System Composer™

User's Guide

MATLAB®&SIMULINK®

R2022b

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✉ The MathWorks, Inc.
1 Apple Hill Drive
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System Composer™ User's Guide

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Revision History

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Architecture Model Editing

Compose Architectures Visually

In this section...

You can create and edit visual diagrams to represent architectures in System Composer™. Use architectural elements including components, ports, and connections in the system composition. Model hierarchy in architecture by decomposing components. Navigate through the hierarchy.

With MATLAB® code and the functions `importModel` and `exportModel`, you can import external architecture descriptions into System Composer. For more information, see "Import and Export Architecture Models" on page 13-5.

Alternatively, you can use MATLAB programming to create and customize the various architectural elements. For details, see "Build Architecture Models Programmatically" on page 1-24.

Create Architecture Model

A System Composer architecture represents a system of components and how they interface with each other structurally and behaviorally. You can represent specific architectures using alternate views.

Different types of architectures describe different aspects of systems:

- *Functional architecture* describes the flow of data in a system.
- *Logical architecture* describes the intended operation of a system.
- *Physical architecture* describes the platform or hardware in a system.

You can define parameters on the architecture level using the **Parameter Editor**.

A System Composer model is the file that contains architectural information, including components, ports, connectors, interfaces, and behaviors.

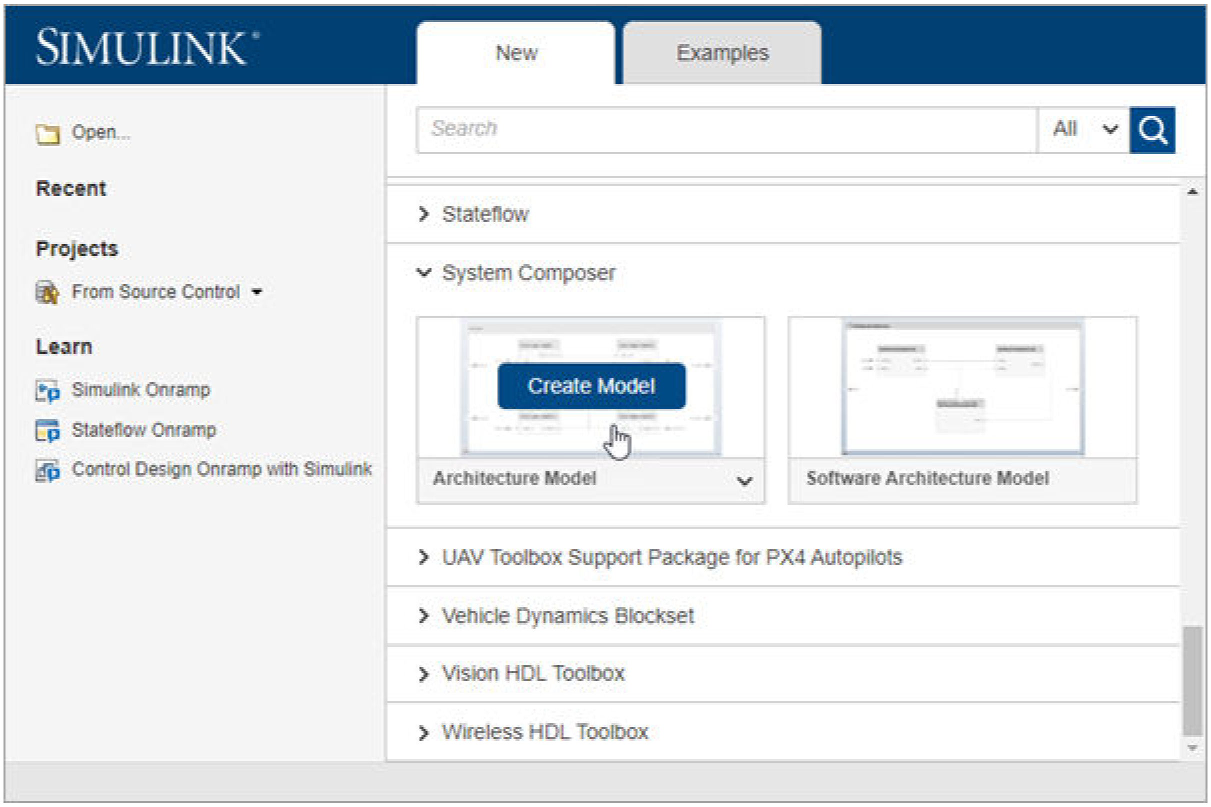
An architecture model includes a top-level architecture that holds the composition of the system. This top-level architecture also allows definition of interfaces of this system with other systems.

