Simulation of AWD Performance with Multi-body Chassis Model and Hardware in the Loop System (HILS)

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HONDA
The Power of Dreams

Contents

SIM PACK

- Background/Scope
- Goals of Activity
- AWD System Overview
- Simulation Method
  - -Model Architecture Overview
  - -MBD Model Validation
  - -HILS Bench Design
  - -Real-Time Model Integration
- Test Scenario
- Summary

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Background/Scope

Current Environment:

- Computer controls are expanding into every major vehicle system.
- OEM and supplier resources are constrained to maintain costs and development schedule.
- Simulation tools have improved so that simulation speed and model fidelity are no longer mutually exclusive

Opportunity and Challenge:

Couple High-Fidelity Simulation Tools (Simpack) with computer controls hardware in order to create a new workspace for control-prototyping

Goals of Activity

- Construct a Real-Time Simpack model that has the correct interfaces to the powertrain models and AWD HILS bench and represents the performance of the base chassis .
- Construct a HILS bench in order to capture the actual AWD ECU control and servo-hydraulic actuator response.
- Construct a co-simulation environment in order to integrate the Simpack model and HILS bench.
- Demonstrate the ability of the co-simulation model to respond to control algorithm changes.

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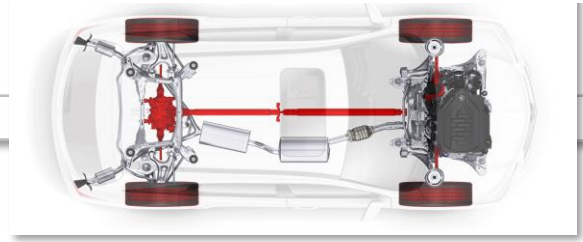
AWD System Overview

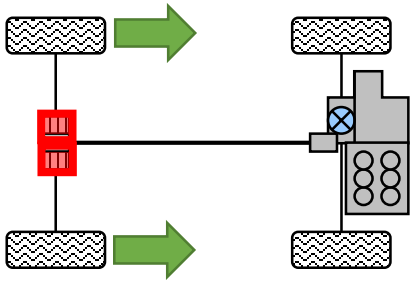
Key Specifications:

-Power take-off torque transfer

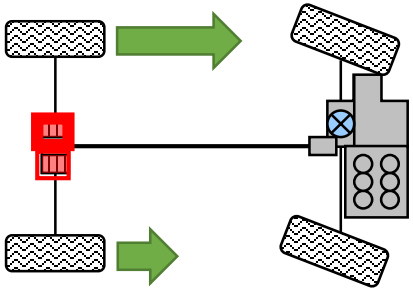
-Dual rear clutches for independent torque control

-Active control for longitudinal slip and lateral torque-vectoring





Control Objective:
Minimize Front Wheel Slip



Control Objective:
Throttle Line-Trace Ability

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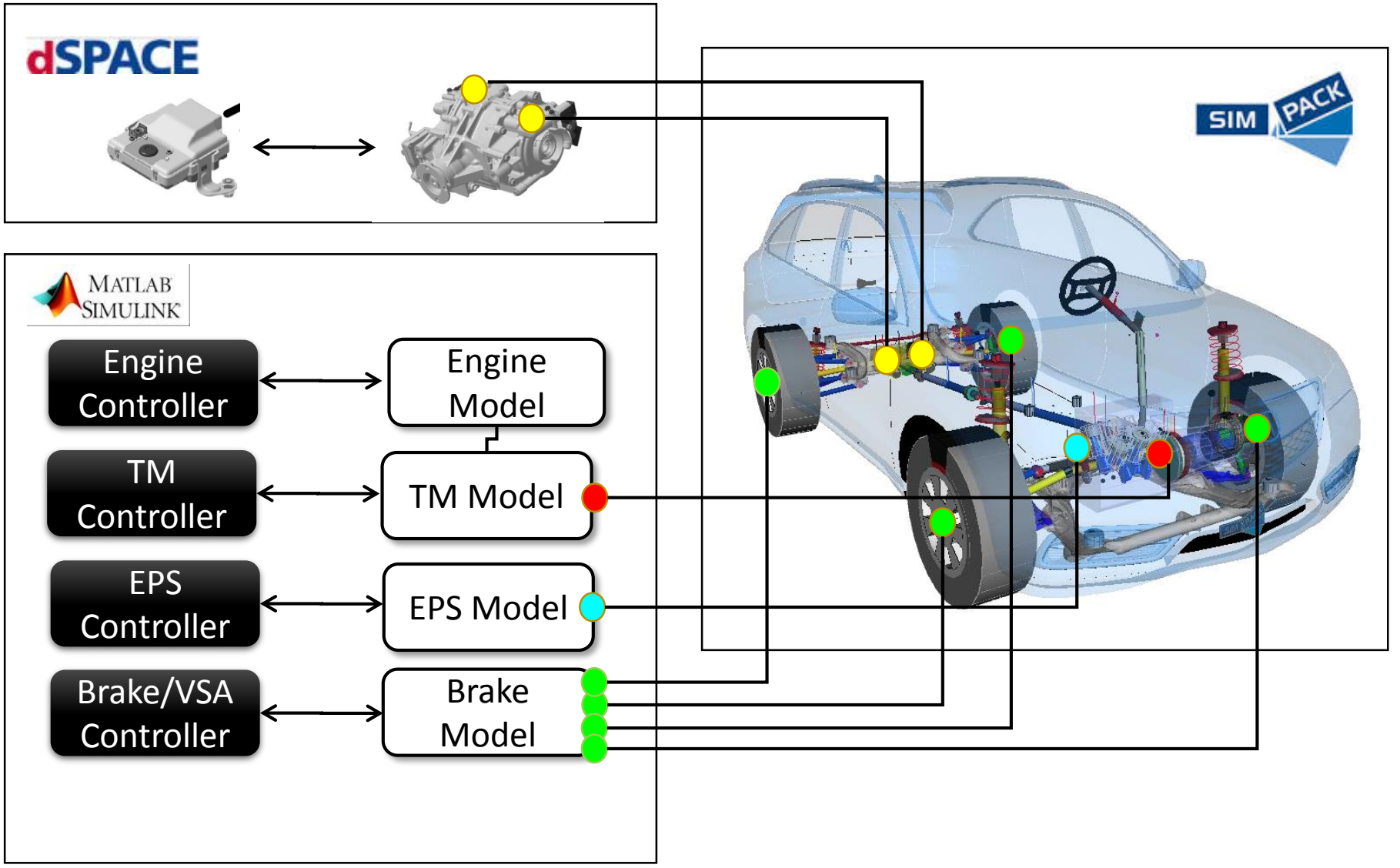
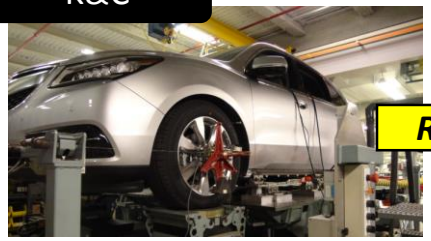
Model Architecture Overview



