Lawrence Livermore National Laboratory

DOE's Effort to Reduce Truck Aerodynamic Drag through Joint Experiments and Computations

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Overview

Timeline

On going

- FY09 large-scale wind tunnel test at NASA Ames research center, NFAC facility, 30% complete

Barriers

Target

- By 2013 - Reduce aerodynamic drag of class 8 tractor-trailers by approximately 25% leading to a 10-15% increase in fuel efficiency at 65 mph

Budget

- Total project funding prior to FY08, $2.5M
- Funding received in FY08, $600K
- Funding for FY09, $300K

Partners

- Navistar, Inc.
- Michelin
- Freight Wing Inc.

NAVISTAR

MICHELIN
A better way forward

FREIGHT WING INC.™
Driving Fuel Efficiency Into Tomorrow

Objectives

- ***In support of DOE's mission,*** provide guidance to industry to improve the fuel economy of class 8 tractor-trailers through the use of aerodynamic drag reduction
- ***On behalf of DOE*** to expand and coordinate industry participation to achieve significant on-the-road fuel economy improvement
- ***Joined with industry in getting devices on the road***
- ***Demonstrate*** new drag-reduction techniques and concepts through use of virtual modeling and testing
- ***Full-scale wind tunnel validation of selected devices with industry collaboration and feedback***

Milestones

- Full-scale wind tunnel test of selected drag reducing add-on devices at NASA Ames research center, NFAC facility.
- Testing schedule
  - Installation Geometry/Concept Design, 23-March-09
  - Requirements Draft Document to NFAC, 20-April-09
  - Statement of Capability (SOC) to LLNL/Navistar, 11-May-09
  - Signed SOC, 18-May-09
  - Test Plan, 1-July-09
  - Test Planning Meeting, 6-July-09
  - Installation at Facility, 3-Aug-09

Approach

Design & test devices/concepts for aerodynamic drag reduction with industry collaboration and feedback

New/existing devices and integration concepts
- Science based

Virtual testing environment
- Full-scale conditions
- Realistic truck geometry

Full-scale wind tunnel validation
- NFAC/NASA Ames 80′x120′
- NRC, Canada
- Freightliner

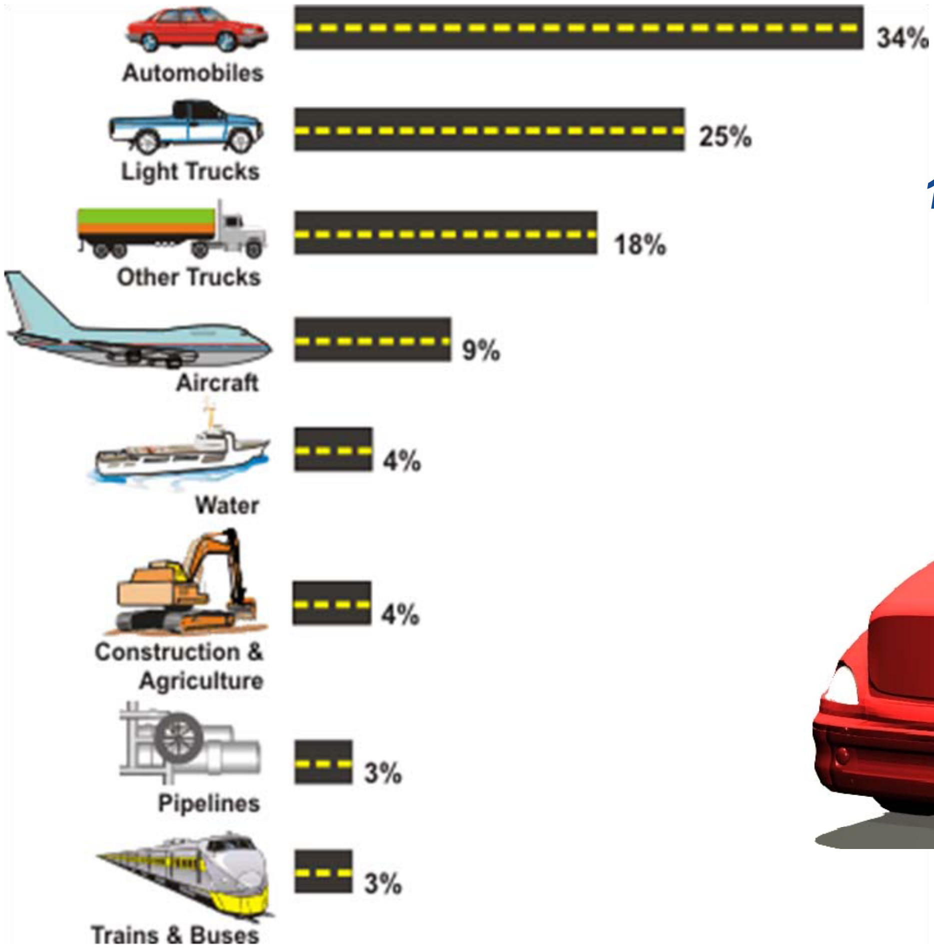
Track & road demonstration
- Manufacturers and Fleets
- Scientists

