

DAIMLER

DETROIT DIESEL



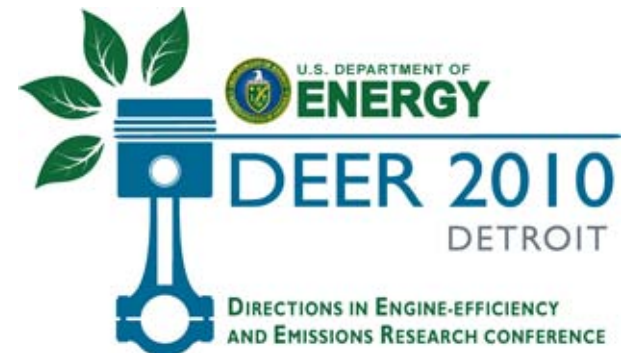
Model-Based Diesel Engine Control With On-Board Fuel Efficiency Optimization

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Outline

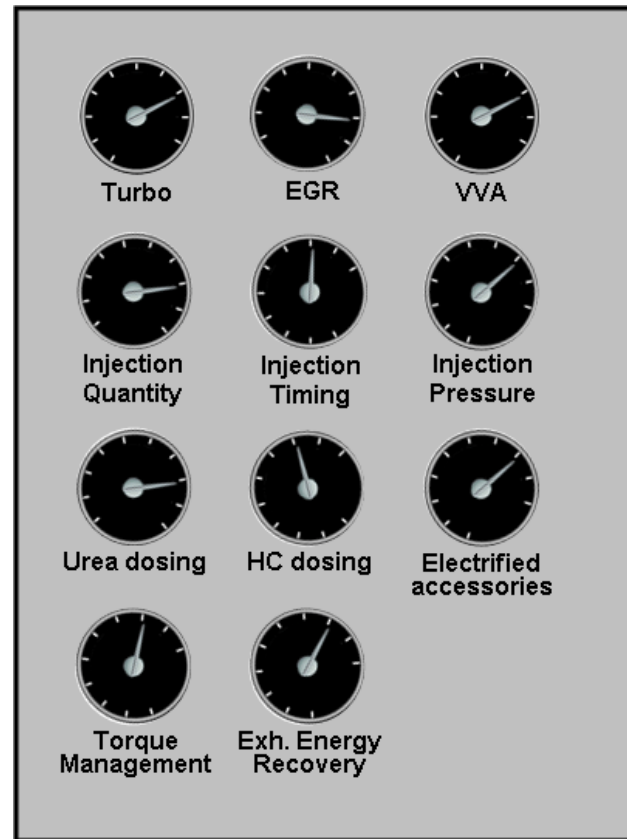
- Objectives
- Technical Approach
- Experimental Set-up
- Experimental Results
- Summary & Next Steps

Objectives

- Develop a map-less, predictive, empirical engine controller
- Reduce calibration and controller complexity
- Include an on-board fuel efficiency optimizer

Calibration Constraints

- Drivability
- Durability
- Fuel economy
- Life-cycle cost
- NO_x / PM / NMHC / CO₂
- OBD
- Exhaust temperature
- GPS / Route / Traffic info.



