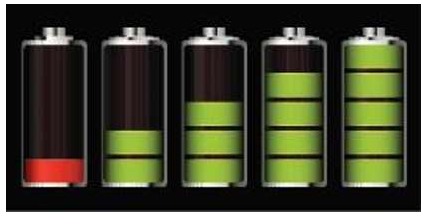
MATLAB EXPO 2018

Full Vehicle Simulation for Electrification and Automated Driving Applications

Vijayalayan R & Prasanna Deshpande
Control Design Application Engineering

Key Trends in Automotive Industry



Vehicle Electrification

Autonomous Driving

Session Key Take Away

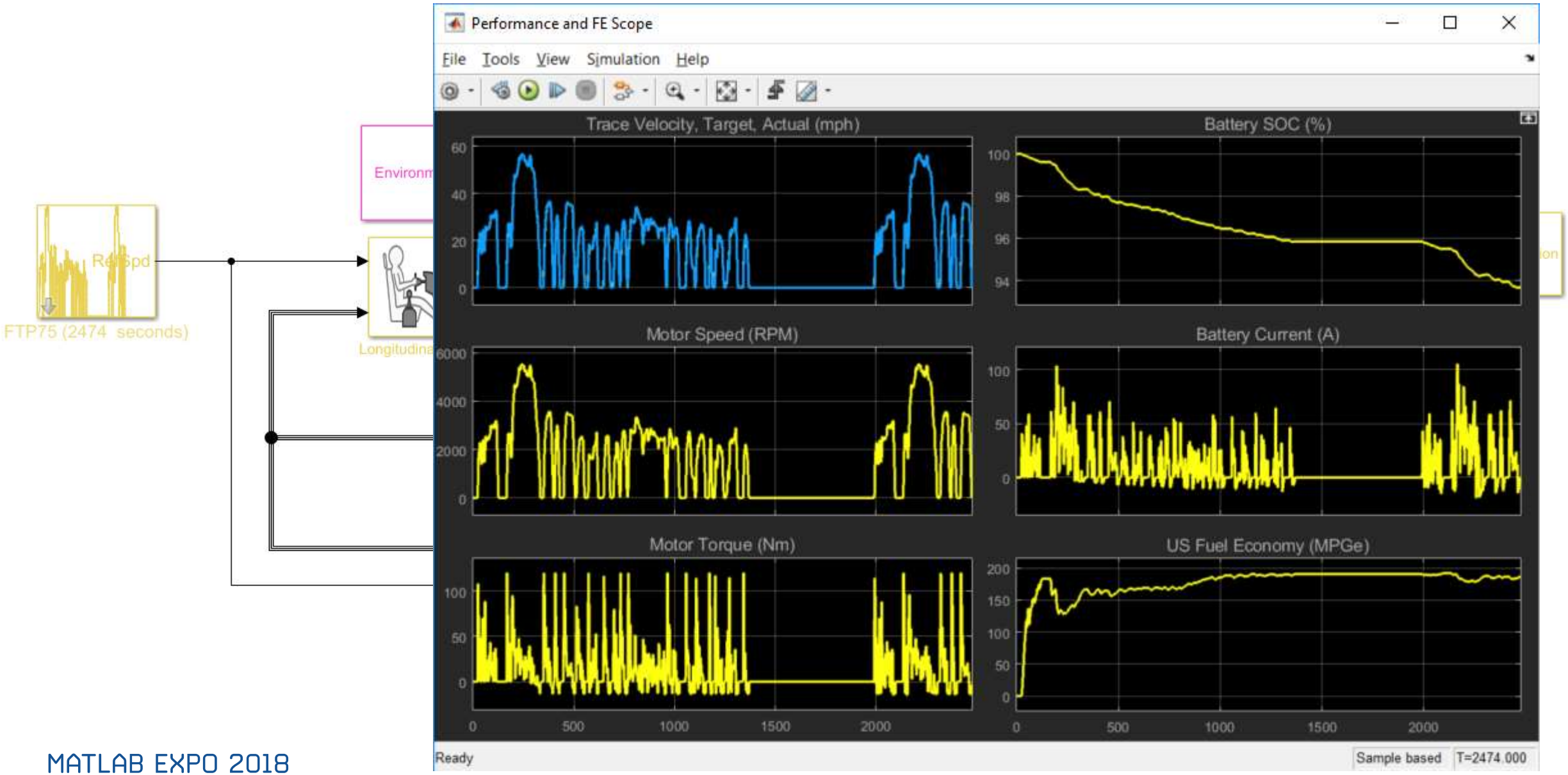
Full vehicle simulation model addresses the new challenges posed by key automotive trends

How to build a full vehicle simulation model?

Scenario- 1

Vehicle Electrification

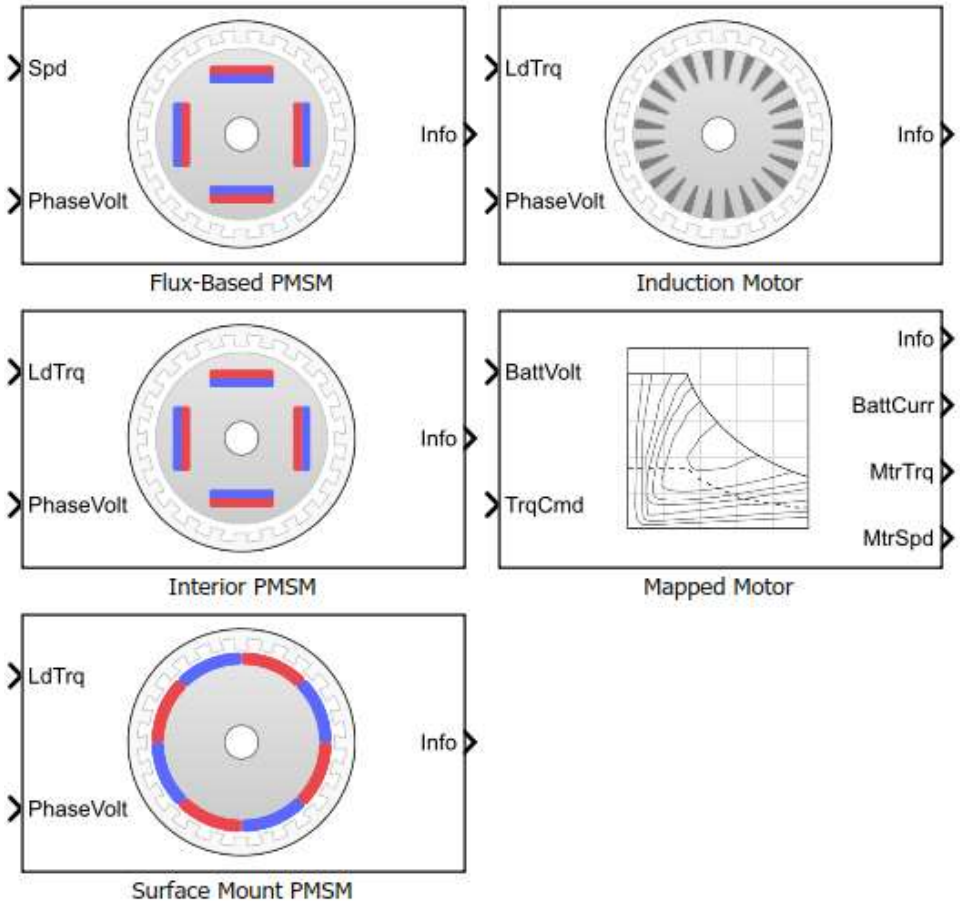
What if we can build . . .

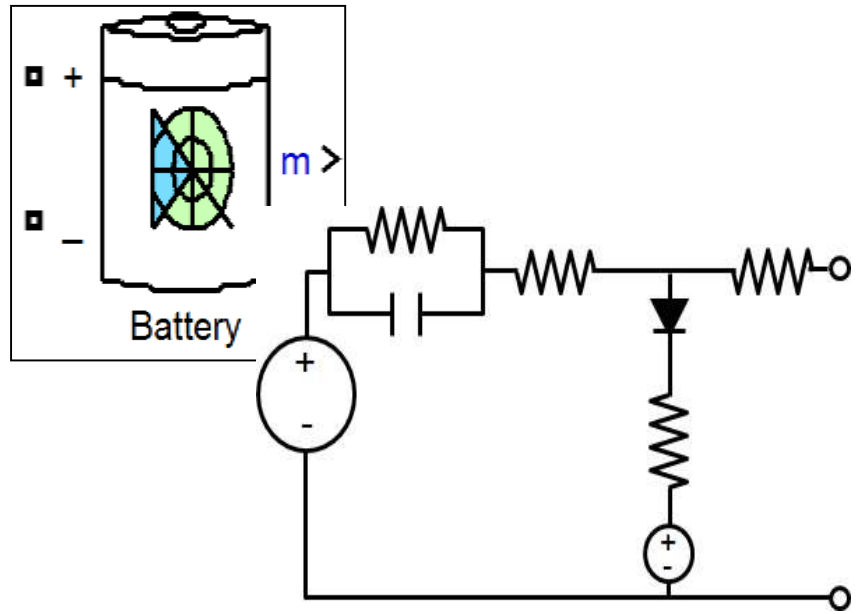


Challenges for Powertrain Electrification

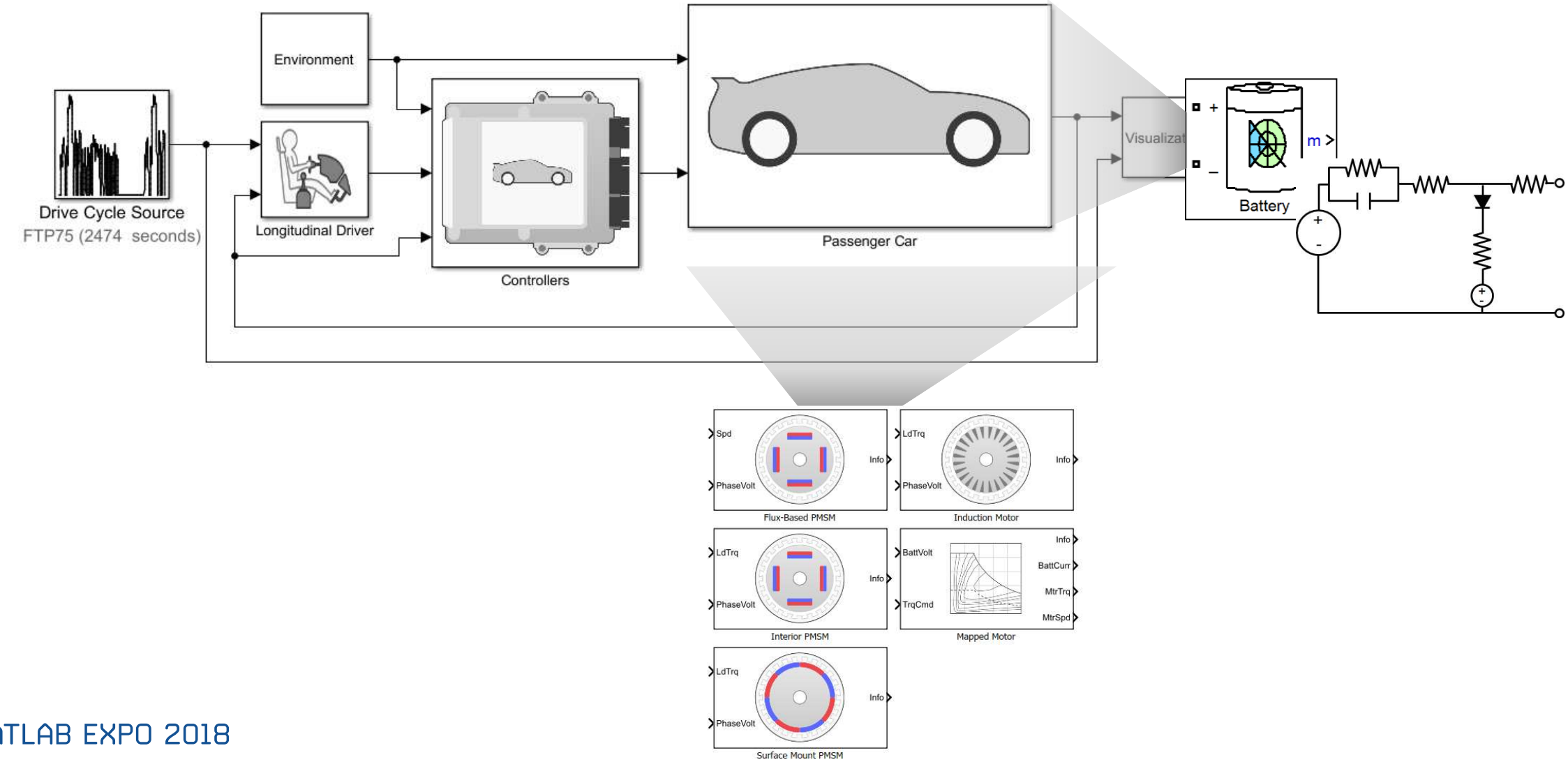
- Benchmark with existing vehicle and determine the requirements for electrification
- Component Selection
- Component Sizing
- Vehicle level performance analysis and optimization:
  - How do the selected components work together ? How does the vehicle perform?
  - With the above set of components, what best Fuel Economy / Range can I get from my vehicle?

