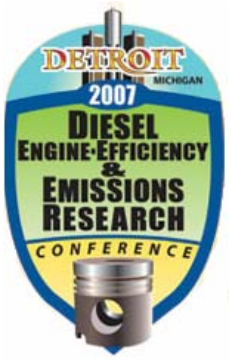


DETROIT DIESEL

Next Generation Diesel Engine Control

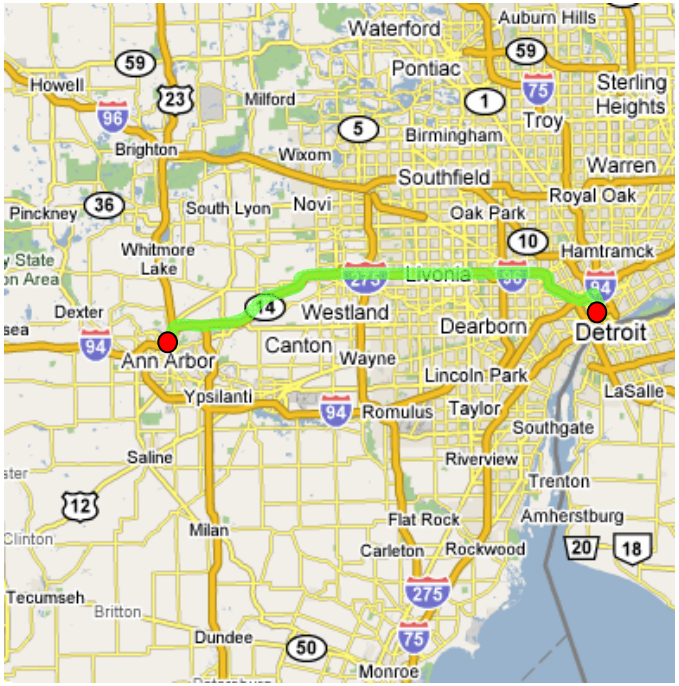
Detroit Diesel Corporation

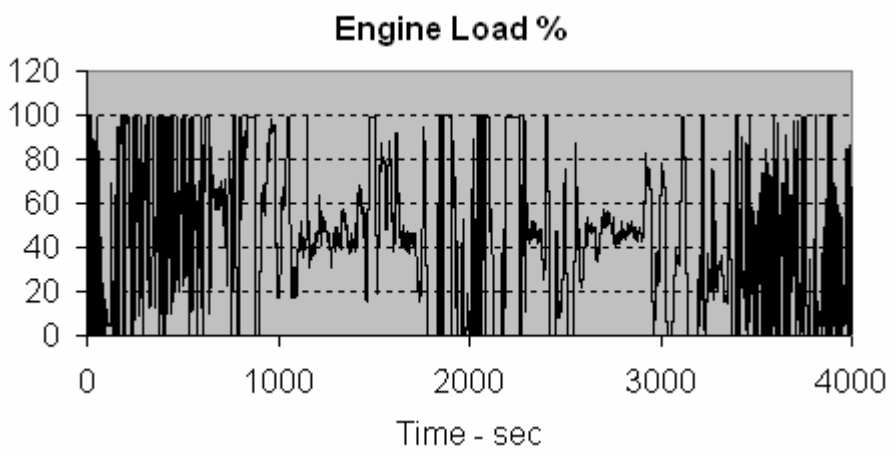
M. Allain, C. Savonen, Y. Kalish, H. Zhang

Outline

- Engine Control Requirements
- Inverted Models For Controls
- Results
- Limitations

Steady-State ?





Transient Engine Control Makes Advanced Combustion Techniques Possible Over-the-road