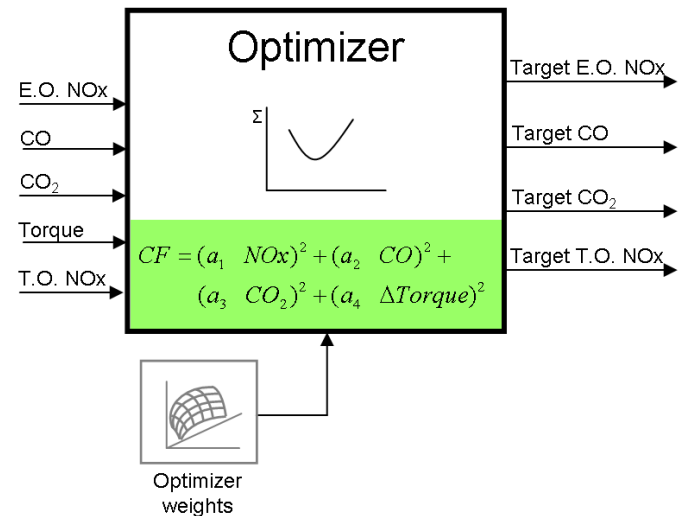
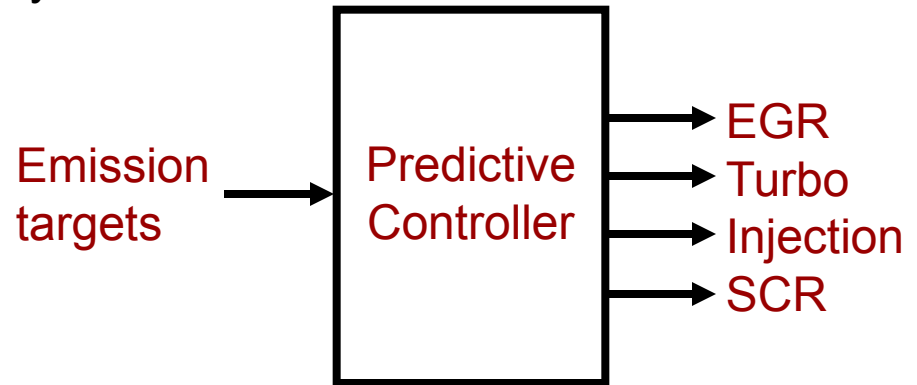
Goal: Mitigate increased calibration complexity

- More degrees of freedom
- Calibration optimization more complex

Technical Approach

- Controller with built-in knowledge of system interactions
 - Nonlinearities
 - Individual system response times