Collaborative Efforts

Industry - Manufacturers
- Fleets

Scientists - National Labs
- NASA
- Universities

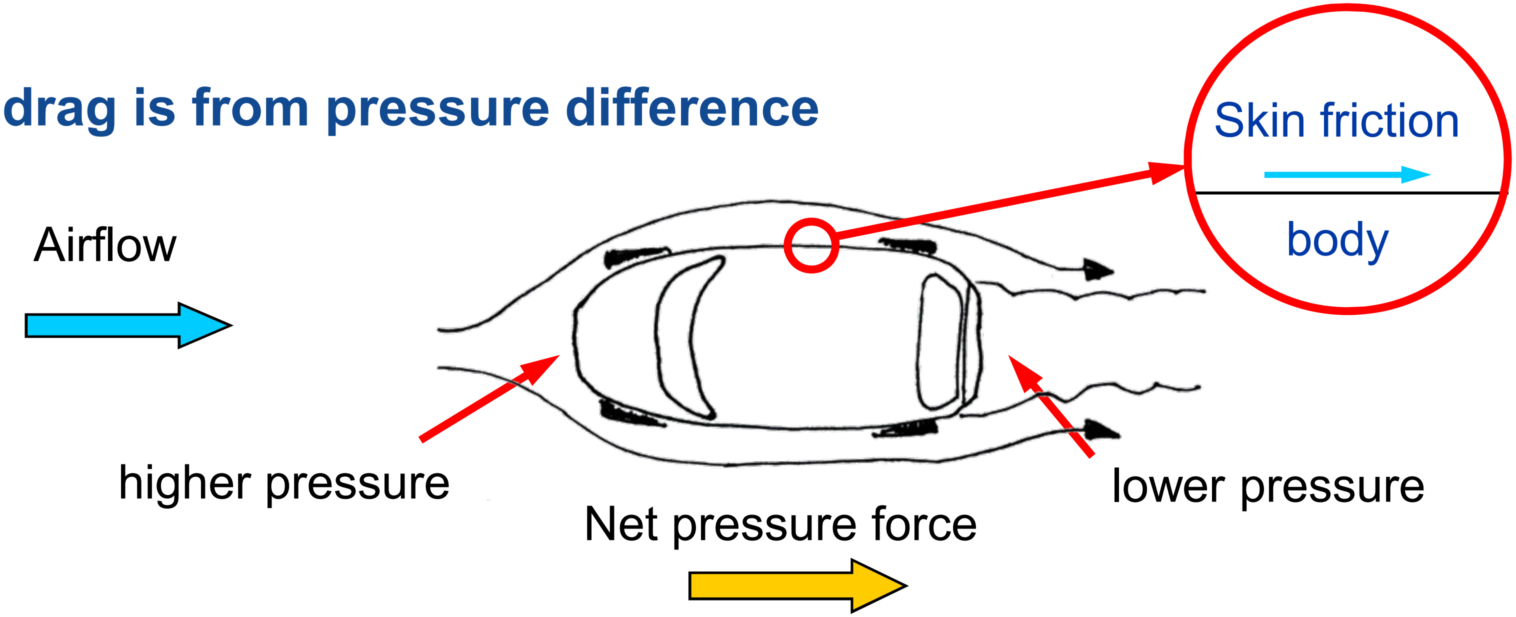
Class 8 tractor-trailers are responsible for 11–12% of the total US consumption of petroleum



