Results from fuel economy testing of a prototype 3-vehicle cooperative truck platooning system

Task Force on Vehicle Weights and Dimensions Policy Meeting
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Project Background

• Cooperative Truck Platooning
  • The prototype system tested is based on Cooperative Adaptive Cruise Control (CACC) technology
  • Multiple vehicles using 5.9 GHz DSRC based V2V communications and forward sensors to help maintain a constant distance between vehicles

• Potential Benefits
  • Improved fuel economy
  • Reduced emissions
  • Improved road-use efficiency
  • Reduce driver stress and workload
Prototype CACC System

- Starts with Volvo’s adaptive cruise control (ACC) using radar/video sensing of forward vehicle
- Adds 5.9 GHz DSRC radio for V2V communication
- Enables faster response to speed changes, with more stable vehicle following
  - Driver-selectable time gaps of 1.5, 1.2, 0.9 or 0.6 s
  - (SAE) Level 1 Automation
  - Saves energy, emissions
Aerodynamics of Cooperative Truck Platooning

• As vehicles approach, they influence the flow-field around each other

Aerodynamics of Cooperative Truck Platooning

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Low-speed air-wake of lead vehicle influences trailing vehicle
(lower airspeed = lower drag)
Aerodynamics of Cooperative Truck Platooning

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High-pressure zone in front of trailing vehicle influences lead vehicle
*(pushes on the front vehicle)*

Schematic adapted from Mihelic, Smith, Ellis (2015)
SAE Paper 2015-01-2897
Aerodynamics of Cooperative Truck Platooning

• As vehicles approach, they influence the flow-field around each other

Magnitude of each effect is dependent on separation distance!

Influences on Fuel Savings

Questions for this study:

• What is the potential fuel savings of practical distances for driver comfort (greater than 15m/50ft)?

• How do aerodynamic trailer treatments affect fuel savings?

• How does load/weight affect fuel savings?

• How does speed affect fuel savings?
Test Plan

• Fuel consumption measurements performed using SAE J1321 procedure
  • Control vehicle used as reference
  • 3 valid runs per configuration
  • 16 laps (64 mi / 103 km) per run

• Many variables to consider:
  1. Separation time/distance: 0.6 s to 1.5 s, 17 m (57 ft) to 43 m (142 ft)
  2. Truck configuration: standard trailer vs. aerodynamic trailer
  3. Vehicle speed: 89 km/h (55 mph) and 105 km/h (65 mph)
  4. Vehicle weight: 29,000 lbs (empty) and 65,000 lbs

Video: https://vimeo.com/187863540/feba3e1efe
Test Results (105 km/h + 65,000 lbs)

Fuel Savings for Individual Trucks

Diagram showing fuel consumption reduction as a percentage for different vehicle positions (Lead, Middle, Trailing) and time gaps. The graph compares standard trailer and aerodynamic trailer configurations.
Test Results (105 km/h + 65,000 lbs)

**Fuel Savings for Individual Trucks**

Negligible savings for lead vehicle observed.
Test Results (105 km/h + 65,000 lbs)

Fuel Savings for Individual Trucks

trailing vehicle shows highest savings
Test Results (105 km/h + 65,000 lbs)

Total Fuel Savings for 3-Truck Platoon (ref. standard truck)
Test Results (105 km/h + 65,000 lbs)

**Total Fuel Savings for 3-Truck Platoon** (ref. standard truck)

no change beyond 22 m for standard trailers
Total Fuel Savings for 3-Truck Platoon (ref. standard truck)

Up to 14% fuel savings when combining aero devices with platooning

no change beyond 22 m for standard trailers
Test Results (17 m separation)

Total Fuel Savings for 3-Truck Platoon
Test Results (17 m separation)

Total Fuel Savings for 3-Truck Platoon

No significant influence of speed (89 vs. 105 km/h)
Test Results (17 m separation)

Total Fuel Savings for 3-Truck Platoon

Greater fuel savings for empty trailer

No significant influence of speed (89 vs. 105 km/h)
Test Results (17 m separation)

Total Fuel Savings for 3-Truck Platoon

Aero-trailer shows greater fuel savings from platooning

Greater fuel savings for empty trailer

No significant influence of speed (89 vs. 105 km/h)
Test Results (17 m separation)

**Total Fuel Savings for 3-Truck Platoon**

Aero-trailer shows greater fuel savings from platooning

Greater fuel savings for empty trailer

No significant influence of speed (89 vs. 105 km/h)

14% from Aero-trailer + Platooning
**Summary**

- Aerodynamic drag reduction is the primary source of fuel savings from truck platoons.
- Even with large separation distances (>100ft) platooning can realize measurable fuel savings (>5% for complete platoon).
- Trailer aerodynamic devices influence platoon performance.
- Changes in vehicle speed (89 vs. 105 km/h) showed no appreciable difference.
- Stronger influence for lighter vehicles (empty vs 31,000 lb load).
- Report to be published in Winter 2017 ([www.tc.gc.ca/eTV](http://www.tc.gc.ca/eTV)).
Project Partners

- Transport Canada
- U.S. Federal Highway Administration
- California Partners for Advanced Transportation Technology (PATH) at the University of California at Berkeley
- California Department of Transportation (Caltrans)
- Volvo Trucks
- National Research Council Canada
- FPInnovations PIT Group
- PMG Technologies