

Transient engine modeling at John Deere using GT-POWER

GT-SUITE NORTH AMERICAN CONFERENCE - 2009



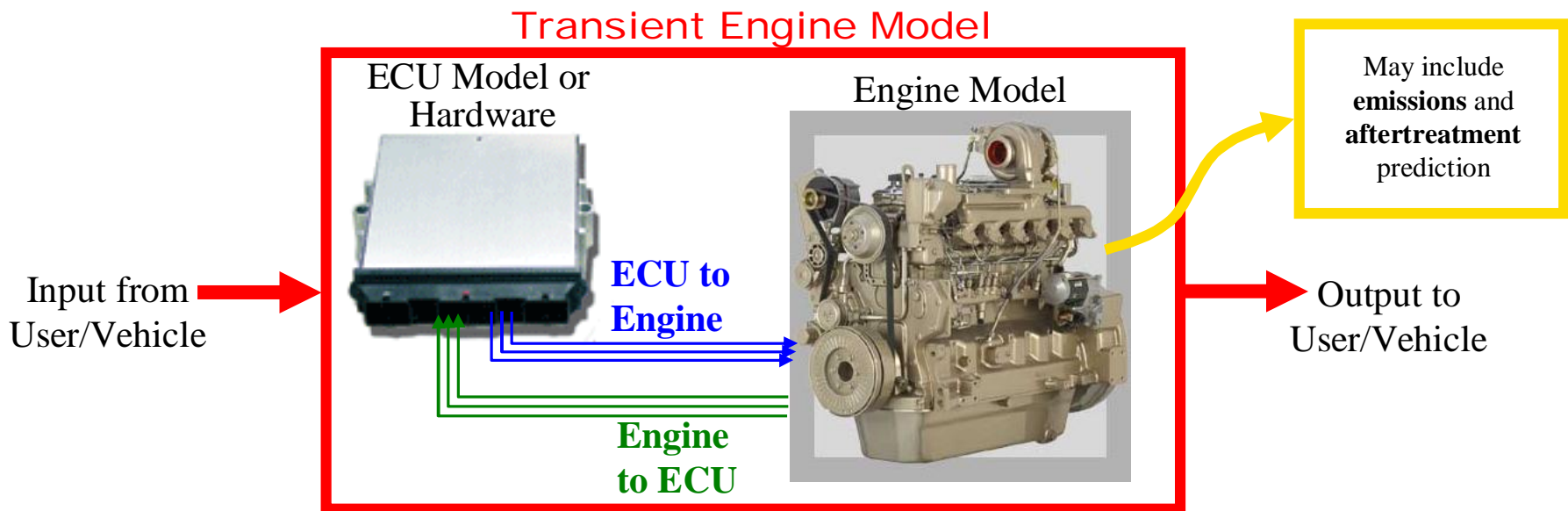
JOHN DEERE

Agenda

- Definition of Transient Engine Model
- Components
 - Engine Model
 - ECU Model
 - Interface Model
- Model Development Process
- Model Applications
- Sample Results A – Performance
- Sample Results B – Emissions
- Summary

