Integrated Simulation of the Engine and Control System of a Turbocharged Diesel Engine

***Yongsheng He*, Chan-Chiao Lin, Anupam Gangopadhyay**
General Motors Corporation

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Outline

- **Introduction**
- **Model Description**
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  - Controller
  - Integration
- **Results and Discussion**
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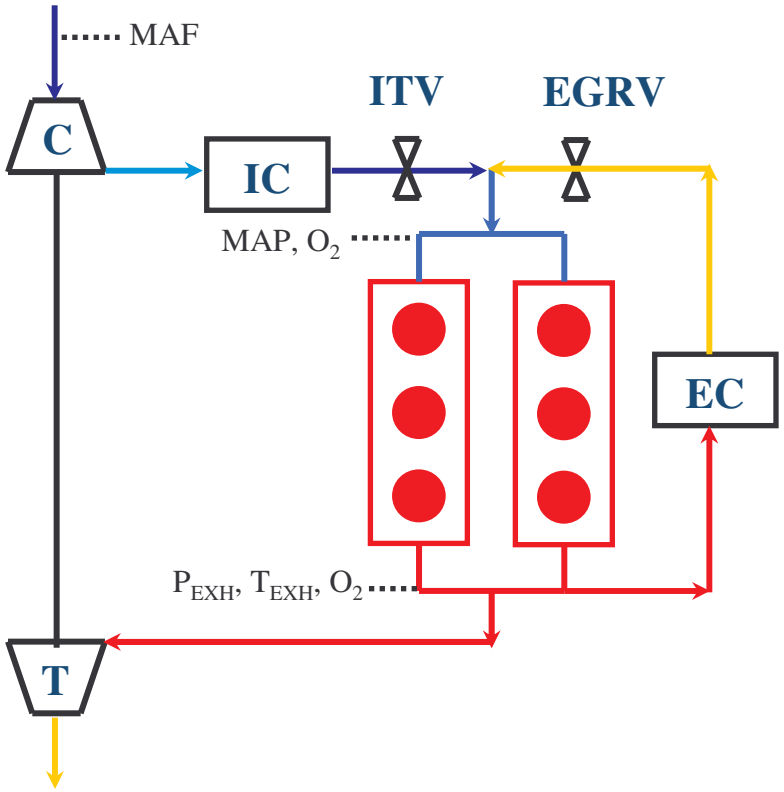
  - Step transients
  - FTP cycle
- **Summary**

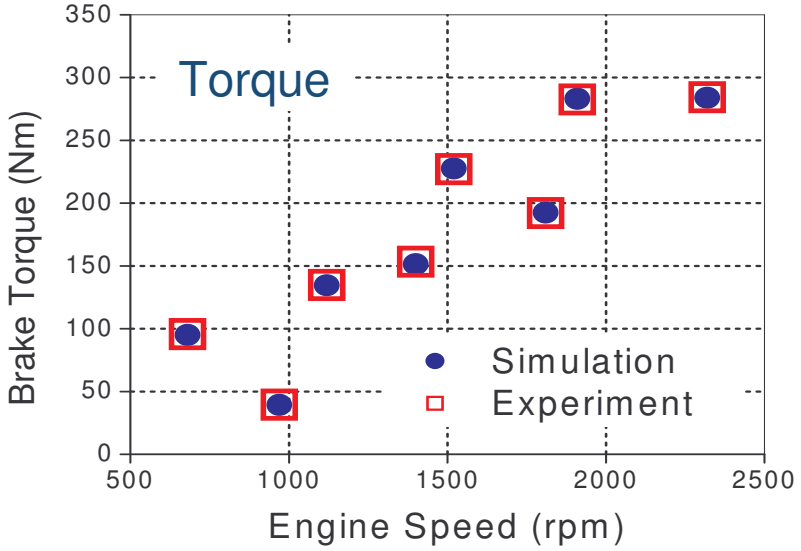
Introduction

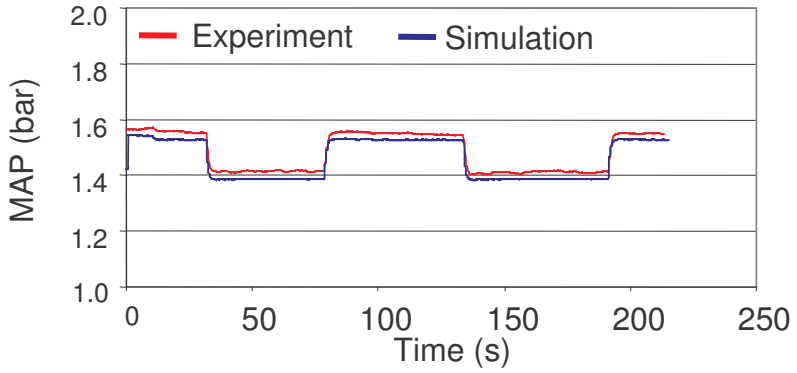
- **Math-based control development in automotive industry**
  - Much of control design and development process could be done off-line using computer simulations
  - Dramatically reduce development time and risk
- **Physical plant/engine model needed**
  - 0D model for control design
  - 1D model for control analysis
- **Integrated engine and control system model valuable**
  - Accurately evaluate control algorithms
  - Explore different control strategies & study parameter sensitivity
    - Before experiments conducted
    - Before hardware selected and built

Model Description: Engine

- **Detailed engine model using GT-Power**
  - Calibrated and validated (SAE 2005-01-3857)
    - Steady-state and transient
  - Turbocharged 4.9L V6 Diesel