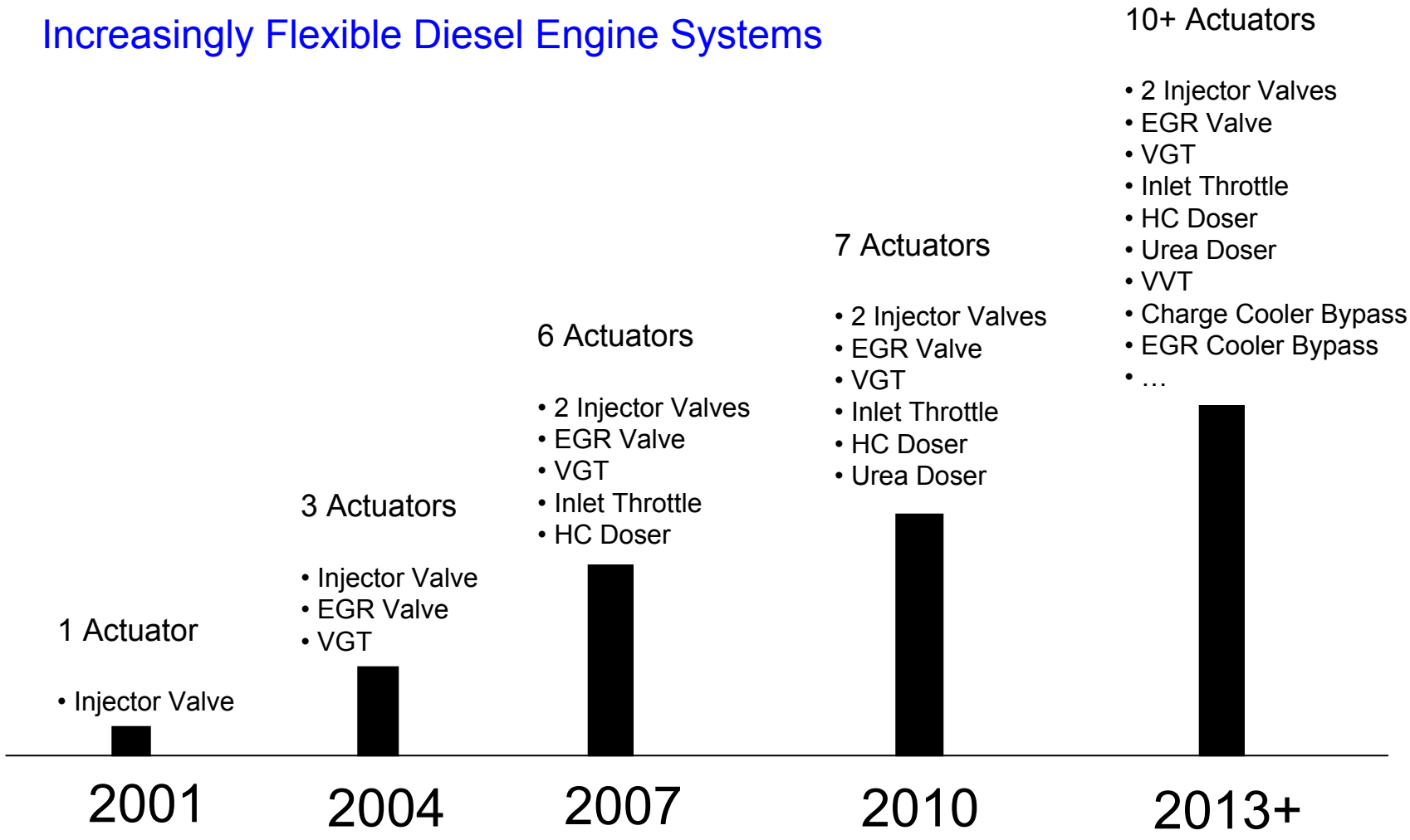
Engine Control Requirements

- **Flawless Steady-State Stability**
- **Fast Transient Response**
- **Reduced Emission Variability**
- **Increased Diagnostic Capability**
- **Integration of Additional Control Variables**