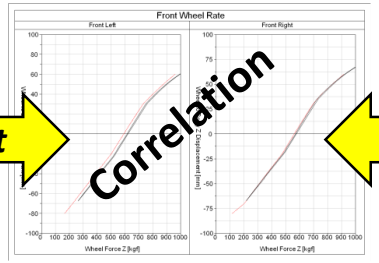
Simpack Validation (Indoor)

Step #1
Steady-state

K&C

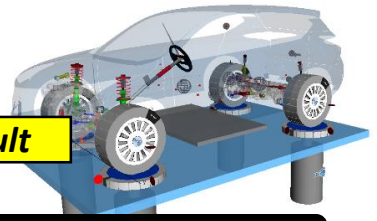


Result



Correlation

Result

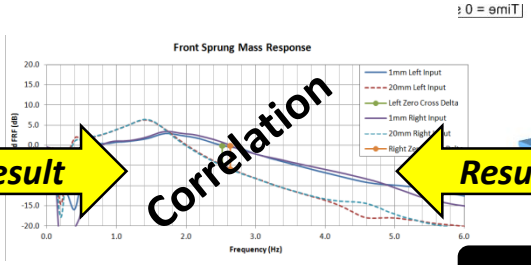


Virtual K&C

Step #2
Dynamic

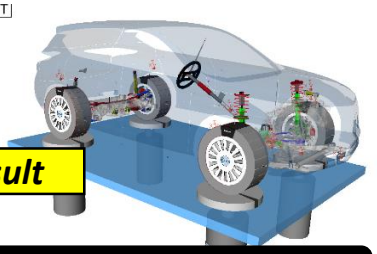
4-Post/Shaker

Result



Correlation

Result

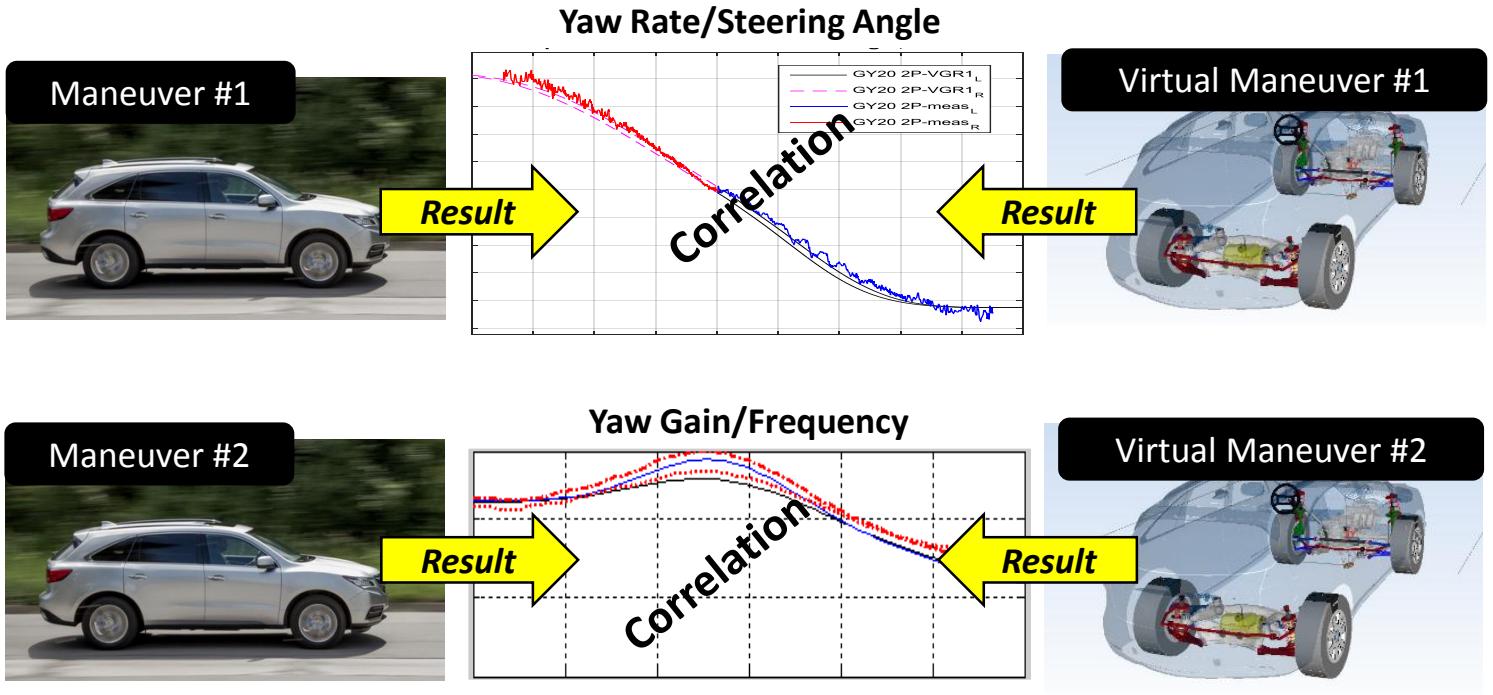


Virtual 4-Post/Shaker

Simpack base-chassis model was constructed and validated with laboratory test results in order to verify basic hard-points, mass properties, and compliances.

Simpack Validation (On Vehicle)

Step #3
Proving Ground
Test Correlation



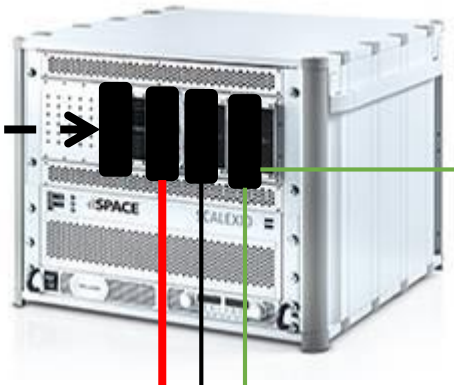
*Multiple maneuvers confirm steady-state and low-frequency dynamic response

The basic chassis system can be validated by laboratory test, so the Tire + Proving Ground Effect can be isolated

HILS Bench Design

Co-Simulation BUS

From Vehicle Model
-Engine Torque
-Gear Position
-Wheel Speeds
-Steer Angle
-G-sensor
To Vehicle Model
-Left Clutch Pressure
-Right Clutch Pressure



