

Cars must drive at a walking pace when going from one area to another with a team member walking beside the car. **The driver must be wearing a helmet, eye protection, and safety harness whenever the car is being driven under its own power.**

Practice for the endurance track event may be provided at the discretion of the host. Practice on any of the other performance tracks will not be allowed. A practice area may be provided in order to test and tune the cars. The practice area will be supervised and the number of cars in the area will be controlled. The cars may not be driven fast anywhere except the practice area and during the actual events. Off-course practice or any fast driving will be prohibited while competition events are in progress. The competition cars are prohibited from driving at any time (day or night) other than official competition or in the supervised practice areas. Unauthorized testing will result in point penalty from the competition officials. Officials will give only one warning to any team.

The safety of this competition and especially the endurance track event will be considered as the ultimate responsibility of the competitors. Thus, aggressive driving, running cars off the track, not yielding to passing signals, etc. will result in a black flag and a discussion of the driving behavior with competition officials in the penalty box. The time spent in the penalty box will be included in run time and serve as a reprimand as well as to inform the driver exactly what he/she did wrong. Drivers should be especially aware that open-wheeled cars are inherently dangerous due to the possibility of two tires touching and throwing one car into the air. The endurance event is a timed event; each driver is competing with the clock and is not racing other cars; therefore, aggressive driving is not necessary.

Passing during the Endurance Event is of primary concern. Two or more passing zones will be established on the track. Passing is allowed only in the passing zones and will be controlled by the track officials. These passing rules do not apply to a competing car passing cars that are disabled on the track or have spun-out and are not moving. The passing zones will be located at the exit of a turn onto a straight-away. There will be two parallel lanes separated by pylons. Upon entrance to the turn, the slower car will be blue flagged and will move to the inside of the turn and enter the inside passing lane; the faster car will move to the outside of the turn and will enter the outside lane. The faster car will make the pass in the outside lane and a flagman at the exit of the inside passing lane will signal the slower car when it can re-enter the track (after the faster car has completed the pass). All cars will use the outside lane under normal conditions.

All drivers of an event must attend the driver's meeting for the event or be disqualified for that event. The Faculty Advisor will verify attendance.

4.10 Definitions

DOO: A cone is "Down or Out" if it has been:

Knocked over

or

The entire base of the cone lies outside the box marked around the cone in its undisturbed position.

DNF: Did Not Finish.

Entry Gate: The path marked by cones which establishes the required path the vehicle must take to enter the course.

Exit Gate: The path marked by cones which establishes the required path the vehicle must take to exit the course.

Gate: The path between two cones through which the car must pass. Two cones, one on each side of the course define a gate: Two sequential cones in a slalom define a gate.

Staging Area: An area prior to the entry to an event for the purpose of gathering those cars which are about to start.

OC: A car is Off Course if it does not pass through a gate in the required direction.

SCHOOL _____ **CAR NUMBER** _____

This form must be completed and sent to the host no later than **December 31, 1994.**

STATEMENT OF COMPLIANCE

I hereby certify that the team members listed below are students currently enrolled in engineering courses. This team has designed and/or modified and prepared this car for the competition without direct assistance from professional engineers, racers, or related professionals. If this car has competed in a previous competition, I have attached documentation to prove that it was significantly modified. This car in any form has not competed in two previous Formula SAE® events.

_____

Signature of Faculty Advisor

Team Members

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____

If you have additional team members, please list them on the back of this form.

nd this form to: 1995 Formula SAE, Educational Relations Department, SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001

SAFETY STRUCTURE EQUIVALENCY FORM

This form must be completed and sent to the host **no later than February 1, 1995** and then will be submitted to the FSAE Technical Committee for approval of designs which deviate from the Formula SAE® construction rules for Roll-over Protection or Side Impact Protection. This form must also accompany the vehicle to Safety and Technical Inspection.

