Truck Manufacturers Program to Reduce Aerodynamic Drag

Robert M. Clarke
Truck Manufacturers Association
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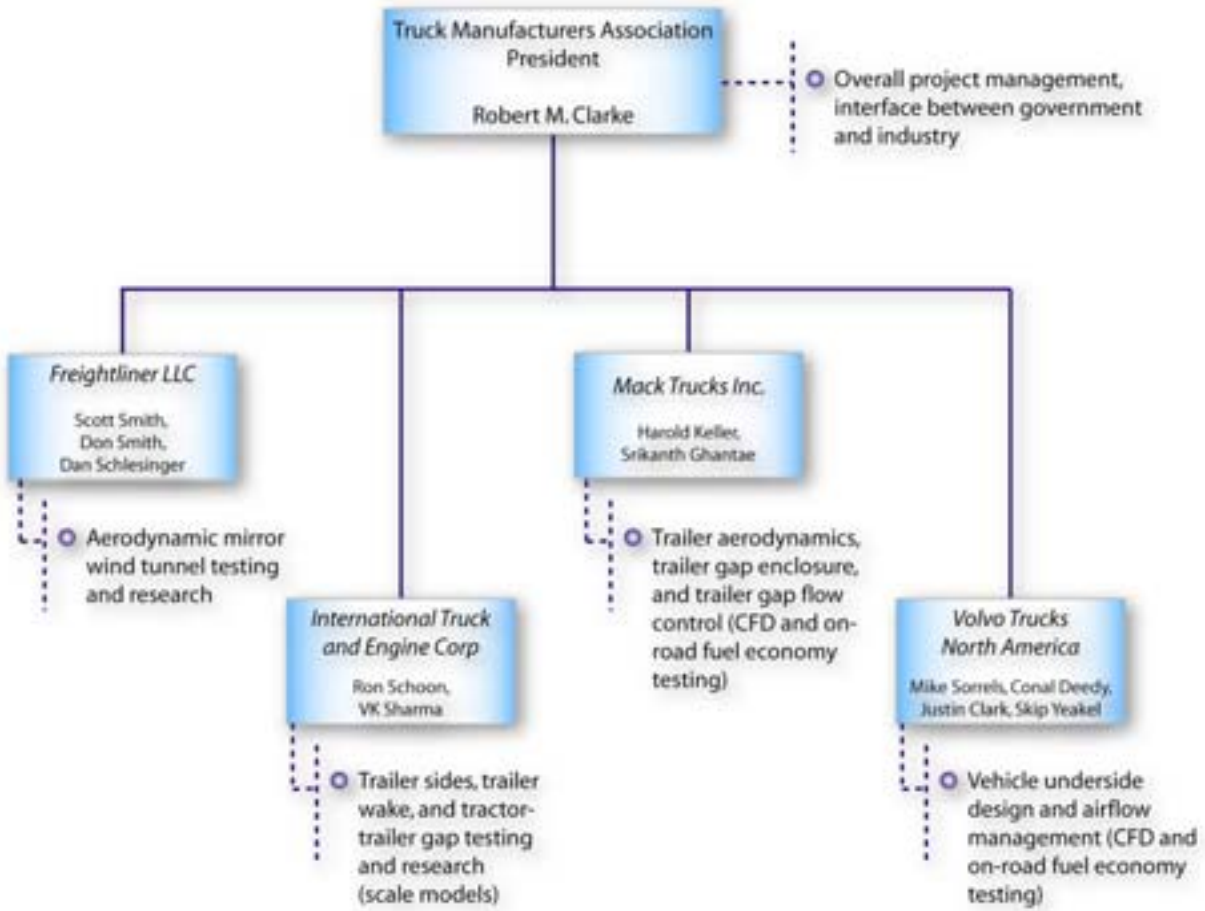
Project Overview

- Trucks dominate freight transportation, moving 64% of the value of all freight, 58% of the tonnage, and 32% of the ton-miles
- Aerodynamic drag is a major component of total horsepower needs and, therefore, fuel use of Class 8 trucks at highway speeds
- DOE goal: reduce aerodynamic drag of tractor-semitrailer systems by 20%, which translates to an approximate 10% reduction in fuel consumption
- Project goal is to develop practical aerodynamic solutions for near-term implementation and immediate fuel savings