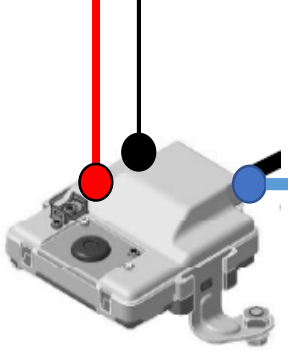
Left Clutch Pressure

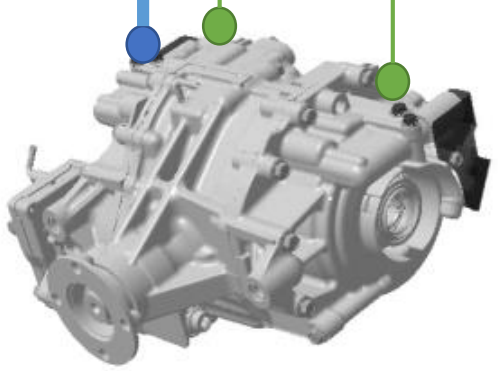
Right Clutch Pressure

12V Power Supply

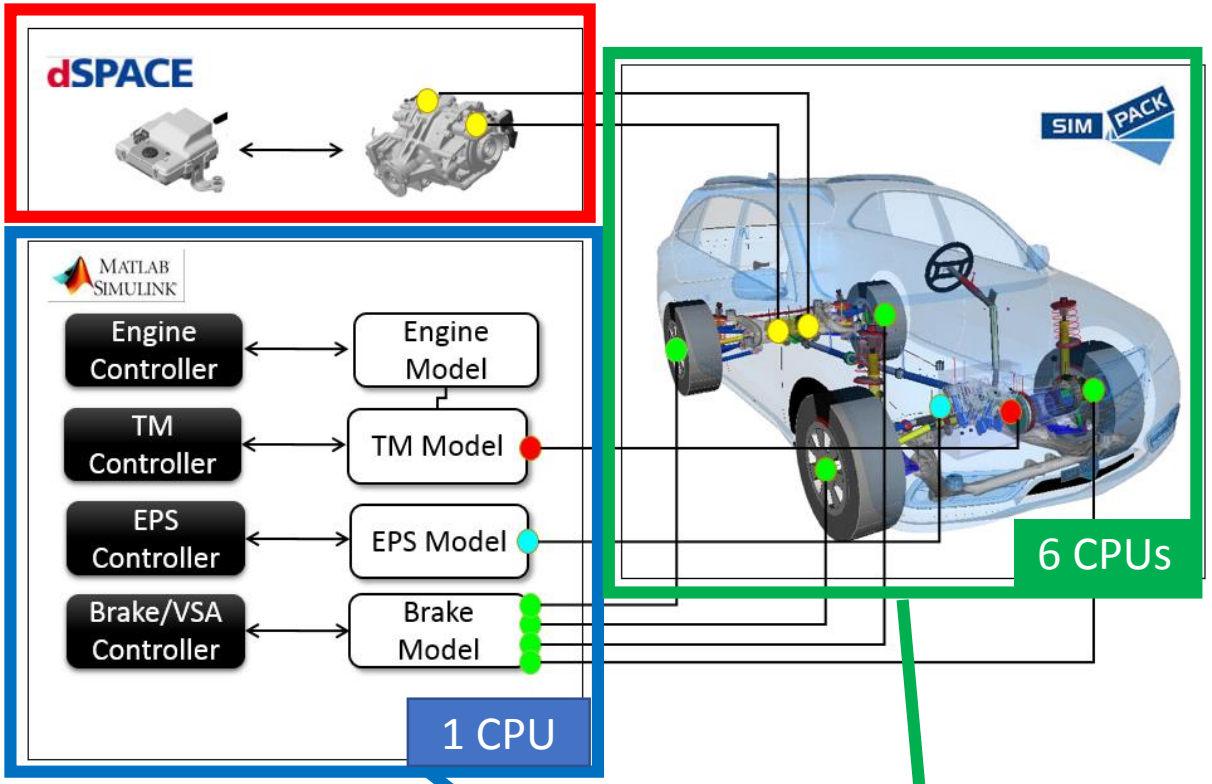
CAN BUS

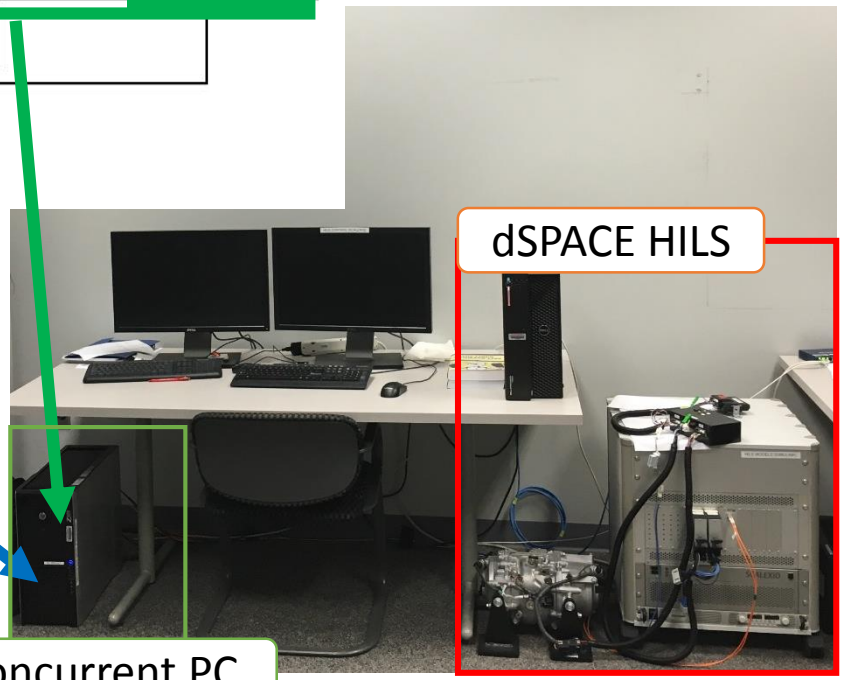
AWD Harness





Real-Time Model Integration





All models are coupled in the Concurrent Real-Time environment with internal I/O (Simpack-Simulink) and external I/O (Simpack-dSPACE)

