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

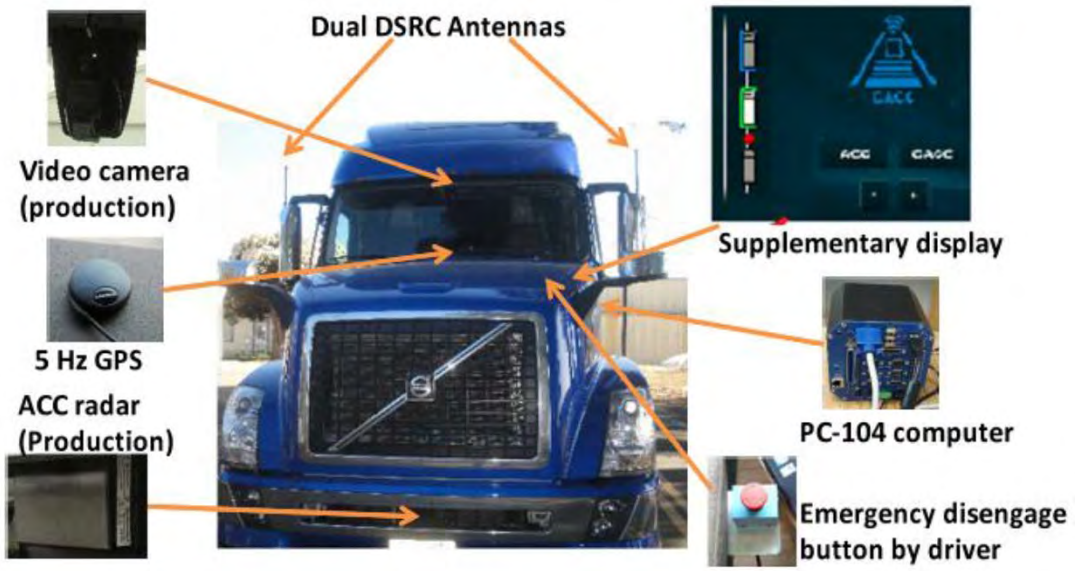
Task Force on Vehicle Weights and Dimensions Policy Meeting
December 14, 2016