Project Approach

- Four major U.S. truck manufacturers independently pursuing complementary research
  - Freightliner LLC, International Truck and Engine Corporation, Mack Trucks Inc., Volvo Trucks North America
- Focus on practical aerodynamic solutions for on-highway tractor-semitrailers
- Combination of wind tunnel testing, computational fluid dynamic modeling, and real-world vehicle testing to determine effects of devices and systems on aerodynamic drag and fuel economy
- Two-phase project
  - Phase I: Preliminary research and testing to determine most promising devices or vehicle modifications (CFD, wind tunnel)
  - Phase II: More in-depth testing of most promising devices or vehicle modifications (wind tunnel, on-road)

Project Structure



Project Accomplishments: General

- Researched tractor and semitrailer aerodynamic devices and their effects using CFD and wind tunnels
  - Aerodynamic mirror wind tunnel testing and research (Freightliner)
  - Trailer side, trailer wake, and trailer gap (International)
  - Trailer aerodynamics, trailer gap enclosure (Mack)
  - Vehicle underside design effects and airflow management (Volvo
- Quantified effects of changes to the tractor-semitrailer relative to baseline vehicles
- Determined best potential devices and vehicle modifications for Phase II work

Project Accomplishments
Freightliner (1)

- Quantitatively assess fuel efficiency performance benefit that might be achieved with advanced mirror technology relative to current baseline technologies
- Combination of full-scale wind tunnel testing in Freightliner dedicated wind tunnel and computational fluid dynamics

Project Accomplishments
Freightliner (2)

AERODYNAMIC DRAG DUE TO MIRRORS (% OF TOTAL VEHICLE DRAG)

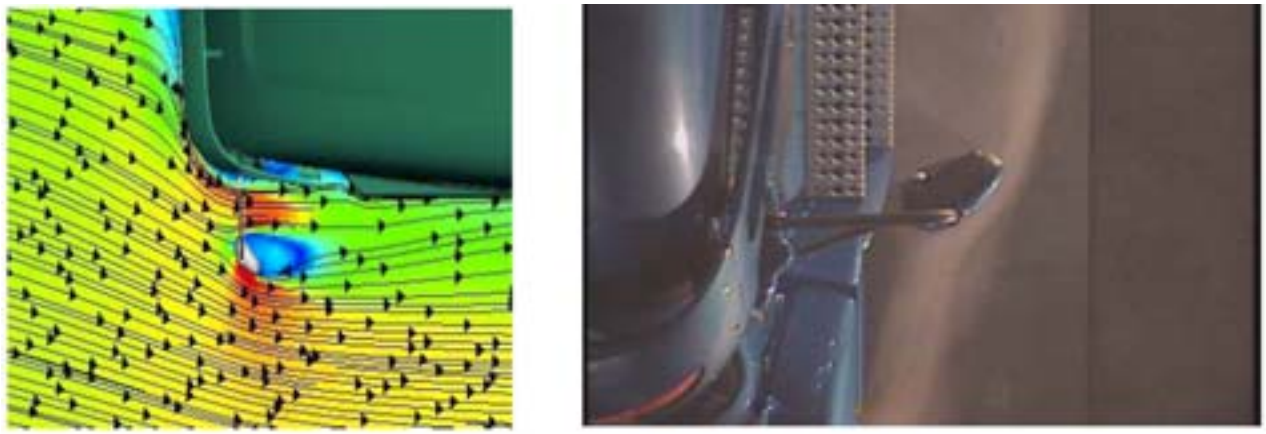
	Yaw Angle		
	-6 degrees	0 degrees	+6 degrees
Wind Tunnel	3.2%	4.5%	2.4%
CFD	4.0%	5.8%	2.1%

- Good agreement of CFD and wind tunnel results (CFD includes moving ground plane and spinning wheels)
- CFD and wind tunnel provide directionally similar results

