Green Park Lutheran School
Mrs. Ryherd
Thomas Eckstein NEED Project

My goal was to decrease oil consumption of semi trucks by increasing their aerodynamics, and fuel economy.

Objective #1

My first objective was to reduce the oil consumption of a semi truck and trailer by increasing their aerodynamics and fuel economy.

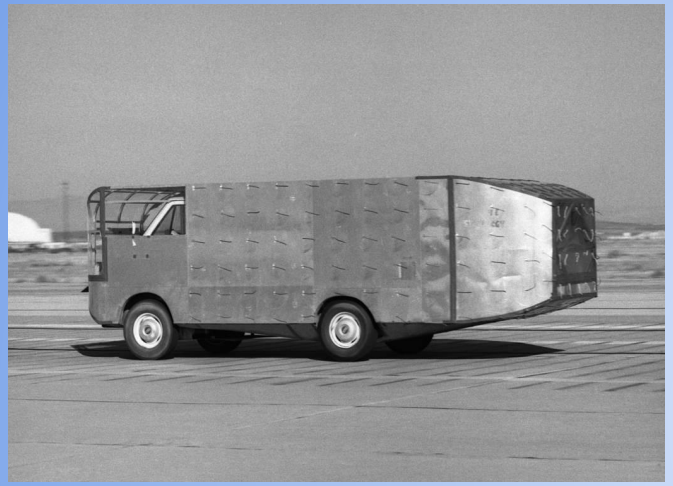
Background research

“Aerodynamics is the study of the forces acting on an object, as the object moves through air or some other fluid” (Plotkin,A 1992)

“Gap treatment Design - the design activity for the gap region focused on narrowing down the drag under crosswind conditions” (Wood, R, Bauer, S 2003)

“Boat tail” is a tapered device which NASA attached to a box shaped cab placed over the engine on a frame. A NASA team modified a vehicle by rounding the corners and adding a fairing and the boat tail during testing to give the air an easier time getting over and around a truck. (Nasa, 2008)

“Aerodynamic Drag, is the force on an object to resist its motion”
(The Physics Hypertextbook, 1998-2021 Glenn Elert)



NASA Aerodynamic study including boat tail device.

Air drag is like a turbulent “tornado” sucking the vehicle backwards. It also sucks about half of your fuel money along with it. Crosswinds add to the price tag. Crosswinds are like tax collectors coming from nowhere and claiming up to 40% more fuel on top of regular air drag by creating another “tornado” that pulls you sideways. During high winds you waste up to 70% of your fuel money to fight air drag. Cross Winds can increase air drag by 50% or more.

NOTE: Approximately 32% of truck accidents are turbulence related. Air drag just doesn’t consume your fuel; it also destabilizes your truck, adds to the driver fatigue and shortens your tires lifespan.

(https://askthetrucker.com/crosswinds-and-air-drag-cost-trucking-companies-thousands-of-dollars-per-truck-each-year/)

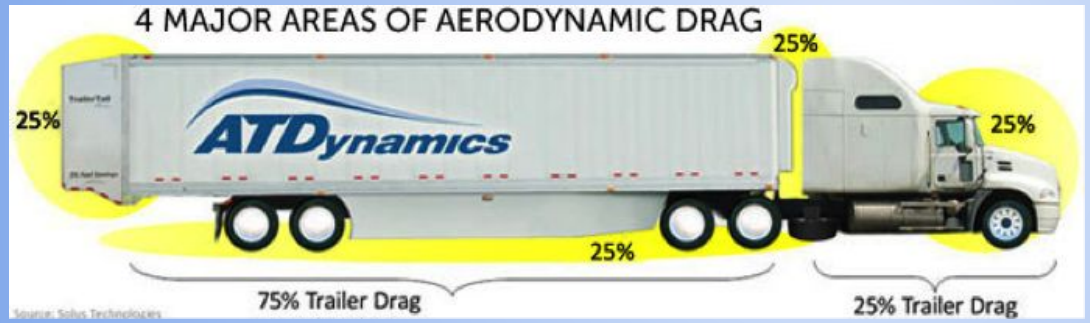
“65% of the energy used to pull a trailer is used to overcome the effects of aerodynamic drag”.
(https://www.teamrunsmart.com/articles/truck-smart/maintenance/july-2013/aerodynamics-101-streamlining-your-trailer)

Turbulent air which causes drag and turbulence.

