
MATLAB EXPO 2018
KOREA

MATLAB EXPO 2018

# [Subtrack 2]
# Vehicle Dynamics Blockset 소개

김종헌 부장

# Agenda

- What is Vehicle Dynamics Blockset?
- How can I use it?

# Agenda

- **What is Vehicle Dynamics Blockset?**
- How can I use it?

# Background

- Context
  - Automotive OEM's and Tier 1 suppliers must assess vehicle's dynamic performance
    - Will the vehicle roll over?
    - What's the stopping distance of the vehicle?
    - Do the stability controls perform adequately?
  - Answer questions by building prototypes and / or running simulations

- Challenges
  - Prototypes are expensive, so must achieve a good design as early as possible
  - Specialized vehicle dynamics simulation software is quite expensive and difficult to use
  - Integrating 3rd party vehicle dynamics software with Simulink controls is cumbersome

# Vehicle Dynamics Blockset

**New product (R2018a)**

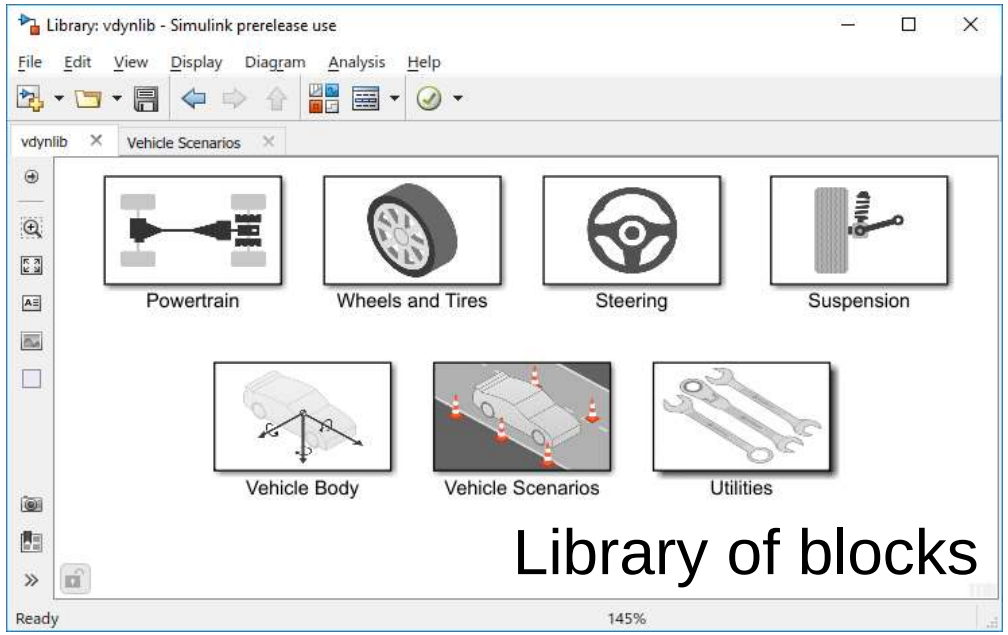
- Model and simulate vehicle dynamics in a virtual 3D environment
- Use Vehicle Dynamics Blockset for:
  - Ride & handling: characterize vehicle performance under standard driving maneuvers
  - Chassis controls: design and test chassis control systems
  - ADAS / AD: create virtual 3D test ground for ADAS and automated driving features