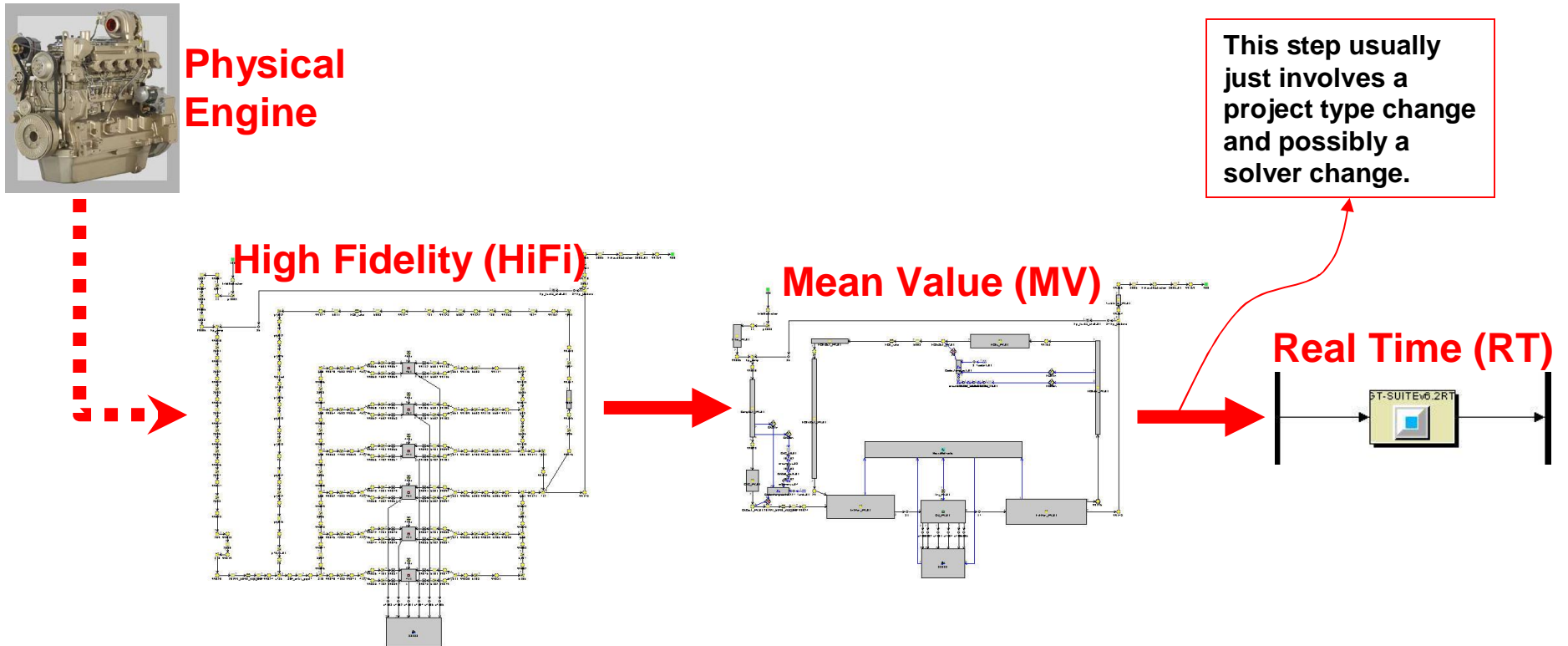
Definition of Transient Engine Model

A co-simulation between an engine model and an Engine Control Unit (ECU) model [Software-in-the-Loop (SiL)] or actual ECU hardware [Hardware-in-the-Loop (HiL)].