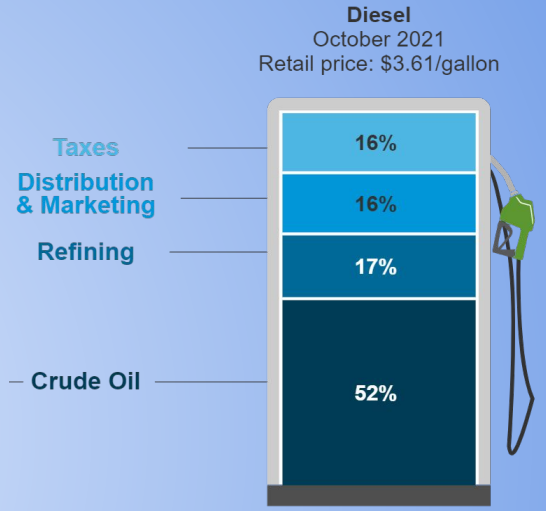
"The average OTR driver will average about **125,000 miles per year** or about 2,500 miles per week".
(https://cdscdltraining.com/blog/life-as-an-otr-truck-driver/)

"Average fuel economy for Class 8 trucks still hovering around 5.97 miles per gallon." (https://www.tecequipment.com/2021/07/13/tips-for-better-semi-truck-fuel-efficiency/)

Crude oil price 11/24/21 $79.13 per barrel.
10.04 gallons Diesel Fuel from 1 barrel crude oil.
https://www.eia.gov/petroleum/gasdiesel/



https://nextexitlogistics.com/semi-truck-aerodynamics-works/



Cost breakdown for refining diesel
https://www.eia.gov/petroleum/gasdiesel/

There are four main areas of aerodynamic drag. Truck manufacturers are constantly working on their designs for improved fuel economy. There are many companies with devices to improve the rear and underside of trailers, but not many for the front. That is why I chose to focus on this area for my project. I found that trailer tails improve fuel economy by 6%. If I could improve between the cab and the trailer by another 6% there would be an additional increase of .3582 miles per gallon.

Project Design Description

My design plan was to use 1/32 scale trucks, that I will quickly attach the “Slip Stream Aero Device” from the back of the cab to the upper and lower rear corners of the trailer on both sides with two bungees. Also one from the rear top of the truck over the front of the trailer and attached to the rear with one bungee cord to allow the truck to still pivot when turning.

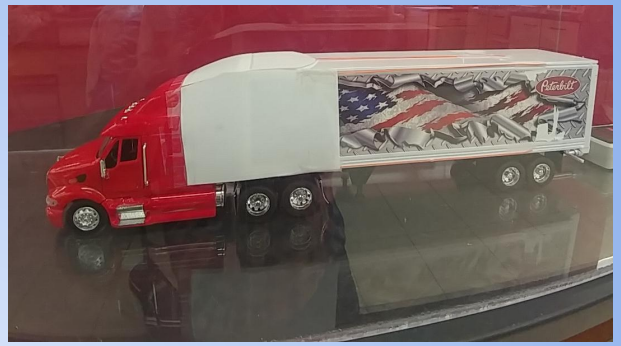
Testing

For my testing I first recorded voltage settings for set wind speeds with an anemometer and voltage regulator. I then set up each truck and trailer as factory equipped in the wind tunnel, set the wind speed by adjusting the voltage and recorded the results. Then I equipped each truck and trailer with the “Slip Stream Aero Device.” I reset the wind tunnel with each truck, equipped the device and retested, recording the results. I compared the results and could see the numbers showing the force put on the trucks was lower when equipped with the device. One obvious difference with the Freightliner was the truck shook a lot without our aero device, and very little once equipped.

Wind Tunnel Setup

Pictures of the trucks before I added the Slip Stream Aero Device.