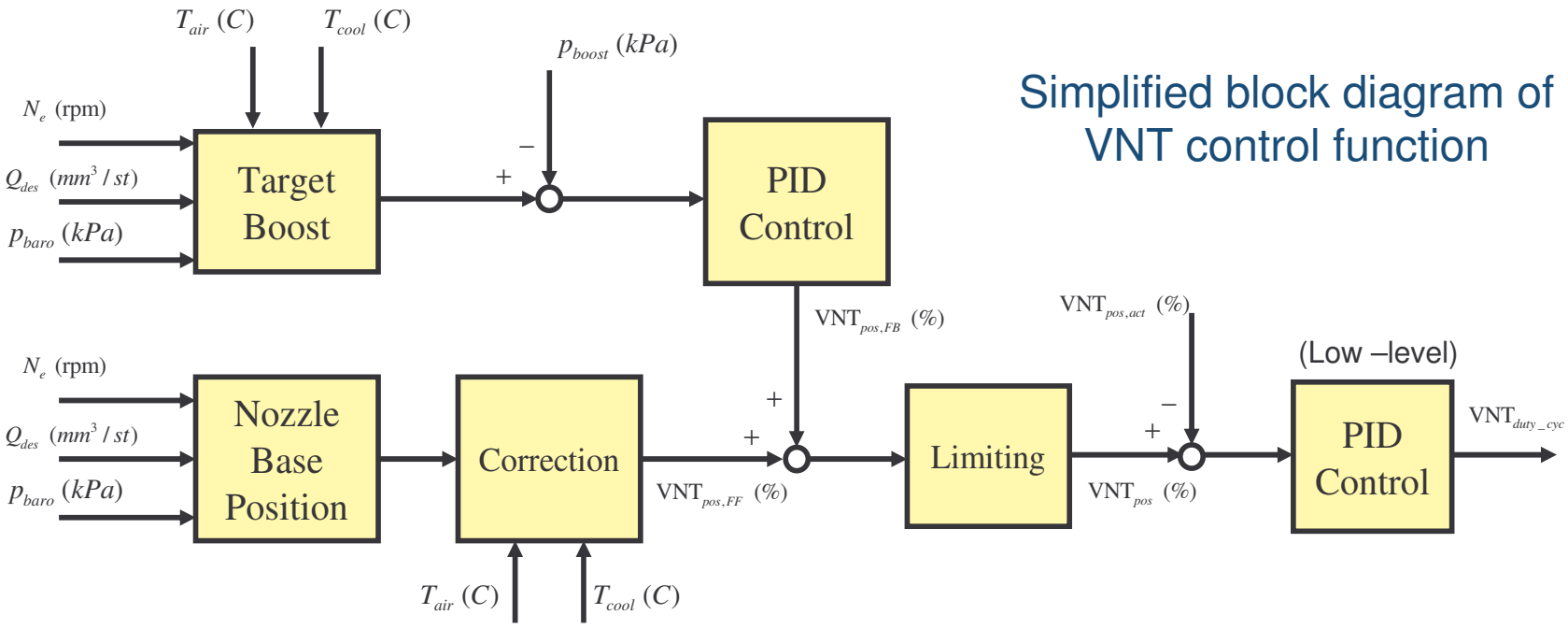






Model Description: Controller

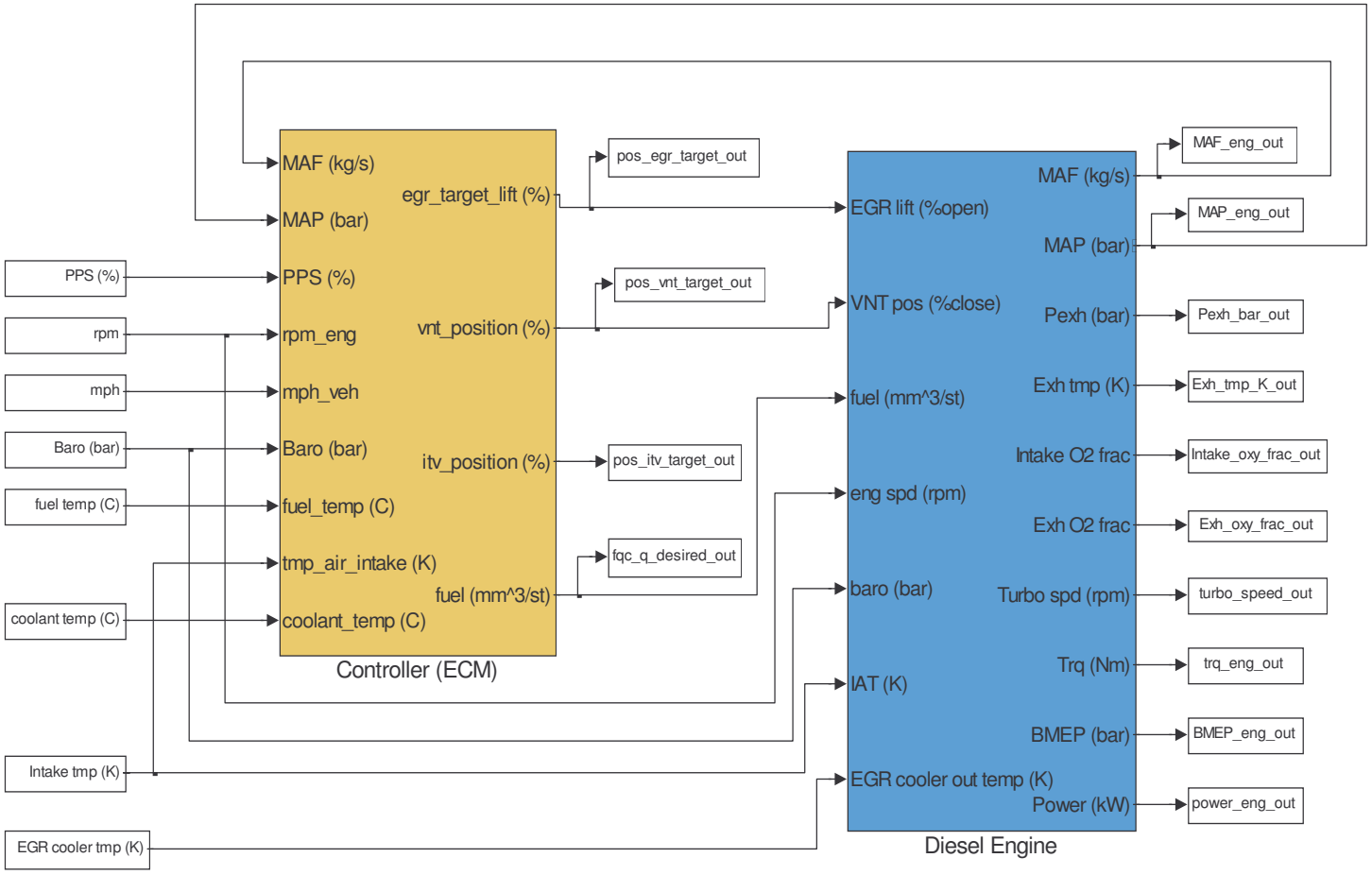
- **Comprehensive controller model in Simulink**
  - Reproduce production-like ECM algorithms
    - Rapid Prototyping Controller operated as the ECM with production calibrations and verified on chassis dyno (SAE 2005-01-1344)
  - An example – VNT control