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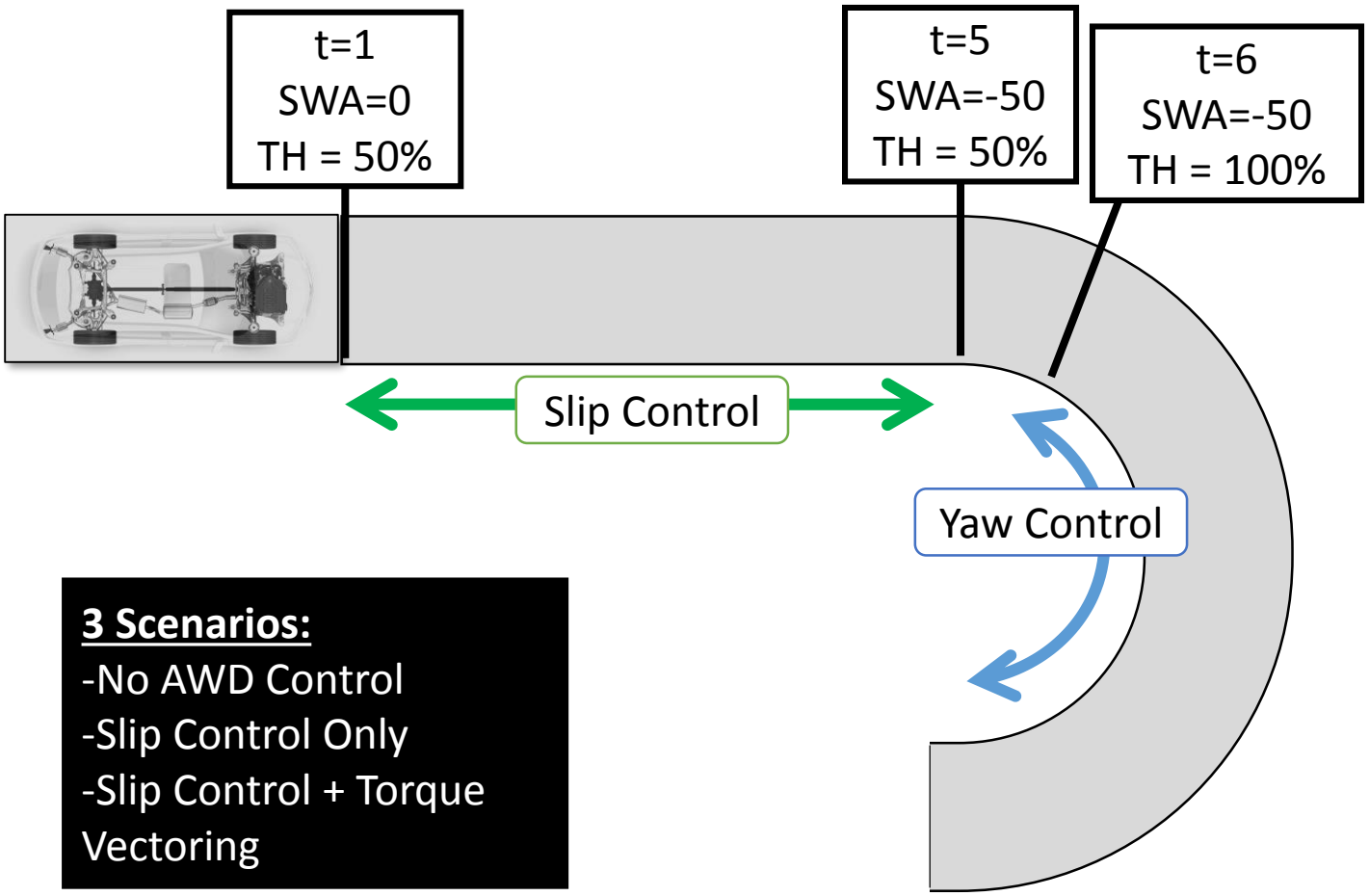
