Vehicle Dynamics Blockset™ Release Notes

MATLAB® & SIMULINK®

MathWorks®

How to Contact MathWorks

Latest news: www.mathworks.com

Sales and services: www.mathworks.com/sales_and_services

User community: www.mathworks.com/matlabcentral

Technical support: www.mathworks.com/support/contact_us

Phone: 508-647-7000

The MathWorks, Inc.
1 Apple Hill Drive
Natick, MA 01760-2098

Vehicle Dynamics Blockset™ Release Notes

Contents

R2019b

R2019a

R2018b

R2018a

R2019b

Simulation 3D Blocks: Visualize simulations and communicate with the Unreal Engine 3D visualization environment

The Vehicle Scenarios > Sim3D > Sim3D Core block library contains new blocks and updates to existing blocks. Use the blocks to visualize simulations and communicate scene information with the Unreal Engine® 3D visualization environment. This table summarizes the updates.

Block	Update
Simulation 3D Message Get	*New* The block retrieves data from the Unreal Engine 3D visualization environment. To use the block: • Install the “Support Package for Customizing Scenes”. • In the Unreal Engine environment, set up blueprint or C++ actor classes that can send the data to Simulink®.
Simulation 3D Message Set	*New* The block sends data to the Unreal Engine 3D visualization environment. To use the block: • Install the “Support Package for Customizing Scenes”. • In the Unreal Engine environment, set up blueprint or C++ actor classes that can receive the Simulink data.
Simulation 3D Scene Configuration	Block renamed from Simulation 3D Config. In R2019b, the block does not include these output ports: • `State` — Visualization engine state • `Ts` — Visualization engine sample time

Block	Update
Simulation 3D Actor Transform Get	Parameters that allow you to get the position, rotation, and scale for scene actors, including vehicles. Previously, you had to specify a vehicle or camera actor type. In R2019b, use the Simulation 3D Camera Get block to configure a scene camera and get the camera image.
Simulation 3D Actor Transform Set	Parameters that allow you to set the position, rotation, and scale for scene actors, including vehicles. Previously, you had to specify a vehicle or camera actor type. In R2019b, use the: • Simulation 3D Camera Get block to configure a scene camera and get the camera image. • Simulation 3D Vehicle with Ground Following or Simulation 3D Vehicle block to configure a vehicle.
Simulation 3D Camera Get	Mounting parameters that allow you to specify the location of the camera in the 3D visualization environment.

For the minimum hardware required to use the blocks, see “3D Visualization Engine Requirements”.

Compatibility Considerations

Models that use these simulation 3D blocks might have compatibility issues, including disconnected line errors. Consider replacing the blocks with the R2019b version.

Vehicle Blocks: Implement vehicles in the Unreal Engine 3D visualization environment

The Vehicle Scenarios > Sim3D > Sim3D Vehicle block library includes blocks that implement vehicles in the Unreal Engine 3D visualization environment. This table summarizes the new vehicle blocks.

Block	Description
Simulation 3D Vehicle with Ground Following	*New* Implements a vehicle with four wheels that follows the ground in the 3D visualization environment. The block uses the vehicle position to adjust the vehicle elevation, roll, and pitch so that the vehicle follows the ground terrain. It determines the vehicle velocity and heading and adjusts the steering angle and rotation for each wheel. You can select the type of vehicle, color, and initial position and rotation.
Simulation 3D Vehicle	*New* Implements a vehicle in the 3D visualization environment. The block uses the vehicle translation and rotation to place a vehicle with four wheels in the visualization environment. You can select the type of vehicle, color, and initial position.

For the minimum hardware required to use the blocks, see “3D Visualization Engine Requirements”.

Scene Interrogation Reference Application: Interactive vehicle control and enhanced dynamics

The scene interrogation with camera and ray tracing reference application includes:

- Dials and gauges to control the vehicle steering, braking, and throttle in the 3D visualization environment.
- Powertrain, driveline, and steering models.
- Vehicle dynamics model for a 3 degree-of-freedom (DOF) vehicle.

Use the reference application to integrate a 3-DOF vehicle in the 3D visualization environment. The 3D visualization environment uses the Unreal Engine by Epic Games®.

