All photos source: FHWA.

OFFICE OF RESEARCH, DEVELOPMENT, AND TECHNOLOGY

USDOT TRUCK PLATOONING EARLY DEPLOYMENT ASSESSMENT - CURRENT STATUS

Automated Road Transportation Symposium
Truck Automation Breakout Session

July 14, 2021

Hyungjun Park, Ph.D.
Office of Operations Research and Development

Xiao-Yun Lu, Ph.D.
California PATH
University of California Berkeley

U.S. Department of Transportation
Federal Highway Administration

TURNER-FAIRBANK
Highway Research Center

DISCLAIMER

This presentation was created and is being copresented by a contractor. The views and opinions expressed in this presentation are the presenter's and do not necessarily reflect those of the Federal Highway Administration (FHWA) or the U.S. Department of Transportation (USDOT). The contents do not necessarily reflect the official policy of the USDOT.

The U.S. Government does not endorse products or manufacturers. Trademarks or manufacturers' names appear in this presentation only because they are considered essential to the objective of the presentation. They are included for informational purposes only and are not intended to reflect a preference, approval, or endorsement of any one product or entity.

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.

Source: FHWA.

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.

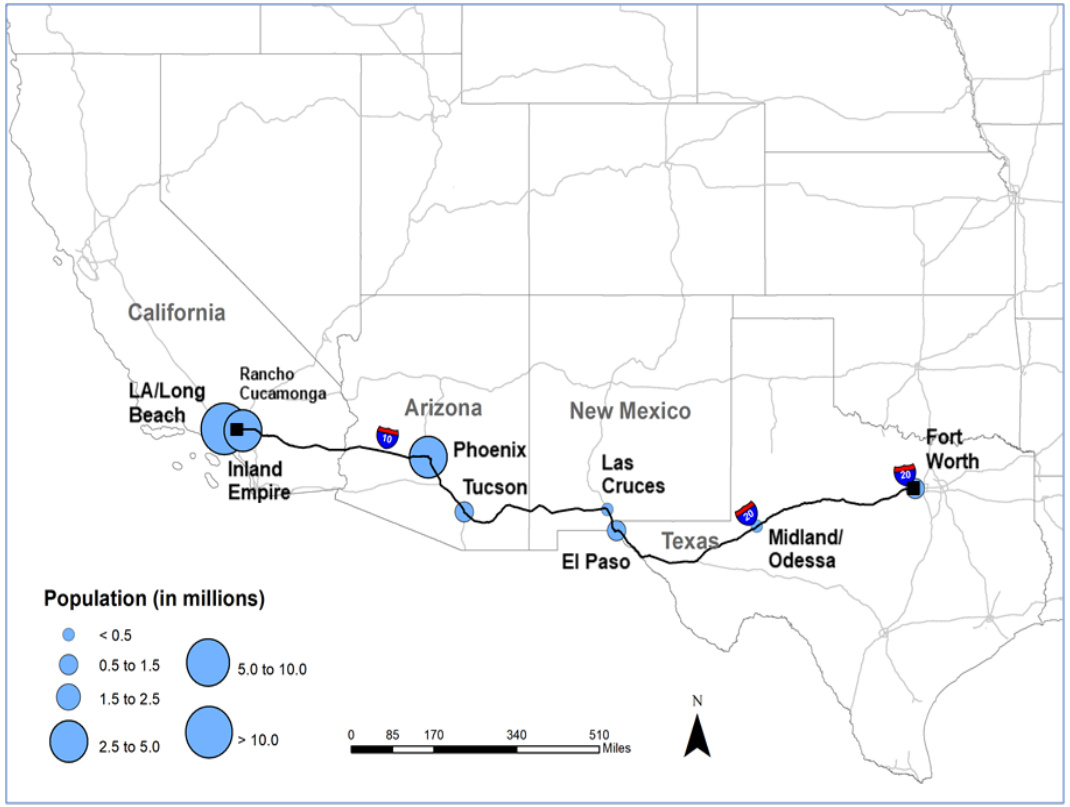
PHASE 2 OVERVIEW

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).

PROPOSED ROUTE AND EXPERIMENTAL DESIGN

- 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.



Source: FHWA.

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

No.	Code	Performance Measure Category	No. of Requirements
1	OP	Platoon operational characteristics	4
2	S	Safety	12
3	M	Mobility	3
4	EE	Energy and emissions	2
5	FLT	Fleet operator and driver impacts	7
6	II	Infrastructure impacts	3
7	SL	State and local government impacts	2
8	VED	Vehicle equipment design implications	3

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.