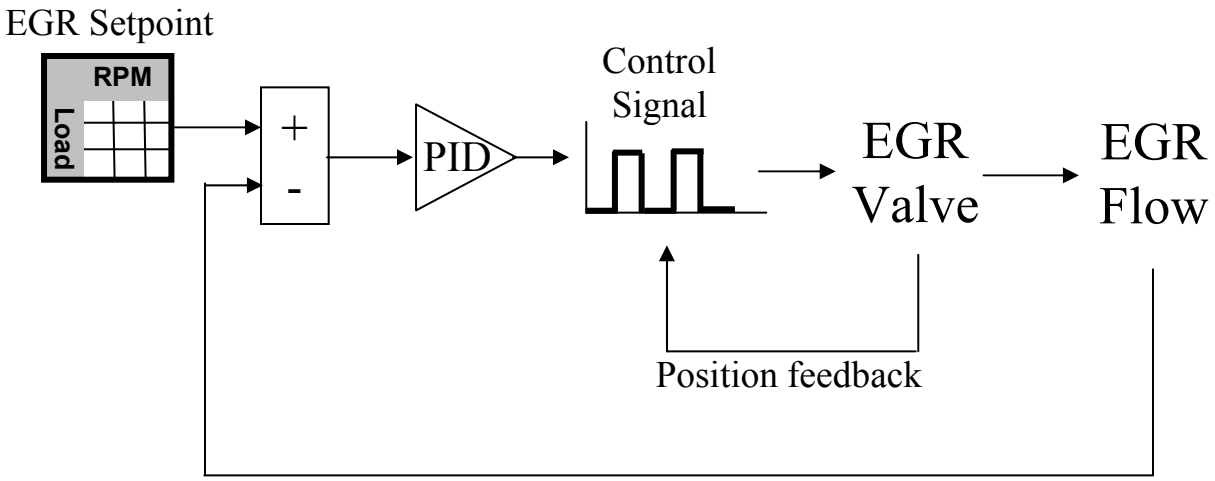
Multiplication Of Control Variables

DETROIT DIESEL

Increasingly Flexible Diesel Engine Systems

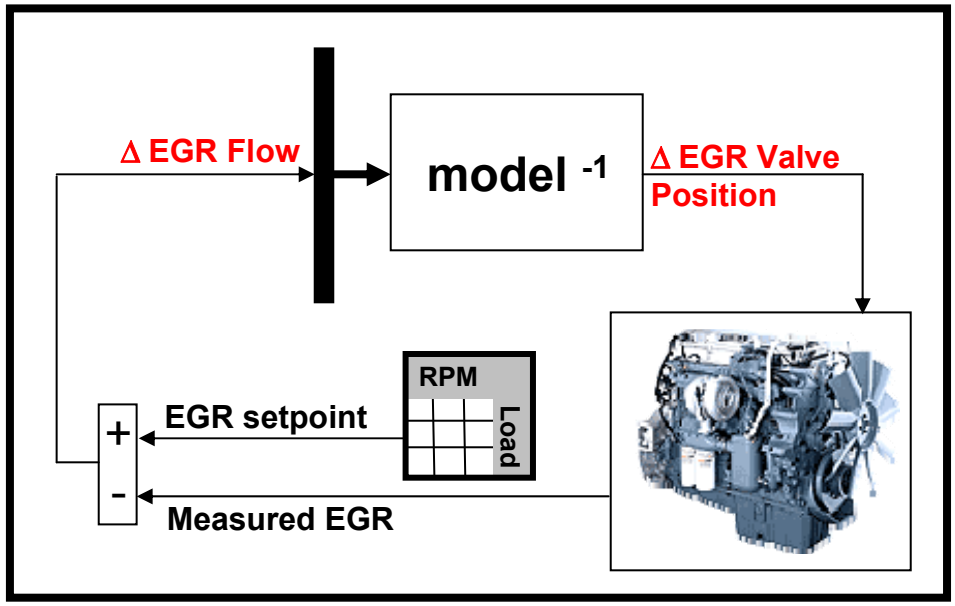


Traditional Engine Control



Next Step: Model-Based Engine Control

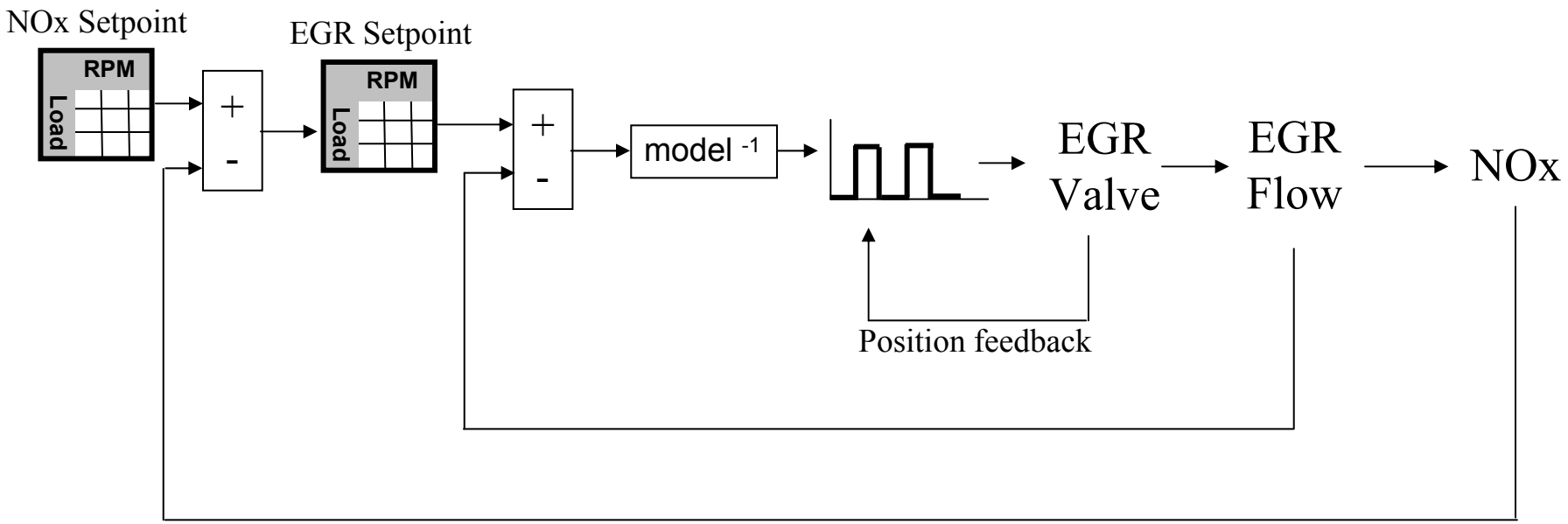
Next Step – Inverted Control Model