To create and open a working copy of the camera and ray tracing reference application project, enter

```
vdynblksSceneCameraRayStart
```

For the minimum hardware required to run the reference application, see “3D Visualization Engine Requirements”.

For more information about the reference application, see “Scene Interrogation in 3D Environment”.

R2019a

Kinematics and Compliance Virtual Test Laboratory: Generate mapped suspension calibration parameters from spreadsheet data

In the kinematics and compliance virtual test laboratory, select **Generate Mapped Suspension from Spreadsheet Data** to generate mapped suspension calibration parameters from measured vertical force and suspension geometry data. The virtual test lab uses Model-Based Calibration Toolbox™ to fit camber angle, toe angle, and vertical forces to generate calibrated suspension parameters for the mapped suspension blocks.

For more information, see Kinematics and Compliance Virtual Test Laboratory.

Active Damping: Implement damping as a function of duty cycle and suspension velocity in suspension blocks

During open-loop and closed-loop suspension feedback control algorithm development, you can configure the Independent Suspension - Double Wishbone and Independent Suspension - MacPherson suspension blocks to implement active damping. Use the **Enable active damping** parameter.

Enable Active Damping Setting	Damping Implementation
`off`	Constant
`on`	Lookup table as a function of active damper duty cycle and actuator velocity

New Fiala Tire Block: Implement a simplified tire with lateral and longitudinal slip capability

Use the Fiala Wheel 2DOF block to implement a simplified tire with lateral and longitudinal slip capability. The block uses a translational friction model to calculate the forces and moments during combined longitudinal and lateral slip, requiring fewer parameters than the Combined Slip Wheel 2DOF block. If you do not have the tire coefficients needed by the Magic Formula, consider using this block for studies that do not involve extensive nonlinear combined lateral slip or lateral dynamics. If your study does require nonlinear combined slip or lateral dynamics, consider using the Combined Slip Wheel 2DOF block.

Constant Radius Test: Use maneuver reference application to characterize steering and lateral vehicle dynamics

This reference application represents a full vehicle dynamics model undergoing a constant radius test maneuver. You can create your own versions, establishing a framework to test that your vehicle meets the design requirements under normal and extreme driving conditions. Use this reference application in ride and handling studies and chassis controls development to characterize the steering and lateral vehicle dynamics. For information about the similar maneuvers, see standards SAE J266_199601 and ISO 4138:2012.

To create and open a working copy of the constant radius reference application, enter

```
vdynblksConstRadiusStart
```

For more information about the maneuver, see Constant Radius Maneuver.

Fiala and Longitudinal Wheel Blocks: Configure blocks for ISO 28580 rolling resistance calculation

To help your models comply with ISO 28580:2018, *Passenger car, truck and bus tyre rolling resistance measurement method — Single point test and correlation of measurement results*, you can configure the Fiala Wheel 2DOF and Longitudinal Wheel blocks to use the ISO 28580:2018 rolling resistance calculation.

To configure the blocks for the ISO calculation, set the **Rolling Resistance** parameter to `ISO 28580`.

Vehicle Body Blocks: Configuration options for external inputs, including forces, moments, and air temperature

The vehicle body blocks have new options for configuring the block with external inputs. The options provide more flexibility when you incorporate your blocks into full vehicle models. The table summarizes the settings.

Block	*New* External Input Ports	Block Option Setting	Description
Vehicle Body 1DOF Longitudinal	`FExt`	**External forces**	External force applied to vehicle CG in vehicle-fixed frame.
	`MExt`	**External moments**	External moment about vehicle CG in vehicle-fixed frame.
	`AirTemp`	**Air temperature**	Ambient air temperature. Consider this option if you want to vary the temperature during run-time.
	`WindXYZ`	**Wind X,Y,Z**	Wind speed along earth-fixed *X*-, *Y*-, and *Z*-axes. If you do not select this option, the block implements input port `WindX` — Longitudinal wind speed along the earth-fixed *X*-axis.
Vehicle Body 3DOF Longitudinal	`FExt`	**External forces**	External force applied to vehicle CG in vehicle-fixed frame.
	`MExt`	**External moments**	External moment about vehicle CG in vehicle-fixed frame.
	`AirTemp`	**Air temperature**	Ambient air temperature. Consider this option if you want to vary the temperature during run-time.
Vehicle Body 3DOF *R2018a included block options to input the external forces, moments,*	`X_o`	**Input signals** pane **Initial longitudinal position**	Initial vehicle CG displacement along earth-fixed *X*-axis, in m
	`Y_o`	**Initial lateral position**	Initial vehicle CG displacement along earth-fixed *Y*-axis, in m
	`xdot_o`	**Initial longitudinal velocity**	Initial vehicle CG velocity along vehicle-fixed *x*-axis, in m/s