Ride & handling

Chassis controls

ADAS / AD

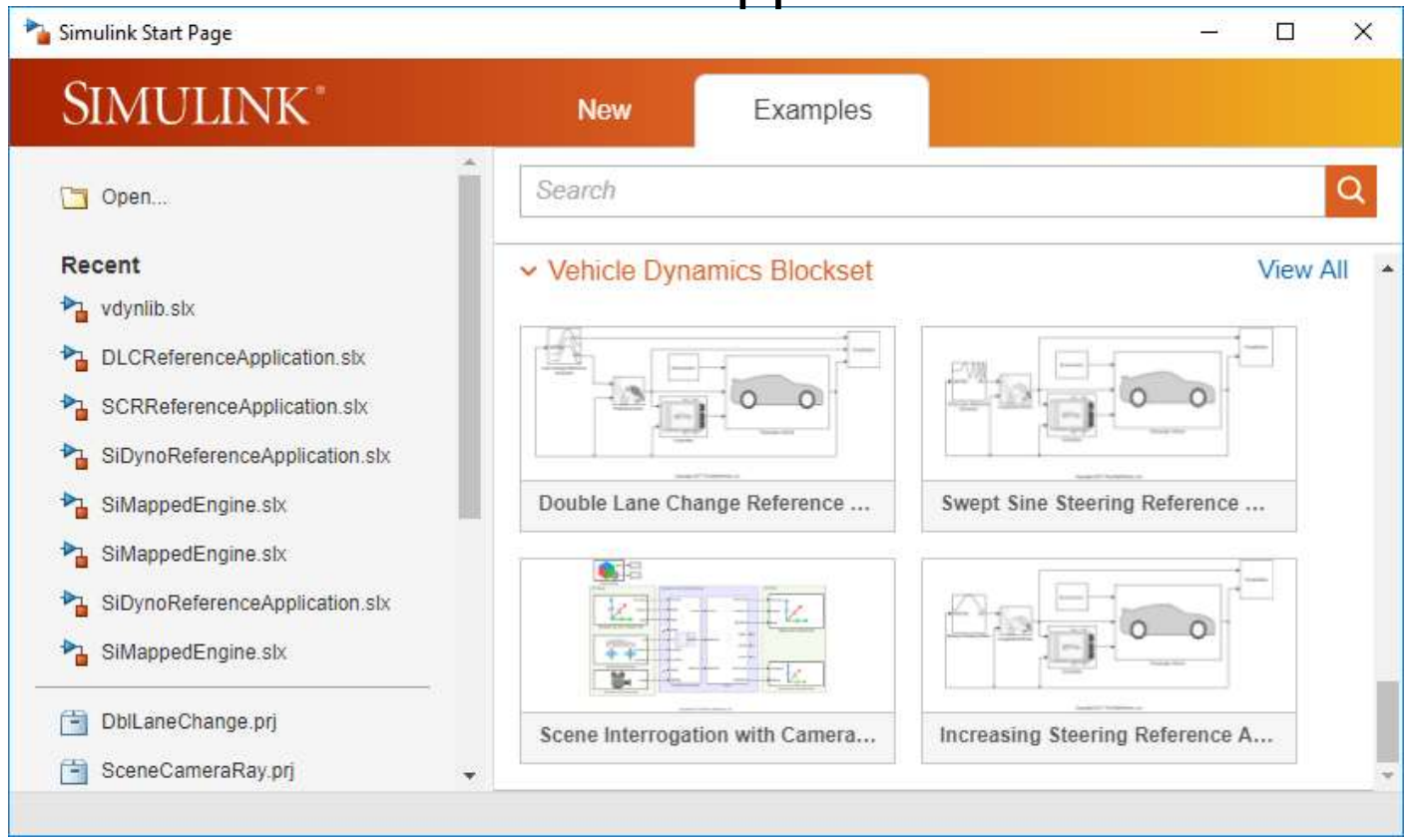
# Vehicle Dynamics Blockset Features



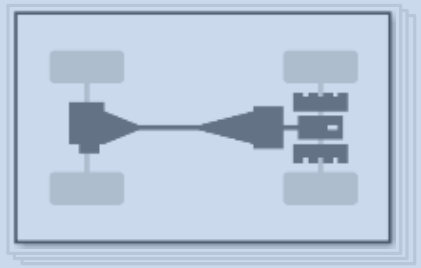

Library of blocks

Game engine

Pre-built reference applications



# Block Library: Powertrain


Powertrain

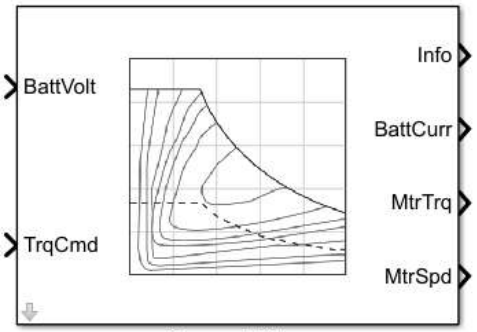

Wheels and Tires


Steering

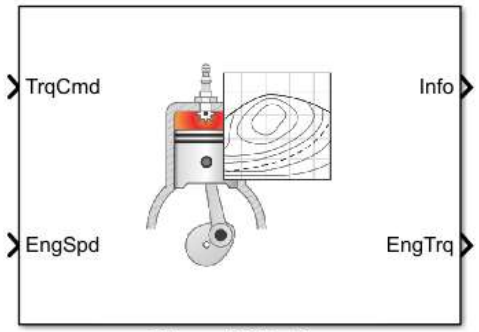

Suspension


Vehicle Body

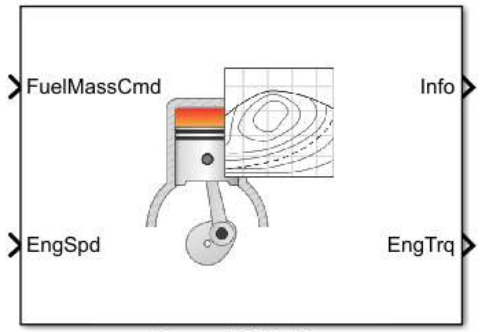

Vehicle Scenarios



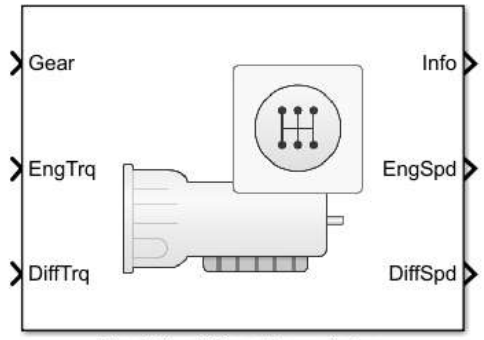
Mapped Motor



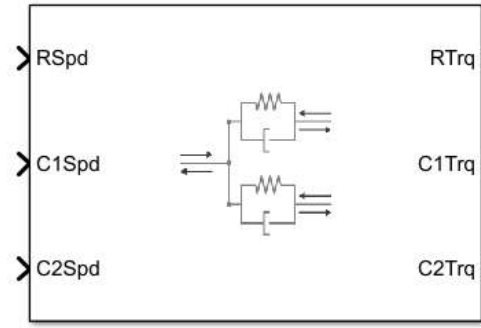
Mapped SI Engine



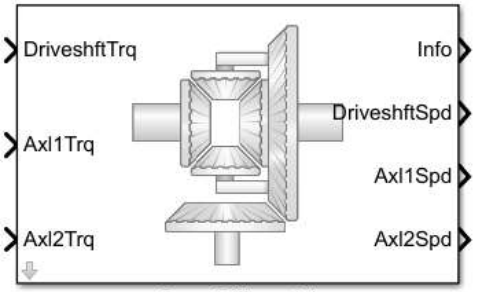
Mapped CI Engine



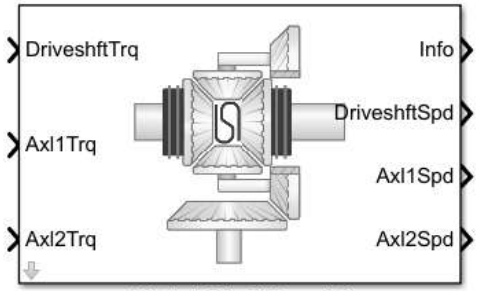
Ideal Fixed Gear Transmission



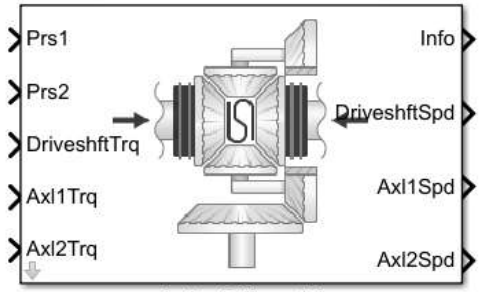
Split Torsional Compliance



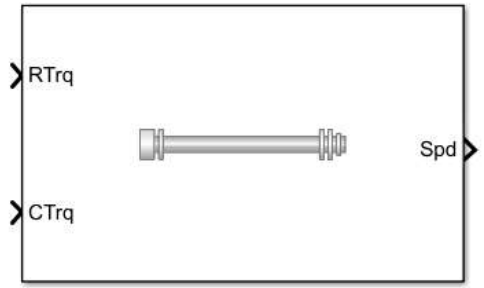
Open Differential



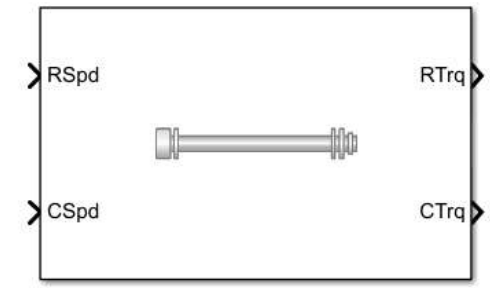
Limited Slip Differential



Active Differential

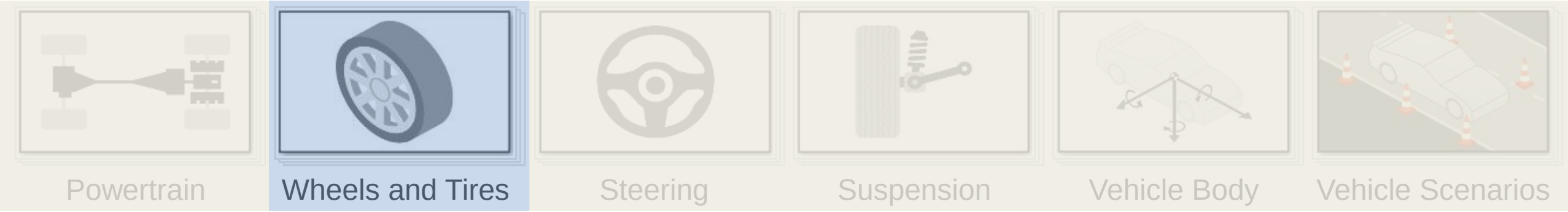


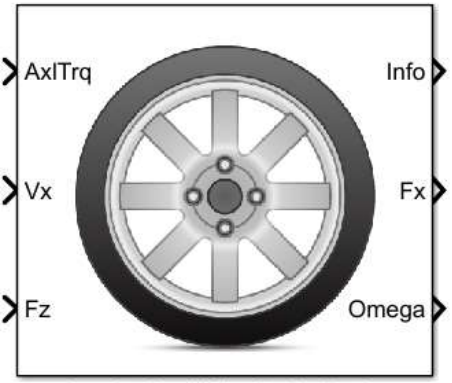
Rotational Inertia



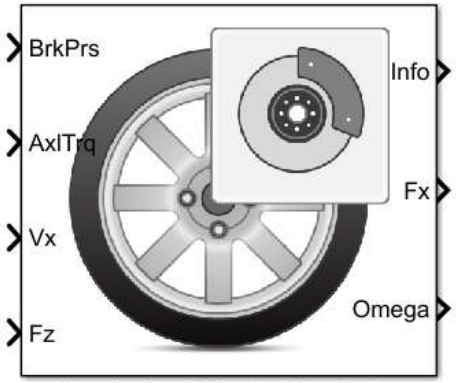
Torsional Compliance

# Block Library: Wheels and Tires

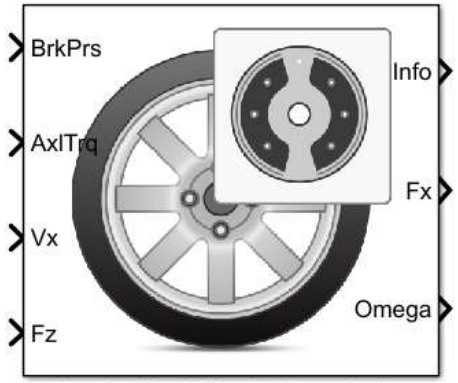


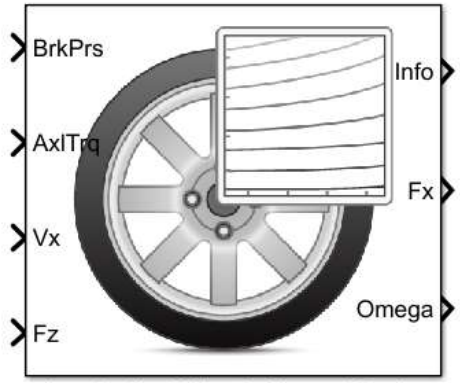
Longitudinal Wheel - No Brake



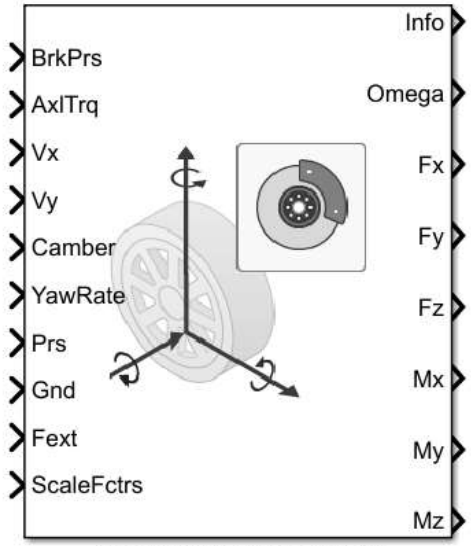
Longitudinal Wheel - Disc Brake



Longitudinal Wheel - Drum Brake

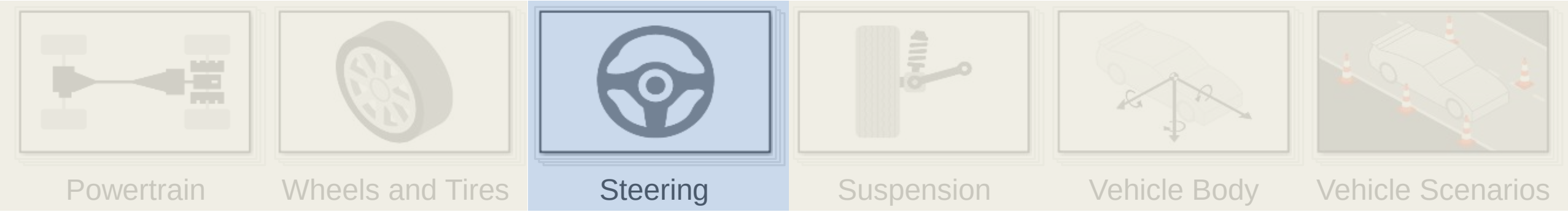


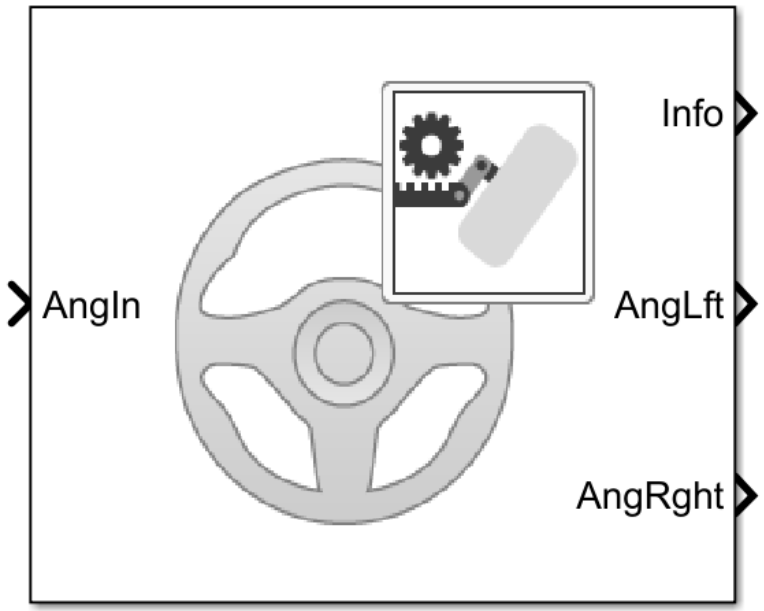
Longitudinal Wheel - Mapped Brake



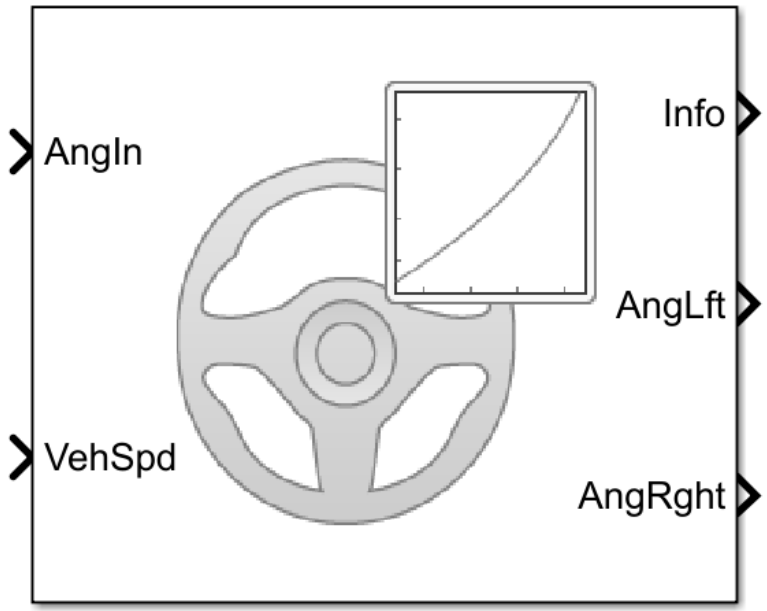
Combined Slip Wheel 2DOF

# Block Library: Steering

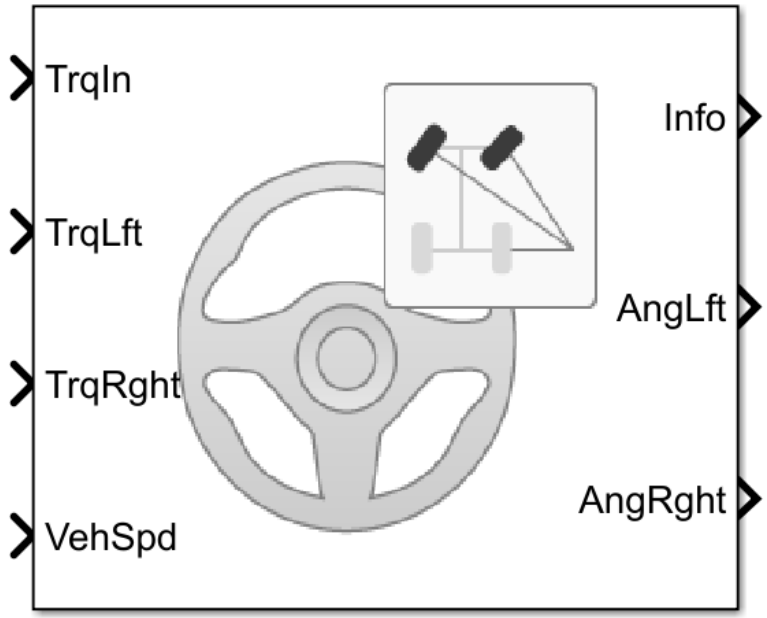



Kinematic Steering

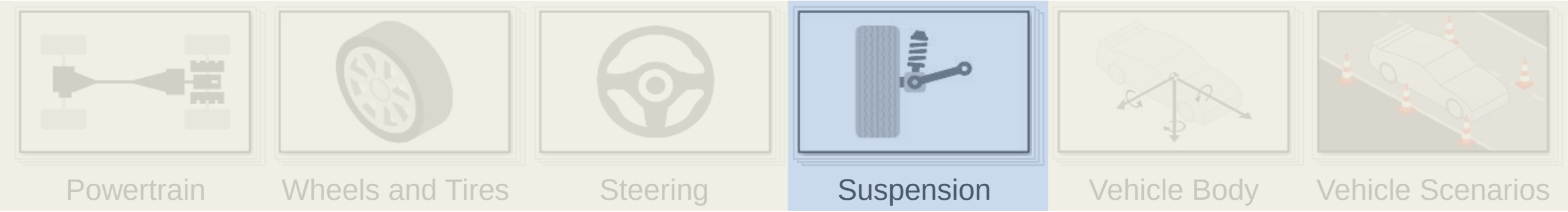


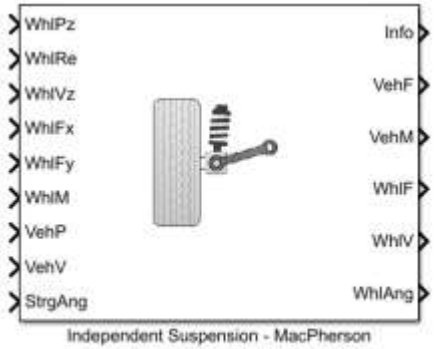

Mapped Steering



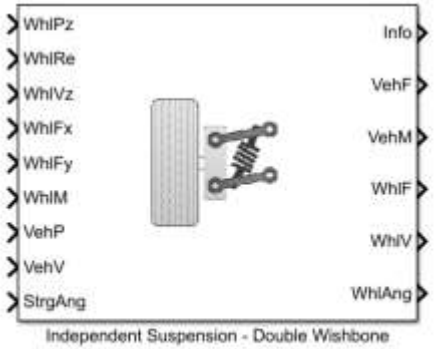

Dynamic Steering

# Block Library: Suspension

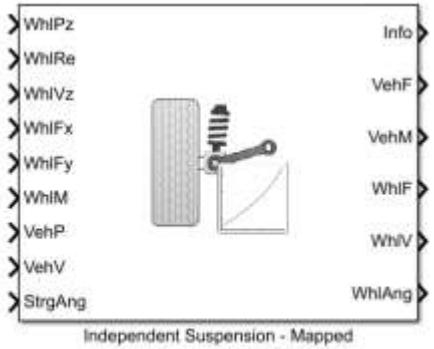


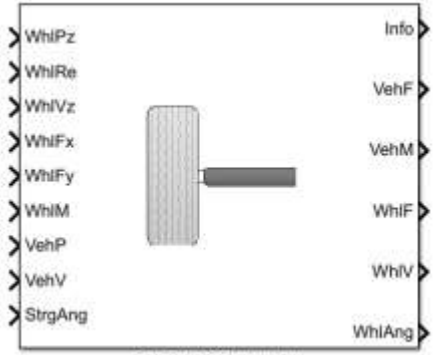
Independent Suspension - MacPherson



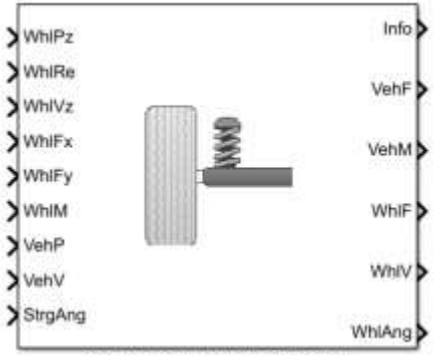
Independent Suspension - Double Wishbone