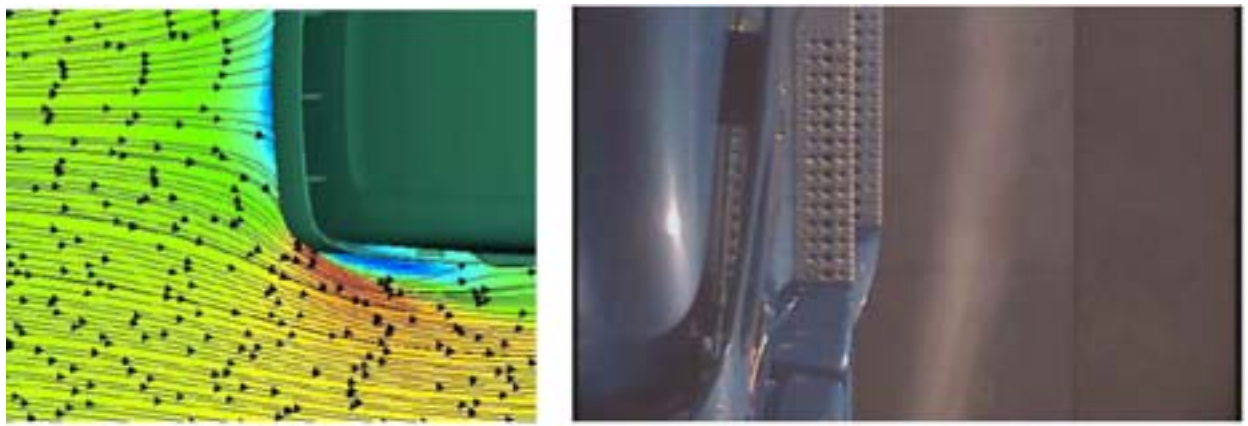
Project Accomplishments
Freightliner (3)

SAMPLE FLOW VISUALIZATION FROM CFD AND WIND TUNNEL

0 degree yaw
with mirrors
CFD (left)
Wind Tunnel (right)



0 degree yaw
without mirrors
CFD (left)
Wind Tunnel (right)