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

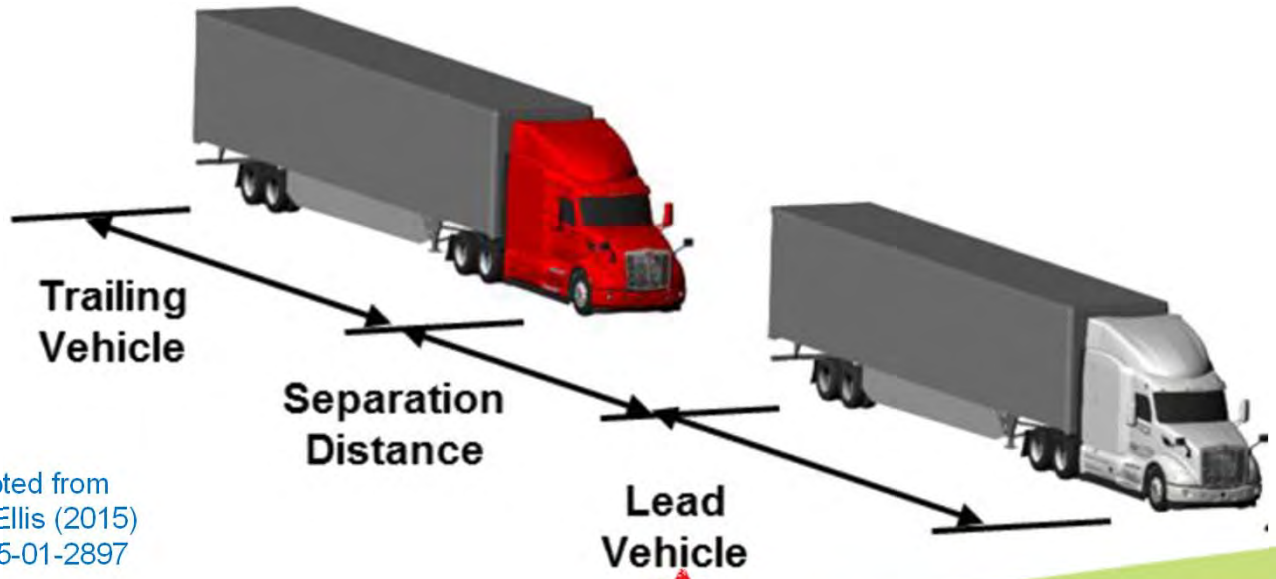
Prototype CACC System

- 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

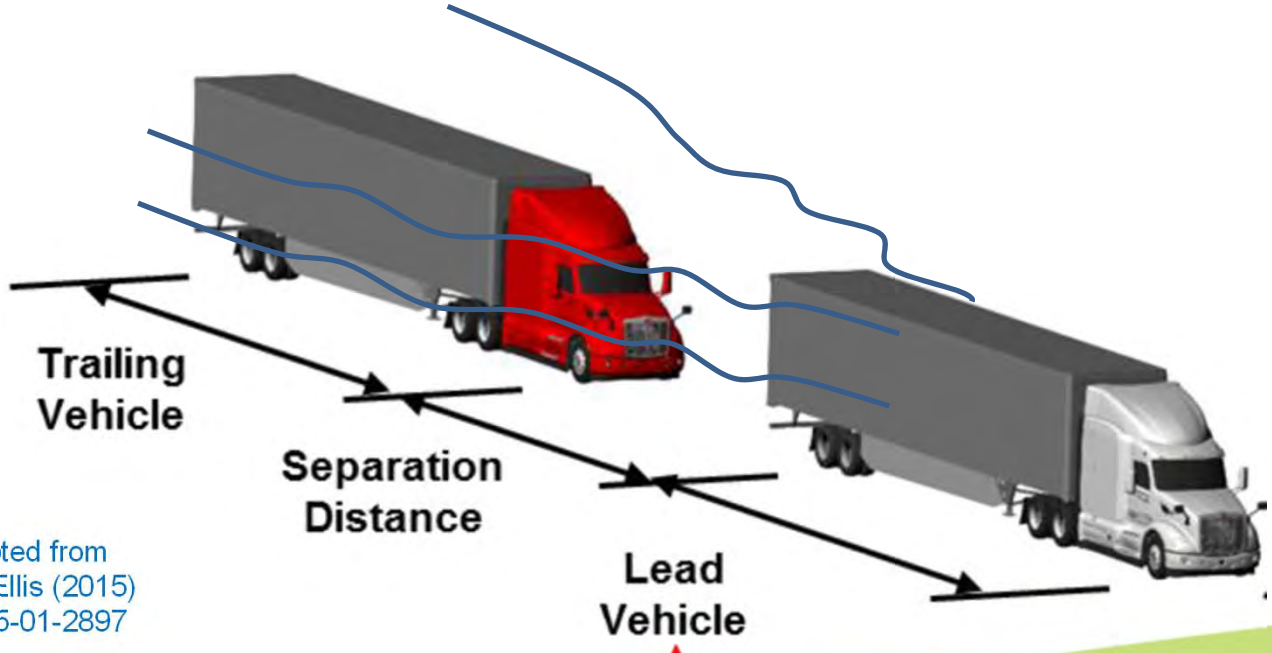


Schematic adapted from
Mihelic, Smith, Ellis (2015)
SAE Paper 2015-01-2897

Aerodynamics of Cooperative Truck Platooning

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

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



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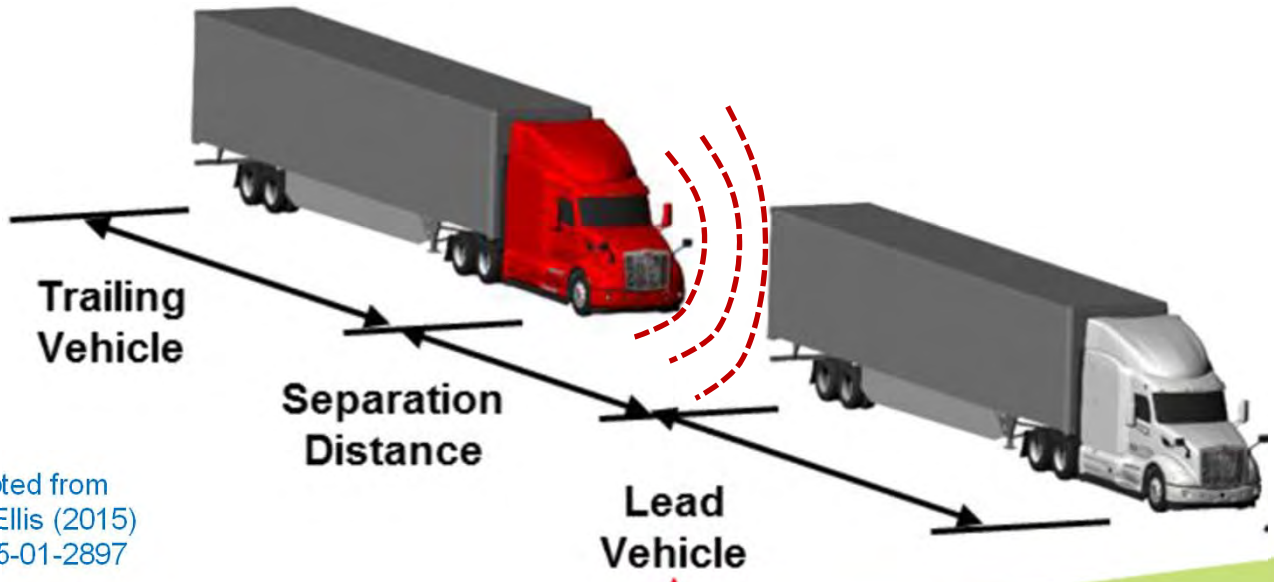
Aerodynamics of Cooperative Truck Platooning

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

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



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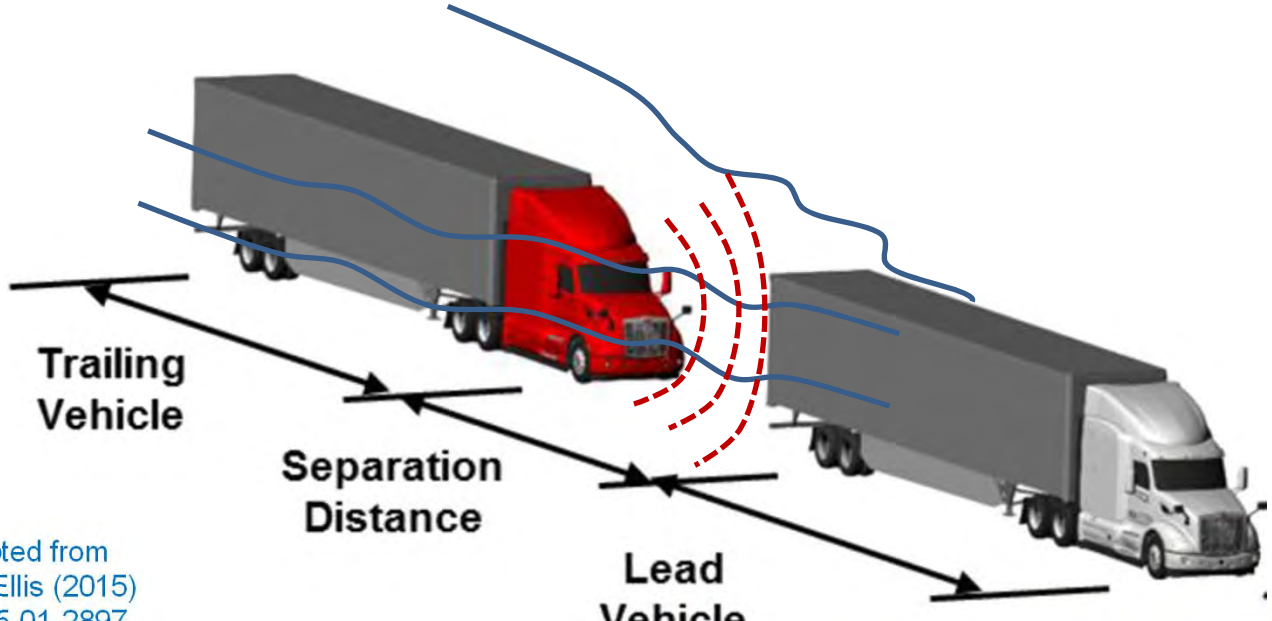
Aerodynamics of Cooperative Truck Platooning

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

Magnitude of each effect is dependent on separation distance!



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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