Simplified block diagram of VNT control function

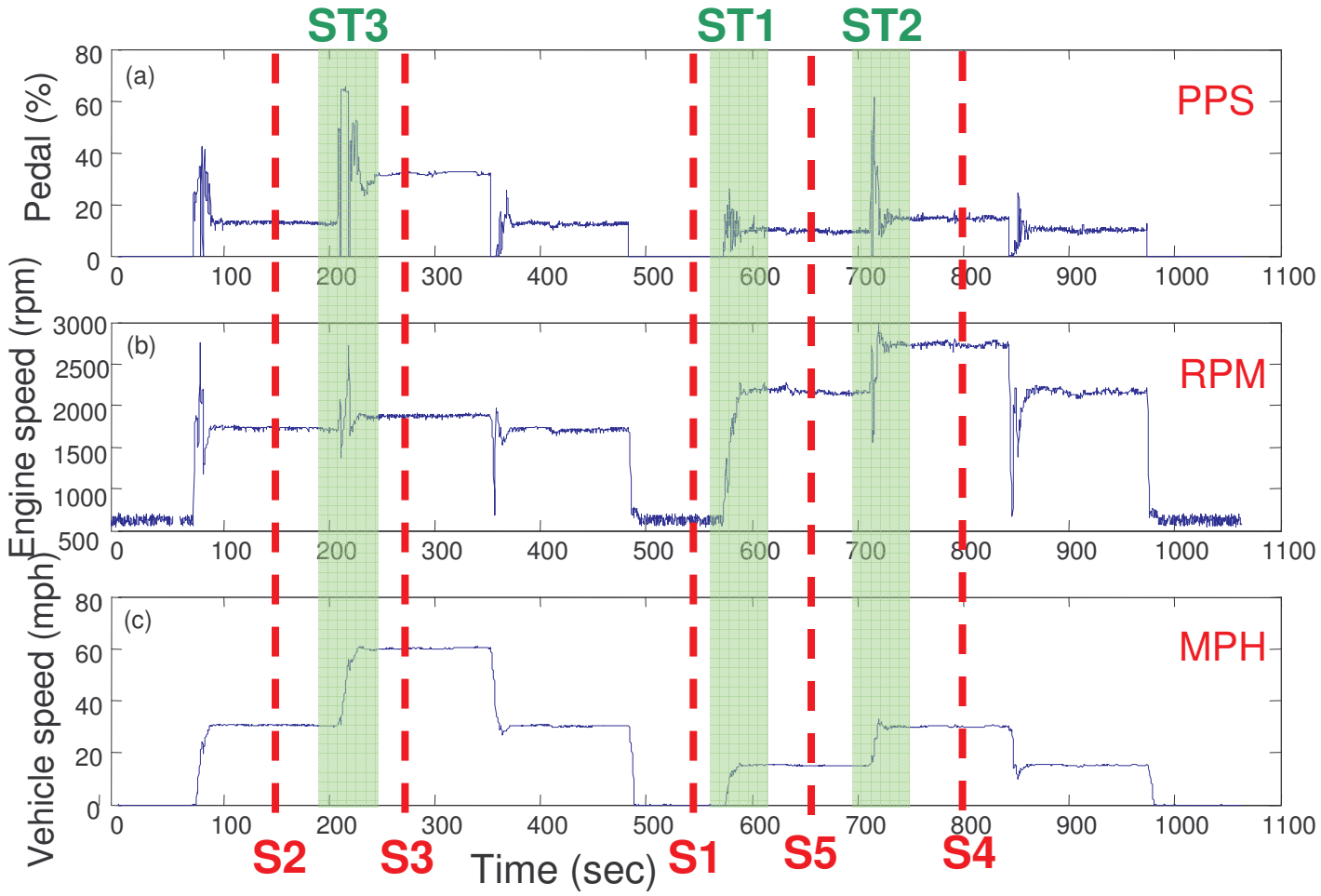
Model Description: Integration

- **Focus on fuel quantity, EGR, and VNT control**
  - Low-level control assumed to be perfectly achieved
  - Simplifications made (e.g. fuel rail pressure control by-passed)