Innovation design

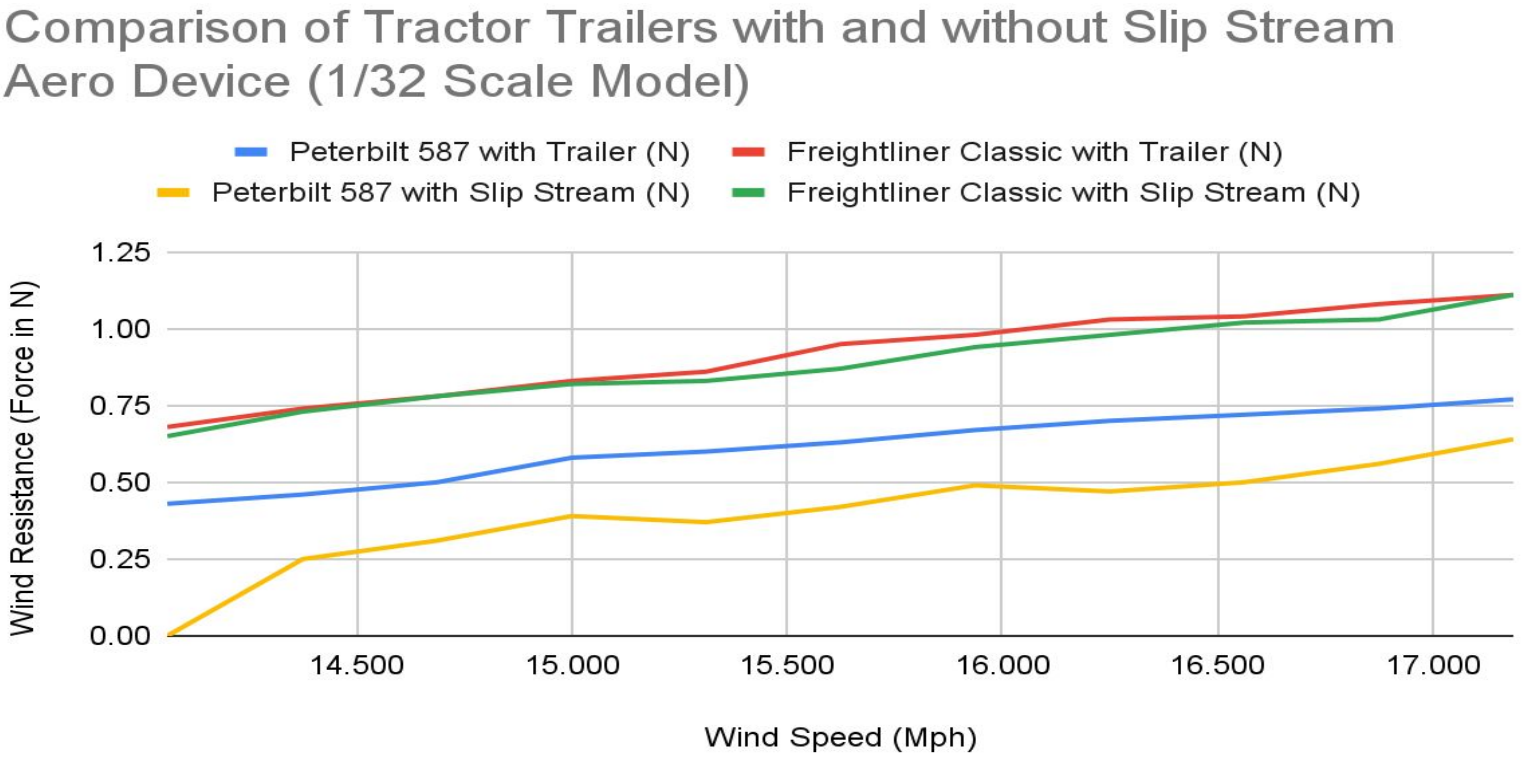


Slip Stream Aero Device (Version 1.0)

Results

Wind Speed (MPH)	Peterbilt 587 with Trailer (N)	Freightliner Classic with Trailer (N)	Peterbilt 587 with Slip Stream (N)	Freightliner Classic with Slip Stream (N)
14.060	0.430	0.680	0	0.65
14.375	0.460	0.740	0.25	0.73
14.687	0.500	0.780	0.31	0.78
15.000	0.580	0.830	0.39	0.82
15.312	0.600	0.860	0.37	0.83
15.625	0.630	0.950	0.42	0.87
15.937	0.670	0.980	0.49	0.94
16.250	0.700	1.030	0.47	0.98
16.562	0.720	1.040	0.5	1.02
16.875	0.740	1.080	0.56	1.03
17.187	0.770	1.110	0.64	1.11