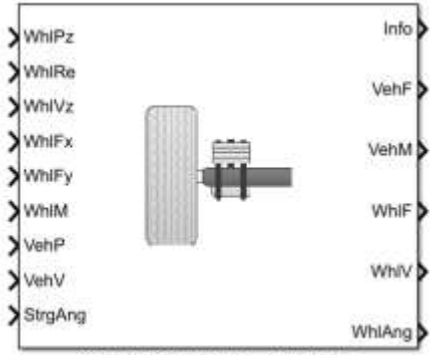
Independent Suspension - Mapped



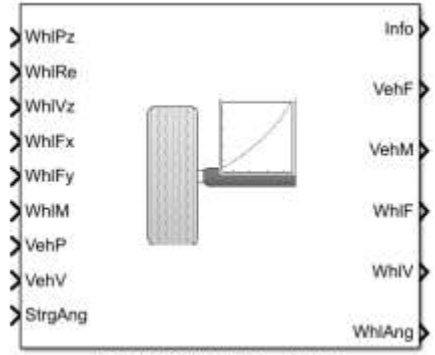
Solid Axle Suspension



Solid Axle Suspension - Coil Spring

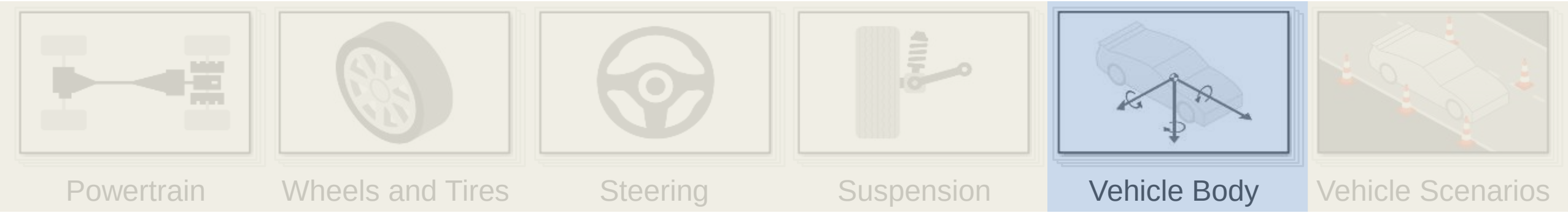


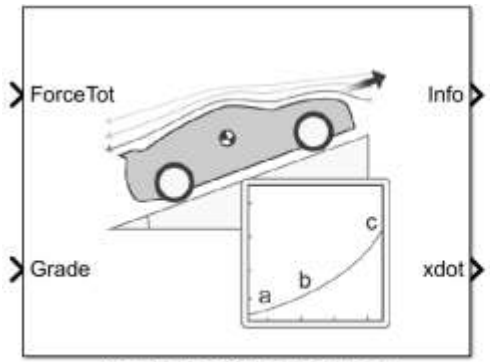
Solid Axle Suspension - Leaf Spring



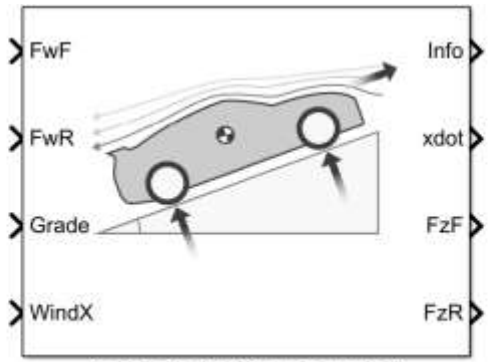
Solid Axle Suspension - Mapped

# Block Library: Vehicle Body

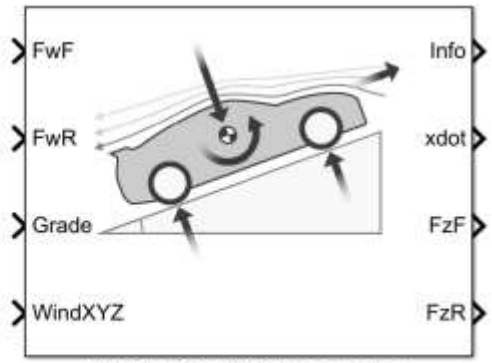


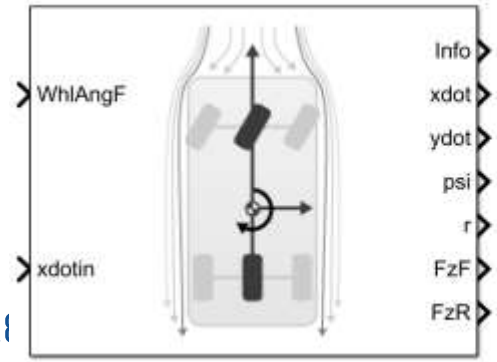
Vehicle Body Total Road Load



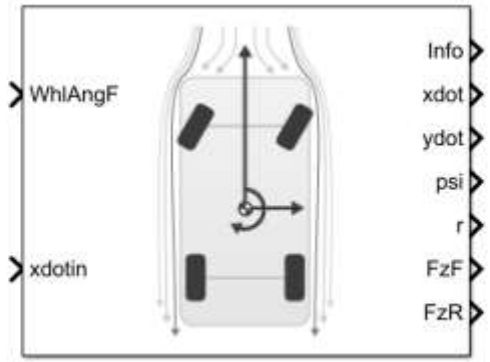
Vehicle Body 1DOF Longitudinal



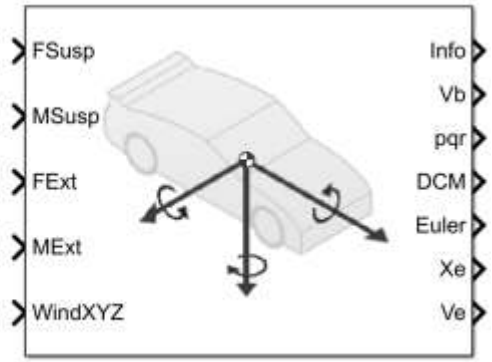
Vehicle Body 3DOF Longitudinal



Vehicle Body 3DOF Single Track

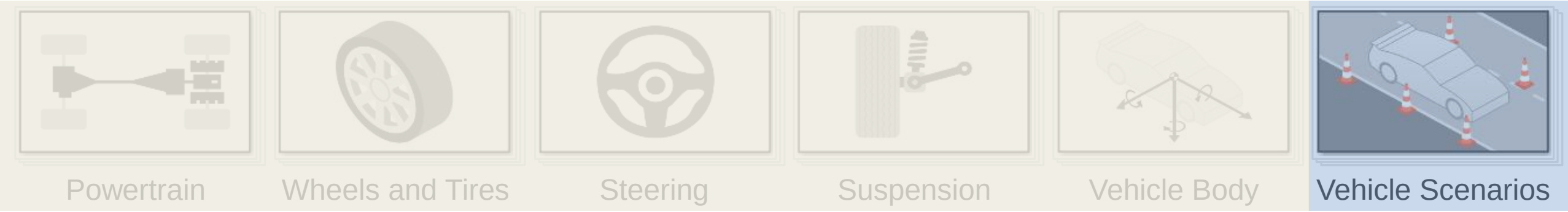


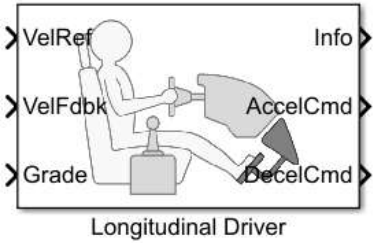
Vehicle Body 3DOF Dual Track



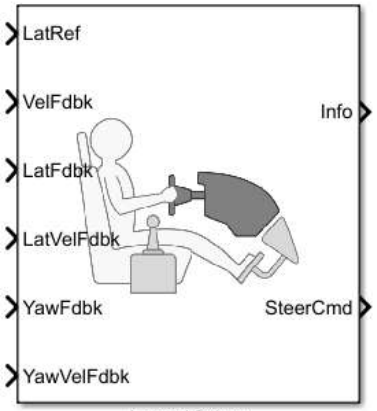
Vehicle Body 6DOF

# Block Library: Vehicle Scenarios

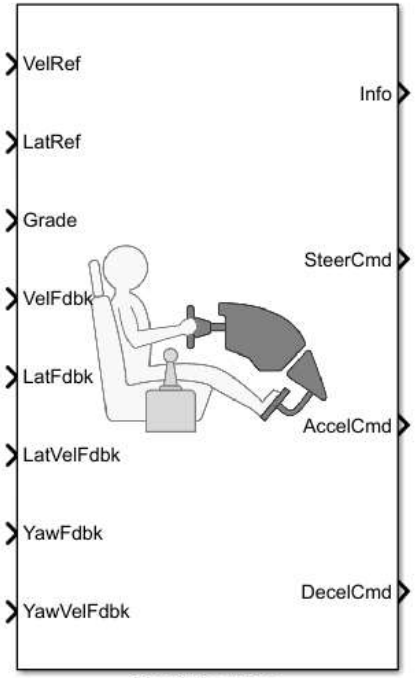


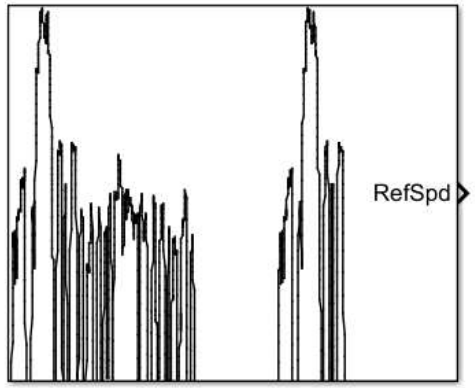
Longitudinal Driver



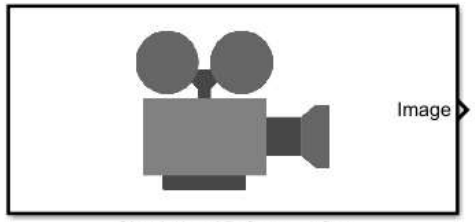
Lateral Driver



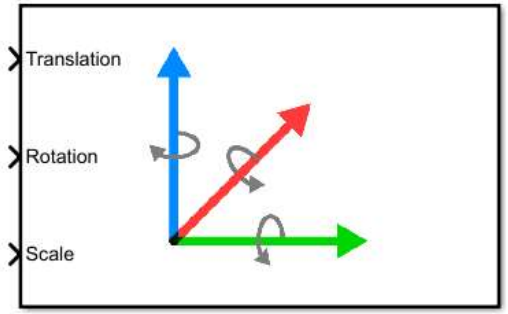
Predictive Driver



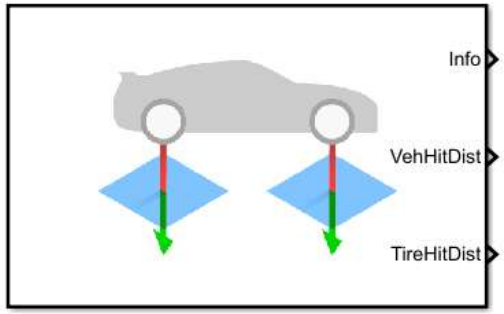
Drive Cycle Source
FTP75 (2474 seconds)



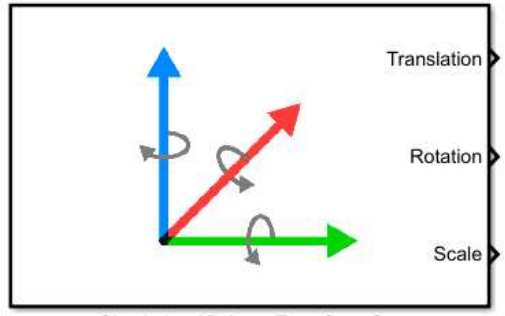
Simulation 3D Camera Get



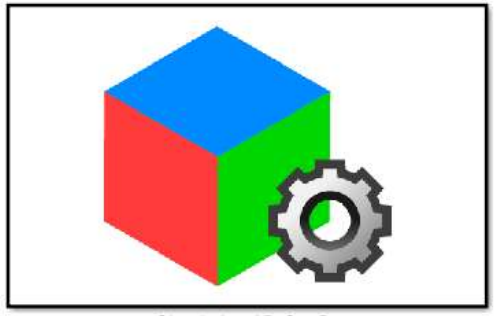
Simulation 3D Actor Transform Set



Vehicle Terrain Sensor



Simulation 3D Actor Transform Get


Simulation 3D Config

# Game Engine Co-Simulation

## Simulink

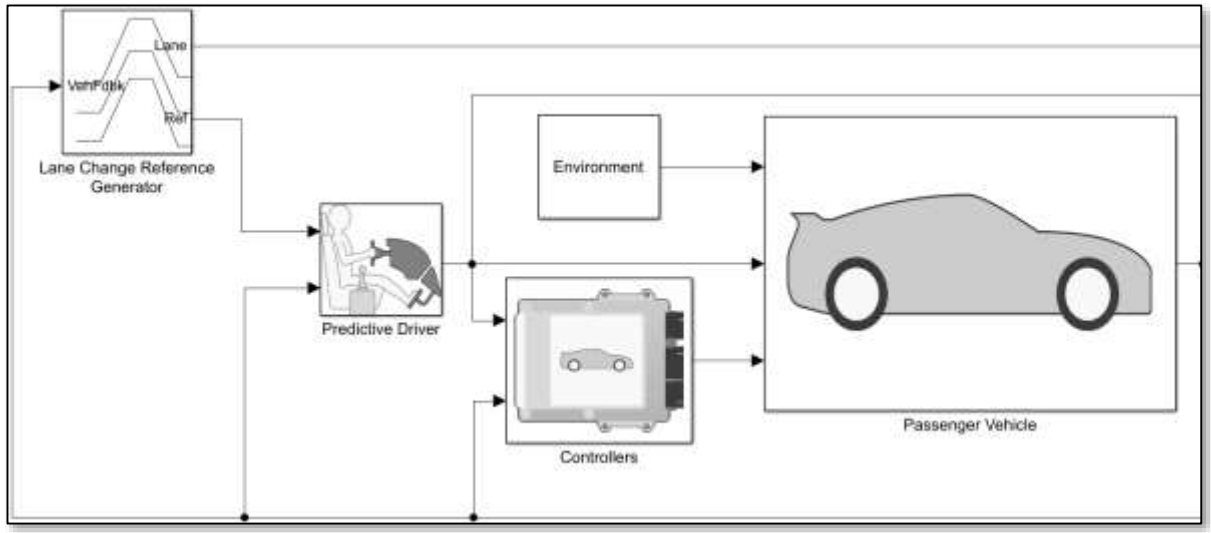
- Physics of vehicle
- Initialization of game engine camera

vehicle / camera location

camera image, ground height, …

## Unreal Engine

- Rendering / lighting
- Physics of non-Simulink objects
- Collision detection

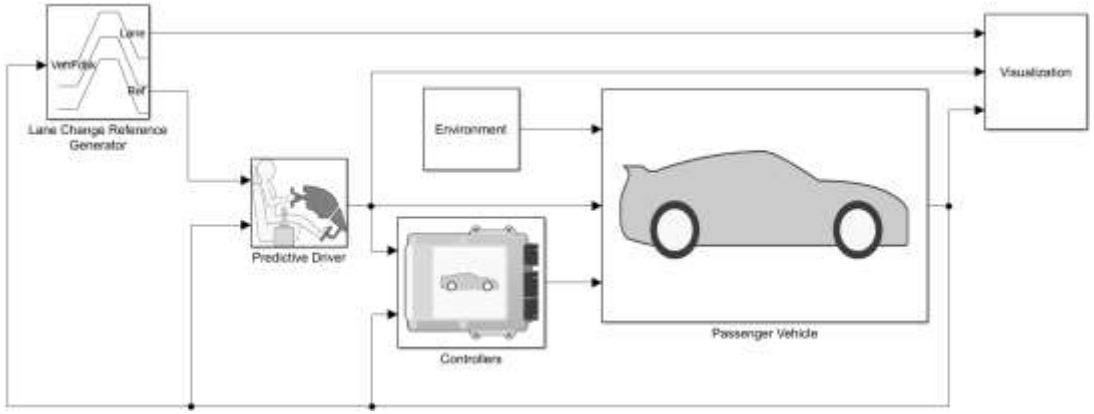



# Reference Applications

## Vehicle Maneuvers

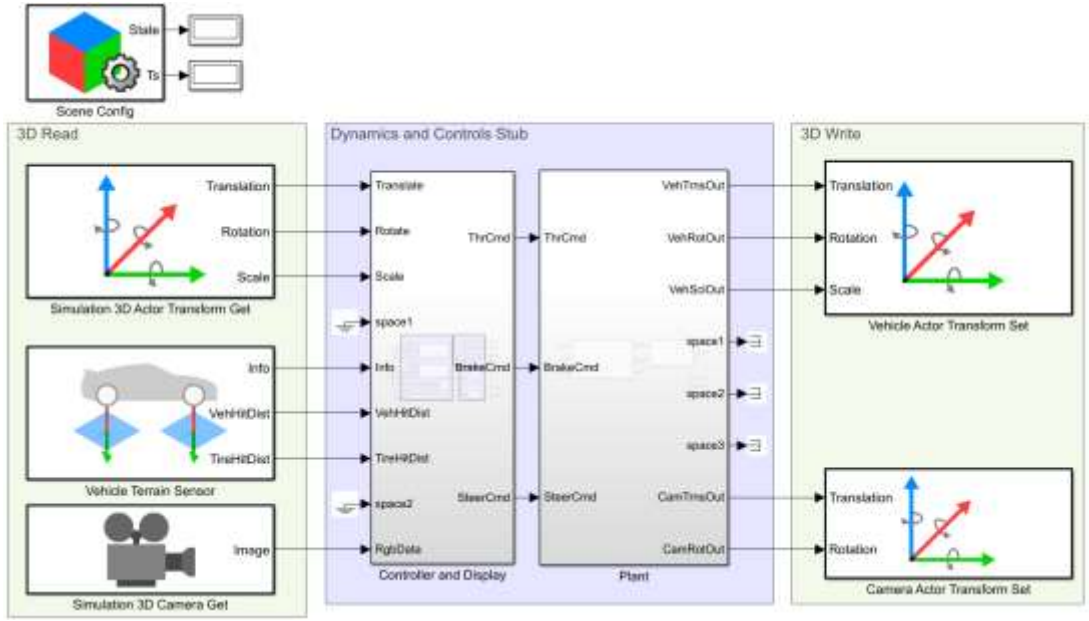
Analyze ride and handling on driving maneuvers such as:

- Double-lane change
- Swept sine steering
- Slowly increasing steering




## Scene Interrogation

Configure the interface to the 3D environment

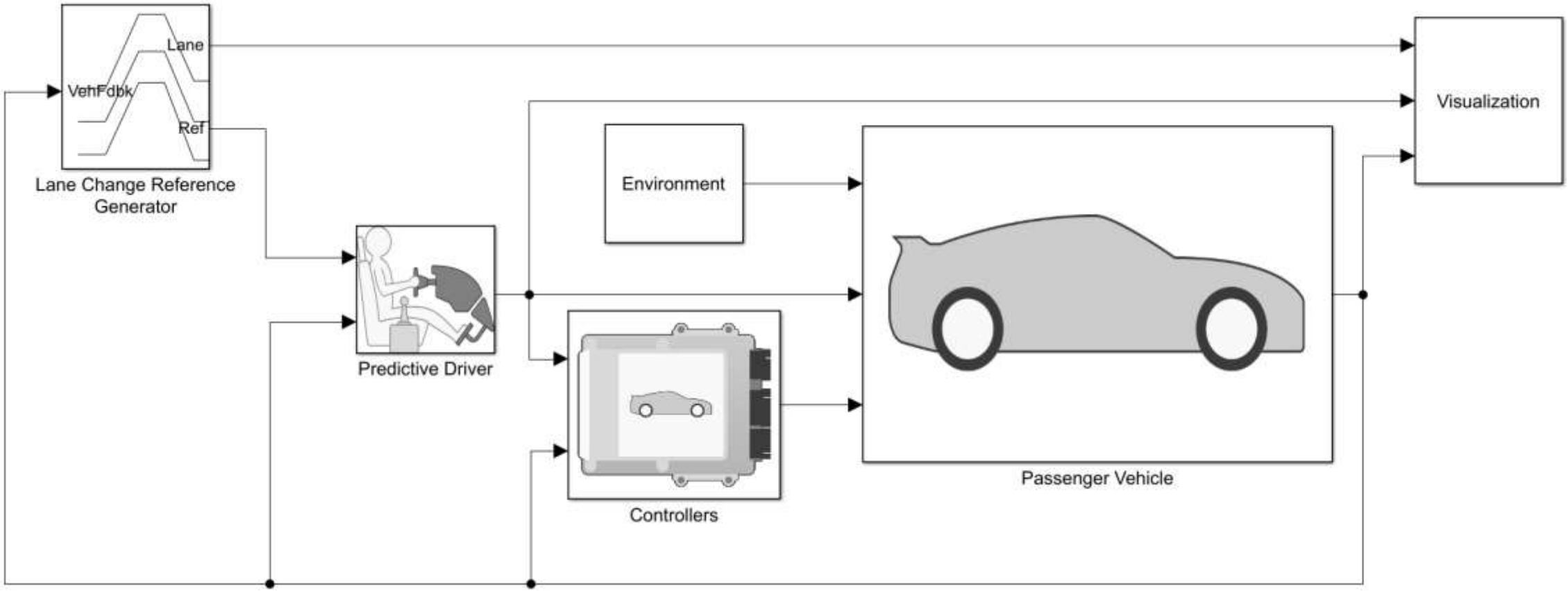


# Agenda

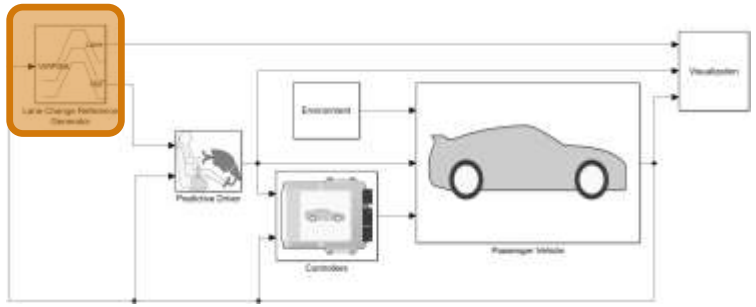
- What is Vehicle Dynamics Blockset?
- **How can I use it?**
  - Ride and handling analysis
  - Chassis controls development
  - ADAS / AD testing
  - Hardware-In-the-Loop Testing