1% increase in fuel economy = 245 million gallons diesel fuel/year saved

Aerodynamic drag and fuel consumption

Most drag is from pressure difference



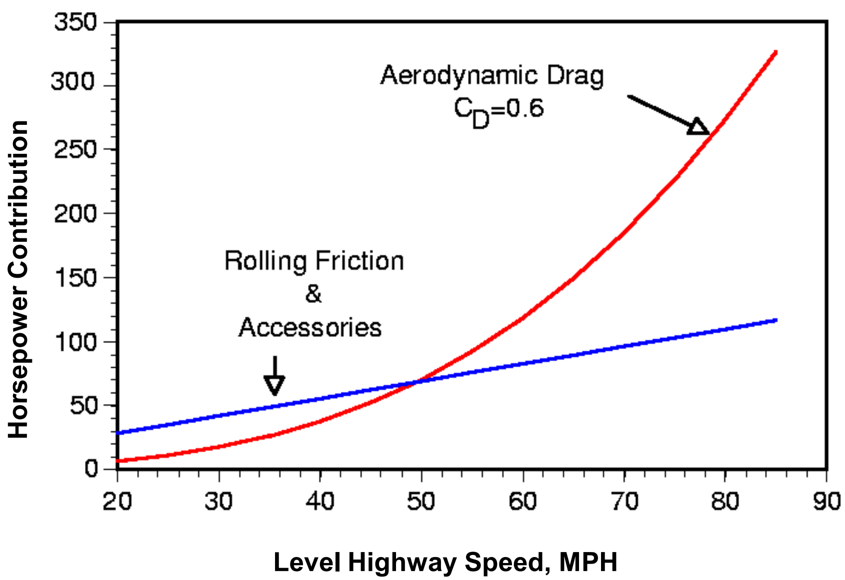
$$Drag = C_D \times S \times (1/2)\rho U^2$$

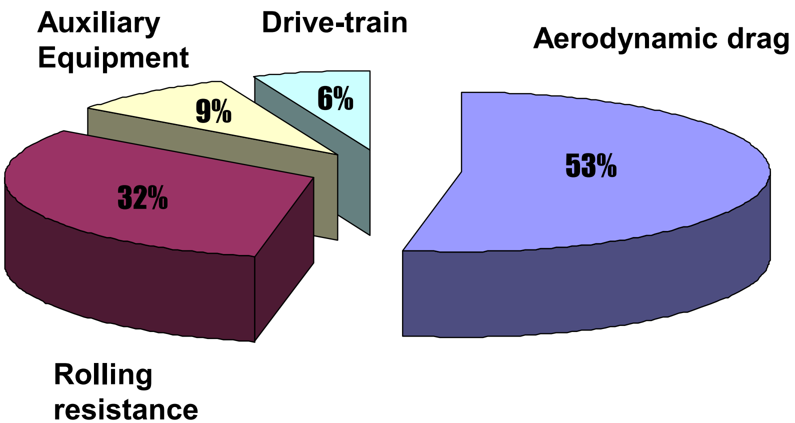
factor of 3 !

$$\frac{\Delta FuelConsumption}{FuelConsumption} = \eta \times \left(\frac{\Delta C_D}{C_D} + \frac{\Delta S}{S} + \frac{3\Delta U}{U} \right)$$