- Inputs: Performance targets
- Outputs: Actuator signals

- Includes an optimizer
 - Cost function that minimizes emissions and fuel consumption
 - Optimizes engine operation in real-time

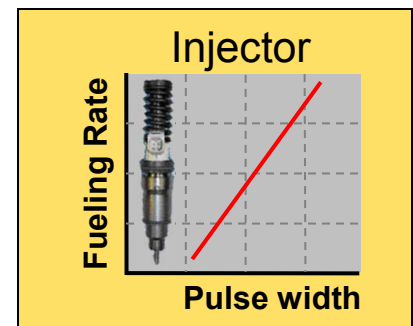
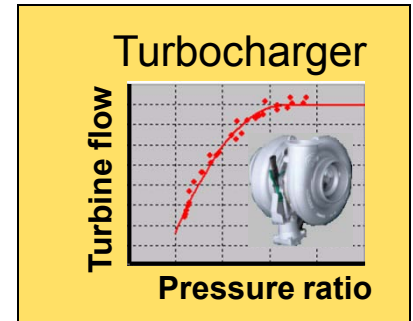
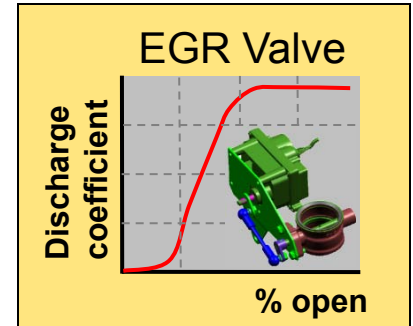
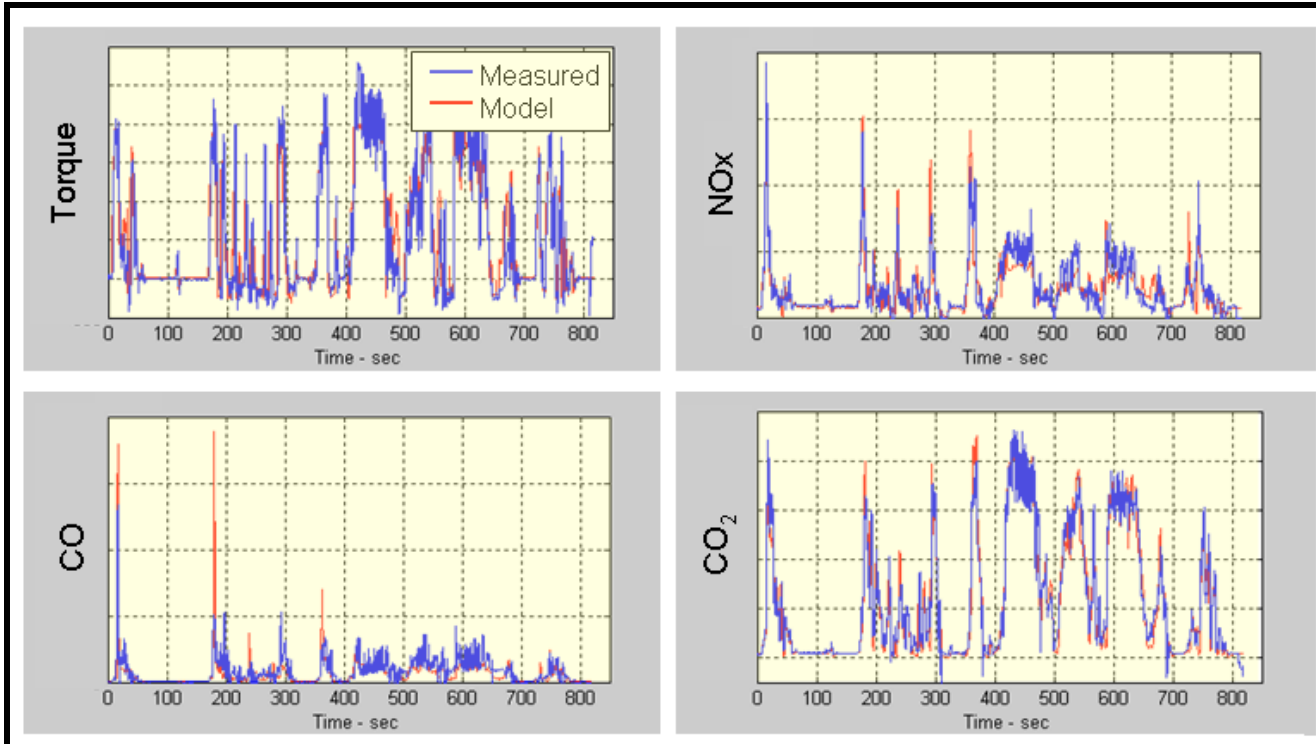