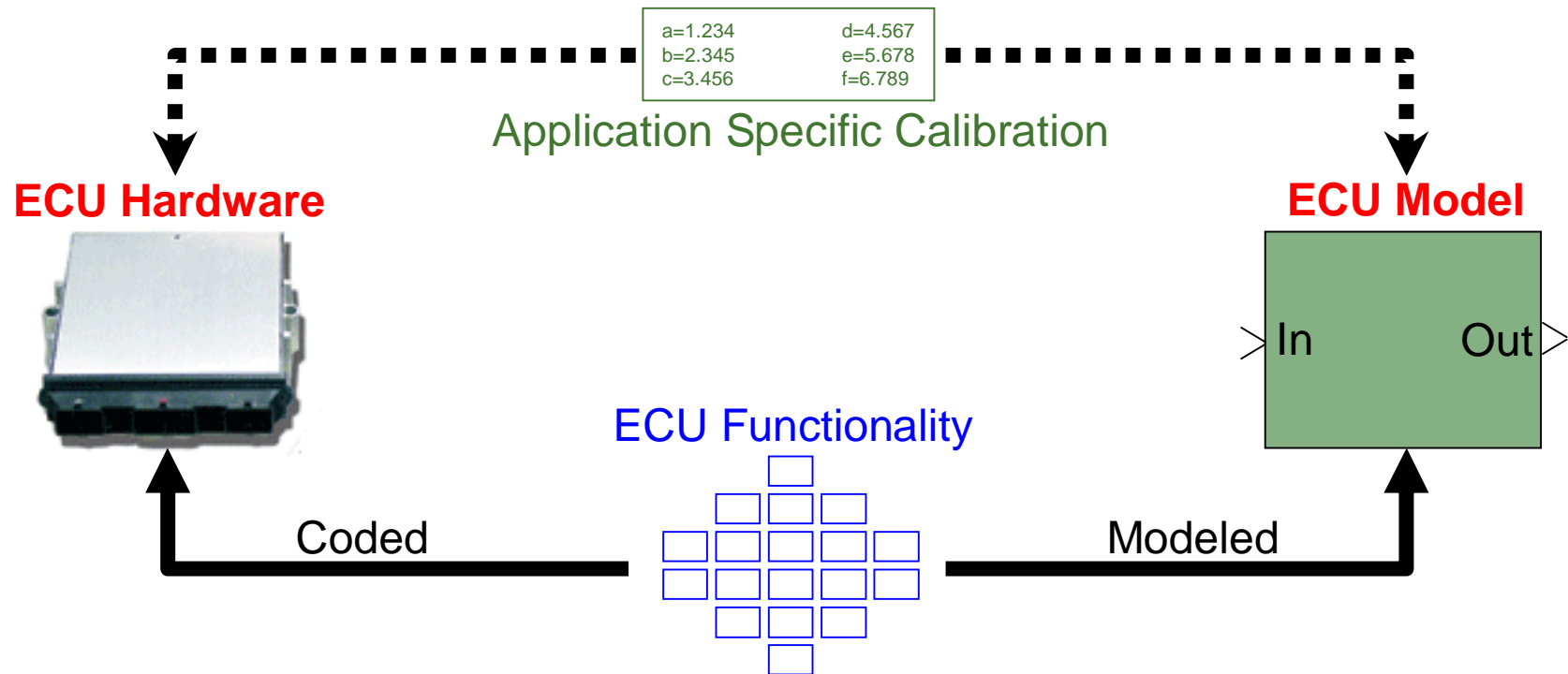
Components – Engine Model

A model of engine performance that may include emissions and/or aftertreatment. Model fidelity is determined by the intended use of the model.



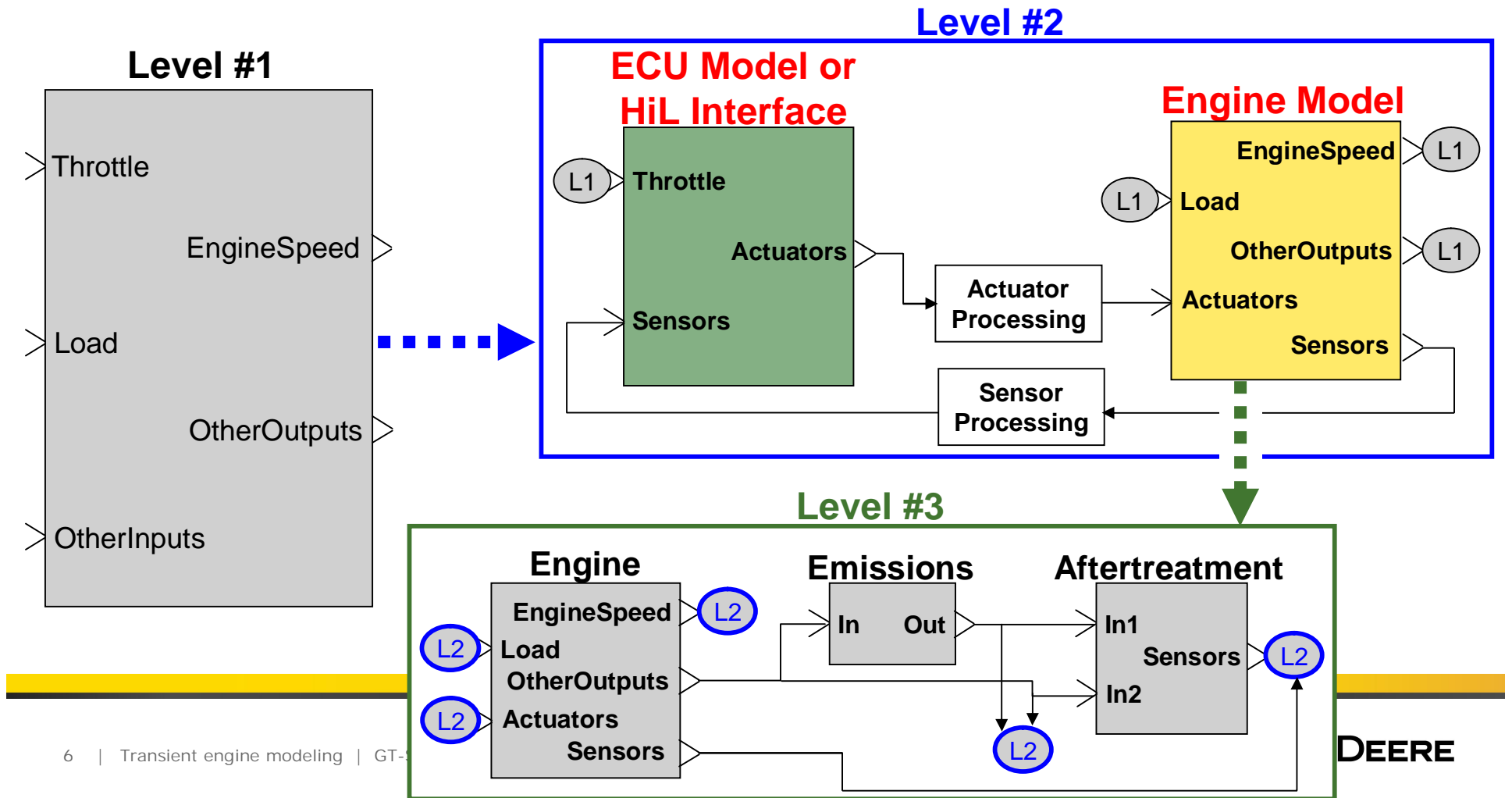
Components – ECU Model

A system level model of ECU software functionality, which can then be used on a standard PC for virtual development. The ECU model is critical to generating accurate transient performance predictions.