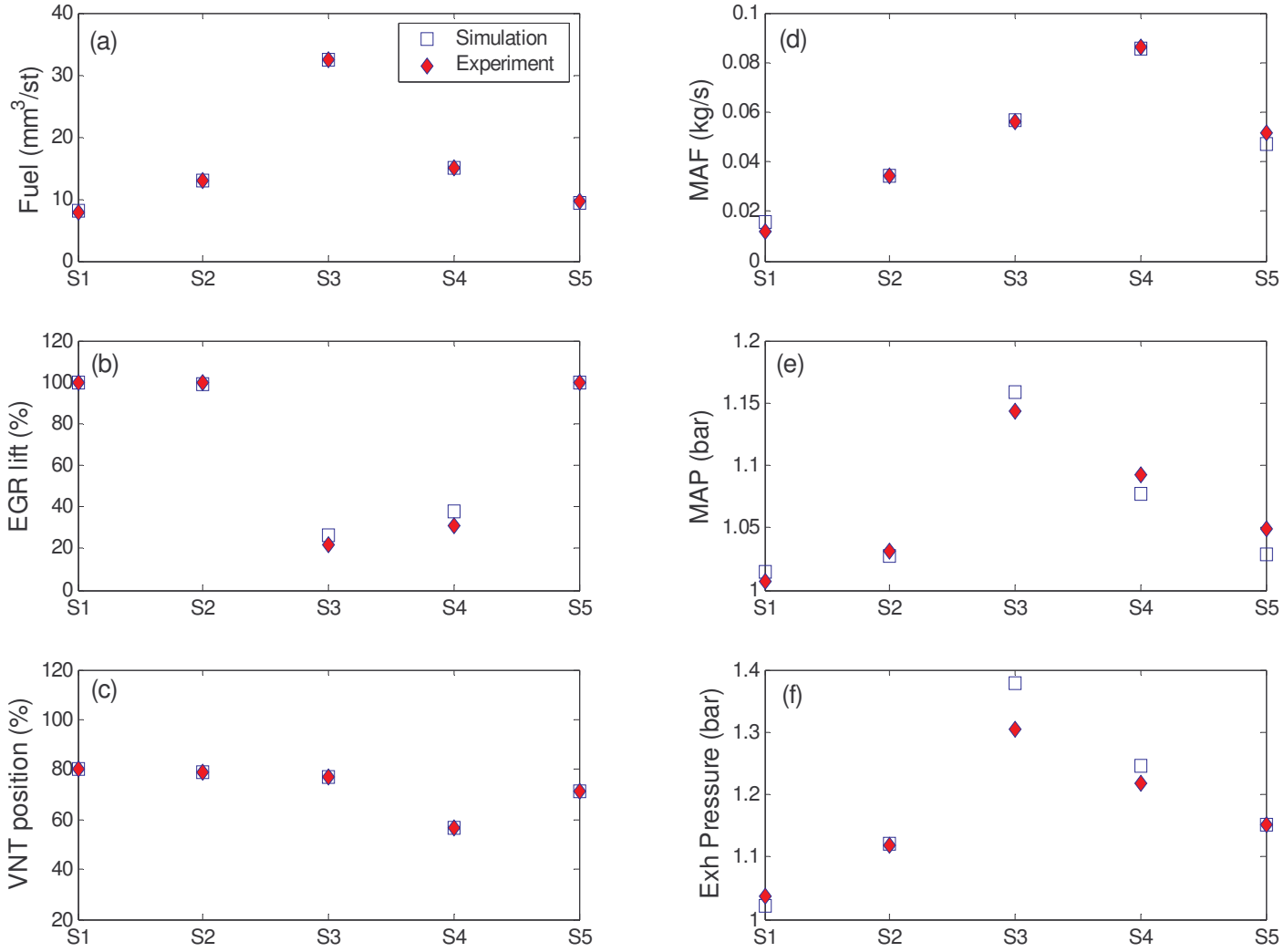


Model Validation: Vehicle Testing

- **Series of different cruising and acceleration conditions**
  - Selected for validation: 5 steady-state (**S**), 3 step transients (**ST**)



Simulation Results: Steady-State



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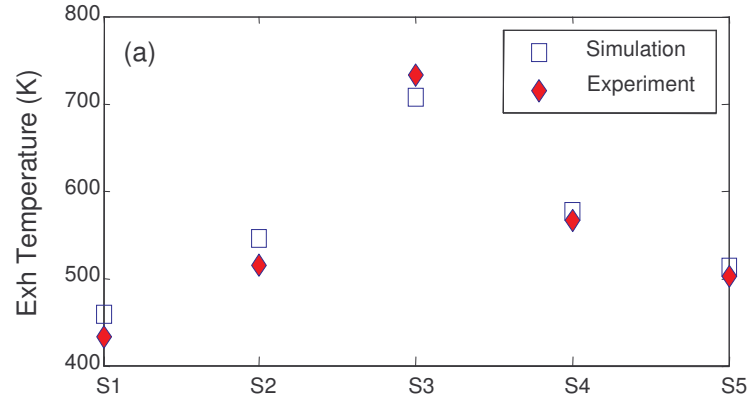