Technical Approach

- Controller based on predictive engine models
 - First principle models
 - Neural networks trained with transient engine data

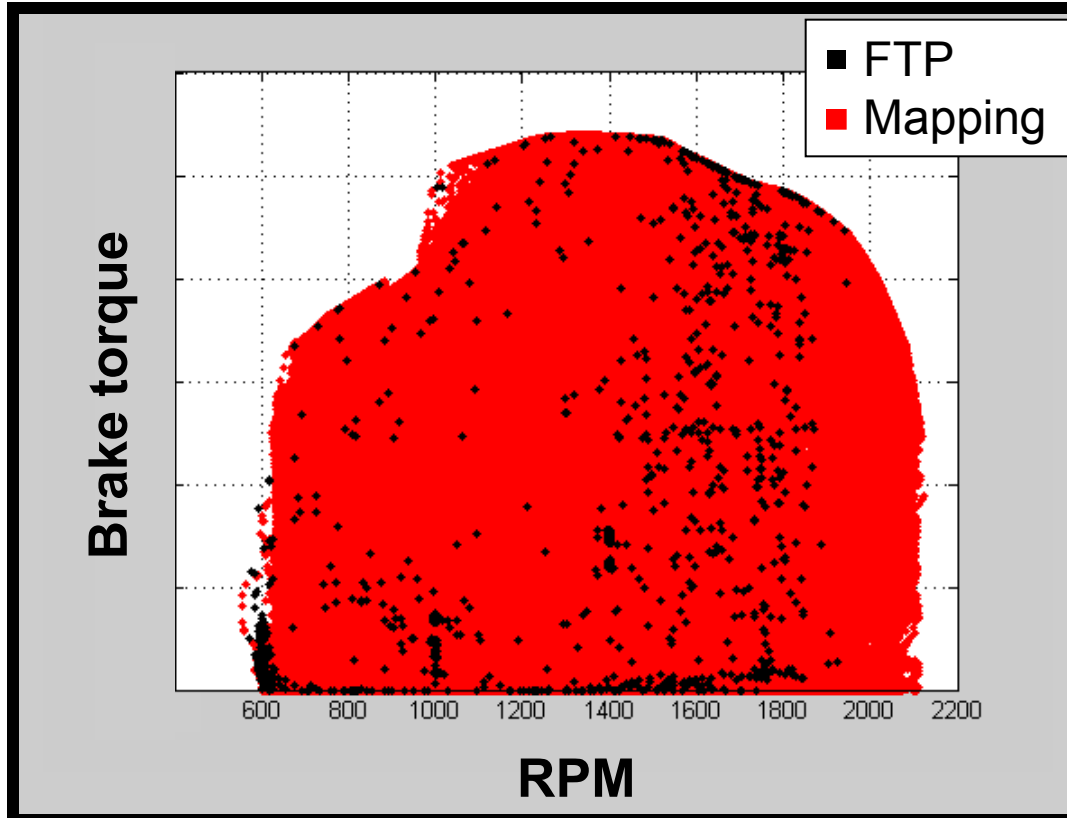
Approach made viable by

- More accurate actuators
- More repeatable systems

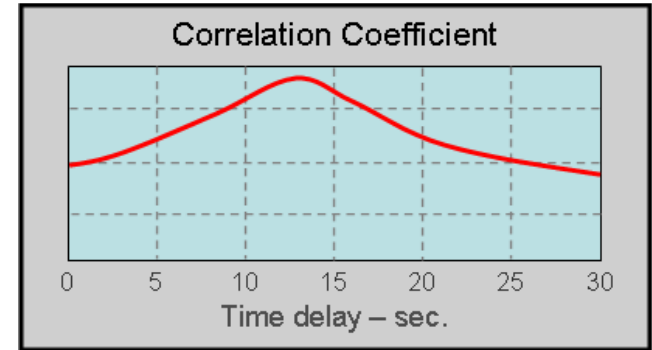


Technical Approach

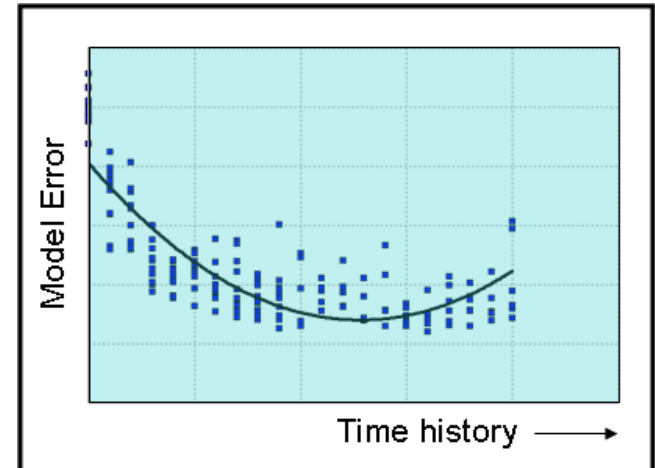
- On-board models based on extensive engine mapping
- Transient test cell data
 - Filtering
 - Time-alignment of emissions data



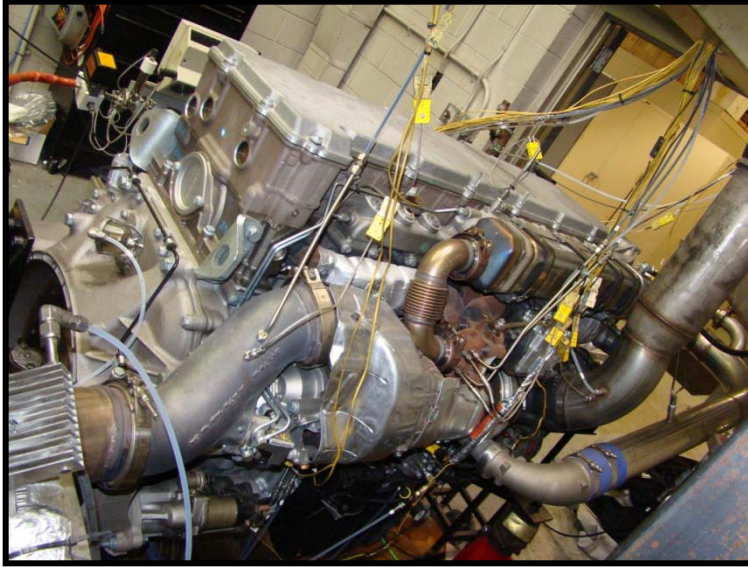
CO₂ vs. fueling rate correlation



Requires input "history"