Solution: Simulation Based Approach

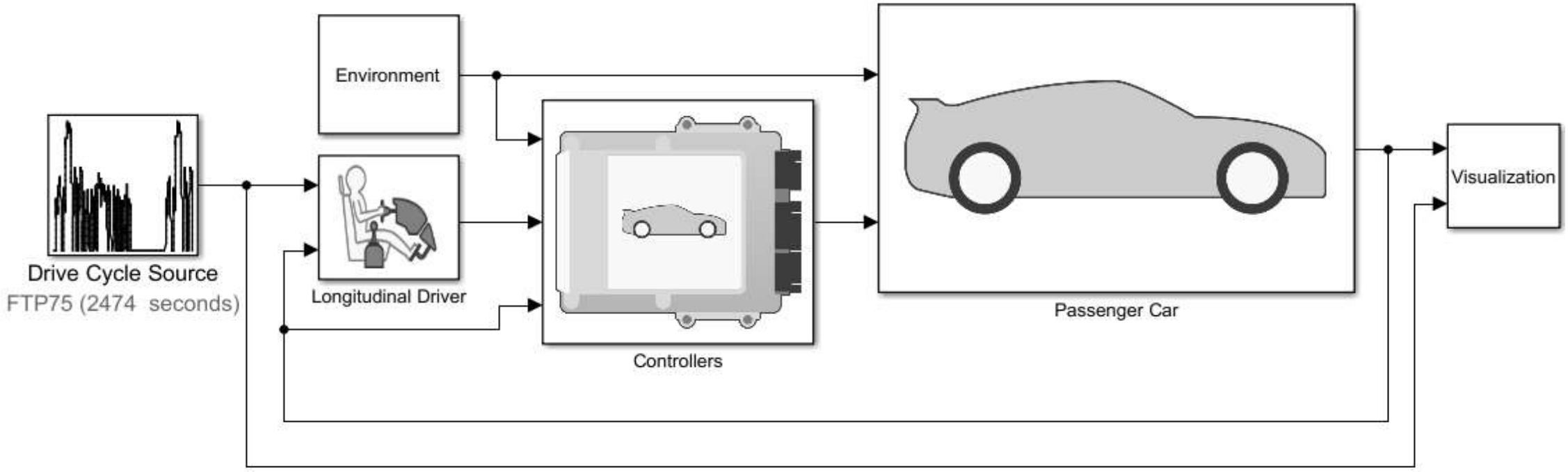




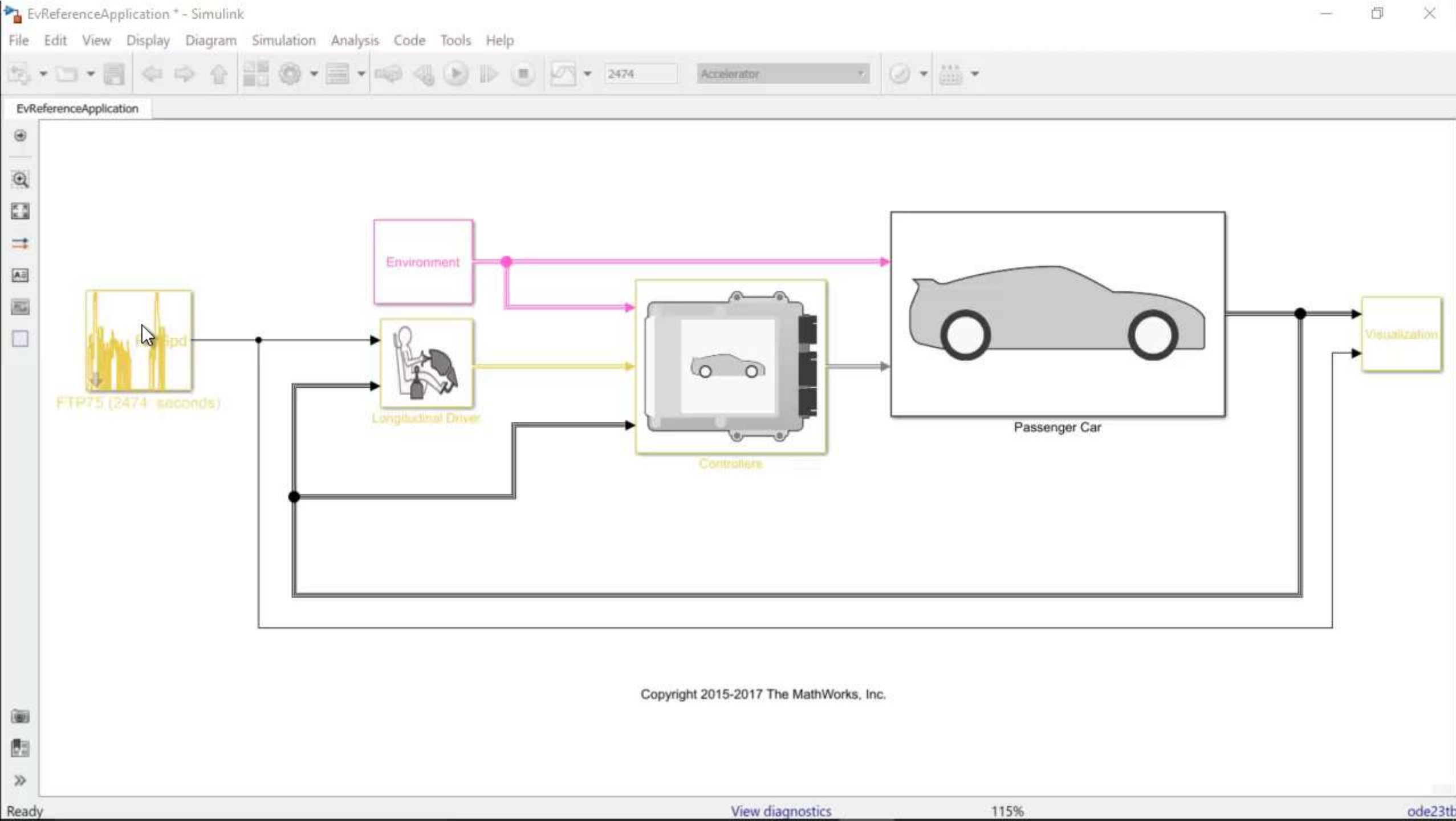
Solution: Simulation Based Approach



What if we get . . .



- Good plant / controller models
- Open for customization and well documented models
- Very fast-running models that work with popular HIL systems


EvReferenceApplication * - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
2474
Accelerator
EvReferenceApplication
Environment
FTP75 (2474 seconds)
Longitudinal Driver
Controllers
Passenger Car
Visualization
Copyright 2015-2017 The MathWorks, Inc.
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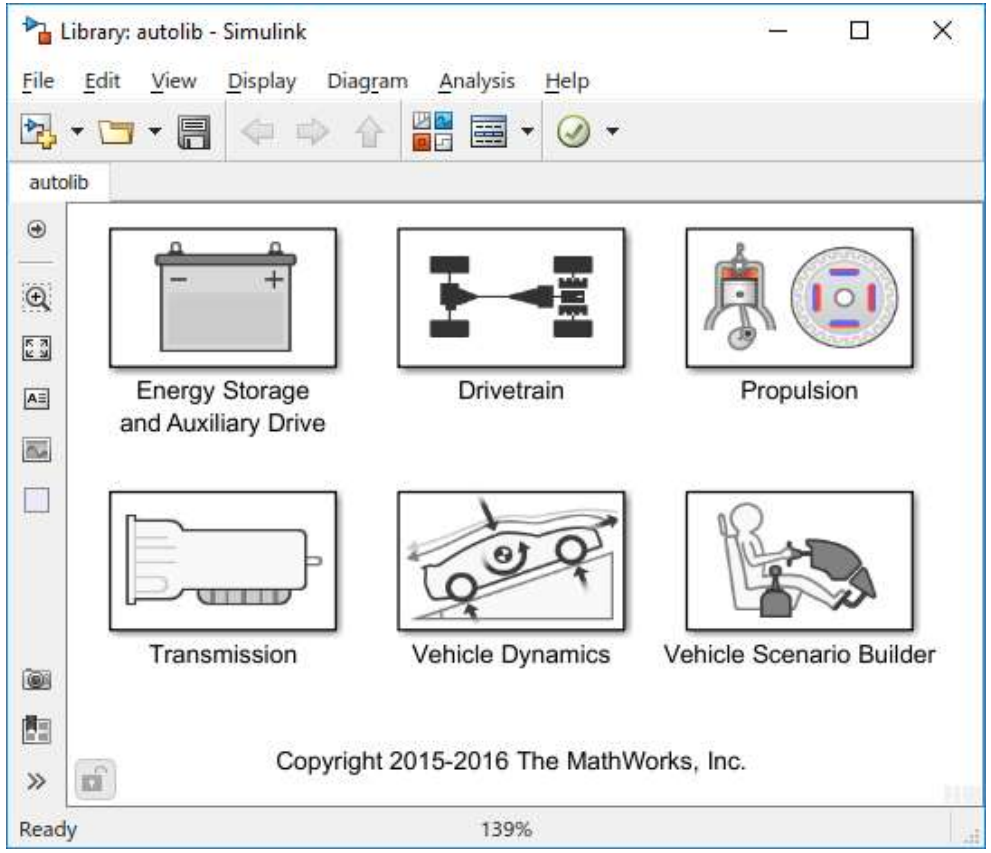
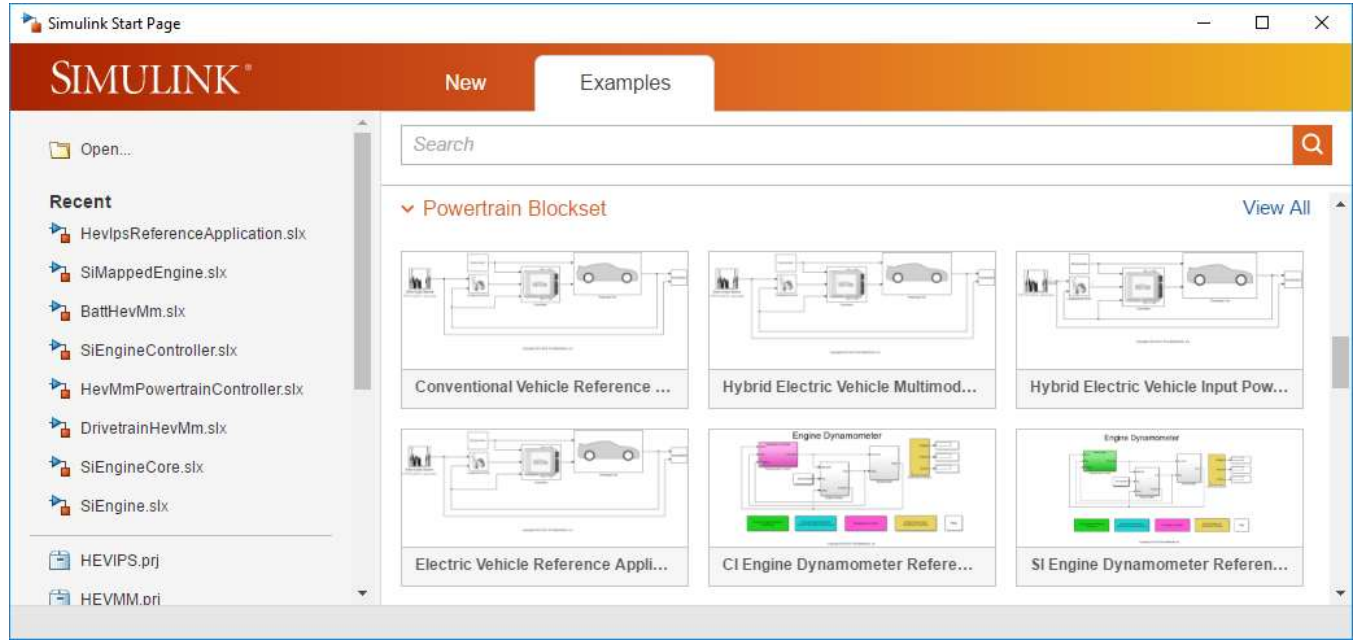
Pre-built reference applications can be used as great starting point, and library blocks help in customizing the system model

