Aerodynamic Performance of a Low Aspect Ratio Active Rear Wing Package Designed for the OSU Formula SAE Team

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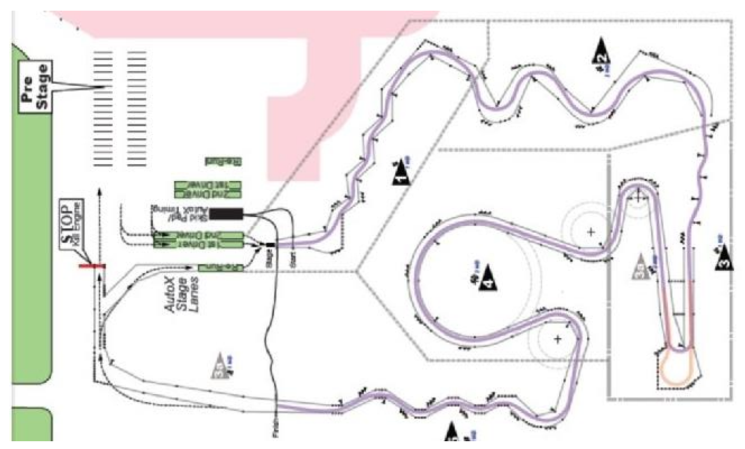
Background

- Subset of the Society of Automotive Engineers (SAE)
- Annual competitions made up of static and dynamic events
- Universities across the globe design, manufacture, and compete
- 400-500lbs

BR 20.5 with V1 of rear wing

FSAE Lincoln autocross track

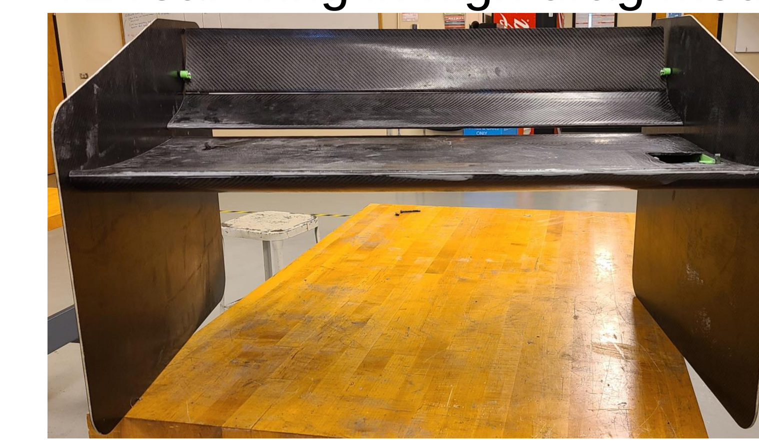


Why Implement an Active Aerodynamics Package?

- Aero packages increase downforce, resulting in increased tire grip, increasing stability, lateral acceleration, and cornering speeds
  - Lateral acceleration with aero can increase by 50% compared to a car without aero
- Static aero packages increase drag, reducing vehicle's top speed in straights
- Making aero 'active' by designing a variable pitch capability allows drag to be reduced when downforce is not necessary
- Downforce to increase grip in high-speed corners to achieve higher speeds through turns
- Drag can be increased to act as 'air brake', permitting later braking prior to corner

This is a competition! Any small design advantage can be the difference between winning and losing