Block	*New* External Input Ports	Block Option Setting		Description
friction, steering angles, and wind speed	`ydot_o`		**Initial lateral velocity**	Initial vehicle CG velocity along vehicle-fixed *y*-axis, in m/s
	`psi_o`		**Initial yaw angle**	Initial rotation of vehicle-fixed frame about earth-fixed *Z*-axis (yaw), in rad
	`r_o`		**Initial yaw rate**	Initial vehicle angular velocity about the vehicle-fixed *z*-axis (yaw rate), in rad/s
	`AirTemp`		**Air temperature**	Ambient air temperature. Consider this option if you want to vary the temperature during run-time.
Vehicle Body 6DOF	`AirTemp`	**Environment** pane	**Air temperature**	Ambient air temperature. Consider this option if you want to vary the temperature during run-time.

Compatibility Considerations

Models that use the vehicle body blocks might have disconnected line errors. Consider replacing the blocks with the R2019a version.

Differential Blocks: Account for efficiency as a function of torque, temperature, and driveshaft speed

To account for Open Differential and Limited Slip Differential block power and energy losses, you can use the **Efficiency factors** parameter. This table summarizes the block implementation for each setting.

Setting	Implementation
`Constant`	Constant efficiency that you can set with the **Constant efficiency factor, eta** parameter.

Setting	Implementation
`Driveshaft torque, temperature and speed`	Efficiency as a function of base gear input torque, air temperature, and driveshaft speed. Use these parameters to specify the lookup table and breakpoints: • **Efficiency lookup table, eta_tbl** • **Efficiency torque breakpoints, Trq_bpts** • **Efficiency speed breakpoints, omega_bpts** • **Efficiency temperature breakpoints, Temp_bpts** For the air temperature, you can either: • Select **Input temperature** to create an input port. • Set a **Ambient temperature, Tamb** parameter value.

Maneuver Reference Applications: Position vehicle in scene-specific recommended locations

When you run the maneuver reference applications in the 3D visualization environment, you can initially position the vehicle in locations that are recommended for the scene. After you open the reference applications for these maneuvers:

- Double-Lane Change Maneuver
- Slowly Increasing Steering Maneuver
- Swept-Sine Steering Maneuver

1. In the Visualization subsystem, open the 3D Engine block. Set these parameters.
   - **3D Engine** to **Enabled**.
   - **Scene** to one of the scenes.
2. To position the vehicle in the scene:
   a. Select the position initialization method:
      - **Recommended for scene** — Set the initial vehicle position to values recommended for the scene
      - **User-specified** — Set your own initial vehicle position

b. Select **Apply** to modify the initial vehicle position parameters.
c. Click **Update the model workspaces with the initial values** to overwrite the initial vehicle position in the model workspace with the applied values.

R2018b

Active Differential Block: Model a spur or dual planetary active differential gear for applications such as torque vectoring

R2018b includes an Active Differential block that can model the active differential as an open differential coupled to either a spur or planetary differential gear set. The block uses external pressure signals to regulate the clutch pressure to either speed up or slow down each axle rotation.

Use the block in hardware-in-the-loop (HIL) and optimization workflows to dynamically couple the driveshaft to the wheel axles when you want to direct the transmission torque to a specific axle. For detailed front-wheel driving studies, use the block to couple the driveshaft to universal joints. The block is suitable to use in system-level closed-loop control studies, for example, yaw stability and torque vectoring.