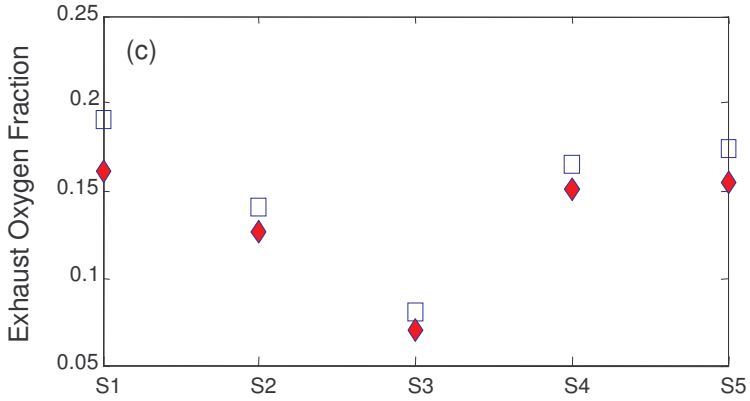

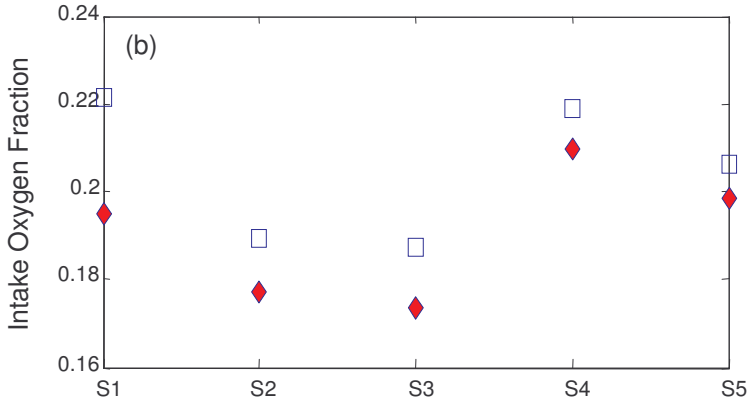

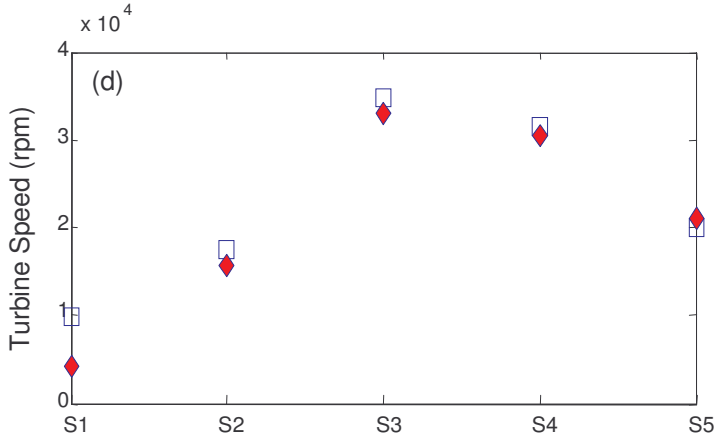

Model Validation: Vehicle Testing