Graph


Comparison of Tractor Trailers with and without Slip Stream Aero Device (1/32 Scale Model)
Peterbilt 587 with Trailer (N)
Freightliner Classic with Trailer (N)
Peterbilt 587 with Slip Stream (N)
Freightliner Classic with Slip Stream (N)
Wind Resistance (Force in N)
1.25
1.00
0.75
0.50
0.25
0.00
14.500
15.000
15.500
16.000
16.500
17.000
Wind Speed (Mph)

Testing Conclusion

I found that the “Slip Stream Aero Device” worked on both trucks and improved the Peterbilt by more than double the results of the Freightliner. By looking at the connection point on the Peterbilt we could see the gap is almost double so there is more chance for wind to get in between the truck and trailer. Even though the Freightliner did not see as good of results my device helped stabilize the truck and reduce the shaking at speed.

Prediction

I predict that with the Slip Stream Aero Device would have a huge improvement on the aerodynamics of semi trucks and reduce the wind resistance on the truck by easily 6%.

I also predict a weekly fuel savings of 23.7 gallons, $85.56 per week, or $4449.60 per year. By doing this there would also be a weekly oil savings of 99.1 gallons, or 122.7 barrels of crude oil per year per truck. With 2 million trucks in the U.S. that is an 8.8+ Billion Dollar fuel savings per year, saving 245 million barrels of crude oil by the U.S. alone. The cost of fuel and oil have also gone up by 25-50% since the start of my project, adding to the concern. That is why the “Slip Stream Aero Device” is good for the companies, good for the environment, and good for the world. Which is a win for everyone.

Objective 2

My second objective was to communicate with the trucking industry on how we can save oil and lower fuel usage by increasing aerodynamics.

Outreach

I shared my project design and requested research data from multiple trucking companies and heard back from 2.

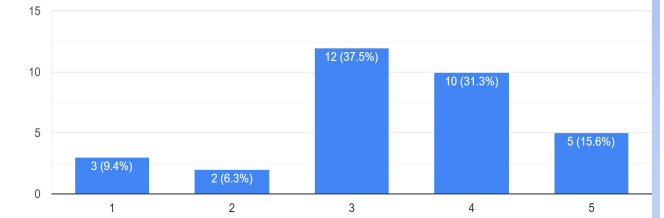
Mr. Davor of JC Transport feels that fuel economy is important because it is one thing that you can control. They found that trailer skirts do work and help save fuel by roughly 8%. Also reducing vehicle speed to 65 mph made a difference. He liked my design and recommended keeping costs low, set up easy and preventing damage in some way would make it a winner.

Mr. McGee, an owner operator, had no experience with aerodynamic devices but did test keeping vehicle speed at 65 vs 75 mph, saving him $186 over 1600 miles. So reducing air pressure against the vehicle by reducing speed allowed the engine to exert less force to move the vehicle and save money.

I also conducted a survey of consumers to help determine concern for the topic and find a rough price range for my product. On the following page you will see my survey results.

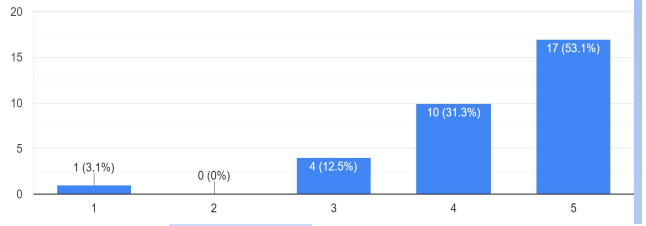
On a scale of 1 to 5. 1 be not very, and 5 being extremely. How important to you is consuming less crude oil?

32 responses



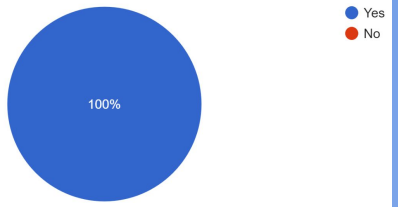
On a scale of 1 to 5. 1 be not very, and 5 being Extremely. How important to you is getting better fuel economy?