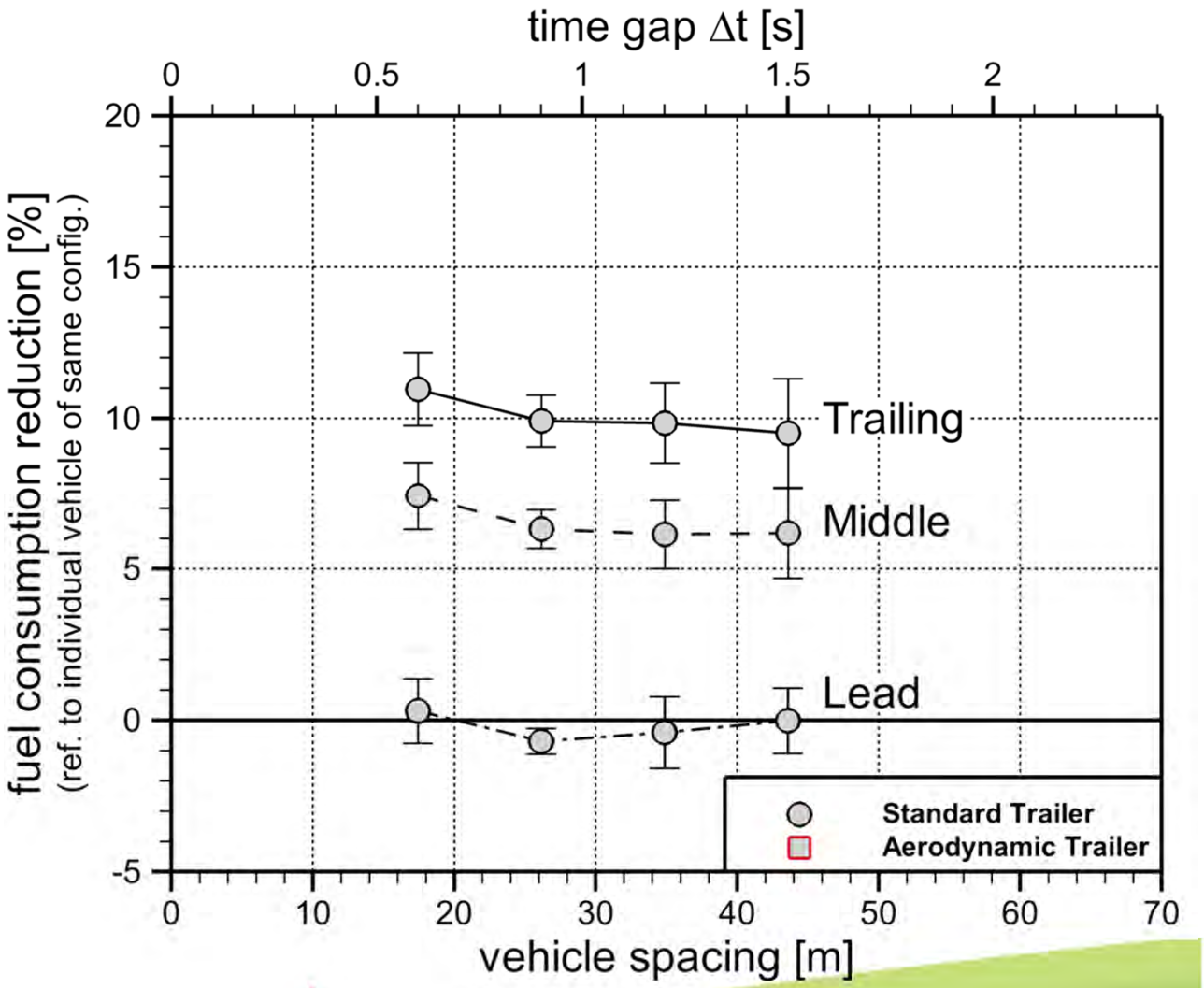
- Fuel consumption measurements performed using SAE J1321 procedure
  - Control vehicle used as reference
  - 3 valid runs per configuration
  - 16 laps (64 mi / 103 km) per run

- 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



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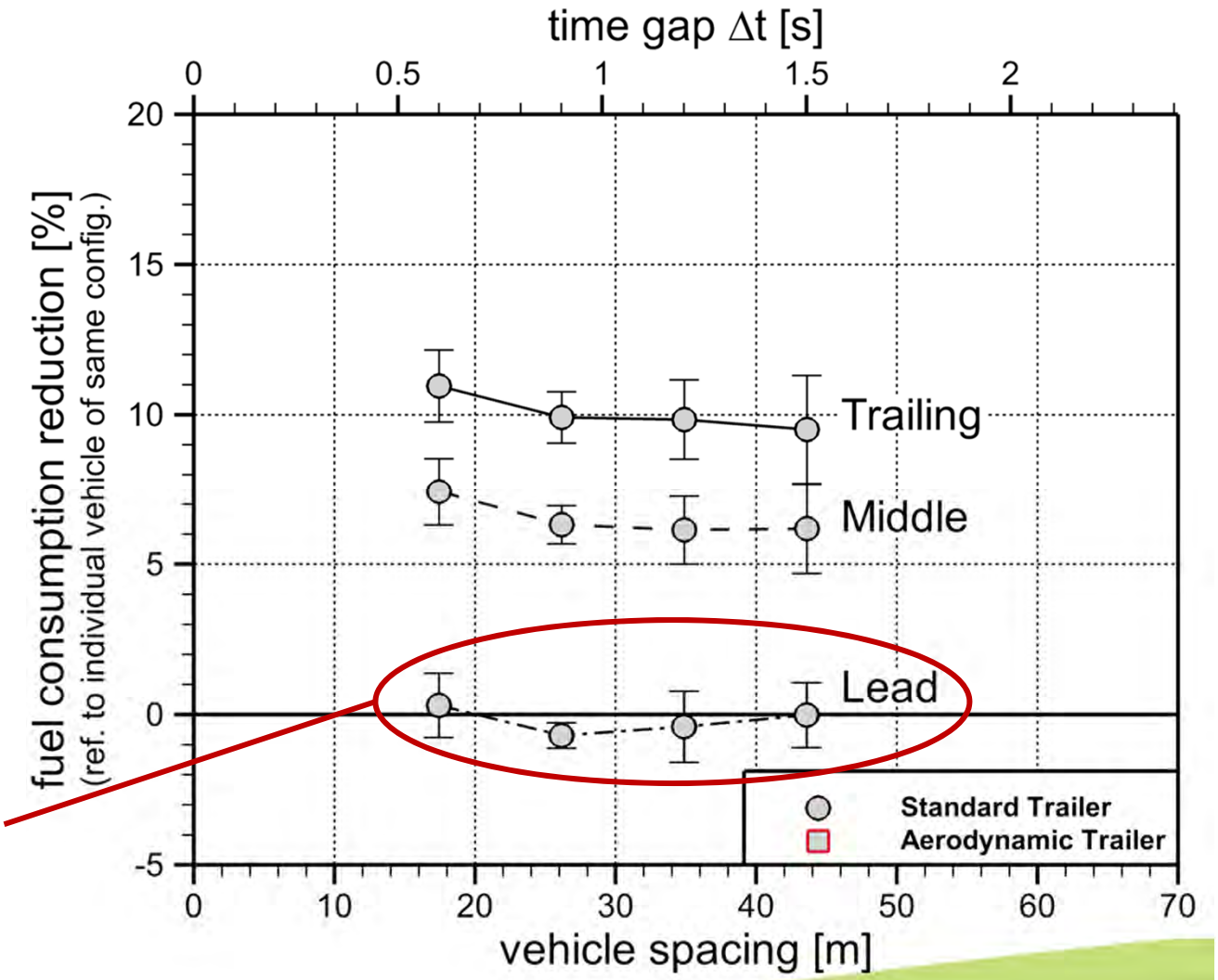
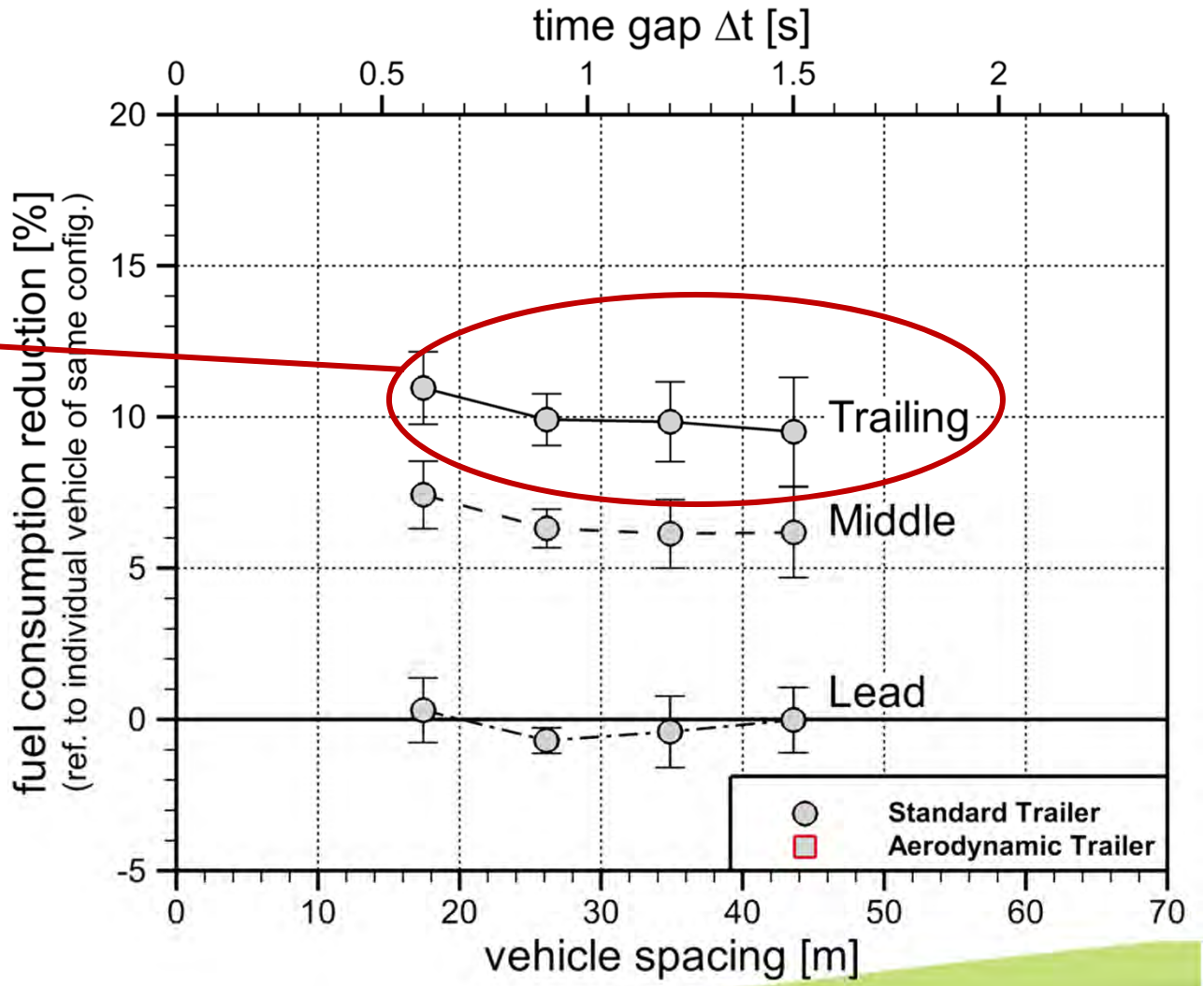