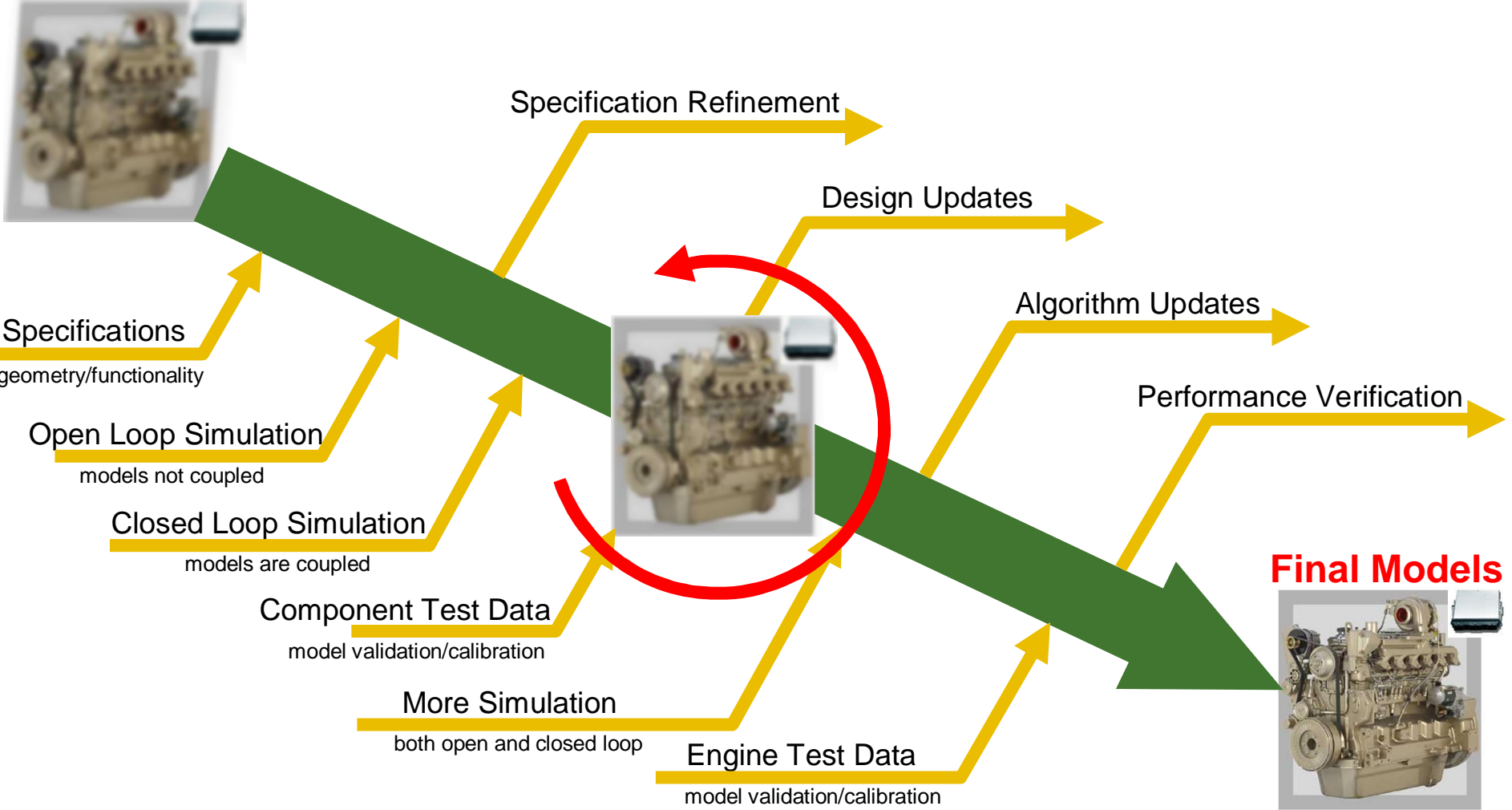
Components – Interface Model

The model that defines the connections between all other models. It has a modular setup to make it easily configurable.



