BREAKOUT SESSION

AUTOMATED VEHICLES SYMPOSIUM 2017
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Truck CACC Fuel Economy Testing: Initial Test Track Results

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July 11, 2017

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Outline

- Background
- CACC Control System Design
- Test Scenarios
- Test Procedures
- Test Results (Weighing Fuel Tanks)
- Alternate Analysis (without Weighing Tanks)
- Conclusions

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 Time-Gap between vehicles**
  - **Level 1 automation: driver steering**
- **Potential Benefits**
  - **Improved fuel economy**
  - **Reduced emissions**
  - **Improved road-use efficiency**
  - **Reduce driver workload**

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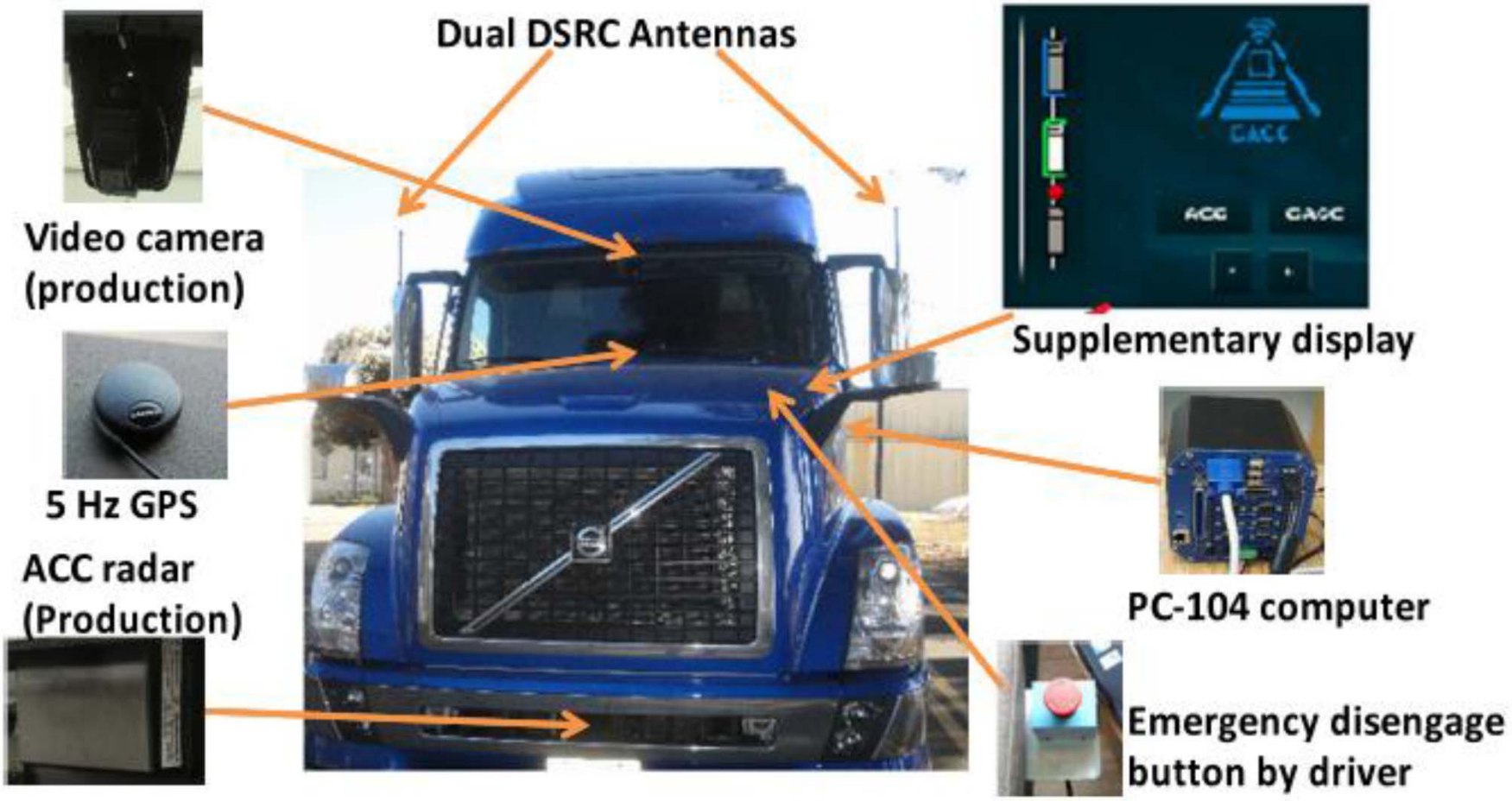
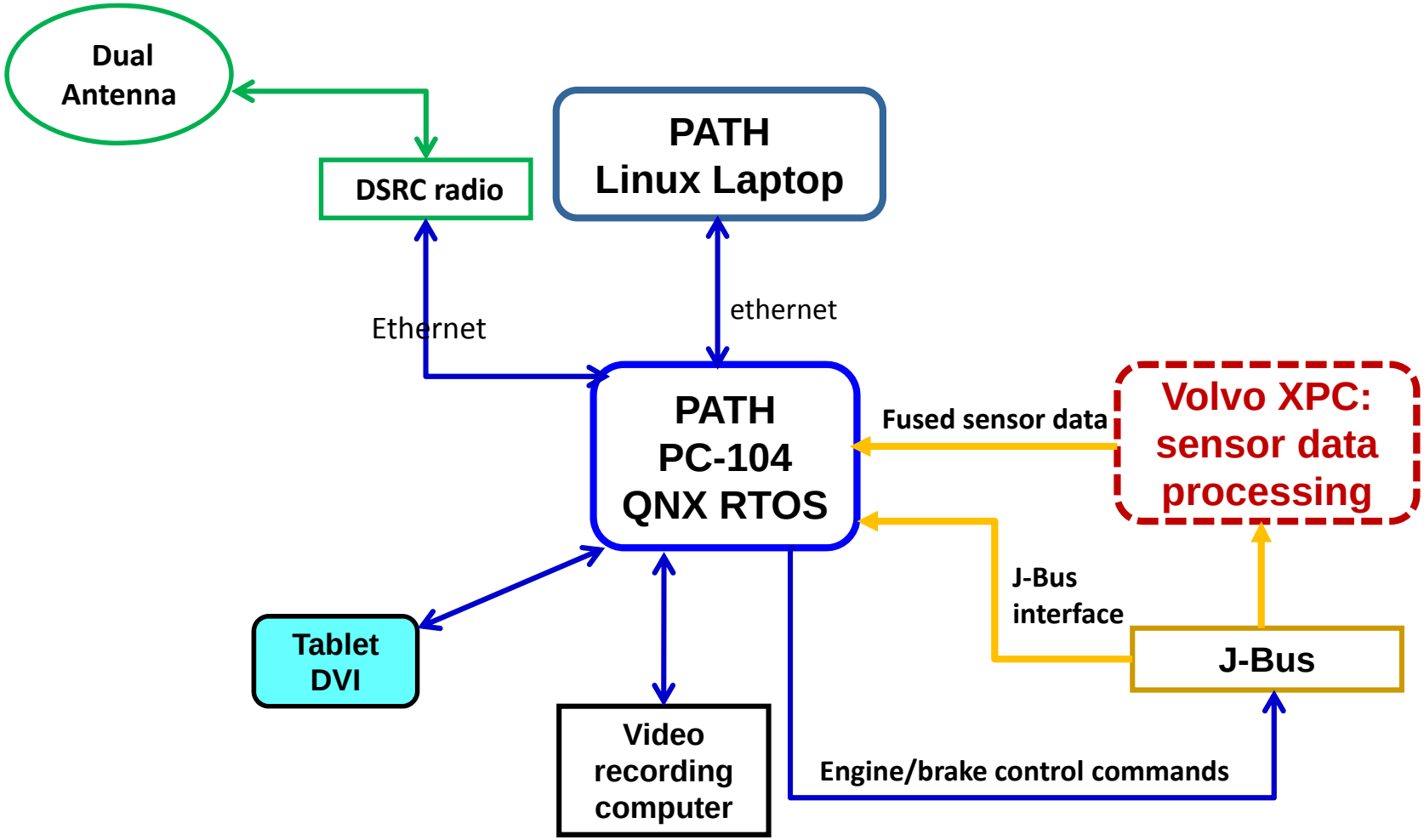
CACC System Design – Structure



