



# Transport Canada - ecoTECHNOLOGY for Vehicles Program

## HDV Aerodynamic Drag Reduction Study

### Task Force on Vehicle Weights & Dimensions

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December 3, 2015





## Project Overview & Goals

- Transport Canada's **ecoTECHNOLOGY for Vehicles** program undertakes safety, environmental and performance studies of new and emerging advanced on-road vehicle technologies.
- Multi-year project (2012 to 2015) undertaken in collaboration with Environment Canada and the U.S. Environmental Protection Agency -- engaged the National Research Council to perform an assessment of drag reduction technologies for HDVs.
- To conduct the testing, significant upgrades were made to the NRC's 9-metre wind tunnel to develop **the most accurate, real-world test conditions ever achieved in wind-tunnel**. Testing was able to account for:
  - Wind averaged drag
  - Turbulent wind conditions
  - Vehicle-ground wind interactions

- **Results will:**

- **Help to identify and quantify the optimal combinations of drag reduction technologies to enhance HDV aerodynamic efficiency, and**
- **Support the regulatory development process and understand Canadian-unique considerations, i.e. drag technologies for long combination vehicles (LCVs).**



# Drag reduction technologies for Class-8 tractor-trailers and Test Program Overview

## Wind Tunnel Model

- 30%-scale
- Tractor
  - Adapted from Navistar/International ProStar
  - Sleeper-cab and day-cab configurations
- Multiple Trailer Models
  - 40ft, 53ft, tandem 28ft dry-vans, 53ft flatbed
  - Configurable underbody and wheels
  - Device mounting locations in gap/underbody/base

## Test Program - 92 truck configurations tested:

- Vehicle Drag Reduction
  - Tractor-trailer gap width
  - Tractor-trailer gap devices
  - Trailer under body
  - Trailer base
  - Trailer upper body
  - Device interactions
- Tractor Type – day-cab vs. sleeper-cab
- Trailer Type – length, tandem, dry-van vs. flatbed
- Flatbed – side-skirts
- Long Combination Vehicles (LCV) – trailer-trailer gap
- Height Matching – tractor roof vs. trailer height

40 ft dry-van



53 ft dry-van



53 ft flatbed with box cargo



tandem 28 ft dry-van



sleeper-cab



day-cab







# Tractor-Trailer Gap Width Configurations



sleeper-cab  
24" gap



sleeper-cab  
36" gap



sleeper-cab  
48" gap

Same tests also performed on day cab (not shown)



# Tractor-Trailer Gap Devices Configurations



trailer fairing



partial plate seal



refrigeration unit



heating unit



full plate seal





# Trailer Underbody Configurations



standard side-skirts



belly box



smoothed + removed landing gear



split side-skirts



diffuser fairing



bogie fairing



extended side-skirts



tridem axle with skirts



# Trailer Base Boat-Tail Configurations



long 4-panel + cover

- All based on same geometry/panel-angles of  $13^\circ$
- Shape variations cover generic length and panel configurations
- Cavity cover to simulate inflatable boat-tail

3" vertical offset  
for lights

long 4-panel



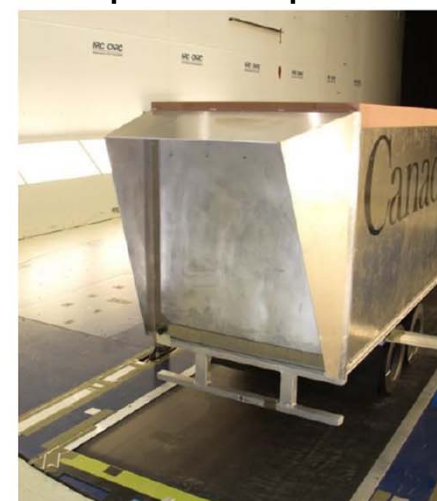
long 3-panel



short 4-panel



tapered 3-panel







# Trailer Upper-Body Roof Configurations

- Adjustments in top 6 inches only



roof mounted vortex generators  
34 per side

Aft taper ( $\sim 3^\circ$ )



rounded side edges



rounded front edge



Aft taper + rounded side edges + rounded front edge





# Device Interactions Device Combinations

- Combinations of:
  - Standard and extended side-skirts
  - Long 4-panel boat-tail
  - Trailer fairing
  - Profiled roof