Library of blocks



Pre-built reference applications



Vehicle System Level Models can be used for Design Optimization

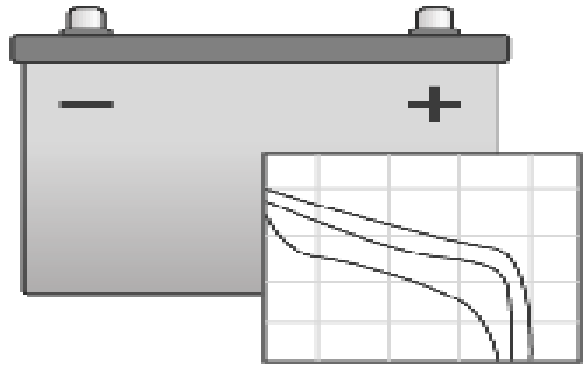
- Maximize fuel economy of HEV / EV

 # Series, # Parallel ?

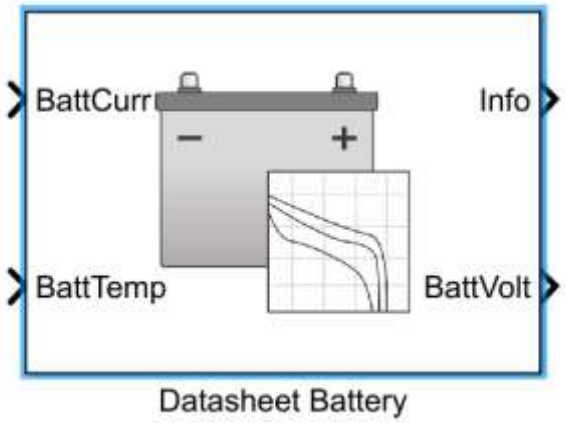
- Minimize the time required for 0-60kmph

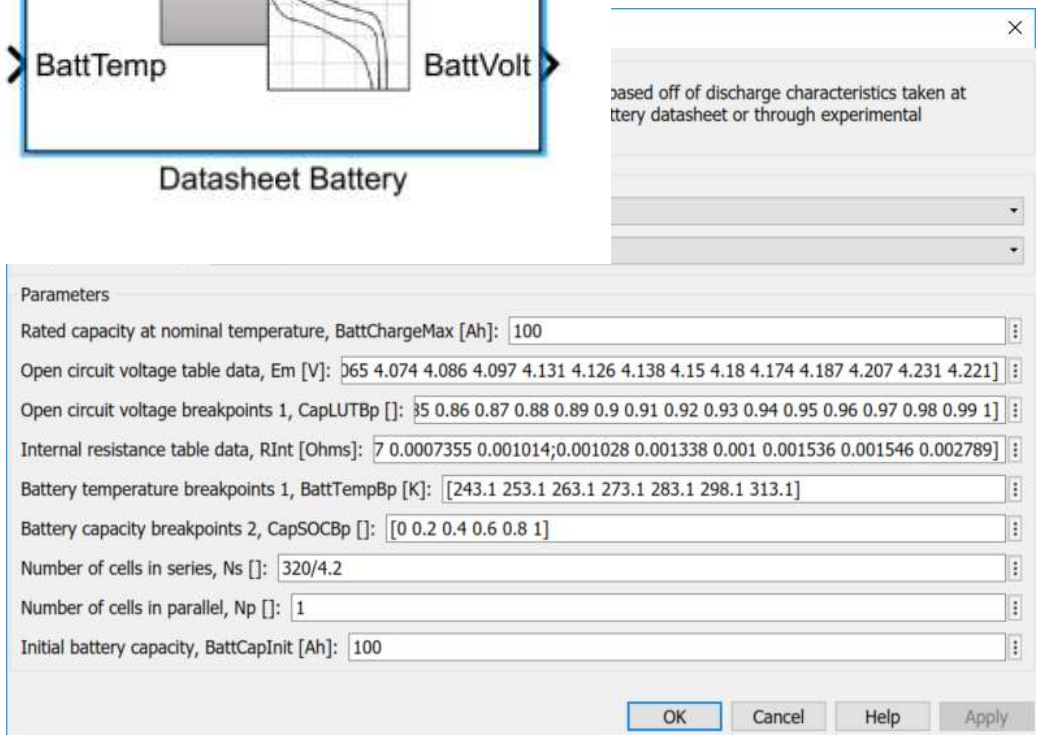
- Verify controller performance for different initial SoC points of battery
- Battery capacity or cell configuration
  - Ah rating
  - Number cells (or modules) in series / parallel
  - Affects vehicle mass

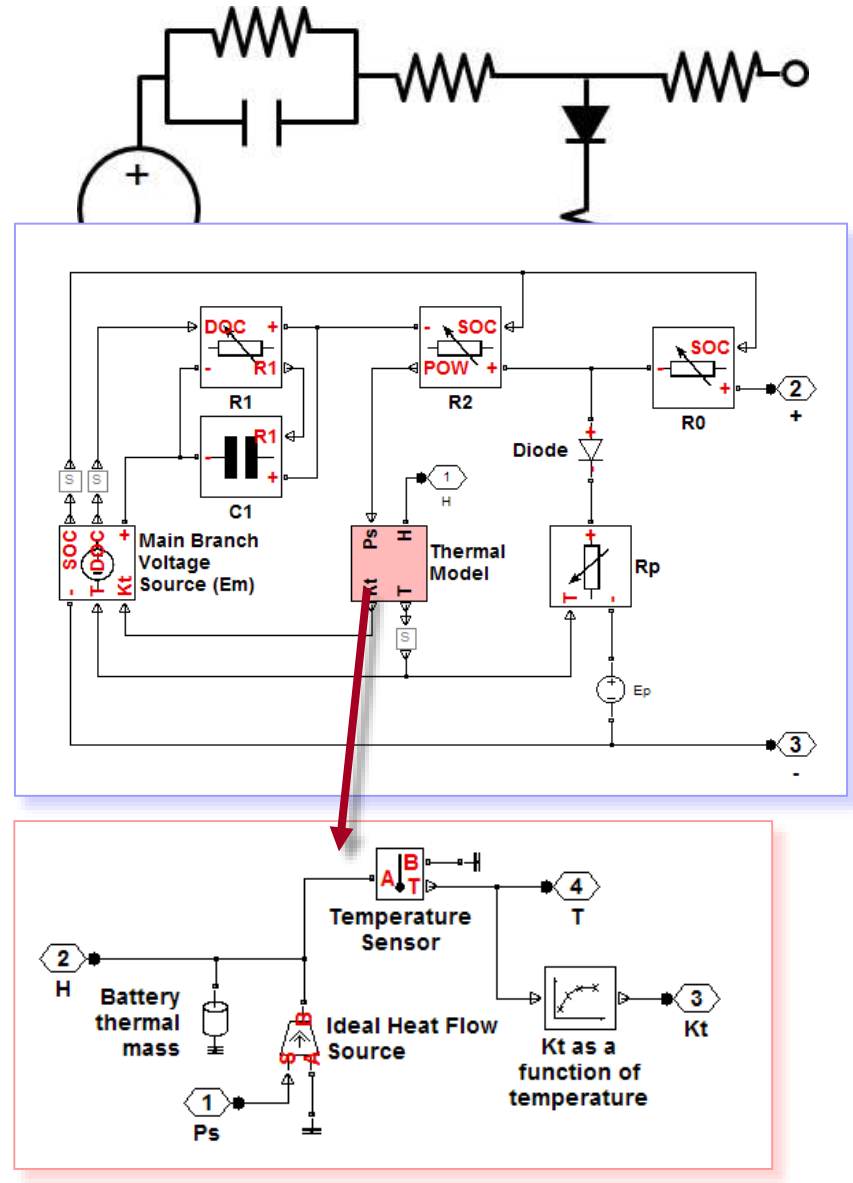
Battery Ah



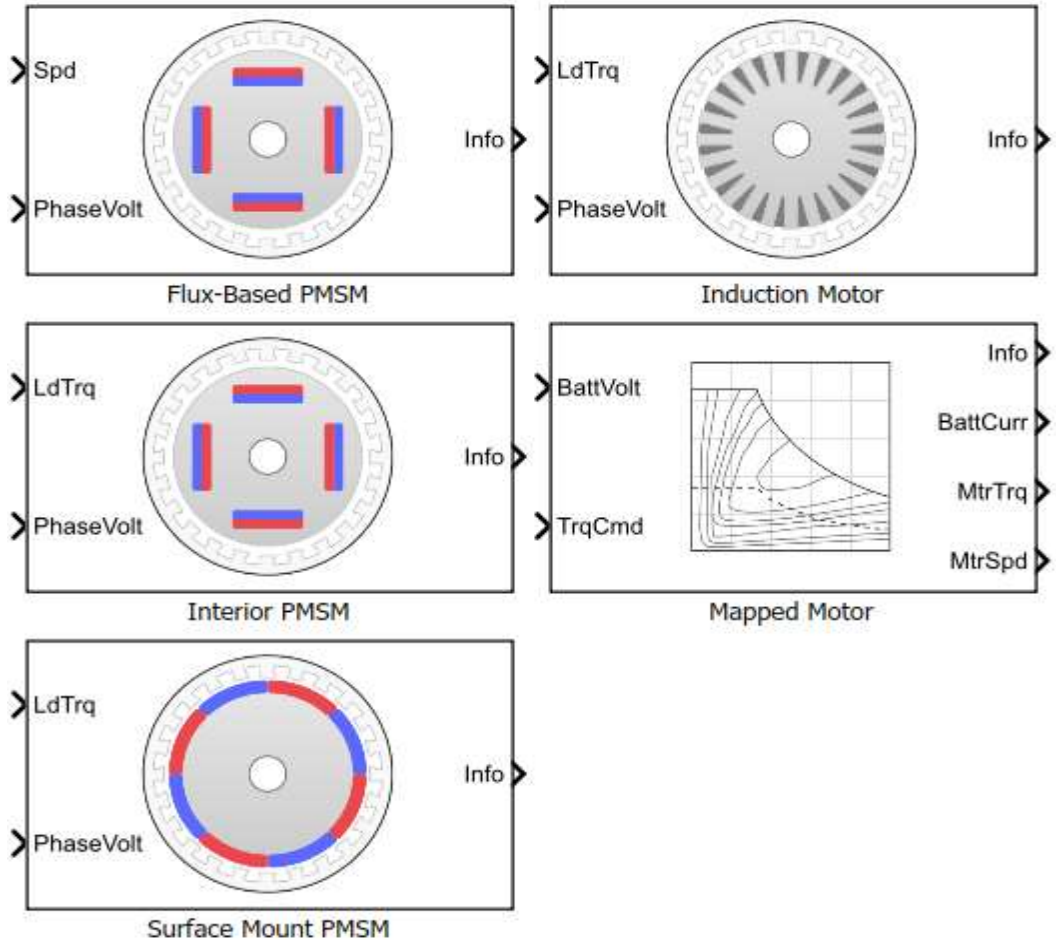
Modeling Battery as a component and Modeling Battery as a system