CACC Control System



Truck CACC Test Scenarios

- **Fuel consumption measurements based on SAE J1321**
  - **Time Gap (T-Gap):**
    - **1.5s, 1.2s, 0.9s, 0.6s**
  - **Standard trailer vs. aerodynamic trailer**
    - **Boat tails & Side skirts**
  - **With/without ballast (rolling resistance)**
    - **65,000lbs & 29,000 lbs**
  - **Maximum speed:**
    - **65mph vs. 55mph**

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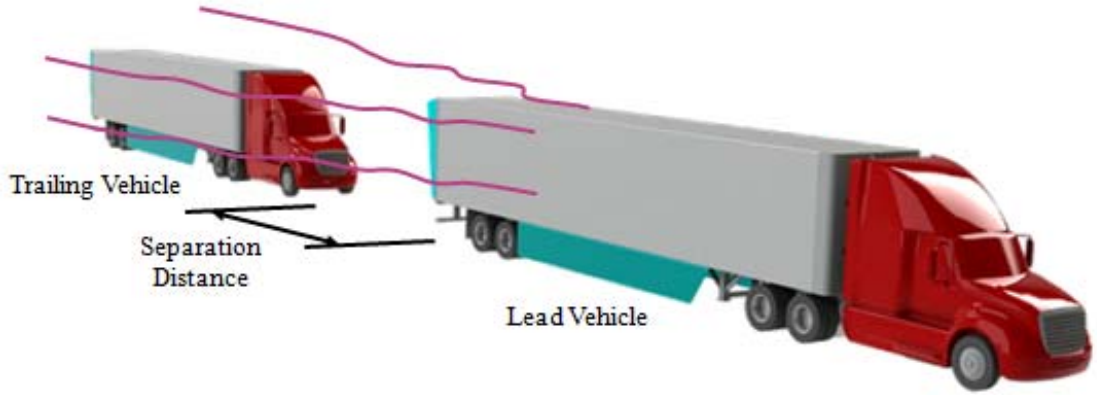
Test Procedures

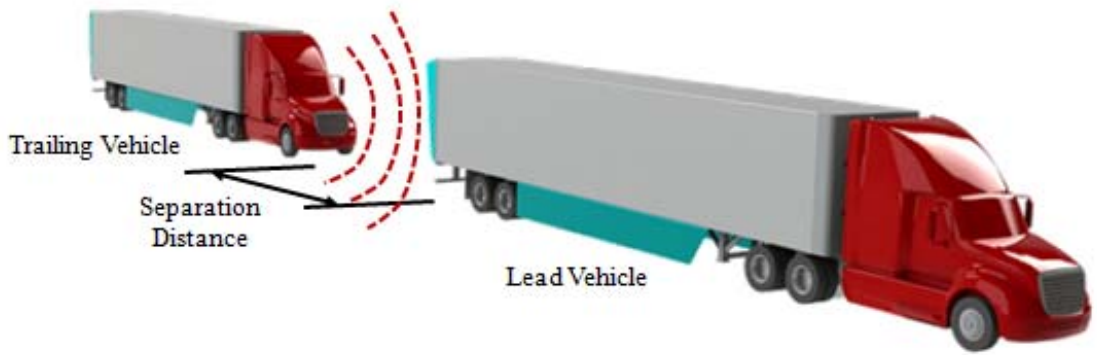
- Synchronized operation of 3 trucks using CACC
- A control truck at the same speed followed 2 miles behind (as baseline for variations in ambient conditions)
- Single truck constant speed reference runs, 4 trucks drove 1 mile apart
- Weighed auxiliary fuel tanks of all trucks after each run (64 miles)
- Each condition repeated at least 3 times to produce average fuel consumption estimates