Negligible savings for lead vehicle observed

Test Results (105 km/h + 65,000 lbs)

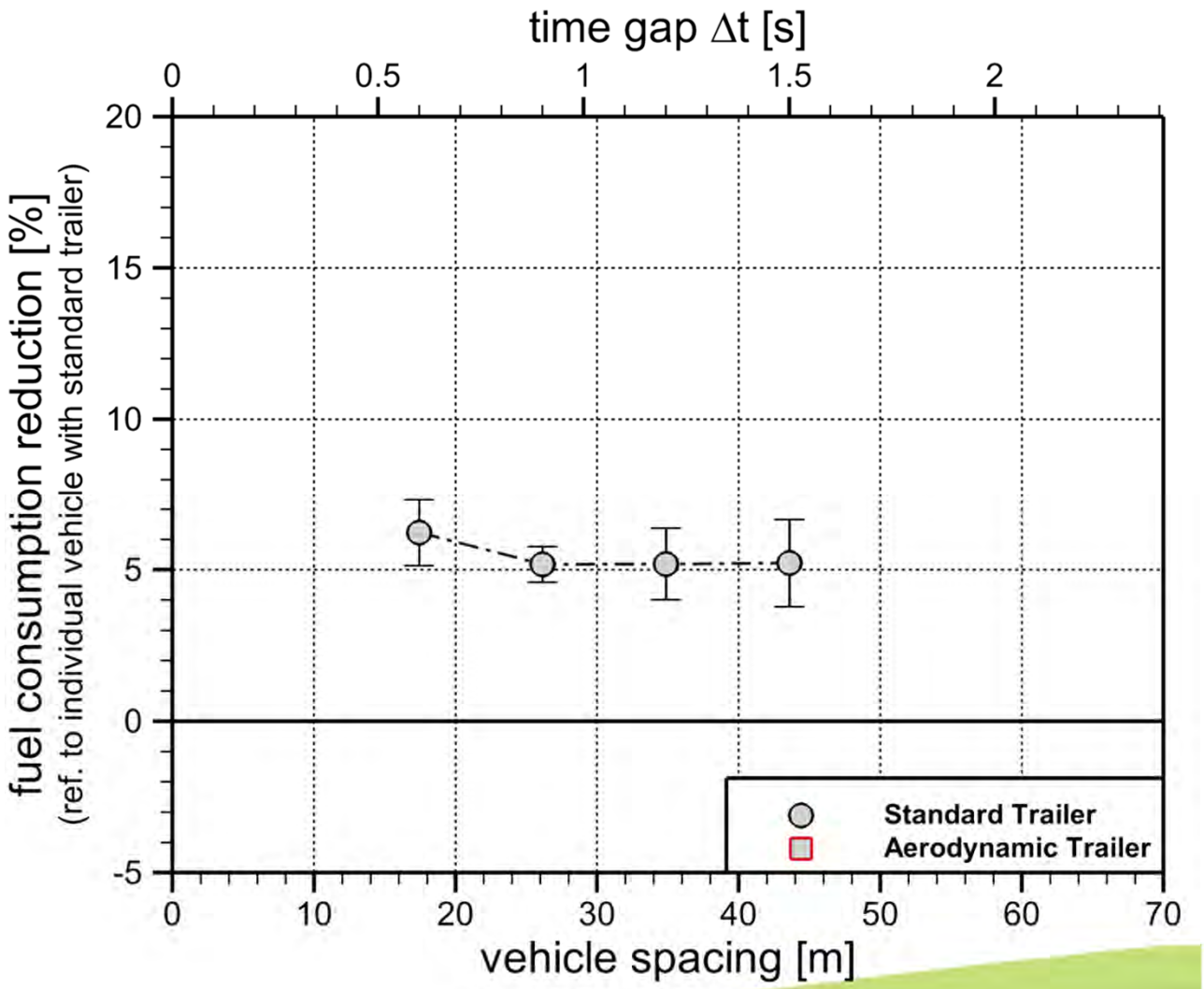
Fuel Savings for Individual Trucks

trailing vehicle shows highest savings



Test Results (105 km/h + 65,000 lbs)