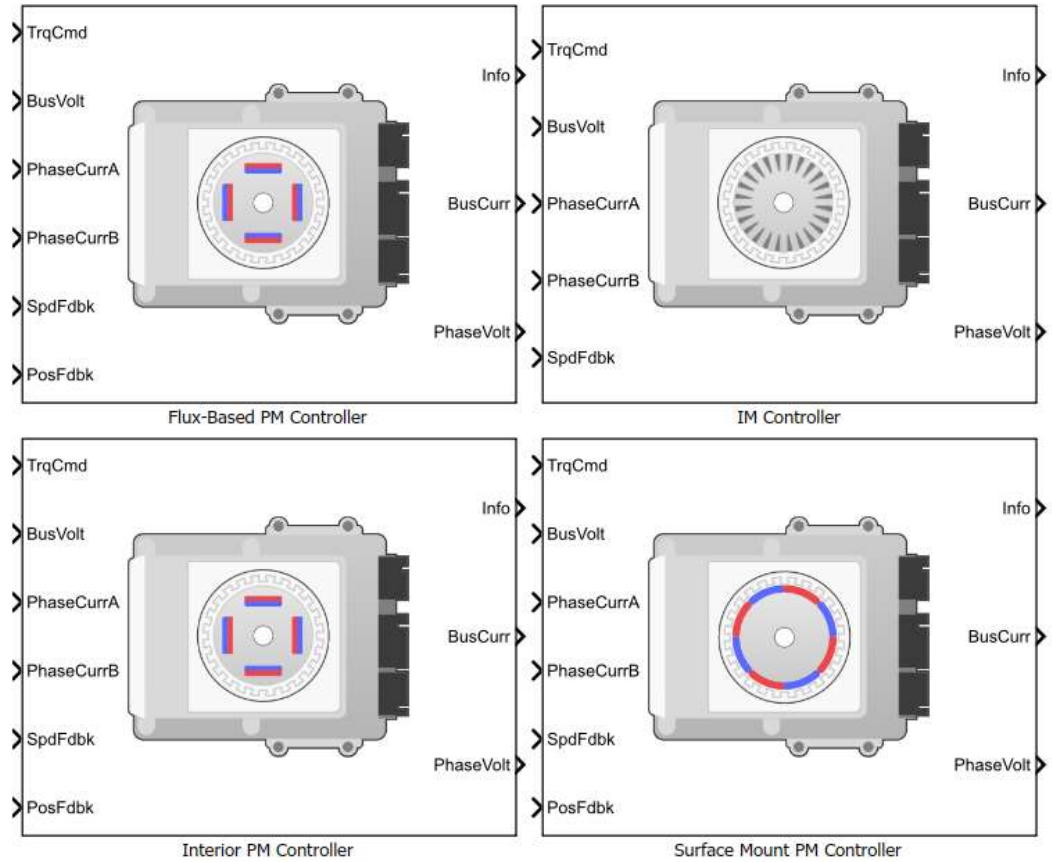




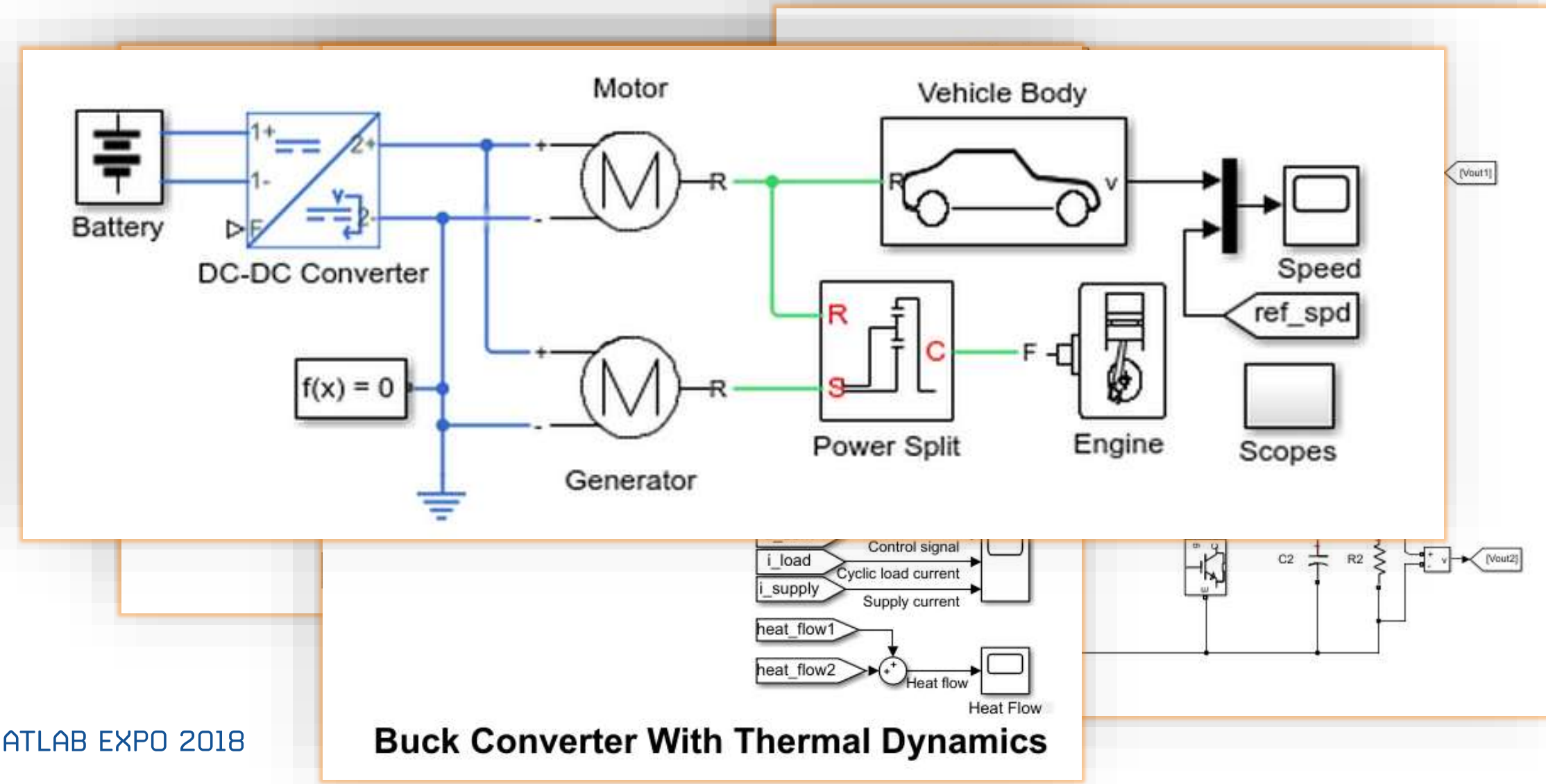


System level models of motor and controller are available with Powertrain Blockset



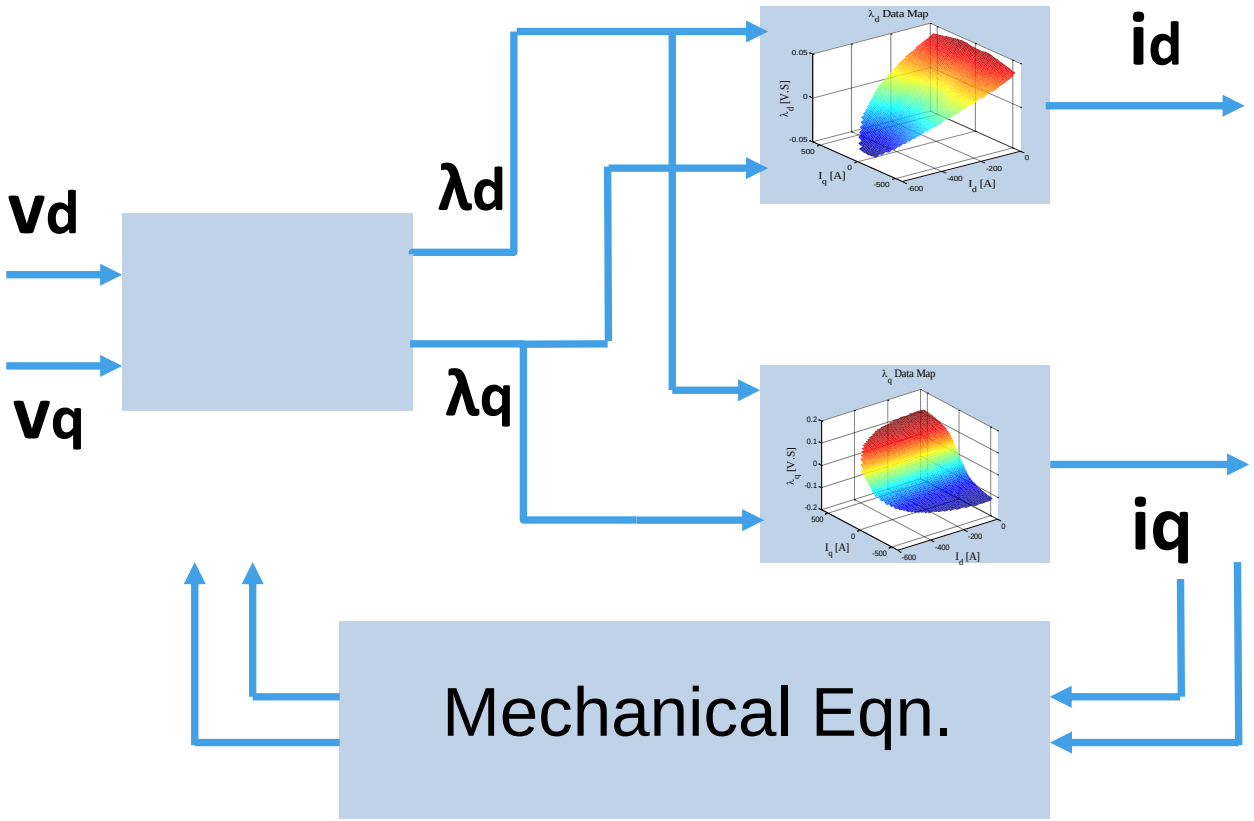


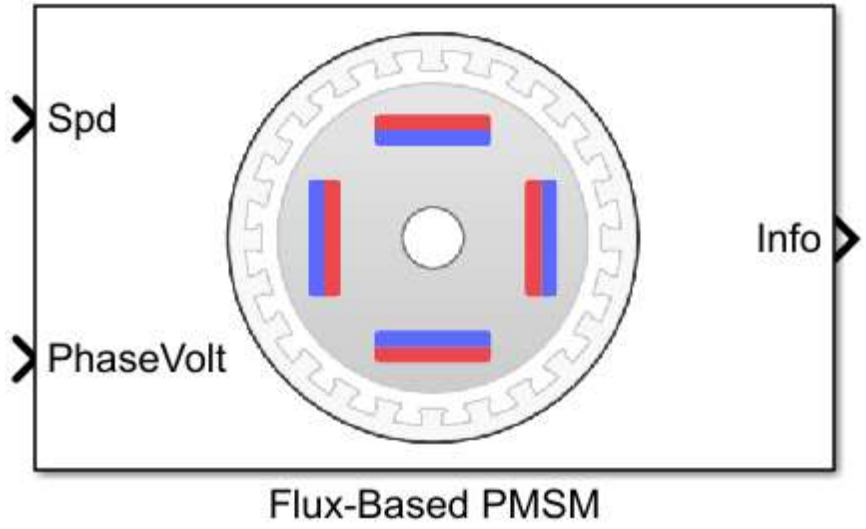
Model Power Electronics, Thermal Dynamics, Vehicle Electrical network using Simscape