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)*



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

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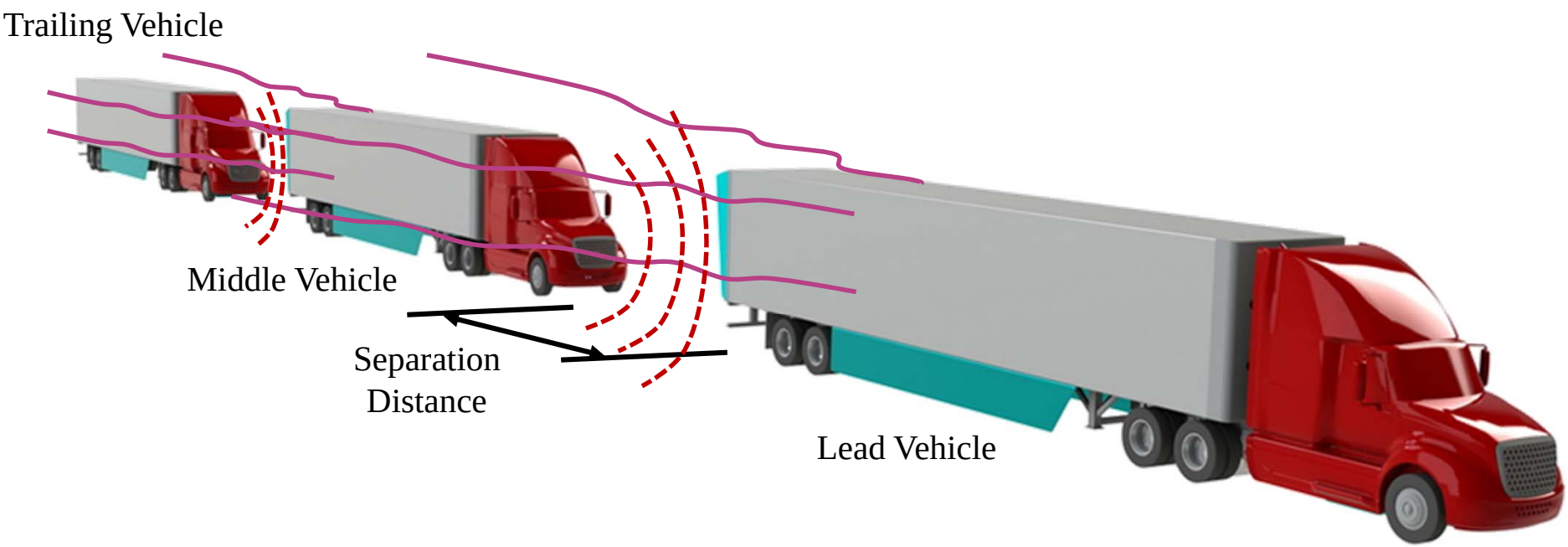
Aerodynamics of Cooperative Truck Platooning

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

Magnitude of each effect is dependent on separation distance!
…what happens for a 3-vehicle platoon?



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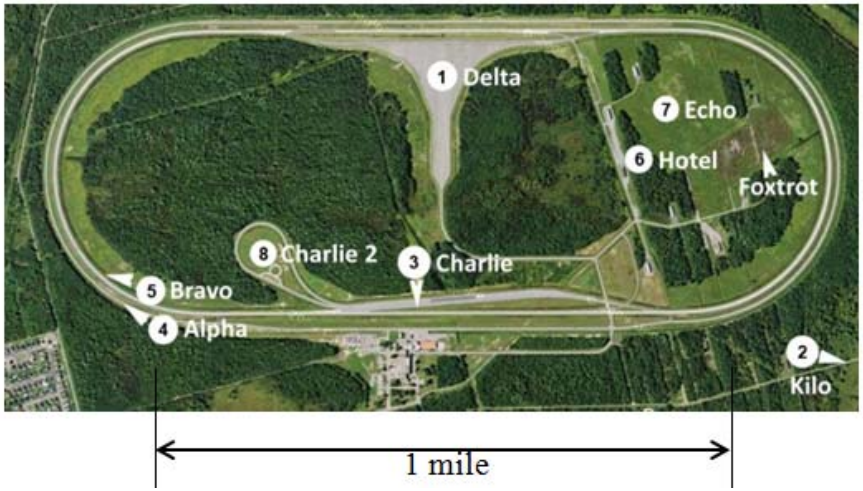
Test Track, Trailer Modification, Fuel Tank Removal/Mounting, and Weighing