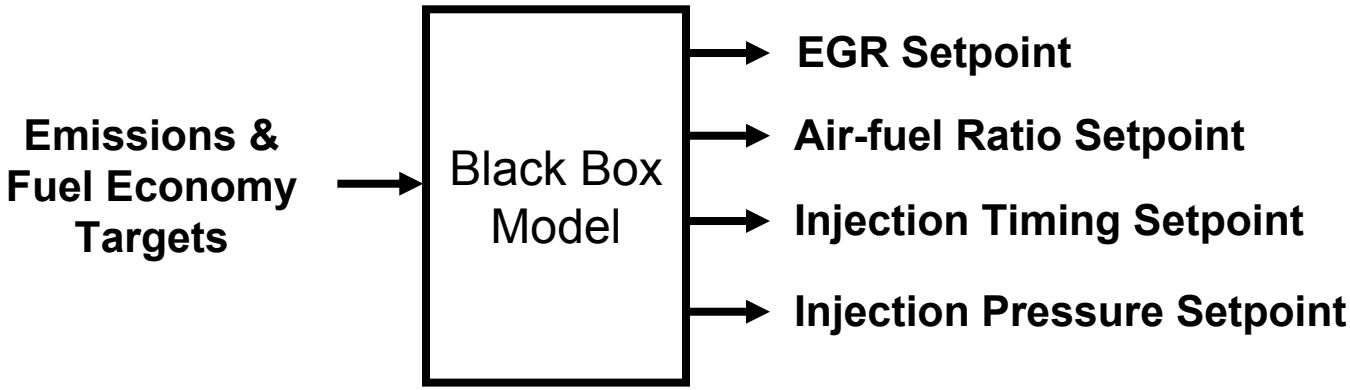
Model-Based Control System

Significant Improvements Obtained in Stability & Response Time

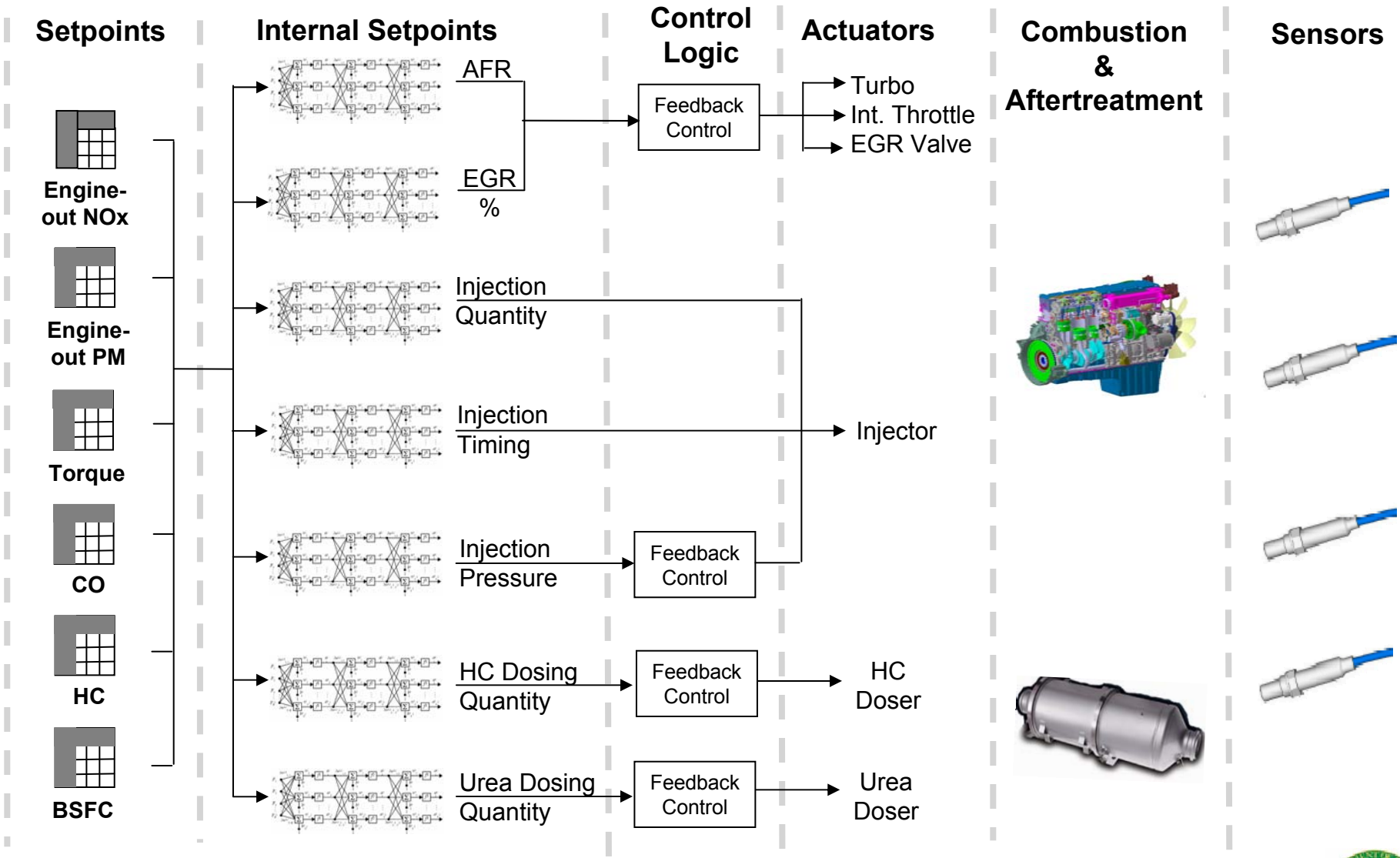
Can We Take It Further ?



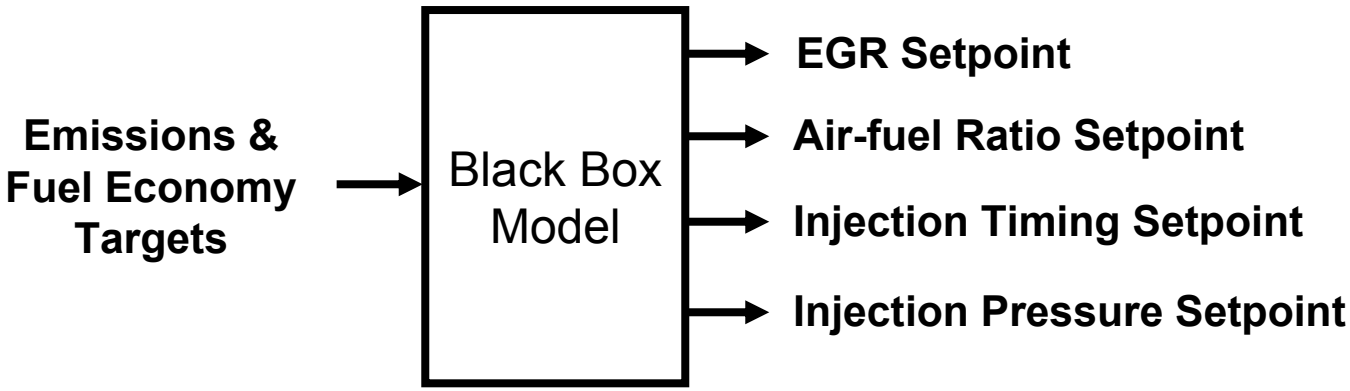
Can we build a model, which calculates optimum setpoints in real-time ?



