Background

- Funded under Federal Highway Administration (FHWA) Exploratory Advanced Research Program solicitation, Spring 2013
- Cooperative Adaptive Cruise Control (CACC) with V2V to achieve:
  - Shorter following distances
  - Enhanced string stability and safety
  - Increased traffic throughput, while reducing fuel use and emissions
- Adaptive Cruise Control (ACC) cannot achieve those objectives due to cumulative delays from downstream to upstream in the string

CACC versus Platooning

<table>
<thead>
<tr>
<th>CACC</th>
<th>Platooning</th>
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<tbody>
<tr>
<td>Constant time gap following strategy</td>
<td>Constant distance/clearance following strategy</td>
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<tr>
<td>Decentralized control with no special responsibilities for the string leader</td>
<td>Hierarchical control with special responsibilities for platoon leader</td>
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<tr>
<td>Ad hoc string membership</td>
<td>Coordinated platoon membership</td>
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ACC and CACC Modes in the Trucks

- ALL trucks – manual or assisted driving modes chosen by drivers on-the-fly
- LEAD truck – generally in ACC mode during testing
- FOLLOWING trucks – in CACC mode when:
  - V2V messages received from preceding and lead truck
  - Cut-in duration < 30 sec
  - Distance from the preceding truck not too large after vehicle cut-out
- FOLLOWING trucks – not in CACC mode if any of the aforementioned conditions are not met

Modeling and Controller Implementation Challenges

- Different vehicle types: models & dynamical capabilities vary a lot
- Manually driven vehicles: significant driver behavior differences
- Reliability in detection and communication is critical for control
- Delays in dynamics, detection and actuation harm string stability
- Cut-in & cut-out by manually driven vehicles at different locations and speeds
- Flexibility in maneuverability and transition between modes
- More reliable control for safety:
  - needs control to be more stiff
  - quick response
- Driver comfort, fuel economy & flexibility in maneuverability:
  - wants control to be softer
- Conflict in control: minimizing distance error and speed error

ACC Controller Flowchart

Inputs:
- preceding vehicle speed, acceleration, and target distance

Outputs:
- desired engine or braking torque

ACC progressive coupling range with respect to Clearance Gap

CACC Controller Flowchart

Inputs:
- preceding and lead vehicle speeds, accelerations, and target distances

Outputs:
- desired engine torque or engine retarder torque

3-Truck Tests at 55 mph on I-580

Next Steps

- Refine CACC controller implementation
- Integrate supplementary Driver-Vehicle Interface for CACC-specific information
- Driver acceptance tests for different gap settings on highways
- Controlled fuel consumption experiments
- Demonstration in LA and Washington DC