RELEVANCE OF AERODYNAMICS OF GROUND VEHICLES

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OBJECTIVE

- The initial investigation reviews the relationship of the coefficient of drag and the resulting aerodynamic horsepower required to overcome air resistance.
- The cars I used in my research are the:

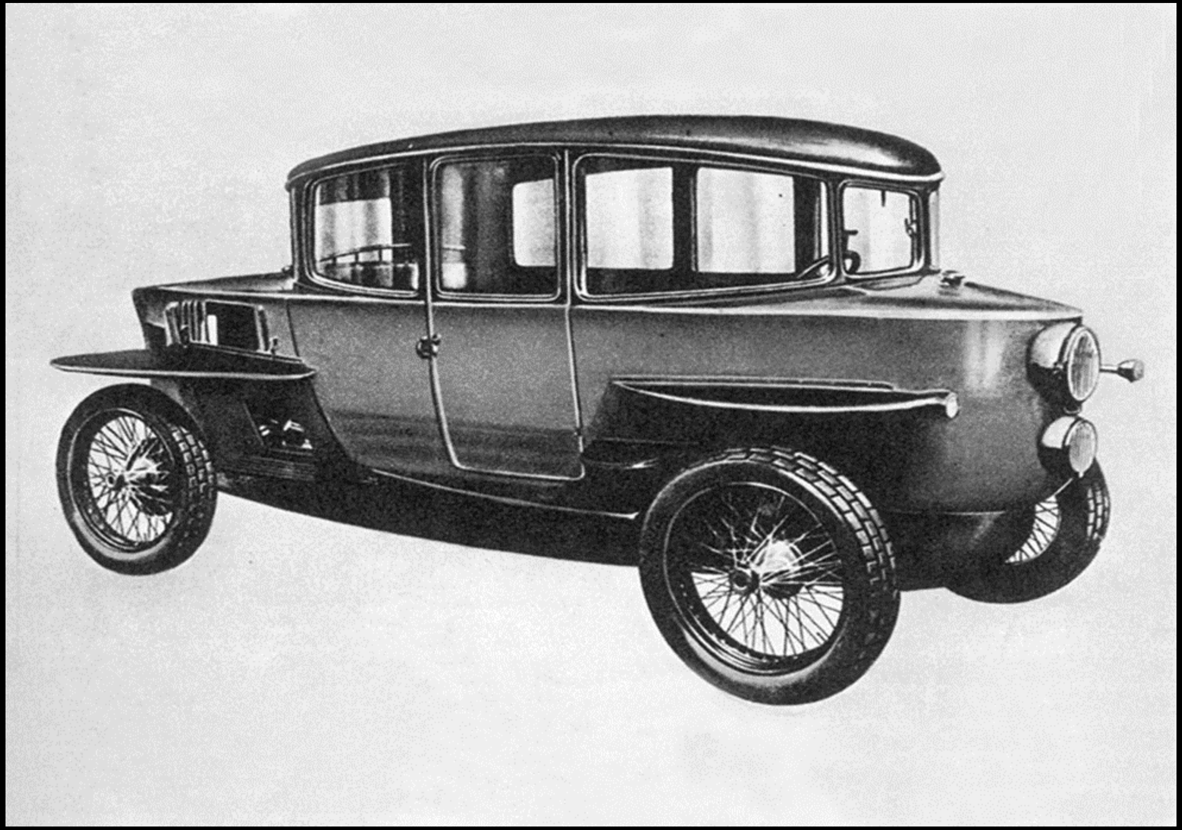
2013 Nissan Leaf, 2013 Mitsubishi Eclipse,

2006 Acura TL, 2006 Thunderbird, 2013 Chevy Volt,

2007 BMW 330i, 2013 Toyota Prius.

HISTORY

- Vehicles in the past were not very aerodynamic mainly because there was no focus on being fast or efficient.
- This is backed by the first car designed with aerodynamics involved not being the trend at the time
- One on these cars in the 1900's were the Rumpler-Tropfenauto, which translates into "tear-drop car".



BACKGROUND

- My research is important because cars are not stable at any great speed if not well designed aerodynamically.
- Aerodynamics affect a car as soon as 10 mph and can completely take over by 35mph.
- In a larger context, vehicles respond in various ways on the road based on total design and not just based on the horse power available in the vehicle.
- Aerodynamic stability of a vehicle is important for safety and gas mileage.