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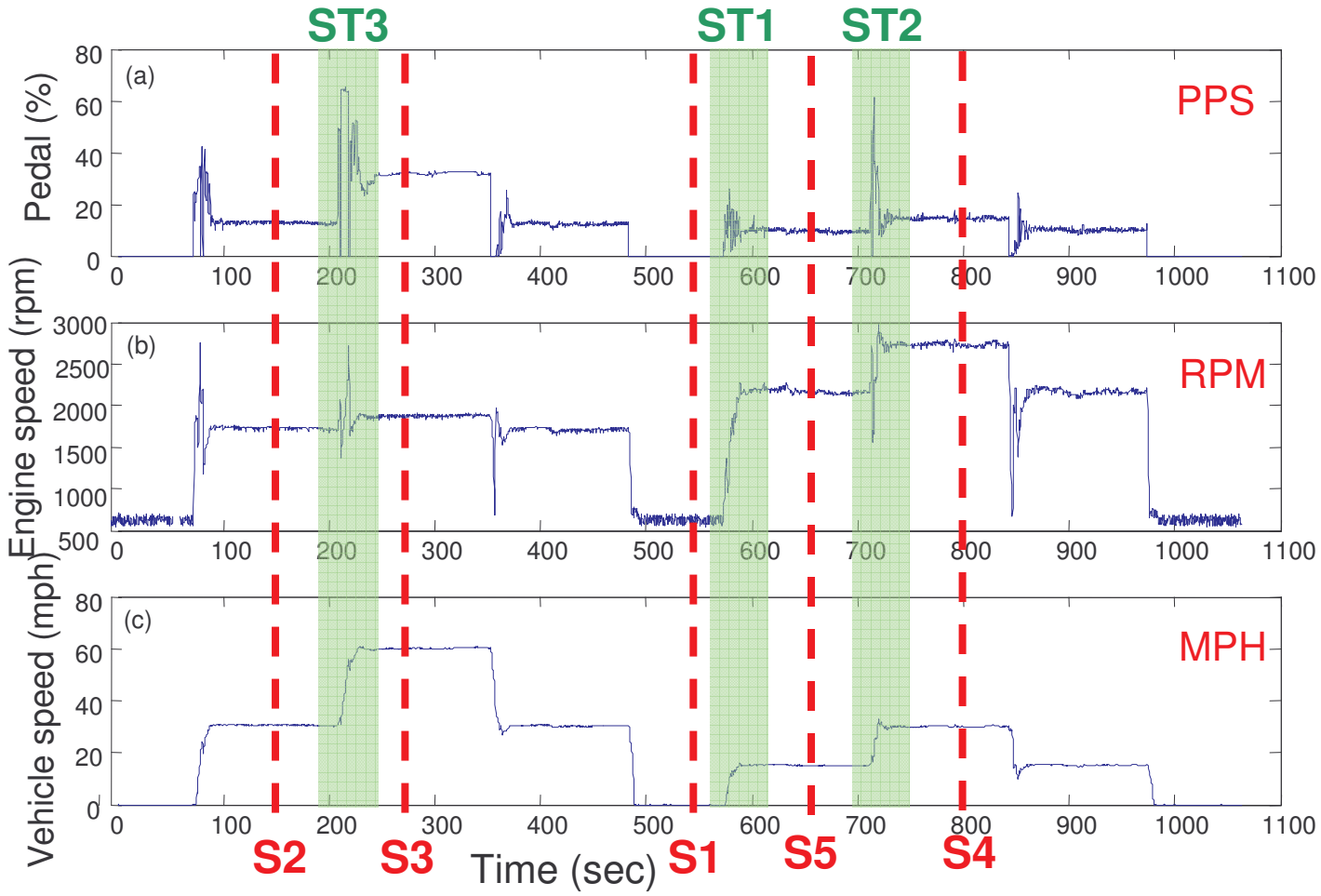
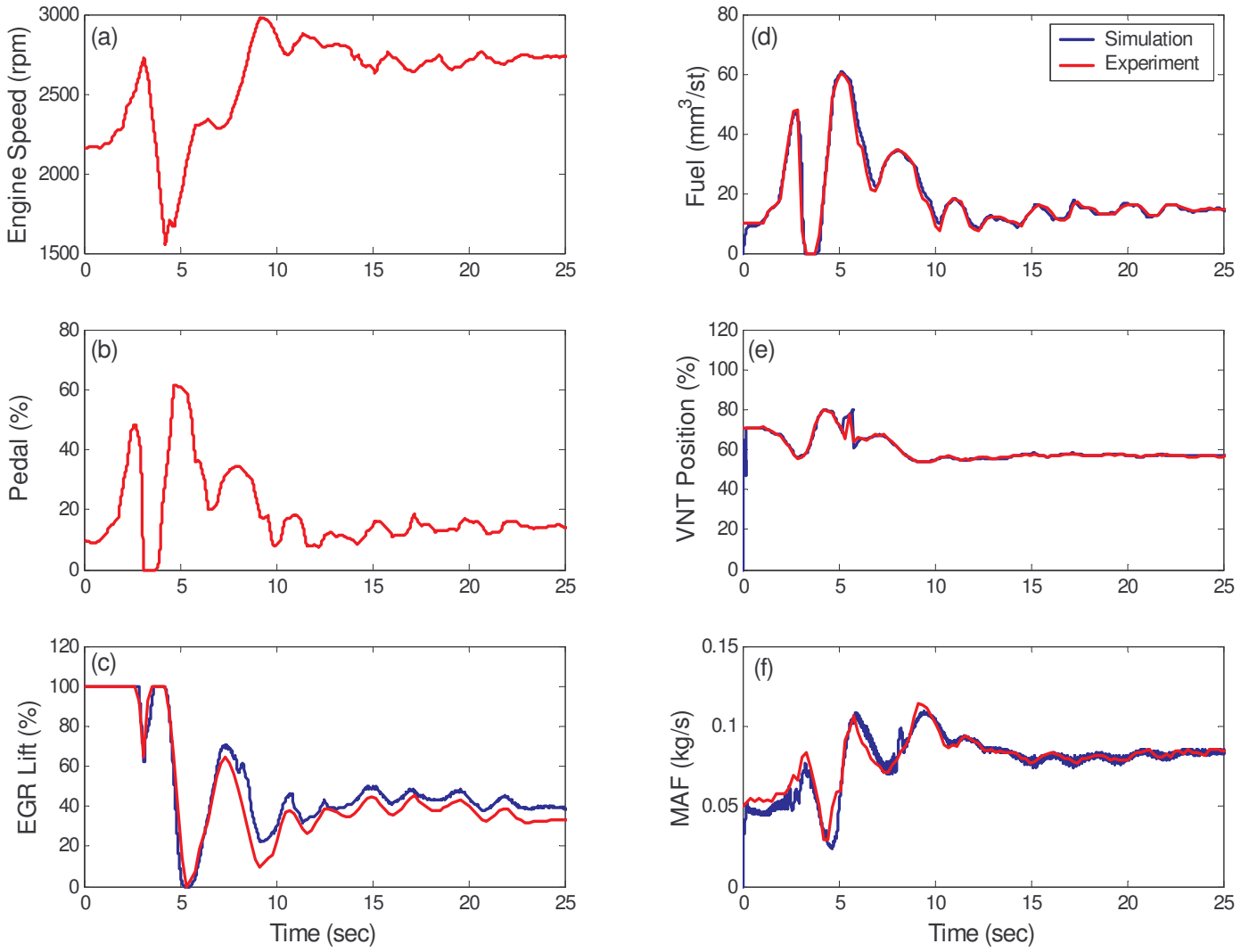


Simulation Results: Step Transient (ST2)