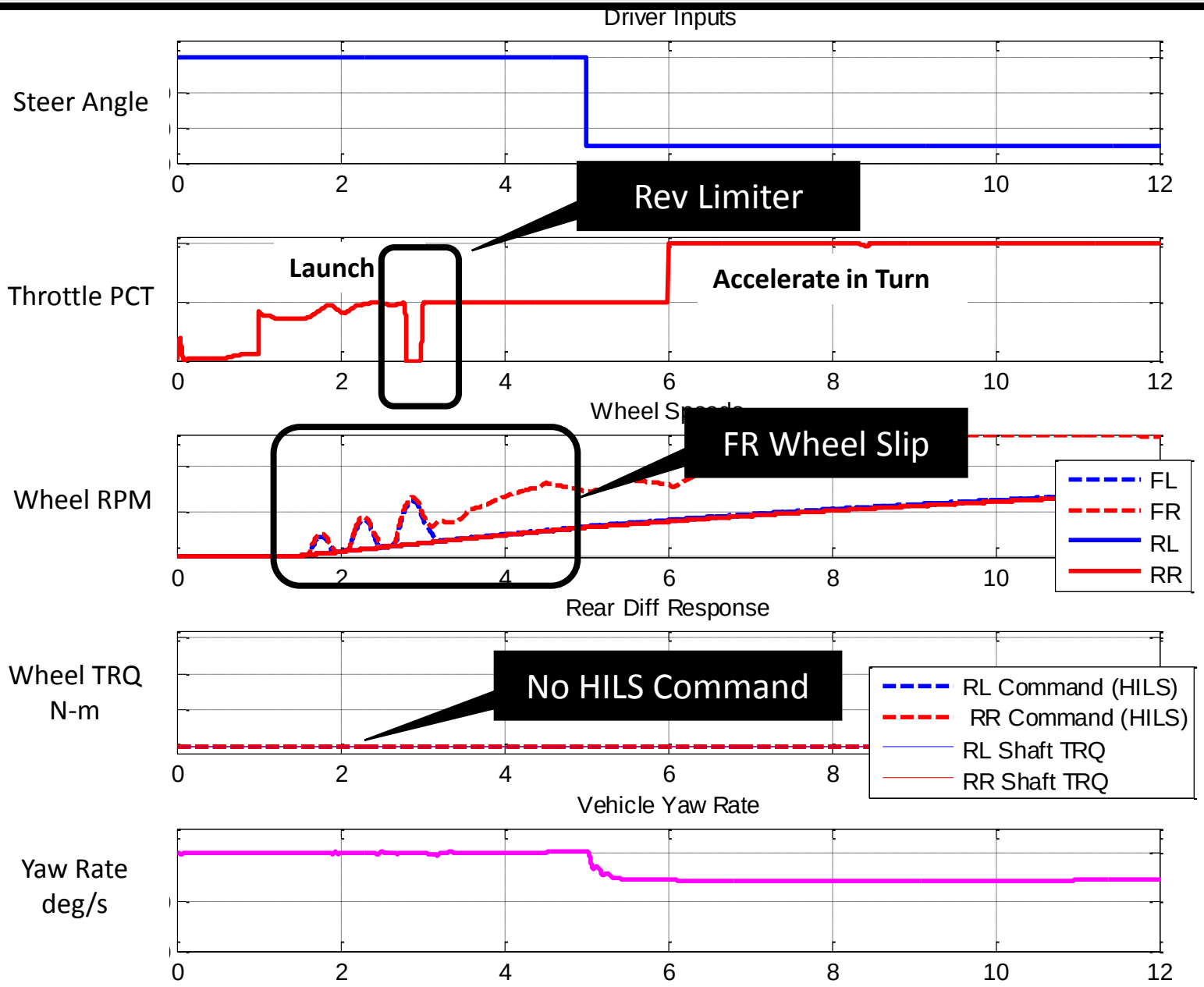
Test Scenario



