



# **Truck Platooning Pilot Deployment on the I-10 Corridor**

**FHWA Truck Platooning Early Deployment Assessment Phase 2**

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**UC Berkeley PATH  
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# Outline

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- **Project Overview**
- **Experimental Design**
- **Safety Considerations**
- **Q & A**



## Project Overview - Goals

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- **For better understanding the impacts of truck platooning on driver behavior, safety, energy consumption, other traffic and public policy**
- **For better understanding Cooperative Adaptive Cruise Control (CACC) or platooning practical performance**
- **Accelerating the deployment of CAV technologies for freight through in-service freight hauling**
- **Assessing the feasibility and efficiency of integrating truck platooning into fleet operations**



# Project Overview - Team and Partners

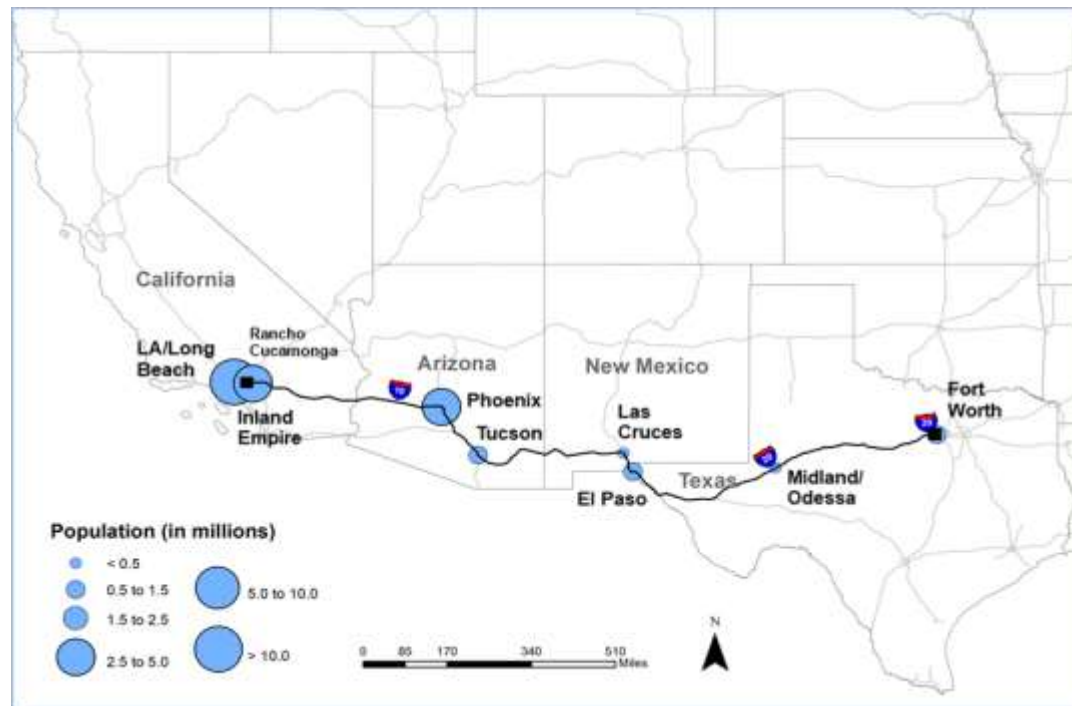
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- **Roly's Trucking Inc.**
- **Westat**
- **Cambridge Systematics**
- **Caltrans DRISI and CHP**
- **Volvo Group North America & HQ**
- **Bendix**
- **Other I-10 Corridor (Arizona, New Mexico, Texas) DOTs and Law Enforcement Agencies**
- **California Trucking Association**



# Project Overview - Test Route

- Rancho Cucamonga, CA to Fort Worth, TX – 1400 miles
- Mostly rural (I-10, I-20), with a few urban metro areas (Inland Empire, CA, Phoenix, Tucson, El Paso)
- States: California, Arizona, New Mexico, Texas (3 border crossings each way)
- Mostly flat, with a few mountain passes to cross





## Project Overview – Main Tasks

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- **Implement refined CACC capability (Level 1 automation) on 4 new Volvo trucks; 3-truck platooning and one as the reference**
- **Perform rigorous testing of system performance and capability on test tracks and real roads**
- **Train truck drivers and conduct driver acceptance test**
- **Recruit and train 4 cohorts of truck drivers from fleet partner Roly's Trucking**
- **Test for operational readiness prior to field test on I-10**
- **Conduct a 12-month formal field operational test of truck platooning on a multi-state corridor**