Start with a blank architecture model to model the physical and logical architecture of a system. Use one of these three methods to create an architecture model:

- At the MATLAB Command Window, enter:

  ```
  systemcomposer
  ```

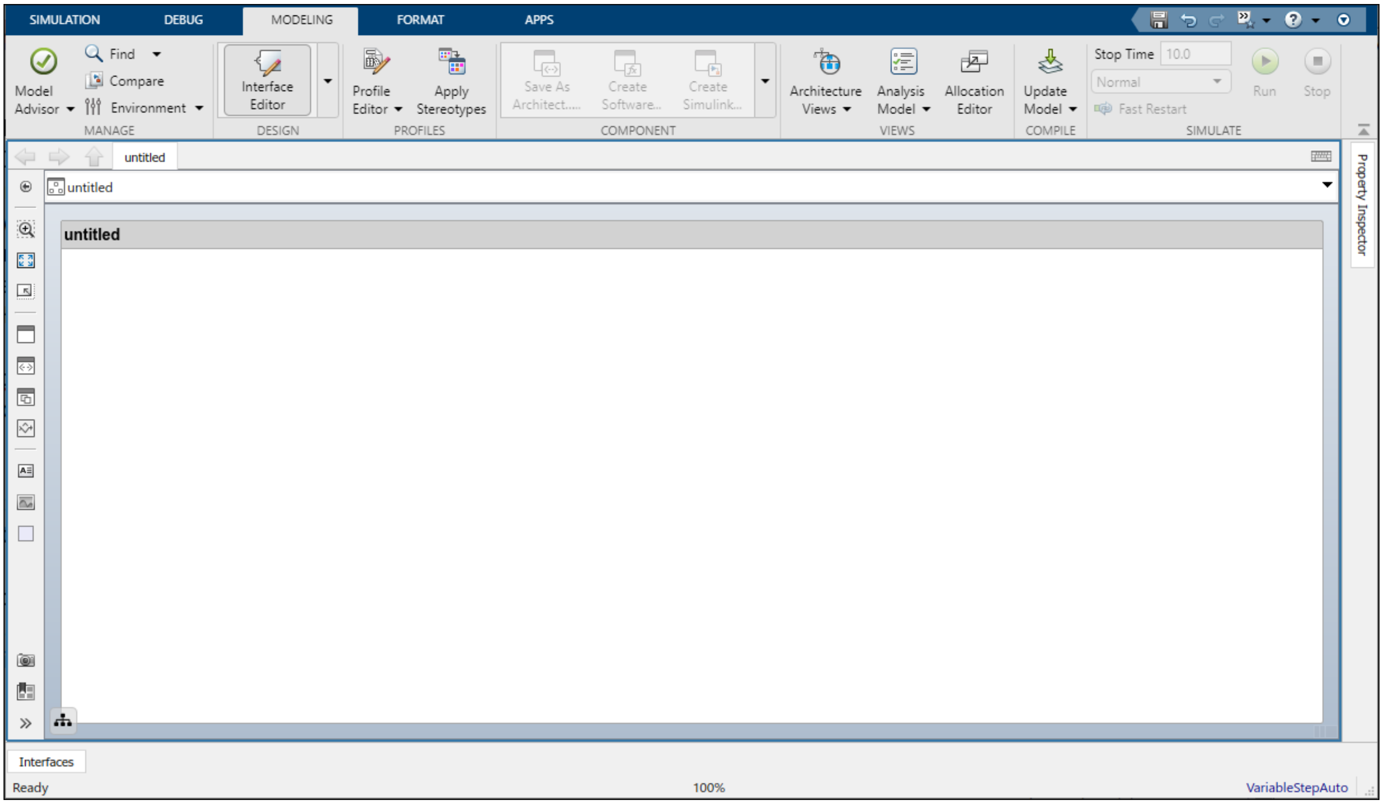
  Select **Architecture Model**.



Use a System Composer **Architecture Model** to describe systems as a combination of structural elements with underlying behavioral descriptions. Use a **Software Architecture Model** to easily define the execution order of your functions from your components, simulate your design in the architecture level, and generate code by linking your Simulink® export-function, rate-based, or JMAAB models to components.

For more information about software architecture models, see “Author Software Architectures” on page 10-2.

- From a Simulink model or a System Composer architecture model. On the **Simulation** tab, select **New** ✚, and then select **Architecture** ⧉.



