



Formula SAE Electric Design Score Sheet



Car # _____ School _____

Paddock # _____ Contact Name/Phone: _____

Category	Areas Covered	Score
Suspension <input type="radio"/> Design <input type="radio"/> Build <input type="radio"/> Refinement/Validation <input type="radio"/> Understanding	Tires, wheels, hubs, uprights, control arms, steering linkage, springs, dampers, anti-roll bars, geometry, kinematics, vehicle dynamics. Selection and use of materials.	___/25
Frame/Body/Aero <input type="radio"/> Design <input type="radio"/> Build <input type="radio"/> Refinement/Validation <input type="radio"/> Understanding	Primary structure/tub/tubing, body, and aerodynamic/ductwork systems. Rigidity and stress-relief methods. Load analyses. Fasteners. Selection and use of materials.	___/25
Tractive/Drive/Recovery System <input type="radio"/> Design <input type="radio"/> Build <input type="radio"/> Refinement/Validation <input type="radio"/> Understanding	Accumulator(s), Power conversion, Motor/Controller selection/design, Wiring considerations, Transmission. Torque vectoring. Gearing. Regenerative braking. Selection/use of materials.	___/25
Cockpit/Controls/Brakes/Safety <input type="radio"/> Design <input type="radio"/> Build <input type="radio"/> Refinement/Validation <input type="radio"/> Understanding	Driver interfaces, seat, belts, steering wheel, steering column, control panel/dash, cockpit sizing & protection, driver comfort/ease of control, pedals, braking system. Is this car as safe as it can be? Selection and use of materials.	___/25
Systems Management/Integration <input type="radio"/> Packaging <input type="radio"/> Electronics/power mgmt <input type="radio"/> Team Organization <input type="radio"/> Analysis methods/tools	Design integration, plumbing/wiring, power management, schematics. Are sensitive items protected? Proper use of data? Do systems compliment another? Are progressive project management/ organization methods evident? Special communication tools utilized? What testing/development tools have been used or created?	___/20
Manufacturability/Serviceability	Ease of repair? Sub-systems accessibility, parts interchangeability, manufacturing complexity? Have fasteners been standardized? Are special tools required to diagnose/service vehicle?	___/15
Aesthetics/Style	Attractive overall appearance? Is car clean, reflective of professional work? Does car instill team pride, or apologies?	___/ 5
Creativity	Will this car cause a rules change? Have the judges learned something new? On rare occasions, creative or innovative design may merit special points.	___/10

Weight: _____ (lb)

PRELIMINARY DESIGN SCORE: _____/150

FSAE Design Event Scoring (Some Insights into the Process)

The design and development process of a FSAE car is a complex process. So is judging! Although many metrics and details are reviewed during judging, it is easy to overlook various features which are critical to a given team's efforts. As such, it is critical for team members to pro-actively highlight these special details, how they support the team's overall goals, and how they distinguish them from the competition. Do not rely on the judges to hunt for the cool bits!

Judges **and** teams should be familiar with the scoring categories. A detailed break-down of each category follows, along with system relevant example questions. These examples exhibit just **some** of the key attributes that teams should be prepared to discuss, both in theory and as applied to their vehicle, with the judges. Note: While some categories may list components not in your design, if you present a data driven argument for omission, along with a demonstrated knowledge on the topic, your team may still receive points in that category. One example being aero.

Judges: Please provide as many detailed comments as time permits, for the benefit of students!

Judge observations and comments shall be provided on the attached sheets for future review.

Remember: Judges are not just scoring your vehicle, they are also scoring **your knowledge and understanding** of vehicle development and performance. Reflective of this, for each major design score category, judges shall evaluate the teams and assess points per the following breakdown:

Design (~25%): Assessment of design process used by team. Is this a new design, evolution, or complete carryover? Were different design options considered? What criteria was used to make design decisions? Were appropriate pre-build analyses performed? Is this an integrated design, or a series of independent sub-system designs?

Build (~25%): Does the physical specimen presented reflect the early design work? Is it reflective of the design report? If not, why not? What special manufacturing considerations were encountered? Were the build methods / processes appropriate and well executed?

Refinement/Validation (~25%): How thorough and objective was the team's testing? Was a test plan developed and executed? Were discrepancies between predicted and tested results documented and acted upon to improve final build?

Understanding (~25%): Does the team presenting the car at competition understand it? Are they intimate with the design and the engineering fundamentals it attempts to exploit?