$\eta \approx$ **0.5-0.7** **shape** **cross-section** **speed**

Most of the usable energy goes into overcoming drag and rolling resistance at highway speeds





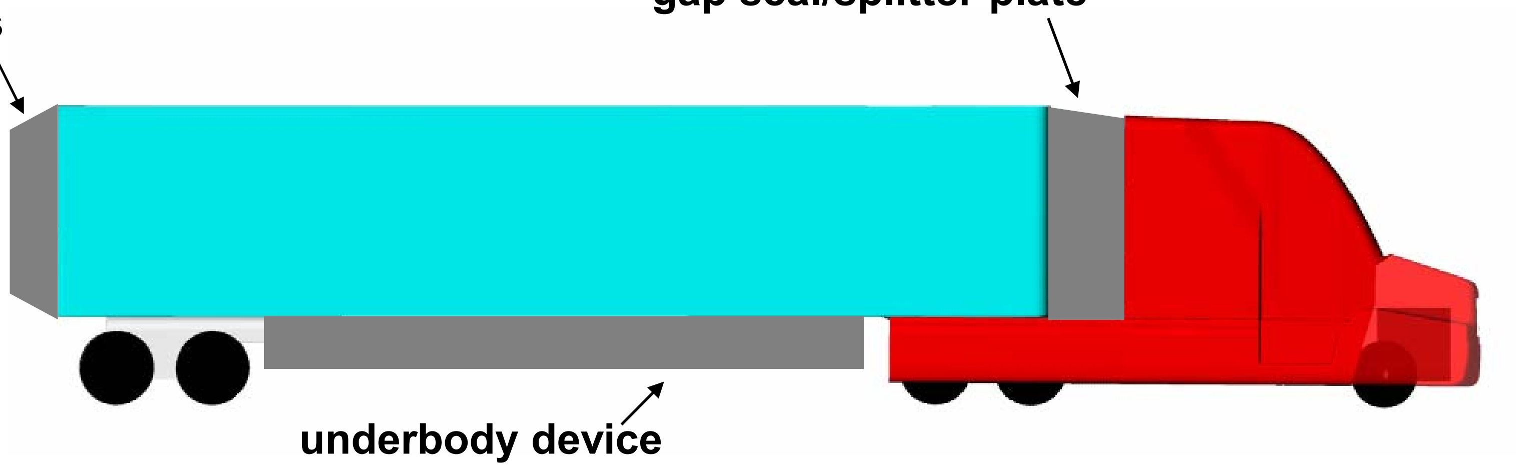
Losses in nearly all of these categories can be reduced by employing presently available technology

Aerodynamic drag breakdown on a typical truck

	C_d	C_d pres	of total	C_d vis	of total
Tractor	0.431	0.417	97%	0.014	3%
Trailer body	0.106	0.078	74%	0.028	26%
Trailer axle & wheel assembly	0.112	0.107	96%	0.005	4%
Vehicle	0.649	0.602	93%	0.047	7%

	C_d	of total
Tractor	0.431	66%
Trailer	0.208	34%
Vehicle	0.649	100%

Add-on devices performance



- Base flaps: 4-10% FEI (Fuel Economy Improvement)
- Underbody devices: 5-6% FEI
- Gap devices: 1-2% FEI
- Super wide single tires: 3-4% FEI