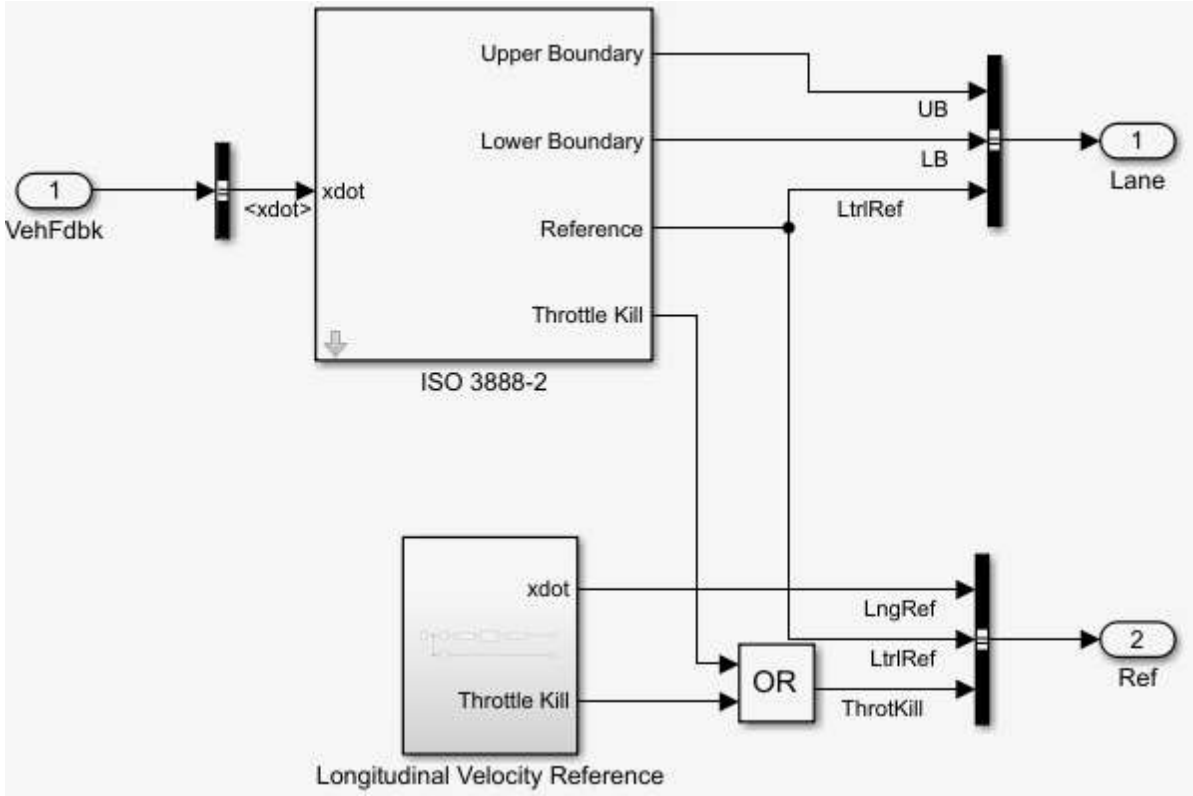
  - Assess longitudinal / lateral dynamics

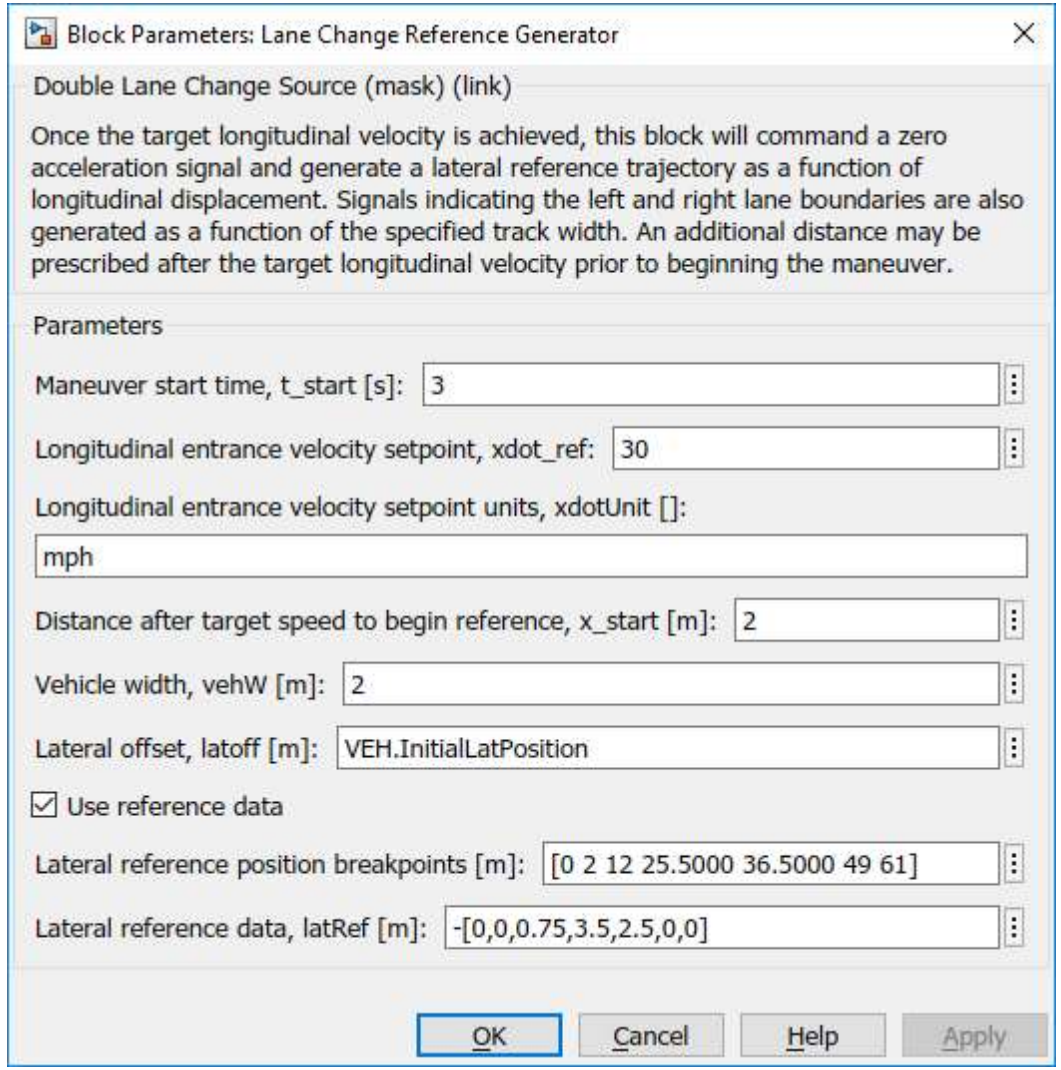
# Reference Application: Double Lange Change



# Reference Application: Double Lange Change (Maneuver)

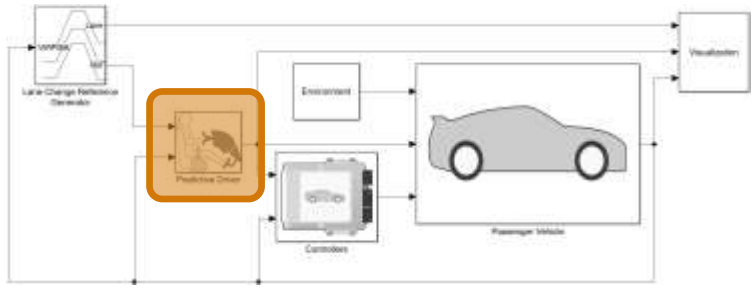


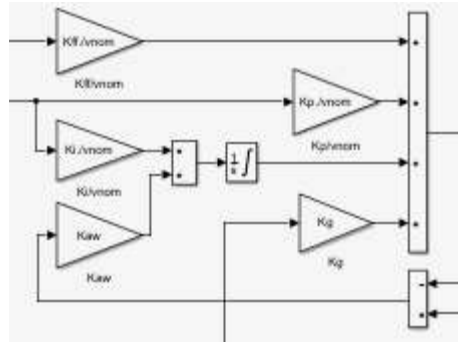



Set target velocity and lateral position

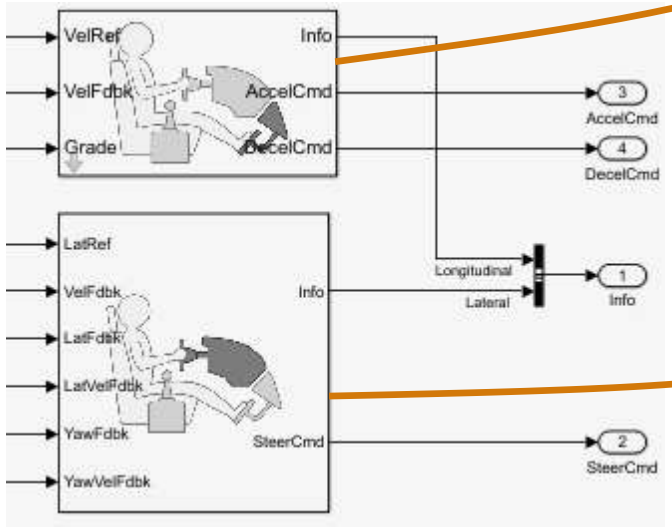
# Reference Application: Double Lange Change (Driver)

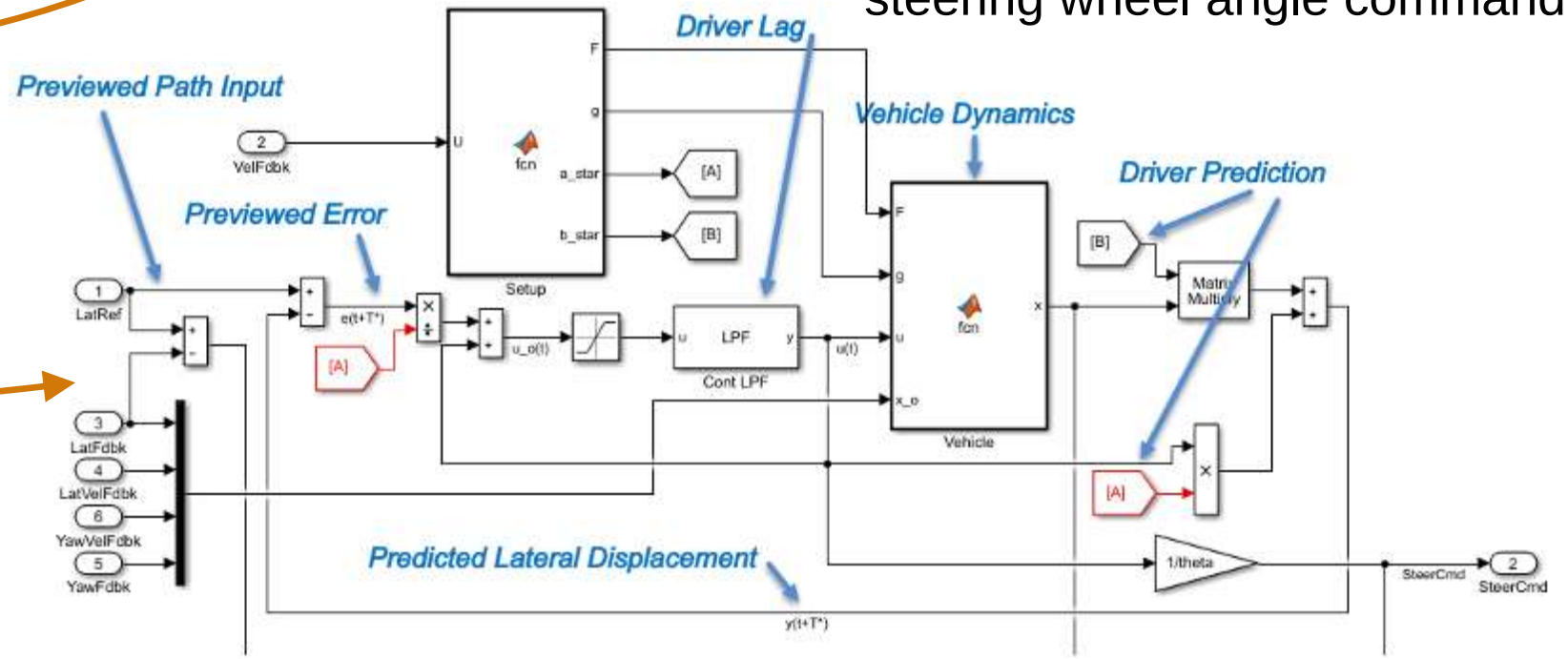




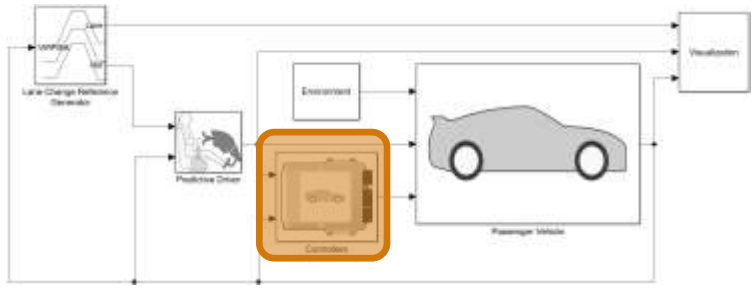
PI controller sets throttle / brake command

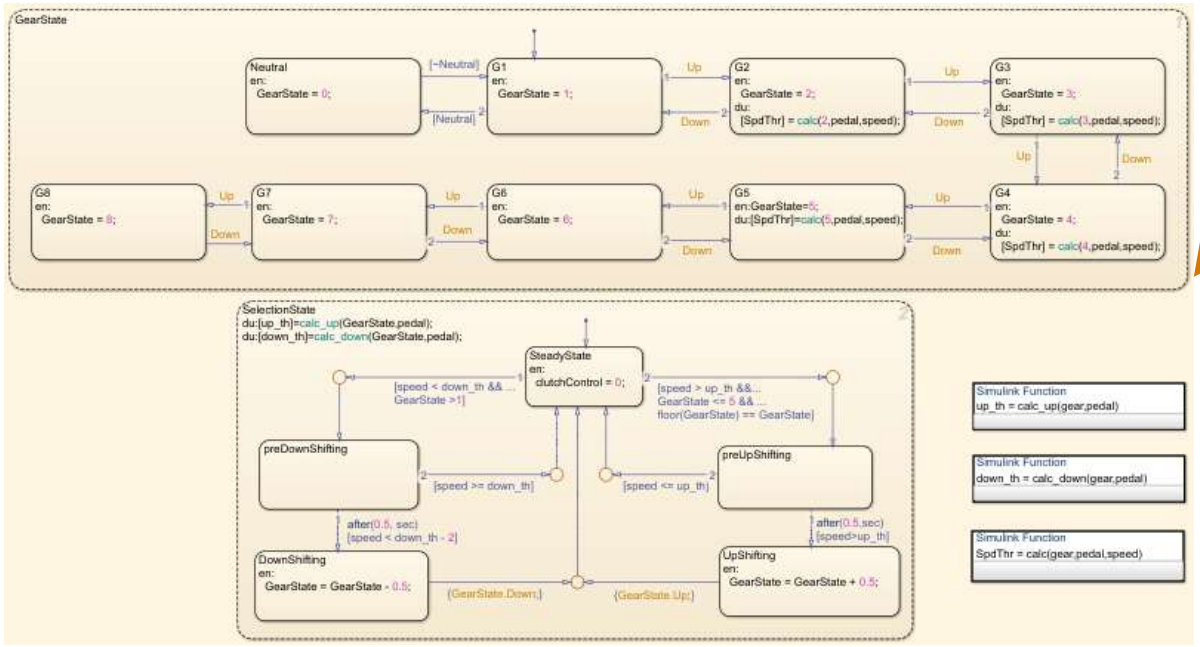
Predictive driver model sets steering wheel angle command