Calibration Layers

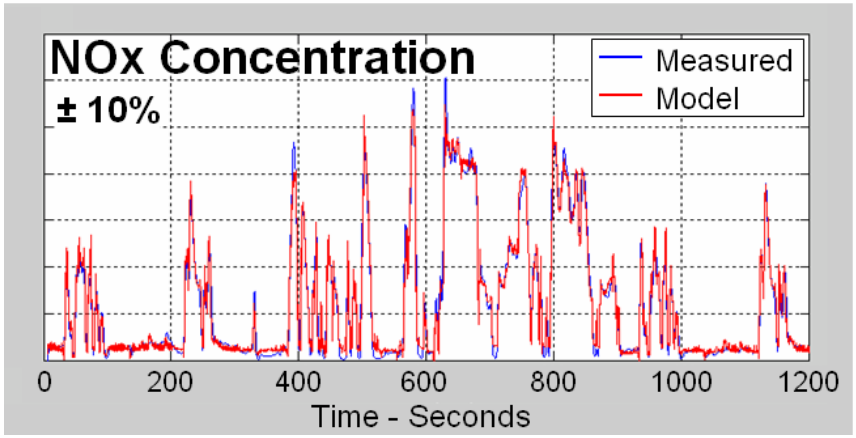


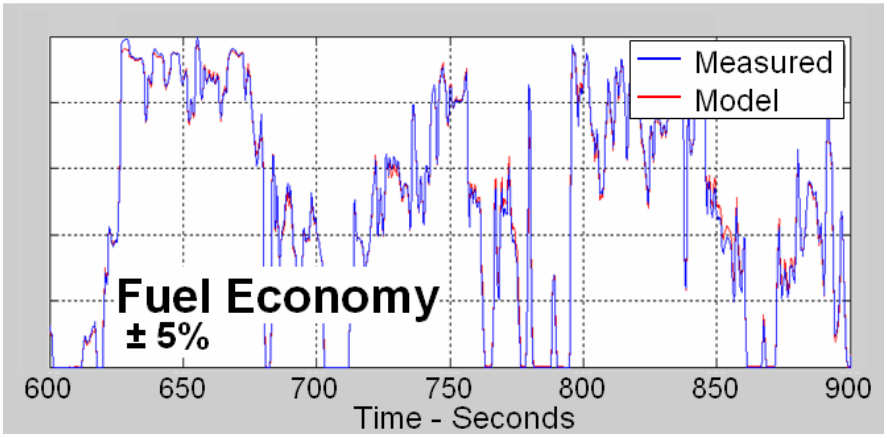
Neural Network Engine Control

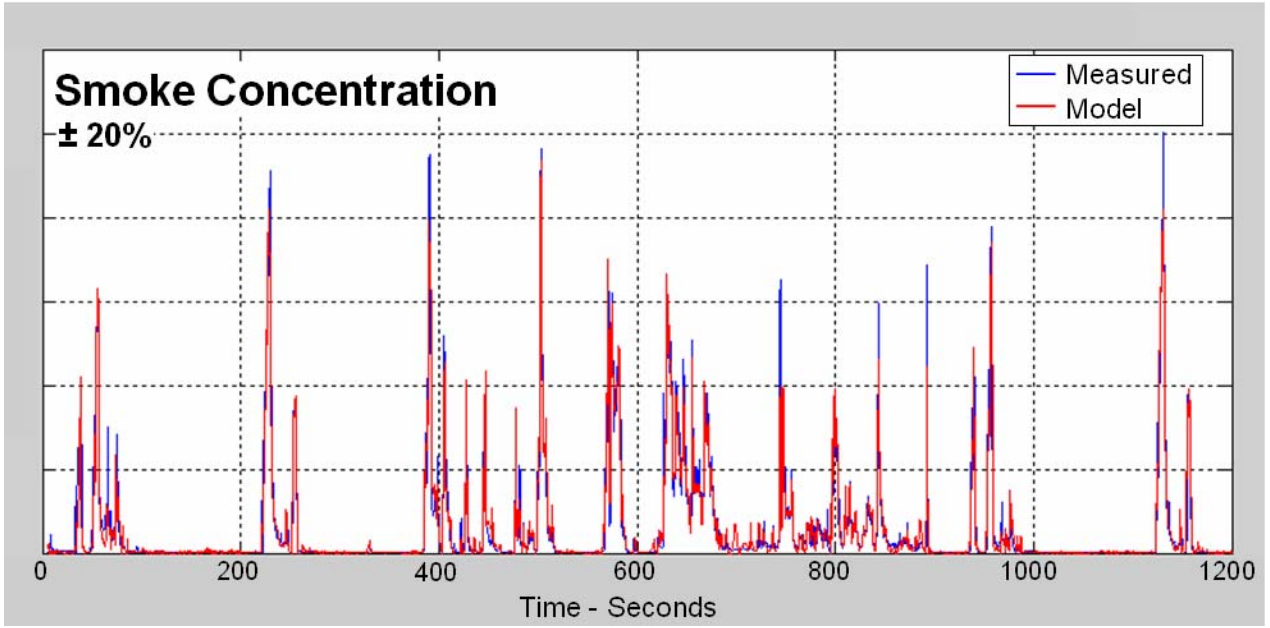


- Are Forward Models Accurate ?
- How Accurate Must The Inverted Models Be ?

