Team Members: David Stout, Carlos Medina Gutierrez

Faculty advisors: Dr. Shreyas Narsipur

Dr. Vivek Khare

Development and Validation of an Aerodynamic-Load Measurement System for Formula SAE and Broader Vehicle Dynamics Applications

Problem Statement

Definition: Design, Calibration, and Experimental Validation of an FSAE Aerodynamic-Load Measurement System.

Research Question: How accurately can an instrumented FSAE vehicle measure the downforce, drag, and center of pressure location under combined loading, and can the aerodynamic effects of two wing settings be reliably distinguished?

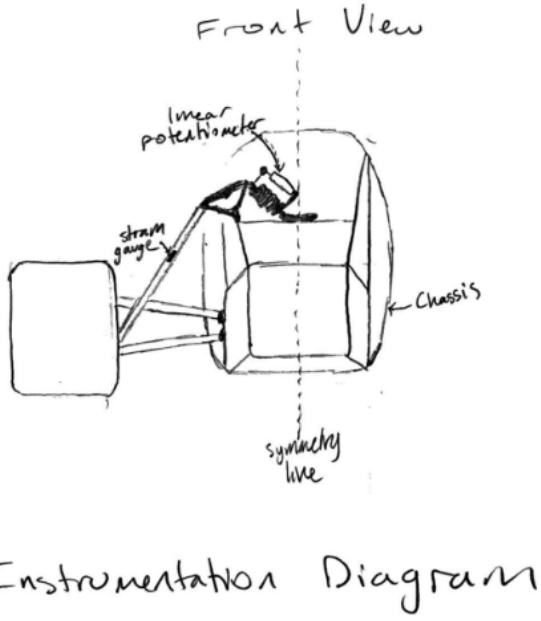


Figure 1 Preliminary System Design

MSU's FSAE team does not currently have a system for measuring the real-world aerodynamic effects of the vehicle's aerodynamic package. Having such a system is very important for understanding the discrepancies between theoretical/computational predictions and real-world physics. Knowing how the

aerodynamic package behaves in the real world and the error with predictions allows for the team to make better predictions for the future and ideally allows the team to produce a vehicle that performs in the real world as intended.

Beyond Formula SAE, a modular aerodynamic-load measurement system could support the development of prototype, aftermarket, and other dynamic systems under combined loading. By directly measuring the forces and moments under real operating conditions, the system could help engineers validate computational predictions, compare design configurations, and improve system stability, safety, and efficiency without relying solely on costly experimental testing.

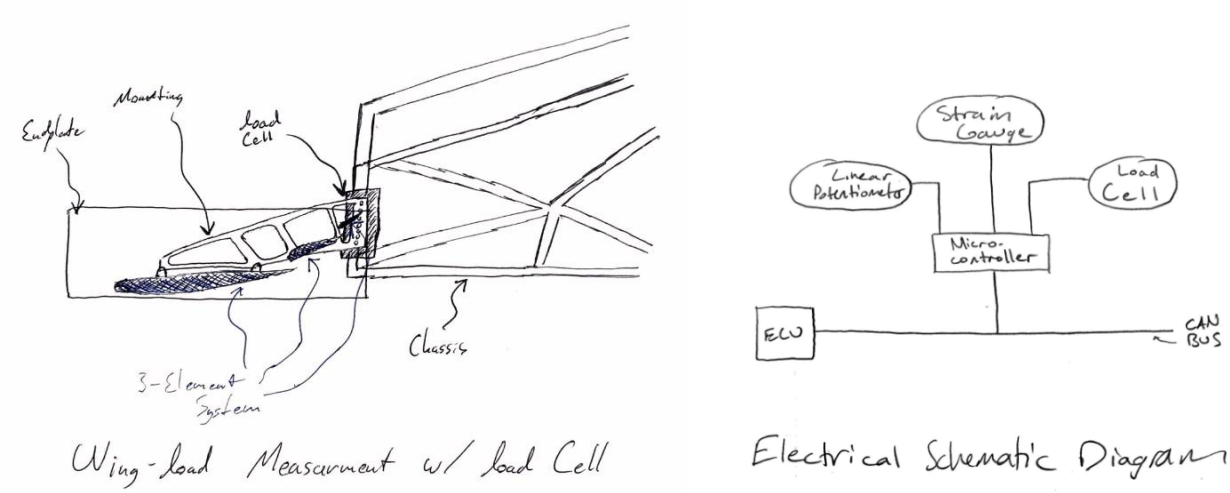


Figure 2 Preliminary System Design Continued

Overall Project Objective(s)

1. **Establish measurement requirements and practical constraints** for evaluating aerodynamic loads on an FSAE wing.
2. **Develop a aerodynamic-load measurement system** suitable for the selected loading conditions and intended testing environment.
3. **Calibrate and independently validate the measurement system** to characterize its accuracy, repeatability, and measurement uncertainty.
4. **Evaluate the system's usefulness for FSAE aerodynamic validation**, including its ability to locate center of pressure and identify changes in aerodynamic loading and its limitations in practical use.
5. **Develop a foundational, robust, and adaptable aerodynamic-load measurement system** suitable for future testing and engineering applications beyond the immediate FSAE use case, with an emphasis on modularity, maintainability, and scalability.

Individual Team Member Responsibilities

David	Carlos
• Aerodynamic Load Analysis Lead • Experimental Test Design Lead • Sensor Calibration Lead • Software Development Lead	• Aerodynamic Modeling & Simulations Lead • Instrumentation Design Lead • Vehicle Test Engineer & Driver • Manufacturing Lead

Reporting

Dr. Narsipur: Weekly in-person meetings with his point-of-contact, Mehdi Ouhabi

Dr. Khare: in-person meetings Twice per month minimum (~bi-weekly)