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Designing a Rear Wing for Binghamton's Formula Race Car: From Small-Scale Simulations and Experiments to Full-Scale Manufacturing

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Designing a Rear Wing for Binghamton's Formula EV Car: From Small-Scale Simulations and Experiments to Full-Scale Manufacturing

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Abstract:
Binghamton Motorsports FSAE Team currently lacks necessary aerodynamic research to compete as a top EV team in the country. A full aerodynamic package must be implemented to increase downforce, and decrease lap time on dynamic events at the international SAE competition in June. To achieve this goal, aerodynamic knowledge must researched and developed. Our research utilized scaled, and full scale simulations and experiments, to successfully manufacture an aerodynamically efficient rear wing out of carbon fiber and high strength to weight materials.

Experimental & Numerical Approach:

1. Utilize Javafoil to determine ideal arrangement of airfoils
2. Determine accurate downforce and lift generation using ANSYS Fluent
3. Verify results using a scale model and wind tunnel located at Binghamton University
4. Utilize lap time simulator to see effects of rear wing on lap time.
5. Utilize FEA optimization on ANSYS Workbench to optimize support ribs and decrease weight for overall assembly

Manufacturing Methods:

1. Create female 3D printed molds for airfoils
2. Use a wet-layup, with vacuum bagging, technique to lay carbon fiber on the molds
3. Mount rib and spars inside the assembly with 3M panel bond and seal interior
4. Mill elephant ears and mounting tabs
5. Utilize honeycomb in interior of carbon fiber parts to increase rigidity while decreasing overall weight

