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

Purdue University, Cummins Inc., Peloton Technology, NREL, Peterbilt, ZF

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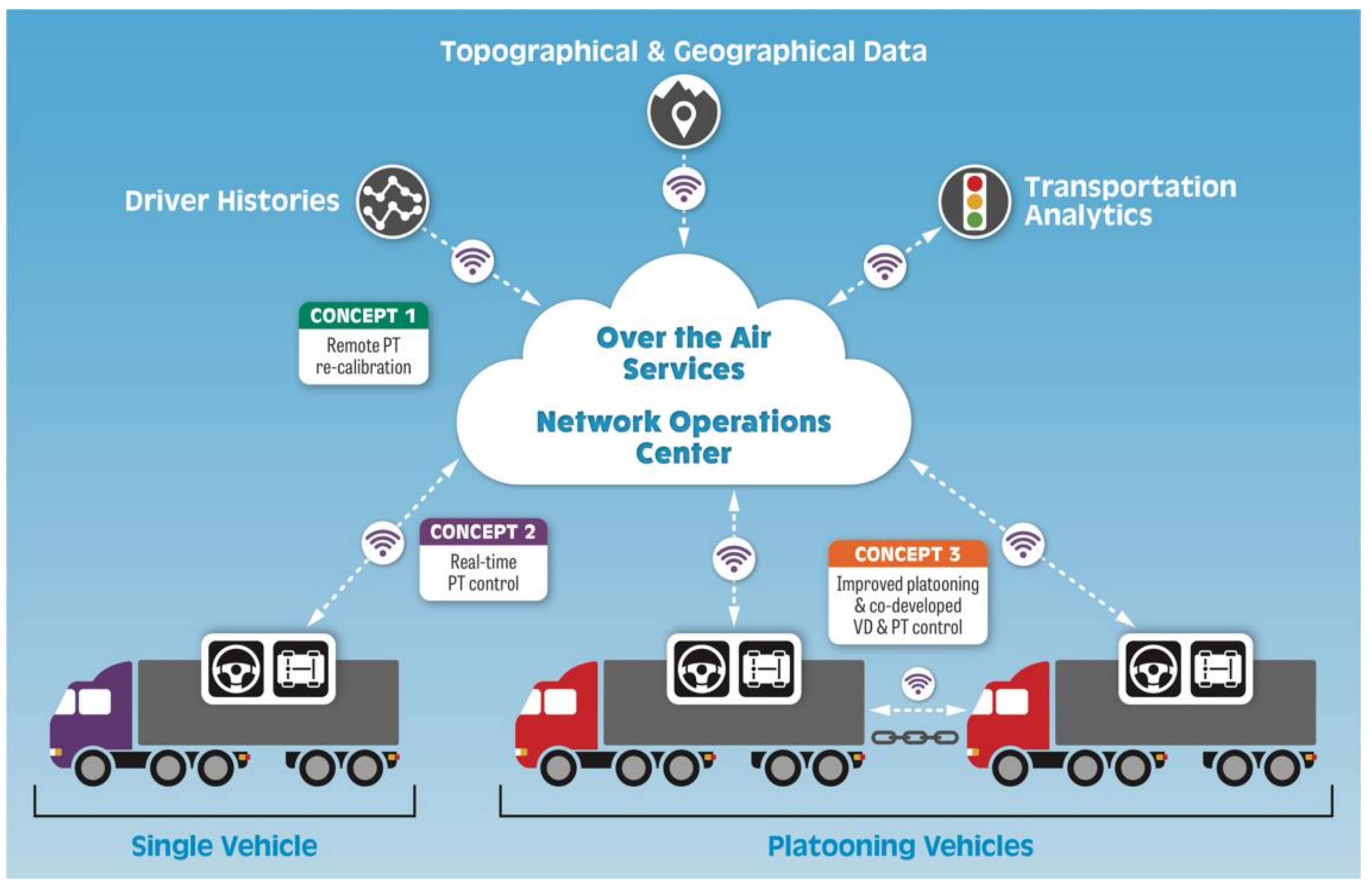
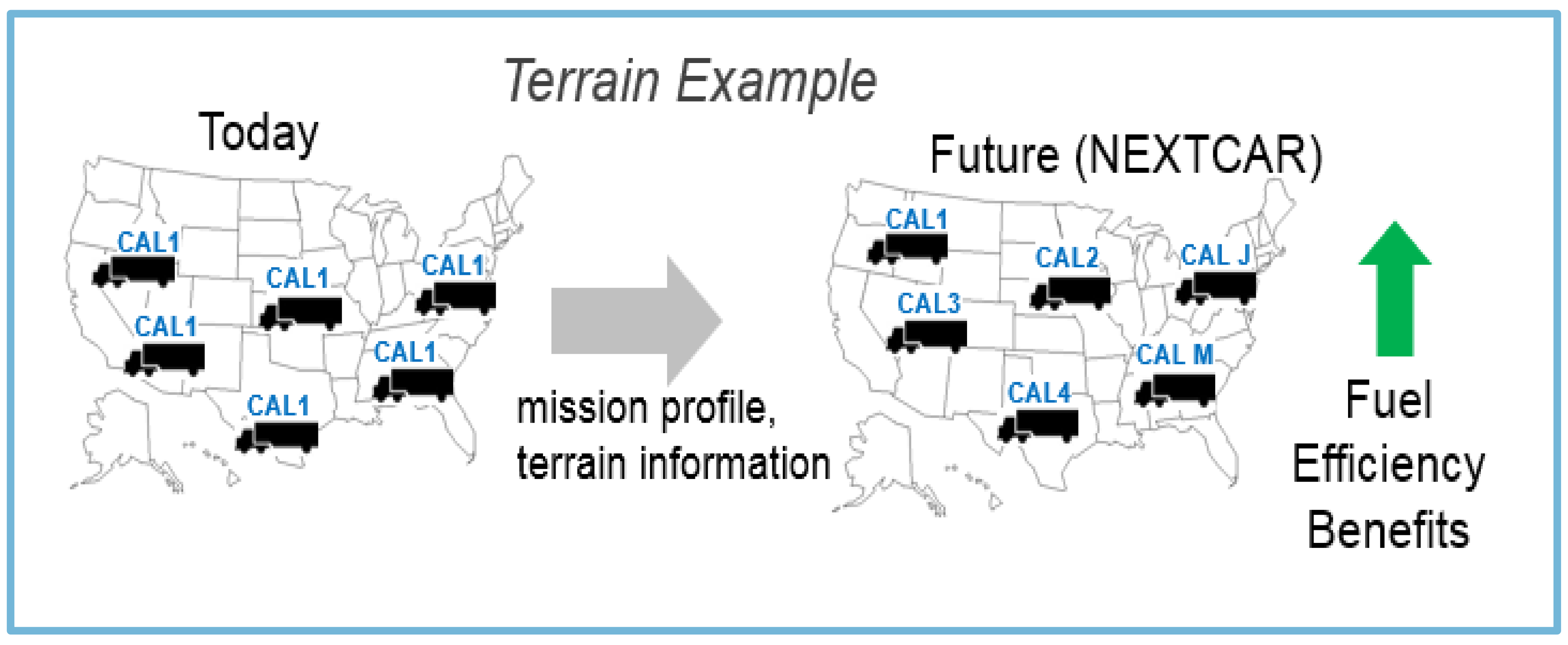
Problem Statement and Goals