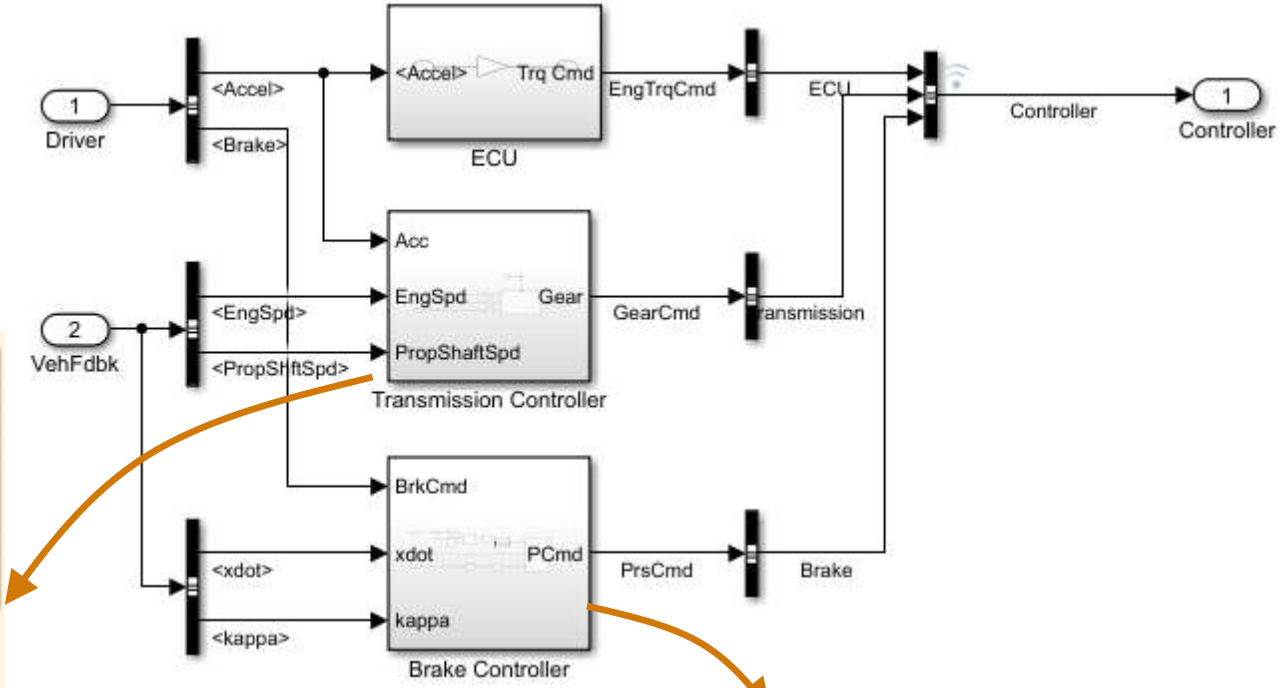


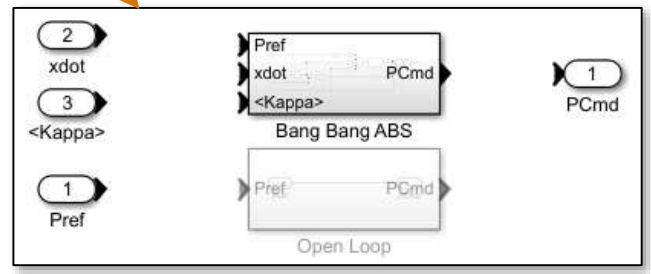



# Reference Application: Double Lange Change (Controllers)



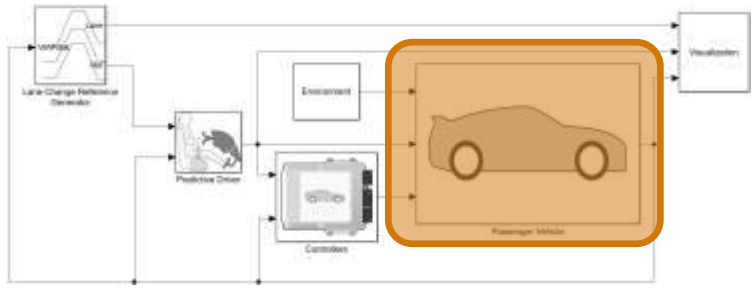


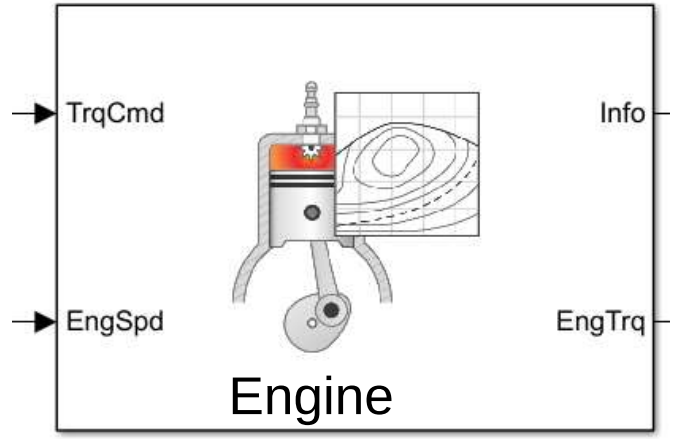



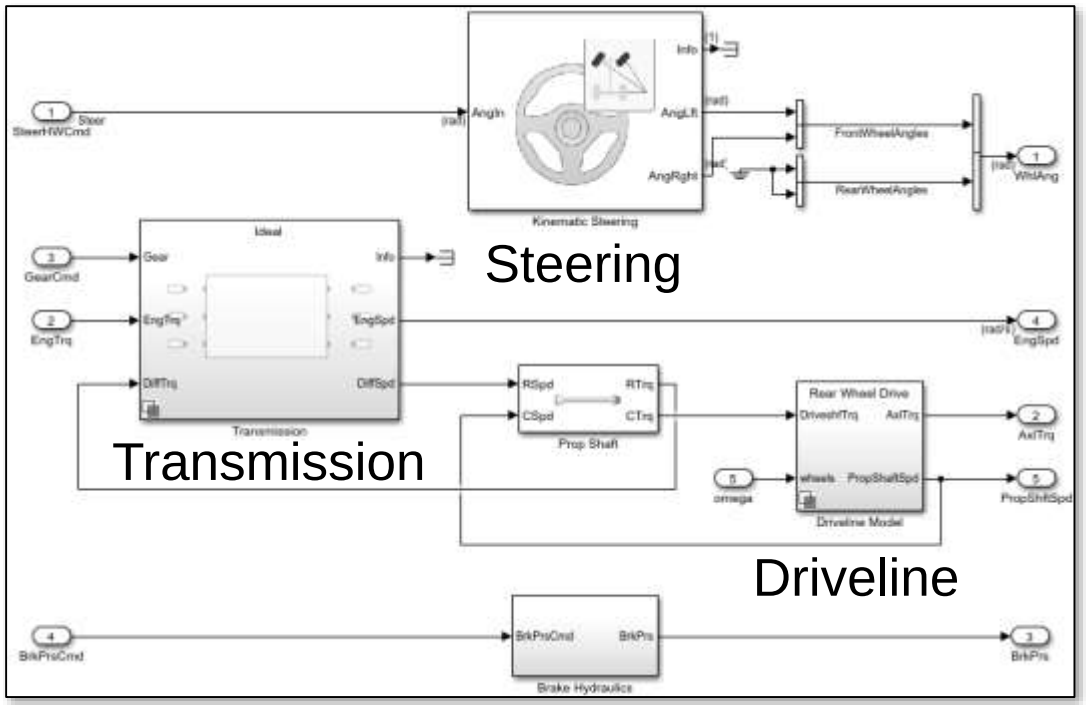

- Basic controllers provided for engine, transmission and brakes
- Incorporate your own variants, as needed

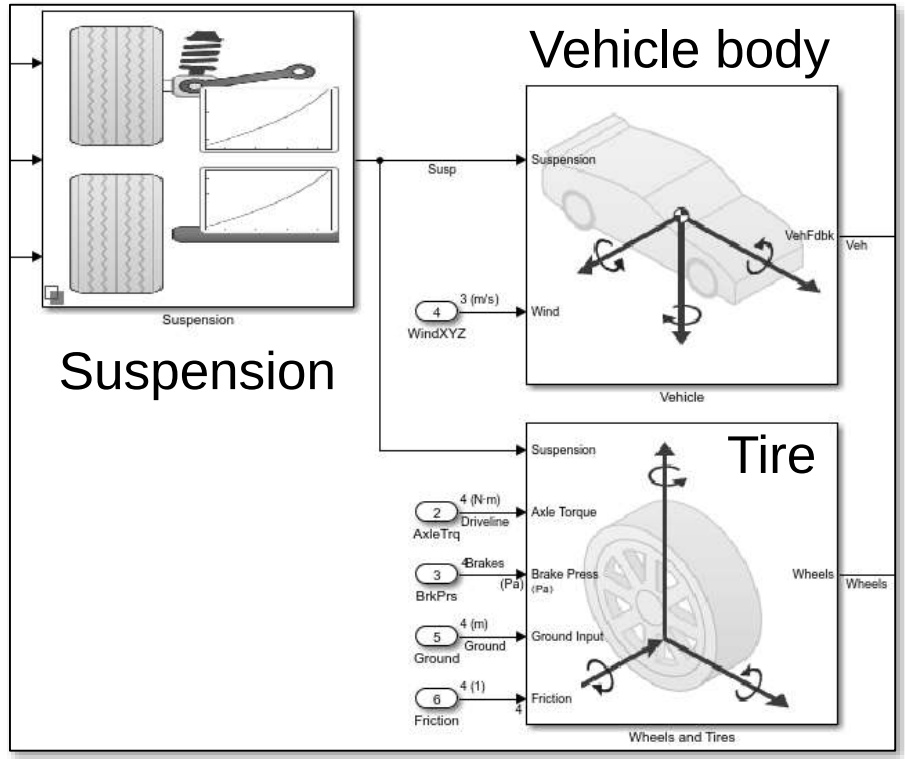
# Reference Application: Double Lange Change (Plant)



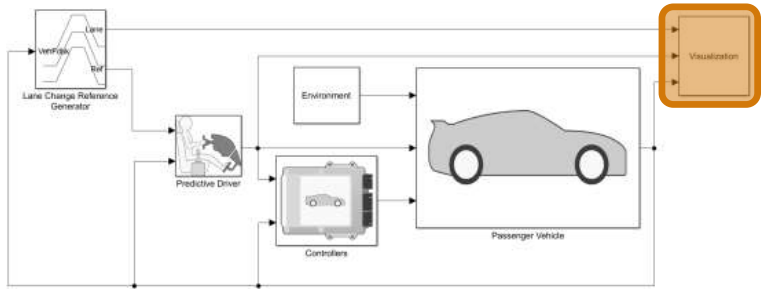
- Use default plant model provided
- Select variants of interest
- Customize subsystems