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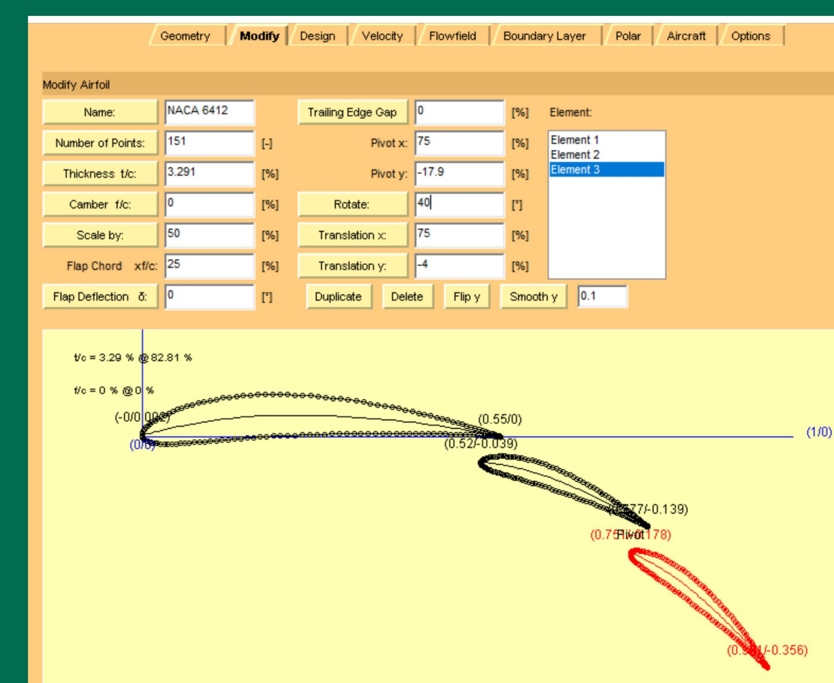
