



PRECISION AERODYNAMICS

The Story of SmartTruck

A vision for the future of truck aerodynamics,
and the heritage to achieve it.

Summer 2015



PRECISION AERODYNAMIC SOLUTIONS

www.SmartTruckAero.com



The idea behind SmartTruck began in the minds of a group of engineers who had previously focused their attention and careers on improving the aerodynamic performance of commercial aircraft, commercial ground vehicles, motorsports and ballistics.

The concept of improved aerodynamics, while mind-numbingly complex to many of us, is actually quite simple: helping solid objects move through their environments—whether it is air (gas) or water (liquid) —with less drag and less expenditure of energy.

The Idea

Our engineering team began thinking about the concept of applying aerodynamics to the trucking industry just as C.A.R.B. rules were emerging, and complex computer modeling was becoming less expensive and more accessible. As any innovator would, our team began with the universal dreamer’s proposition of “what if?”

- What if we could improve the aerodynamic performance of the long-haul truck?
- What if we could develop products that would reduce the drag of the low pressure wake that forms just behind the trailer and creates a backward pull on the vehicle?

How far could we take long-haul trailer aerodynamics? How big an improvement in fuel economy could we make?

Industry Validation

And as any good business person would do, we first approached the trucking industry and asked them: IF we could improve trailer aerodynamics, reduce drag and improve fuel economy, would that be appealing to your business? Although the aerodynamic and drag reduction conversations can quickly become bogged down in minute details, we resoundingly heard the word “yes!”

- Yes, the industry is not satisfied with current trailer performance.
- Yes, the industry wants and needs better fuel economy if it is to not only survive, but thrive.
- Yes, trucking wants to benefit from the new computer modeling capabilities, ideas and possibilities that have become the bread and butter of the aerospace industries.

Design

We started with a wide variety of trailer fairing design ideas. A grant from the U.S. Department of Energy allowed us to gain access to the supercomputers at the Oak Ridge National Labs (ORNL) that are critical to our design testing.

Sophisticated Computational Fluid Dynamics (CFD) and an optimization process using a Genetic Algorithm (GA) allow us to hone our designs. Essentially, GA allows SmartTruck engineers to morph design elements until the absolute best possible shape, size and configuration are achieved.

CFD changed everything for SmartTruck, as it has for commercial aeronautics. It's CFD that allow aircraft designers to not only know that their new design will actually fly, but how it will perform. Prior to CFD, designers had to rely exclusively on wind tunnel studies.

In the early days of aerodynamic design, wind tunnels were a go-to testing method for designers looking at aircraft and automotive modeling. However, wind tunnels are a limited alternative to CFD, since what's called the "boundary layer", i.e., the thin layer of air sticking to the trailer, can't be precisely duplicated, and accurately modeling the space between the trailer and the road is nearly impossible.

SmartTruck has utilized the expertise of both CD-Adapco and University of Tennessee at Chattanooga to verify the stated CFD performance of its products.

Materials

At SmartTruck we manufacture our products with long term reliability in mind.

We use two predominant types of manufacturing for our plastic components. Rotational molding is used on all the undercarriage products. They are made from Linear Low Density Polyethylene (LLDPE) similar to other rotational molded products found in automotive and highway applications. This provides a strong UV stable product that is capable of maintaining its structure and shape in a variety of road conditions, as well as having excellent impact resistance.

Thermoforming was chosen for the ARG and Side Fairings for its ability to maintain its molded shape under extreme conditions. Thermoformed TPO (Thermoplastic Polyolefin) has the capacity to return to its molded shape after taking some load. This manufacturing process is common in bumpers and other plastic molded parts for highway use.

This results in a user friendly robust product that allows STS to offer a lifetime warranty.

Product Validation

All SmartTruck products are designed and validated with CFD and coast down testing. Once optimal designs are modeled and fabricated, each undergoes a full regimen of road testing on a variety of 53' tractors and trailers.

SmartTruck J1321 Testing

The SAE J1321 was designed to test two or more vehicles side by side, to determine the fuel economy gain of a particular application. In February 2012, SAE released the most recent revision to the J1321 protocol, further enhancing the stringency of the test, but not fully fixing it.

Since a third party impartial observer is required for all certifications, SmartTruck used the engineering firm KTM Solutions to help plan, execute and oversee our certification process. This ensured that all tests adhered to required SAE/EPA protocols.

SmartTruck started off with two brand new identical tractor-trailer combos (sequentially off the assembly line). This allowed us to ensure that both vehicles were broken in together, in identical fashion and with consistent mileage. In doing so, both vehicles were as close as possible to mirror images of one another before testing was performed.

While adhering strictly to the guidelines of the test, SmartTruck took a much more sophisticated and technological approach. SmartTruck instrumented each vehicle with state of the art data acquisition systems. These systems had 60 available channels to monitor and record a wide variety of vehicle systems and effects, including: split and lap times, air speed and wind direction, vehicle speed and distance traveled, fuel tank temperature, ECU/ECM Data and Driver Interactions.

SmartTruck Systems also used 50 gallon water tanks bolted directly to the trailer's floor. Each tank was then filled with tap water to a specific level to ensure accurate and repeatable cargo simulation.