Neural Network Model Evaluation



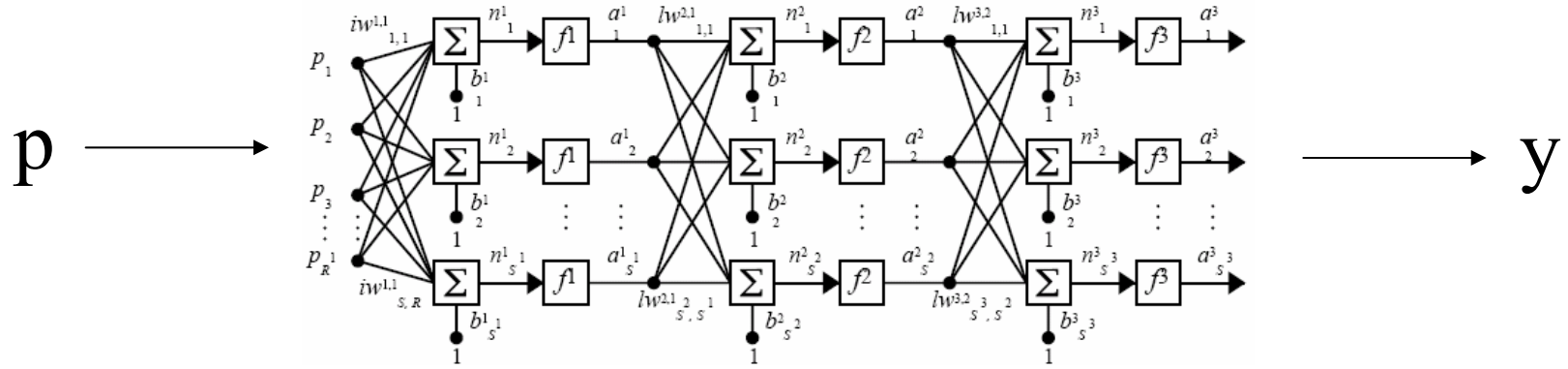




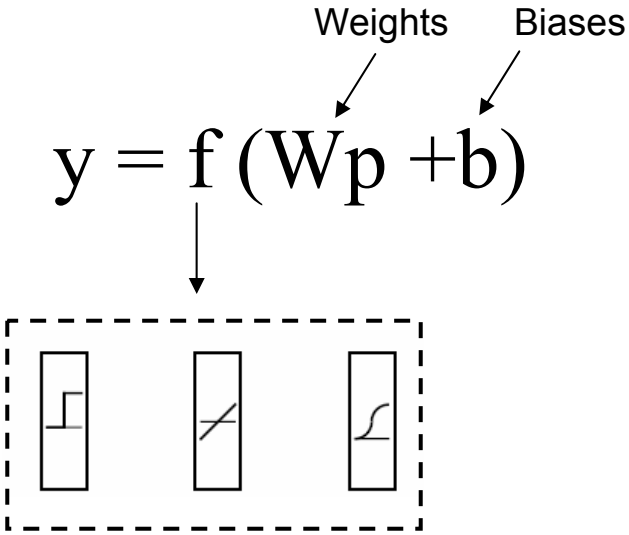
PM Model Is More Challenging:

- Additional Inputs
- Time History of Inputs

Neural Networks



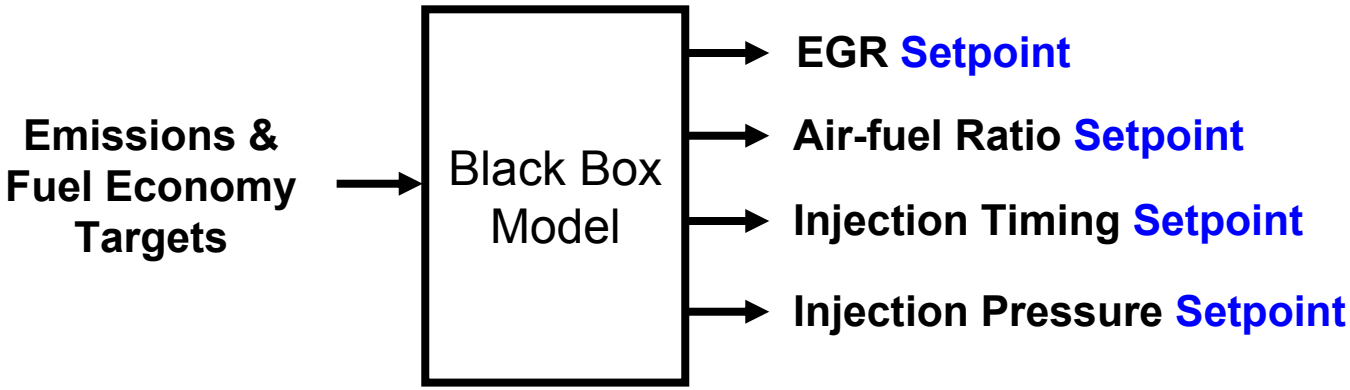
- Fixed Pre-defined Structure
- Training With Existing Input-Output Data