Asare, S., J. Chang, and B. Staples. 2019. *Truck Platooning Early Deployment—Independent Evaluation: Requirements for Performance Measures*. Report No. FHWA-JPO-20-808. Washington, DC: FHWA.

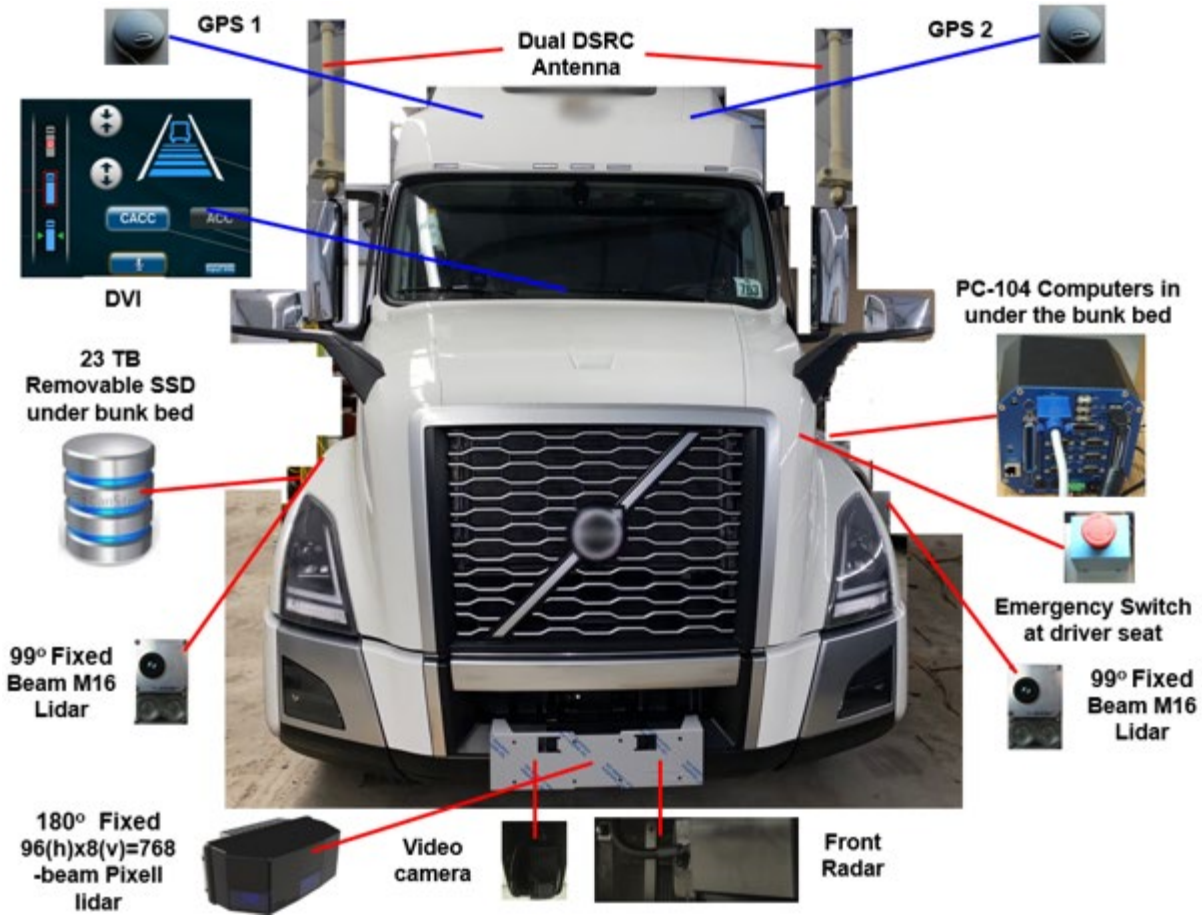
PHASE 2 MILESTONES

- 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.