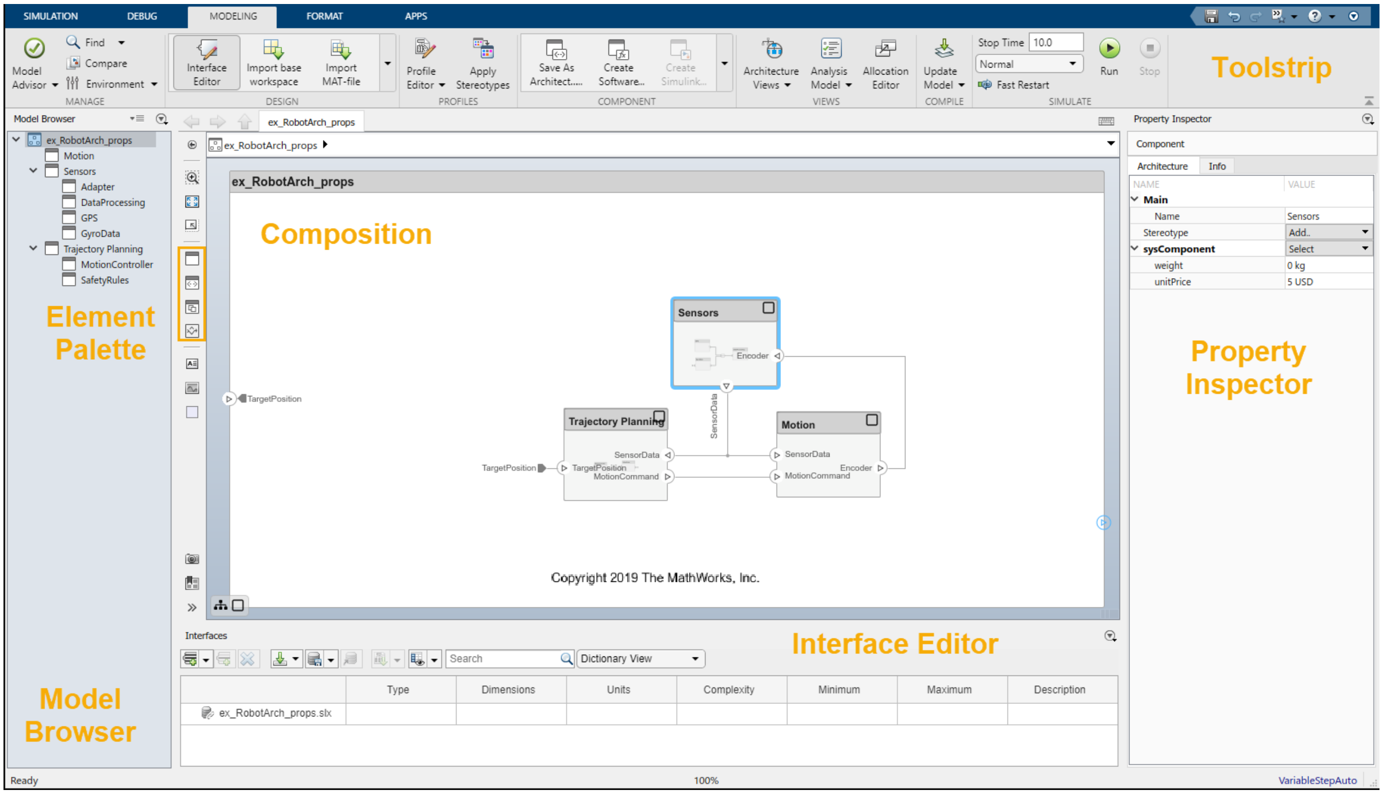
- At the MATLAB Command Window, enter:

  ```
  archModel = systemcomposer.createModel("ModelName");
  systemcomposer.openModel(archModel);
  ```

  where `ModelName` is the name of the new model.

Save the architecture model. On the **Simulation** tab, select **Save** . The architecture model is saved as an SLX file.

The architecture model includes a top-level architecture that holds the composition of the system. This top-level architecture also allows definition of interfaces of this system with other systems. The composition represents a structured parts list — a hierarchy of components with their interfaces and interconnections. Edit the composition in the Composition Editor.



NAME	VALUE
Main	
Name	Sensors
Stereotype	Add..
sysComponent	Select
weight	0 kg
unitPrice	5 USD

	Type	Dimensions	Units	Complexity	Minimum	Maximum	Description
ex_RobotArch_props.slx							

This example shows a motion control architecture, where a sensor obtains information from a motor, feeds that information to a controller, which in turn processes this information to send a control signal to the motor so that it moves in a certain way. You can start with this rough description and add component properties, interface definitions, and requirements as the design progresses.