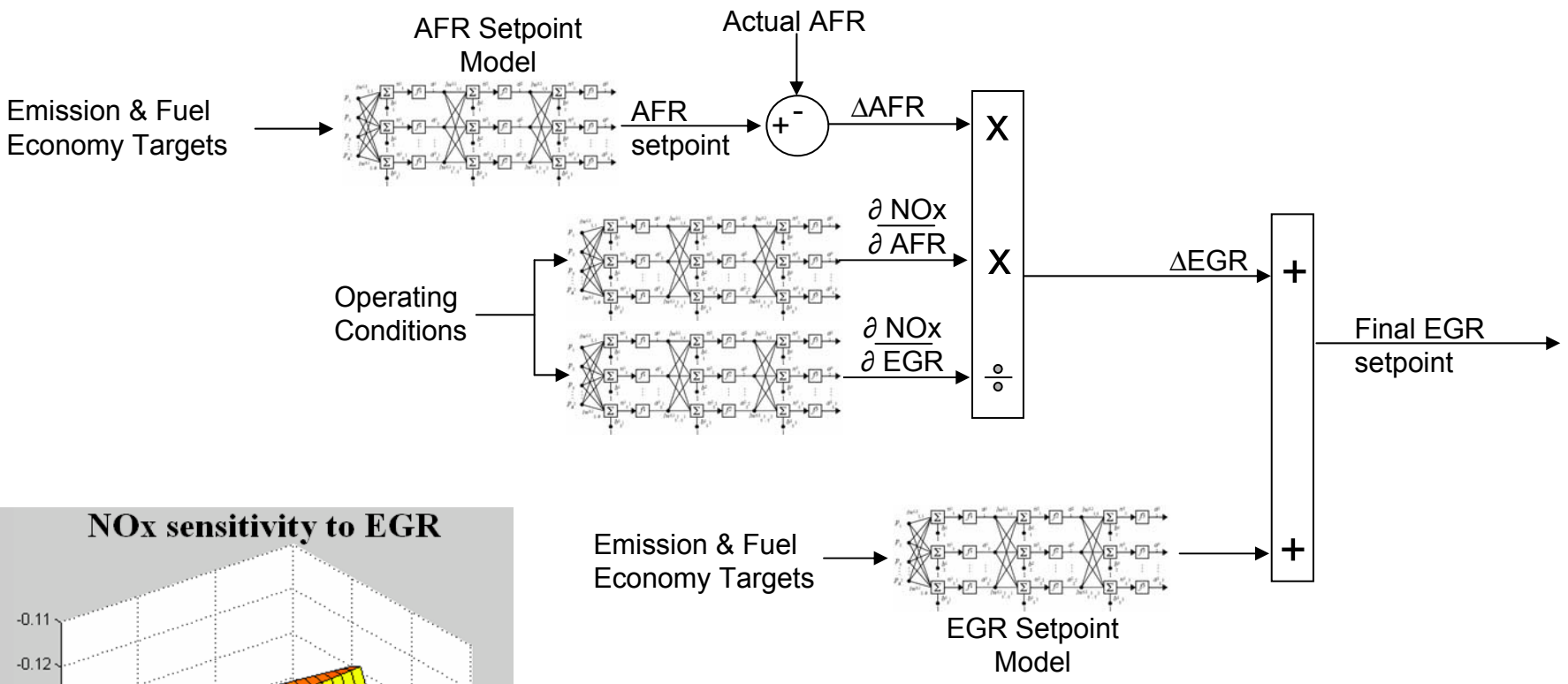
Neural Network Engine Control

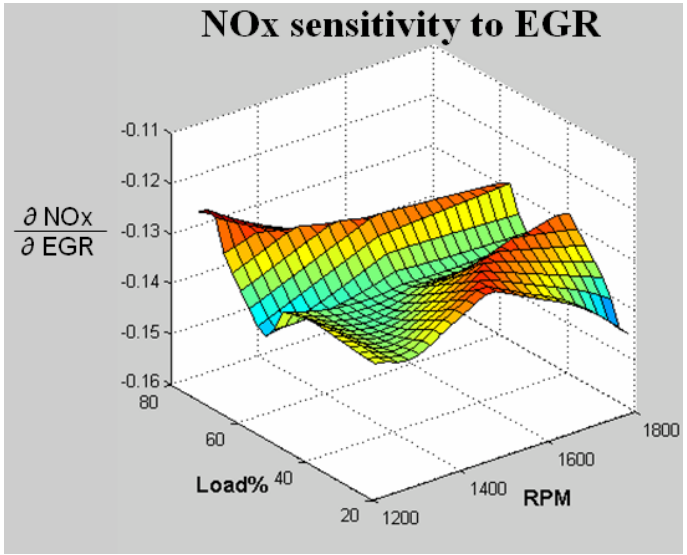
DETROIT DIESEL

Problem: Setpoint vs. Actual !