High Fidelity Detailed Motor Model in Simscape

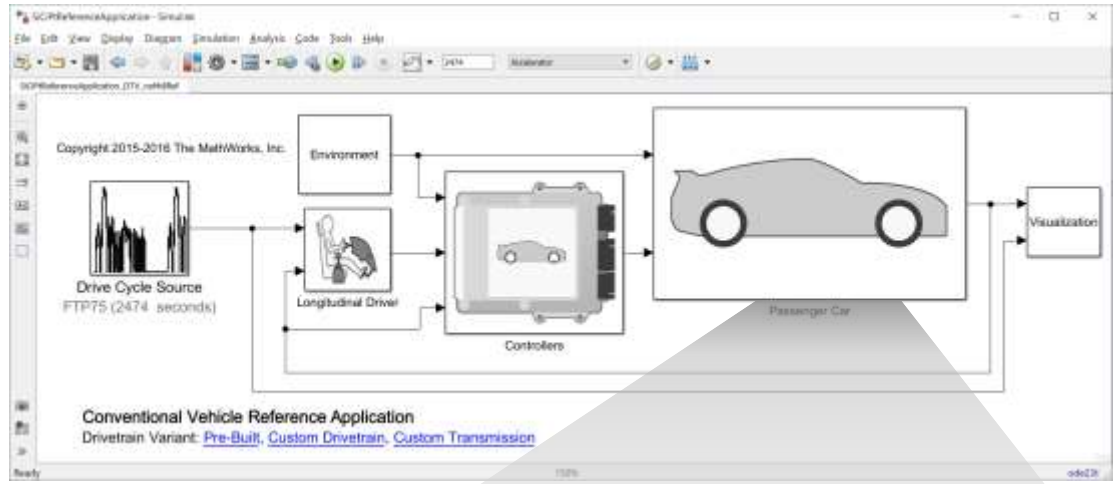
- FEA simulations or dynamometer data used to obtain non-linear flux table
- Flux-based PMSM model created to capture this effect

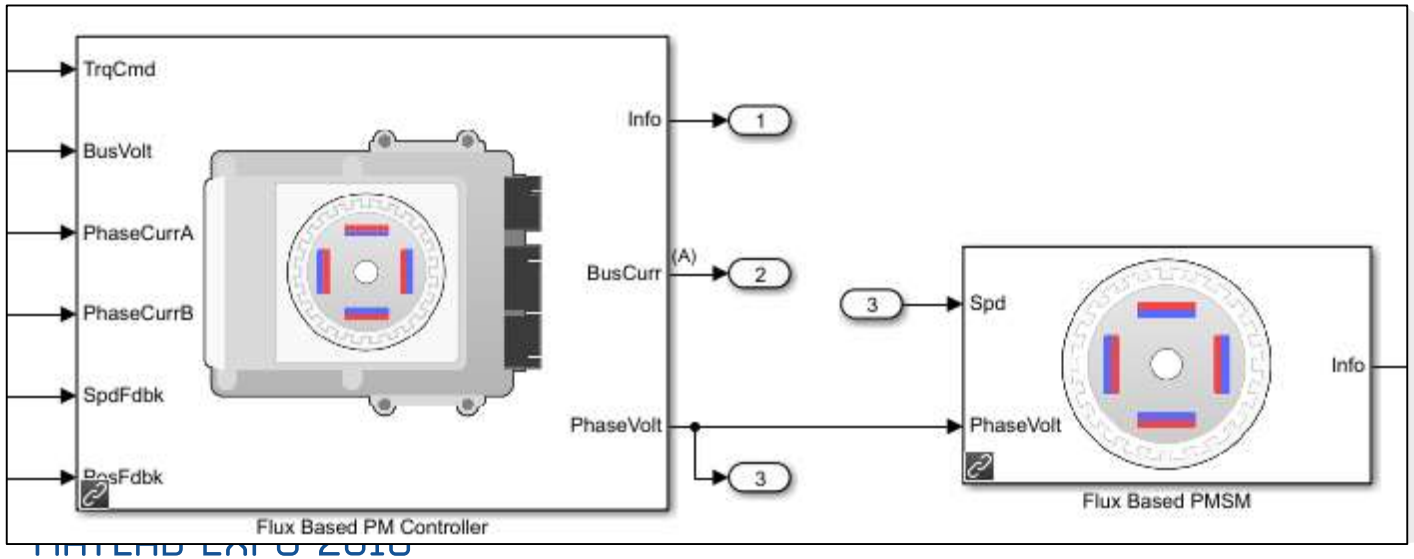


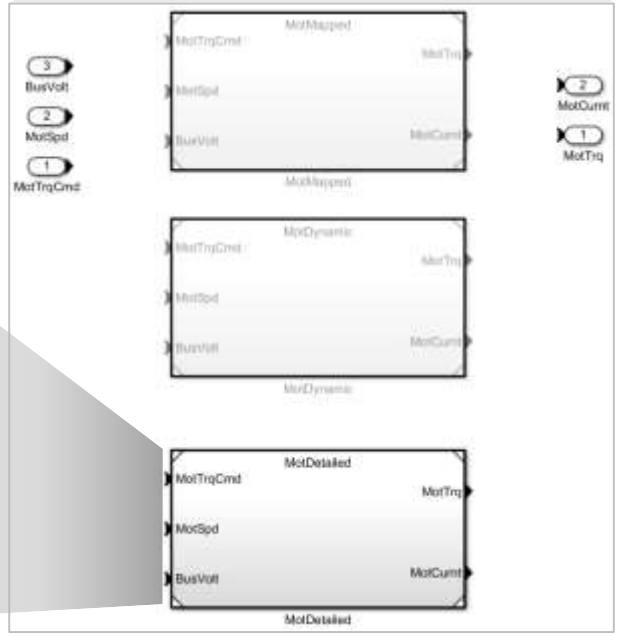


Including Detailed Subsystem Variants

- Add your own subsystem variants to the existing vehicle models
  - Simulink-based
  - Simscape-based
  - S-function
  - FMI Interface



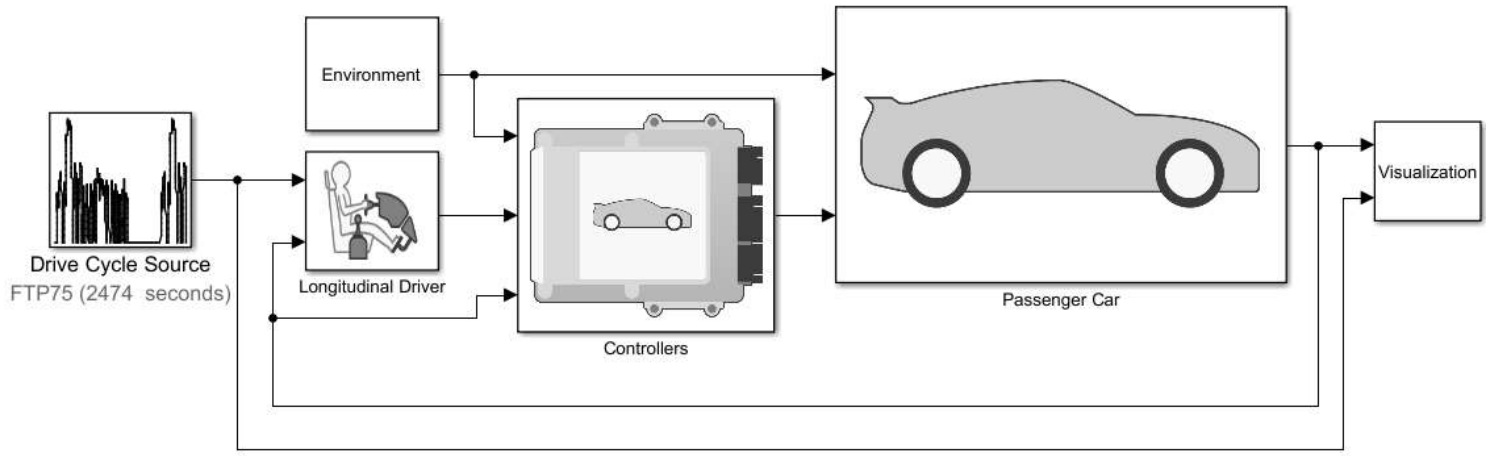




Session Key Take Away

Full vehicle simulation model addresses the new challenges posed by key automotive trends.

- Reference application model from Powertrain Blockset can be used as a starting point for:
  - Design optimization studies
  - Multi-domain simulation via Simscape
  - Component controller design and parametrization
  - Hardware-in-the-loop (HIL) testing



Scenario- 2

Chassis Control | Vehicle Dynamics | Automated Driving

What if we can…

- Model and simulate vehicle dynamics in a virtual 3D environment

- 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

Challenges faced by Chassis Controls, Vehicle Dynamics & ADAS Engineers

- Quickly achieving a good vehicle design with limited number of prototype builds
- Verifying system behavior for conditions that are too time consuming or risky to test on the road
- Single simulation environment for design and verification of controls

Challenges faced by Chassis Controls, Vehicle Dynamics & ADAS Engineers

- **Quickly achieving a good vehicle design with limited number of prototype builds**
- Verifying system behavior for conditions that are too time consuming or risky to test on the road
- Single simulation environment for design and verification of controls

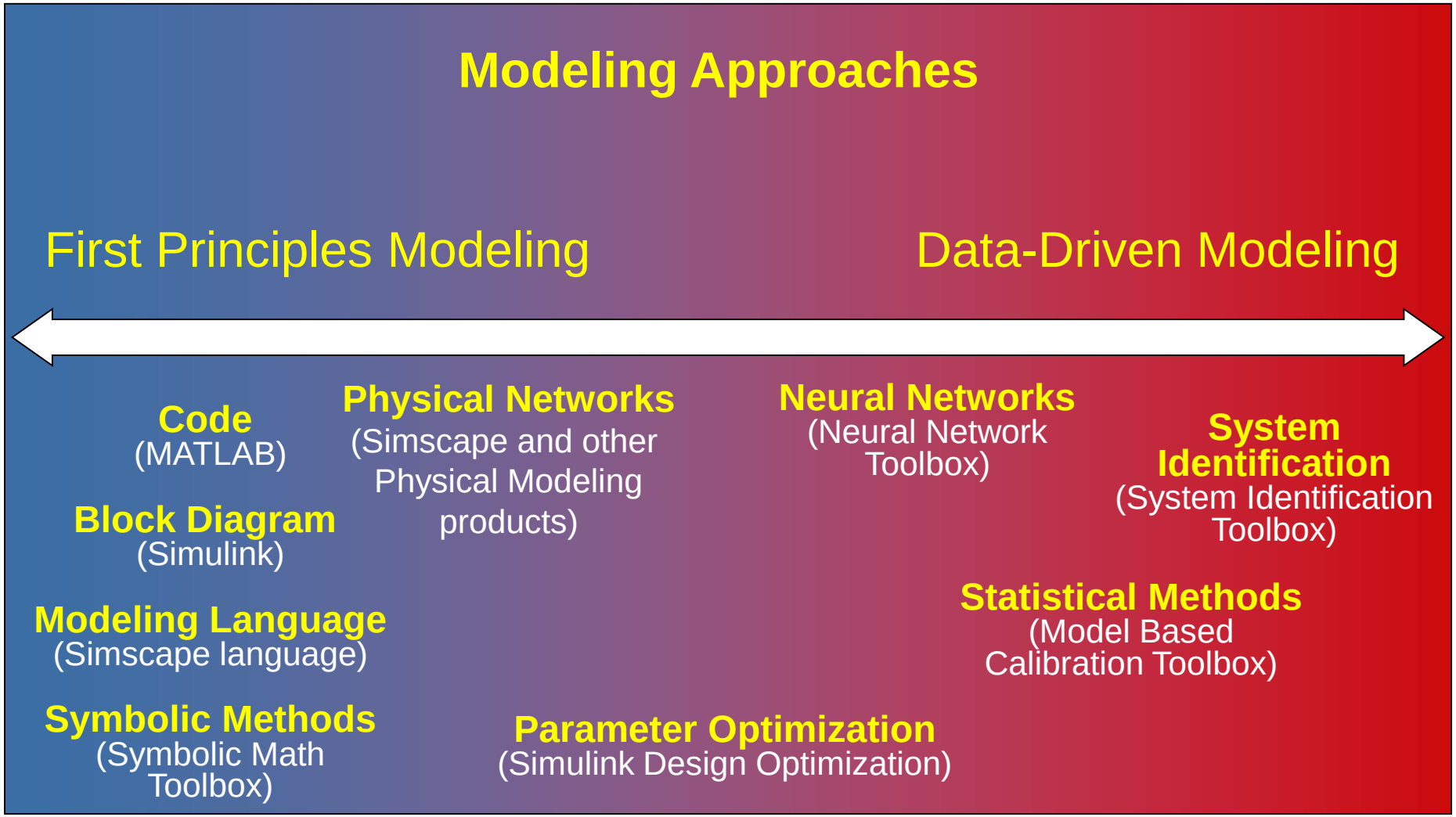
Ride and Handling Study: Double Lane Change at 30 mph