Vehicle Body 6DOF Block: Include additional loads on the vehicle body such as passengers, powertrain components, and cargo

To analyze the vehicle dynamics under different loading conditions, use the Vehicle Body 6DOF block **Inertial Loads** parameters. Specifically, you can specify these loads:

- Powertrain components
- Front and rear row passengers
- Overhead cargo
- Rear cargo

Kinematics and Compliance Virtual Test Laboratory: Use a reference application to calibrate suspension parameters

If you have Model-Based Calibration Toolbox and Simscape™ Multibody™, you can use the kinematics and compliance virtual test laboratory to generate optimized suspension parameters for the Independent Suspension - Mapped and Solid Axle Suspension - Mapped blocks.

Using Model-Based Calibration Toolbox, the reference application performs a Sobol sequence design of experiments (DoE) on the suspension height, handwheel angle, chirp minimum and maximum frequency, chirp amplitude, and simulation time. At each operating point, the reference application stimulates the Simscape Multibody suspension system. The reference application then uses the data to fit the suspension force and camber angle to a Gaussian process model (GPM). Finally, the reference application uses the GPM to generate suspension parameters for the suspension blocks.

For more information, see Kinematics and Compliance Virtual Test Laboratory.

Unreal Engine 4 Interface: Use support package to customize and install additional 3D scenes

To customize and install additional scenes, use the Vehicle Dynamics Blockset™ Interface for Unreal Engine 4 Projects support package. The support package includes these scenes:

Scene	
US	

Scene	
US Blo	

For information about installing the support package, see Supporting Scene, Drive Cycle, and Maneuver Data.

Driver Blocks: Implement predictive driver control to generate commands that track lateral reference and longitudinal speed, including reverse

You can configure the Longitudinal Driver and Predictive Driver blocks to generate acceleration and braking commands that track lateral reference and longitudinal speed, including reverse. The blocks include these control type options.

Control Type Setting	Block Implementation
`PI`	Proportional-integral (PI) control with tracking windup and feed-forward gains.
`Scheduled PI`	PI control with tracking windup and feed-forward gains that are a function of vehicle velocity.
`Predictive`	Optimal single-point preview (look ahead) control model. The model represents driver steering control behavior during path-following and obstacle avoidance maneuvers. Drivers preview (look ahead) to follow a predefined path. To implement the MacAdam model, the block: • Represents the dynamics as a linear single track (bicycle) vehicle • Minimizes the previewed error signal at a single point T* seconds ahead in time • Accounts for the driver lag deriving from perceptual and neuromuscular mechanisms

The blocks include these shift type options.

Shift Type Options	Block Implementation
`None`	No transmission. Block outputs a constant gear of 1. Use this setting to minimize the number of parameters you need to generate acceleration and braking commands to track forward vehicle motion. This setting does not allow reverse vehicle motion.

Shift Type Options	Block Implementation
`Reverse, Neutral, Drive`	Block uses a Stateflow® chart to model reverse, neutral, and drive gear shift scheduling. Use this setting to generate acceleration and braking commands to track forward and reverse vehicle motion using simple reverse, neutral, and drive gear shift scheduling. Depending on the vehicle state and vehicle velocity feedback, the block uses the initial gear and time required to shift the vehicle up into drive or down into reverse or neutral. For neutral gears, the block uses braking commands to control the vehicle speed. For reverse gears, the block uses an acceleration command to generate torque and a brake command to reduce vehicle speed.
`Scheduled`	Block uses a Stateflowchart to model reverse, neutral, park, and N-speed gear shift scheduling. Use this setting to generate acceleration and braking commands to track forward and reverse vehicle motion using reverse, neutral, park, and N-speed gear shift scheduling. Depending on the vehicle state and vehicle velocity feedback, the block uses these parameters to determine the gear: • Initial gear • Upshift and downshift accelerator pedal positions • Upshift and downshift velocity • Timing for shifting and engaging forward and reverse from neutral For neutral gears, the block uses braking commands to control the vehicle speed. For reverse gears, the block uses an acceleration command to generate torque and a brake command to reduce vehicle speed.

Shift Type Options	Block Implementation
`External`	Block uses the input gear, vehicle state, and velocity feedback to generate acceleration and braking commands to track forward and reverse vehicle motion. For neutral gears, the block uses braking commands to control the vehicle speed. For reverse gears, the block uses an acceleration command to generate torque and a brake command to reduce vehicle speed.