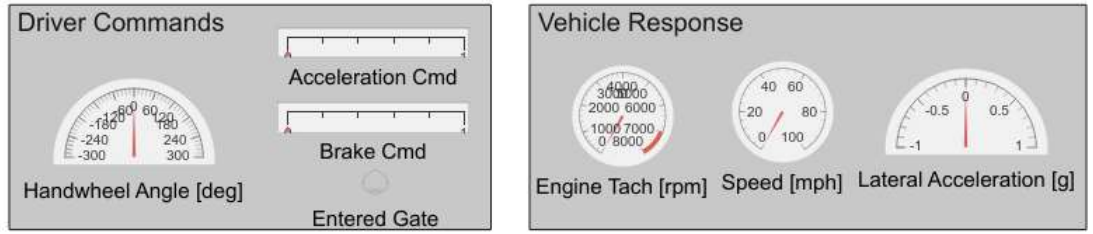


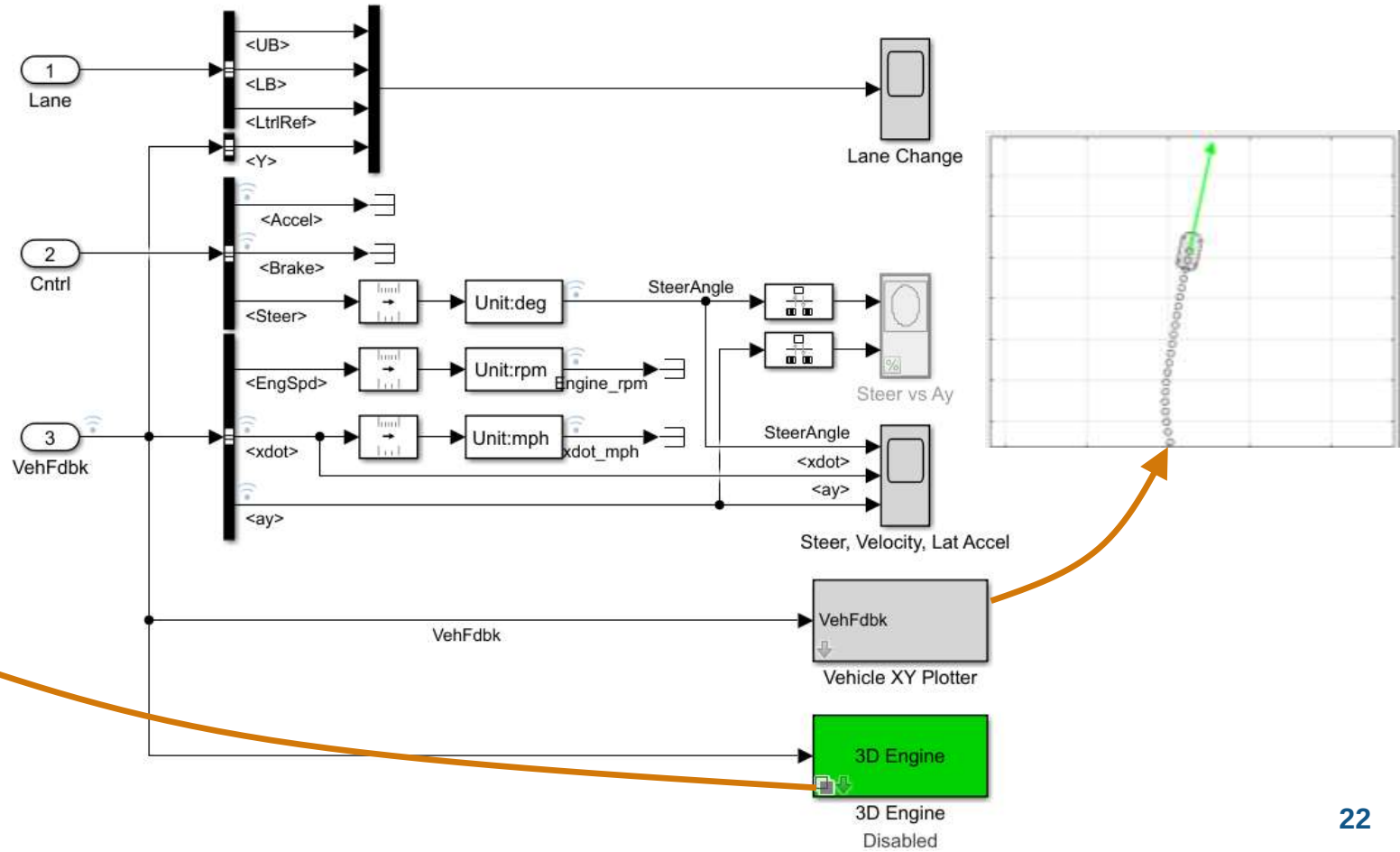



# Reference Application: Double Lange Change (Visualization)




- Scopes, gauges, plotters, logs
- 3D engine interface

# Ride and Handling Study: Double Lane Change

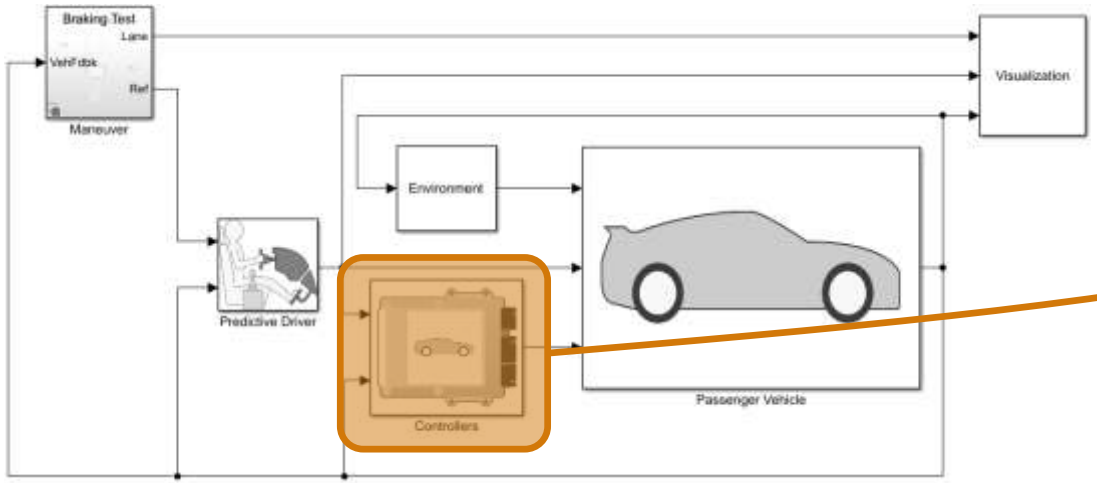
At 30 mph

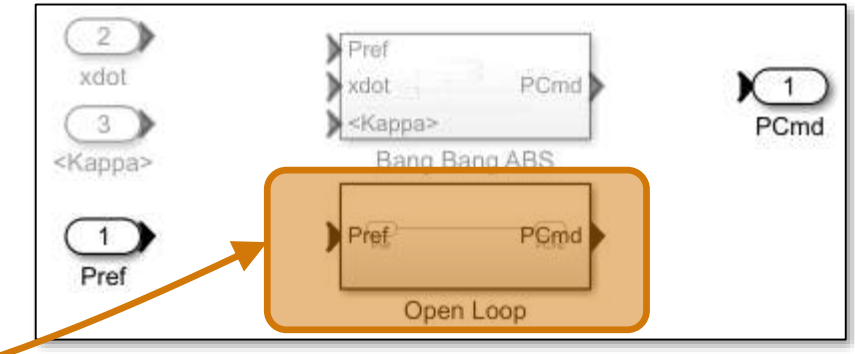
At 50 mph

# Agenda

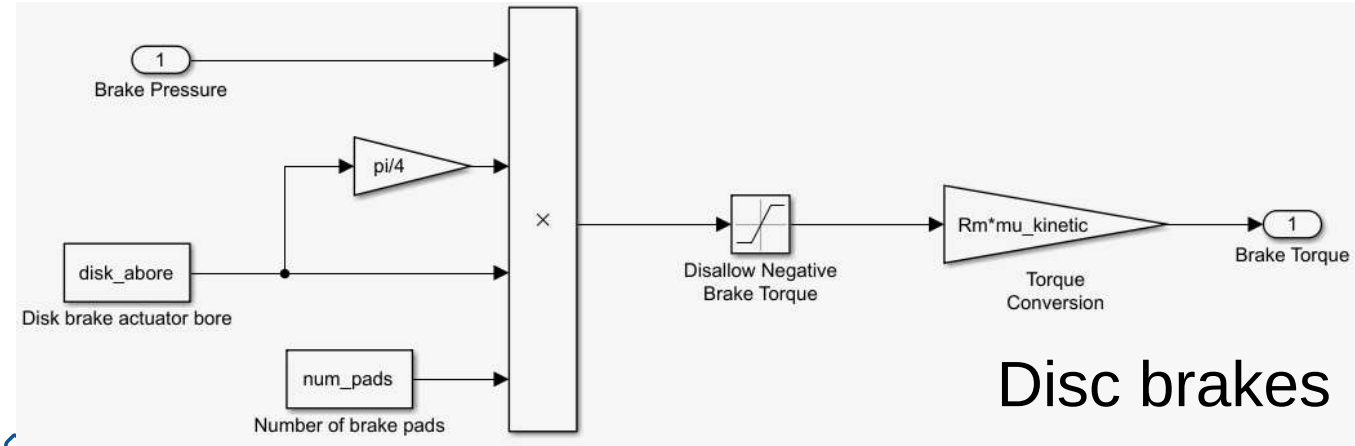
- What is Vehicle Dynamics Blockset?
- **How can I use it?**
  - Ride and handling analysis
  - Chassis controls development → Perform closed-loop testing
  - ADAS / AD testing
  - Hardware-In-the-Loop Testing

# Chassis Controls Study: Braking Test



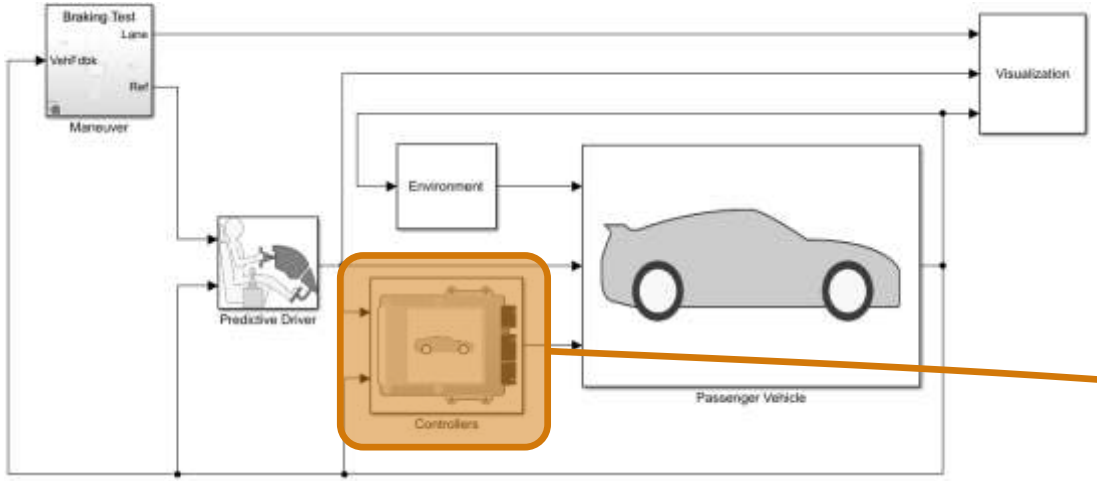



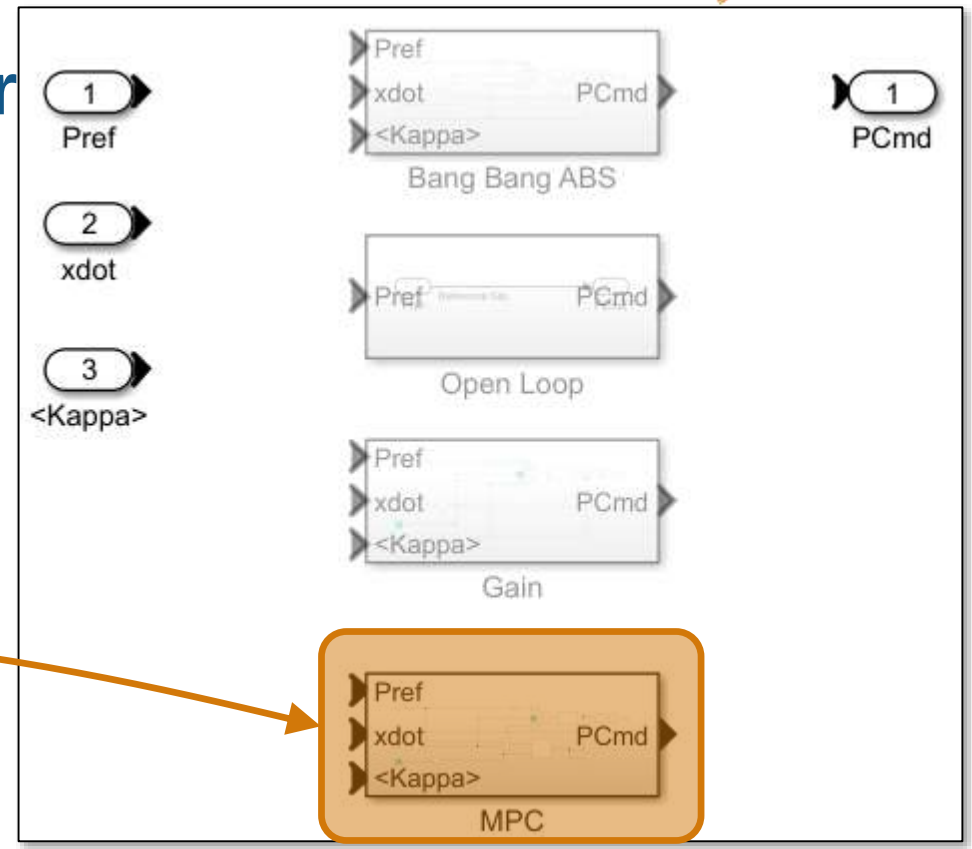

Open loop brake controller simply passes through brake pressure command



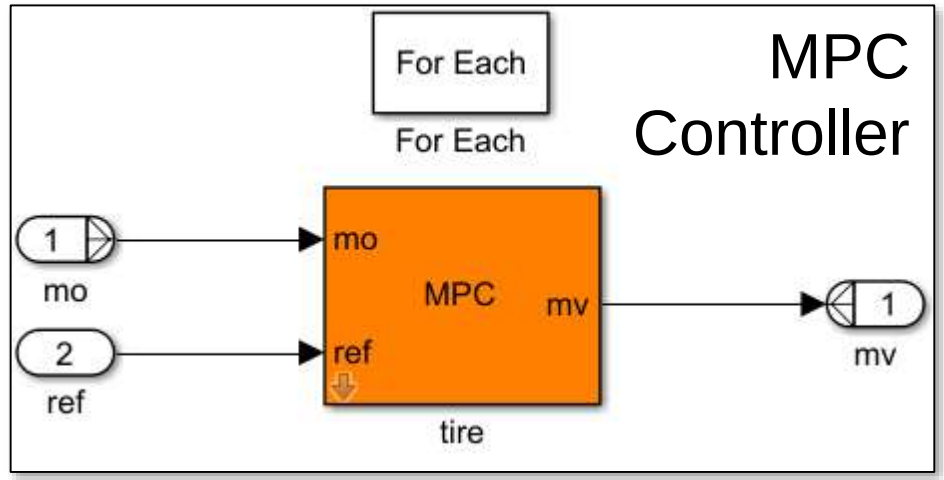

Disc brakes

# Chassis Controls Study: ABS Controller

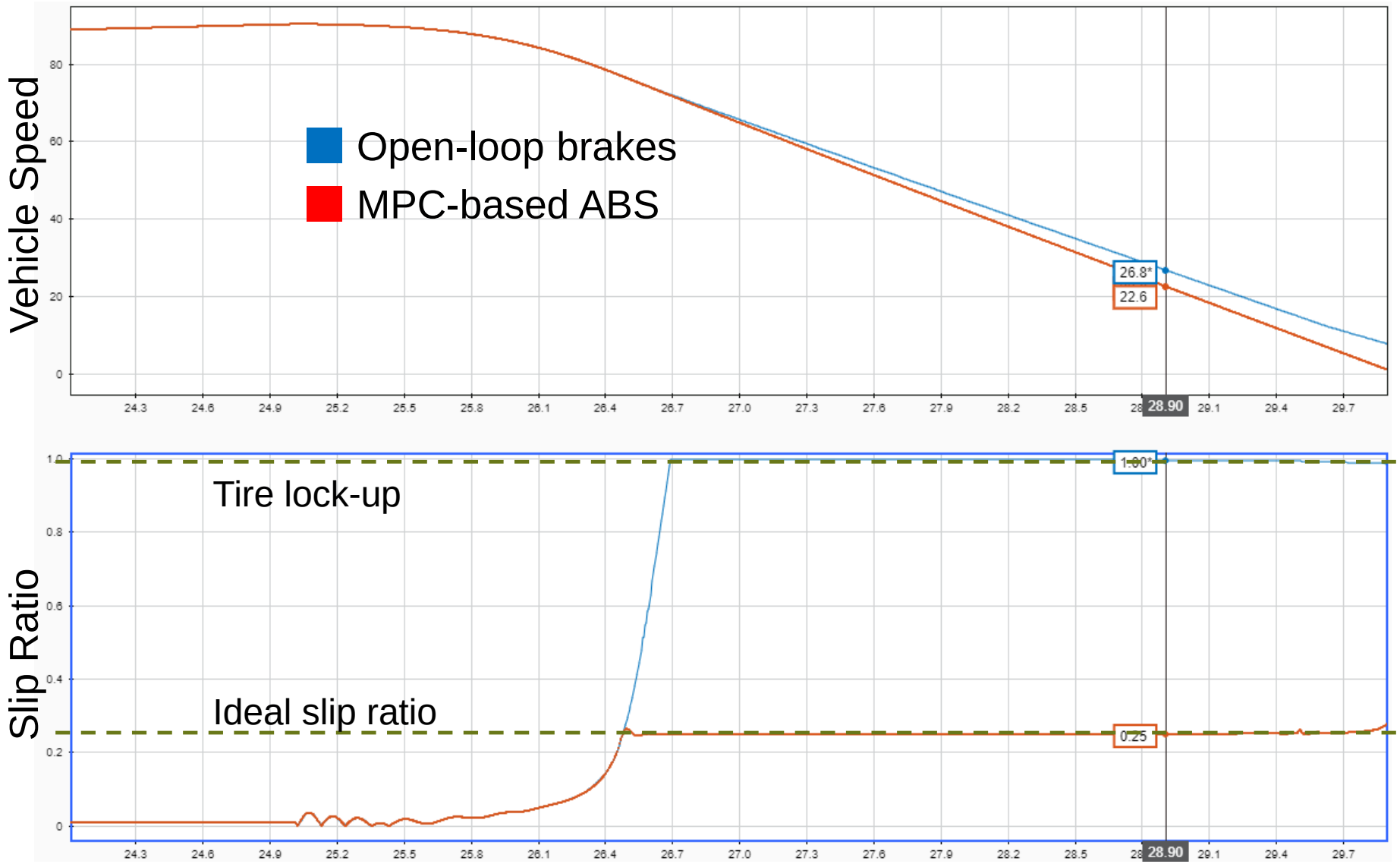



- Added custom MPC variant to brake controller subsystem
- At each time step, finds optimal brake pressure for target slip ratio



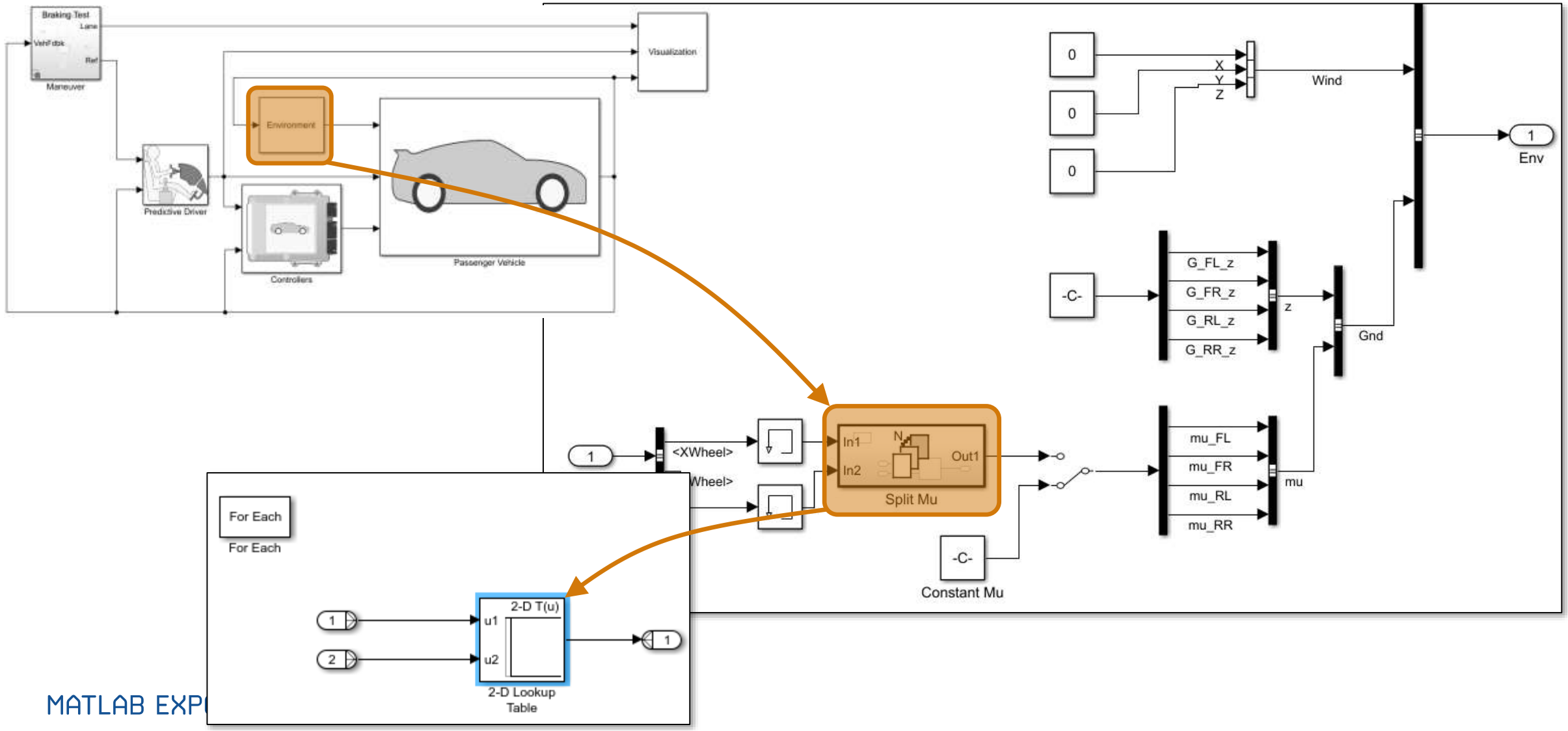
# Chassis Controls Study: ABS Controller



