

## VorBlade™ Invisible Fairings – No Magic, just Science and Hard Work

### *What are the problems?*

Backsides of tractors and trailers are aerodynamic bluff bodies creating low-pressure air wakes and large areas of harmful unstable turbulence. The wakes and unstable turbulence create two major problems for heavy vehicles – air drag and instability, and both problems are significantly magnified by crosswinds.



The low-pressure wakes generate an aerodynamic force pulling a vehicle backwards like a giant parachute, and this force is called air drag. More than half of fuel is spent to overcome air drag and 53% of the drag is produced behind tractor & trailer.

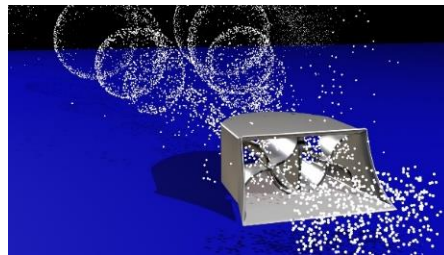
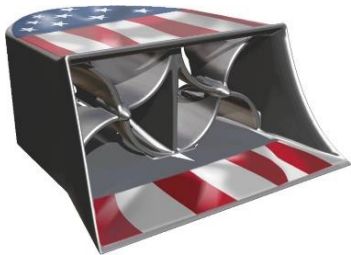
Large unstable turbulent vortices shake truck and trailer randomly to the left or right reducing vehicle stability and increasing driver workload.



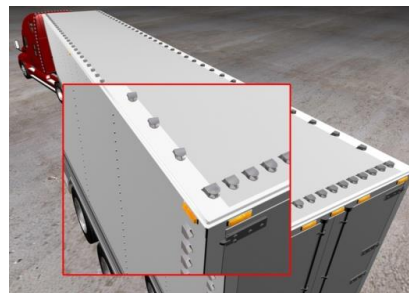
Crosswinds could double the air drag adding up to 40% of fuel consumption and 25% to driver fatigue. At crosswinds, turbulent low-pressure wakes are formed behind and on leeward side of tractor and trailer. These wakes have much larger size than without crosswind thus increasing significantly fuel consumption. Asymmetric airflow creates

large side forces and yaw and rolling moments continuously pushing a vehicle towards leeside. The forces and moments might throw the vehicle from a lane or a road or roll it over thus increasing greatly driver's fatigue and risk of an accident.

### *What is VorBlade™? How does it address the problems?*



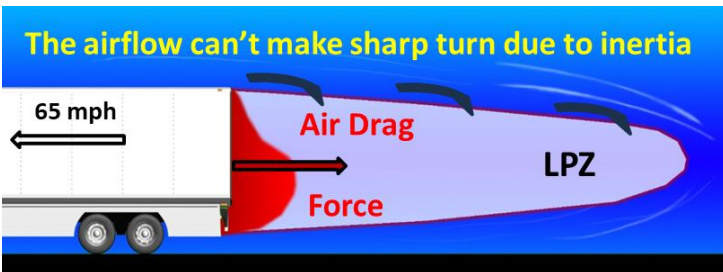
VorBlade™ is a generator of uniquely powerful and lengthy small-scale vortices optimized for reducing significantly air drag and destroying harmful turbulence on heavy vehicles at highway speeds and conditions.



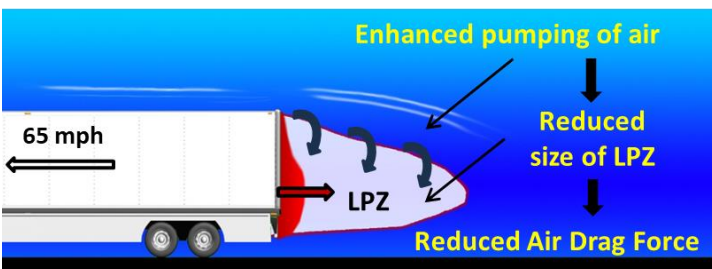
VorBlade™ Systems are combinations of VorBlade™ vortex generators installed on rear edges of tractor and trailer and on the trailer roof sides.