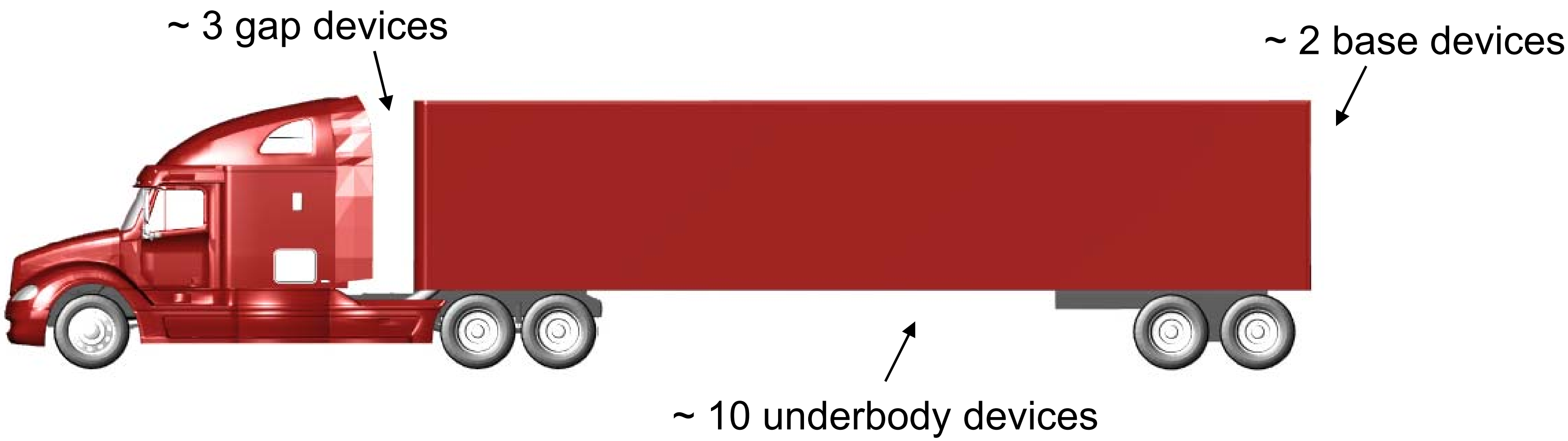
A full-scale wind tunnel test is planned

NASA Ames, NFAC 80′×120′ wind tunnel

Full-scale heavy vehicle

- Evaluate and understand the performance of aerodynamic drag reduction devices
  - Multiple tractors and trailers to determine the influence of the upstream and downstream flow on the device performance
  - Varying yaw angle to determine the sensitivity of the device performance to crosswinds
- Measure the acoustic signature of drag reduction devices

Selected drag reduction devices will be tested



- Devices are selected based on existing performance data
- Individual and combinations of devices will be tested
- Device performance will be evaluated under different tractor-trailer combinations
- Top-performing devices will be down-selected for track testing

Technical accomplishments

- ***Drag reduction concepts developed/tested***
  - Base devices: at least 12
  - Underbody: at least 6
  - Tractor-trailer gap: at least 5
- ***Joined with industry*** to perform a full-scale wind tunnel validation test of high-potential candidate devices at NASA Ames research center, NFAC facility
- ***In support of the DOE's objective (awarded solicitation)***, we have coordinated with industry to form a team that includes tractor, trailer, 3rd party device, and wide tire manufacturers and a large fleet to bring candidate devices to the market within 2.5 years
- ***Insight and guidelines*** for drag reduction provided to industry through computations and experiments
- ***International recognition* achieved** through open documentation and conferences

Future plans

- Apply the candidate devices from the full-scale wind tunnel test toward the DOE solicitation
  - Optimize the performance of candidate devices
  - Perform track testing on candidate devices
- Continue to evaluate and design new and existing drag reduction devices/concepts using LLNL's virtual testing environment
- Explore the benefits of tractor-trailer integration for drag reduction (Geometry, flow, and thermal)
- On behalf of DOE, continue to coordinate industry participation and achieve industry accepted drag reduction devices

Summary

- Conducting full-scale experiments in the world's largest acoustically-treated wind tunnel to obtain performance data with significant industry participation
  - Multiple tractors and trailers up to 53 feet in length
  - High quality data due to negligible wind tunnel blockage effects
  - Obtain acoustic signatures of drag reduction devices
- All performance data will be made publically available and will serve as the foundation for the awarded DOE solicitation