Project Definition Document

Aerospace Senior Projects (ASEN 4018 & 4028)
Fall 2004 and Spring 2005

1.0 Information

1.1 Project Title

Formula Adaptive Airfoil and System Technology (FAAST)

1.2 Project Customers

CU Formula SAE Team:
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2.0 Background and Context

Aerodynamics are an important factor in every type of motor vehicle, especially in Formula 1 and NASCAR racing. Most F1 cars now have several airfoils: front, rear, top and bottom all working together to enhance the aerodynamic efficiency. The airfoils are used to create downward force so that the tires always have enough static friction to move the car without losing momentum to skidding or peel-outs. Currently these airfoils do not adapt to different modes of the car such as acceleration, high speeds and cornering.

Formula SAE is an intra-collegiate race which uses scaled down vehicles and a slower track with many sharp turns.

There are no airfoils in any type of racing which adapt to the different parts of the course. More down force on the tires is needed around turns and during acceleration to prevent tire spinout. To reach high speeds, it is desirable to decrease drag induced drag produced by the airfoil. An aerodynamic wing is necessary to optimize the down force for all sections of the track. An adaptive airfoil, as proposed, could increase the cornering and straightaway speed of these vehicles.

3.0 Objectives

3.1 Overall Objective

To conceive, design, fabricate, integrate, test and verify a race car airfoil which will optimize the resultant downward force and drag; depending on the particular operation of the car such as acceleration, cornering, braking and high speeds. This requires that the airfoil be dynamic and able to quickly alter the down force it creates. The aerodynamic system will increase the normal force between tires and track in corners, thereby increasing the static friction. However, at high straightaway speeds, the system will work to reduce drag by decreasing airfoil drag.

3.2 Measure the Speed of the System

3.2.1 Measure the speed of the airfoil or the car transporting it within 2 mph throughout the duration of the test (race if possible).

3.2.2 In order to provide the appropriate amount of downward force, the speed of the system must be known.

3.3 Measure the Forces on the System

3.3.1 Accurately, within 0.1 g, measure the lateral and longitudinal g-forces, from 0-2 g's, on the system.

3.3.2 In order to properly change the downward force according to the race track, the forward acceleration, deceleration, and lateral accelerations must be known.

3.4 Design an Airfoil System

3.4.1 Design an airfoil system which can create a force equal to 15% of a small vehicle (weighing approximately 450 lbs unmanned) on the rear axle. The airfoil system will increase the tolerated lateral force by 0.05 g's around turns and will weigh less than 20 lbs. The airfoil will produce insignificant drag (~5lbs) when required.

3.4.2 The use of an airfoil is the most efficient method of creating downward force on racing vehicles.

3.5 Design a Control System

3.5.1 Design a method to change the effects of the airfoil in 0.5 s or less with down force adjustability within ± 5 lbs.

3.5.2 During a fast moving race with many turns, it is imperative that our system can react to any course obstacle while running at top speeds (60 mph +).

3.6 Design a Driver Interface

3.6.1 Create a simple cockpit control to enable or disable the system.

3.6.2 If problems occur within the system, the driver should be able to disable or restart the system.

3.7 Wind Tunnel Verification

3.7.1 Wind tunnel testing will be used to verify the aerodynamics of the airfoil and a test stand will be obtained or developed as needed.

3.7.2 Wind tunnel testing may be accomplished using a scaled model of the airfoil. Optimally wind tunnel testing of the full system (scaled) will be used to verify the downward force provided at various free-stream velocities and modeled accelerations; however, this may be achieved during testing on the integrated SAE car and the FAAST system.

3.8 Integrate to the SAE Car

3.8.1 The airfoil and control system must be integrated and mounted to the Formula SAE Car from 2003 or another vehicle as necessary.

3.8.2 Beyond wind tunnel tests, this will be a method of functional verification of all systems. Since the 2003 car currently exists this will remove interdependency of the FAAST project and the 2004 Formula SAE project. If proven prior to the 2004 SAE team cutoff date the FAAST system may be integrated into the 2004 car. If integrated with the SAE car, fabrication or design of the integration may be done in part by the SAE team.

4.0 Anticipated Engineering Expertise

Technical Expertise	***How Applied***
Precision Mechanical Design	Develop conceptual and detailed solid 3D models of the device components
Airfoil Design	Designing for fabrication of wing(s)
Aerodynamic Optimization Studies	Develop ideal operation for adjusting airfoil
Data Acquisition Software	Real-time measurement subsystem
Control Software	Real-time control subsystem
Mechanical Fabrication	Part machining
Electronic Fabrication	Analog and digital electronic subsystems

Mechanical and Dynamic Test	Verification of the project
Materials	Material selection of wing(s)
Structural Design	Flexibility and strength for wing internals

5.0 Resources

5.1 Facilities

The project will have access to the IMI Race Track in Erie, CO, on which the SAE team practices. Use of the ITLL wind tunnel will also be coordinated with Walt Lund to verify design goals.

5.2 Additional Advisors

Professor Donna S. Gerren
Professor Dennis Akos

SAE teams from other Universities with aerodynamic packages will be contacted for advice.

5.3 Funds

The CU aerospace department will provide $4000 for this project. The CU SAE team has expressed interest in supporting our project with additional funding.