Freightliner Cascadia and the Freightliner-Daimler DOE SuperTruck

Peter Lobner, 2 April 2020

Introduction

With a market share of 36.5% in December 2019, Freightliner (https://freightliner.com) is the largest manufacturer of Class 8 tractor-trailers for the North American market. Freightliner is owned by Daimler Trucks North America. The Freightliner flagship Class 8 truck is the Cascadia. Freightliner participated in the DOE SuperTruck I program, which was conducted from 2010 to 2016. The Freightliner (Daimler) team is continuing their participation in SuperTruck II, which runs from 2017 to 2022.

Freightliner Cascadia

Freightliner's current flagship truck, the Cascadia, was introduced in 2007 and received a major design refresh for the 2018 model year. Freightliner reports, "To maximize the performance of the Cascadia, engineers used computational fluid dynamics (CFD) and Daimler Trucks North America's proprietary wind tunnel — the only full-scale OEM-owned- and-operated wind tunnel in North America — to test, modify and optimize the aerodynamics, which are available in three packages."

These three aero packages are: standard aero features, the Aero Package, and the Aero X package.
Standard aero features include:

- Optimally sloped hood & grille
- Bumper with integrated air deflector
- Aerodynamic side mirrors
- Door seals
- A-pillar deflector
- Integrated antenna
- Side extenders and side extender seals

The Aero Package adds the following:

- Longer side extenders
- Full chassis fairings with flexible side skirts
- Removable rear wheel covers

The Aero X Package adds the following:

- Even longer side extenders
- Optimized low ground clearance bumper
- Optimized roof deflector behind the cab
- Optimized drive wheel fairings
- Front wheel well closeouts

Freightliner Cascadia with AeroX. Source: Freightliner

In addition, Freightliner offers a Dual Ride Height system to further improve fuel efficiency by lowering the tractor height at highway speeds, reducing under-chassis airflow and associated drag.

Freightliner Cascadia.
Source: Freightliner via HDT Truckinginfo, 30 May 2012

See the following short YouTube video (2:36 minutes) for an overview of the aerodynamic and powertrain features on the Cascadia:

https://www.youtube.com/watch?v=fkgqVAGJO7w

In 2012, two Cascadia tractor-trailers demonstrated an average 9.31 mpg on a 2,400 mile (3,862 km) route from San Diego, CA to Gastonia, NC at a cruise speed of 62 mph (100 kph) and a gross vehicle weight of 76,000 pounds (34,472 kg).

Freightliner SuperTruck

On their website, Freightliner describes their process for developing the SuperTruck's aerodynamic design as follows:

> "The SuperTruck Challenge presented a unique opportunity. For the first time, Freightliner engineers were tasked with making an efficient tractor and trailer…….A 3D computer model was used to design the basic shape; using digital wind, aerodynamicists carefully refined the basic shape to make it more aerodynamic. After six months of analysis and countless computer simulations, the SuperTruck took shape, every curve and surface optimized to reduce drag and boost efficiency."

The Freightliner SuperTruck I. Source: Both photos, Daimler AG

The Freightliner SuperTruck I with the active grill in the closed (high-speed, aerodynamic) position. Source: Daimler AG

The Freightliner SuperTruck I with the active grill in the open (low-speed, high-torque) position. Source: Business Tribune, 28 April 2015

Key aero features for the tractor included:

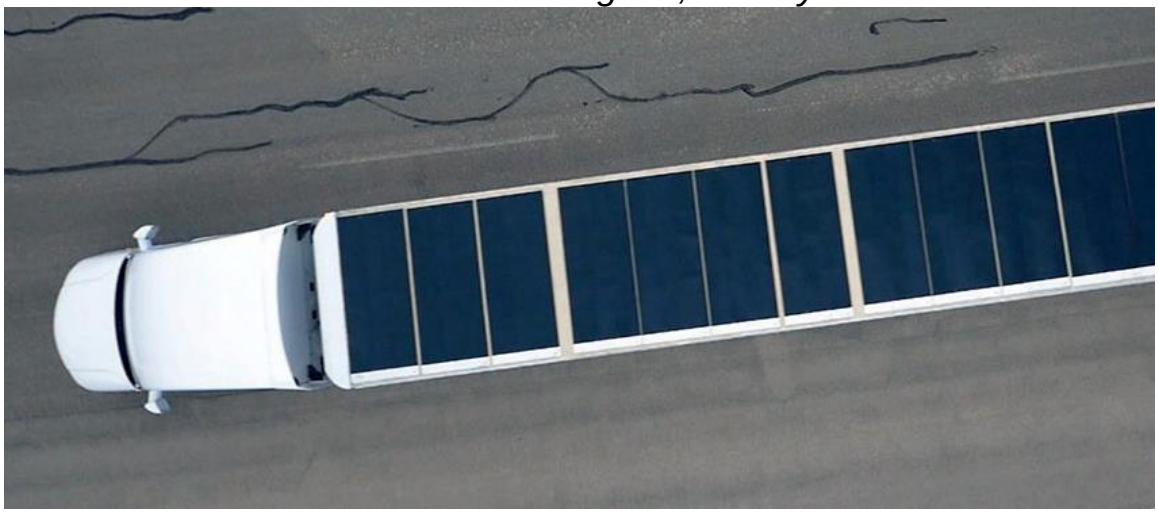
- Bumper and Ride Height: The SuperTruck's overall ride height can be adjusted, raising the chassis for extra ground clearance at low speed for maneuverability and lowering it at highway speeds to reduce drag.
- Active Grille: In low-speed, high-torque situations, the grille stays open to maximize cooling flow. At highway speeds, it automatically closes, improving aerodynamic efficiency.
- Windshield: The windshield is raked backward to guide air more efficiently over the hood and cab and generating less drag.
- Mirrors: These are the most aerodynamic mirrors allowed by the U. S. Department of Transportation. The main mirrors are as aerodynamic as the truck itself.
- Articulating Side Extenders: Optimized side extenders shield cab components as air flows smoothly from tractor to trailer.
- Articulating Wheel Fairings: Tires are infamous for creating turbulent air, so wheel fairings were designed to divert air past the tractor's rear wheels and tires.

Key aero features for the trailer included:

- Side skirts: Testing revealed significant drag occurred underneath the trailer. The side skirts were added to reduce the inflow of air to the space under the truck and to channel air smoothly past the trailer's wheels.
- Adjustable tail fins: Testing also revealed significant drag occurred behind the trailer. Tail fins and a third-party boat tail were installed to guide airflow to reduce drag and fill the low-pressure void behind the trailer.

Freightliner reported that "The integrated design matched tractor components such as side extenders, roof spoiler and drive wheel covers to trailer components such as the nose cone and trailer skirts….. The testing indicates that over two-thirds of the aerodynamic benefits actually come from the trailer."

A commercially-available boat tail was installed on the trailer.
Source: HDT Truckinginfo, 12 July 2015



A large array of solar panels built into the roof of the trailer charges a large battery that powers the HVAC system and other "hotel" loads.
Source: Daimler AG

With all of these changes, the optimized tractor-trailer achieved a 54% reduction in aerodynamic drag. In DOE testing, the Freightliner SuperTruck exceeded all Phase I objectives:

- 115% freight efficiency improvement vs. DOE objective of 50%
- Average 12.2 mpg over a 312 mile (502 km) test course
- The prototype 11-liter engine with waste heat recovery achieved 50.2% Brake Thermal Efficiency (BTE)

The Freightliner-led team is continuing development of their SuperTruck during Phase 2 of the DOE program.

You'll find more information on this SuperTruck on Freightliner's website here:

- "SuperTruck - The Future – Five Years in the Making," on the Freightliner website: https://freightliner.com/why-freightliner/industry-leading-results/supertruck/
- John Vincent, "It's efficient! It's a truck!I t's a SUPERTRUCK!," Business Tribune, 28 April 2015: https://pamplinmedia.com/but/239-news/258538-127442-its-efficientits-a-truckits-a-supertruck?wallit_nosession=1
- Stephanie Babcock, "Daimler's SuperTruck Revealed," HDT Truckinginfo, 12 July 2015: https://www.truckinginfo.com/156165/daimlers-supertruck-revealed
- SuperTruck II presentation: "Improving Transportation Efficiency Through Integrated Vehicle, Engine, and Powertrain Research - SuperTruck II," June 2019, on the DOE website here: https://www.energy.gov/sites/prod/files/2019/06/f63/ace100_Rotz_2019_o_5.1_10.55am_jl.pdf

Also see the following short videos for additional information:

- "Focus On… Daimler's SuperTruck" (5.12 minutes), provides a tour of the Freightliner (Daimler) SuperTruck: https://www.youtube.com/watch?v=P2tP9F6VvgI
- "Test drive: Freightliner SuperTruck" (2:23 minutes): https://www.youtube.com/watch?v=Dr4pMynBXJc