METHODS

$$F_d = c_d \, 1/2 \, \rho \, v^2 \, A \qquad (1)$$

where

F_d = *drag force (N)*

c_d = *drag coefficient*

ρ = Density of fluid *(1.2 kg/m³ for air at NTP)*

v = *flow velocity (m/s)*

A = *characteristic frontal area of the body (m²)*

The force required to overcome air resistance for a normal family car with drag coefficient *0.29* and frontal area 2 m^2 in *90 km/h* can be calculated as:

$F_d = 0.29 \; 1/2 \; (1.2 \; kg/m^3) \; ((90 \; km/h) \; (1000 \; m/km) \; / \; (3600 \; s/h))^2 \; (2 \; m^2) = \underline{217.5} \; N$

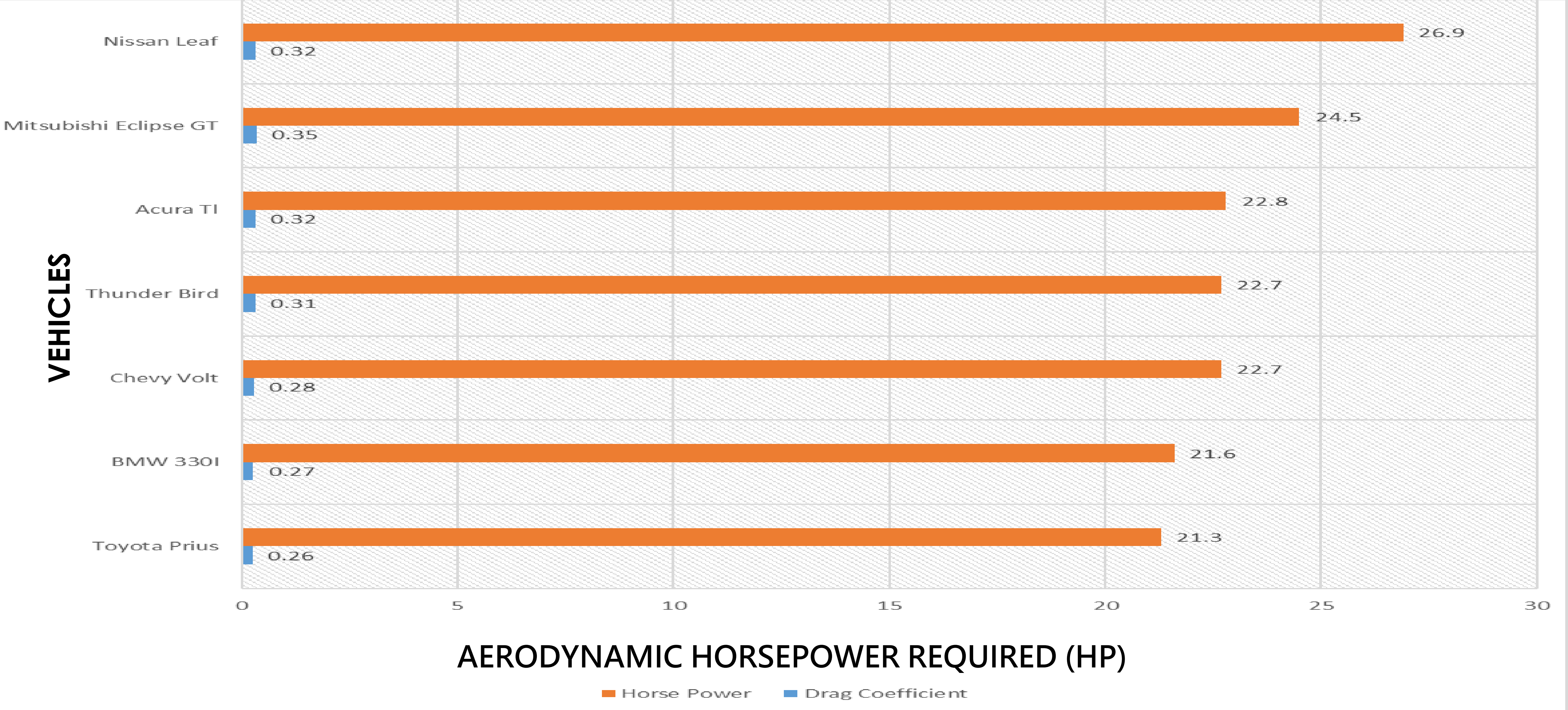
RESULTS

- This spreadsheet represents all the variables used in my research to calculate aerodynamic horsepower for a particular vehicle.
- I found my data from sources online that had the frontal area of the vehicles I chose.
- I analyzed seven cars of different makes and models, including luxury, sport, and ecofriendly models.
- With a bar simple bar graph I sorted my results by the drag coefficients to see if there were any irregularities.

RESULTS

Vehicle Type or Aero Shape	Frontal Area A	ft^2	m^2	A (m^2)	Drag Coeff C_d	Drag Area C_d x m^2	Drag Area C_d x ft^2	Air Density ρ (kg/m^3)	Velocity V	mi/hr	km/hr	Velocity V (km/hr)	Drag Force F_d (N)	Drag Force F_d (lbs)	Aerodyna Power Reqd (KW)	Aerodyna Power Reqd (hp)
Chevy Volt	23.70	1		2.20	0.28	0.62	6.64	1.2	80.0	1		128.8	474.0	106.6	17.0	22.7
Nissan Leaf	24.50	1		2.28	0.32	0.73	7.84	1.2	80.0	1		128.8	560.0	126.0	20.0	26.9
Toyota Prius	23.90	1		2.22	0.26	0.58	6.21	1.2	80.0	1		128.8	443.8	99.9	15.9	21.3
Acura TL	20.80	1		1.93	0.32	0.62	6.66	1.2	80.0	1		128.8	475.4	107.0	17.0	22.8
BMW 330I	23.36	1		2.17	0.27	0.59	6.31	1.2	80.0	1		128.8	450.5	101.4	16.1	21.6
Motsubishi Eclipse Gts	20.40	1		1.90	0.35	0.66	7.14	1.2	80.0	1		128.8	510.0	114.7	18.2	24.5
Thunderbird	21.40	1		1.99	0.31	0.62	6.63	1.2	80.0	1		128.8	473.8	106.6	17.0	22.7

DRAG COEFFICIENT VS. AERODYNAMIC HORSEPOWER



FUTURE RESEARCH

- Other factors I intend to look into are: friction, surface area, vehicle weight.
- Original intended research was to observe how aerodynamic extensions such as spoilers affect aerodynamic performance.