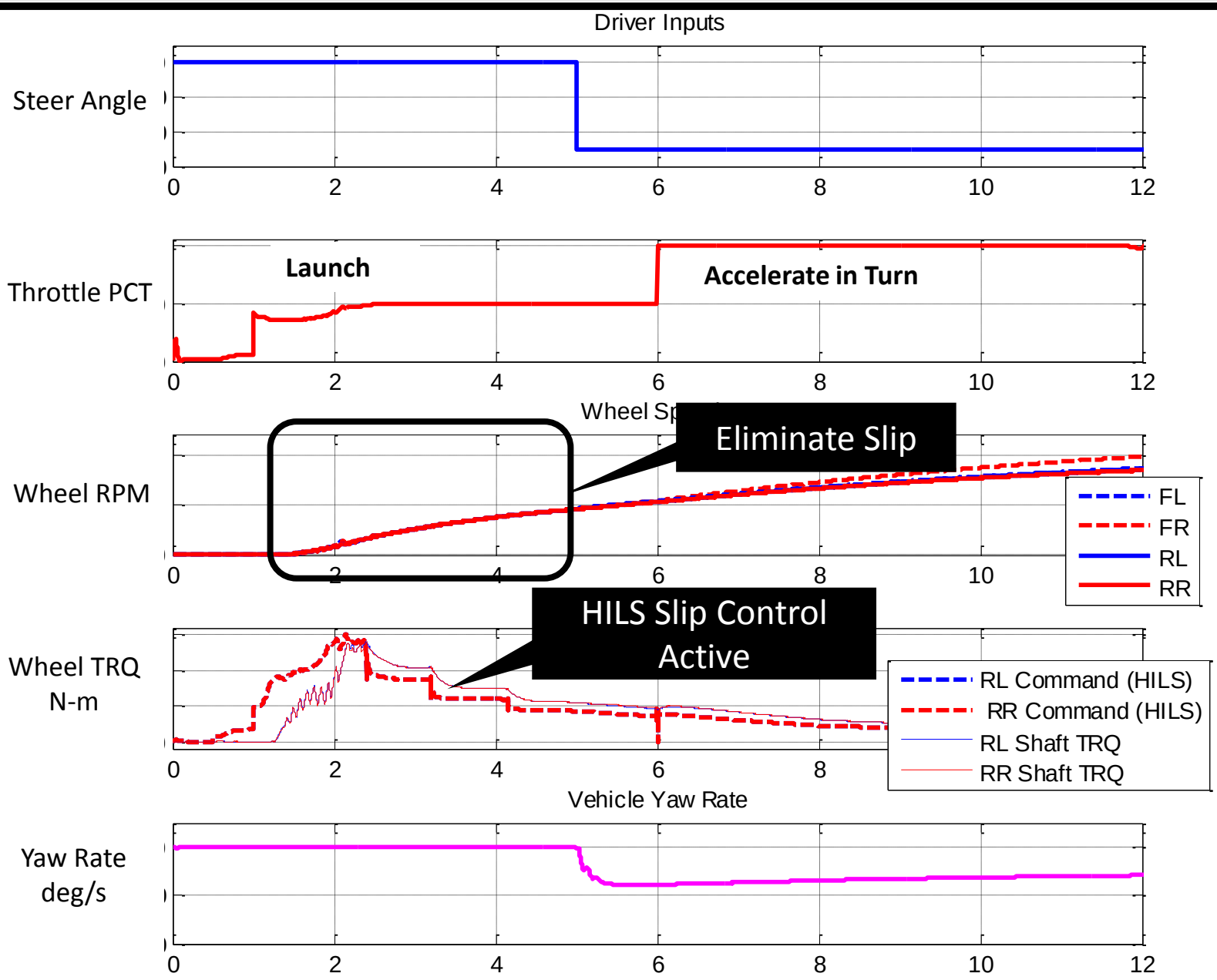
3 Scenarios:
-No AWD Control
-Slip Control Only
-Slip Control + Torque Vectoring