About your score...

The Design Event Score Sheet totals 150pts. At the end of competition, you will most likely find that your final score does not match the score listed on page 1. **Do not panic!** This scoresheet is a working tool.

The score listed on this sheet is reflective of your assigned judges' assessment, relative to other teams in your queue. Despite attempts to ensure consistency, the reality is that judge scores vary slightly from queue to queue. Hence, the chief judges compare notes about cars between different queues, and with the assistance of floating judges, work to normalize scores and minimize bias via multi-tier rankings of teams. This is typically performed after the initial score sheet has been submitted and thus, please consider the score on this sheet as a first cut review, and subject to discussion among judges.

Score sheets and written judges' comments shall be distributed to the teams but are not shared with other teams. Do not attempt to compare your scores on this sheet to that of another team as the comparison may not be valid.

Tractive Drive/Recovery System (0-25pts)

Score: _____

Is the tractive system lightweight, efficient & robust? Does it have manageable power delivery?

This category focuses on design of the drive management systems, motor(s), accumulators and driveline. Where appropriate, understanding of failure modes and critical limp-home requirements should be addressed. Teams should demonstrate competent and reasonable analysis methods, appropriate physical execution, and validation within their design. Sample areas include, but are not limited to:

- Are the benefits of electric motors fully utilized (e.g. over powering/boosting, regenerative braking, vehicle control)?
- Is the system well packaged/integrated into the remainder of the vehicle?
- Has a good balance of Make vs. Buy decisions been employed?
- Were motor(s) appropriately selected and developed? Does the team have a good insight in the limitations of their motor(s) and the trade-offs on weight and energy efficiency?
- Which power/torque ratio is chosen? Are the reasons for this understood?
- Are cooling systems properly sized for the motor, battery, electronics, accumulator, etc...?
- Is the accumulator configuration properly designed to meet the team's stated goals? (e.g. capacity, power, temperature dependence)
- Is an energy management strategy clearly defined and implemented?
- Temperature management: which are the weakest components and under which conditions? (consider short term and long term failure modes).
- Is there data communication/feedback between different parts of the tractive system?
- Has data logging of tractive system been well executed? Was gathered data properly utilized?
- Are safety hazards well understood? (e.g. battery over/under charging, arcing, energy storage, battery leakage due to impact and/or vibration, personal safety concerns, etc...)
- Regenerative braking: How does it influence overall weight, motor temperatures, controller and battery reliability? Have the strategies been well defined and developed?
- Has the team demonstrated adequate working knowledge of tractive system simulation tools? If so, what tools were used and how were they validated?
- Torque vectoring: which strategy is used Is the strategy and implementation effective to sufficiently benefit vehicle dynamics?
- Have the transmission and final drive been adequately engineered? Gearing Strategy?
- Are the CV / U-joints appropriately sized and properly aligned?
- Has the team demonstrated understanding of tribology, viscosity characteristics, viscous drag, additive packages, coatings, etc.?
- Have special materials or surface prep been used to reduced drag, weight, increased strength, or heat management? (Ti, Inconel, ceramic bearings, coatings, heat-treat, peening, etc.)
- Other _____
- Other _____
- Other _____

Comments: _____

COCKPIT / CONTROLS / BRAKES / SAFETY (0-25pts)

Score: _____

Can a driver comfortably and safely drive this car at speed?

This category focuses on the vehicle from the point of view of the driver. Cockpit ergonomics and safety systems, including steering, brake and shifter controls are covered. A potent vehicle will not perform well if the driver cannot get the most from it. The driver must be able to use all controls with comfort and within his/her physical limits of strength, girth, & reach. The vehicle should also be capable of adequately protecting the driver, in case of an accident or component failure. Where appropriate, understanding of failure modes and critical limp-home requirements should be addressed as well. Teams should demonstrate analysis methods, appropriate execution, and validation within their design. Sample areas include, but are not limited to:

- Have Driver Controls (Throttle, Clutch, Shifter, Brake, Steering) been designed, sized, executed, and tested for reliable consistent operation?
- Regenerative braking (EV/Hybrid): how did it influence the design of the mechanical brake system? Have provisions been made to improve pedal feel/feedback?
- Are Active Controls (Traction Control, Launch Control, No-Lift-Shift, Auto shift, ABS) intuitive to use, well marked?
- Do the team drivers understand how to use on-vehicle control systems?
- Have adequate limp/backup modes been employed, in case of system failures?
- Does the team appreciate the importance of consistent / reliable brakes?
- Were proper kinetic energy calculations employed during brake system design?
- Have pedal-force gain requirements been addressed?
- Were properly sized brake components selected / developed?
- Were proper brake materials utilized (rotors, pads, and pedal assembly)?
- Have instant brake bias requirements been analyzed and properly implemented?
- Is the driver adequately supported during lateral, longitudinal, vertical, and combined g-forces?
- Is visibility, arm/leg room, head restraint well thought out and implemented?
- Are controls properly placed for efficient operation? (i.e., will it pass the blindfold test?)
- Are controls easily adjustable for different driver needs?
- Does cockpit size permit 5th-95th percentile drivers?
- Are the essential instruments easily readable?
- Is the interior free of potentially injury-causing projections, etc.?
- Does the design advance safety beyond the minimum requirements?
- Other _____
- Other _____
- Other _____

Comments: _____

SYSTEMS MANAGEMENT & INTEGRATION (0-20pts)

Score: _____

Is the vehicle and team well integrated? Do the electronic/electrical systems effectively support performance? Is the team progressive, well-balanced, and appear capable of repeating their efforts?

In addition to electrical systems, this category considers the overall vehicle strategy and approach. This is inclusive of architectural trade-offs, packaging, instrumentation, and team development/management.

- Are accessory devices (ECU, Data, Comm. Equip., Control system components) complementary, efficiently packaged and adequately protected? Do they perform as a system?
- Do test equipment / data systems effectively support vehicle development? Or just look good?
- Is data collected and utilized during the competition to improve performance? If so how?
- Has wiring been correctly selected, safely routed, color coded, and marked for function?
- Can the team produce wiring, plumbing, and sub-system schematics for the vehicle?
- Is the team’s approach to each system congruent with the overall goals? Is the integrated vehicle better than just the sum of its parts?
- Has the team proven its fluency with simulation and advanced analysis techniques?
- Has Project Management been a priority for the team? Can they show detailed schedules?
- Can the team provide engineering and build documentation
- Have the organizational skills of the team been well demonstrated?
- Has the team really read the rulebook?
- Other _____
- Other _____

Comments: _____

MANUFACTURABILITY / FIELD SERVICEABILITY (0-15pts)

Score: _____

Can the team efficiently build more than one car? Can it be fixed in the field?

This category addresses the ability of a reasonable manufacturing facility to construct the vehicle *as presented* and for teams campaigning the vehicle to perform maintenance and repairs.

- Are unusual, or specialized, machining operations required? Exotic / expensive materials?
- Are fasteners standardized (SAE or Metric?) throughout vehicle?
- Have the number of fastener sizes been minimized?
- Are components from various corners of the car interchangeable?
- Can all areas of vehicle be accessed without major component (engine) removal?
- Can components be substituted in-field with conventionally available items?
- Is special training or equipment required to service subsystems? Will this prove unreasonable as the car is campaigned outside the university environment?
- Other _____
- Other _____

Comments: _____

AESTHETICS & STYLE (0-5pts)

Score: _____

Is the car visually appealing?

This category may not seem engineering / design oriented, but is an important reflection of the professionalism and seriousness of the team. It is the first impression of the vehicle, and often influences the ability of the team to diagnosis emerging problems (leaks, cracks, etc.) before they become catastrophic.

- Is the overall appearance attractive?
- Does the car look fast?
- Does the car exhibit high levels of fit and finish?
- Is the car clean (washed, free of oil, grease, debris, etc.)?
- Does the car instill pride in driver/owner/team/sponsors? Or apologies...?
- Other _____
- Other _____
- Other _____

Comments: _____

CREATIVITY (0-10pts)

Score: _____

Is the design and execution of this car going to cause a rule change?

Strictly speaking, innovation is extremely rare in FSAE. It implies a marketing success coupled to a new paradigm. Creative interpretation or adoption of ideas in new ways is certainly encouraged in this competition, however: If it makes us go redress the rule-book, then perhaps it is even better!

- Are any components or systems unique or unusual, due to special analytical finding?
- Has there been creative use of materials, manufacturing processes, or test procedures?
- If so, do the creations contribute to the potential performance of the vehicle or to its overall effectiveness? (Creativity that does not have a function is "art".)
- Do the students understand why and how their idea is better than the classic method?
- Other _____
- Other _____
- Other _____

Comments: _____