CACC 0.6s Gap @ 65 mph

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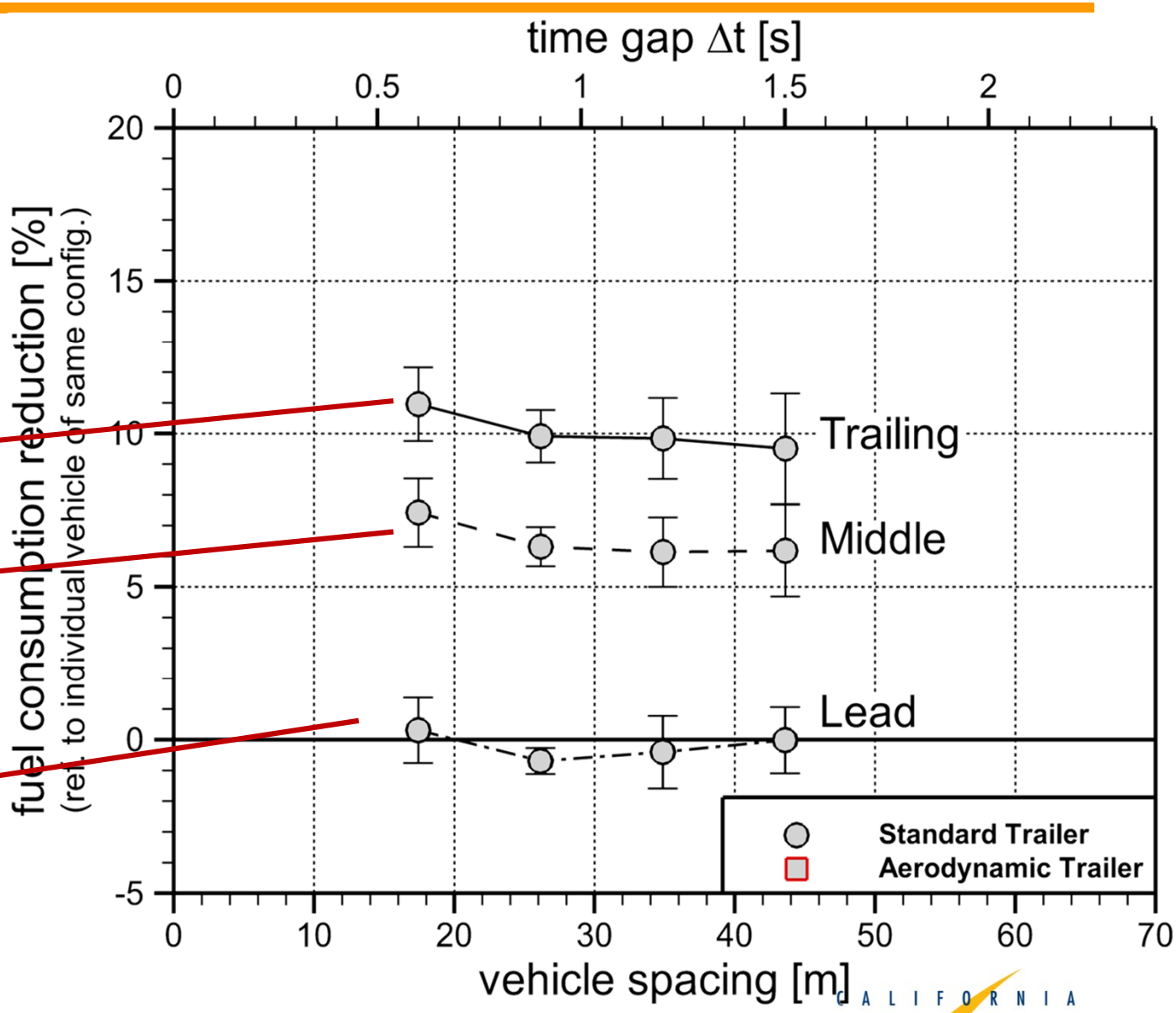
Test Results - NRC Canada Fuel Saving Estimates (65 mph + 65,000 lbs)

Fuel Savings for Individual Trucks
(ref. standard truck)