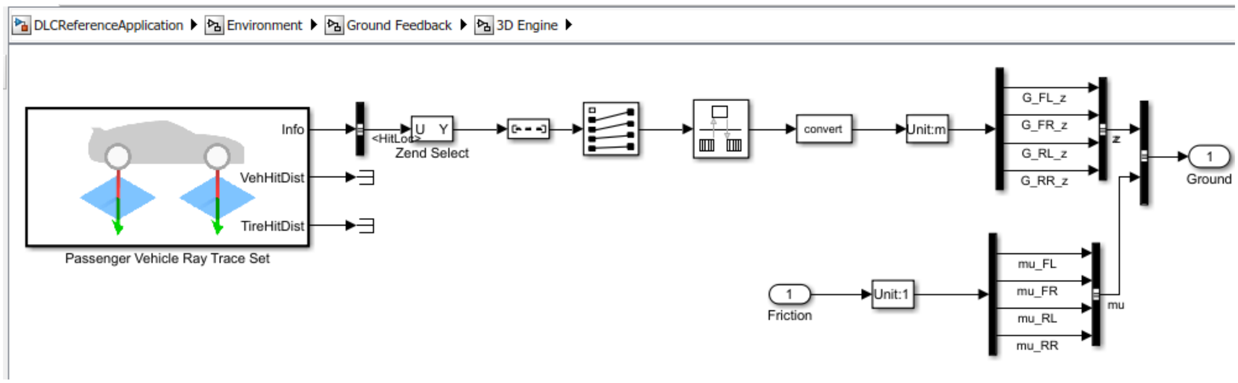
Maneuver Reference Applications: Use 3D environment ray tracing to determine ground location under tires during vehicle maneuver

To detect the terrain below the tires in the 3D visualization environment, you can configure the maneuver reference applications to use the Vehicle Terrain Sensor block. The reference application uses the terrain feedback to determine the friction forces acting on the vehicle during the maneuver.

1. Open the maneuver reference application. For example, to create and open a working copy of the double-lane change maneuver reference application, enter

   ```
   vdynblksDblLaneChangeStart
   ```
2. In the Visualization subsystem, open the 3D Engine block. Set these parameters.

   - **3D Engine** to **Enabled**.
   - **Scene description** to one of the scenes, for example `Straight road`.
3. In the Environment subsystem, open the Ground Feedback subsystem. The 3D Engine variant uses the Vehicle Terrain Sensor block to determine the ground location under the tires during a vehicle maneuver.



For more information about the maneuver reference applications, see:

- Double-Lane Change Maneuver
- Slowly Increasing Steering Maneuver
- Swept-Sine Steering Maneuver

Virtual Calibration: Use Model-Based Calibration Toolbox to calibrate SI and CI mapped engine blocks

If you have the Model-Based Calibration Toolbox, you can use measured engine data to calibrate these parameters for the Mapped CI Engine and Mapped SI Engine blocks:

- Power
- Air mass flow
- Fuel flow
- Exhaust temperature
- Efficiency
- Emissions

Maneuver Reference Applications: Display ISO 15037-1:2006 standard measurement signals after you run a maneuver

You can configure the maneuver applications to display ISO 15037-1:2006 standard measurement signals in the Simulation Data Inspector, including steering wheel angle and torque, longitudinal and lateral velocity, and sideslip angle.

To configure the ISO signal display, in the reference application Visualization subsystem, open the ISO 15037-1:2006 block. Select **Enabled**. After you run the maneuver, the Simulation Data Inspector opens with ISO standard signal measurements. For more information, see ISO 15037-1:2006 Standard Measurement Signals.