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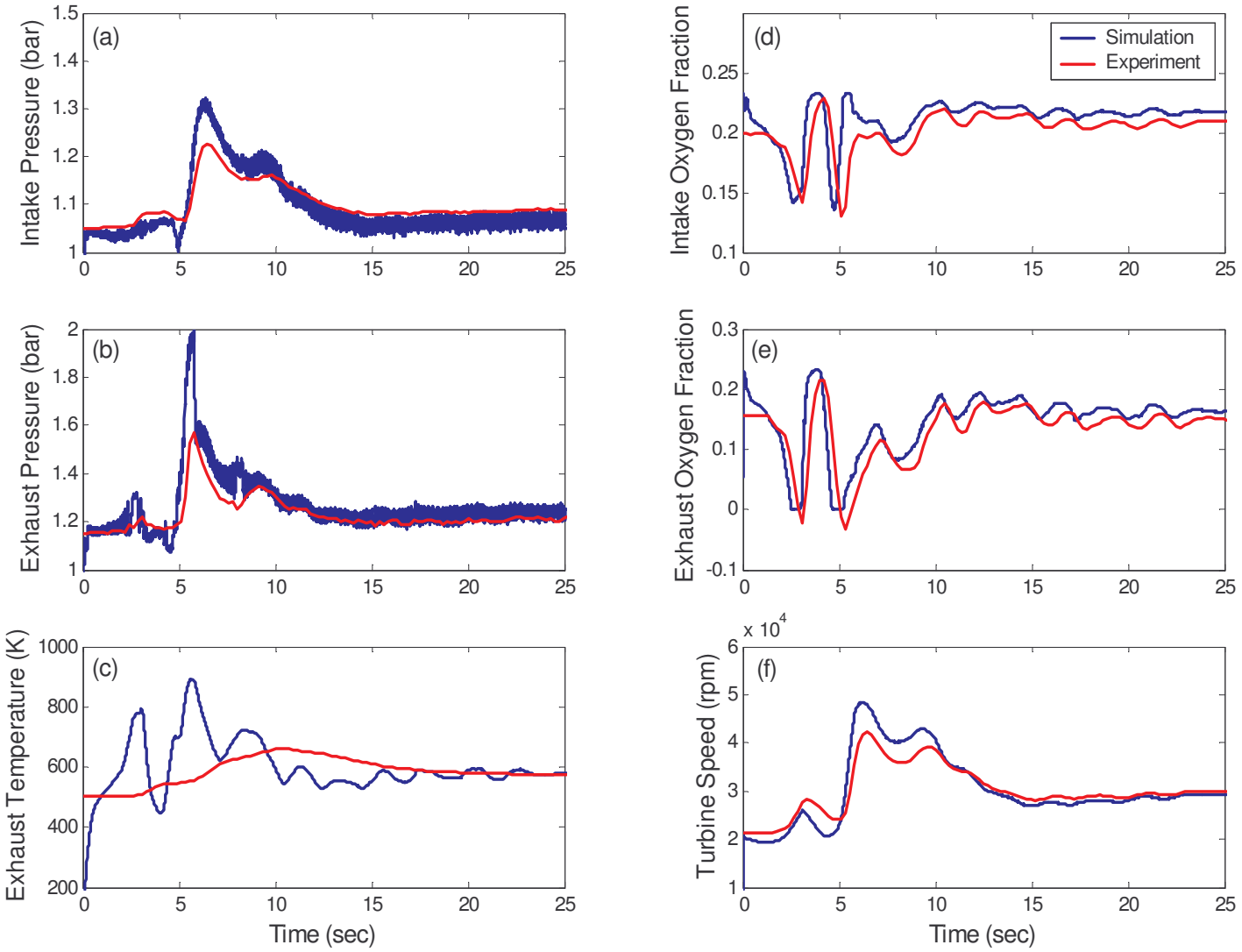
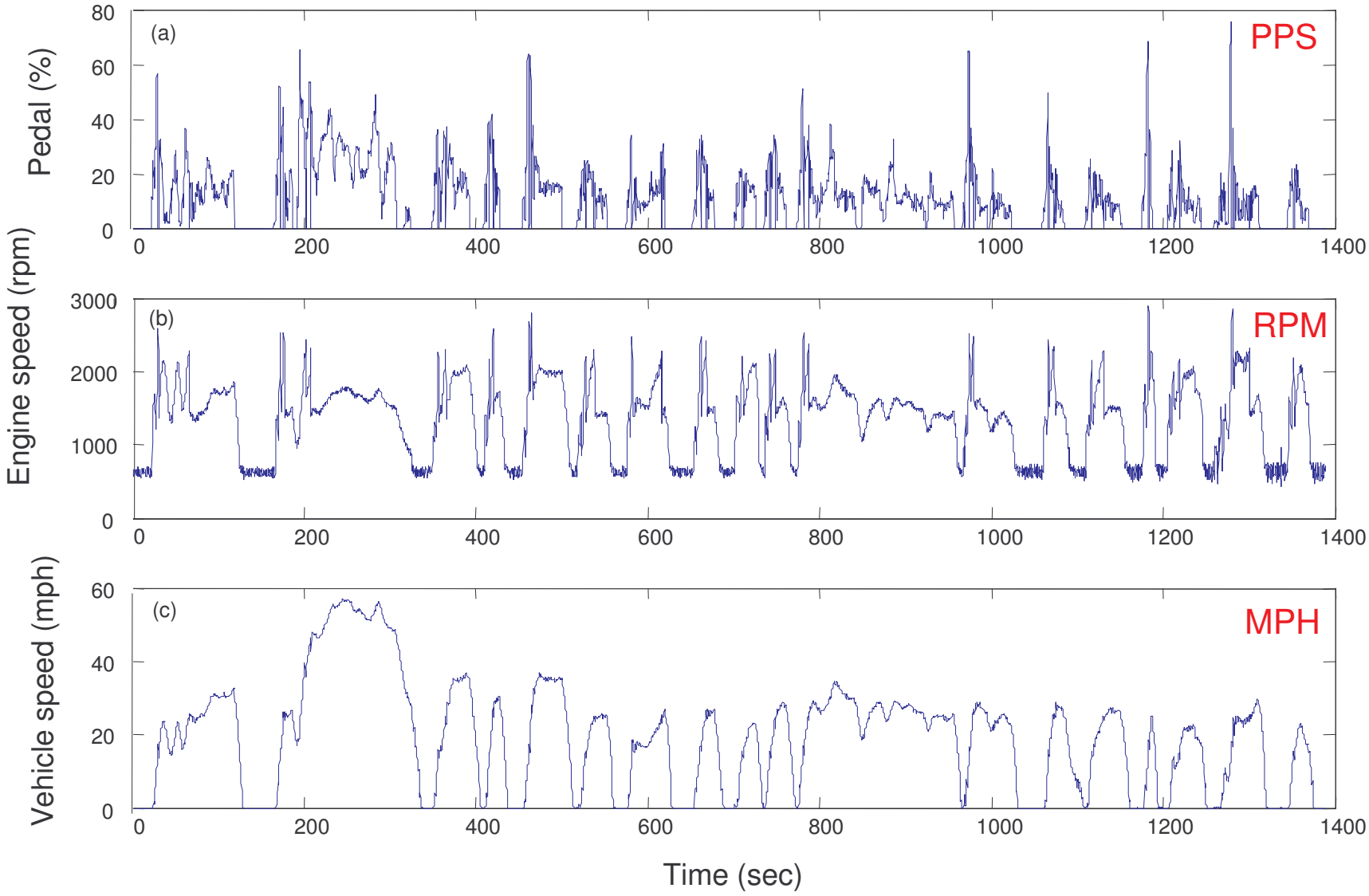
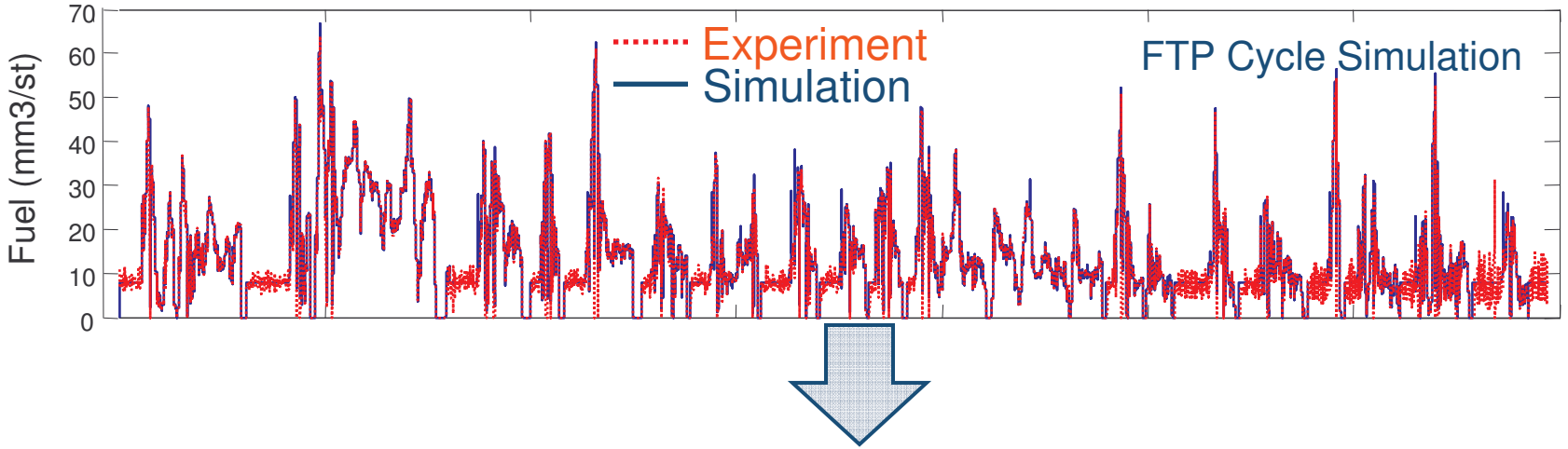