Pitfalls of J1321 Testing

There are many pitfalls to this type of testing, including the vehicle's systems tolerances, driver impact, and, most importantly, the fact that emission control devices have overtaken fuel efficiency as a priority. This leads to the undesirable circumstance of engine map creep. The vehicle's engine maps, or more precisely, knowledge about which engine map is used and when, and how the need for a change in maps is determined, is not 100% known. Since the rise of "carbon scrubbing" after-treatment systems, engine maps have become even more variable. Class 8 trucks were never designed to be a scientific measuring device.

SmartTruck Systems continues to test with all three methods including J1321, coast down and CFD. SmartTruck's general trend is to move away from J1321 type fuel mileage testing, due to some of the issues outlined above.

(For additional information on SmartTruck's SAE J1321 Testing, see the document entitled "Summary of SmartTruck System's SAE J1321 Testing to Date", available upon request from your SmartTruck representative.)

Product Validation, continued...

Coast Down Testing

All SmartTruck products have been performance-validated through coast down testing at either Michelin's Laurens Proving Grounds in Mountville, SC, or at the Kennedy Space Center. This coast down testing is used to validate the results achieved in our predictive CFD modeling.

At high speeds, coast down testing helps evaluate the effectiveness of our aerodynamics. At low speeds, coast down testing reflects the amount of frictional rolling resistance and mechanical drag that is present. Testing at the Kennedy Space Center's Shuttle Landing Facility, with its 15,000 ft. runway, has allowed us to perform unparalleled coast down testing from high speed to full coast stop.

EPA SmartWay® Verification

Each SmartTruck UnderTray System and our TopKit Fairing System have been verified by U.S. EPA's SmartWay Transport Partnership. SmartTruck's original products were submitted to the EPA utilizing the testing and data calculation protocols described in the Joint TMC/SAE J1321 Fuel Consumption Test Procedure – Type II and subsequent EPA modifications. The more recent products have been submitted using CFD and coast down testing results.

Third Party Performance Validation

The stated drag reduction of SmartTruck's TopKit and UT6 UnderTray Fairing System have also been independently verified as accurate by University of Tennessee at Chattanooga SIMCENTER. CD-Adapco, a commercial CFD developer, has also independently verified SmartTruck's UT6 UnderTray Fairing System.

Precision Aerodynamic Product Development Protocol

As we go forward, our experience in this industry, as well as our prior engineering experience in the aerospace, motorsports and ballistics industries, has helped us to establish and rely upon our industry's most vigorous product development protocol. We don't use the words "precision aerodynamics" lightly. Our products are the result of rigor, intellect, experience, and extensive testing, applied in a culture of curiosity and imagination, based on the simple question, "how big a difference can we make?" Here's a snapshot of how we bring new products to the trucking industry:

CONCEPT

- 1) Concept sketching for performance gain, targeting specific area of trailer
- 2) Determination if concept will fit within practical envelope
- 3) Conceptual engineering manipulation of air flow, to estimate ideal specification /configuration
- 4) Model is input and run through computational fluid dynamic (CFD) model
- 5) Where appropriate, SmartTruck engineers have the option to manipulate the model utilizing the genetic optimizer within given constraints (such as drag, down-force, etc.) and run the optimized shape concept through CFD testing.

PROTOTYPING

- 6) Fabricate prototype and fit to full scale 53' test trailer
- 7) Run rigorous coast down tests using prototype install and install variations/settings at Michelin Test Track in Mountville, SC.
- 8) Determine if test results are significant enough to markedly benefit trailer efficiency and worthy to take model into production
- 9) Pass model on to engineering group to engineer final shape for production, solve any attachment or fastener challenges, and determine fabrication material best suited to overcome potential future failure issues such as road debris, buffeting, etc.
- 10) Refine shape as necessary to accommodate engineering requirements /recommendations
- 11) Pass/Fail test for marketability (product cost vs. potential cost benefit)

FABRICATION

- 12) Coast Down retest on new production component itself, and exploration of synergistic performance benefits when combined with other SmartTruck aerodynamic components
- 13) Crush and impact damage testing for resiliency
- 14) Forward EPA SmartWay proposal to EPA with production parts.
- 15) Inventory Production

PRODUCT BECOMES AVAILABLE TO MARKETPLACE

The Value of Long Term Road Testing

Long Term Road Testing is believed by many industry experts to be the most reliable method to determine the fuel economy value for an individual operator or fleet. J1321 testing could prove to be too short (50 miles / 3 test segments) to provide valid results that will take into account variations in engine performance, road conditions and weather variations.

For those operators seeking to measure the performance effectiveness of our aerodynamic products on their vehicles, SmartTruck recommends a minimum two to three month test period over a set and regularly repeated long-haul run. We realize that an ideal year-over-year testing comparison is not feasible for many operators or fleets, and this shorter but still rigorous test should provide solid results.

What's Next

We continue every day to refine, explore and create the next generation of aerodynamic solutions for the trucking industry. We aggressively challenge the status quo on how far long-haul trailer aerodynamics can take the industry, and how big an improvement in fuel economy we can make. Precision aerodynamics is in our blood. It's changing the world, and will change the future of trucking.