PRIUS ANALYSIS

- While researching the Toyota Prius, I found that its hatchback style is significant in why the car is gives good aerodynamic performance.
- If the hatch angle is correct, the airflow will be more laminar as it moves over the back of the car. This reduces vortices, turbulence, and drag.

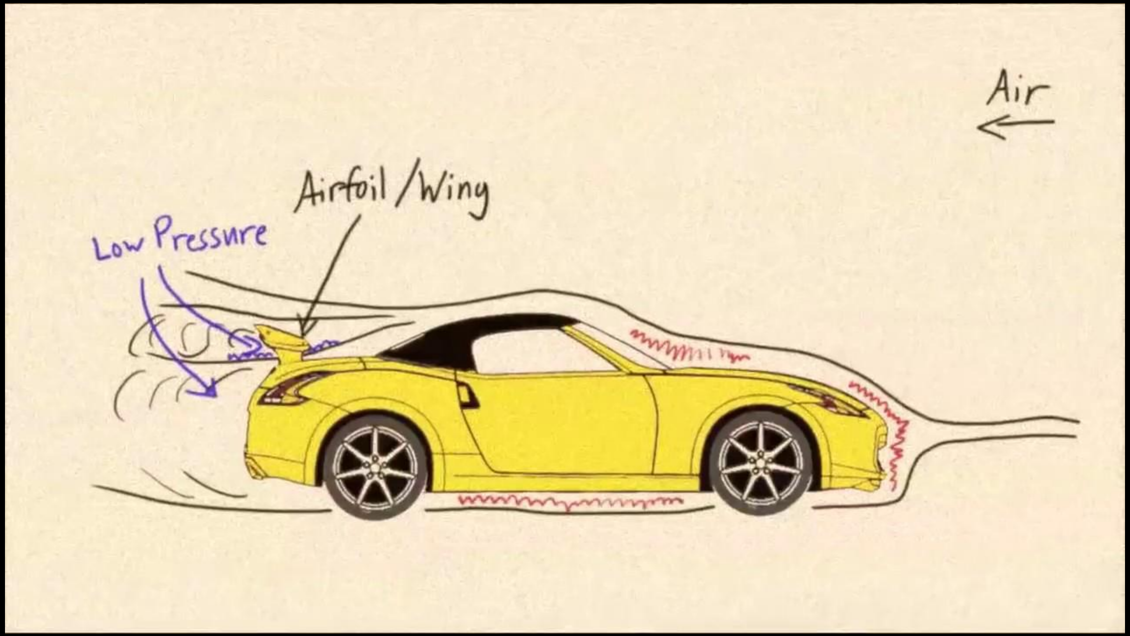
PRIUS ANALYSIS CONT.

- Hatchback cars are a contradiction to the main premises we proposed earlier in our research.
- This is interesting because the most aerodynamic style should be the tear-drop shape, which a Prius doesn't use.

SPOILER RESEARCH

- Over the past week I have been tasked to look for the lift coefficient for a spoiler.
- During this time, I have researched several sources that highlight the fact that spoilers add to the drag coefficient, and reduce the lift coefficient.
- That is reasonable because a spoiler would add more weight and more drag to the car.
- If the intention is more speed, then minimizing unnecessary weight is usually the best approach.
- However, when the vehicle reaches a particular speed, a spoiler provides useful stability with the added drag and reduced lift.
- Knowing this, we can expect our lift to be substantially less than our drag.

SPOILER RESEARCH CONT.



- This picture illustrates how a spoiler works when attached to a vehicle.
- It adds weight and also reduces lift.

CONCLUSION

- From the spreadsheet, I found that from sorting based on drag coefficients, all of the horsepower results came in numerical order except for the Nissan Leaf.
- Based on aerodynamic horse power required, the Leaf was the least aerodynamic even though it had a drag coefficient that was less than or equal to two others.
- I have found that a car that has the shape of a hatch back has an air void in the back that catches air the way a spoiler would, thereby reducing drag and possibly lift.

ACKNOWLEDGEMENT

This research was supported by the NSF HBCU-UP Implementation Grant HRD-0811219

- **Dr. Dwyane Smith**

  Provost & Vice President for Academic Affairs
  Harris-Stowe State University
  Principal Investigator for this grant

- **Dr. Tommie Turner**

  Director institute for Science and Mathematics
  Harris-Stowe State University

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