Optimization of Aerodynamic Aids for Autocross Racing

B3 Team Members:
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What is Autocross?

- Car Racing Competition based on lap times
- Different classes to separate cars based on performance, focusing on driver skill
- Speeds relatively low, ~60 mph max
- Track is narrow and outlined by cones
- Usually held in large parking lots

Overall Project Goals

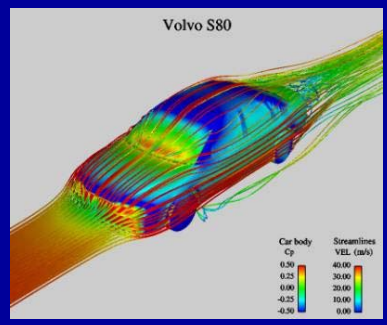
- Optimize car aerodynamics for best overall autocross score
- Experimentally determining aerodynamic characteristics (drag and streamlines) of different car configurations
- Correlate experimental data to full-scale car

Team Assignments and Organization

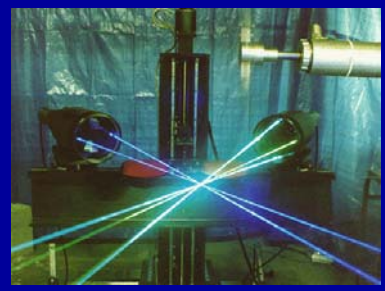
- CFD Team
  - Jason and James
- Water Tunnel Team
  - Mike and Joey
- Full-Scale Testing
  - Everyone

Task Descriptions Overview

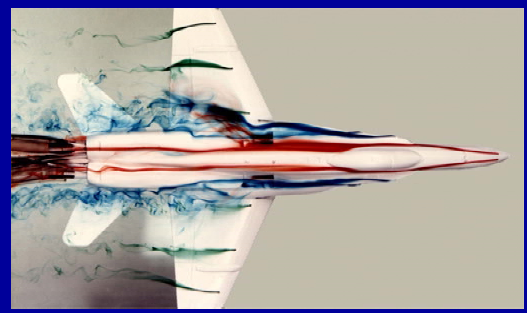
- CFD Flow Analysis



- Water Tunnel LDV Testing



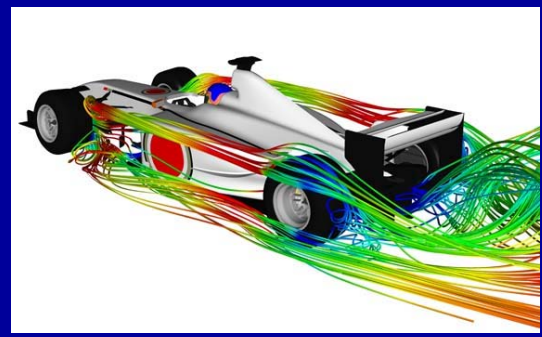
- Water Tunnel Flow Visualization



- Full-Size Car Testing

Task Descriptions

- Computational Fluid Dynamics (CFD) Flow Analysis
  - COSMOS FloWorks will be used to run simulations
  - All simulations will run on 1:1 scale model from SolidWorks
  - Several configurations will be simulated (targa top, windows, spoilers)
  - Collect quantitative measurements of drag and qualitative data on streamlines



- Water Tunnel LDV Testing
  - Compare/measure drag between configurations
  - 2-D flow velocity survey upstream / downstream of model

Task Descriptions

- Water Tunnel Flow Visualization
  - Dye used to visualize streamlines around car
  - Each configuration will be tested
  - Will validate the FloWorks CFD analysis
- Full-Size Car Testing
  - Coast down testing to compare drag between configurations
  - Yarn Testing to visualize flow around car