- Test the obstacle avoidance performance of a vehicle as per ISO 3888-2

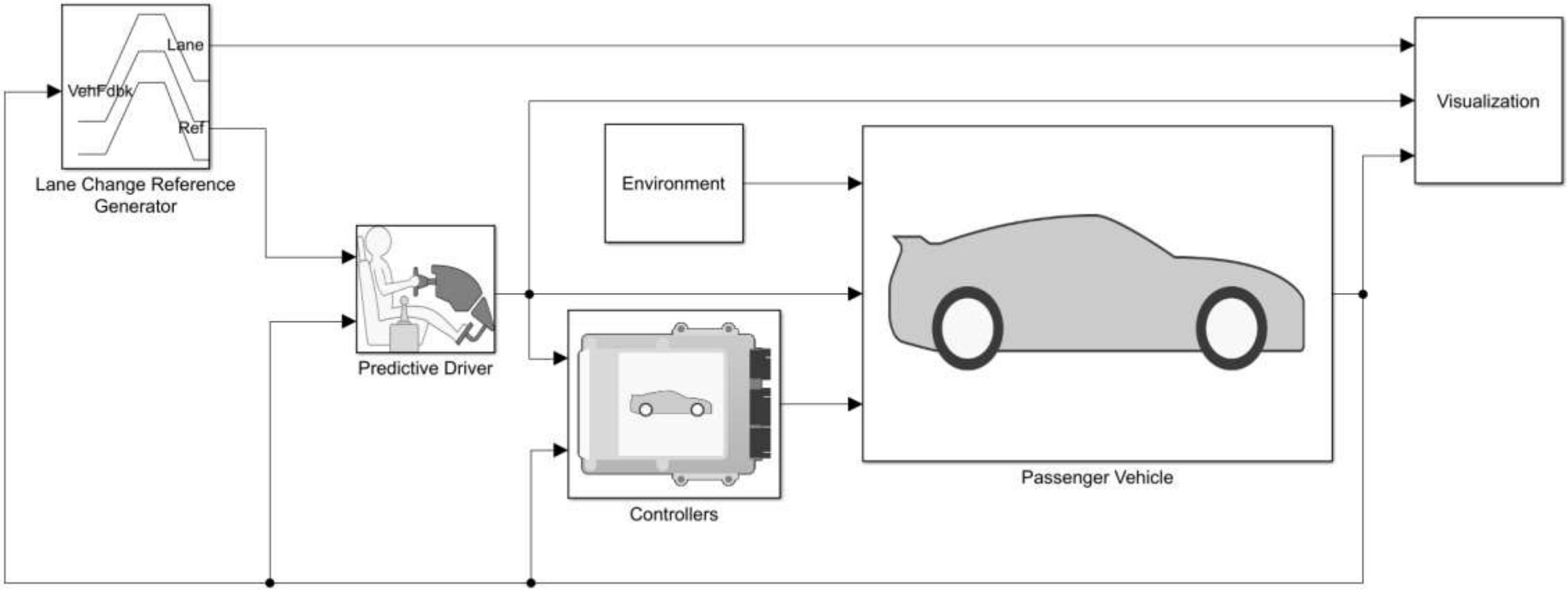
In the test, the driver:

- Accelerates until vehicle hits a target velocity
- Releases the accelerator pedal
- Turns steering wheel to follow path into the left lane
- Turns steering wheel to follow path back into the right lane

Modeling Dynamic Systems in the Simulink Environment

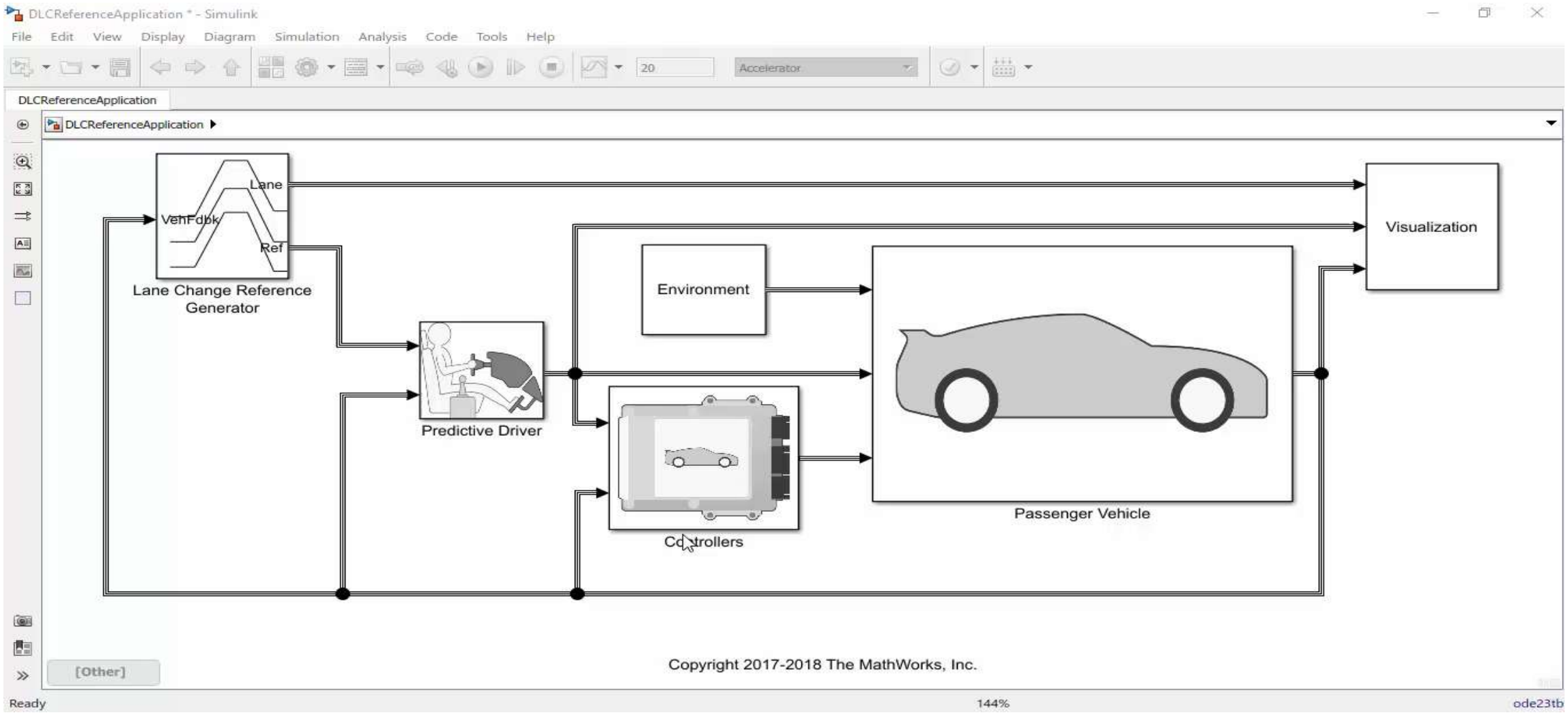


Need for a good starting point to build good plant/controller models



Lower the barrier to entry for Model-Based Design

Demo : Double Lange Change Reference Application



Challenges faced by Chassis Controls, Vehicle Dynamics & ADAS Engineers

- Quickly achieving a good vehicle design with limited number of prototype builds

- **Verifying system behavior for conditions that are too time consuming or risky to test on the road**

- **Single simulation environment for design and verification of controls**

Game Engine Co-Simulation

Simulink

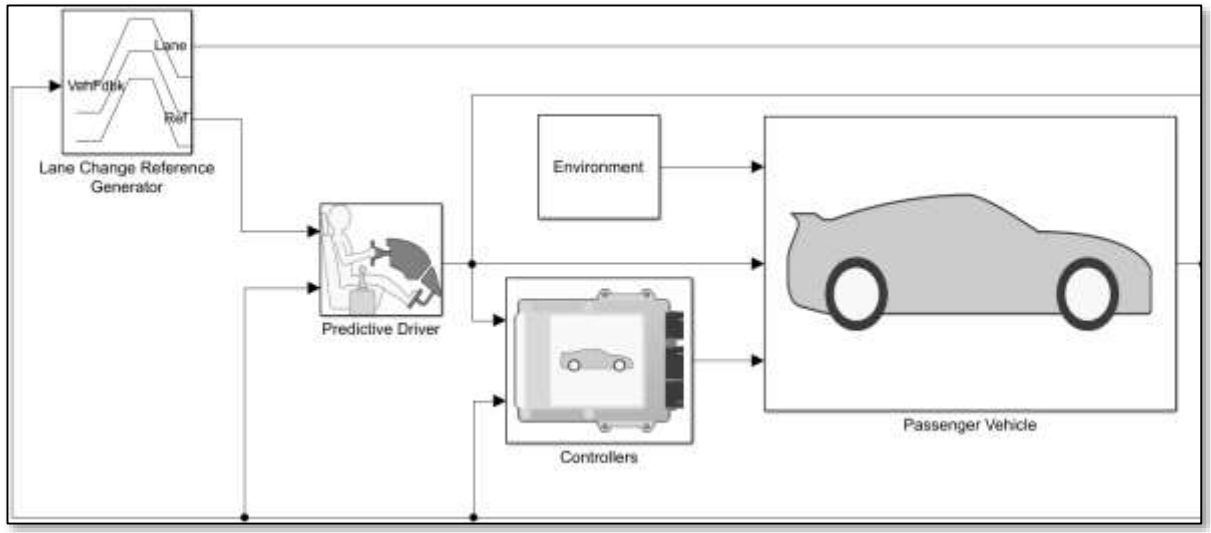
- Physics of vehicle
- Initialization of game engine camera

