Truck CACC System Development and Testing

under FHWA Exploratory Advanced Research Project: Partial Automation for Truck Platooning (PATP)

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Project Team

- FHWA - EARP
- Caltrans DRISI
- U.C. Berkeley PATH Program
- L.A. MTA (L.A. Metro)
- Gateway Cities COG
- Peloton Technology
- Volvo Technology Americas (VTA)
- Cambridge Systematics, Inc. (CSI)
Project Goals

• Develop truck CACC system that can be deployed in near term, coexisting with other highway traffic
• Implement the CACC on three tractor-trailer trucks
• Test truck driver preferences among different CACC gap settings
• Measure energy savings when trucks are driven in the preferred gap setting range
• Estimate broader traffic and energy impacts in simulation
Recent Progress

- Preliminary analysis tasks completed
  - User needs survey (jointly with Auburn project)
  - Concept of operations, focused on driver interactions
  - Infrastructure support opportunities
  - Adding intelligence to trailers/chassis
- Three trucks delivered to PATH for modification
  - Adding computers, DSRC radios, secondary displays
- CACC use cases defined in detail to support definition of V2V messages and driver interfaces
  - Activity diagrams
- Two-truck platoon tested at low speeds
Overall Truck CACC System Structure

- Ethernet
- Video recording computer
- PC-104 QNX RTOS
- PATH
- Linux Laptop
- Volvo XPC: sensor data processing
- J-Bus
- Dual Antenna
- DSRC radio
- Wide angle Lidar
- Tablet DVI
- Engine/brake control commands
- Fused sensor data
- J-Bus interface
Hardware Installed on Trucks

- DSRC Antenna mounted on each side mirror
- 5 Hz GPS
- PATH Laptop for system development
- Emergency switch to cut-off link with J-Bus
- New PC-104 computer to run QNX real-time operating system
Control Logics for Different Scenarios

Transitions between Driving Modes

- Transition from CACC to manual
- Transition from Manual to CACC
- Transition from CACC to ACC
- Transition from ACC to CACC
- Transition from manual to ACC
- Transition from ACC to manual
CACC String Formation

Initial Conditions

Driver
- Manual Driving
- CACC Enabled
  - Opt: ACC On/Engaged
  - Opt: Adjust Gap
  - Opt: Set Speed
  - Opt: Pos. Preference

Follower
- Listening for Followers
- Listening for Leaders

Leader
- Driver Confirmation
  - Opt: Speed Adjustment

Time

Solo
- BSM
- CACC Solo MSG

V2V
- Listening for Leaders
- Listening for Followers

Coordination Messages

Ad Hoc Join
- Vehicle Status
- String Status
- Micropayments

Driver Actions

Local Coordination
- Vehicle / String Status
  - CACC String Leader Request
  - Follower Distance / ETA
  - Requested Speed

- CACC Coordination MSGs
  - Join Request
  - Suggested Speed

- List of Nearby Trucks/Strings
- Select Nearby String to Join

- Opt: Speed Adjustment
- Opt: Lane Change
- ACC On/Engaged

Joining Driver Actions

Coordination
- Instructions to Join with Leader Ahead
  - CACC Coordination MSGs
    - Join Request
    - Suggested Speed

- Vehicle Status
- String Status
- Micropayments

Join Request
- String Pos. 2
- String Length 2

Drivers
- Driver Confirmation
  - Opt: Speed Adjustment

Drivers
- Listening for Leaders
- Listening for Followers

Drivers
- Manual Driving
- CACC Enabled
  - Opt: ACC On/Engaged
  - Opt: Adjust Gap
  - Opt: Set Speed
  - Opt: Pos. Preference

Drivers
- BSM
- CACC Solo MSG

Drivers
- Listening for Leaders
- Listening for Followers

Drivers
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- Listening for Followers
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CACC Human Factors Experiments

• Volvo Truck Simulator
  – Testing HMI for joining/leaving a CACC string
    • Situational awareness during cut-ins
  – Performance at gap settings from 1.0 to 0.4 s
    • Lane keeping / workload / fatigue impact

• California On-the-Road Experiments
  – Conferring with CHP on test sites – freeways with moderate traffic density, at least 3 traffic lanes and mixture of flat and grades
  – Testing driver comfort at gaps from 1.0 to 0.6 or 0.4 s
  – Previous passenger car studies saw cut-ins at 0.6 s, mostly near entrance/exit ramps
  – Surveying drivers regarding gap preferences