Enabling High-Efficiency Control Systems for Connected and Automated Class 8 Trucks

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Problem Statement and Goals

- Engine and transmission fuel efficiency improvements have remained isolated from emerging Connected and Automated Vehicle (CAV) applications
- Use a collaborative vehicle and powertrain solution to reduce fuel consumption and CO\textsubscript{2} emissions by up to 20%
- Target $2,000-3,000 incremental vehicle cost at mass production scales

Concept 1: Calibration Variation

- Variable engine calibrations based on terrain
- Adaptive calibrations based on system configuration
- Dynamic calibrations based on look-ahead information
- Connectivity-enabled, remote powertrain calibration

- Tune engine calibration using connectivity-enabled information about:
  - Mission profile, terrain, traffic, weather
  - Application Variation
  - System-to-system variation
  - Component aging
- Impacts vehicle performance and fuel consumption
- Two-way communication between cloud and powertrain
- Expected fuel savings contribution: 2.5%

Concept 2: Cloud-Based Optimization

- Use off board computation power to improve control of the powertrain
  - Enables sophisticated real-time optimization
  - Enables long horizon MPC
- Expected fuel savings contribution: 5%

Concept 3: Improved Vehicle Coordination

- More efficient two-truck platooning using connectivity-enabled shifting coordination and lead truck predictive cruise

- Platooning
  - Optimization of platooning controller integrated with engine and transmission controllers
  - Platoon broken less frequently on grades
  - Driver experience improved
- Expected fuel savings contribution: 7.25%

- Predictive cruise
  - Both vehicles at SAE J3016 Level 1
  - Compute optimal speed profile and vehicle gaps
  - Avoid torque saturation of rear truck
  - Expected fuel savings contribution: 4%

- Coordinated Shifting
  - Preventing inefficient (and annoying) disturbances in the platooning gap when trucks shift independently
  - Coordinate shifting of both trucks to minimize gap disturbance
- Expected fuel savings contribution: 1%

Experimental Validation of Concepts

- Hardware-in-the-Loop (HIL) engine test cell at the Ray W. Herrick Labs at Purdue University
- On-vehicle concept demonstration
- Demonstration of concepts via hardware-in-the-loop (HIL) engine testing and vehicle experimentation

Partners