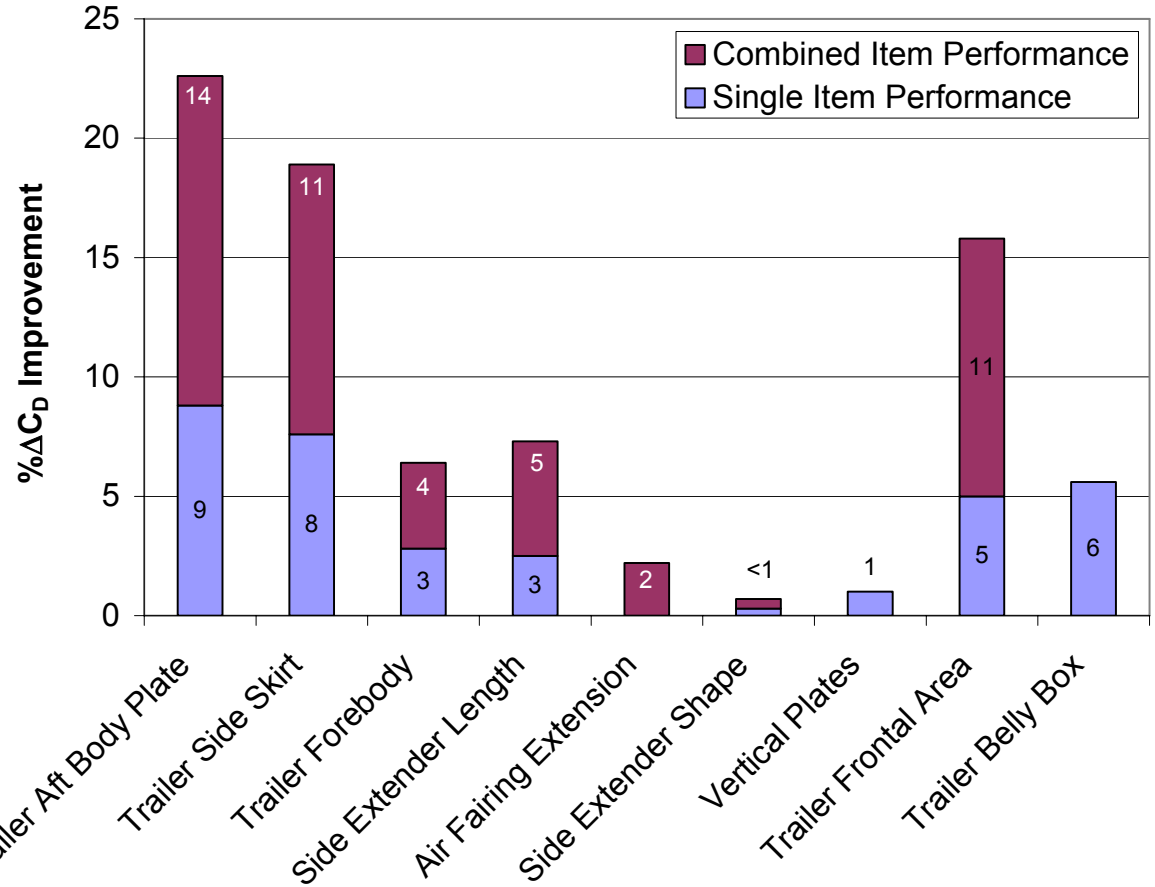


Project Accomplishments International (1)

- Focus on practical devices to reduce aerodynamic drag
  - Tractor trailer gap closure
  - Trailer side
  - Trailer wake
- Scale model testing (1/8 scale models) at Texas A&M wind tunnel
- Incrementally evaluate about one dozen concepts

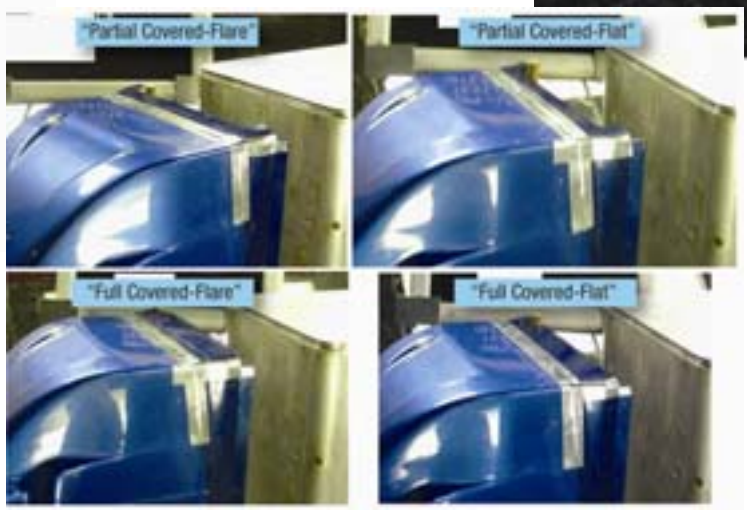
Project Accomplishments International (2)

Up to 23% improvement in drag coefficient with combination of devices (trailer aft body plates and trailer skirts)



Project Accomplishments International (3)

SAMPLE SCALE MODEL DEVICES



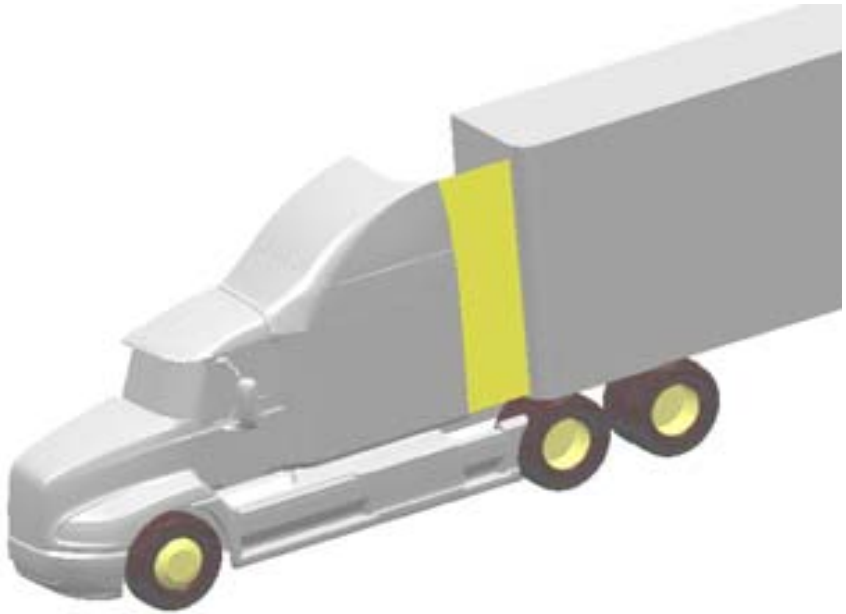
Project Accomplishments
Mack (1)

