Automated Road Transportation Symposium
Truck Automation Breakout Session
July 14, 2021
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OUTLINE

- Project background.
- Phase 2 overview.
- Truck platooning system.
- Safety considerations.
- Next steps.
PROJECT BACKGROUND
WHAT IS LEVEL 1 TRUCK PLATOONING?

- Employs longitudinal control only (throttle and brakes); driver steers the truck.
- Builds on production adaptive cruise control (ACC).
- Uses vehicle-to-vehicle communication to deploy cooperative adaptive cruise control (CACC).

Source: FHWA.
INTRODUCTION

- Truck Platooning Early Deployment Assessment builds on prior FHWA research in truck platooning.

- Goals and objectives of the project are as follows:
  - Understand truck platooning in real-world operations (i.e., real fleet operators carrying real loads).
  - Assess benefits and impacts across key areas of interest.
  - Inform future State/local departments of transportation (DOT) about planning process and decisionmaking.
PHASED APPROACH

A phased approach manages risks and uncertainties in dynamic environments.

■ Phase 1 (March 2019–December 2019)—completed:
  — Awardees developed the concept, partnerships, and evaluation plan.
  — Awardees completed the proposal for phase 2.
  — Independent evaluation team supported performance measures and evaluation planning.

■ Phase 2 (July 2020–January 2023)—in progress:
  — Awardee will finalize the plans and make sure the truck platooning systems are ready for deployment testing.
  — Awardee will conduct a field operational test (FOT).
  — Independent evaluator will conduct an evaluation.
PHASE 2 OVERVIEW
PROJECT TEAM

- **Project team:**
  - California Partners for Advanced Transportation Technology (PATH) (team lead and technology supplier).
  - Roly’s Trucking (fleet operator).
  - Westat® (human factors).
  - Cambridge Systematics (partnership).

- **Other partners:**
  - Caltrans Division of Research, Innovation and System Information, providing match funding, and California Highway Patrol.
  - Volvo Group North America.
  - Bendix®.
  - DOTs and law enforcement agencies in Arizona, New Mexico, and Texas along the I–10 corridor.
  - California Trucking Association.

- **Noblis® (independent evaluator).**
The FOT will take place on a 1,400-mi route of I–10 from California to Texas.

The proposed route goes through California, Arizona, New Mexico, and Texas.

The FOT will utilize 4 trucks and 20 drivers.

The plan is to complete one round trip per week for 1 yr, resulting in data for 145,000 mi driven.
DATA TO BE COLLECTED

- Engineering data using onboard sensors: J1939 bus and Dedicated Short Range Communications (DSRC).
- Surrounding traffic data using extra sensors: fixed-beam light detection and ranging (LiDAR) and video cameras.
- Truck driver data using two dedicated sensors: one collecting electroencephalogram (EEG) readings and the other recording videos.
- Wireless modem connection with trucks for monitoring: CACC system operation and data loggers for health.
### PERFORMANCE MEASURES

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An independent evaluation team worked with USDOT to develop performance measure requirements in eight key areas to:

- Propose specific requirements to be addressed in phase 2.
- Determine measures and supporting data.

PHASE 2 MILESTONES

- Implementation stage (July 2020–November 2021):
  - Test and evaluation plan.
  - Partnership plan.
  - Human-use approval plan.
  - Comprehensive truck platooning deployment plan.
  - System acceptance testing.
  - Operational readiness testing with a go/no-go decision.

- FOT stage (November 2021–January 2023):
  - Conduct an FOT.
  - Collect and evaluate data.
  - Produce a final report.
TRUCK PLATOONING SYSTEM
OVERALL SYSTEM

- Built on the integrated ACC/CACC capability from California PATH for longitudinal control only.
- Used four new trucks:
  - Three trucks for the CACC/platooning field test.
  - Fourth truck used as a baseline control truck.
- Employed typical and additional components.