University Name _____

Team Contact _____

Telephone Number _____

Department _____

Room and Building _____

Address _____

City, State, Zip _____

Faculty Advisor _____

Telephone Number _____

Rule Deviated (include number) _____

Description of Deviation (include drawing if necessary) _____

_____

_____

_____

_____

Attach Proof of Equivalency

Roll bar documentation should include material type(s), material certification(s), properties, heat treatment, and strength calculations showing equivalency. Side impact documentation should include material type(s), material certification(s), properties, heat treatment, cloth weights, resin type, fiber orientation, number of layers, core material, layup technique, and strength calculations showing equivalency.

TECHNICAL COMMITTEE DECISION/COMMENTS

_____

_____

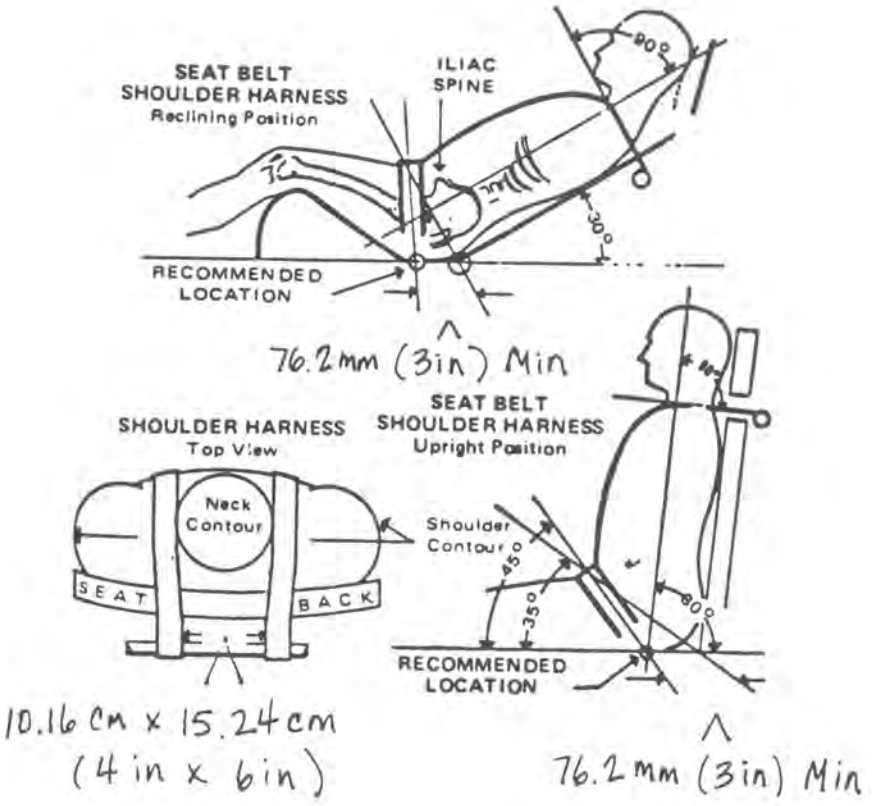
_____

_____

Send this form to: 1995 Formula SAE, Educational Relations, SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001

Figure I

Anterior Superior Iliac Spines



SCHOOL _____ **CAR NUMBER** _____

TALLEST DRIVER _____ **HEIGHT** _____ **NUMBER OF DRIVERS** _____

IMPORTANT

THIS FORM MUST STAY WITH THE CAR UNTIL ALL THREE PARTS OF INSPECTION HAVE BEEN COMPLETED

PRESENT THE CAR FOR INSPECTION IN THE FOLLOWING ORDER:

1. SAFETY AND TECHNICAL INSPECTION
2. FUEL CAPACITY AND TILT TABLE INSPECTION
3. NOISE LEVEL AND BRAKING PERFORMANCE INSPECTION

PART 2

FUEL CAPACITY AND TILT TABLE INSPECTION

	FUEL TANK CAPACITY 5.678 liter (1.75 US gallon) max. for M85 fueled cars 3.785 liter (1 US gallon) max. for gasoline fueled cars		FUEL SPILLAGE No fuel spill permitted when car is tilted to 45°
	FUEL STICKER M85 fueled cars must have M85 sticker		ROLL OVER STABILITY Car must not roll over when tilted to 57° in either direction with tallest driver on board