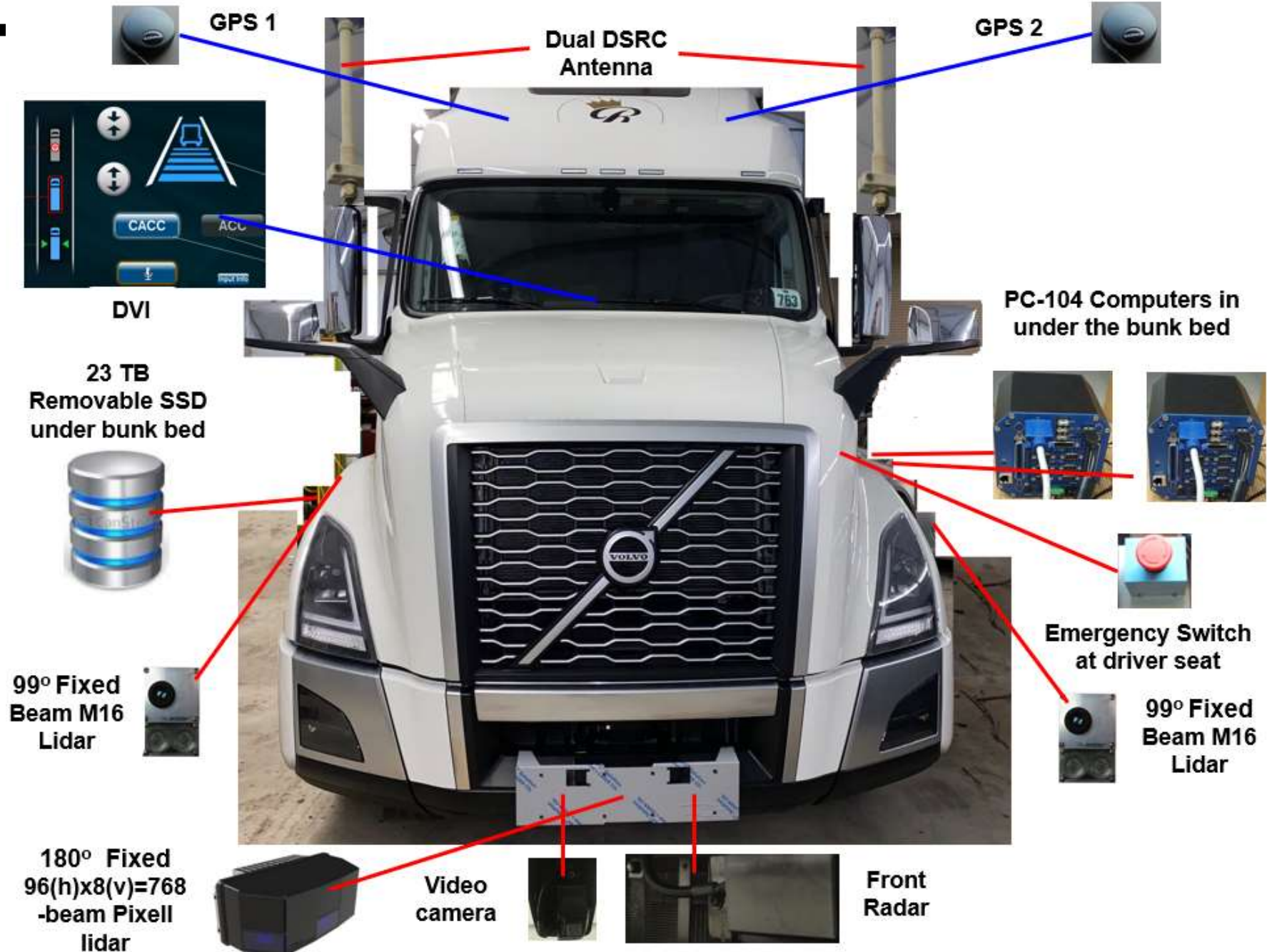


# Project Overview - Critical Milestones

- **Project planning: Jul 2020 ~ Dec 2020**
  - **System design and preparation**
  - **Stakeholder outreach**
  - **Test and evaluation planning**
  - **Human use approval**
- **New truck acquisition: Dec 2020 ~ Jan 2021**
- **CACC/platoon implementation: Jan ~ Jun 2021**
- **Driver acceptance tests in CA: Aug ~ Sep 2021**
- **Operational readiness test in all 4 states: Oct ~ Nov 2021**
- **Field tests and data sharing: Nov 2021 ~ Oct 2022**
- **Project final report: Dec 2022 ~ Jan 2023**