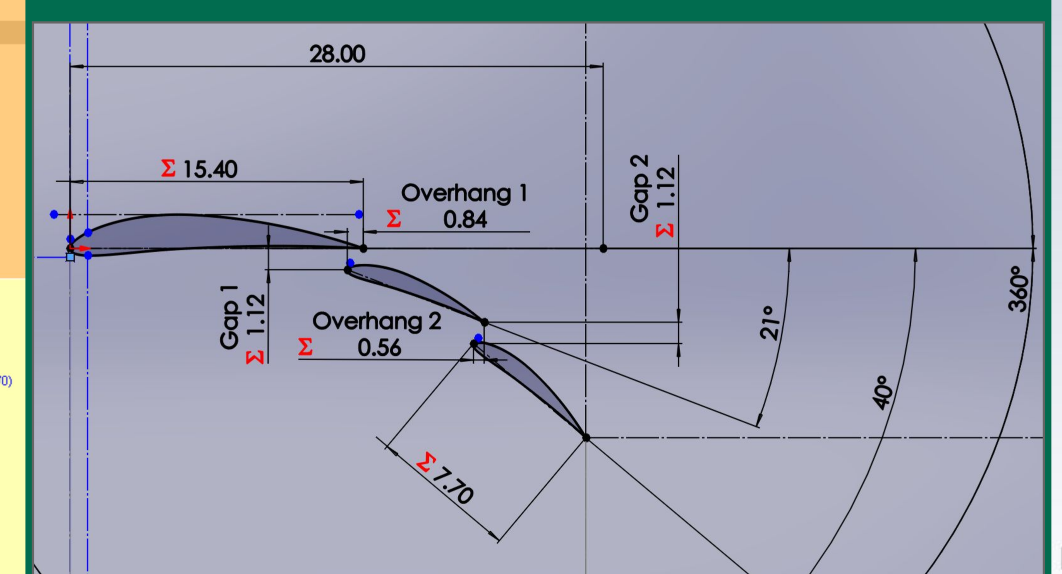
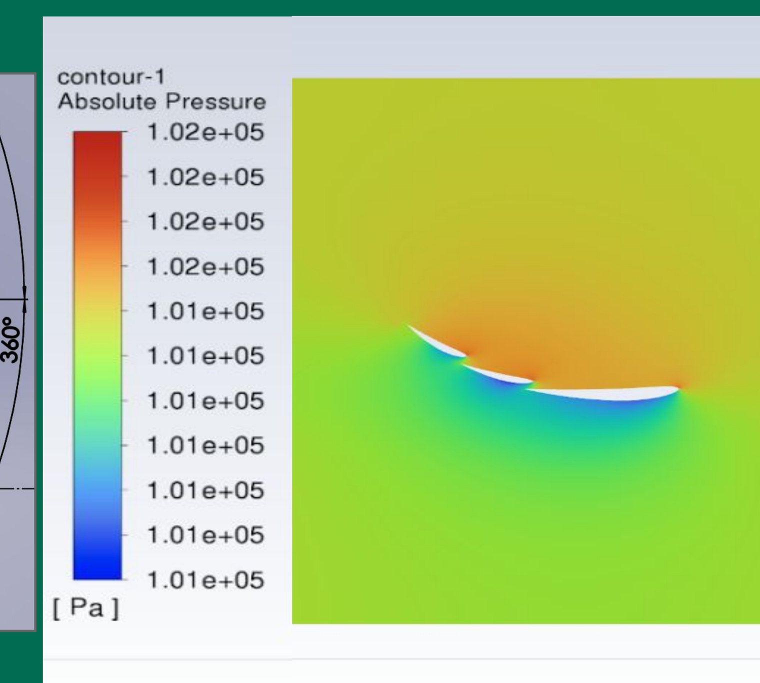
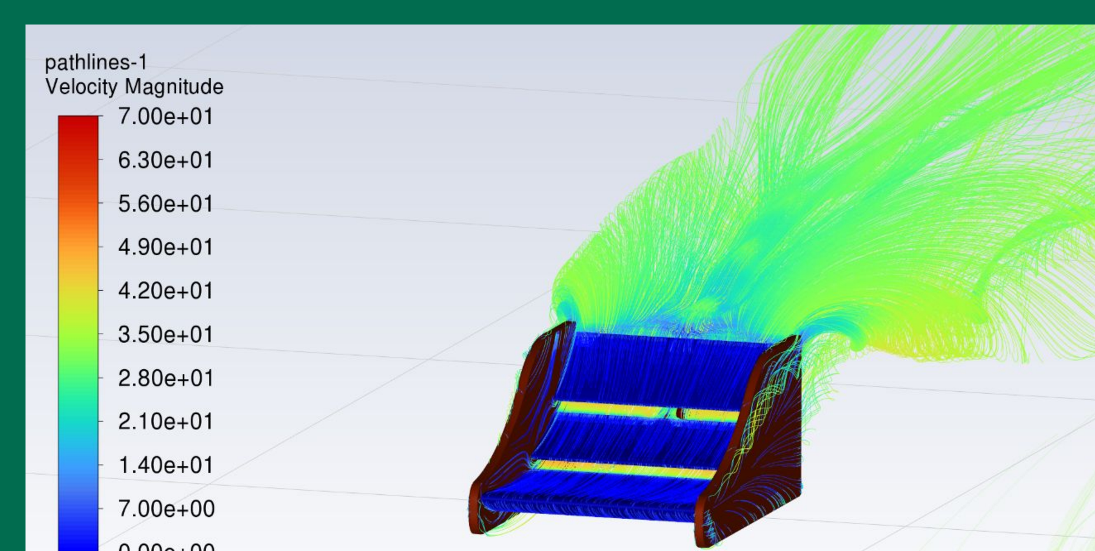