side-skirts + boat-tail

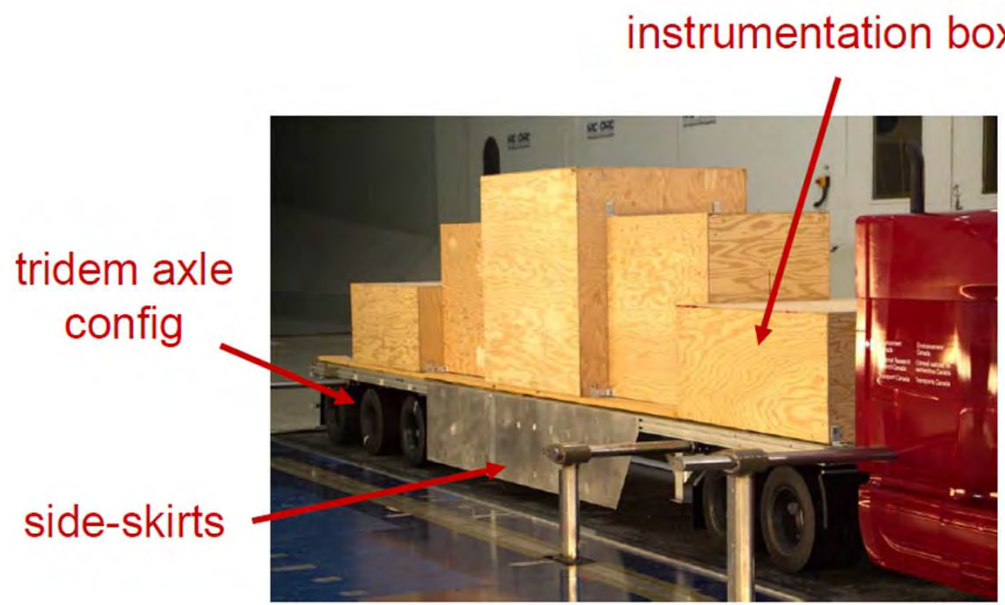


extended side-skirts + boat-tail + trailer fairing + profiled roof





# Flatbed Study Configurations

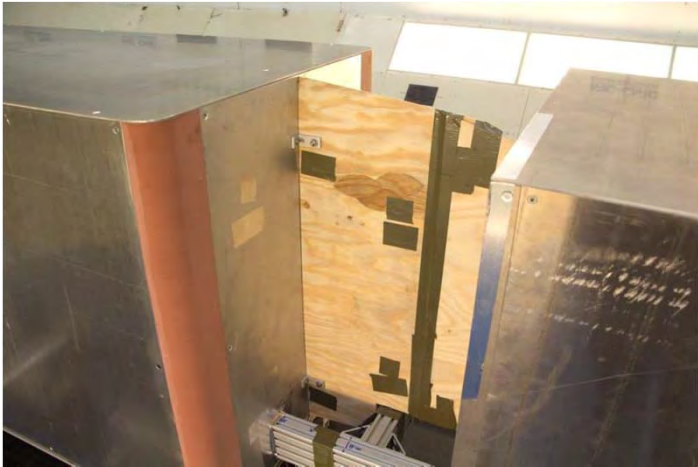






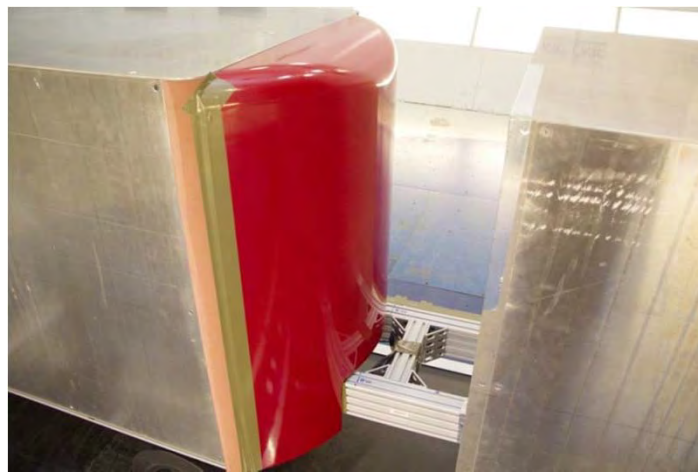
# Long-Combination-Vehicle Study Configurations

tandem 28 ft trailers with adjustable trailer-trailer gap (3 ft and 5 ft)



Full plate seal

with trailer aero package (TAP)