32 responses



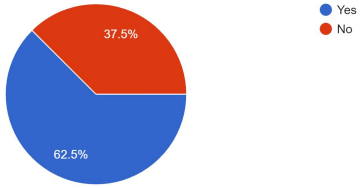
If you have the option, would you want to gain .35 mpg?

32 responses



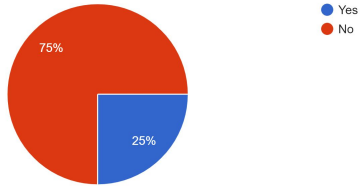
Would you be willing to spend $5000 today to save $5000, and 5000+ gallons of crude oil every year?

32 responses



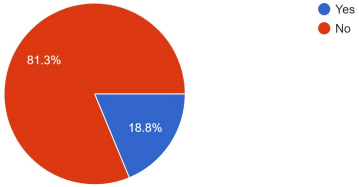
Would you be willing to spend $7500 today to save $5000, and 5000+ gallons of crude oil every year

32 responses



Would you be willing to spend $10000 today to save $5000, and 5000+ gallons of crude oil every year?

32 responses



My survey results show that people don't often think in terms of saving oil, but when you start talking about getting better fuel economy, specifically gaining .35 mpg everyone agrees they are all for it. When asked what a person would be willing to spend to save money each year people would be willing to make the investment as long as the cost isn't too high. If the initial cost is more than double the yearly return less than 20% would be willing to take the chance, showing that people are willing but have severe doubts until you can prove your results in real life.

Objective 3

My third objective was to consult with engineering professionals about my design and scale up the design.

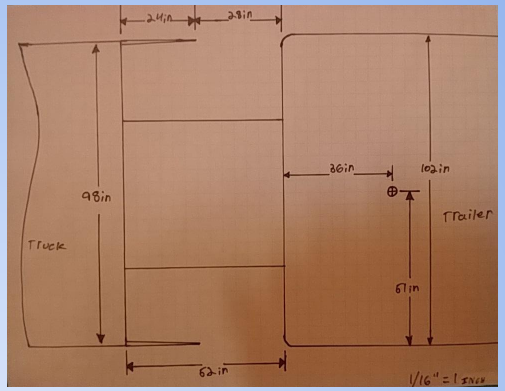
Engineer Interview

I interviewed Mr. Nick Eckstein, a Mechanical Engineer with Boeing and shared my project with him. We discussed failure analysis and possible points of failure and the outcomes of those failures. We also talked about scaling up the design and how the materials would act and react as bigger sizes were used. He felt the base idea was a good one and the background research as well as the small scale testing showed a real possibility for improvement. My design used solid sheets of a plastic material to bridge the gap and the bungee cords were there to keep the sheets under tension. As the sheet gets bigger the bungee cords would not hold up and could cause the sheet to come loose and damage other vehicles of hurt others. He suggested trying to redesign so that the sheet stayed between the truck and the trailer to control them more.

Project Redesigns

I was able to contact Peterbilt of St. Louis with the help of my dad and we went to measure a 2019 Peterbilt 579 Epic Ultraloft truck and trailer that they had in stock. With those measurements I was able to draw out on paper my first redesign. I was planning on having the panels rolling up behind the cab like a garage door that uses a spring for tension. My dad helped me again and we made a ¼ scale model using plywood, pvc pipe to roll the panel on and a spring in the middle. I found that I needed alot of material to allow the truck to still turn while connected and could not fit the roll behind the cab. I then worked on a second redesign. The following are pictures of the Peterbilt, my measurements and my design revisions.