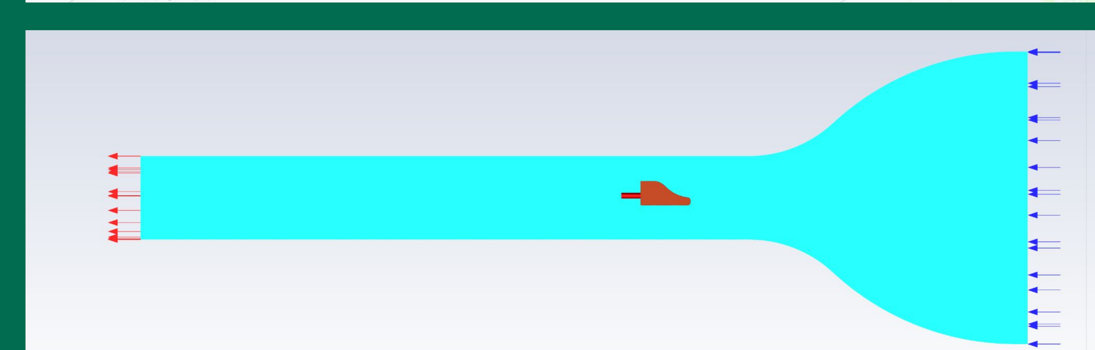
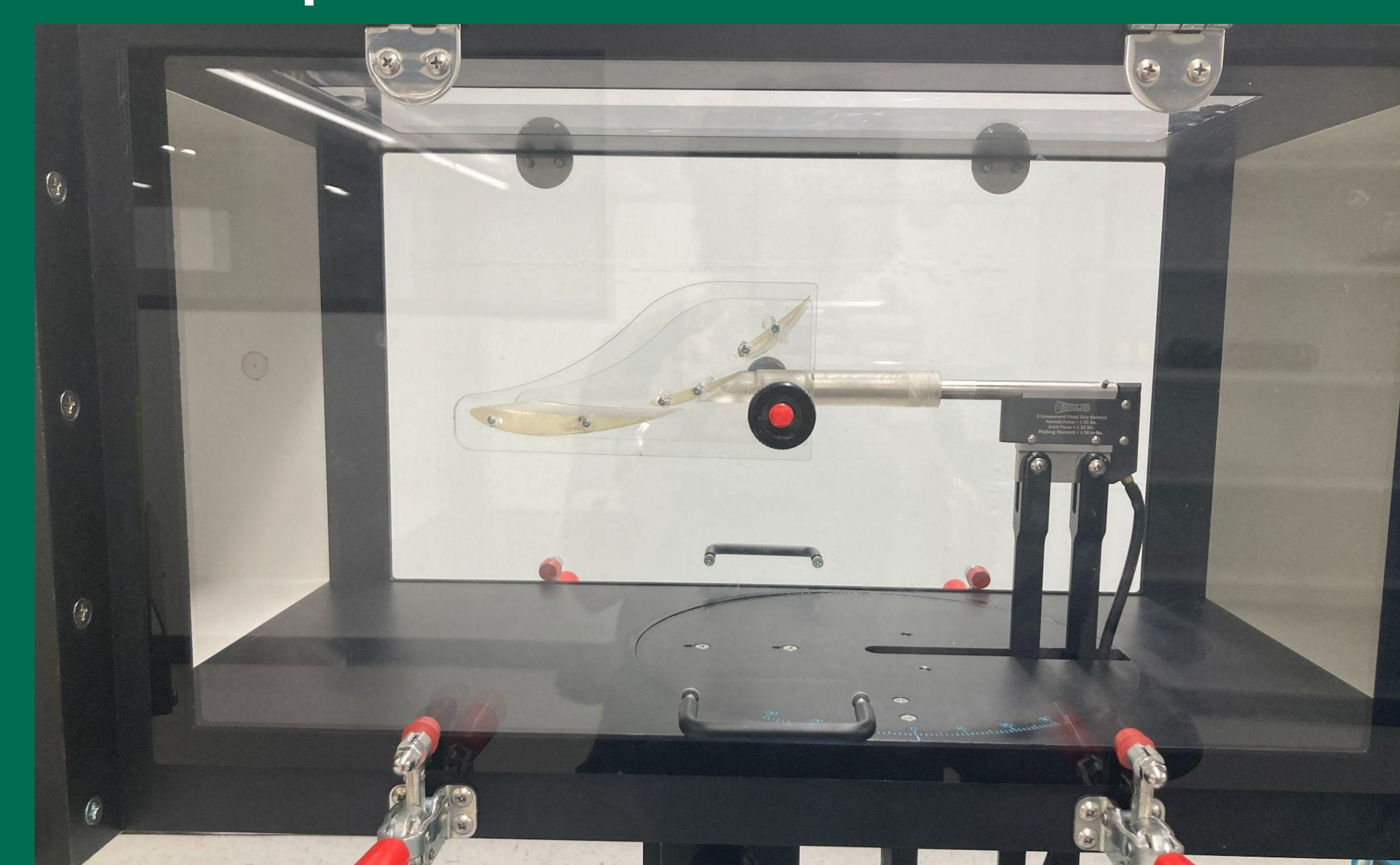
Javafoil and 2D Results