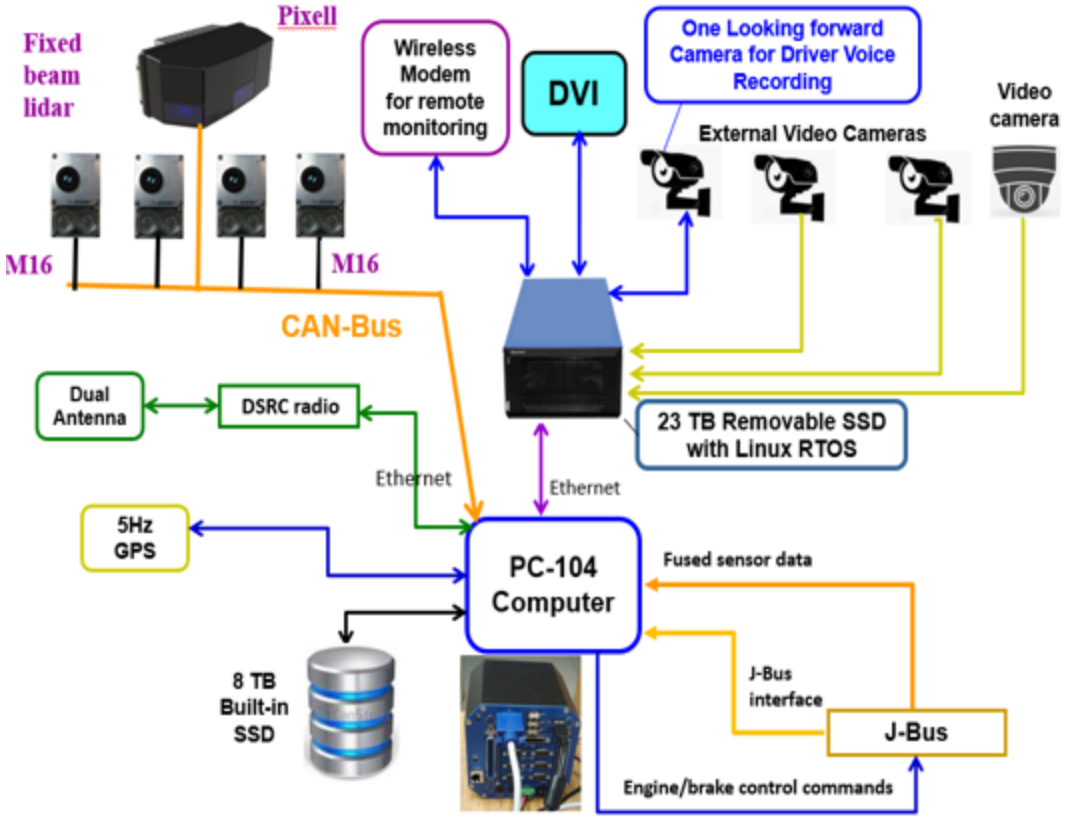


GPS = Global Positioning System; DVI = drive vehicle interface; SSD = solid state drive.

Source: FHWA.