COMMENTS: _____

APPROVED BY _____ **DATE** _____

PART 3

NOISE LEVEL AND BRAKING PERFORMANCE INSPECTION

	NOISE LEVEL 105 dba (A) maximum 6.1 m (20 feet) from car during full power acceleration		BRAKING PERFORMANCE Must lock-up all four wheels on dry asphalt at any speed
	NOISE READINGS		ATTEMPTS 1 2 3

COMMENTS: _____

PPROVED BY _____ **DATE** _____

PART 1

SAFETY AND TECHNICAL INSPECTION CHECK-LIST

	HELMETS - Snell M85, SA-85, M90 or SA-90 rating		WHEELS - Four wheels, 20.32 cm (8 in) min dia
	GOGGLES (Or Face Shields) - Impact resistant material		WHEELBASE - 1524 mm (60 in) min
	GLOVES/SHOES - Fire resistant material, no holes		SUSPENSION - Full-operation with ± 25.4 mm (1 in) wheel travel and shock absorbers front and rear
	RIVERS SUITS - Fire resistant: Nomex, Kynol, FPT, IWS (wool), Fiberglass, Durette, Fypro, PBI, Kevlar		STEERING - On at least two wheels with positive stops to prevent linkage lock up and tires from contacting any part of car, 15° max freeplay
	SAFETY BELTS - 5 or 6 pt w/ single metal quick release, 76.2 mm (3 in) lap belt must pass over pelvic area, 35.56 cm (14 in) max between lap belt attachments, 50.8 mm (2 in) shoulder belts must attach behind & below driver's neck but above a plane 40° from horizontal, 50.8 mm (2 in) anti-submarine belt(s), all fasteners must be secured		BRAKES - Operating on all four wheels, one brake acting on a limited-slip differential is acceptable but car must be marked by orange sticker, brake system must be protected from drivetrain failure or minor collisions by scattershields
	ROLL BAR - Mild steel: 25.4 mm (1.0 in) o/dia x 2.36 mm (0.093 in) wall, Alloy steel: 25.4 mm (1.0 in) o/dia x 1.57 mm (0.062 in) wall, other designs need approval documents, a 4.76 mm (3/16 in) inspection hole must be drilled in a non-critical location		CRITICAL FASTENERS - Must be secured, rod ends not in double shear must be retained by a washer larger than the spherical bearing
	ROLL BAR BRACING - Both sides, for or aft, within 15.24 cm (6 in) of top of roll bar and at least 30° from vertical		GROUND CLEARANCE - Sufficient to prevent any portion of car from touching ground during track events
	ROLL BAR HEIGHT - Helmet of tallest driver to be 50.8 mm (2 in) min below line between front and rear roll hoops		ENGINE - A four-cycle piston engine 600 cc max
	HEAD RESTRAINT - 38.1 mm (1.5 in) thick crushable, damped padding not more than 25.4 mm (1.0 in) from helmet		THROTTLE AND RESTRICTOR - Must meet the requirements in 3.4.4
	ROLL BAR PADDING - Roll bar/bracing which could be contacted by helmet must have 12.7 mm (0.5 in) thick padding		THROTTLE CABLE - Must have a push/pull type cable with a compression spring at either end, a second spring must be installed such that failure of one spring cannot affect the other
	MIRRORS - Two functional rearview mirrors required		THROTTLE PEDAL - Must have a stop to prevent overstressing the cable or the actuation system