# Project Overview – The CACC System







# Experimental Design

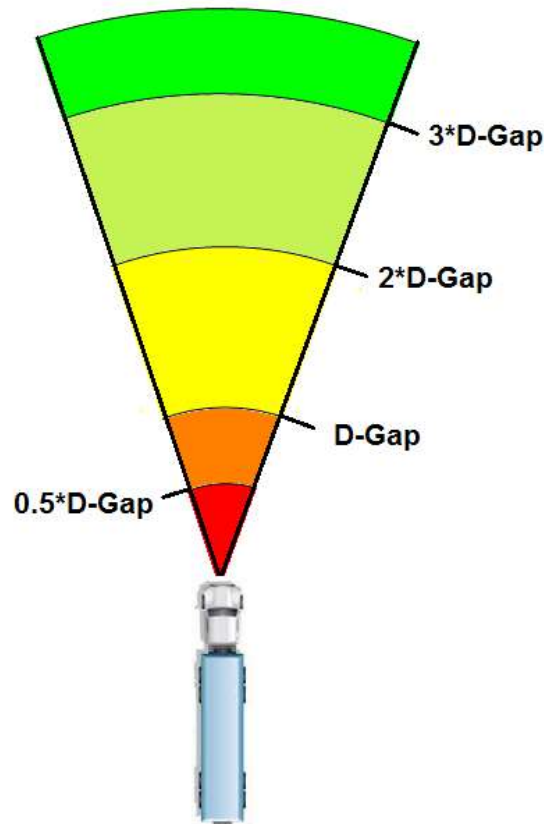
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- **12 months to cover a full range of weather conditions**
- **Focusing on a fixed-route interstate highway with good road geometry/conditions (including grade and flat);**
- **Route with urban and rural traffic**
- **Varieties of positions in platoon, loads, time gaps, driver selections on time gaps and driving modes**
- **Both daytime and night-time driving, to understand driver time-gap preferences**
- **Obtaining objective driver drowsiness (fatigue) and attentiveness to their driving related tasks**
- **Incorporating structured questionnaire-based interviews with drivers and dispatchers**



# Safety Considerations - CC & ACC Control Logics

- Progressive and defensive driving approach
- Input: target distance, speed, acceleration
- ACC progressive coupling range with respect to D-Gap