R2018a

Version: 1.0

New Features

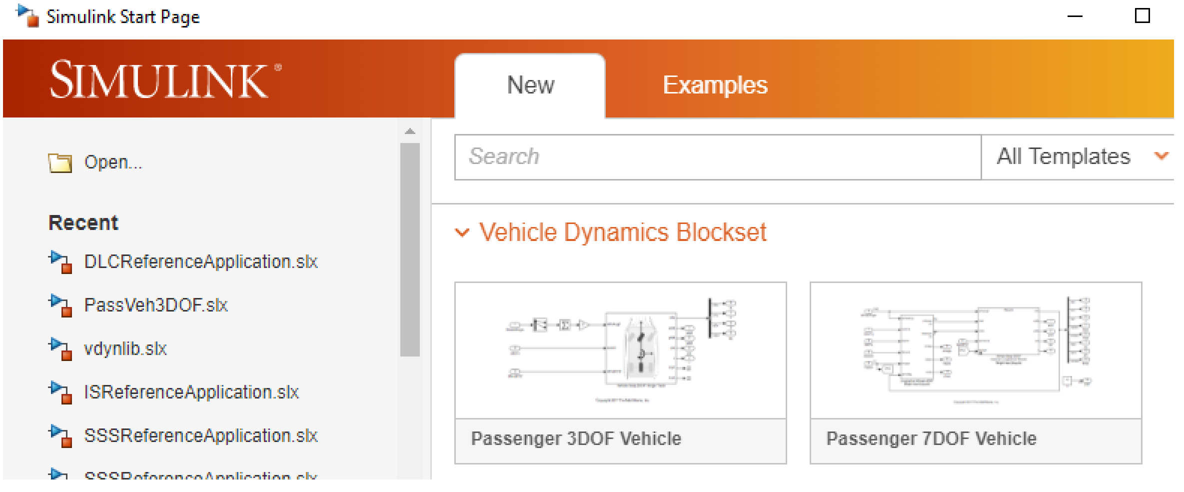
Introducing Vehicle Dynamics Blockset

Vehicle Dynamics Blockset provides fully assembled reference application models that simulate driving maneuvers in a 3D environment. You can use the prebuilt scenes to visualize roads, traffic signs, trees, buildings, and other objects around the vehicle. You can customize the reference models by using your own data or by replacing a subsystem with your own model. The blockset includes a library of components for modeling propulsion, steering, suspension, vehicle bodies, brakes, and tires.

Vehicle Dynamics Blockset provides a standard model architecture that can be used throughout the development process. It supports ride and handling analyses, chassis controls development, software integration testing, and hardware-in-the-loop testing. By integrating vehicle dynamics models with a 3D environment, you can test ADAS and automated driving perception, planning, and control software. These models let you test your vehicle with standard driving maneuvers such as a double lane change or with your own custom scenarios.

Preassembled vehicle dynamics models for passenger cars and trucks

Vehicle Dynamics Blockset provides preassembled vehicle dynamics models that you can use to analyze the dynamic system response to common ride and handling tests. Open project files that contain the vehicle models from the Simulink start page.



<table>
<tr><th>Vehicle Model</th><th>Description</th><th>Vehicle Body Degrees-of-Freedom (DOFs)</th><th>Wheel DOFs</th></tr>
<tr><td>Passenger 14DOF Vehicle</td><td>Vehicle with four wheels
Available as model variant in the maneuver reference applications</td><td>Six<table><tr><th colspan="2">Translational</th><th colspan="2">Rotational</th></tr><tr><td>Longitudinal</td><td>✓</td><td>Pitch</td><td>✓</td></tr><tr><td>Lateral</td><td>✓</td><td>Yaw</td><td>✓</td></tr><tr><td>Vertical</td><td>✓</td><td>Roll</td><td>✓</td></tr></table></td><td>Two per wheel - eight total<table><tr><th colspan="2">Translational</th><th colspan="2">Rotational</th></tr><tr><td>Vertical</td><td>✓</td><td>Rolling</td><td>✓</td></tr></table></td></tr>
<tr><td>Passenger 7DOF Vehicle</td><td>Vehicle with four wheels
Available as model variant in the maneuver reference applications</td><td>Three<table><tr><th colspan="2">Translational</th><th colspan="2">Rotational</th></tr><tr><td>Longitudinal</td><td>✓</td><td>Pitch</td><td></td></tr><tr><td>Lateral</td><td>✓</td><td>Yaw</td><td>✓</td></tr><tr><td>Vertical</td><td></td><td>Roll</td><td></td></tr></table></td><td>One per wheel - four total<table><tr><th colspan="2">Rotational</th></tr><tr><td>Rolling</td><td>✓</td></tr></table></td></tr>
<tr><td>Passenger 3DOF Vehicle</td><td>Vehicle with ideal tire</td><td>Three<table><tr><th colspan="2">Translational</th><th colspan="2">Rotational</th></tr><tr><td>Longitudinal</td><td>✓</td><td>Pitch</td><td></td></tr><tr><td>Lateral</td><td>✓</td><td>Yaw</td><td>✓</td></tr><tr><td>Vertical</td><td></td><td>Roll</td><td></td></tr></table></td><td>None</td></tr>
</table>