	VISIBILITY - Must be adequate to front, rear and sides, roll bar and bracing must allow free rotation of driver's head to 90° either side		COMPRESSORS - Turbo or super -chargers are allowed if not originally fitted to engine, must be downstream from restrictor, intercoolers must be ambient air cooled
	FRONT IMPACT PROTECTION - 150 mm (5.91 in) crush zone forward of drivers heels or master cylinders, whichever foremost and 100 mm (3.94 in) min high x 200 mm (7.87 in) min wide		EXHAUST - Routing must not subject driver to fumes, must have a muffler (or a turbocharger)
	SIDE IMPACT PROTECTION - One 25.4 mm (1.0 in) tube between 200 mm (7.87 in) and 350 mm (13.78 in) from the ground and two 25.4 mm (1.0 in) diagonals must connect front and rear roll hoops, monocoques need approval documents		FUEL FILLERS - 25.4 mm (1 in) min dia x 38.1 mm (1.5 in) min vertical height with a scribed line inside 12.7 mm (0.5 in) to 25.4 mm (1.0 in) below top, design must prevent refueling spillage contacting driver, exhaust, hot engine parts or ignition
	ARM RESTRAINTS - Must be installed in a manner such that the driver can release them and exit unassisted regardless of the vehicle's position		FUEL VENTS - Must have a check valve to prevent leakage when inverted and exit outside of bodywork
	FIRE EXTINGUISHER - One 0.91 kg (2 lb) 10BC or 1A10BC hand held type, visible and accessible from inside and outside of car, must be marked by SCCA red "E" symbol, if on board type, actuation location must meet intents above		FUEL LINES - Must have appropriate lines and fittings, high pressure systems must use metal braided hose, except where comercial fuel system components are used without modifications, with threaded fittings, must be securely attached and protected from rotating equipment failure
	FLOOR PANEL - From foot area to firewall		BELLYPANS - Vented to prevent accumulation of fuel
	EGRESS - 5 seconds max to side of vehicle		OIL LEAKS - None permitted
	STEERING WHEEL - Near circular with driver operable quick disconnect		CATCH CANS - All oil breathers and coolant overflows must exit into one quart min catch can(s)
	JACKING POINT - Must have an exposed tube at the rear perpendicular to the longitudinal axis 30.46 cm (12 in) long by 25.4 mm (1 in) outside diameter		SCATTERSHIELDS - Exposed high speed equipment such as torque converters, clutches, drive belts and chains must be protected by 12 gauge 2.67 mm (0.105 in) mild steel or documented equivalent scattershields
	KILL SWITCH - One switch located driver's right, near roll bar accessible from outside of car, one switch located where it is accessible by driver, both switches must kill all electrical systems and must be marked by SCCA blue triangle with lightening bolt symbol		AERODYNAMICS - No powered devices used to remove air from under car, no aerodynamic devices that can be adjusted while car is in motion, wings must meet the requirements in 3.5.2
	BRAKE LIGHT - Clearly visible from rear		BODY - Formula type, open wheels and cockpit
	FIREWALL - Fire resistant material, must separate driver from fuel and liquid coolant systems		NUMBERS - 15.24 cm (6 in) min tall both sides of car