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



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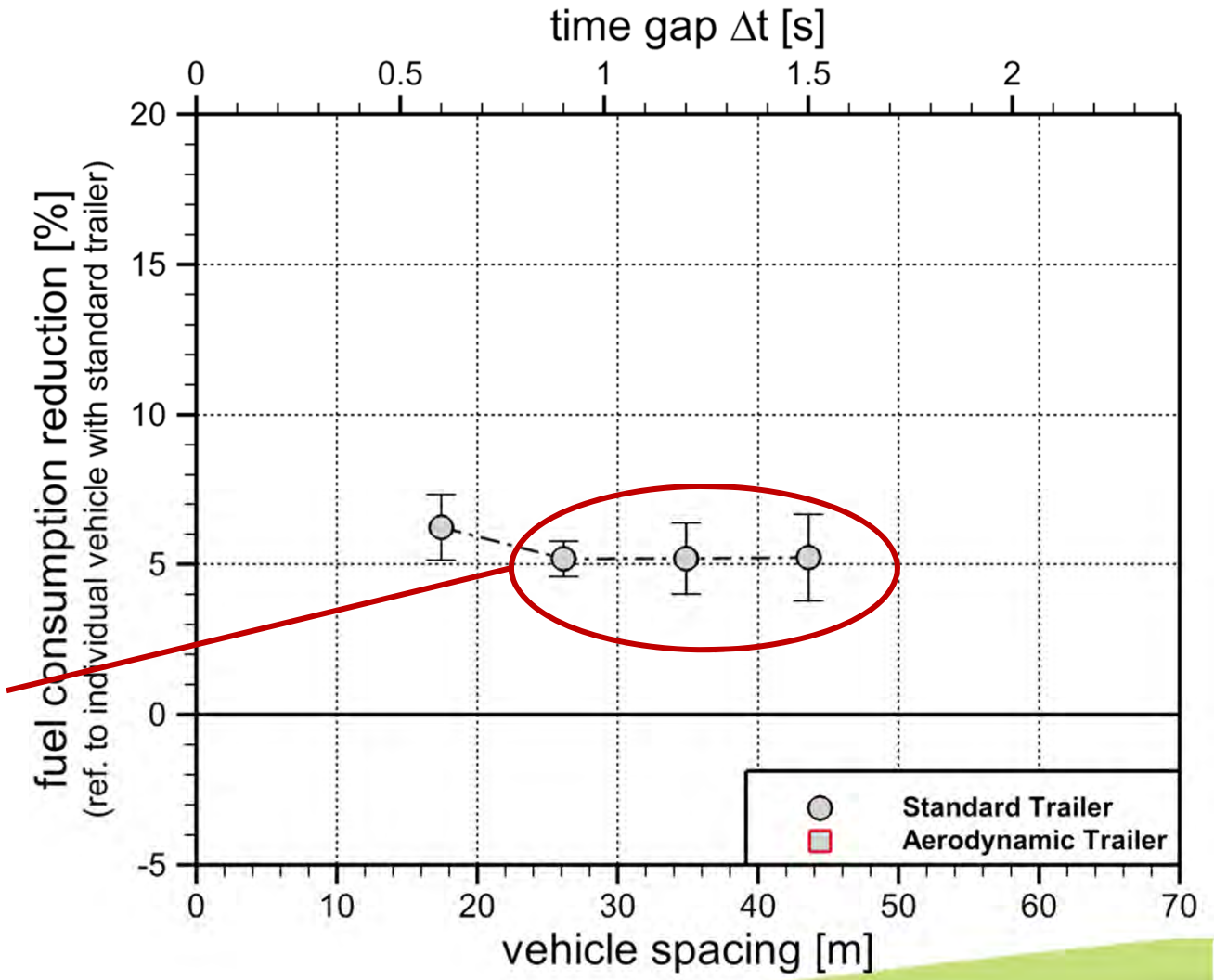
no change beyond 22 m for standard trailers



Test Results (105 km/h + 65,000 lbs)

Total Fuel Savings for 3-Truck Platoon
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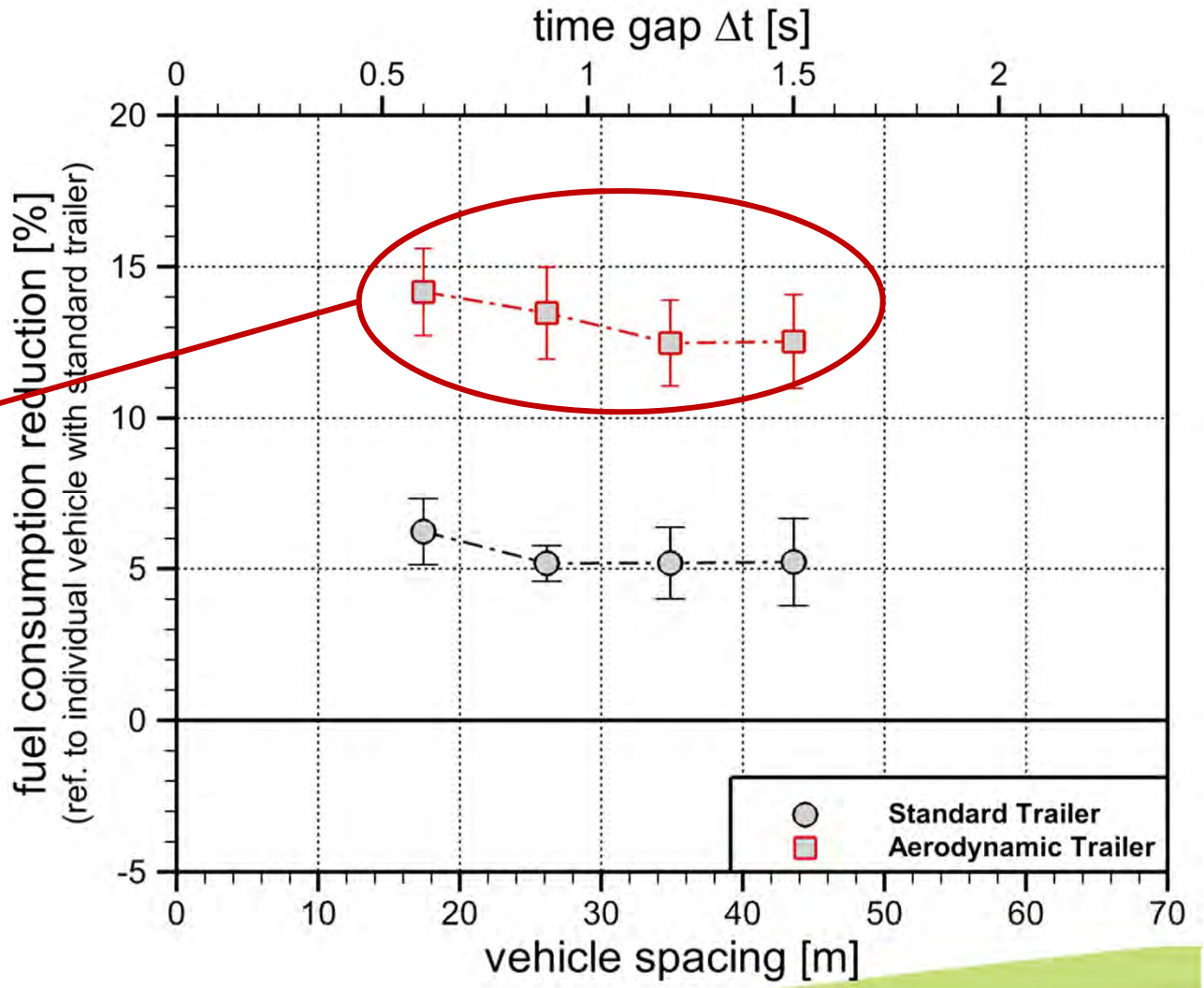
Up to 14% fuel savings when combining aero devices with platooning