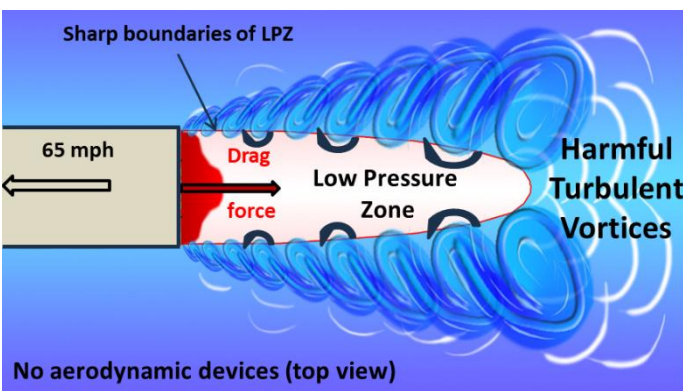
VorBlade™-generated powerful vortices create an invisible shield streamlining airflow around a vehicle. It saves a fuel by reducing air drag in the tractor-trailer gap and behind the trailer and improves vehicle's stability by destroying harmful large-size turbulence at crosswinds or no winds.



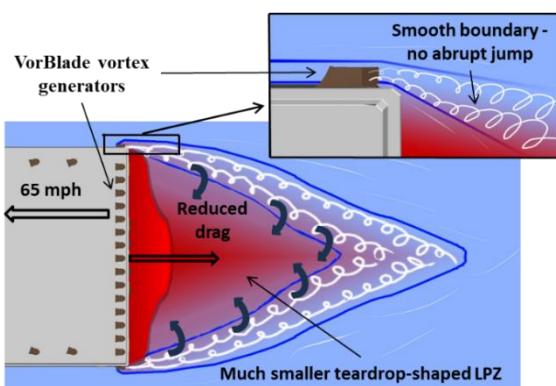
Airflow cannot follow fast-moving bluff vehicle and fill the space behind it. The air shortage creates a low-pressure zone (LPZ), also called a "vacuum", and the low pressure on the vehicle back side creates back-pulling force – air drag.



VorBlade-generated powerful vortices pump air into the LPZ reducing its size and the air drag. The more air is pumped into LPZ and the smaller it is, the higher is the pressure on the vehicle's backsides and the lower is air drag.



Also, the abrupt jumps in air speed and pressure on sharp boundaries of low-pressure zone generate harmful large-size turbulent vortices. These tornado-like vortices prevent ambient air from pouring smoothly into LPZ and compensating low pressure which results in larger LPZ behind fast-moving bluff vehicle which in turn creates a larger drag force and increases fuel consumption.



VorBlade™ vortex generators produce strong and stable small-size vortices and direct them towards the LPZ. The vortices intensely mix high-pressure ambient air with low-pressure air inside LPZ which smoothens its boundaries and eliminates harmful tornado-like turbulent vortices. Surrounding air smoothly pours into the LPZ, shrinks it and compensates low pressure which reduces air drag and saves fuel. VorBlade helps airflow to streamline itself to a teardrop shape creating a "bubble" with the least possible air drag. Nature is perfect, VorBlade just helps it to perform!

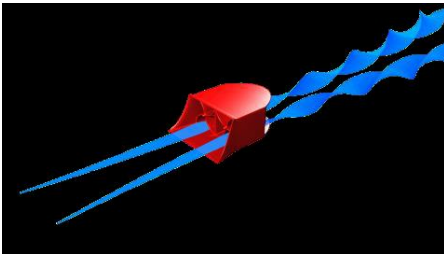
## What is so “unique” about the VorBlade™ design?



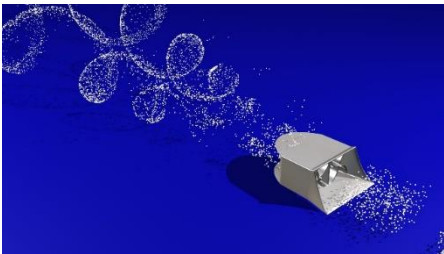
Small-scale vortex generators (SSVG) has been successfully deployed in aircraft technologies over the last 80 years and aerospace-designed SSVG have been and still are used on motor vehicles. However, designed for high-speed airplanes generators, triangular, wishbone and others, are open on the top and the sides. At highway speeds incoming airflow just bypasses them as obstacles which results in generating low-intensity short-living vortices inefficient for large vehicles.