vehicle / camera location

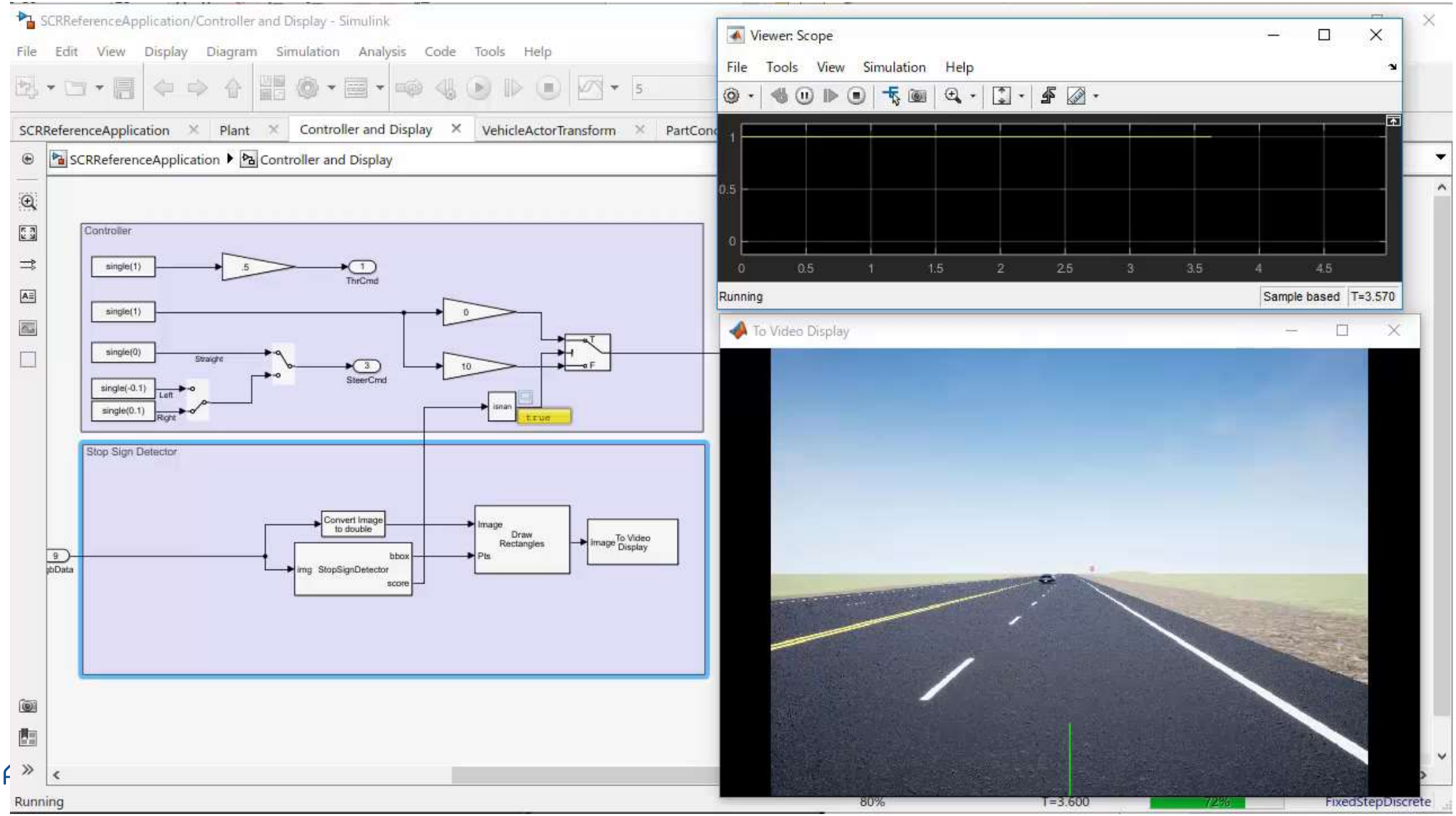
camera image, ground height, …

Unreal Engine

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

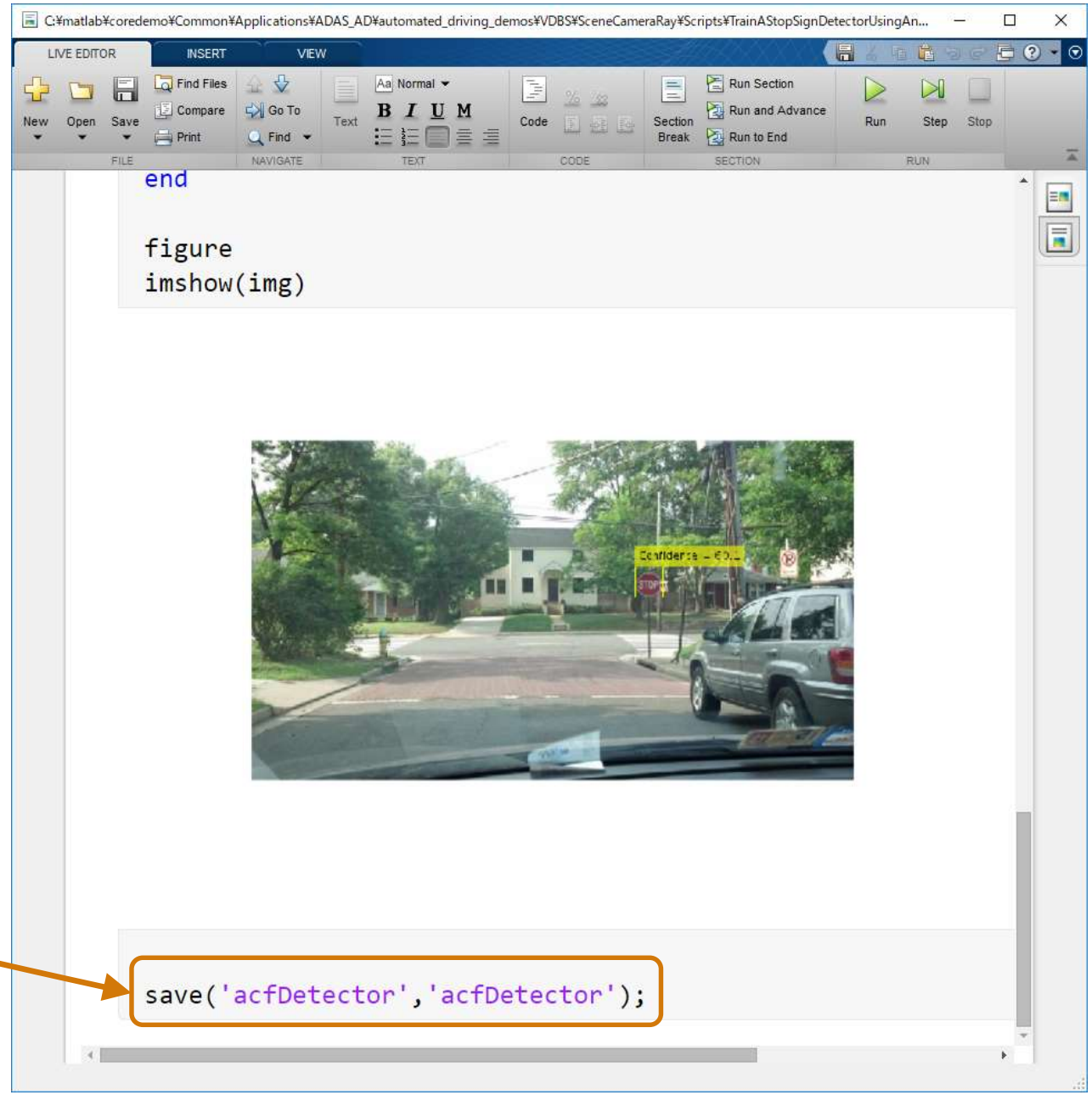


Stop Sign Detection and Braking



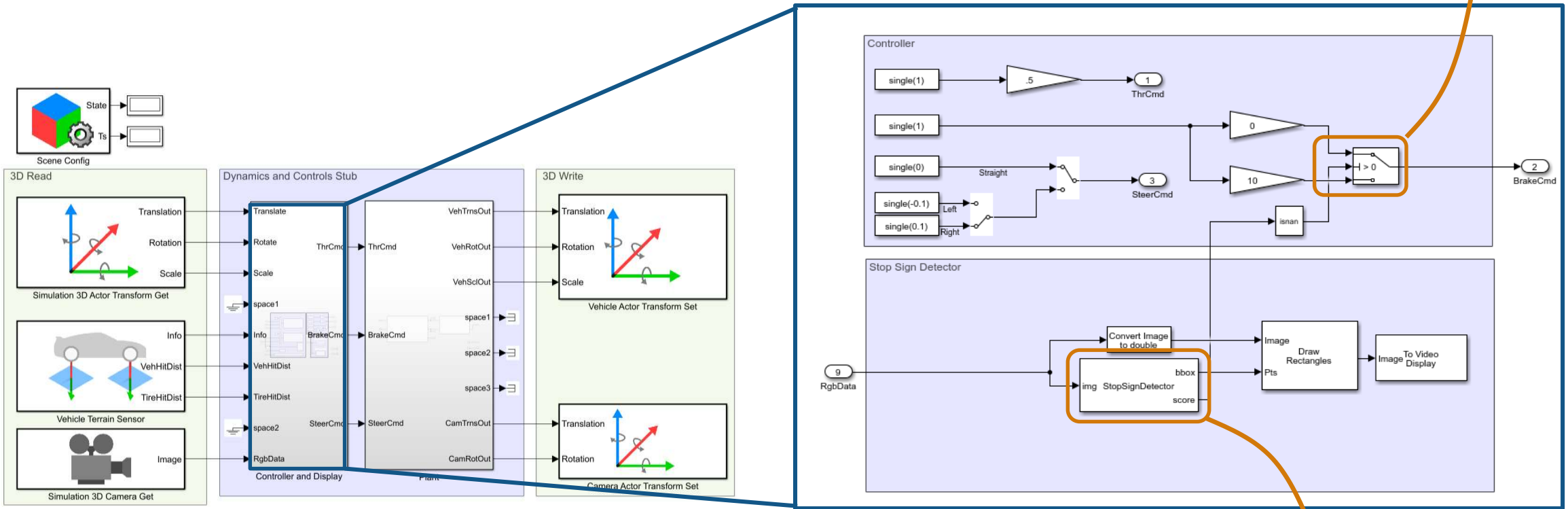
Training Stop Sign Detector

- Train a stop sign detector as an ACF object detector
- The detector is trained based on the CVST example and saved as a MAT-file



Implementing Braking Logic

- Start with Scene Interrogation reference application
- Add braking logic to stop when the stop sign appears