no change beyond 22 m for standard trailers



Test Results (17 m separation)

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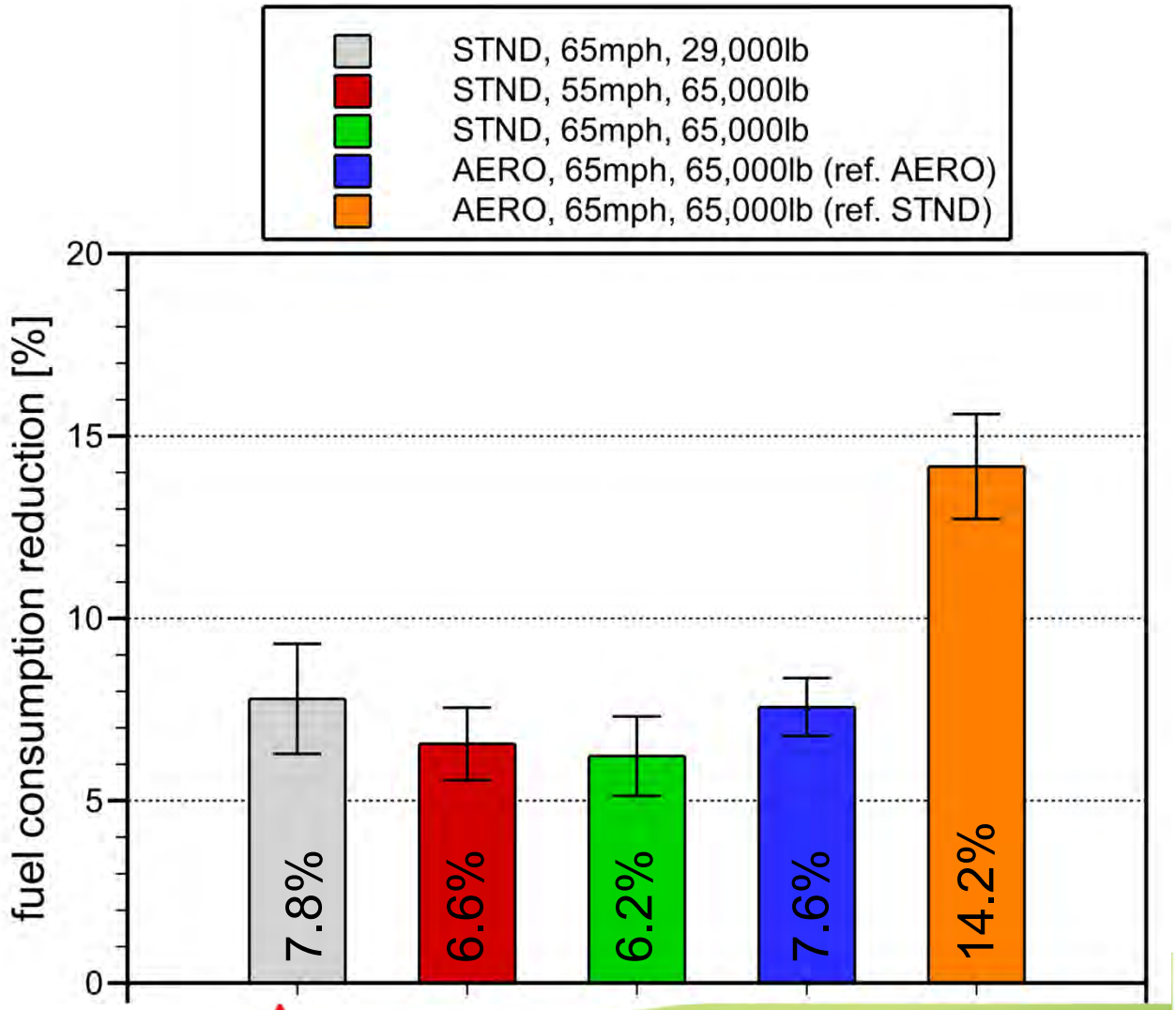