Components

A component is a nontrivial, nearly independent, and replaceable part of a system that fulfills a clear function in the context of an architecture. A component defines an architectural element, such as a function, a system, hardware, software, or other conceptual entity. A component can also be a subsystem or subfunction.

The Component element in System Composer can represent a component at any level of the system hierarchy, whether it is a major system component that encompasses many subsystems, such as a controller with its hardware and software, or a component at the lowest level of hierarchy, such as a software module for messaging.

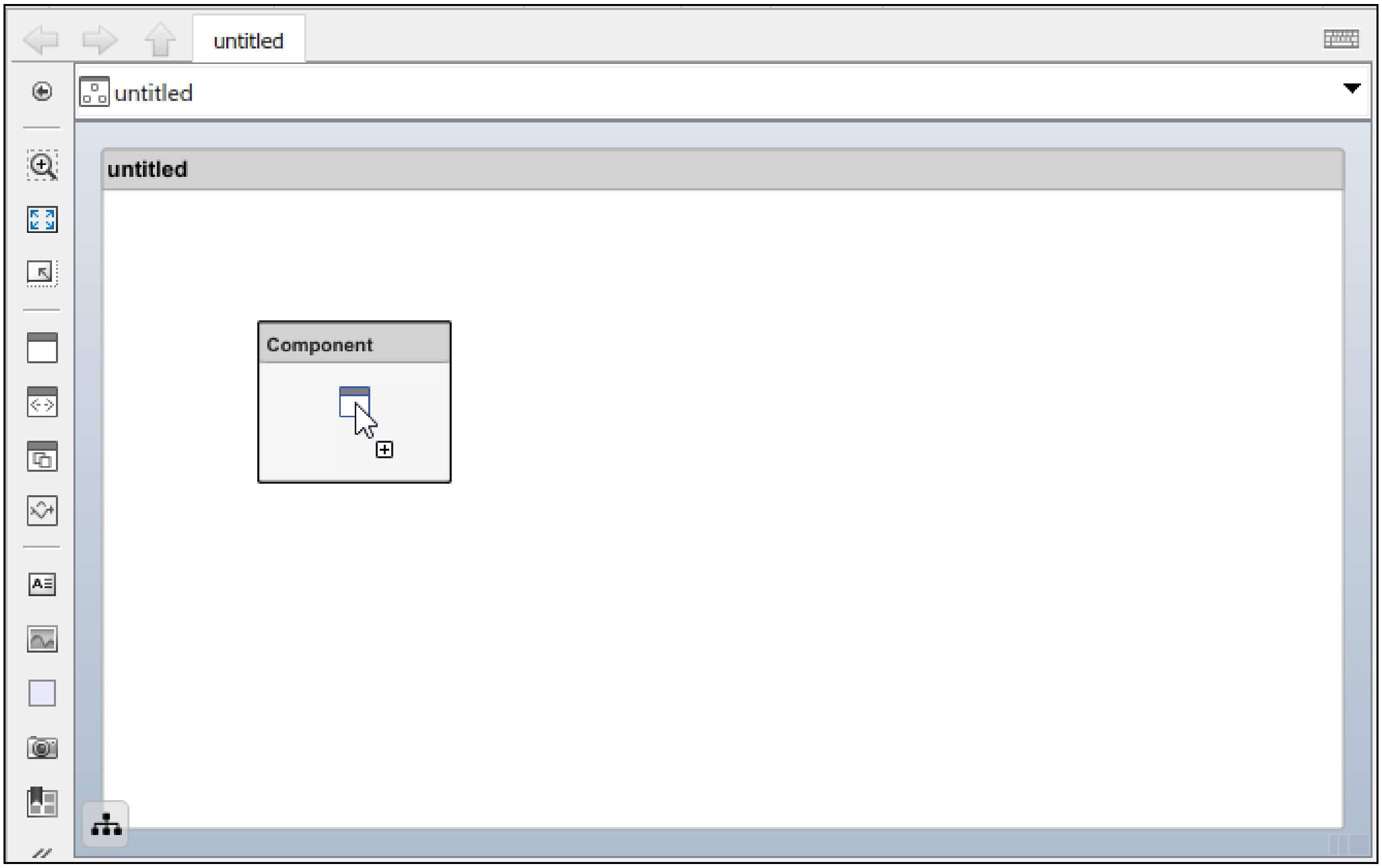
Represented as a block, a component is a part of an architecture model that can be separated into reusable artifacts. Transfer information between components with:

- Port interfaces using the **Interface Editor**
- Parameters using the **Parameter Editor**