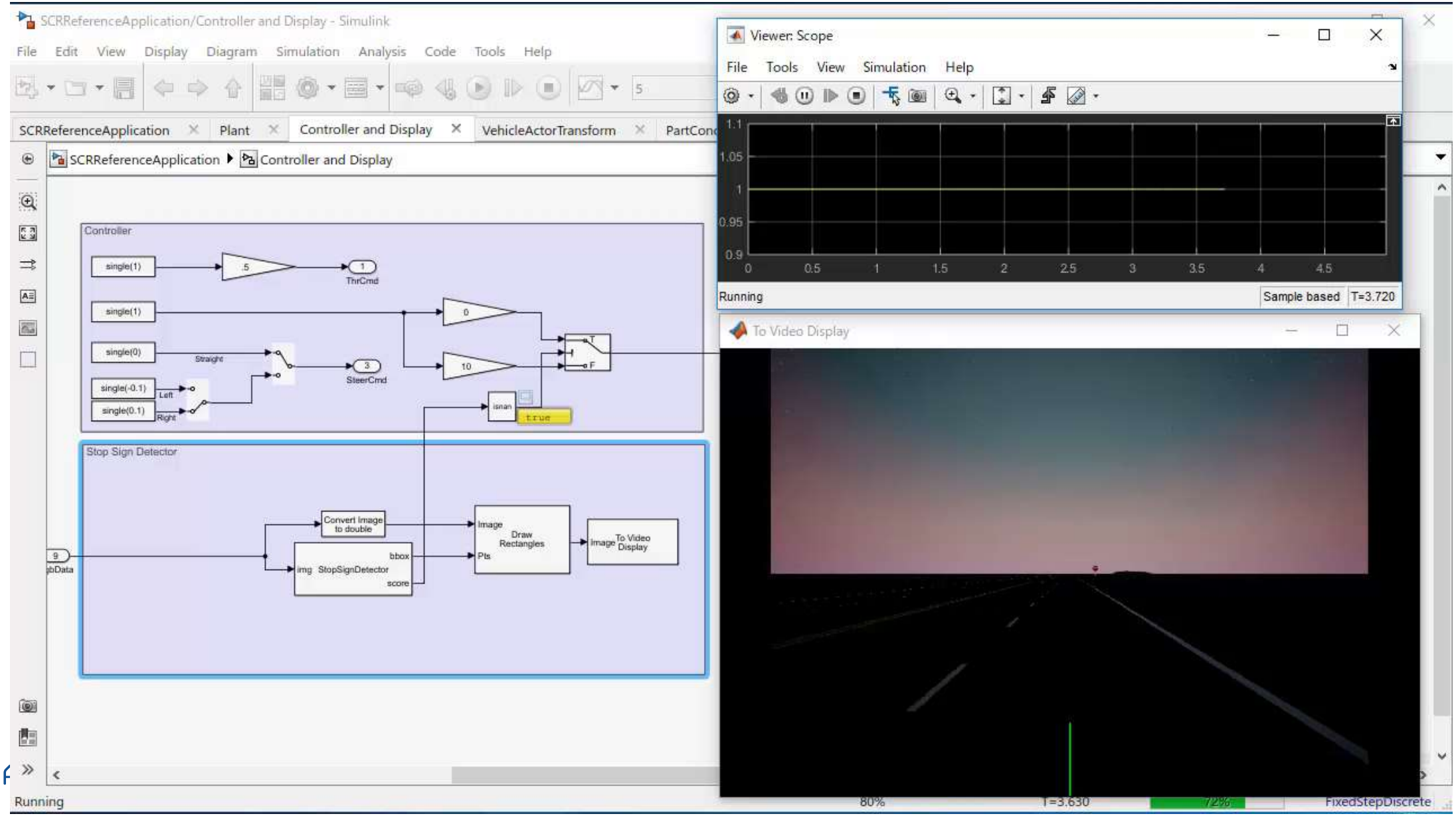


ADAS / AD Testing: Virtual 3D Scene

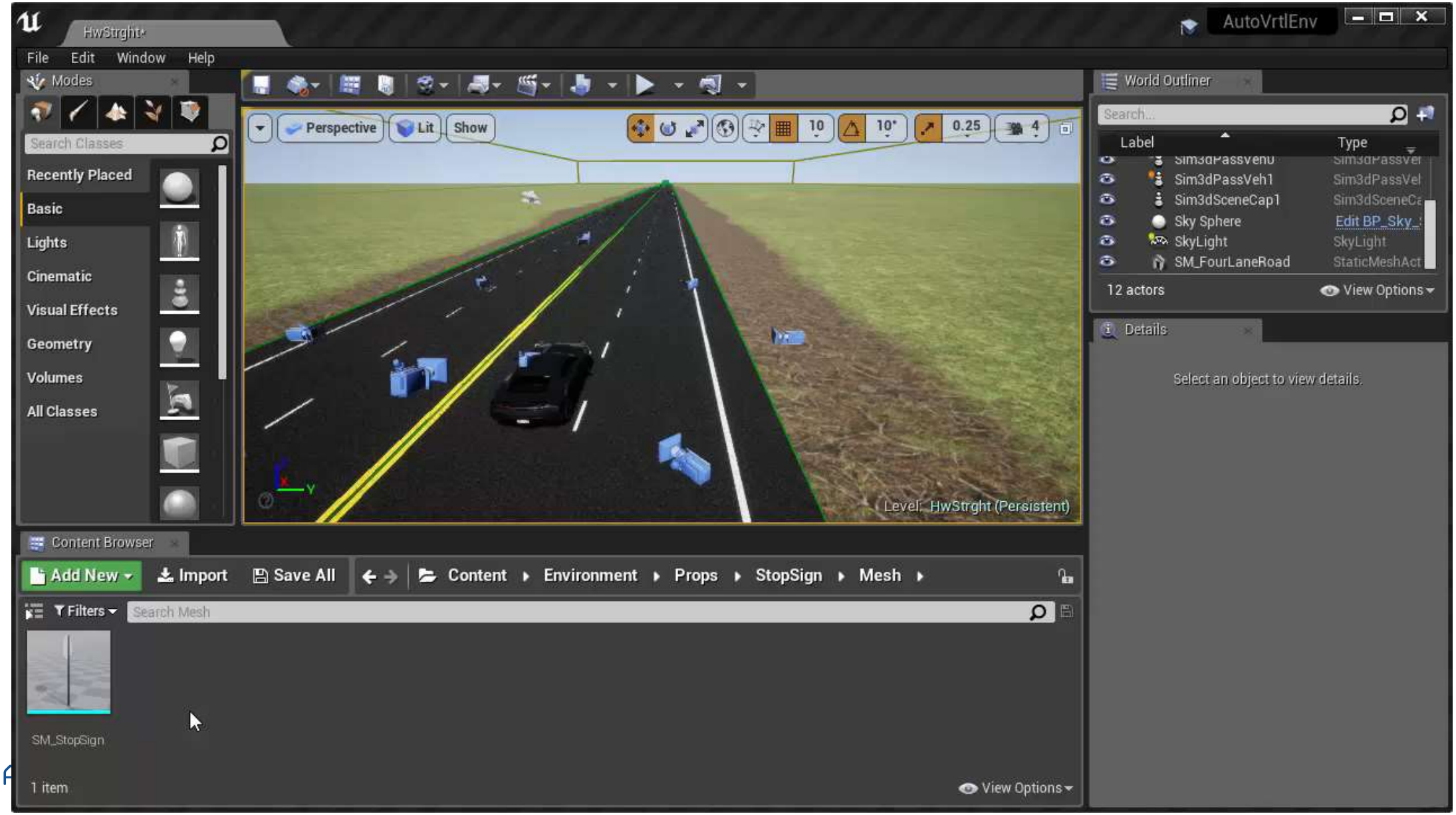
Camera sensor sends video to Simulink

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

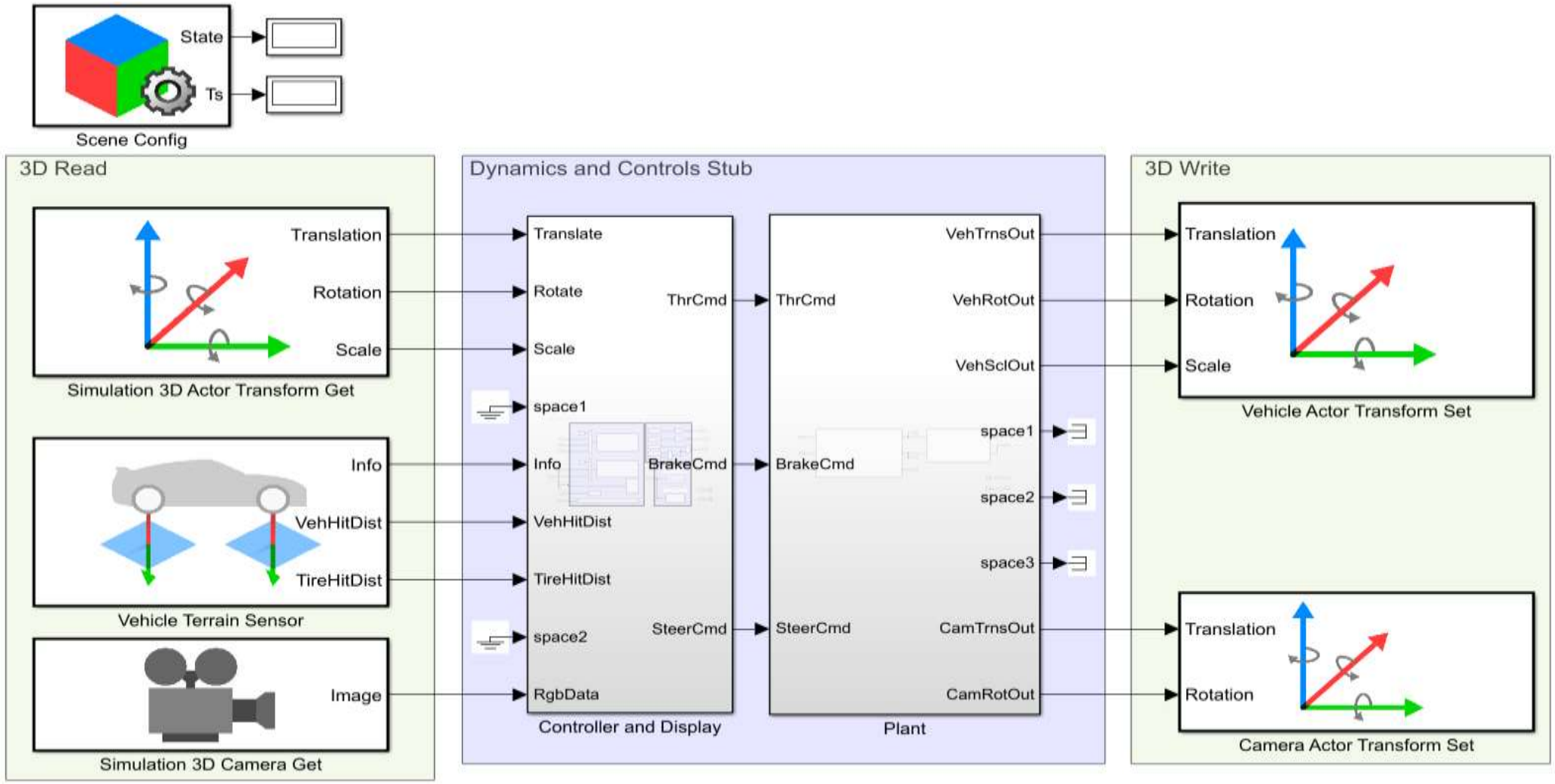
Changing the Lighting to Night Conditions



Editing Support Package Scene to Add Stop Sign



Configuring the interface to the 3D environment



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"

Model and simulate vehicle dynamics in a virtual 3D environment: Vehicle Dynamics Blockset

- 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

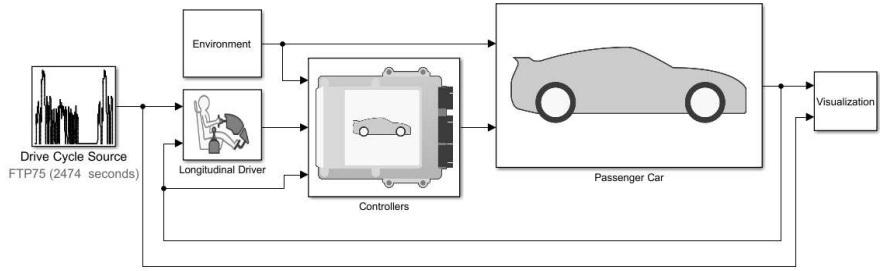
Chassis controls

ADAS / AD

Session Key Take Away

Full vehicle simulation model addresses the new challenges posed by key automotive trends.

- ***MathWorks provides vertical products to serve automotive industry, including***
  - ***Powertrain Blockset: powertrain controls, fuel economy and performance simulation***



  - ***Vehicle Dynamics Blockset: ride and handling, chassis controls, AD / ADAS testing***

Call to action

- In case you are working on EV applications, you can get started with Exploring the Reference Application Model of an Electric Vehicle

- Else if you are working on Vehicle Dynamics/Chassis Controls/Automated Driving, you can get started with Building a Vehicle Dynamics Model

- After identifying a problem statement ,you can evaluate the new products using a 30 day trial license

Thank You

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  - Examples
    - I use #MATLAB because it helps me be a data scientist! Attending #MATLABEXPO
    - Learning new capabilities in #MATLAB and #Simulink at #MATLABEXPO.
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Speaker Details

Email: Prasanna.Deshpande@mathworks.in

LinkedIn: https://in.linkedin.com/in/deshprasan

Twitter: @InfPrasanna

Speaker Details

Email: Vijayalayan.R@mathworks.in

LinkedIn: https://in.linkedin.com/in/Vijayalayanr

Twitter: @r_Vijayalayan