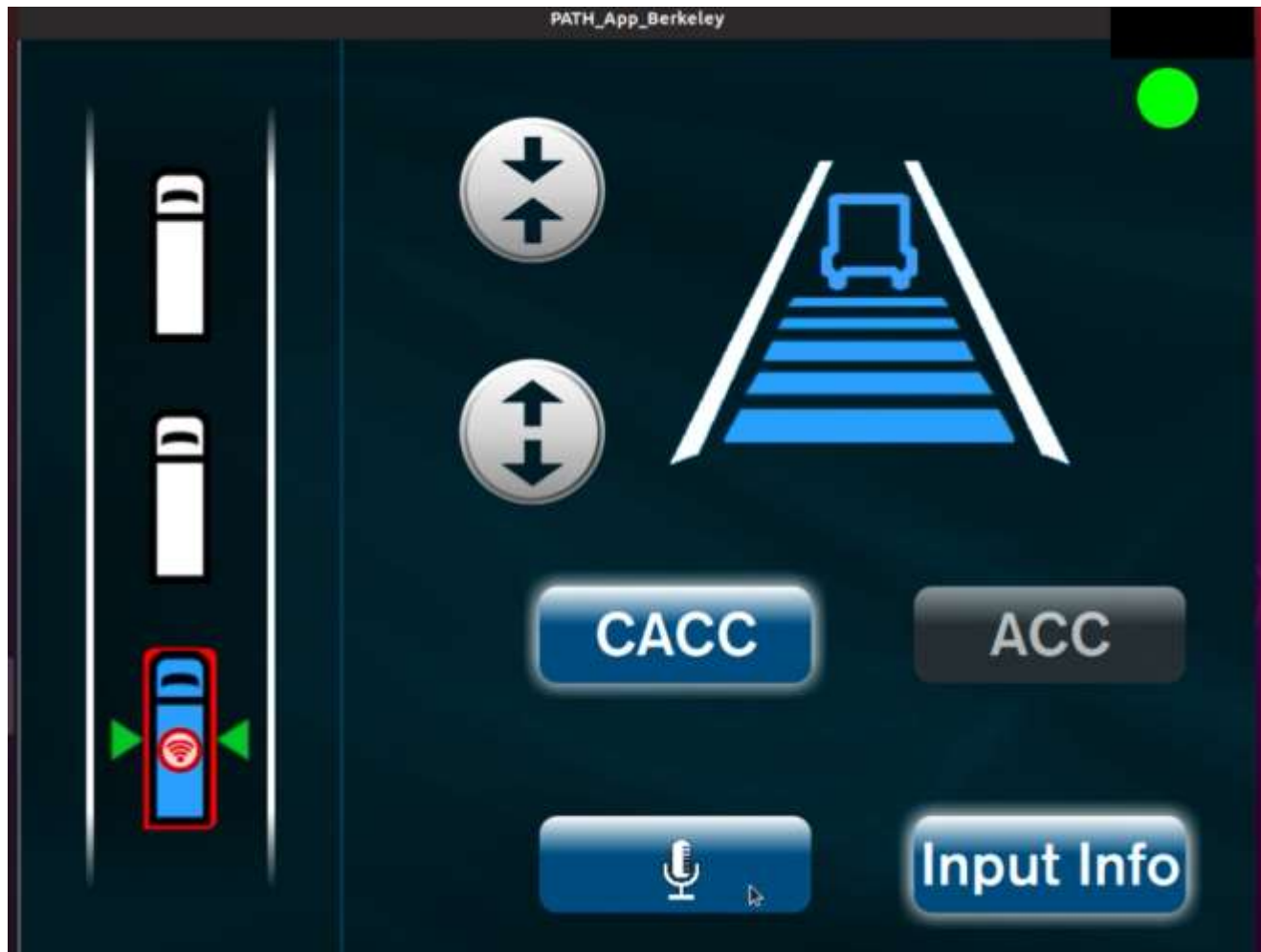
# Safety Considerations

- **Active handling cut-in and cutout maneuvers:**
  - **Relative speed/distance/acceleration**
  - **Duration of stay in between**
  - **GPS used for deal with multiple cut-ins**
- **Preliminary Fault Detection and Handling**
  - **Communication**
  - **Radar + Video camera (from X-PC); Fixed beam lidar as back up**
  - **Engine torque**
  - **Engine brake**
  - **Service brake**