VorBlade™ is the first and the only vortex generator specifically developed for large vehicles operating at highway speeds and conditions. Its unique design is a result of two-year work of a team of fluid mechanics scientists, engineers and technicians. VorBlade addresses the highway driving speeds (60 mph vs airplane’s 500 mph), bluff backsides of heavy vehicles, bulky shape of trailers, box trucks, flatbeds and RVs, and inability of motor vehicles to adapt to cross winds - truck cannot lean or “dog-tail” like an airplane.

*“Design is not just what it looks like & feels like. Design is how it works.” - Steve Jobs*

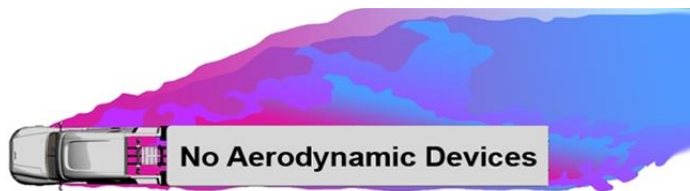


VorBlade™ is the only generators designed with the funnel-type inlet to catch airflow incoming at any angle that may occur in strong, light or no crosswinds and “trap” the air in the enclosed channel which no other generator has. The trapped air cannot evade unique vortex-producing elements, turbine-like blades, which rigorously spin the airflow and generate strong small-size vortices with unique length well over 10 ft. Such long vortices are crucial for dealing with air drag-producing low-pressure zones (LPZ) behind and leeward a trailer which may reach 15 ft or more at strong crosswinds. The vortices go directly towards the LPZ at any winds and create 10+ ft-long invisible aerodynamic shield around the drag-generating LPZ. This airflow-streamlining shield destroys harmful turbulent large-size vortices, reduces greatly size of LPZ and compensates the low pressure thus reducing greatly the air drag.



VorBlade™ is a revolutionary invention, protected by the US patents 8,770,649 “Device, assembly, and system for reducing aerodynamic drag” and D667,373 “Vortex generator”.

## How does VorBlade™ fight crosswinds?



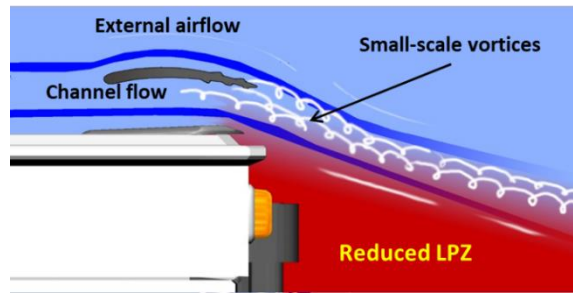
VorBlade-generated vortices adapt naturally to any changes in vehicle speed and surrounding conditions. Crosswind itself carries the vortices towards low-pressure zones on backsides and a leeside of a vehicle. These powerful small-diameter spirals destroy harmful tornado-like turbulent vortices, pour intensely high-pressure air into the low-pressure zone (LPZ), shrink it and compensates effectively low pressure. Altogether those effects reduce greatly air drag and the hazardous side forces and yaw and rolling moments. The force and the moments might throw the vehicle from a lane or a road or roll it over and thus increase greatly driver’s fatigue and a risk of an accident.



Unique VorBlade Crosswind Mitigator™ subsystem consists of VorBlade generators on both sides of a trailer roof. Strong lengthy vortices go straight towards LPZ on the leeside of a trailer, streamline airflow changing LPZ into teardrop-shaped of much smaller size and thus compensate leeside low pressure. Affecting directly LPZ on the vehicle's leeside is the only way to reduce efficiently crosswind-related air drag and dangerous side force and moments acting on a vehicle. The Crosswind Mitigator™ is the only commercially available aerodynamic device which really reduces all harmful impacts of crosswinds on a trailer, not just claims it.

**EPA Certified & CARB Compliant**

VorBlade Trailer Wing™ System is EPA SmartWay Certified and CARB Compliant aerodynamic device meeting the CARB minimum requirement to improve fuel efficiency by over 5% for dry vans and reefers with swing doors or rollup door.