Trailer fairing





# Height-Matching Study Configurations

- Drag increase of ~20% or greater for poorly-matched tractor/trailer



mid-height sleeper-cab  
w/ full-height trailer



low-roof day-cab w/  
full-height trailer



day-cab deflector  
w/ full-height trailer



full-height sleeper-cab  
w/ half-height trailer



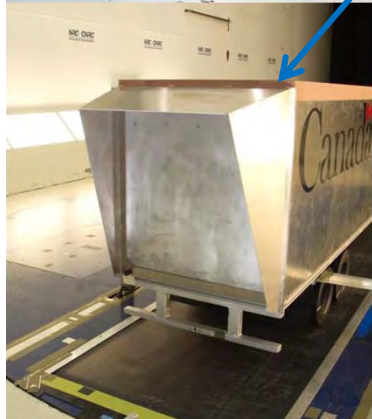
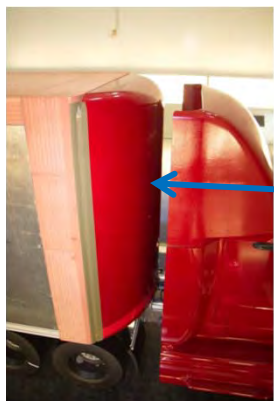
low-roof day-cab  
w/ half-height trailer



high-roof day-cab w/  
half-height trailer



# Results Summary Data



Drag-Reduction Technology	Drag Change $\Delta WACD$	Drag Reduction [%]	Fuel Saved [l]		CO <sub>2</sub> Reduction [kg]	
			(for 125,000 +/- 35,000 km/tractor/year @ 100km/h)			
<b>Tractor-Trailer Gap</b>						
add trailer fairing for day-cab w/ 36" gap	-0.033	-5.4%	1,600	+/- 500	4,200	+/- 1,300
<b>Trailer Side-Skirts</b>						
add side-skirts to tandem axle trailer	-0.058	-10.1%	2,900	+/- 800	7,700	+/- 2,100
add side-skirts to tridem axle trailer	-0.077	-12.2%	3,800	+/- 1,100	10,000	+/- 2,900
<b>Trailer Boat-Tails</b>						
add long 4-panel boat-tail to trailer base	-0.038	-6.6%	1,900	+/- 500	5,000	+/- 1,300
add tapered 3-panel boat-tail to trailer base	-0.033	-5.7%	1,600	+/- 500	4,200	+/- 1,300
<b>Trailer Roof</b>						
profile the trailer roof (top 6")	-0.020	-3.5%	1,000	+/- 300	2,600	+/- 800
<b>Interaction Effects (side-skirt and boat-tail)</b>						
48" to 36" gap, trailer fairing, side-skirts, boat-tail (sleeper)	-0.136	-22.9%	6,700	+/- 1,900	17,700	+/- 5,000
48" to 36" gap, trailer fairing, side-skirts, boat-tail (day-cab)	-0.160	-25.6%	7,900	+/- 2,200	20,900	+/- 5,800
<b>Flatbed Trailers</b>						
add side-skirts to flatbed with high irregular cargo	-0.058	-8.5%	2,900	+/- 800	7,700	+/- 2,100
add side-skirts to flatbed with low irregular cargo	-0.032	-5.4%	1,600	+/- 400	4,200	+/- 1,100
<b>Long-Combination Vehicles (LCV)</b>						
add trailer fairing to LCV trailer-trailer gap	-0.029	-4.5%	1,400	+/- 400	3,700	+/- 1,100
add trailer fairing and reduce gap, and add full aero package to LCV	-0.159	-24.9%	7,900	+/- 2,200	20,900	+/- 5,800



## Key Findings

- Today's drag reduction technologies can improve the aero performance of dry-van trailers by up to 20%.
- This is the equivalent of:
  - Fuel savings of \$10,000/tractor/year [1] (simple payback)
  - CO<sub>2</sub> emissions reduction exceeding 20,000 kg/tractor/year
- Confirms significant positive interaction effects of combining side-skirts & boat-tails (1-3% depending on configuration).
  - Drag reductions are influenced by tractor style
  - Flatbeds benefit from side-skirts and a low tractor roof
  - LCV trailer-trailer gaps can be optimized (gap width, fairing)

- To access the full report:


<http://www.tc.gc.ca/eng/programs/environment-etv-menu-eng-2980.html>

[1] Does not include maintenance / operational costs.





# Thank You

  
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