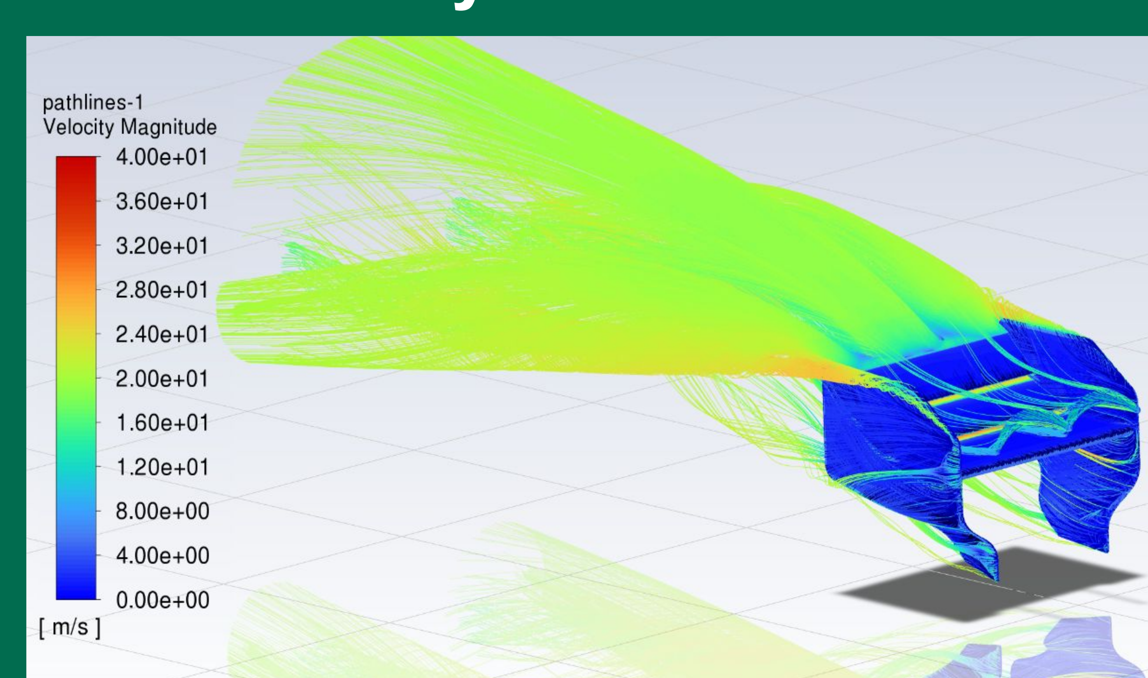


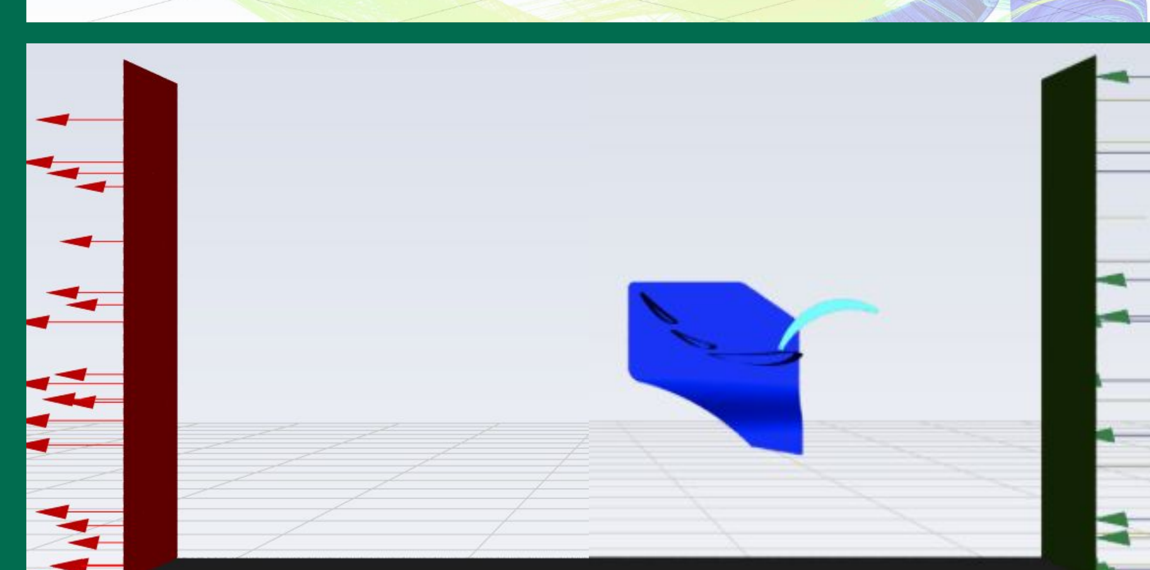
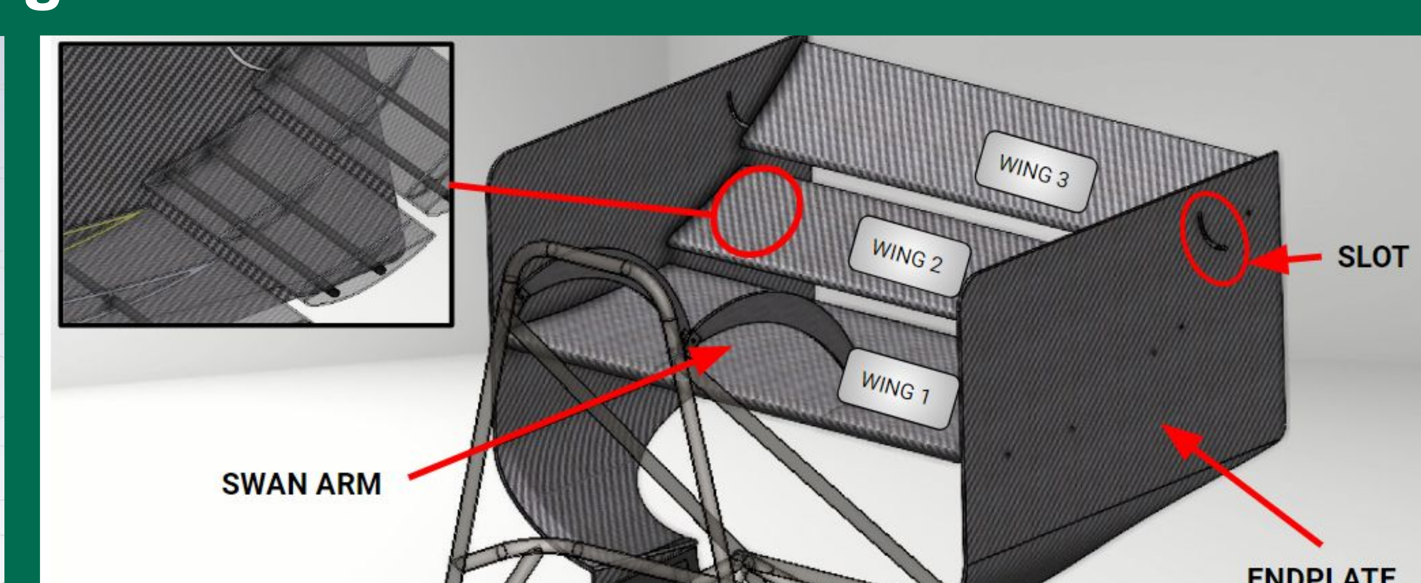
Scale Model Simulation and Wind Tunnel Experiment