# Chassis Controls Study: Braking Test

## Green: Open-loop brake, white : with ABS

# Split Mu Test



# Chassis Controls Study: Split Mu Test

# Agenda

- What is Vehicle Dynamics Blockset?
- **How can I use it?**
  - Ride and handling analysis
  - Chassis controls development
  - ADAS / AD testing
  - Hardware-In-the-Loop Testing

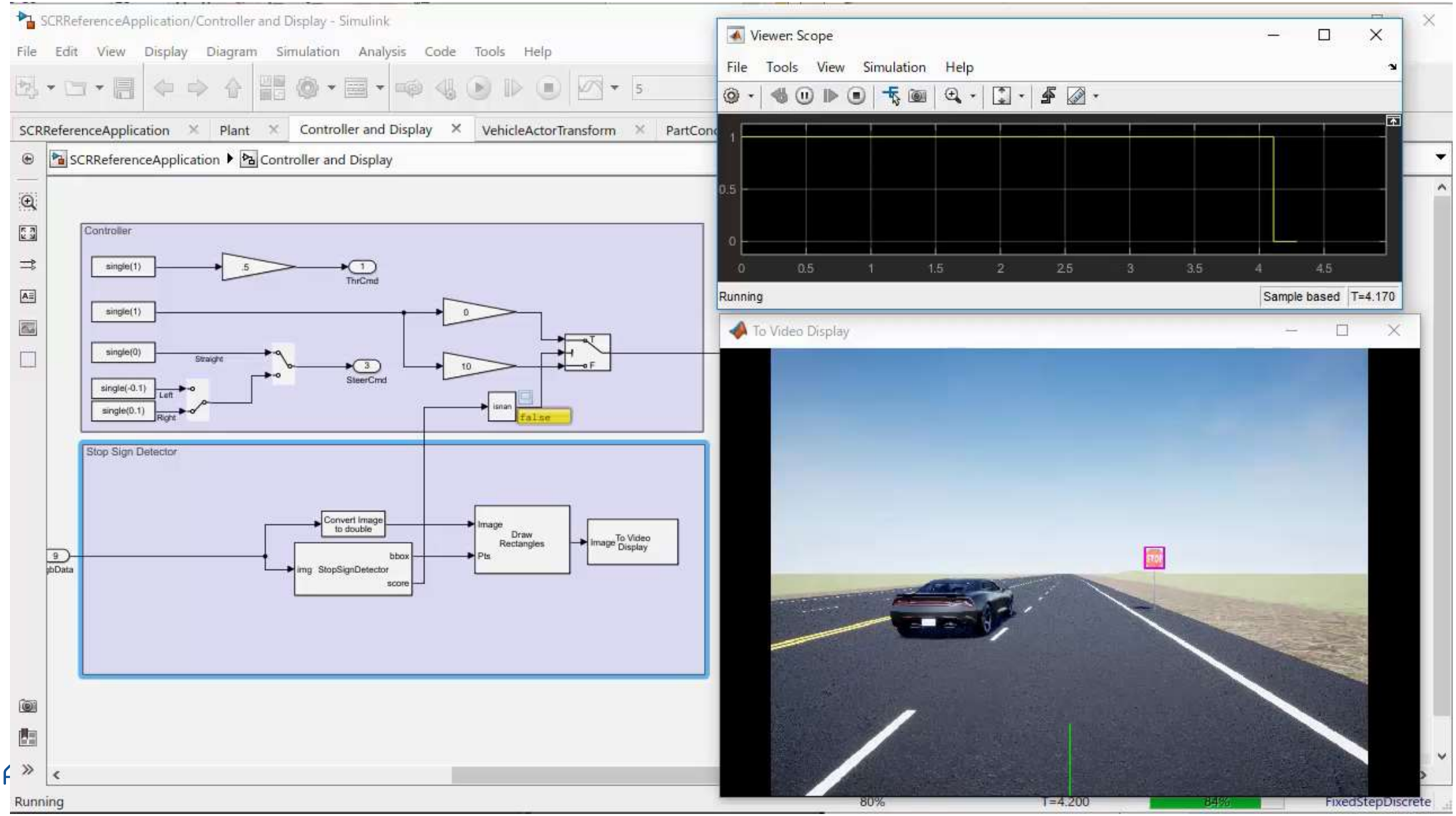
  - Test in a virtual 3D environment

# ADAS / AD Testing: Virtual 3D Scene

Camera sensor sends video to Simulink

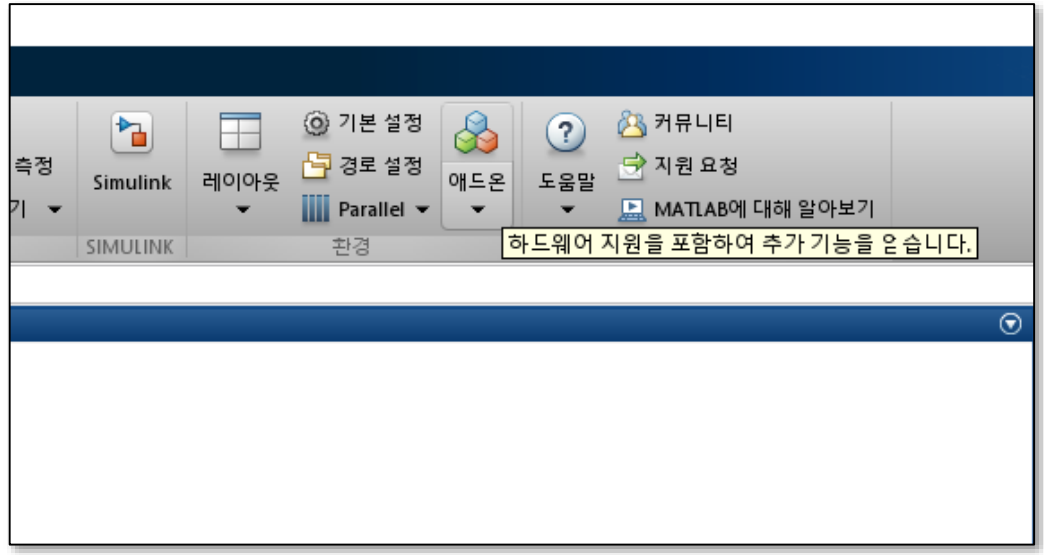
Synthetic video used for testing vision-based algorithms (e.g., lane detection)

# Stop Sign Detection and Braking

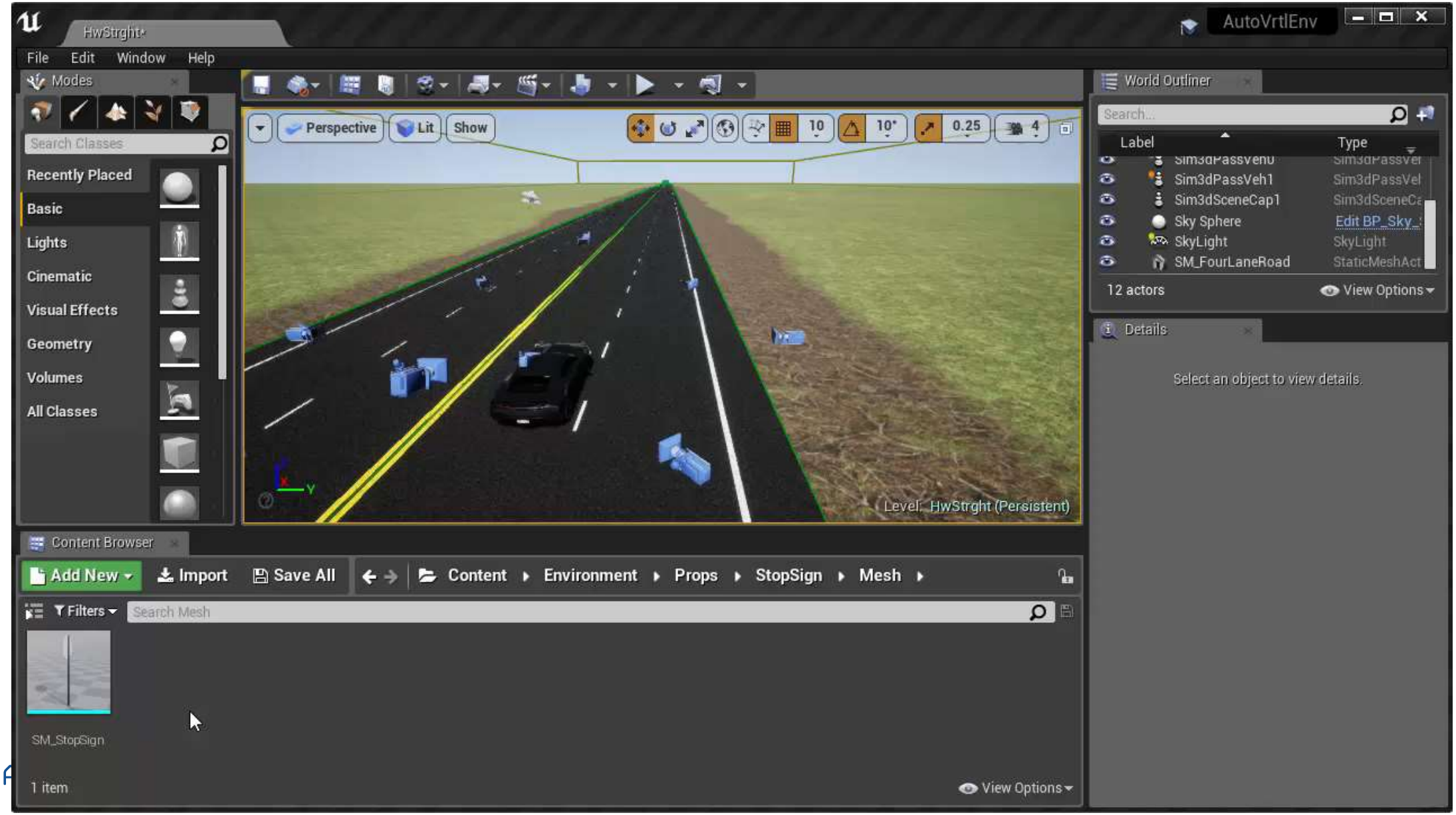


# Customizing Scene with Support Package

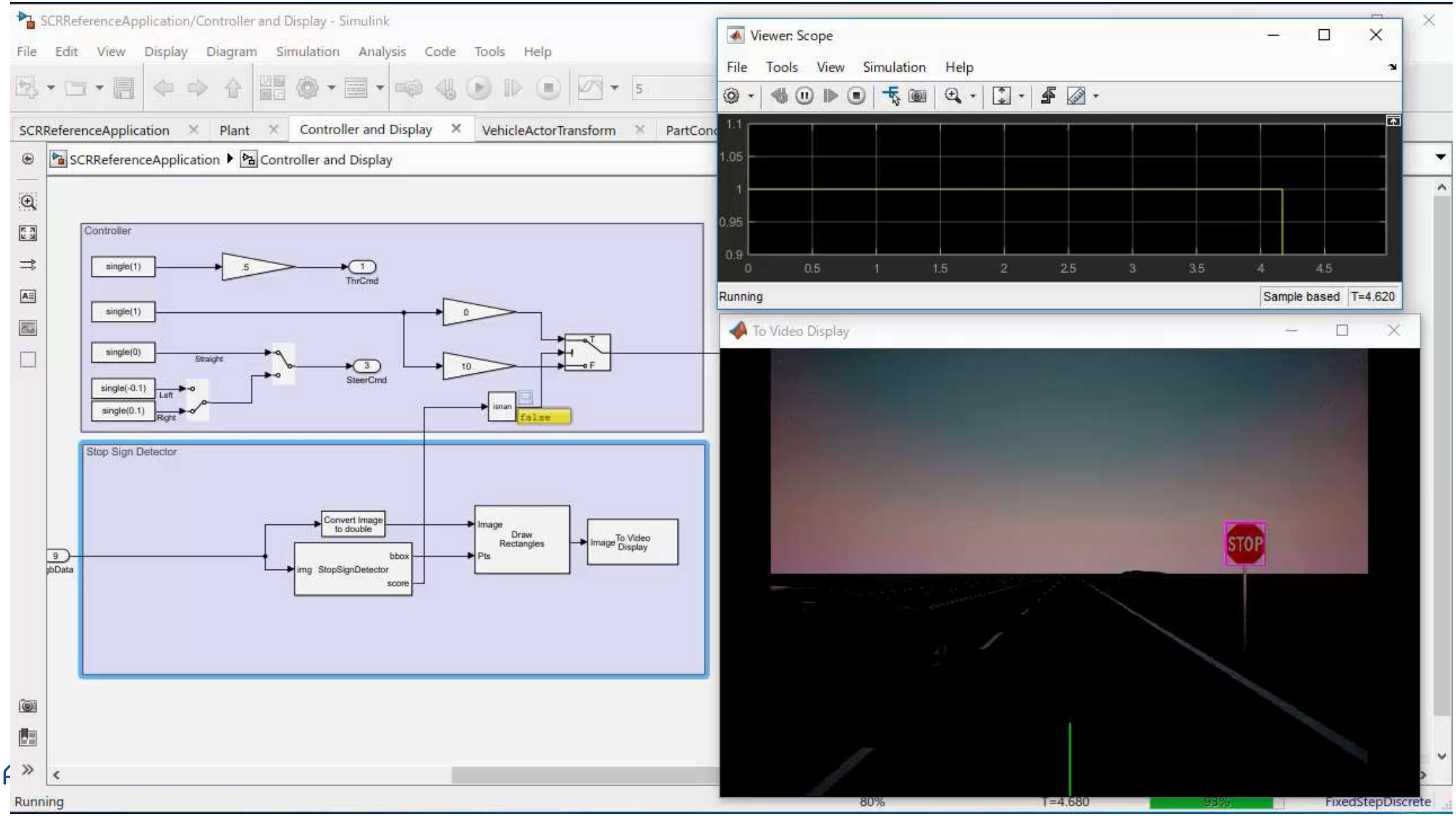
- Create your own scenes with Unreal Editor and our Simulink plug-in
- Unreal Editor project files available in our Support Package: "Vehicle Dynamics Blockset interface for Unreal Engine 4"

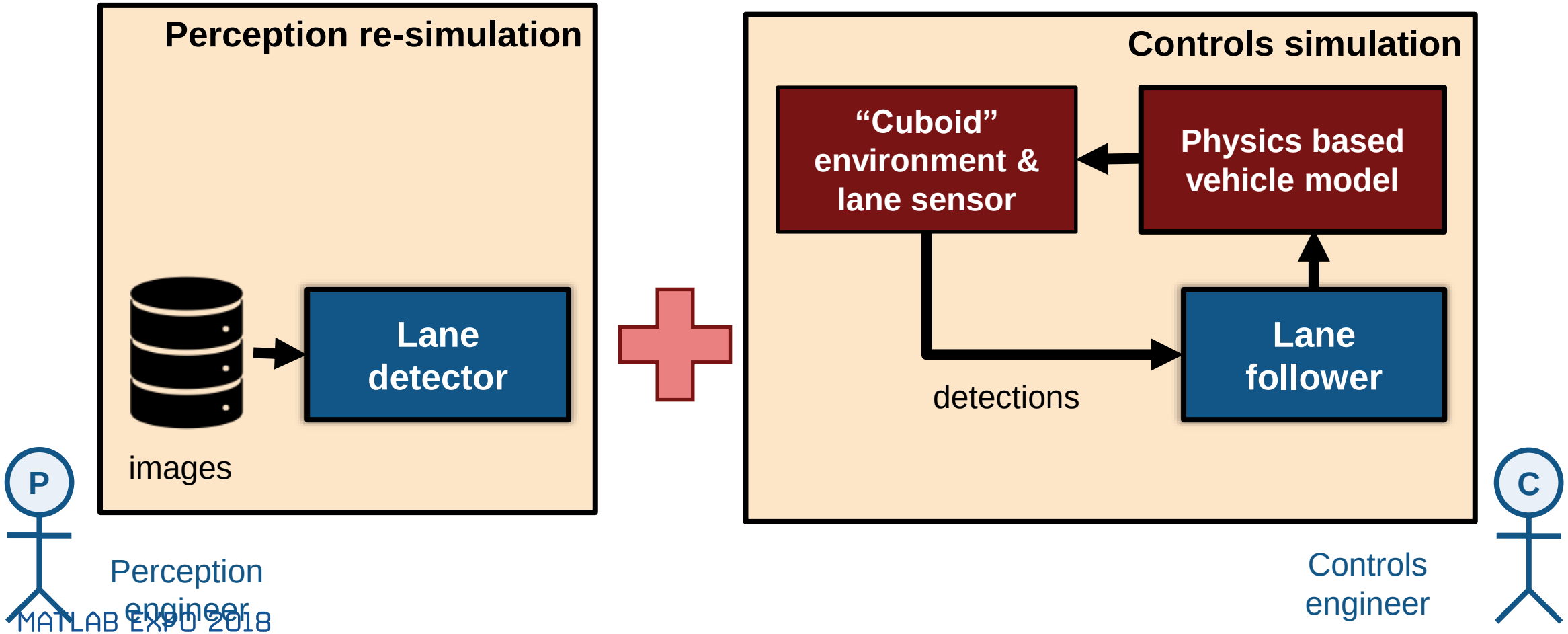
# Editing Support Package Scene to Add Stop Sign



