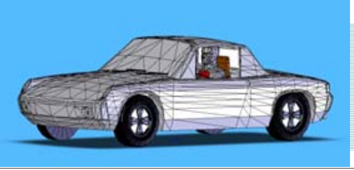
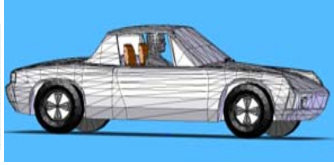


Optimization of Aerodynamic Aids for Autocross Racing



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Introduction

The goal of this project is to study the aerodynamic characteristics of a Porsche 914 and investigate possible aerodynamic aids and modifications that may reduce the drag coefficient. This car will be raced in Porsche autocross racing events with the primary goal of lap time reduction

Autocross

•Car racing competition based on lap times
•Different classes separate cars based on performance, focusing on driver skill
•Maximum Speeds of 70 mph
•Track is narrow and outlined by cones
•Usually held in large parking lots

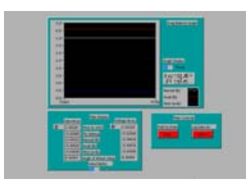
Objectives and Achievements

•Experimentally determining aerodynamic drag and lift characteristics of different Porsche 914 configurations
•Model 2 best designs with 1/18th scale model to achieve wind tunnel data
•Run as many different aerodynamic aids as time is allotted in FloWorks

Experimental Methods

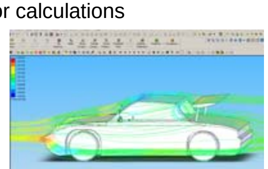
Wind Tunnel Testing

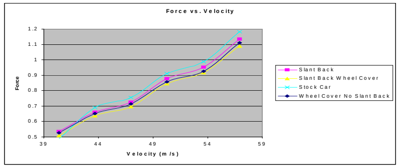
•1:18 scale models tested at maximum velocity
•Mechanical Force Balance to measure drag and lift
•Labview vi used to record data



FloWorks Testing

•Full scale models tested at 32 m/s
•Lift and Drag force calculated
•2006 base models used for calculations
•New 2007 model created





Design Analysis

A variety of resources and technologies were used to analyze and design the aerodynamic characteristics of the different cars:

•Researched books and Porsche Forums on aerodynamic aids
•3-D modeling of the aerodynamic aids
•400 hrs of FloWorks modeling and testing
•Wind tunnel models created and tested

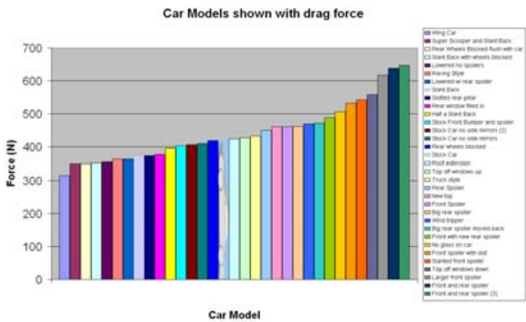
Theory

There are many aspects to consider when attempting to minimize the lap time of an autocross racecar. The first important aspect is the aerodynamics of the body of the vehicle involved. Minimizing drag or streamlining is the most important characteristic of aerodynamics because the automobile must be able to move through the air easily.
. To compare the drag of the different configurations of the Porsche 914, the coefficient of drag will be used.

$$C_D = \frac{F_D}{\frac{1}{2}\rho U_\infty^2 \cdot A_{frontal}}$$

Drag on an object in a fluid is the force parallel to and in the direction of the flow associated with the interaction of fluid particles with the object's surface. There are two types of drag: pressure and viscous. Viscous drag arises from the interaction of fluid particles with the surface of an object. Pressure drag depends on the pressure gradient across an object and the frontal area of the object.