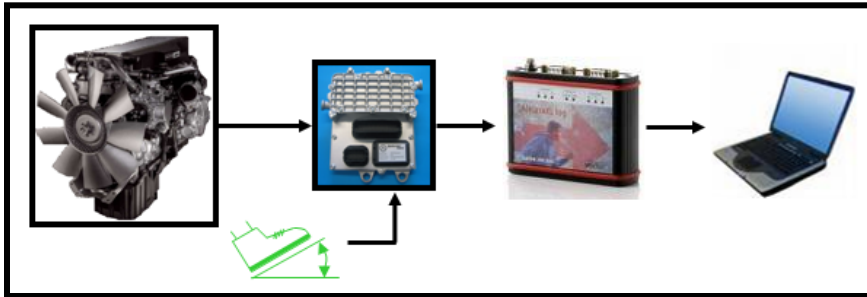


Experimental Setup



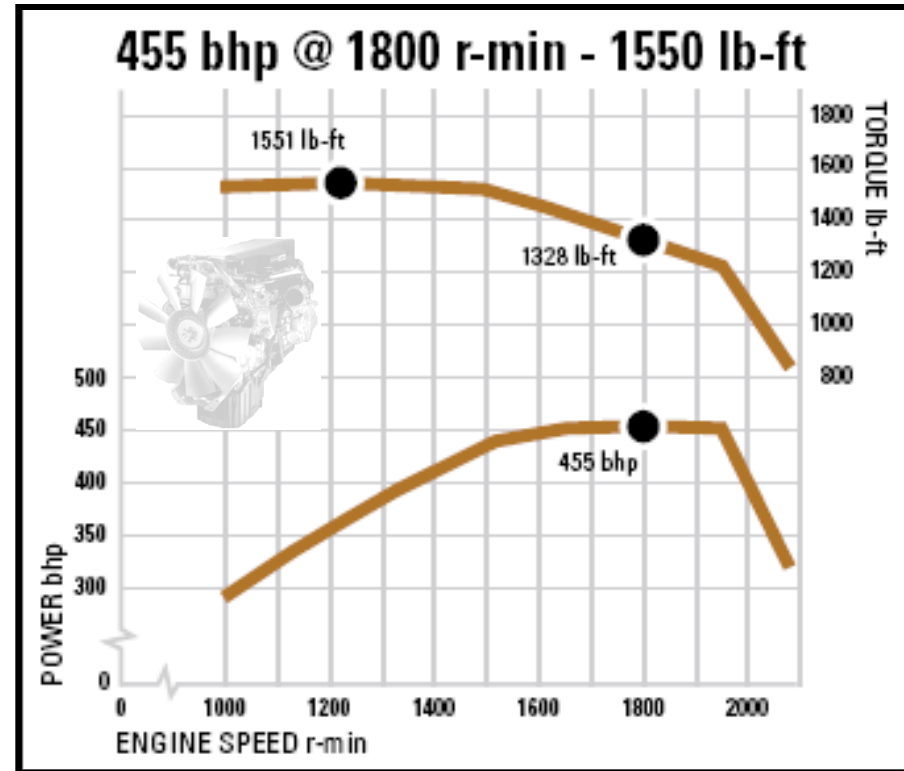
ECM bypass