3rd truck

2nd truck

lead truck



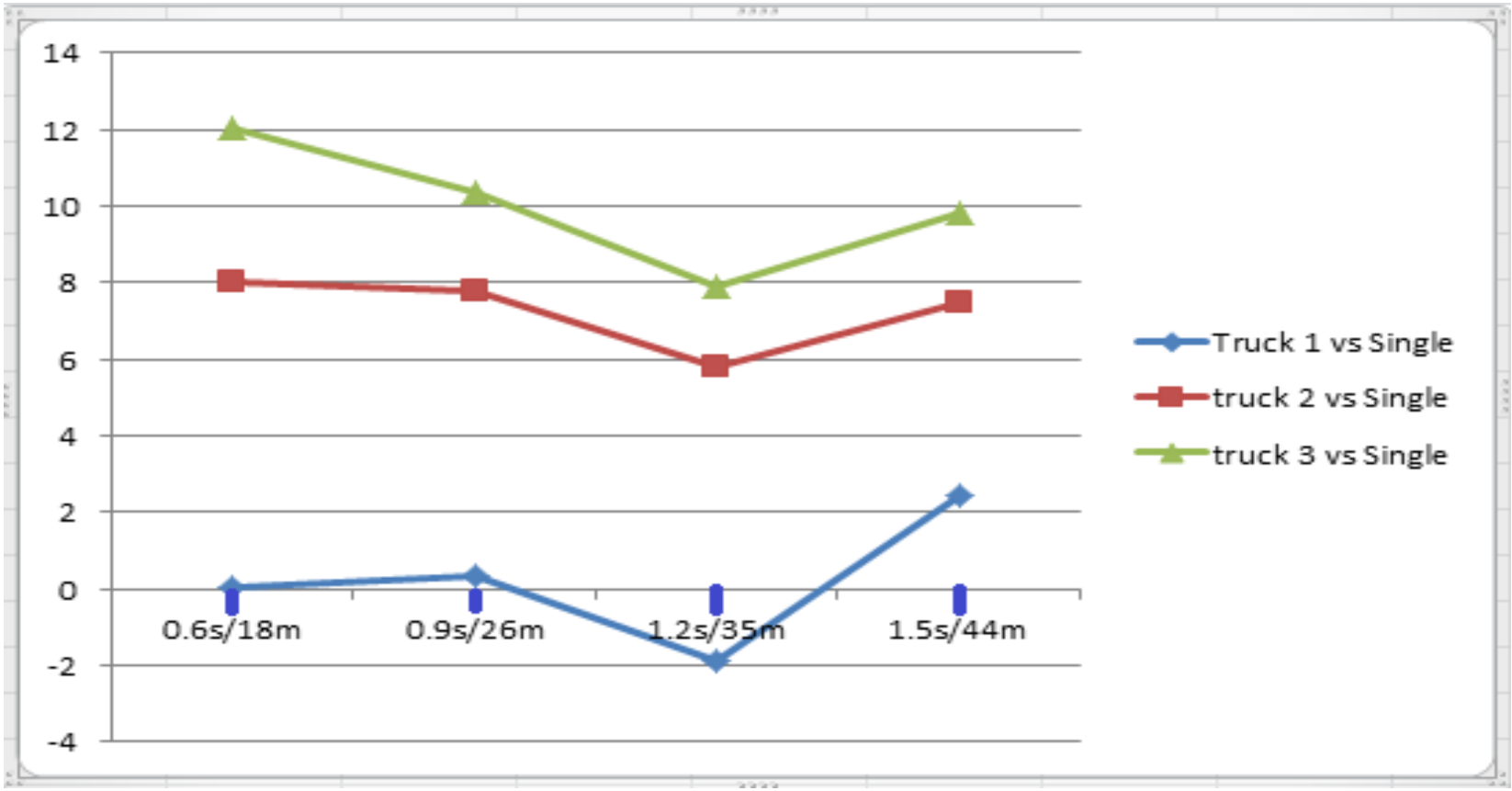
Alternate Analysis – without Weighing Tanks

- **Data used:**
  - **Trailers with side skirts and rear end flaps**
  - **Only in reasonably good weather conditions**
- **Based on vehicle measurement**
  - **Cumulative distance from J-1939 Bus speed**
  - **Cumulative fuel consumption of fuel rate from J-1939 Bus**
  - **Average Fuel Rate:**

$$\text{Ave Fuel Rate} = \frac{\text{Cumulative fuel Consumption}}{\text{Cumulative Distance}}$$

Alternate Analysis (65 mph + 65,000 lbs)

- **What's happening at 1.2s might be due to weather (e.g. windy), which we will work on further.**



Following Distance [m] or Time Gap [s]

Conclusions

- Collaboration among multiple project partners conserved resources, close cooperation promoted mutual learning
- Truck CACC showed significant energy savings for followers, but not for leader, for selected range of gaps
- Consistent with findings from other research projects
- Test drivers were professionals and enthusiastic about use of the system
- Additional experiments needed for other conditions to show wider range of trends including shorter distance