- 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_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

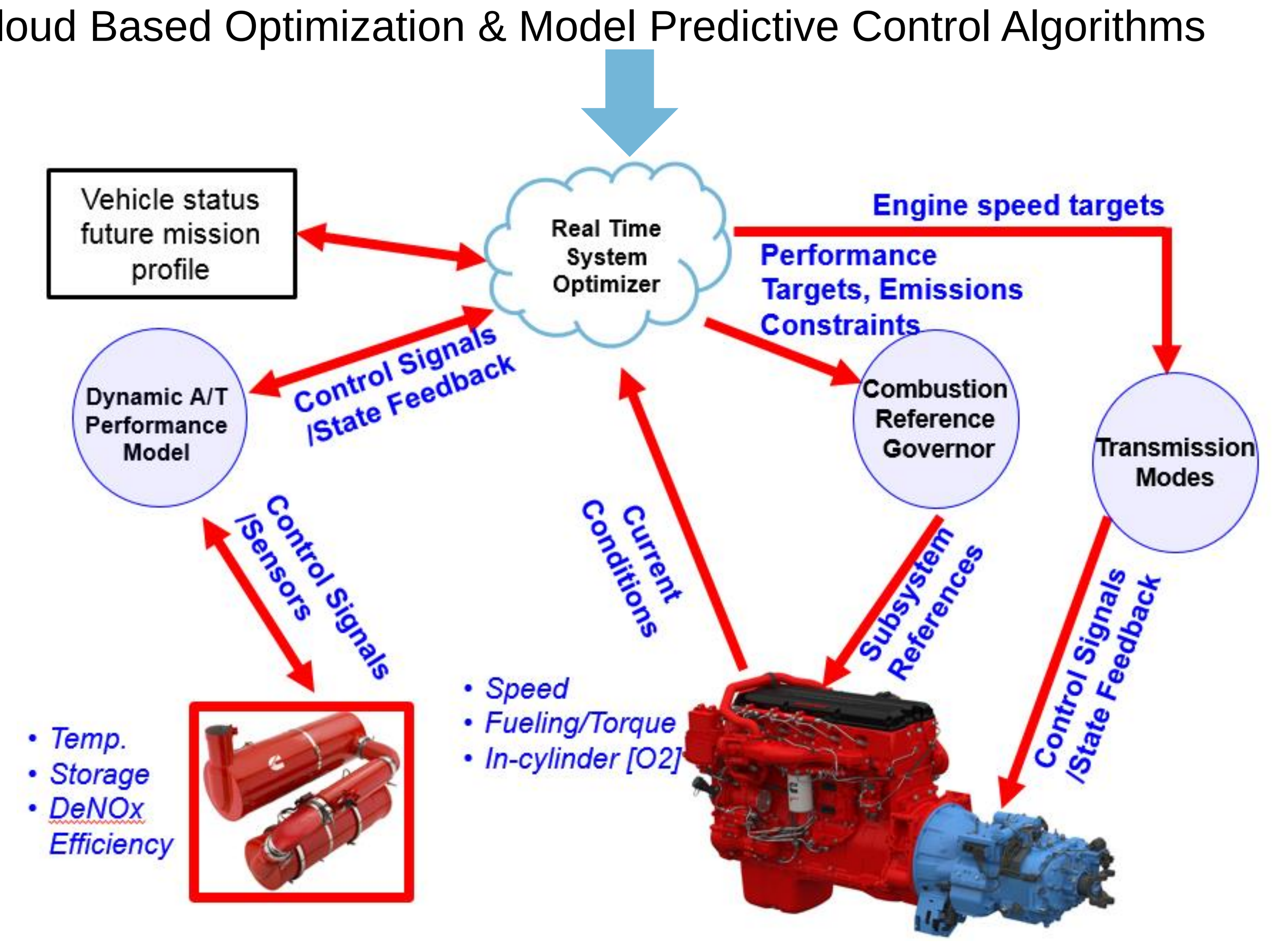
Dynamic calibrations based on look-ahead information

