Truck CACC Fuel Economy Testing: Initial Test Track Results

Xiao-Yun Lu and Steven E. Shladover, PATH, U. C. Berkeley
Brian McAuliffe, National Research Council of Canada
Barry Pekilis, Transport Canada
Stefan Bergquist and Aravind Kailas
Matt Hanson, Caltrans
Osman Altan, FHWA

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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
CACC System Design – Structure

- Dual DSRC Antennas
- Video camera (production)
- 5 Hz GPS
- ACC radar (Production)
- Supplementary display
- PC-104 computer
- Emergency disengage button by driver
CACC Control System

PATH PC-104 QNX RTOS

Volvo XPC: sensor data processing

Dual Antenna

DSRC radio

Ethernet

Fused sensor data

J-Bus interface

J-Bus

Engine/brake control commands

Tablet DVI

Video recording computer
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
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)
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?*
Test Track, Trailer Modification, Fuel Tank Removal/Mounting, and Weighing
CACC 0.6s Gap @ 65 mph
Test Results - NRC Canada Fuel Saving Estimates (65 mph + 65,000 lbs)

Fuel Savings for Individual Trucks (ref. standard truck)

- Lead truck
- 2nd truck
- 3rd 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.
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