A simple drive maneuver was designed to activate longitudinal slip and active yaw control in order to demonstrate the coupling of Simpack and HILS in Real-time

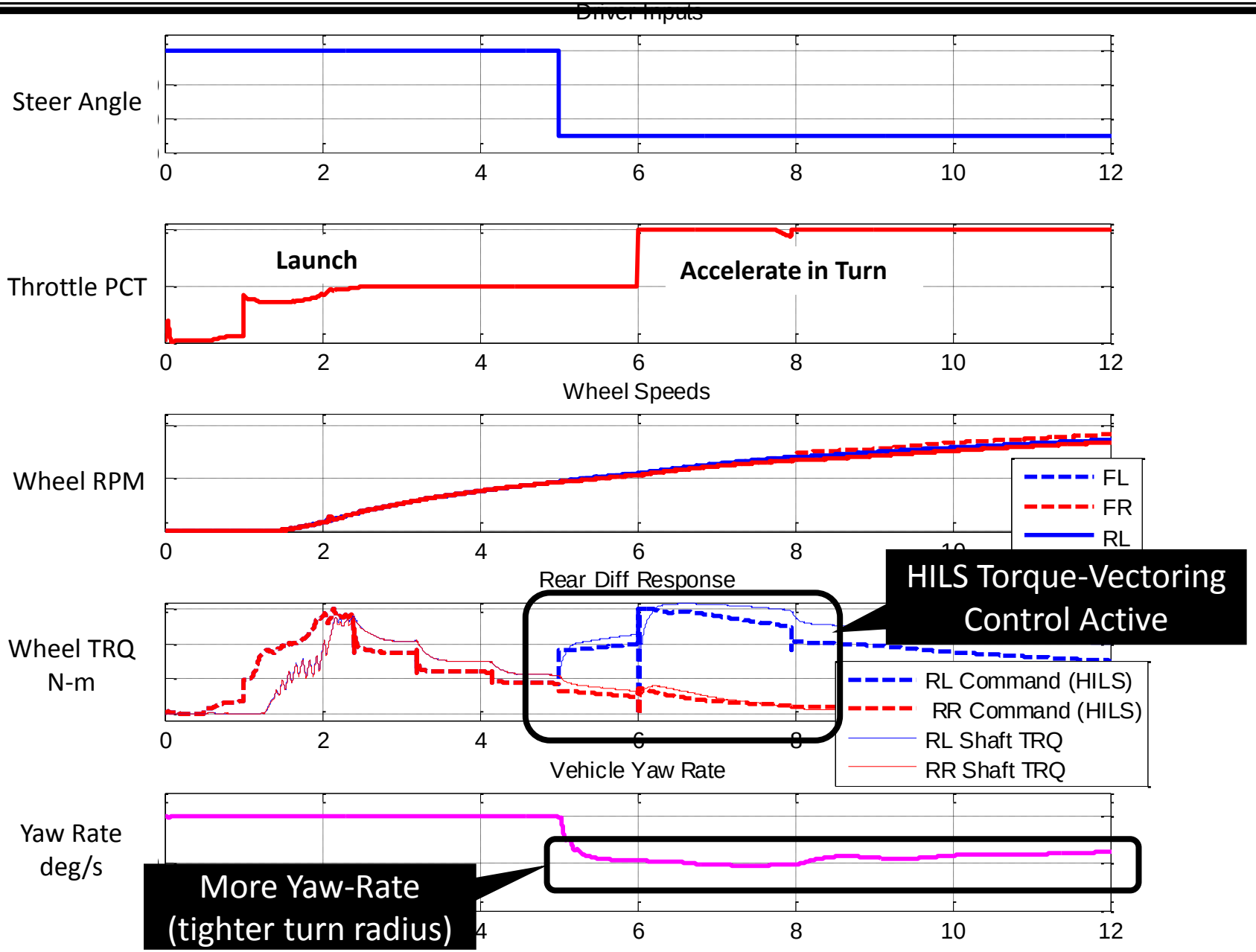
Results (No AWD Control)