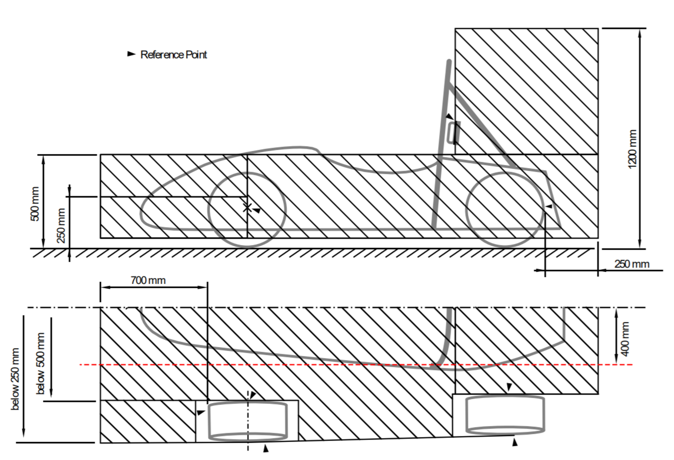
V2 rear wing in high drag mode



V2 rear wing in drag reduction mode

Design and Regulations

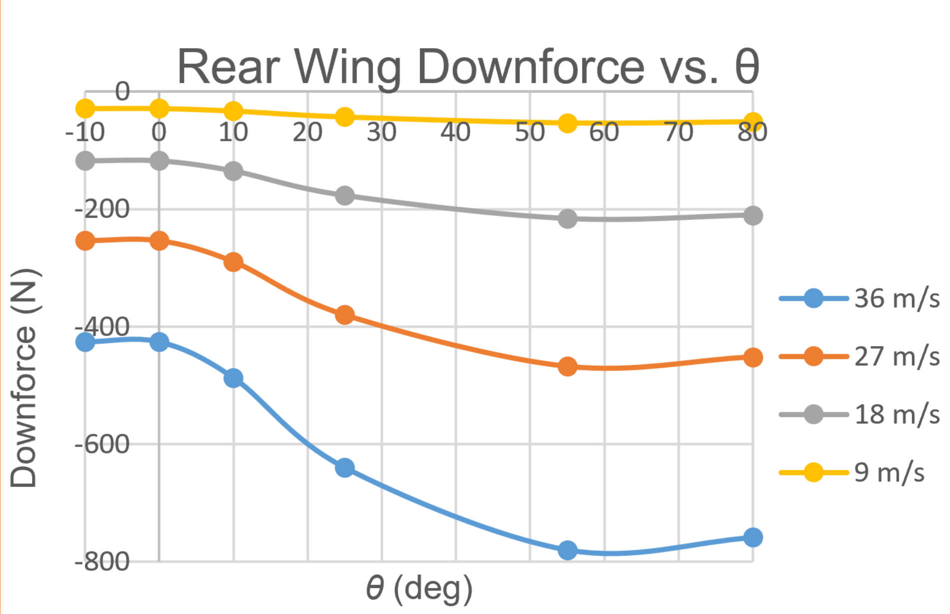
- High Aspect Ratio wing is more efficient based on results of Lifting Line Theory
- Design restricted to low AR per FSAE rules
  - Incorporate endplates to increase efficiency
- Geometry restricts use to a small-span wing, limiting amount of downforce developed
  - Use a 3-tier lift system rather than a single wing
- 2'x2'x3' outer dimensions
- V1 16.3lb weight
- V2 6.3lb weight

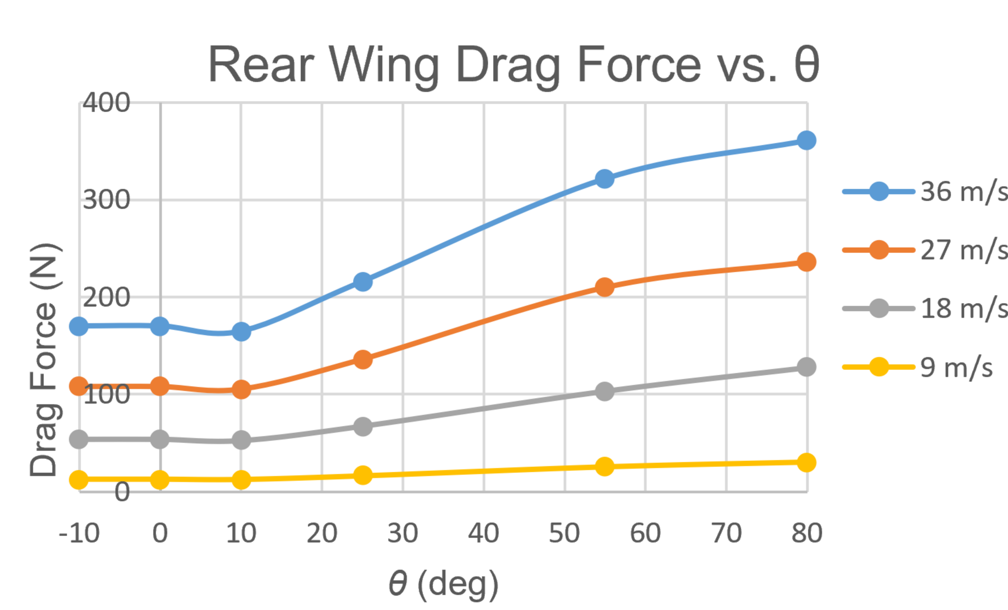


Results

- Speeds on track typically range between 20-70mph
- Average speed roughly 18m/s (40mph)

- Maximum downforce of ~200N (45lb) at 60°, ideal for cornering
- Maximum drag of ~125N (25lb) at 80°, ideal for air-braking
- Minimum drag of ~50N (11lb) at 10°, ideal for straights