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

Cloud Based Optimization & Model Predictive Control Algorithms



Computationally expensive optimizations enabled by cloud-based computing

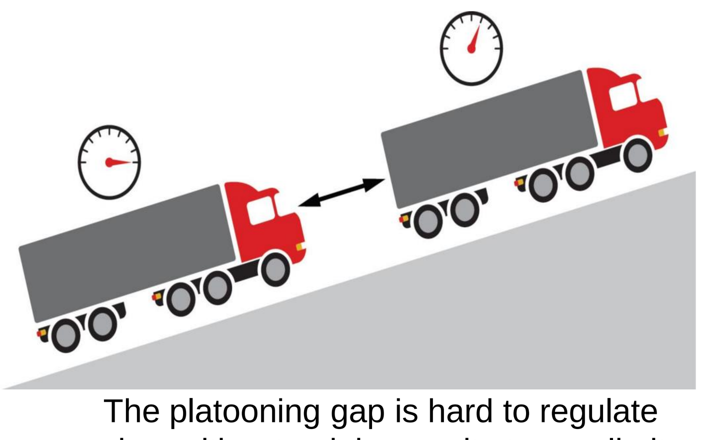
Connectivity-enabled, real-time, powertrain control and optimization

- 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

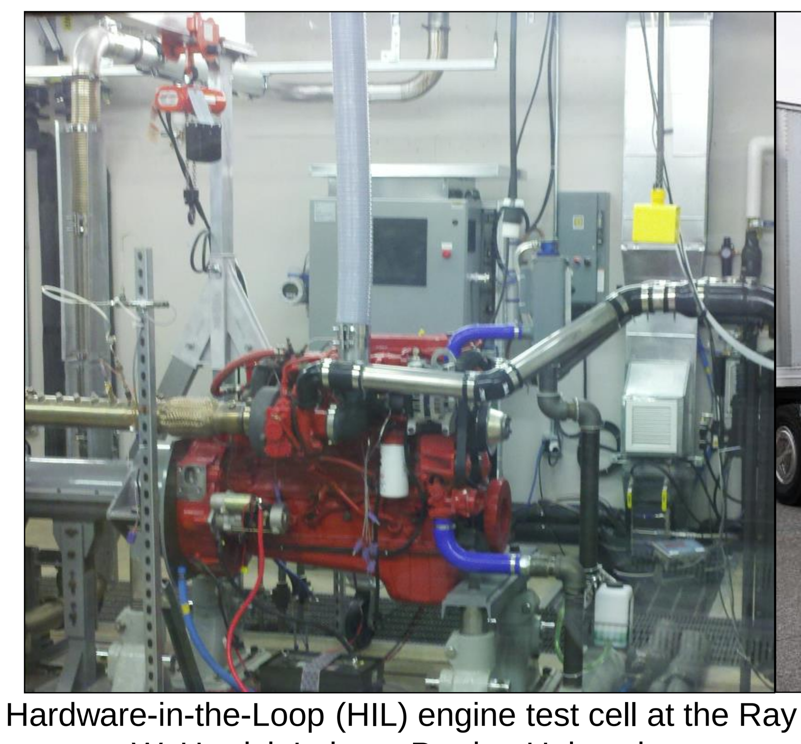
- Platooning
  - Optimization of platooning controller integrated with engine and transmission controllers
  - Platoon broken less frequently on grades
  - Driver experience improved
  - Expected fuel savings contribution: ***7.25%***
- Predictive cruise
  - Both vehicles at SAE J3016 Level 1
  - Compute optimal speed profile and vehicle gaps
  - Avoid torque saturation of rear truck
  - Expected fuel savings contribution: ***4%***



The platooning gap is hard to regulate when either truck is near its torque limit

- 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

PURDUE UNIVERSITY

Cummins

Peloton

NREL NATIONAL RENEWABLE ENERGY LABORATORY

Peterbilt CLASS PAYS

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CHANGING WHAT'S POSSIBLE