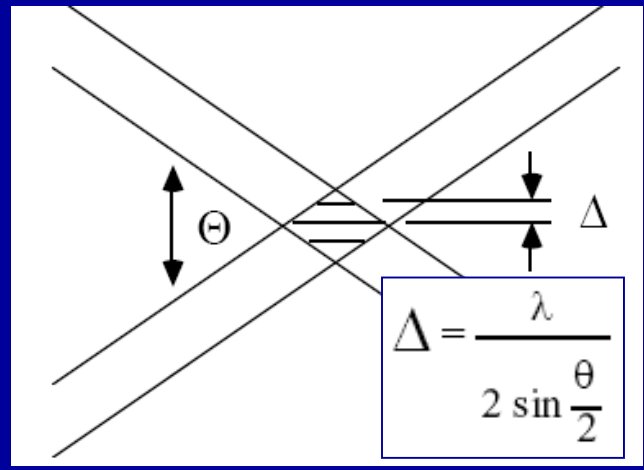
Schedule

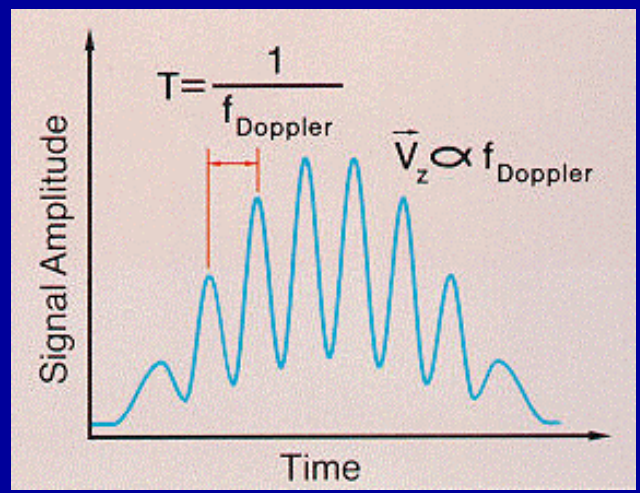
Task	owner	week 1	week 2	week 3	week 4	week 5	week 6	week 7	week 8	week 9	week 10
>> Setup Phase											
Meet with Project Advisors	Group										
Low Speed Aerodynamics Research	Jason										
Finalize Plan of Action	Group										
Learn COSMOS FloWorks	James										
Fab. Adapter for WC mount	Mike										
Purchase/Fabricate necessary parts	Group										
Prepare Scale Models for Testing	Joey										
Improve Solidworks Model	Jason										
Setup Water Channel	WC Team										
Setup Dye Chamber	WC Team										
Setup FloWorks Model	CFD Team										
>> Testing Data Analysis Phase											
Run Solidworks Flow Analysis	CFD Team										
Run Water Channel Tests	WC Team										
Analyze Data	Group										
Write Report	Group										
Hand Over Results	Group										

- Issues
  - Three other teams working with water channel this quarter
  - Sealing plate w/ mount needs to be fabricated for dye-visualization water tunnel

Theoretical and Experimental Methods

- **Laser Doppler Velocimetry**
  - Two intersecting lasers create a fringe pattern with known maxima spacing Δ .
  - Particles inserted in flow travel through fringe pattern, scattering light at measured frequency $f_{Doppler}$
  - Local flow velocity $V = f_{Doppler} * \Delta$
  - Comparing upstream / downstream flow velocity profiles and applying momentum principles yields object drag





Theoretical and Experimental Methods

Coast-down Drag Testing

- Will provide drag comparisons for various aerodynamic configurations

- Measure time t to decelerate between set V_1 and V_2
  - Average Acceleration Rate: $a = (V_2-V_1)/t \quad (a<0)$
  - Average total drag force $F_d = m * a \quad (= \underbrace{F_{roll}}_{\text{Const. @ given speed}} + \underbrace{F_{aero}}_{\text{Varies w/ aero setup}})$
  - Can then estimate C_d:

$$C_D = \frac{\text{Drag}}{\frac{1}{2}\rho U_{1\infty}^2 \cdot A_p}$$

Progress to Date: Mike

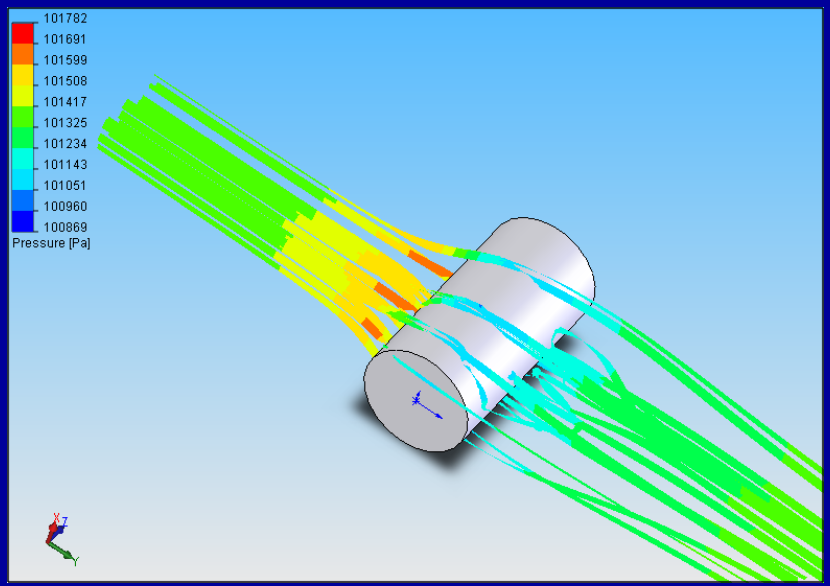
- Designed and fabricated mounting system to hold car model in water tunnel.
- Currently ready for LDV testing.