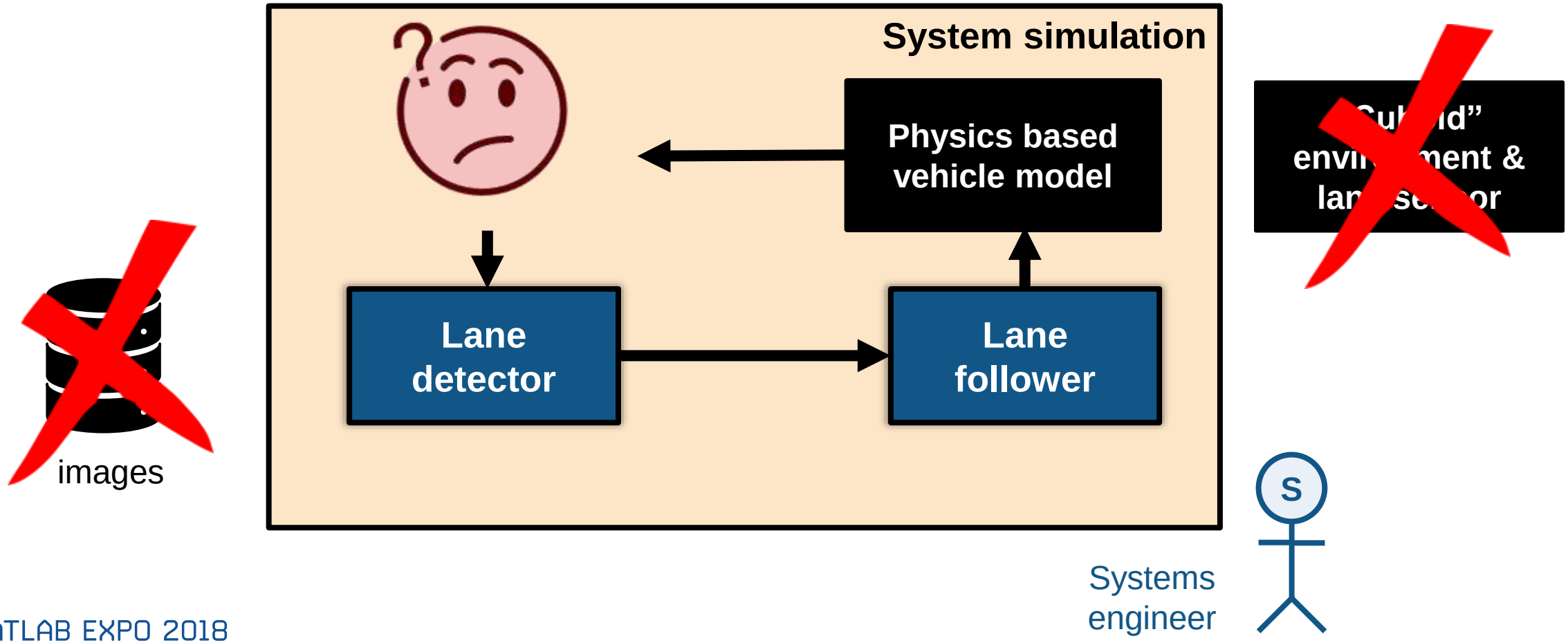
# Changing the Lighting to Night Conditions



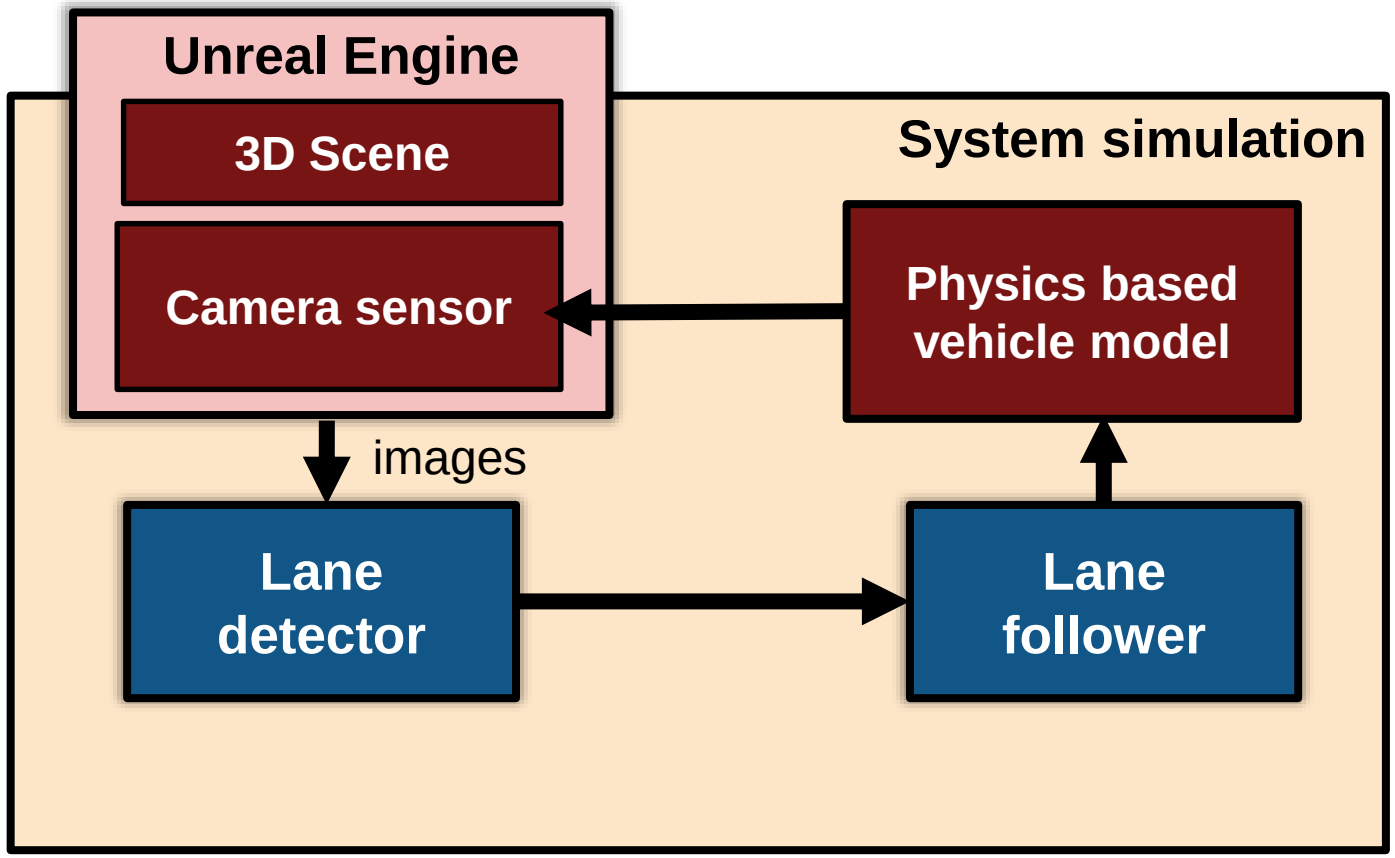
# Perception algorithms are typically developed with different workflows than control algorithms



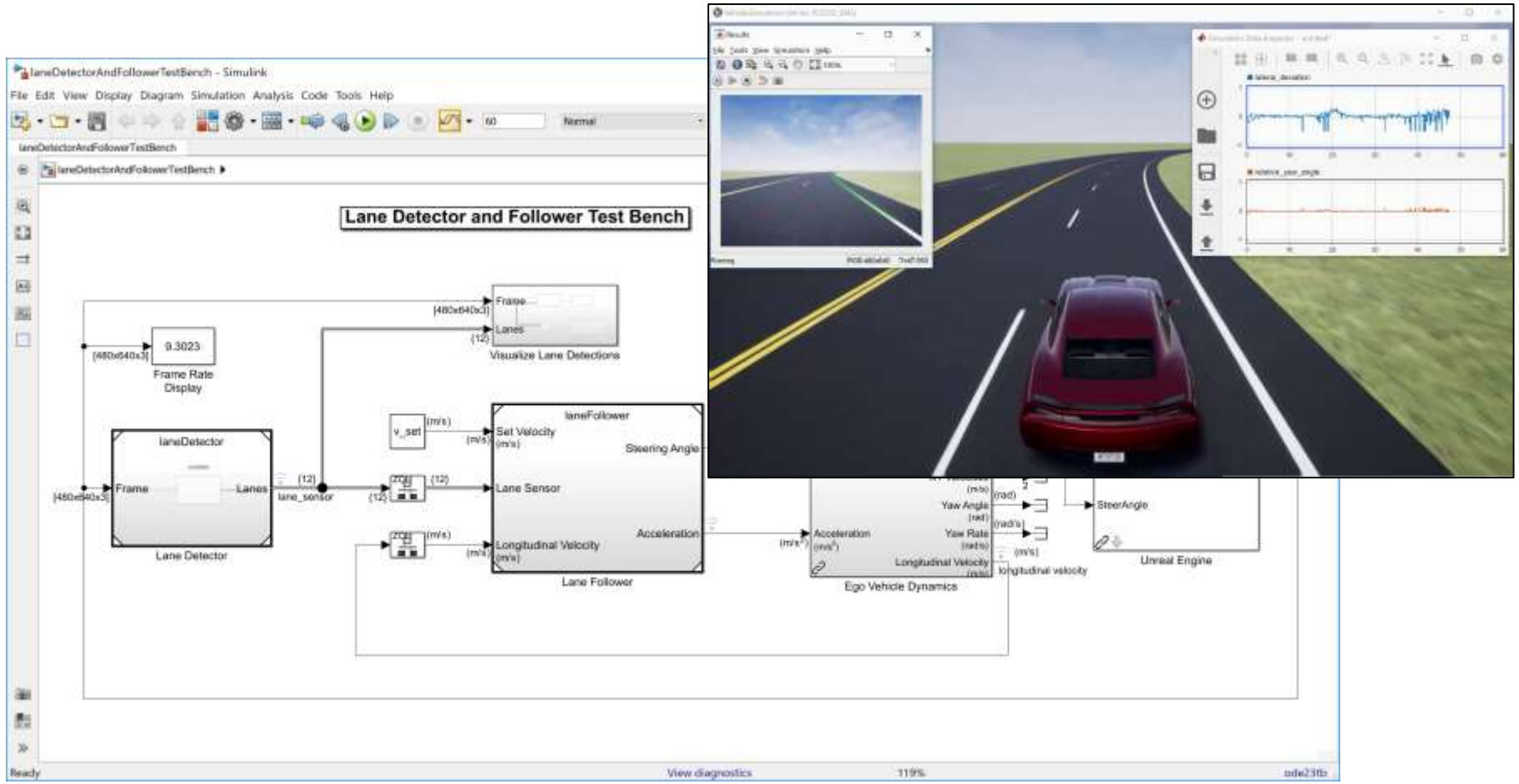
# What is required to combine lane detector and follower components into a system level simulation



# Lane detector and follower system



# Lane detector and follower system test bench simulates vehicle dynamics with Unreal Engine to synthesize camera images

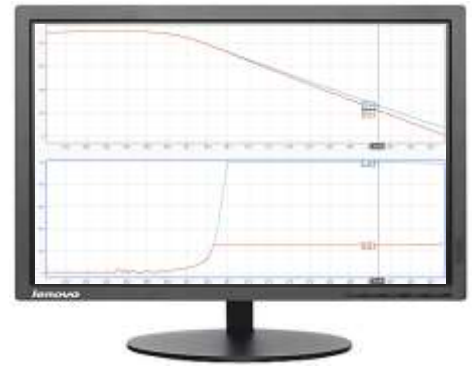


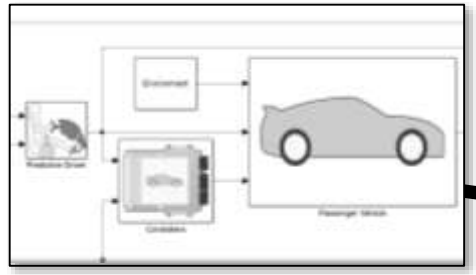
# Agenda

- What is Vehicle Dynamics Blockset?
- **How can I use it?**
  - Ride and handling analysis
  - Chassis controls development
  - ADAS / AD testing
  - Hardware-In-the-Loop Testing

# HIL Testing

- Do these models run on HIL simulators?
  - Yes!, All blocks in VDBS support code generation except visualization block
  - Tested with Simulink Real-Time on Speedgoat target computer
  - ~270μs turn-around time for 1000μs time step





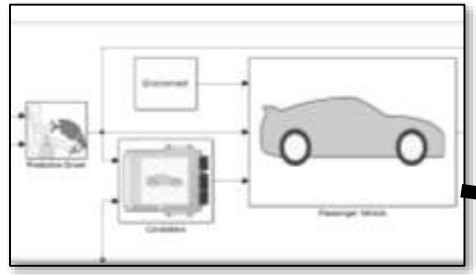
SL plant + controller

Speedgoat
Mobile Machine

Data collection

# HIL Testing with UE

- Can you perform HIL testing with Unreal Engine running?
  - Yes!, but UE visualization block doesn't support code generation.
  - Unreal Engine can run on host PC with GPU.



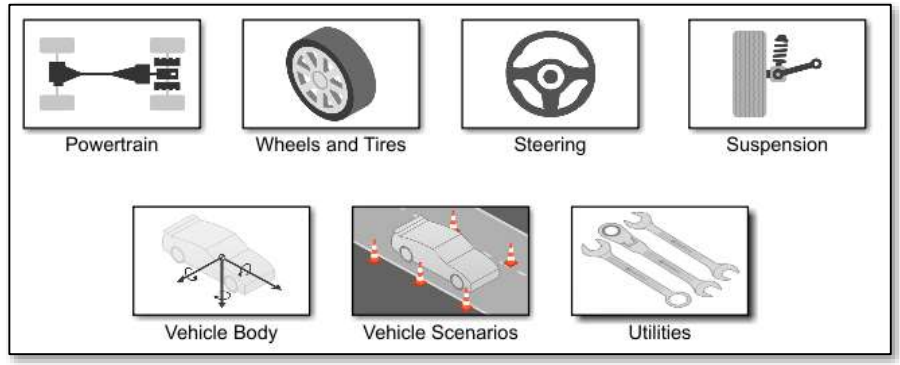
SL plant + controller

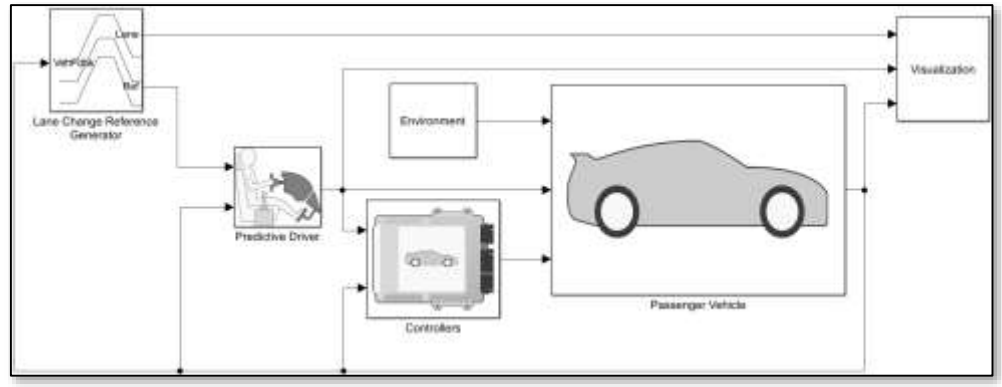
Speedgoat
Mobile Machine

Data collection
+ UE4

# Summary

- Vehicle Dynamics Blockset provides:
  - Open and documented library of component and subsystem models
  - Pre-built vehicle models that you can parameterize and customize
  - Fast-running models that are ready for HIL deployment
  - Interface to Unreal Engine



# Frequently Asked Questions: Hardware

- What hardware is required to run these models?
  - Simulink only: reference applications run faster than real-time on a modern laptop
  - With 3D engine enabled: Need a good GPU (tested on 1080 nVidia graphics card with 8 GB on-board RAM)


- Do we support Mac / Linux?
  - The Simulink models will run on any platform that Simulink supports
  - The UE4 games are compiled for Windows only, so Mac and Linux users must run in Simulink-only mode (for now)