**Fuel Economy Testing Results**  
 TECHNICAL REPORT  
 Heavy Duty Trucks Equipped with VorBlade™ Wing Trailer End Fairings System  
 Submitted by the TEXAS A&M TRANSPORTATION INSTITUTE  
 Authors: Jeremy Johnson, Michael Kader

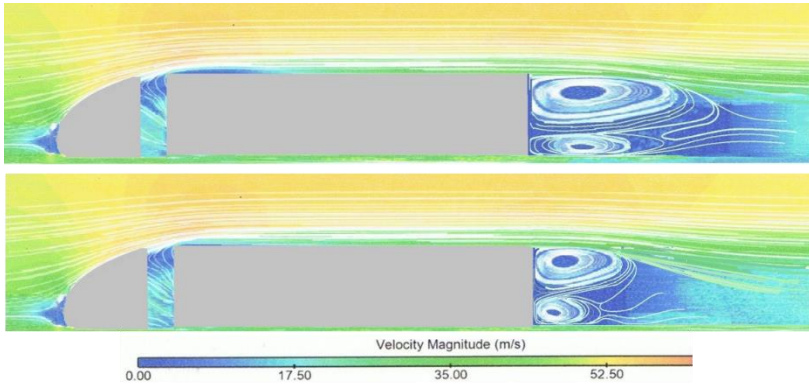
VorBlade Trailer Wing™ is the optimum configuration of a fairing for the trailer backsides consisting of two components: an aerodynamic profile and a set of VorBlade vortex generators. The profile works as a regular fairing, streamlines airflow thus reducing a size of a low-pressure zone (LPZ) and air drag, and it also forms intensive channel flow through the VorBlade generators. The profile and the generators produce a stable layer of rigorous small-scale vortices and direct that layer towards the sharp boundaries of LPZ. The vortices intensively mix high-pressure ambient air with that in LPZ, erase abrupt pressure and speed jumps, reduce further a size of LPZ and streamline it to a teardrop shape thus reducing significantly pressure drop and air drag.

The controlled fuel economy tests of the system have been performed by the Texas Transportation Institute and resulted in 9.46% fuel savings for the Trailer Wing™ System with Crosswind Mitigator™ subsystem. Accuracy of the results was verified by the EPA SmartWay engineering team.

## How has VorBlade™ been tested?

VorBlade™ systems have been thoroughly analyzed theoretically and using computational fluid dynamics (CFD). The systems have also undergone real-life road tests on a freeway and independently performed fully controlled track tests.

CFD simulations were performed for a modified Ground Transportation System model of a heavy vehicle using averaged Navier-Stokes equations with k-ε eddy viscosity turbulence model and a discrete-eddy model for VorBlade vortex generators on a tractor and a trailer at the vehicle speed of 30 m/s (67 mph) and yaw angle from 0 to 15° corresponding to crosswinds from 0 to 18 mph.



Example of CFD air drag simulation at zero yaw angle: the center plane for the MGTS without aerodynamic devices (top), and MGTS with VorBlade vortex generators (bottom).

Overall, CFD simulations have shown that VorBlade vortex generators on tractor and trailer reduce air drag of the MGTS model of heavy vehicle by 23% at zero yaw angle and by 31% at 15° yaw angle.



The road tests were performed on March 2 - 4, 2012 under guidance of the 1986 SAE Recommended Practice J1321 and the 2011 EPA SmartWay modifications. The control and test vehicles were identical Freightliner Cascadia 2012 tractors with high roof fairing, side cab extender fairings and aerodynamic profile towing identical 53' Wabash 2012 dry van trailers with DuraPlate AeroSkirts.

The tests were executed in Colorado on interstate I-70 over a circular route of about 114 miles between road markers 295 and 352 at a speed of about 60 mph. Fuel efficiency of VorBlade™ vortex generators was tested for the Tractor System (generators only on a tractor) and for a full Tractor & Trailer System (generators on a tractor and a trailer). The tests have shown about 3.7% fuel saving by the VorBlade™ Tractor System and about 8.8% by VorBlade™ Tractor & Trailer System.



Controlled tests of the VorBlade Trailer Wing™ System with Crosswind Mitigator™ Subsystem were performed by the independent authority, the EPA-authorized Texas A&M Transportation Institute, in accordance with the SAE J1321 testing procedures and the 2011 EPA SmartWay modifications outlined in the EPA-420-F-09-046 document.

The testing was conducted on August 13 – 14, 2012 at the Pecos Research and Testing Center in Texas on a 9-mile circular track at a speed 64 mph. The control and test tractors were identical Freightliner Cascadia Sleepers towing identical Hyundai 53-ft dry van trailers. The

tests have shown fuel saving of about 9.5% with the accuracy within ±1%.