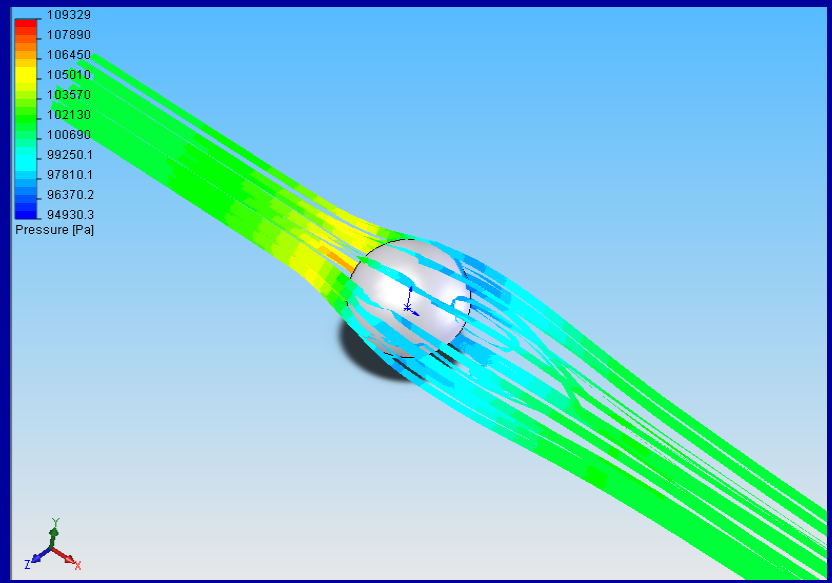
Progress to Date: Joey

- Prepared 1/18th Scale models for water tunnel testing (windows, smoothing, etc.)
- Wrote LDV macros for water tunnel drag measurements

Progress to Date: James

- Familiarized with FloWorks
- Completed Drag Analysis On Cylinder and Sphere





cylinder 1m.SLDPRT [Re 1e5]

Goal Name	Unit	Value	Averaged Value	Minimum Value	Maximum Value
GG X - Component of Force1	[N]	0.475516538	0.48948	0.475052	0.502829
Drag Coefficient	[ ]	0.463924241	0.477547	0.463471	0.490571

Progress to Date: Jason

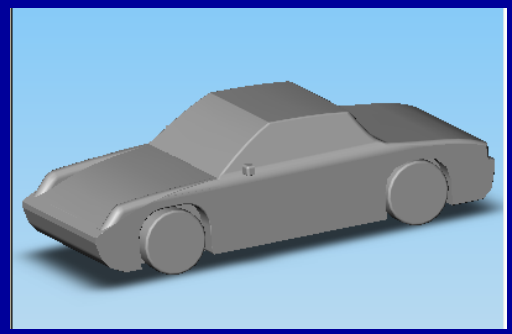
SolidWorks CAD Model

Properly scaled

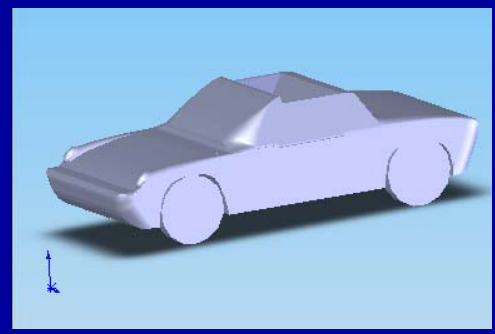
Added side mirrors

Improved modeling of:

- Headlights
- A-pillar
- Front end
- Rear end



New Model



Last Year's Model

Actual Vehicle

Questions?