- Air / EGR / Fuel / SCR



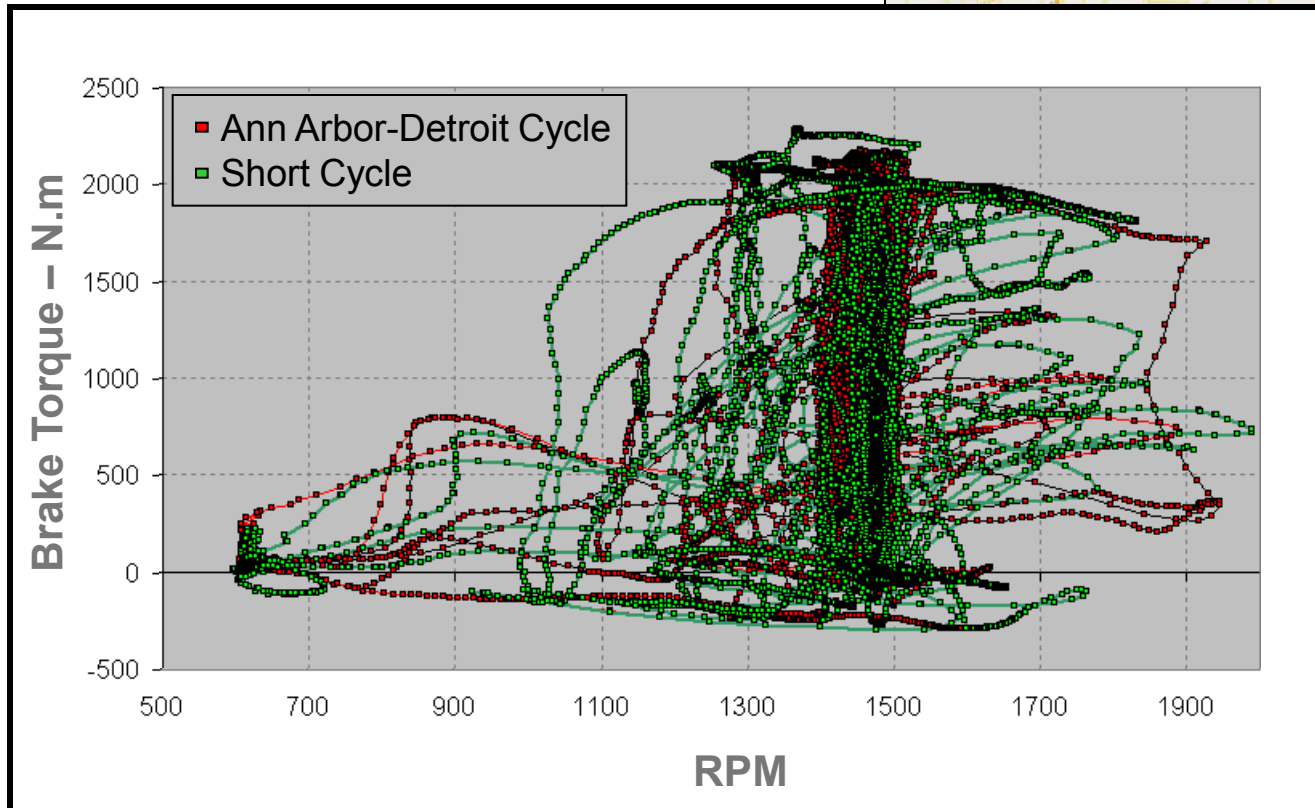
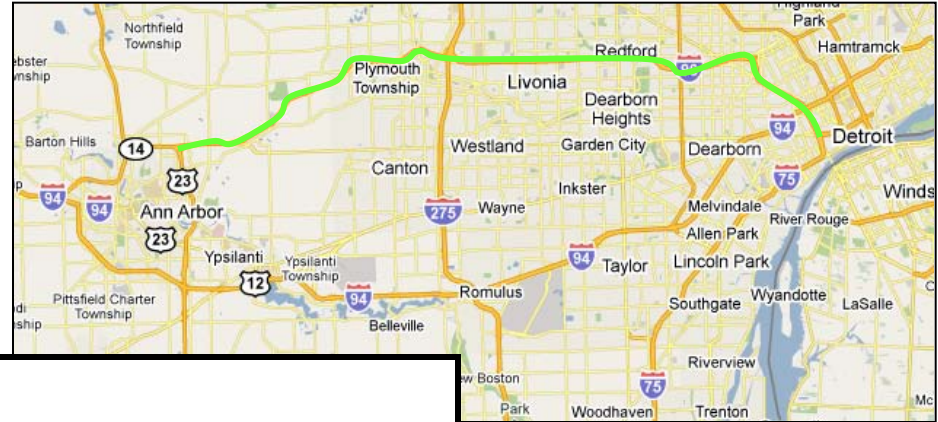
Baseline engine