COMMENTS:

APPROVED BY _____ **DATE** _____

SCHOOL _____ CAR NUMBER _____

COST ANALYSIS	
Engine and Drive Train	
Frame and Body	
Wheels, Wheel Bearings and Tires	
Suspension and Shocks	
Steering System	
Brake System	
Instruments, Wiring and Accessories	
Miscellaneous and Finishing Assembly	

GRAND TOTAL _____

Judges adjustments _____ x 2 = _____

TOTAL ADJUSTED COST _____

SCHOOL _____ CAR NUMBER _____

COST ANALYSIS

PART 1 - REPORT POINTS

CONTENT (0 - 12.5)

- Does the report appear to be complete?
- Do all parts and processes appear to be represented?

_____

PRESENTATION (0 - 12.5)

- Is the information presented in a logical format?
- Is the report easy to understand?
- Is the report professional in appearance?
- Was effort placed on the quality of the report? _____

THE FOLLOWING (0 - 12.5) SCALE SHOULD BE APPLIED TO THE ABOVE

0	=	inadequate or no attempt
3.0	=	attempted but below expectation
6.0	=	average or expected
9.0	=	above average but not perfect
12.5	=	excellent, meets intent

_____

TOTAL _____

COMMENTS: _____

_____

_____

_____

SCHOOL _____ CAR NUMBER _____

COST ANALYSIS

PART 2 - PRODUCTION COST

ACCURACY OF REPORT (-50 TO 75)

- Are all costs accounted for?
- Did team research production costs for materials requiring special processing?
- If parts or processes were not included, or costs were underestimated, apply the following penalty:

PENALTY = (2 X $ COST ERROR)

PRODUCTION COST = _____ (REPORT COST) + _____ (PENALTY)

= _____ (TOTAL)

COMMENTS: _____

SCHOOL _____ CAR NUMBER _____

PRESENTATION JUDGING

Score the following categories on the basis of 0-10 points each according to the following scale (any number or fraction along this scale may be used).

0.0	=	inadequate or no attempt
2.5	=	attempted but below expectation
5	=	average or expected
7.5	=	above average but still lacking
10	=	excellent, perfectly meets intent

_____ **CONTENT:** Were the concepts presented appropriate and adequate to explain how the car meets the intent of the customer? Were enough technical details presented without being boring?

_____ **ORGANIZATION:** Were the concepts presented in a logical order progressing from basic concept and showing how the engineering accomplished the concept? Was it clear to the audience what was to be presented and what was coming next? Were distinct introduction and overviews as well as summary and conclusions given?

_____ **VISUAL AIDS:** Were visual aids used or clear visual references made to the car? Were the illustrations visible for all of the audience?

_____ **DELIVERY:** Did the presenter speak in a clear voice? Did the presenter show enthusiasm and promote confidence in the technical aspects? Did he maintain eye contact?

_____ **QUESTIONS:** Did the answer illustrate that the team fully understood the question? Is there doubt that the team understood the answer? Did the team promote complete confidence in their response to the questions?

_____ **TOTAL = PRESENTATION POINTS (50 points maximum)**

COMMENTS: _____

_____

_____

_____

_____

SCHOOL _____ CAR NUMBER _____

DESIGN JUDGING

_____ **AESTHETICS (0-5)** - Does the vehicle look attractive? Does it have a high performance appearance?

_____ **MECHANICAL DESIGN (0-20)** - Do components appear to have been sized properly for the load? Does form follow function? Do brackets serve more than one purpose?

_____ **CHASSIS DESIGN (0-30)** - Does the suspension design consider kinematics, roll center placement or load transfer? How was vehicle handling designed for and developed? How was brake system designed? Was weight distribution and C.G. height optimized?

_____ **MANUFACTURABILITY (0-10)** - Can 1000 units per year be economically produced? Was manufacturing and ease of assembly a major consideration?

_____ **SERVICEABILITY (0-15)** - Is the engine easy to service or remove? Is the suspension easy to adjust?

_____ **INNOVATIVENESS (0-15)** - Are any of the components or systems unique? Do the innovations add to the product's functions?

_____ **ERGONOMICS/INTERIORS/SAFETY (0-20)** - Is the vehicle designed to accommodate & function with a wide variety of body sizes? Are controls and instruments easy to use? Does the design consider occupant safety beyond the requirements?

_____ **POWERTRAIN (0-30)** - Does the engine have significant modifications with respect to fuel injection, turbocharging, intake or exhaust? Was the drivetrain well done? Were throttle, drive controls designed well?

_____ **BUILD QUALITY (0-5)** - Fit and finish, quality of materials, detail work, quality appearance.

_____ **MISCELLANEOUS (0 to -50)** - If this is a carry over from last year and did not undergo significant improvements, or if the team does not exhibit a good understanding of the car, then a penalty may be applied.

_____ **TOTAL = DESIGN POINTS (150 points maximum)**

COMMENTS: _____

_____

_____

_____

_____

ACTION DEADLINES

1.	Registration Form Due to Host	December 31, 1994
2.	Statement of Compliance (see 2.)	December 31, 1994
3.	Safety Structure Equivalency Form (see 3.2.1)	February 1, 1995
4.	Cost Report (see 4.2)	April 30, 1995