- Test and evaluation of practical devices and systems to improve aerodynamic drag
  - Trailer gap enclosure (side extensions)
  - Trailer aerodynamics
- Combination of CFD modeling, discussion with experts in aerodynamics field, on-road testing

Project Accomplishments
Mack (2)

TRAILER AERODYNAMIC AIDS

CAB SIDE EXTENDERS



Project Accomplishments
Mack (3)

- Estimated drag force improvement for side extenders
  - 4% reduction at 0 degree yaw
- Through consultation with aerodynamics experts, determined most promising concepts and combinations for Phase II testing (see chart)

Device Description \ Test Number	0	1	2	3	4	5	6	7	8
Boat Tail 48"	●								●
Boat Tail 18"			●	●	●			●	
Vortex Trap				●					●
Side Skirts					●		●	●	●
Strakes	●	●	●	●	●	●	●	●	●
Cab Side Enclosures						●		●	

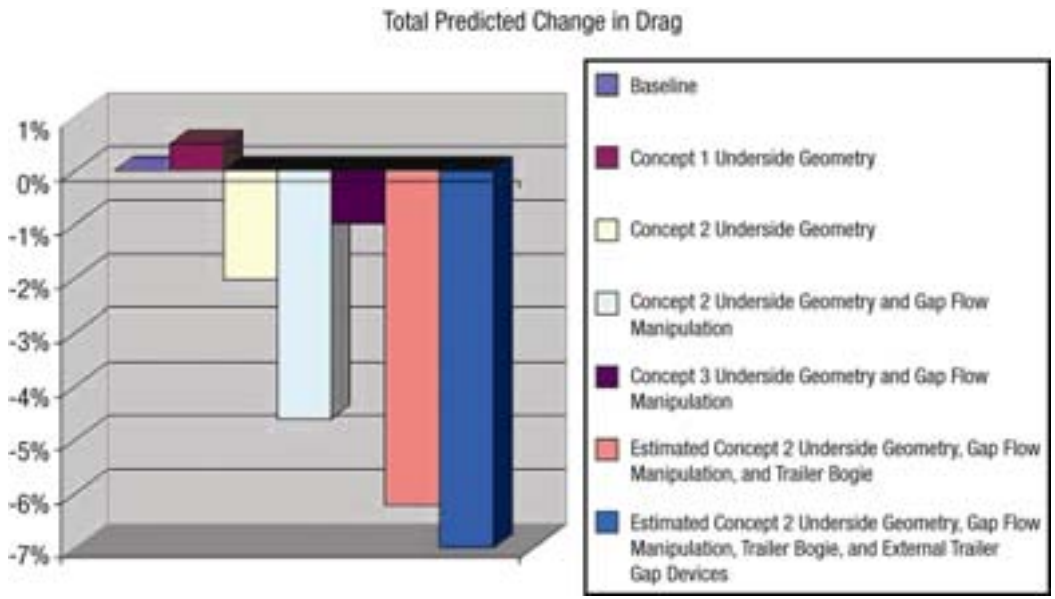
● Devices Included in the Test

Project Accomplishments
Volvo (1)