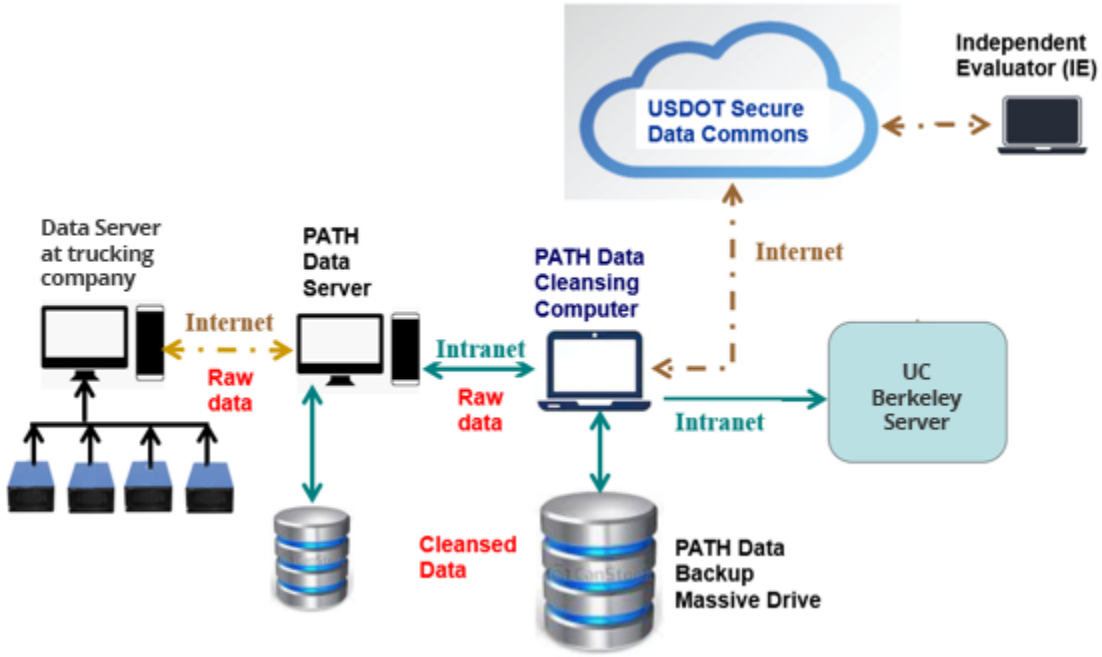
DATA SYSTEMS

Control and Data Collection Systems



Source: FHWA.

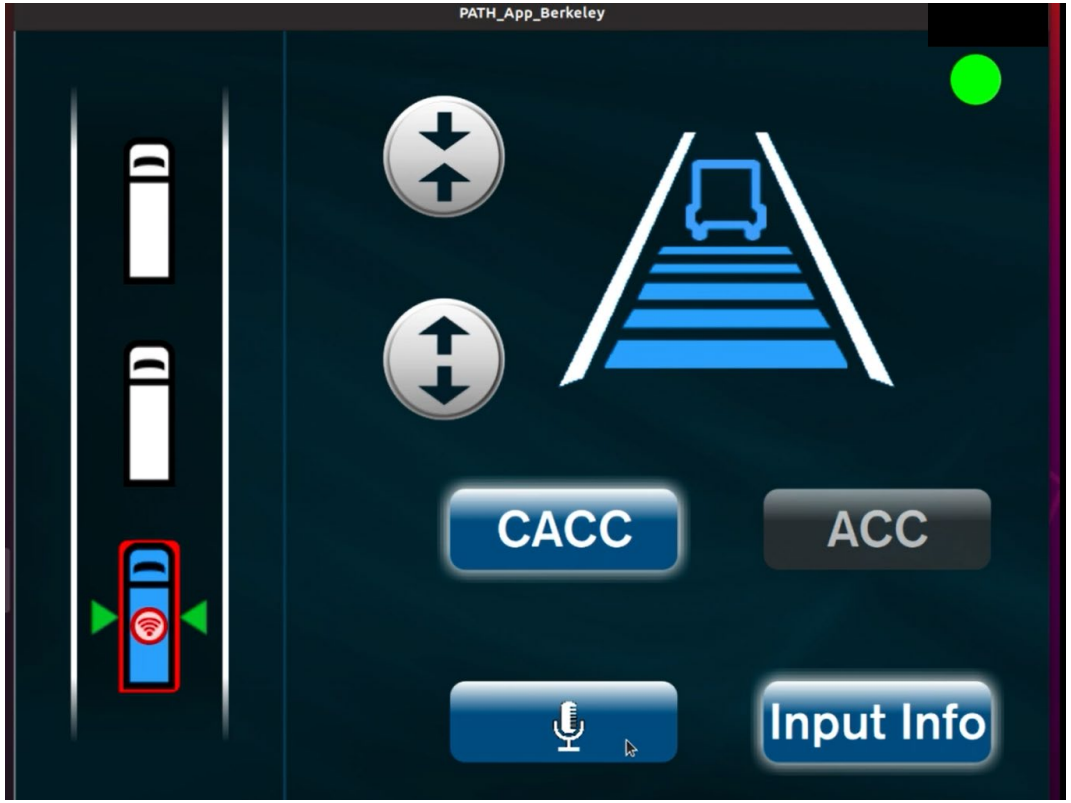
Data Management and Sharing Systems



Source: FHWA.

DVI AND GAPS

DVI Design



Source: FHWA.

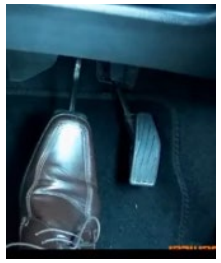
Time Gaps for ACC and CACC Modes

ACC Level	ACC Time Gap [s]		CACC Level	CACC Time Gap [s]
1	1.1		1	0.6
2	1.3		2	0.9
3	1.5		3	1.2
4	1.7		4	1.5
5	1.9		5	1.8

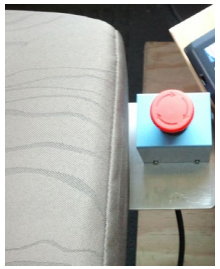
ACTIVATION AND TRANSITIONS

Three Convenient Ways to Activate and Deactivate ACC/CACC

Use ACC stalk.