Preassembled maneuvers for common ride and handling tests, including a double-lane change

Vehicle Dynamics Blockset provides fully assembled reference applications of vehicle models running driving maneuvers in a 3D environment that is integrated with Simulink. You can create your own versions of these maneuver applications, providing a framework to test your vehicle model and subsystems.

- Double-Lane Change Maneuver
- Slowly Increasing Steering Maneuver
- Swept-Sine Steering Maneuver

To analyze the vehicle ride and handling and develop chassis controls, use the maneuvers to test your vehicle model and subsystems. Specifically, use the maneuvers to perform vehicle studies, including:

- Friction, speed, and steering sweeps
- Yaw stability
- Understeer and oversteer
- Steering sensitivity
- Lateral acceleration limit
- Split-mu
- Driveline comparisons

3D environment for visualizing simulations and communicating scene information to Simulink

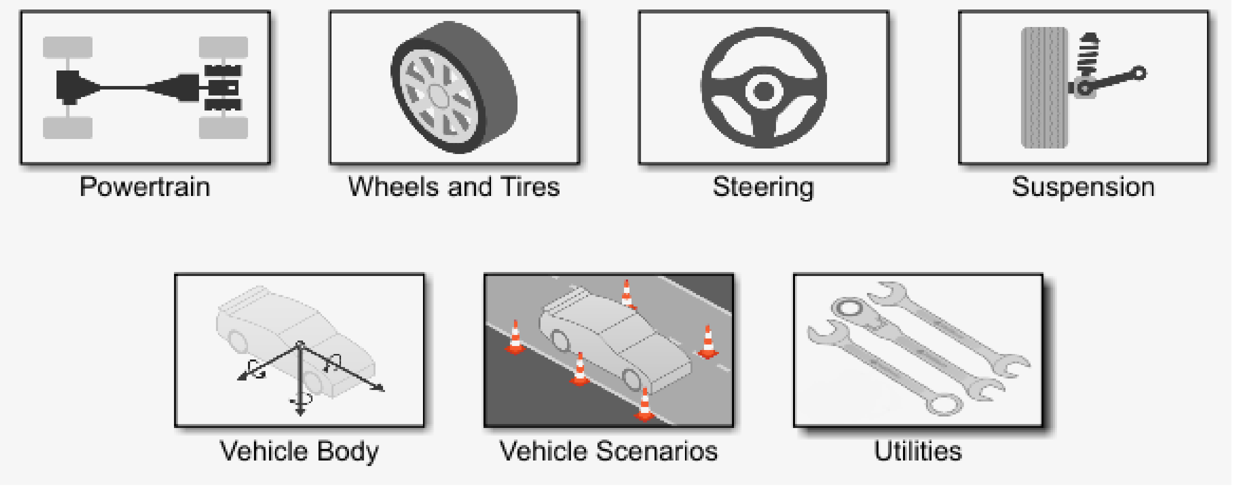
Vehicle Dynamics Blockset integrates the 3D simulation environment with Simulink so that you can query the world around the vehicle for virtually testing perception, control, and planning algorithms. The Vehicle Dynamics Blockset visualization environment uses Unreal Engine by Epic Games.

Topic	See
How Simulink communicates with the 3D environment	Vehicle Dynamics Blockset Communication with 3D Visualization Software

Topic	See
3D visualization engine platform requirements, hardware recommendations, and limitations	3D Visualization Engine
Configuring the reference applications for the 3D environment	Scene Interrogation

Libraries of propulsion, steering, suspension, vehicle body, brake, and tire components

The Vehicle Dynamics Blockset provides blocks that you can use to simulate vehicles, scenarios, and scenes with vehicle body, powertrain, steering, suspension, tires, and scenario blocks. To open the block library, at the MATLAB® command–line, type `vdynlib`.