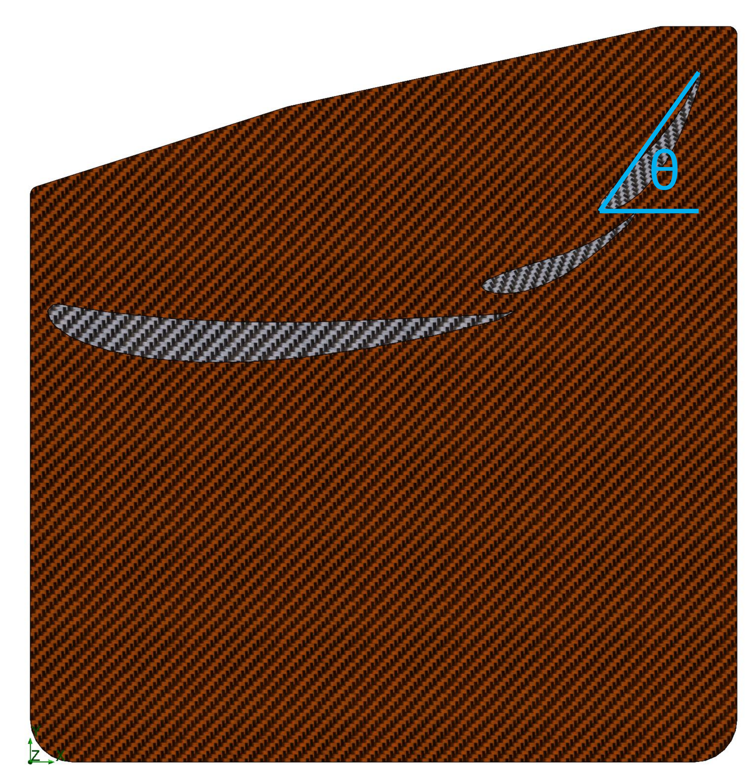




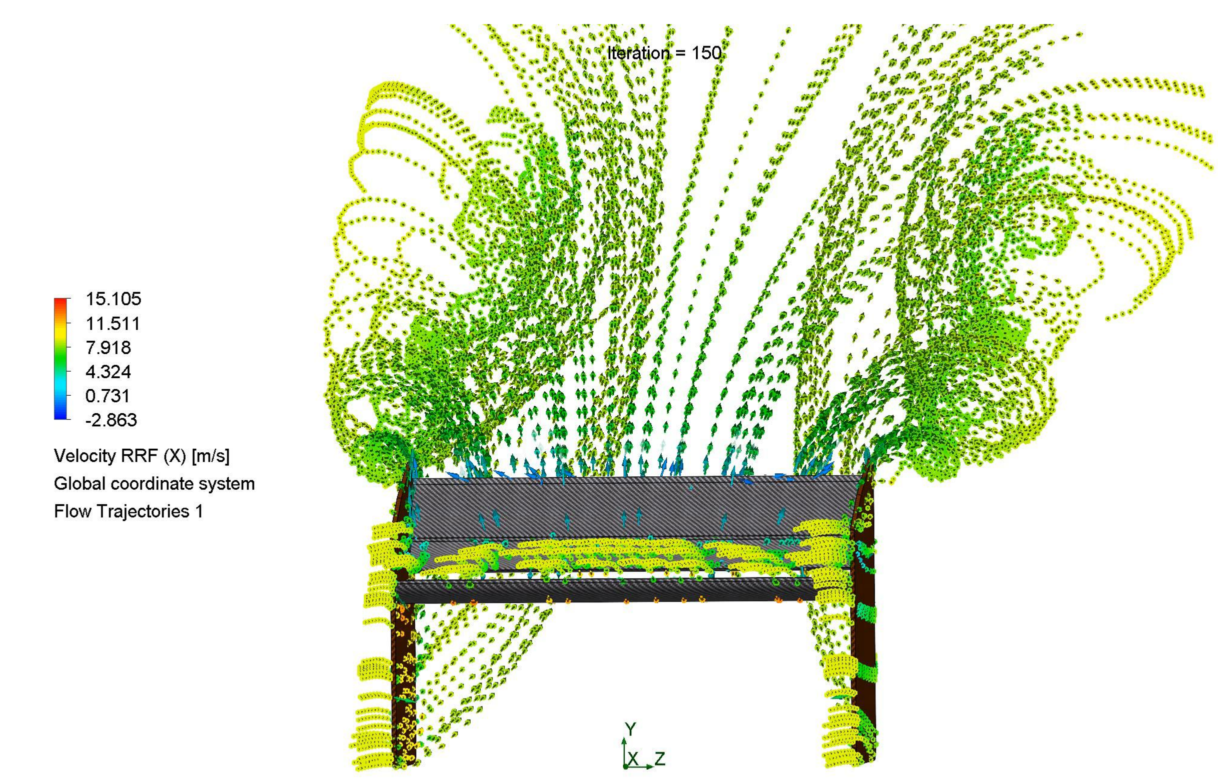
Analysis

- Determine what pitch angle, θ, to maximize downforce in turns, minimize drag in straights, and maximize drag in braking
- Analysis is difficult to run due to complex geometry, rendering basic equations and lower-order codes unsuitable
  - Solidworks CFD utilized

Side view of rear wing with active 3rd tier element



3D CFD study analyzing velocity and generated vortices



Conclusions

- V2's endplate-mounted system is lighter and stiffer than V1's
  - Superior manufacturing techniques and materials, utilizing foam core and vacuum bagging
- More track data is necessary, but data on an accompanying front wing of identical geometry suggests a 5% decrease in lap time between no aero and fixed aero and similar performance between static and active aero
  - Data from one track with 3 drivers
  - Limited fixed and active aero data points due to time restriction
  - Plan to collect more data with more drivers on different tracks in coming days to eliminate skewed data




*Questions? Please email cpric11@okstate.edu

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