- 2010 Detroit Diesel DD15
 - 14.8-liter inline 6-cylinder



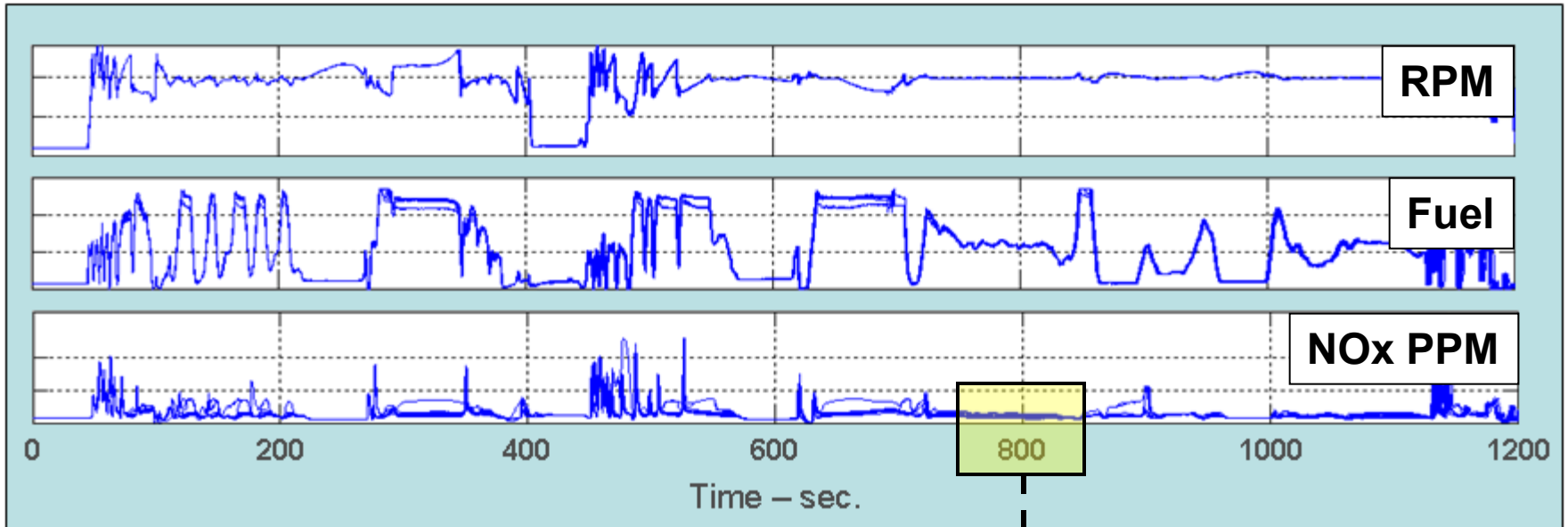
Experimental Setup

- 20-minute dynamometer cycle
- Shortened version of Detroit-Ann Arbor vehicle load cycle