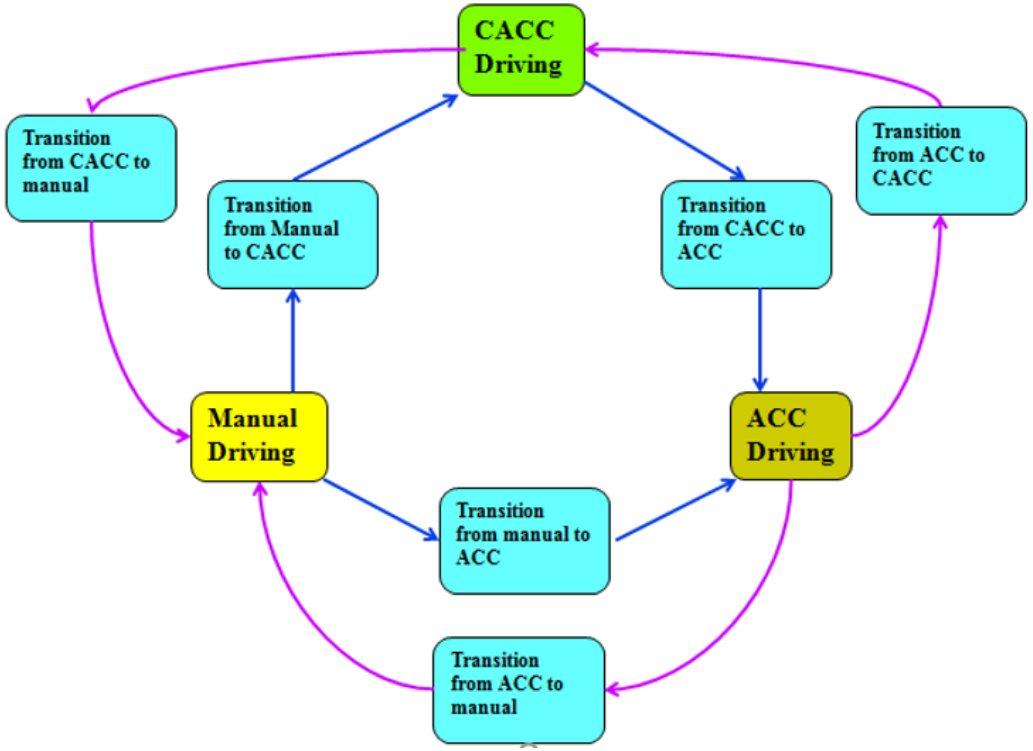
Touch the brake pedal.



Press down emergency switch.

Source: FHWA.

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



Source: FHWA.

DRIVER MONITORING SYSTEM

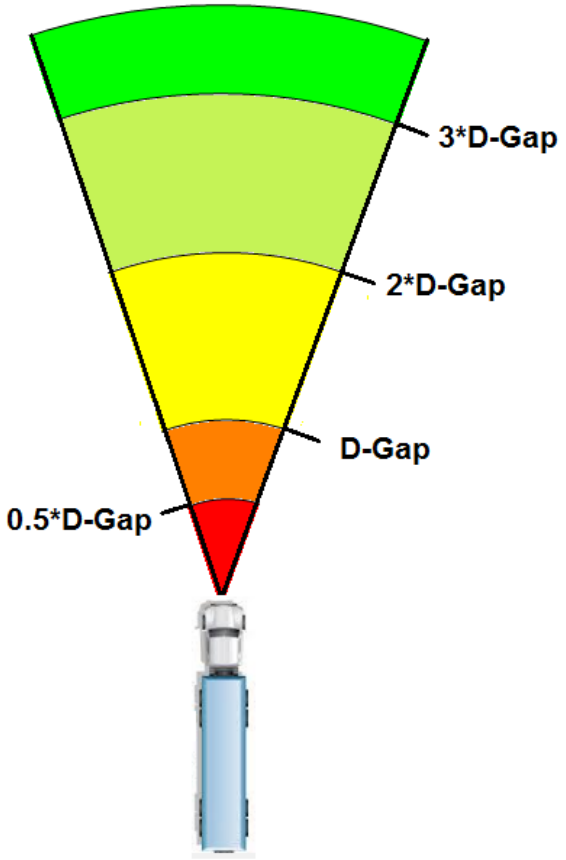
Two different sensors will be used to monitor driver status:

- 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.