			Drag Force (N)	Down Force (N)	HP Gain	Picture of model
Best	15	**Wing Car** This car shows an ideal but impractical model for aerodynamics	334.6647	487.3500	4.05	
	14	**Super Scooper and Slant Back** The front spoiler helps by giving the car a longer profile	348.2342	179.3425	3.22	
	35	**Rear Wheels Blocked flush with car** This model has the rear wheels blocked while being flush with the car	349.4988	150.3524	3.166	
	36	**Slant Back with wheels blocked** This is a combination of the slant back and having the rear wheels blocked	351.541	392.9032	3.078	
	27	**Lowered no spoilers** Car is resting on the ground decreasing its frontal area.	354.5583	55.9792	2.949	
	34	**Racing Style** This style is by racers, the entire roof line is removed	363.3768	216.758	2.570	
	24	**Lowered w/ rear spoiler** Car is resting on the ground, with a rear spoiler proving down force	363.5047	-78.6575	2.565	
	10	**Slant Back** The roof is slanted back to the rear of the car, stopping the air from separating the car	371.5502	312.9594	2.220	
	29	**Slotted rear pillar** There are slots in the rear pillar to allow air to flow into the rear window area	373.5535	128.058	2.134	
	3	**Rear window filled in** The rear window id filled in, decreasing the possibility of air separation	376.8071	149.8792	1.994	
	16	**Half a Slant Back** The roof is slanted back to half the distance to the rear, this helped to increase down force from the whole slant back	395.6157	246.1498	1.187	
	37	**Stock Front Bumper and spoiler** This car has the stock license plate, and bumper crush pads	403.449	186.308	.851	
	19	**Stock Car no side mirrors** A stock car with the side mirrors removed (a second test used to validate results)	407.9162	170.2023	.659	
	17	**Rear wheels blocked** The rear wheels were blocked form the sides	419.4105	120.0618	.166	
	33	Stock car	423.2849	124.6718	0	
	24	**Roof extension** The roof was lengthened by a few inches	423.7065	117.0403	-.018	
	2	**Top off windows up** The roof was removed, while the windows were kept up.	427.124	-29.6744	-.164	
	26	**Truck style** This was molded after a truck with a camper shell			-.413	
	5	**Rear Spoiler** Stock car with a rear spoiler on the back	449.4513	-158.38	-1.122	
	4	**Front Spoiler** Stock car with front spoiler	461.0624	-21.3427	-1.603	
	11	**Big rear spoiler** Molded after some of the racing cars, large rear spoiler provides downward force	461.6225	-94.9431	-1.621	
	28	**Wind tripper** In front of the car, and inline with the roof a small bar was placed to crate a turbulent flow.	46937396	-20.125	-1.653	
	23	**Big rear spoiler moved back** Large rear spoiler provides downward force, moved behind the rear axle	471.8675	-94.1195	-1.993	
	13	**Front with new rear spoiler** Test of car with a new design for the rear spoiler.	487.4942	-146.109	-2.084	
	22	**No glass on car** Used for racing safety, but hurts aerodynamics.	505.9927	-207.926	-2.755	
	38	Front spoiler with slot	532.3303	196.3682	-3.549	
	1	**Top off windows down** The front spoiler was Stock car with the top off and windows down	557.7067	-118.299	-5.123	
Worst	9	**Front and rear spoiler** Stock car with front and rear spoilers	647.3	-131.695	-9.216	



Discussion of Results

In Auto Cross racing there are generally several sharp turns and tricky maneuvers, therefore down force is something to consider. The data obtained from this laboratory shows that the general trend is that decreased drag force is a trade off with decreased lift. The ideal race car would have very little drag force and high down force so that the tires would grip the road allowing for faster turns.. The fluid forces encountered by cars are largely dominated by changes in the momentum of the fluid that the vehicle is traveling through. If all of the fluid was redirected upwards then there would be a huge amount of down force, but also a huge amount of drag. Conversely, if the fluid maintained all of its traverse momentum then no down force would result. Fortunately the particular vehicle that is being analyzed here is a mid engine car. This means that the weight of the engine and transaxle is distributed towards the rear of the car, giving it the grip it needs. Thus, drag force is the primary focus of this investigation.

The Porsche 914 varies from the stereotypical Porsche in that the back is not a long slope. Instead, it has a steep step abruptly dropping from the roof to the rear trunk with a vertical rear window. This transition is problematic because eddies develop and boundary layer separation is induced. Knowing that this was the greatest cause of drag, we developed an aerodynamic "add on" filling this gap with a planar surface connecting the back of the roof to the back of the car This modification minimized the drag force by 52N at 32m/s. This corresponds to a 2.23HP reduction in power required to overcome drag at this speed.

Analyzing the streamlines, it became evident that another area on the car that produced eddies was the gap between the tires and the wheel wells. To remedy this we designed wheel covers that make this area flush with the body. FloWorks analysis shows a 3.8749N reduction in drag force for this modification.