# Safety Considerations – DVI: Simple & Info Rich

- **DVI Design: Simple but information rich to reduce driver distraction**





# Safety Considerations – Driver T-Gap Selection

| 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               |



# Safety Considerations – Activation & Transision

- 3 convenient ways to activate and deactivate ACC/CACC



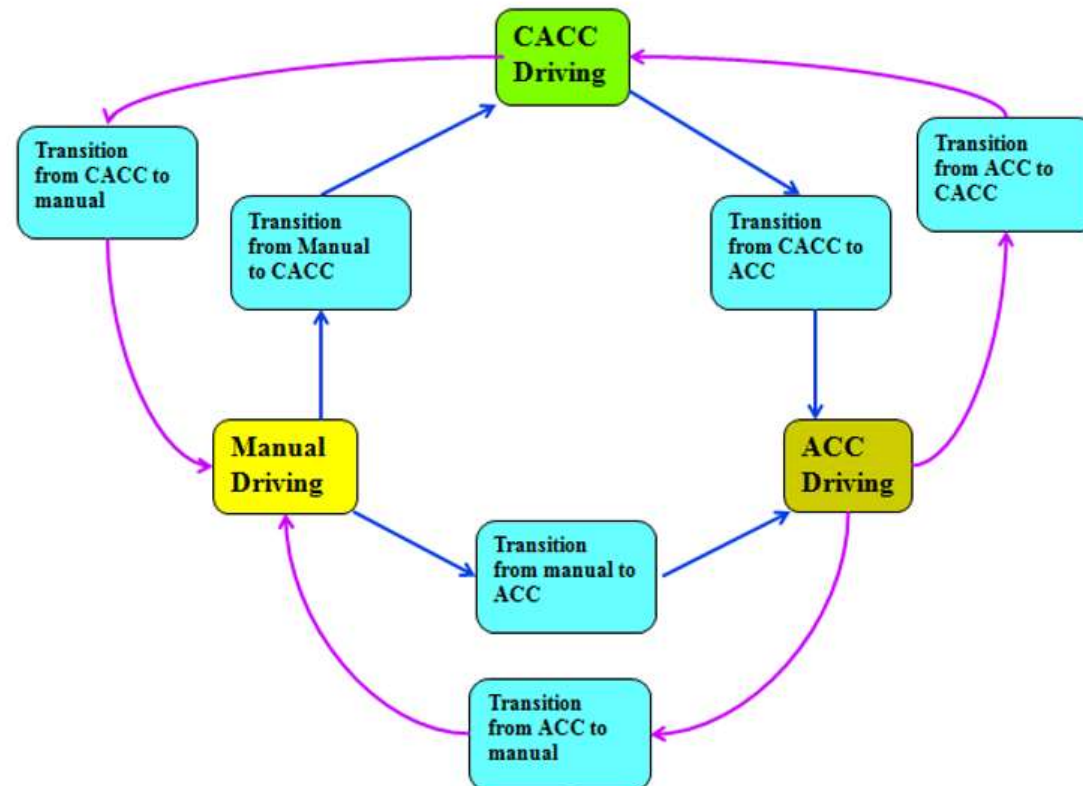
Use  
**ACC  
stalk**

**Touching  
the brake  
pedal**



**Press down  
emergency  
switch**

Smooth transitions between driving modes: manual, ACC and CACC





# Safety Considerations – Driver Monitoring

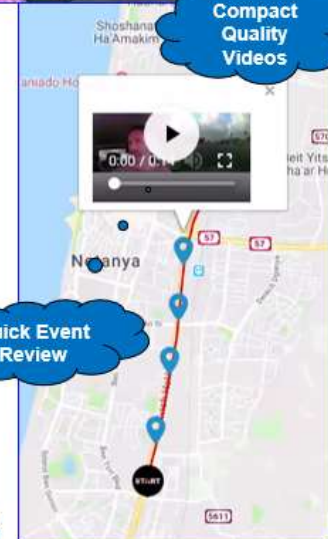
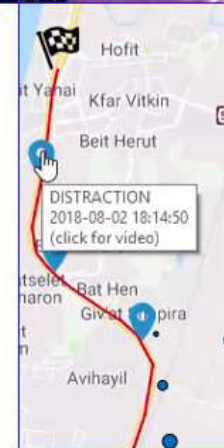
- SmartCap EEG – Gold standard for fatigue



LifeBand and App

|    |   |   |
|----|---|---|
| 2  | <b>TYPICAL LEVEL OF ALERTNESS</b>                   | No immediate action required  |
| 3  | <b>ALERT WITH SOME EARLY INDICATORS</b>             | No immediate action required  |
| 3' | <b>TRANSITIONING PHASE FROM 3-4 (EARLY WARNING)</b> | Your risk of a microsleep is increasing, take action to help manage your fatigue. |
| 4  | <b>HEIGHTENED RISK OF MICROSLEEP</b>                | You are at heightened risk of microsleep and need to take IMMEDIATE action.       |

- JunGo: Driver attentiveness
- Provides monitoring and warning





# Safety Considerations – Driver Activated Coordinated Braking

- **Driver Activated Coordinated Braking**
  - **Driver of the lead or the second truck manually applies service brake**
  - **Using both service brake for all trucks automatically**
  - **Truck 2 & 3 using closed-loop automatic control to regulate the distance gap during the braking process**
  - **Quantitatively tested on Nov. 23 2019**
    - **Loaded 3 trucks with weight *21,000~22,000 kg***
    - **Truck 2 & 3 respond based on DSRC information and sensor data**





# Safety Considerations – Automatic Coordinated Braking

- **Coordinated braking (automatically):**
  - **Service braking on truck 1 at: 1.0, 1.5, 2.0, 2.5, 3.0, and 3.5 [m/S<sup>2</sup>]**
  - **Apply above service brake command + full engine retarder to truck 1**
  - **DSRC Info: Service brake switch signal, vehicle actual deceleration, engine retarder command**
  - **Truck 2 & 3 apply the maximum deceleration + maximum engine retarder commands of front truck(s)**



# Safety Considerations – Bendix Collision Mitigation System (CMS)

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- **Warnings:**
  - **Frontal/side collision**
  - **Lane departure**
- **ABS**
- **Emergency braking: Bendix CMS to run in the background with the highest priority**



# Safety Considerations – Clear Operation Domain

- **Avoid operation in questionable conditions**
  - **Setting operation speed range: e. g. 35~65 mph**
  - **Switching to CACC only if the driver feel comfortable**
  - **Limited to freeways, not for on-ramps or off-ramps**
  - **Limited to weather & road surface conditions: e. g. avoid slippery road, heavy snow & dust**
  - **Manual driving for lane changing**
  - **Arranging heavier vehicle in the front in a platoon**
  - **Platooning Indicator Light when in operation**
  - **Driver behavior video data recording**
  - **Remote monitoring if driver wears SmarCap (EEG)**



# Safety Considerations

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- **Manual operation for long downgrade**
- **Well training and practice before CACC operation**
- **Providing convenient Driver Manual**
- **Determining (and train truck drivers for) abnormal situations in which driver should take over manual control**



Q & A

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# *Questions & Comments*