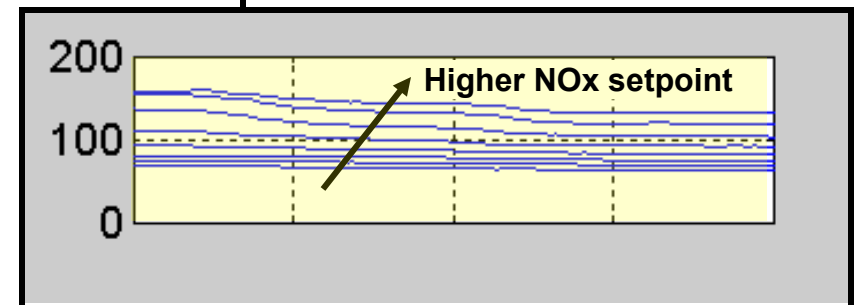


Experimental Results

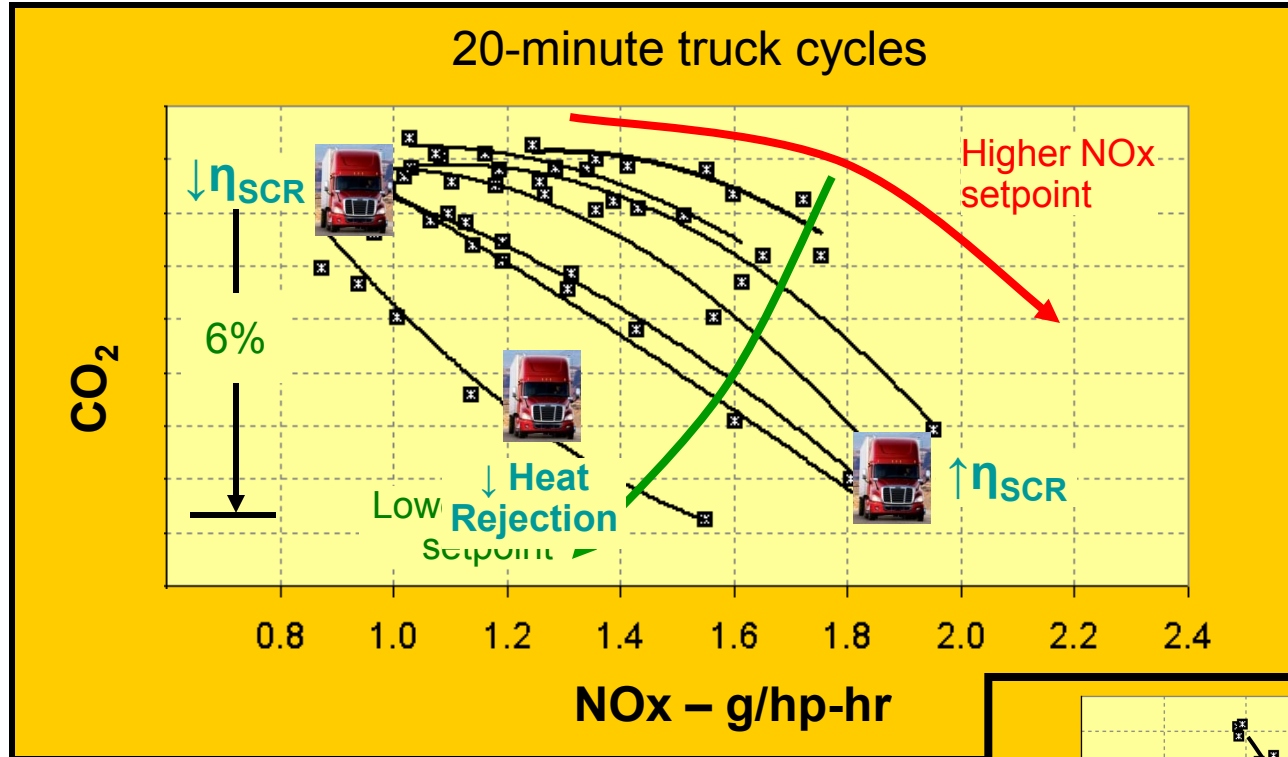
Multiple cycles with varying NOx / CO / CO₂ setpoints



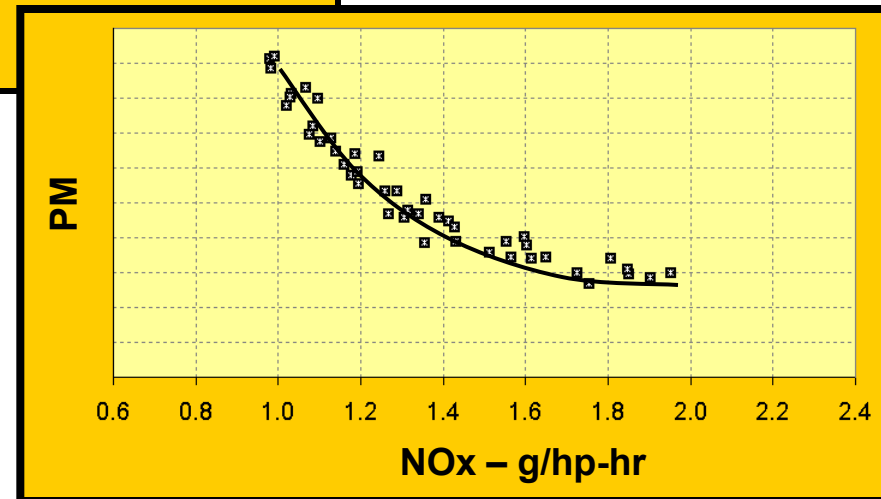
- Controller provides real-time NOx flexibility



Experimental Results



- Flexible engine control
- Modulates NO_x & CO₂ output



Summary & Next Steps

- Empirical, predictive engine control concept is viable
 - Concept demonstrated in test cell on truck cycles
 - Provides flexible engine control
 - Significant reduction in calibration effort

- Main limitation of the approach
 - Vehicle-to-vehicle variability
 - Mitigated by over-the-road adaptation

- Next Steps
 - Integration of additional control variables
 - Vehicle Predictive information
 - Waste Heat Recovery
 - Electrified Accessories

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