GPS = Global Positioning System; DVI = drive vehicle interface; SSD = solid state drive.

Source: FHWA.
DVI AND GAPS

DVI Design

Time Gaps for ACC and CACC Modes

<table>
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Source: FHWA.
ACTIVATION AND TRANSITIONS

Three Convenient Ways to Activate and Deactivate ACC/CACC

Use ACC stalk.

Touch the brake pedal.

Press down emergency switch.

Smooth Transitions Between Driving Modes: Manual, ACC, and CACC

Source: FHWA.
DRIVER MONITORING SYSTEM

Two different sensors will be used to monitor driver status:

■ EEG-based sensor:
  — Measures driver fatigue.
  — Collects EEG readings, the gold standard for fatigue monitoring and warning.
  — Uses a headband-type sensor.

■ Video-based sensor:
  — Measures driver attentiveness.
  — Collects two video files.
  — Uses two cameras inside the cabin: one to capture the driver’s face and one to capture the road ahead.
SAFETY CONSIDERATIONS
BASIC RULES

- Take a progressive and defensive driving approach.
- Input target distance, speed, and acceleration.
- Adopt an ACC progressive coupling range with respect to D-Gap, which is a desired gap determined based on a driver’s preference and current vehicle status.

Source: FHWA.
BASIC RULES (CONTINUED)

■ Active handling of cut-in and cut-out maneuvers:
  — Relative speed/distance/acceleration.
  — Duration of stay between vehicles.
  — GPS used to deal with multiple cut-ins.

■ Preliminary fault detection and handling:
  — Communication.
  — Radar and video camera.
  — Fixed-beam lidar as back up.
  — Engine torque/brake and service brake.
COORDINATED BRAKING

■ Driver-activated:
  ― Applies the service brake manually in the lead or second truck.
  ― Activates both service brakes for all trucks automatically.
  ― Uses closed-loop automatic control to regulate the distance gap during the braking process for trucks 2 and 3.

Tested on November 23, 2019:
  ■ Loaded three trucks with approximately 21,000–22,000 kg of weight.
  ■ Measured response of trucks 2 and 3 based on DSRC information and sensor data.
COORDINATED BRAKING (CONTINUED)

Automatic:

- Truck 1 service braking occurs at 1.0, 1.5, 2.0, 2.5, 3.0, and 3.5 m/s$^2$.
- Truck 1 applies the service brake command as described in the first bullet point plus full engine retarder.
- DSRC provides service brake switch signal, vehicle actual deceleration, and engine retarder command information.
- Trucks 2 and 3 apply the maximum deceleration plus maximum engine retarder commands of the lead truck(s).
COLLISION MITIGATION

The collision mitigation system (CMS) includes the following:

- Warnings, including frontal/side collision and lane departure.
- Automatic braking system.
- Emergency braking: the CMS to run in the background with the highest priority.
OPERATIONAL DESIGN DOMAIN AND MORE

- Operating in a speed range of approximately 35–65 mph.
- Using CACC only if drivers feel comfortable.
- Limiting usage to freeways, but not on/off ramps and work zones.
- Restricting usage under certain weather and road-surface conditions (e.g., avoiding slippery roads, heavy snow).
- Driving manually for lane changing.
- Arranging the heavier vehicle in the front in a platoon.
- Employing a platooning indicator when in platoon operation.
- Operating manually on long downgrades.
- Providing training and practice before CACC operation.
- Furnishing a convenient driver manual.
- Determining (and training truck drivers for) abnormal situations in which the driver should take over manual control.
NEXT STEPS

- **System development:**
  - CACC system development and tuning to continue.
  - Data collection and remote monitoring system development.
  - Data management system development.

- **Testing:**
  - System acceptance test.
  - Driver acceptance test.
  - Operational readiness test.

- **Decision on go/no-go.**

- **Field operation tests (November 2021–January 2023):**
  - FOT.
  - Data collection and evaluation.
  - Final report.
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Source: FHWA.