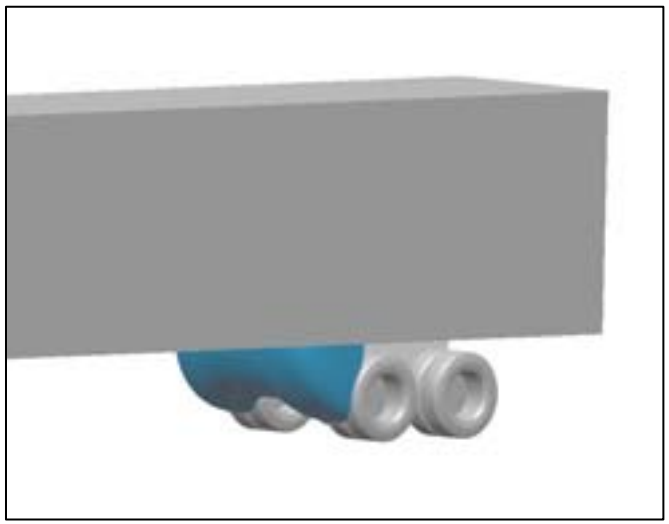
- Develop and demonstrate practical solutions to improve fuel economy by reducing aerodynamic drag in the focus areas
  - Focus areas = tractor and trailer underside and tractor-trailer gap
- Combination of CFD simulation, analysis of wind tunnel results, and on-road testing

Project Accomplishments
Volvo (2)

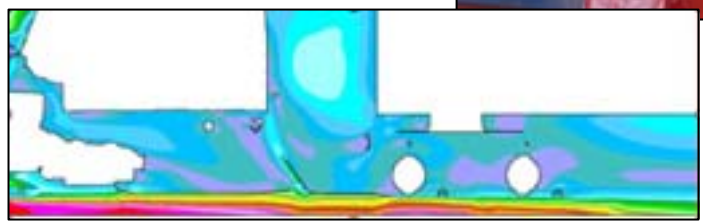
- Several combinations of underside geometry and trailer gap manipulation examined
- Trailer bogie deflector also examined
- Underside of tractor and trailer contribute about 35% to total vehicle drag
- Estimated effect of underside geometry modification, trailer gap manipulation, and trailer bogie deflector is 7% drag reduction

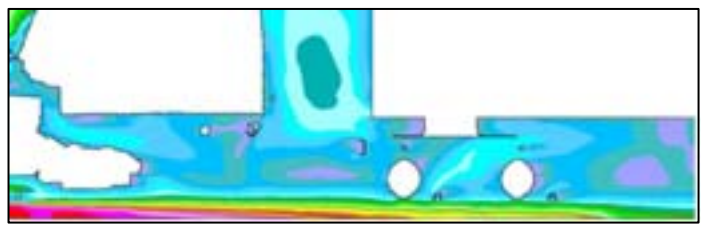


Project Accomplishments
Volvo (3)



Trailer gap manipulation devices





Underside air flows

Collaborations

- Collaboration among four competitor OEMs to pursue complementary research and share results
- Work with existing DOE aerodynamic consortium
  - Presentation of project goals and objectives to consortium meeting (mid-2005)
  - Use of consortium members in Mack project to identify areas of potential interest for trailer aerodynamics

Future Plans

- Complete Phase II work for each manufacturer to achieve real aerodynamic benefits for Class 8 tractor-semitrailer combinations
  - Freightliner: Full-scale wind tunnel testing of different common mirror systems (West Coast style and aerodynamic) to determine aerodynamic drag effects
  - International: Full-scale prototype testing of concepts for tractor-trailer gap, trailer side, and trailer wake, for on-road impact on fuel economy
  - Mack: Full-scale prototype testing of combinations of boat tails, vortex traps, side strakes, side skirts, and cab enclosures for on-road impact on fuel economy
  - Volvo: Full-scale prototype testing of combinations of trailer bogie deflector, underside devices, and trailer gap devices for on-road impact on fuel economy
- Conduct end-of-project demonstration (location and date TBD, but probably in the fall of 2006) with sample test vehicles from all four manufacturers to illustrate results to government and industry representatives

Summary

- Relevance: Contribute toward DOE goal of reducing aerodynamic drag of Class 8 vehicles by 20%
- Approach: Examine aerodynamic devices and changes in vehicle configuration to understand drag effects through combination of CFD modeling, wind tunnel testing, and on-road vehicle testing in order to develop more aerodynamic tractor-semitrailer combinations
- Accomplishments: Calculated potential aerodynamic drag reductions of 4% to 23% for tractor-semitrailer systems
- Collaboration: Cooperation among four major truck manufacturers, work with existing aerodynamic consortia
- Future Research: Pursue combination of wind tunnel testing and on-road testing to demonstrate actual aerodynamic drag and fuel economy effects of changes to vehicle configuration