Model Validation: FTP Cycle

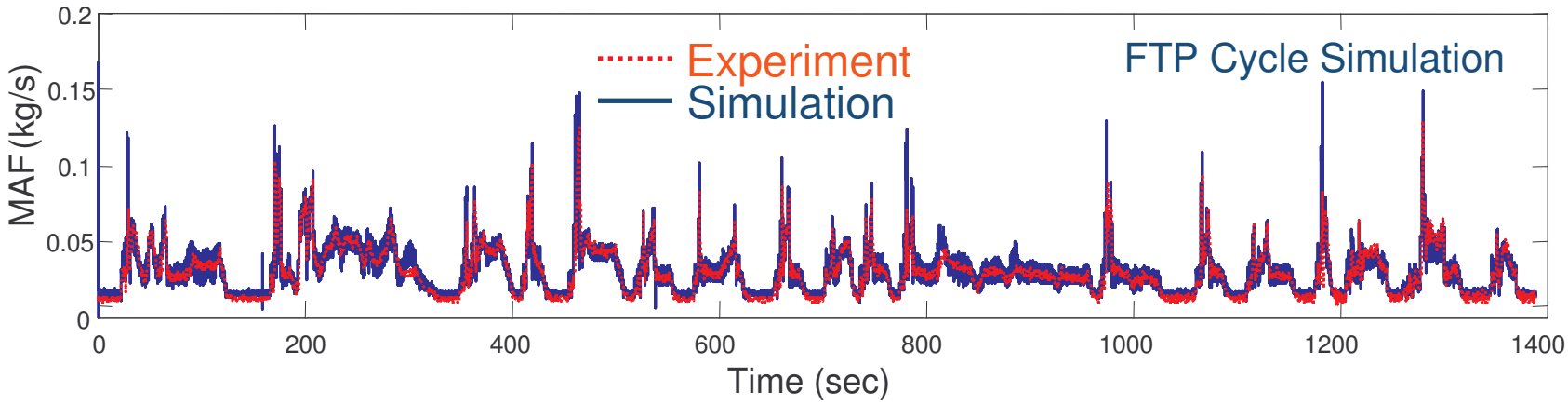


Integrated Engine/Controller Simulation

- **Control Actions (*Fueling*, VNT, EGR control …)**



- **Engine Response (*Mass Air Flow*, Intake/Exhaust Pressure …)**



Summary

- **An integrated model of the engine and control system has been developed.**
  - Detailed engine model in GT-Power
  - Comprehensive controller model in Simulink
    - Production-like ECM algorithms with production calibrations

- **The integrated engine and control system model has been extensively validated with satisfactory accuracy achieved.**
  - 5 Steady states
  - 3 Step transients
  - 1 FTP cycle

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