Intermediate Solution - Dynamic Compensation



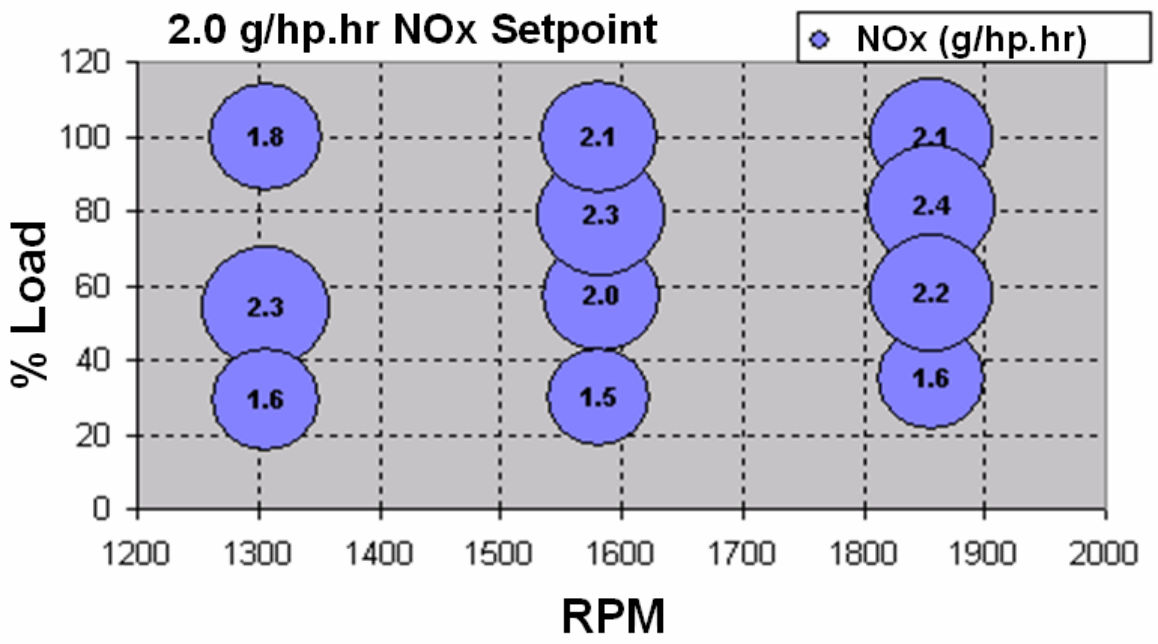


Take Advantage of Fast-responding Engine Systems

Preliminary Controller Evaluation

DETROIT DIESEL

Steady-state Results



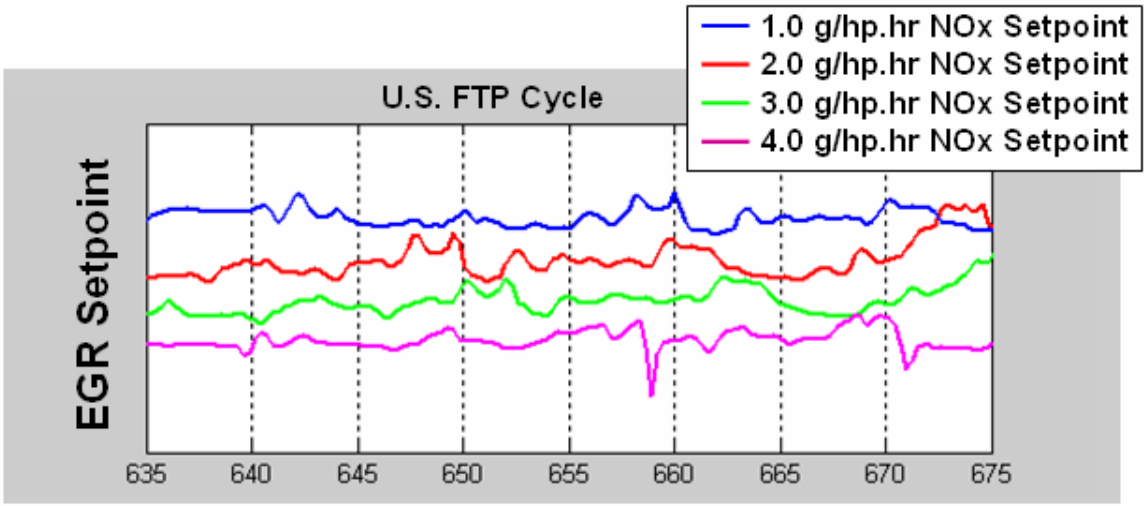
Objective:

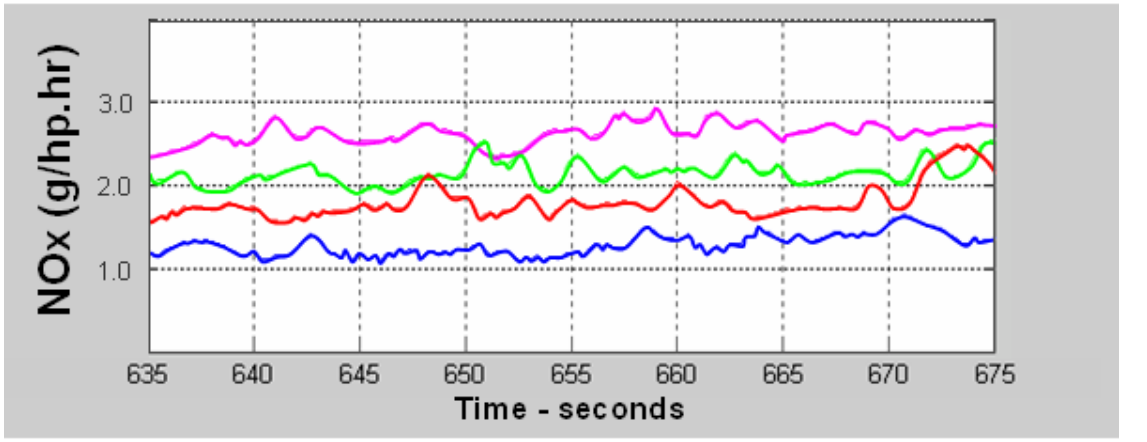
- Dial-in the Requested NOx Level
- Have the Controller Adjust the Engine Setpoints to Meet the Emission Targets

Preliminary Controller Evaluation

DETROIT DIESEL

Transient Results





Dynamically Calculating
The Optimum Setpoints

Model Inaccuracy Can Be
Compensated
By Adjusting the Emission
Setpoints

Limitations

- Large Amount Of Transient Data Required
- Over-the-road Application
- Hardware Variability (engine-to-engine)
- Increased Computing Power Requirement

Summary

- Developing Transient Engine Models For Real-time Use
- Models Were Inverted For Control Application
- Results Obtained To Date Indicate Strong Potential
- Major Challenge Is Applicability To Varying Ambient Conditions
  - Possible On-board Model Adaptation
- Next Steps Include The Application To Standard ECU

Acknowledgements

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