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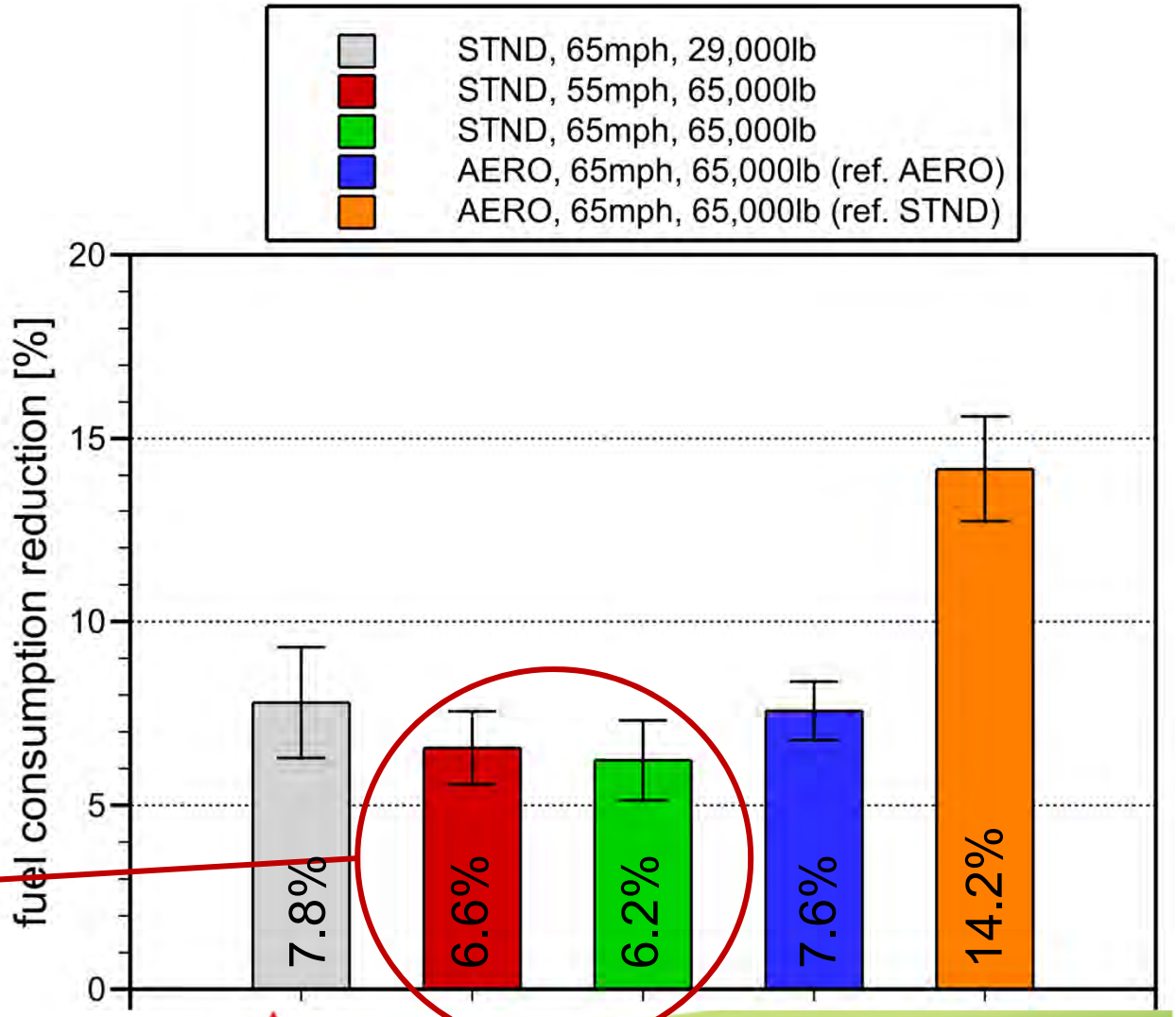
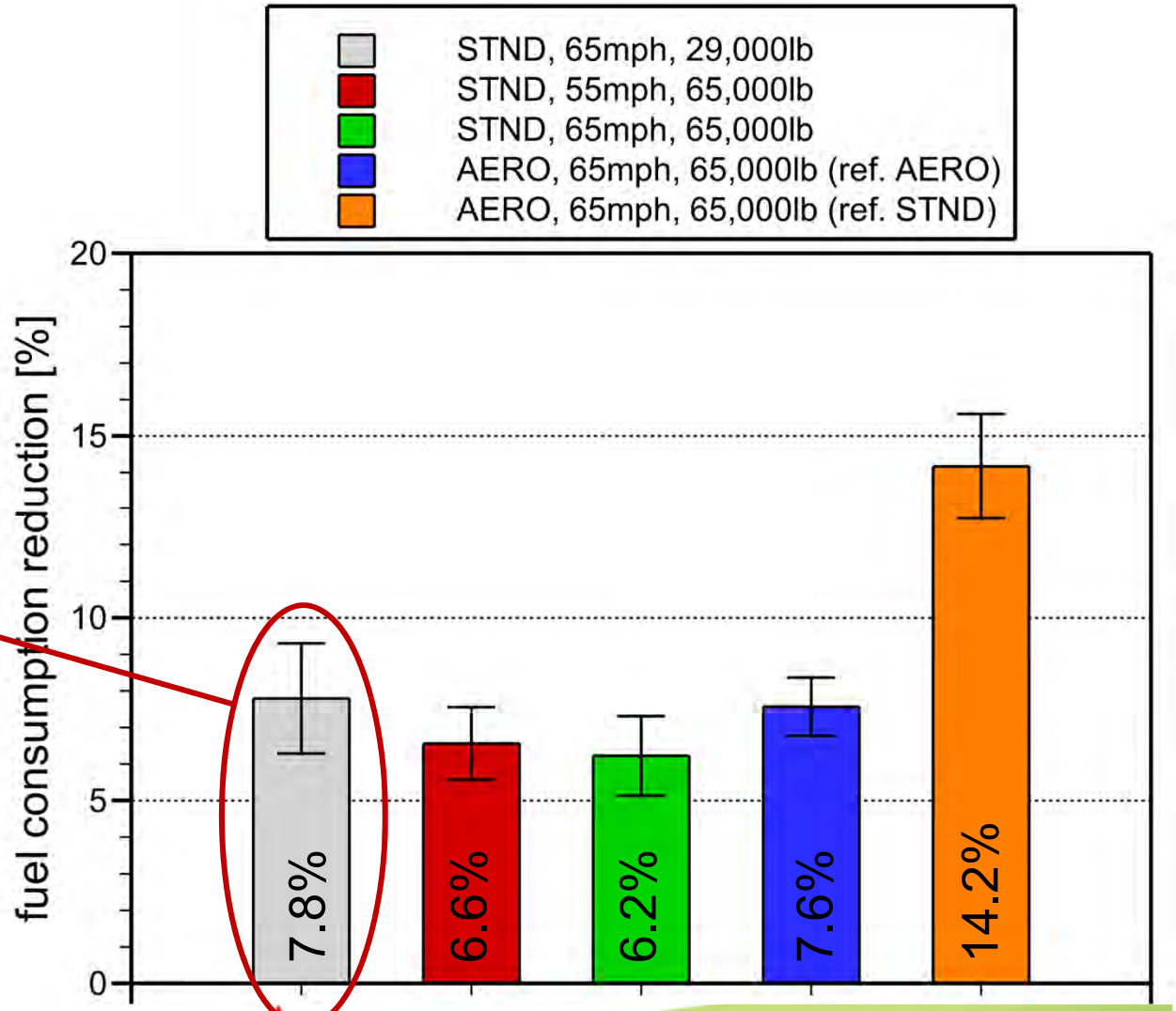


No significant influence of speed (89 vs. 105 km/h)

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)