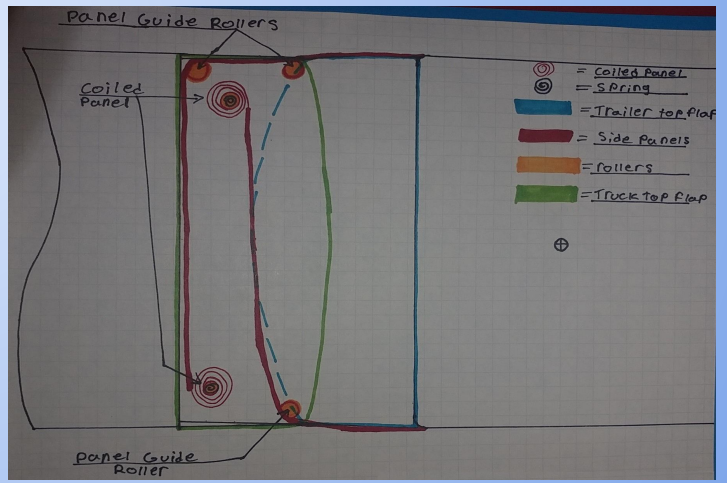
2019 Peterbilt 579 EPIC UltraLoft



Measurements

Back of cab

First Redesign

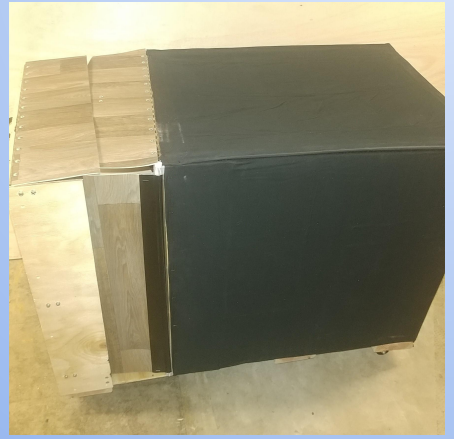


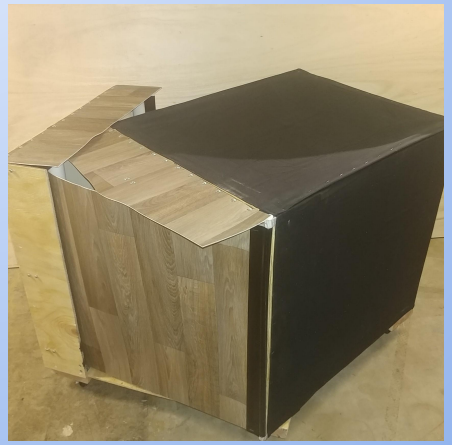
Final Design

Above you see my final design. I found to get the material to roll up behind the cab on a small enough roll I had to move the rolls to the opposite corners from where they were extending. This allows the panel to still be able to fully retract when not connected to a trailer and extend fully when turning tightly. This required extra rollers to guide the panels. I still used springs to allow the panels to recoil completely on their own mechanically. To seal the top gap there are panels that fold up from the truck and also from the trailer with the trucks panel overlapping the trailers allowing the air to transfer across smoothly.

The materials I have used so far is a vinyl sheet because it is flexible and still solid when held on edge. I plan on switching to a plastic sheet but am having a hard time locating the correct thickness to test. I also used a pvc tube, a metal spring, and a threaded rod to allow the pvc to spool in and out. My goal was to use materials that are not heavy due to every extra pound my designs weighs is added weight the truck can not haul.

Below are pictures of my ¼ scale model. I was able to share my new design with Mr. Nick Eckstein again. He thought the design was, “Very well thought out and has very real possibilities.” He suggested I work on finding materials for the panel that are more durable and will hold up better in different climates and last many years to provide added value to the customer.





Far Left: ¼ Scale Model with the Slip Stream Aero Device stored away when not in use.

Left Center: ¼ Scale Model with the Slip Stream Aero Device Connected from the truck to the trailer while simulating driving straight ahead.

Near Left: ¼ Scale Model with the Slip Stream Aero Device connected and from the truck to the trailer and the truck simulating a Right Turn.

Conclusion and Future Plans

I feel my design, the “Slip Stream Aero Device”,has very real possibility to change the trucking industry, both benefiting the companies by saving them money on fuel as those costs continue to rise and also everyone else. Not only will it save environment by saving 245 million barrels of crude oil by the U.S. alone, but if the trucks dont have to burn the fuel that is less emissions they put out. I plan to continue my research on materials. I am looking into the possibilities of patents. I hope to share my design with more trucking companies, to finalize a full scale design, and I look forward to finding a company willing to try out my design and give me real world feedback.

Thank you so much for taking time to view my project.
Sincerely,
Thomas Eckstein

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