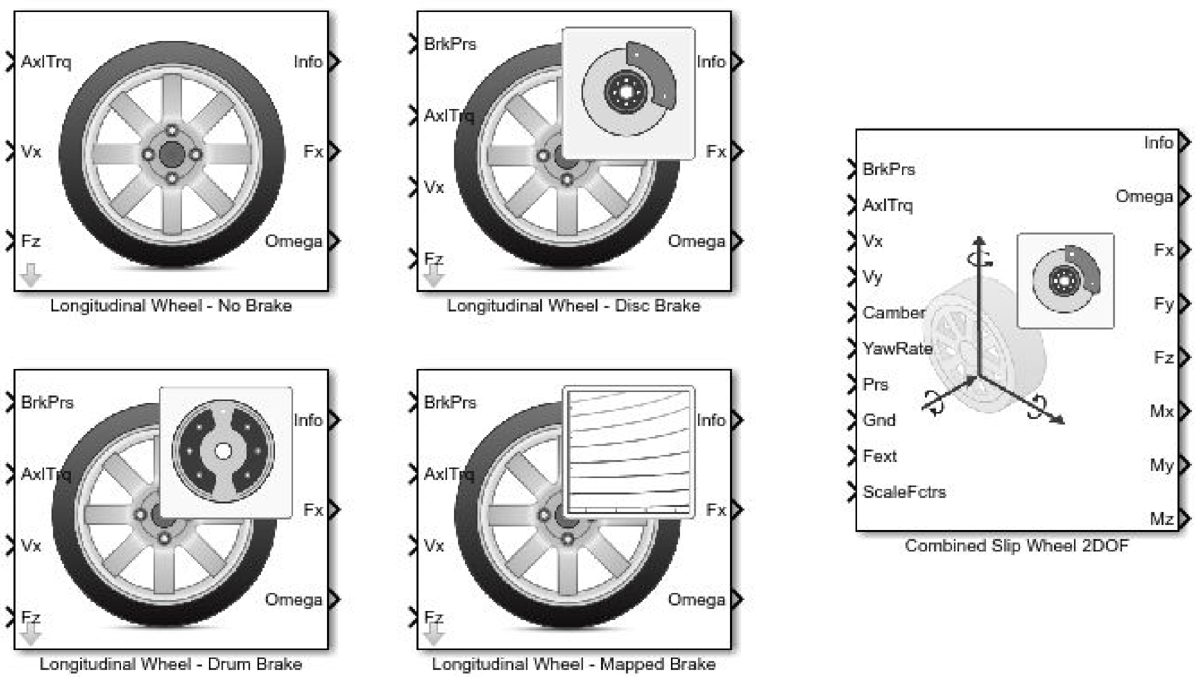
Combined longitudinal and lateral slip dynamic tire models

The Vehicle Dynamics Blockset has these tire blocks:

- Combined Slip Wheel 2DOF — Longitudinal and lateral tire dynamics. Use the **Brake Type** parameter to specify disc, drum, mapped, or no brakes.

- Longitudinal Wheel — Longitudinal tire dynamics with disc, drum, mapped, or no brakes.

To open the block library, at the MATLAB command–line, type `vdynlib`. Open **Wheels and Tires**.



Predictive driver model for generating steering commands that track a predefined path

The Predictive Driver block implements a controller that generates normalized steering, acceleration, and braking commands to track longitudinal velocity and a lateral reference displacement. Use the block to:

- Close the loop between a predefined path and actual vehicle motion.
- Generate steering commands that track predefined paths. You can connect the Predictive Driver block output to steering block inputs.

- Generate braking and acceleration commands that track a longitudinal drive cycle.

Prebuilt 3D scenes, including straight roads, curved roads, and parking lots

You can simulate driving maneuvers in prebuilt 3D scenes, including straight roads, curved roads, and parking lots. To configure the scene for a reference application driving maneuver:

1. Open a reference application. For example, open the double lane change reference application.

   ```
   vdynblksDblLaneChangeStart
   ```
2. In the Visualization subsystem, set the 3D Engine block parameter **Scene description** to one of the scenes, for example `Straight road`.