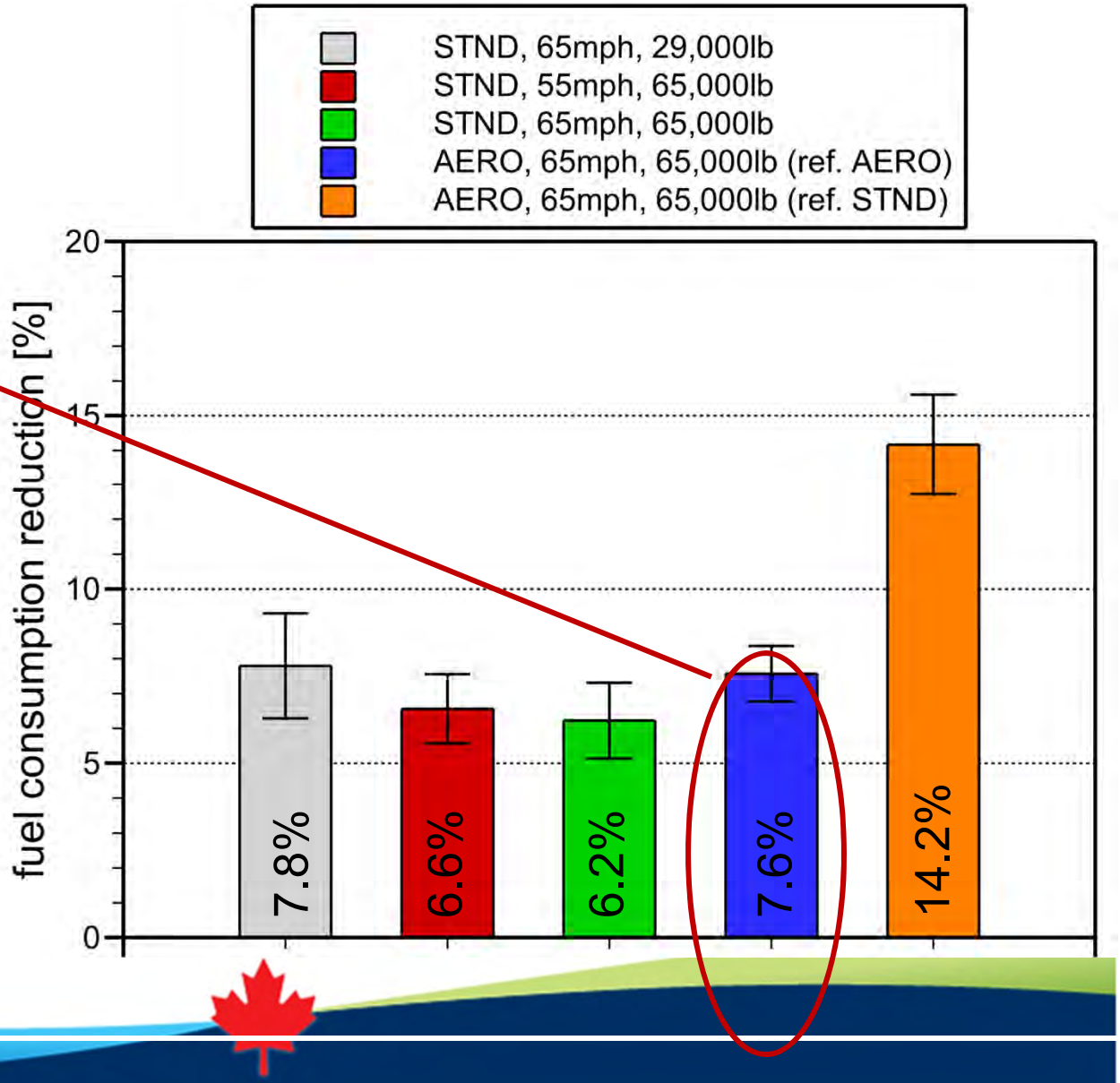
Test Results (17 m separation)

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)



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Total Fuel Savings for 3-Truck Platoon

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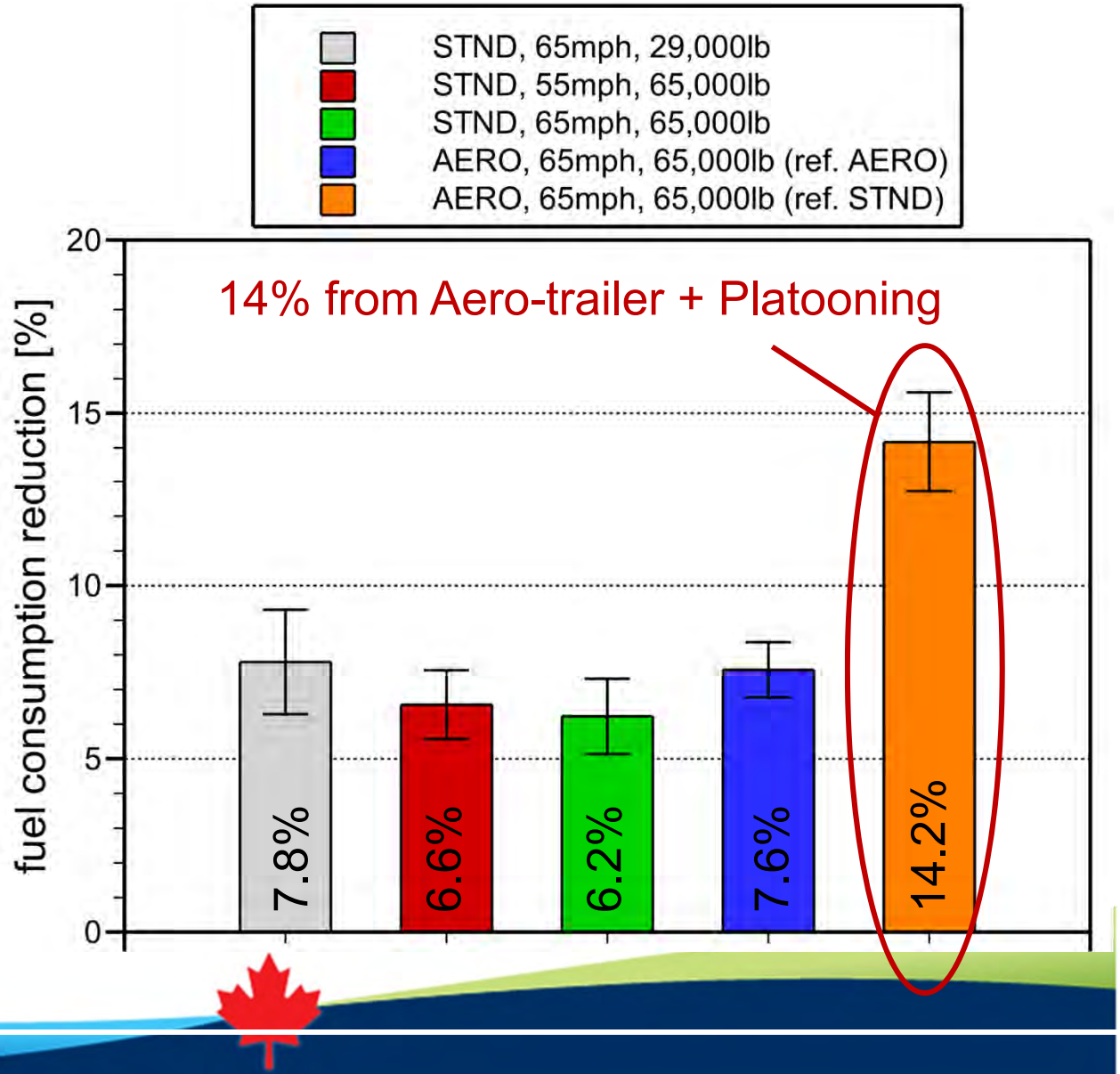

Summary

- 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)

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