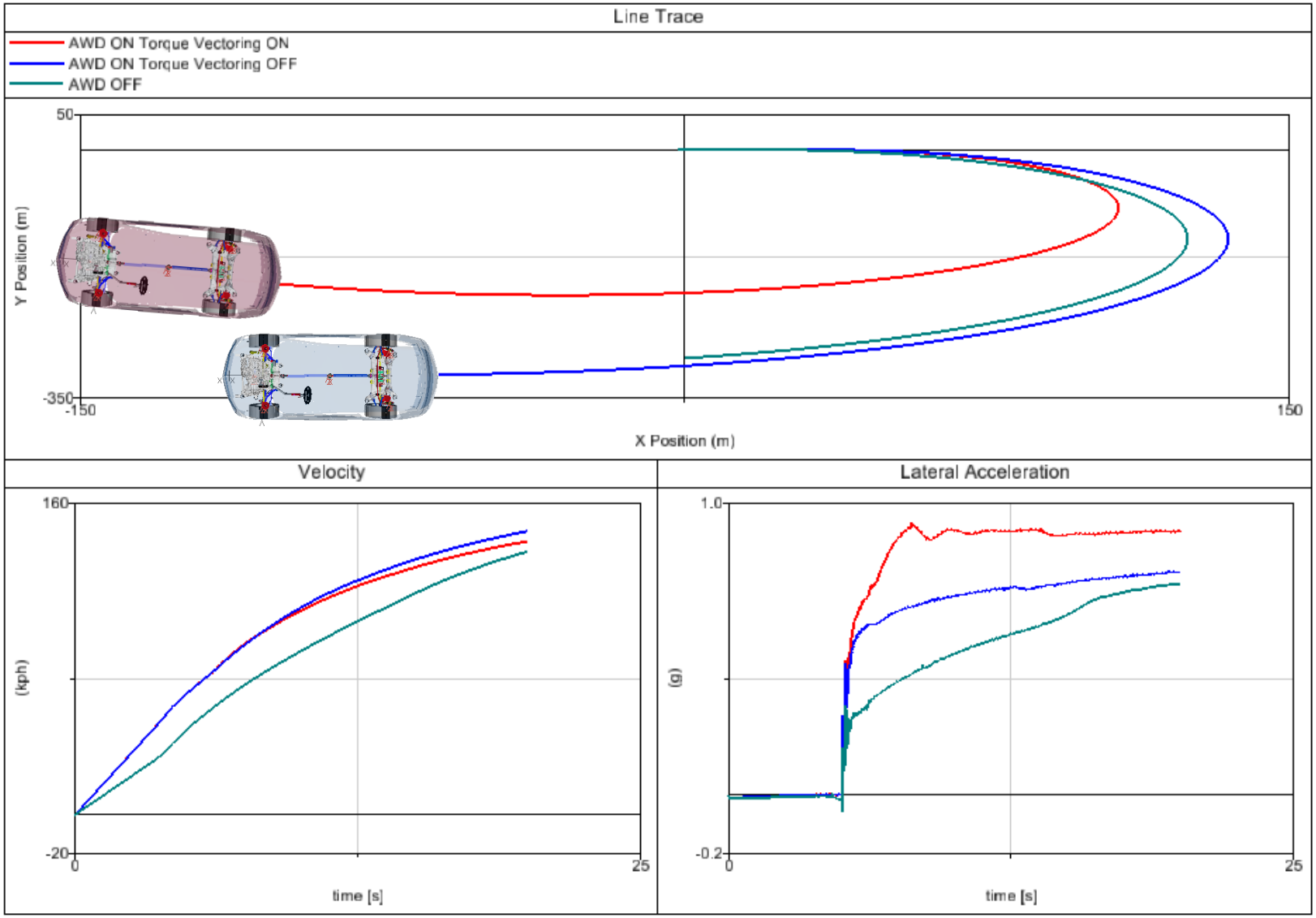
Results (Slip Control Only)



Results (Slip Control + Torque Vectoring)



Test Scenario Comparison



The combined Simpack and HILS simulation produced the expected result when combined with different AWD control algorithms

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Summary

- A Real-Time Simpack model and AWD HILS bench were integrated using Concurrent and dSPACE.
- A driving scenario was simulated in order to demonstrate the coupling between the virtual model and the hardware controller.
- The vehicle model responded to changes in the control code deployed on the HILS bench