Model Development Process

Rough Models



Model Applications

Model based software development:

- Control algorithm development
- Control algorithm testing and validation
- Auto-generation of ECU code

Engine system performance:

- Optimization
- Non-standard conditions
- Gain tuning

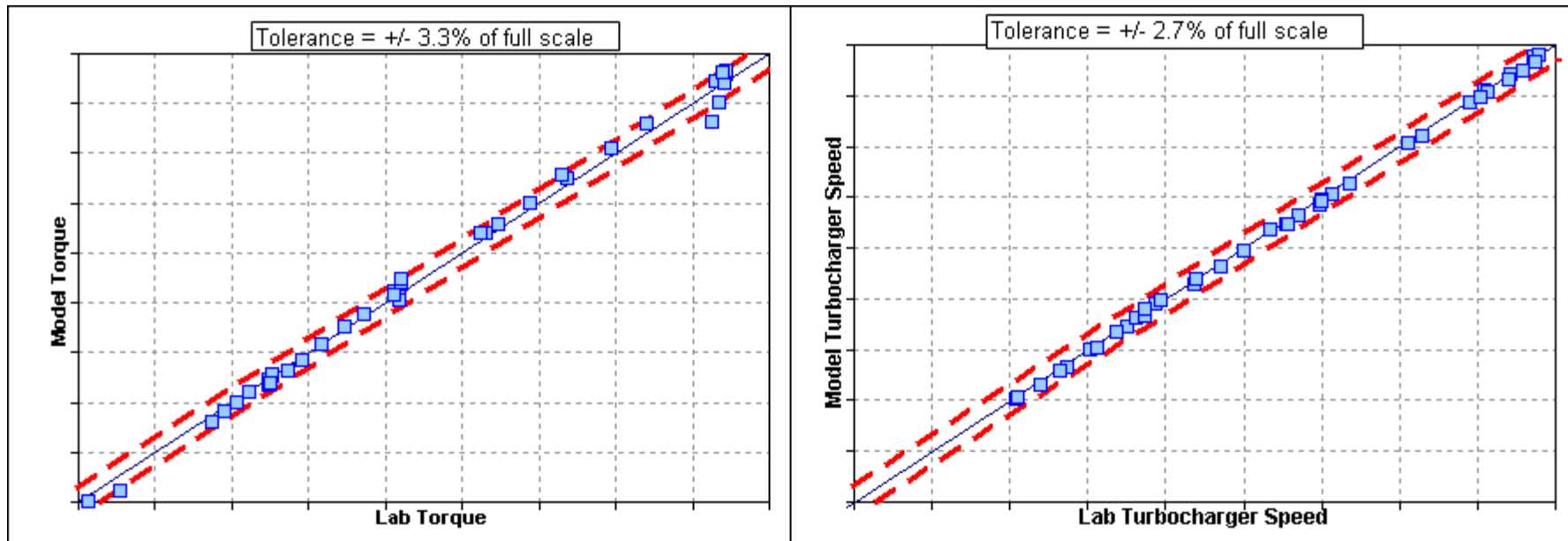
Integration of engine into vehicle:

- Controller interaction
- Performance verification and optimization

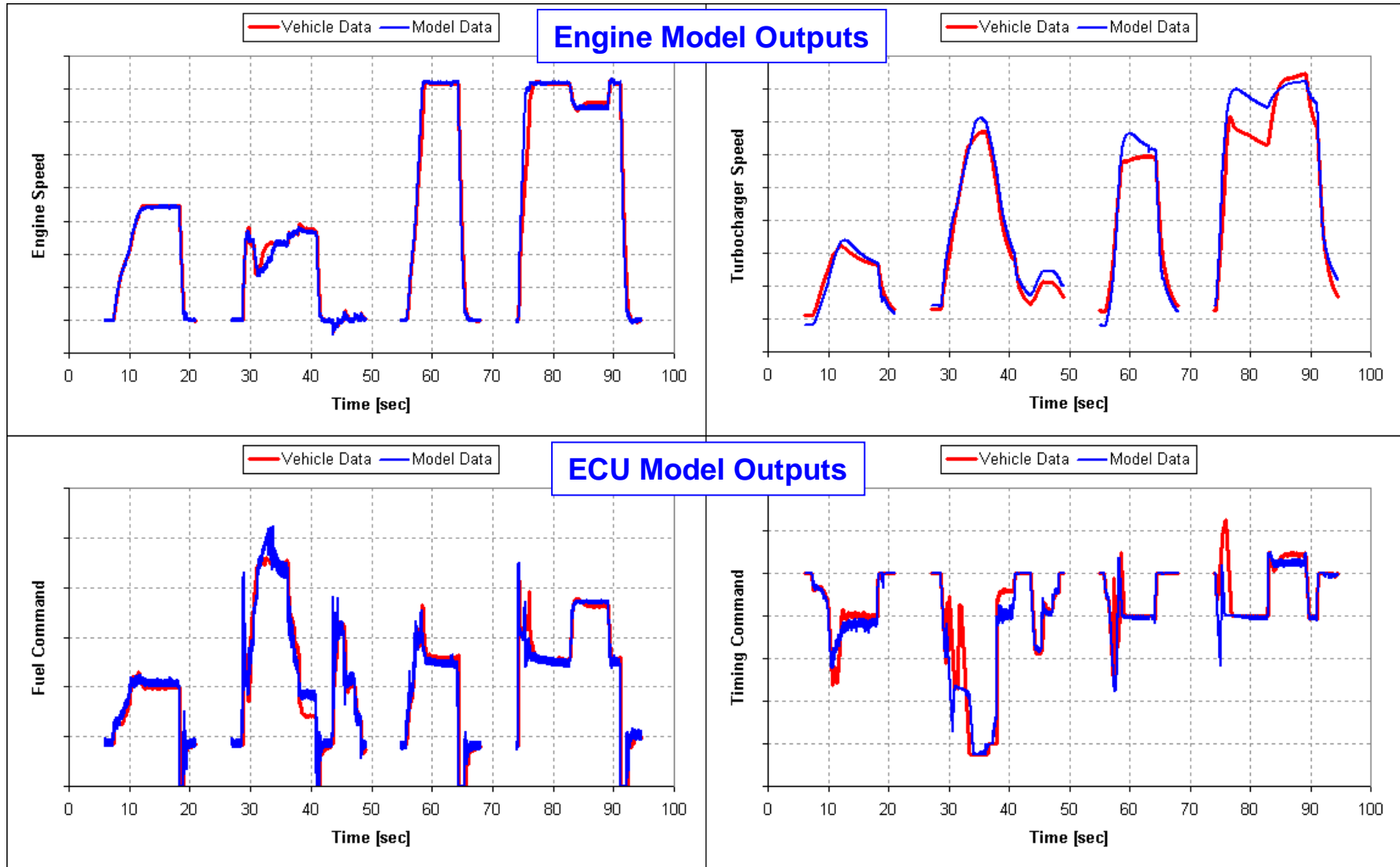
Sample Results A – Performance

High Fidelity transient engine model versus vehicle data:

- Engine model calibrated to 41 steady state data points (see below).
- Engine model coupled with ECU model for transient comparison.
- Two inputs applied to transient engine model from vehicle test.
 - Throttle
 - Load (drive shaft and auxiliaries)



Sample Results A – Performance (continued)



Sample Results B – Emissions

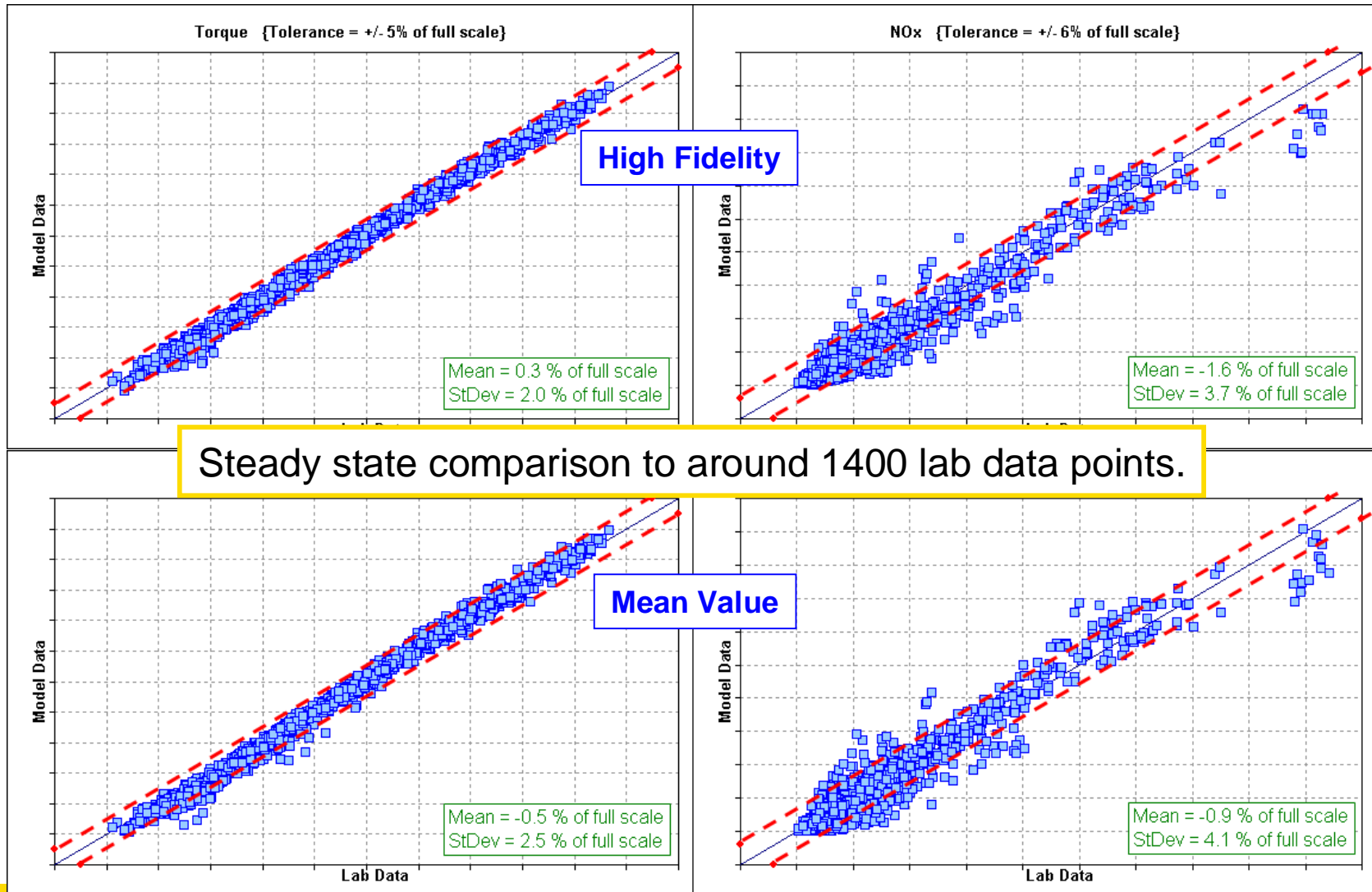
Engine models versus dynamometer data:

- High fidelity engine model calibrated to 29 steady state data points.
- Mean value engine model created from high fidelity model.

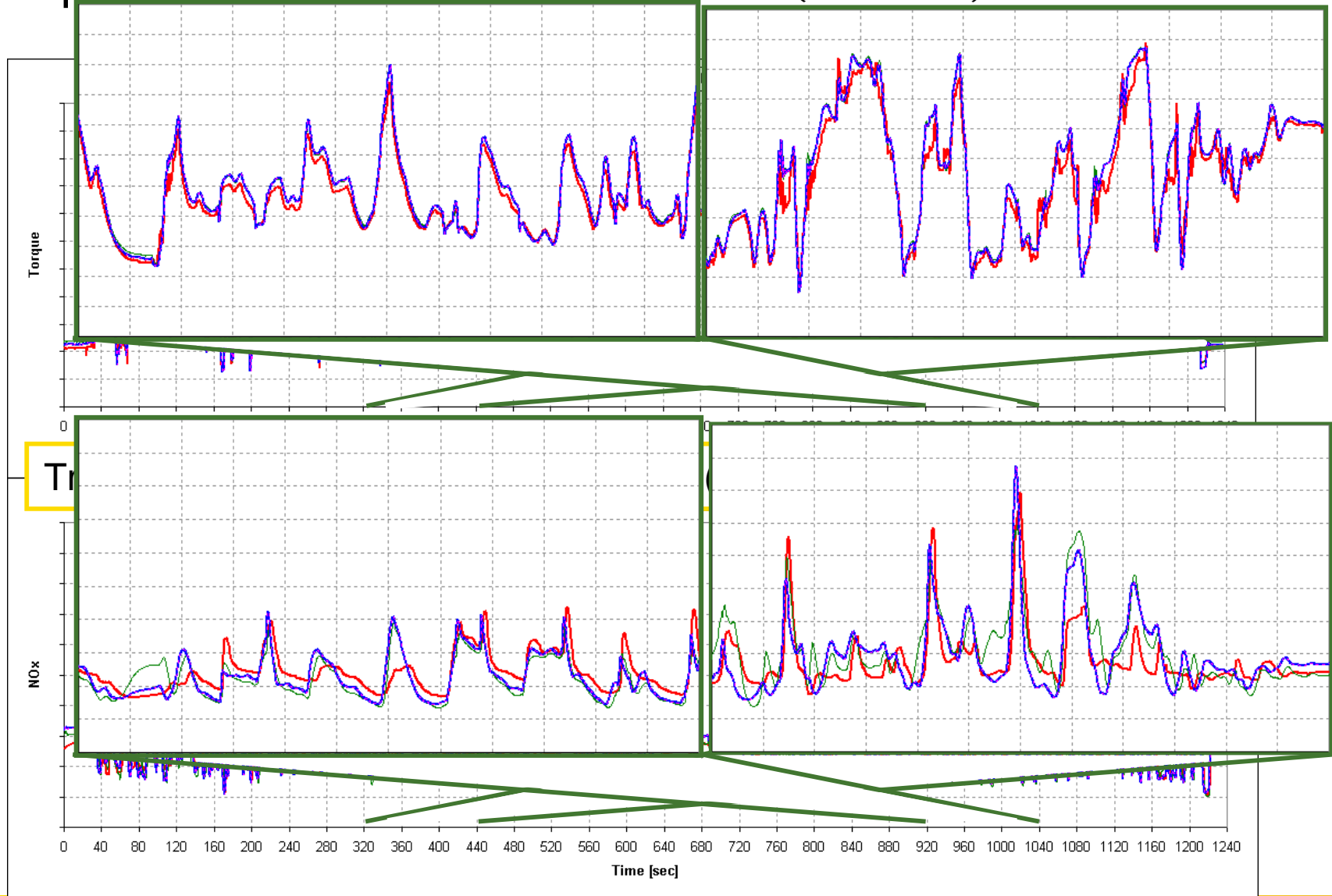
Additional steady state and transient model validation without an ECU model, which requires additional inputs from the lab data:

- Engine speed
- Actuator commands from ECU (e.g. fuel, timing, EGR valve, etc.)
- Steady state comparison to around 1400 lab data points. Includes ranges of operation not included in the original calibration.
 - Wider range of actuator positions.
 - Swings in various system restrictions.
 - Swings in ambient temperature.
- Transient comparison to a set of NRTC (Nonroad Test Cycle) lab data.

Sample Results B – Emissions (continued)

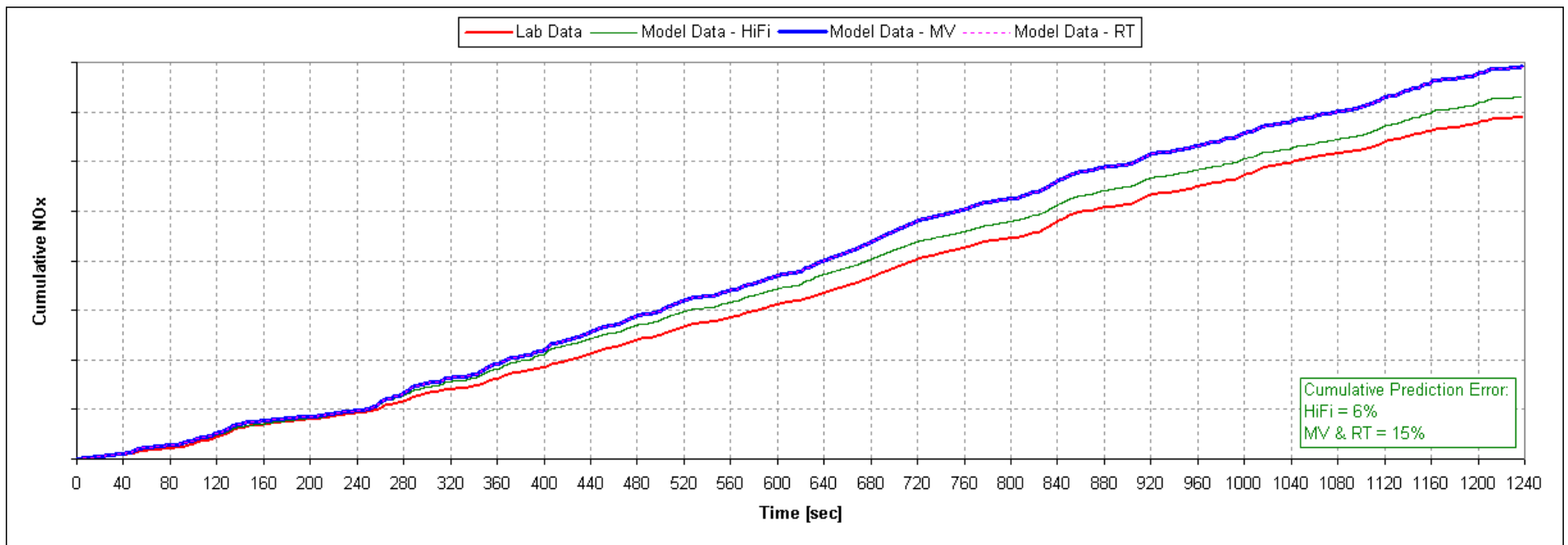


Sample Results B – Emissions (continued)



Sample Results B – Emissions (continued)

Transient comparison to a set of NRTC (Nonroad Test Cycle) lab data.



Summary

- A transient engine model for today's engine must include an engine model AND ECU model.
 - Engine model validation can be done without an ECU model but engine performance prediction requires an ECU model.
- Model development is an integral part of hardware development.
- GT-POWER is a very capable tool for developing engine models for each point in the process.

Questions ?



JOHN DEERE