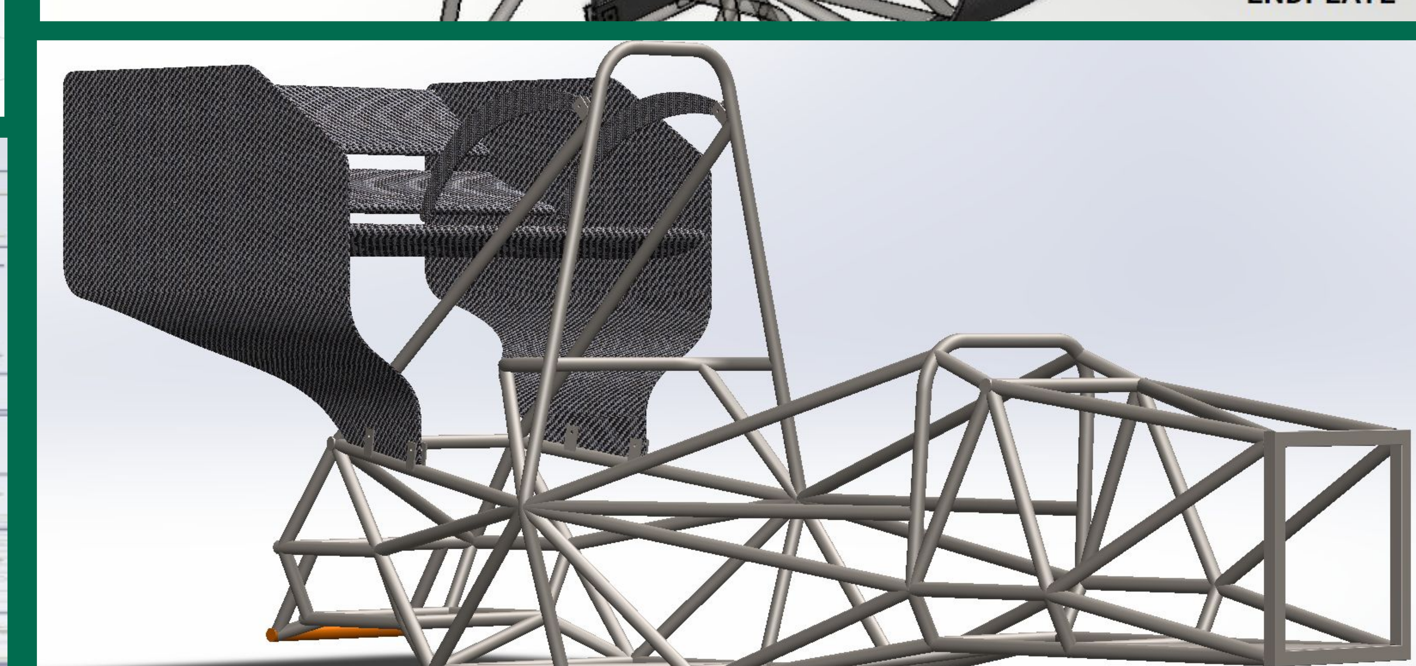


Full Assembly Simulation and Design





Quantitative Comparison:

Scaled Experiment: @ 70.5 Mph
- Drag: 1.57 lbs
- Downforce: 5.20 lbs

Scaled Simulation (3D)
- Drag: 1.59 lbs
- Downforce:4.91 lbs

Discrepancy
- Drag: 1.50%
- Downforce: 5.55%

Full Wing Assembly Simulation
- Drag: 16.35 lbs
- Downforce: 66.34 lbs

Results - Lap Time Simulator:

- Time without rear wing: 75.056 seconds
- Time with a rear wing: 74.599 seconds
- Lap time improvement: .457 seconds

FEA Rib Optimization:

- Average of 60% weight reduction
- Maintained a minimum Factor of Safety (FOS) of 4

Results - Manufacturing

References

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"High Lift Aerodynamics", 1975
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