CONTACTS

Hyungjun Park, Ph.D.

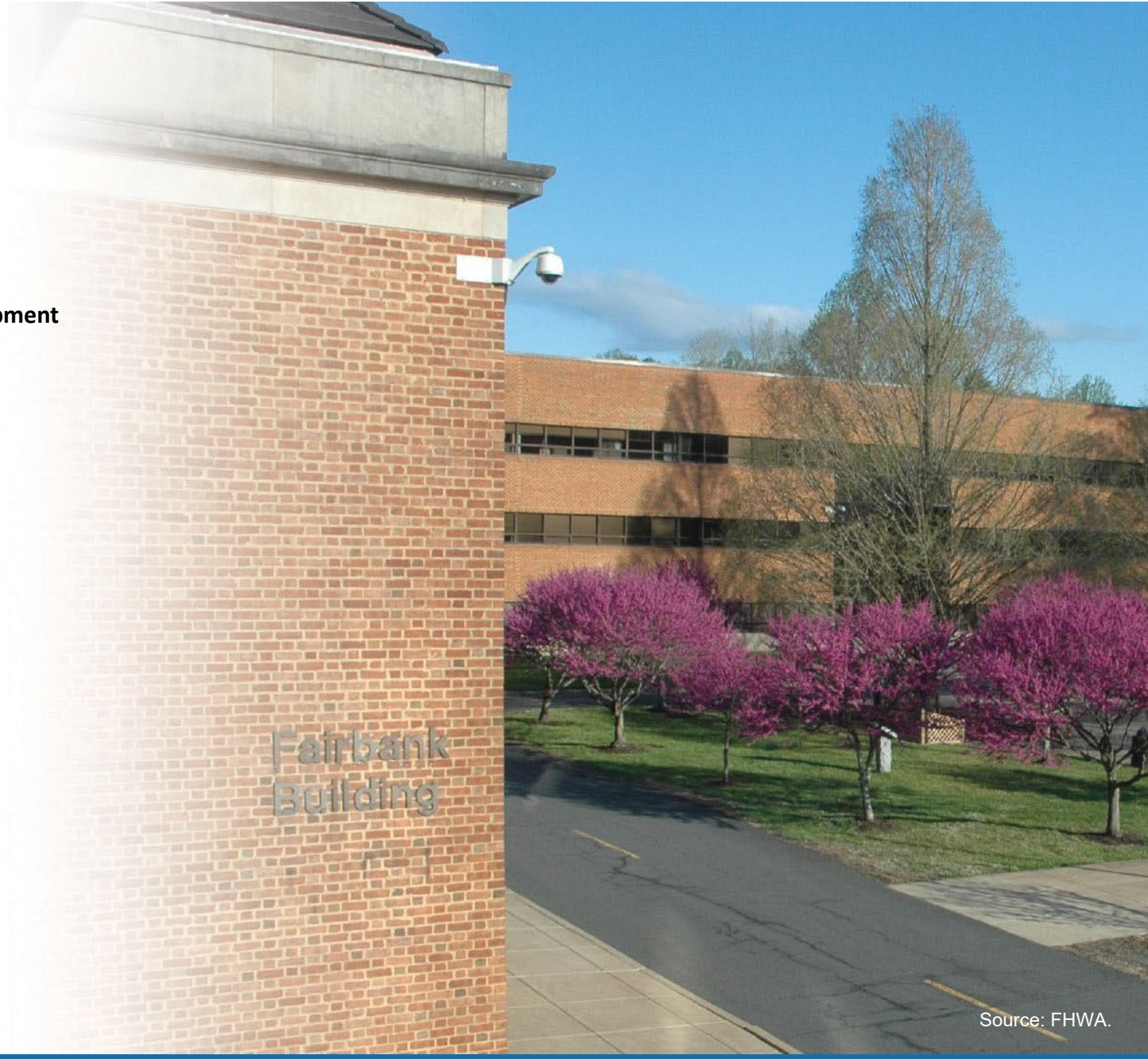
Highway Research Engineer, Office of Operations Research and Development

Hyungjun.Park@dot.gov

Gene McHale, Ph.D., P.E.

Team Leader, Office of Operations Research and Development

Gene.McHale@dot.gov



Source: FHWA.