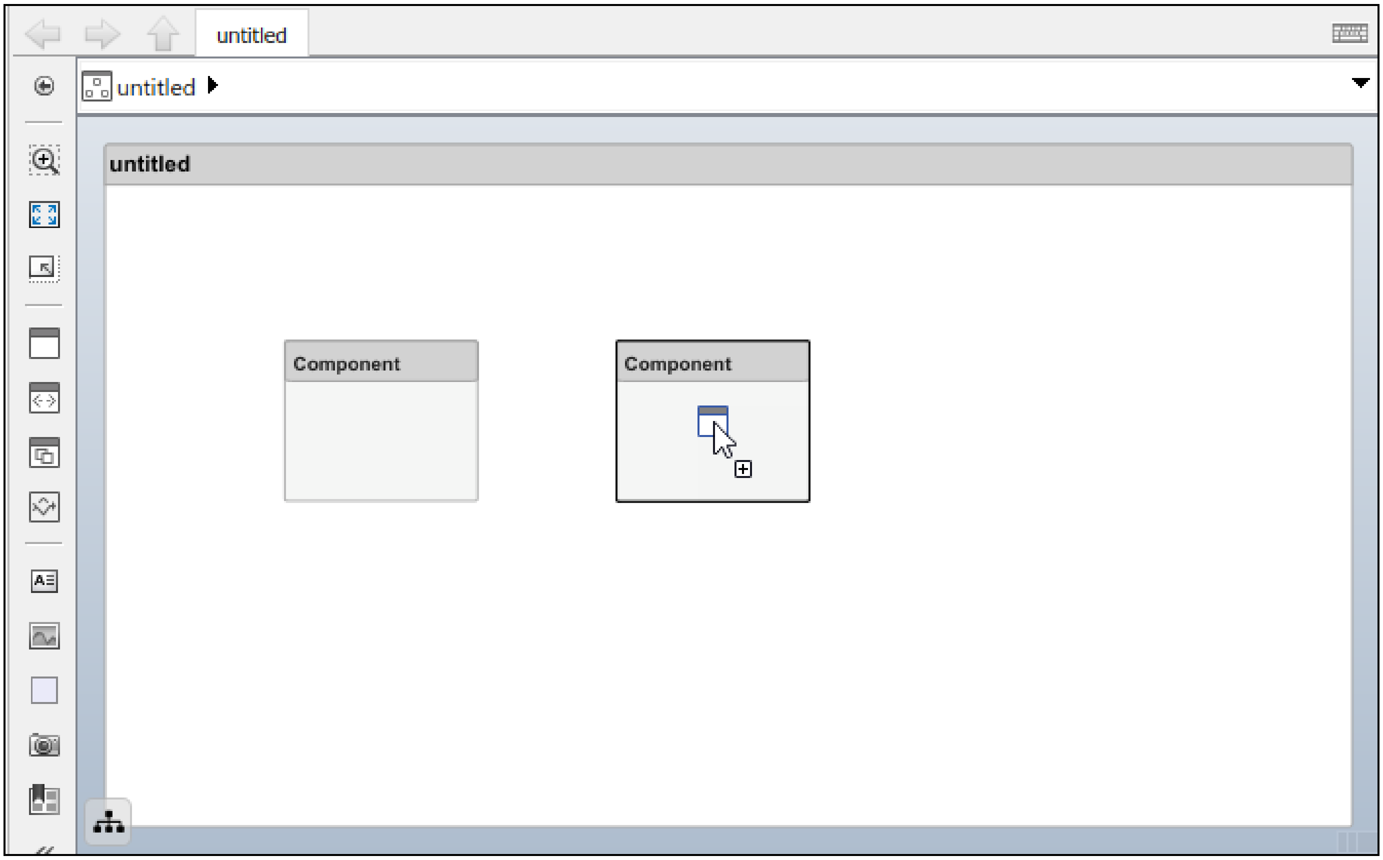
Add Components

Use one of these methods to add components to the architecture:

- Draw a component — In the canvas, left-click and drag the mouse to create a rectangle. Release the mouse button to see the component outline. Select the Component block option to commit.
- Create a single component from the palette —

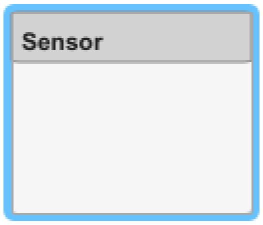


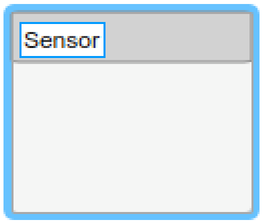
- Create multiple components from the palette —



Name Component

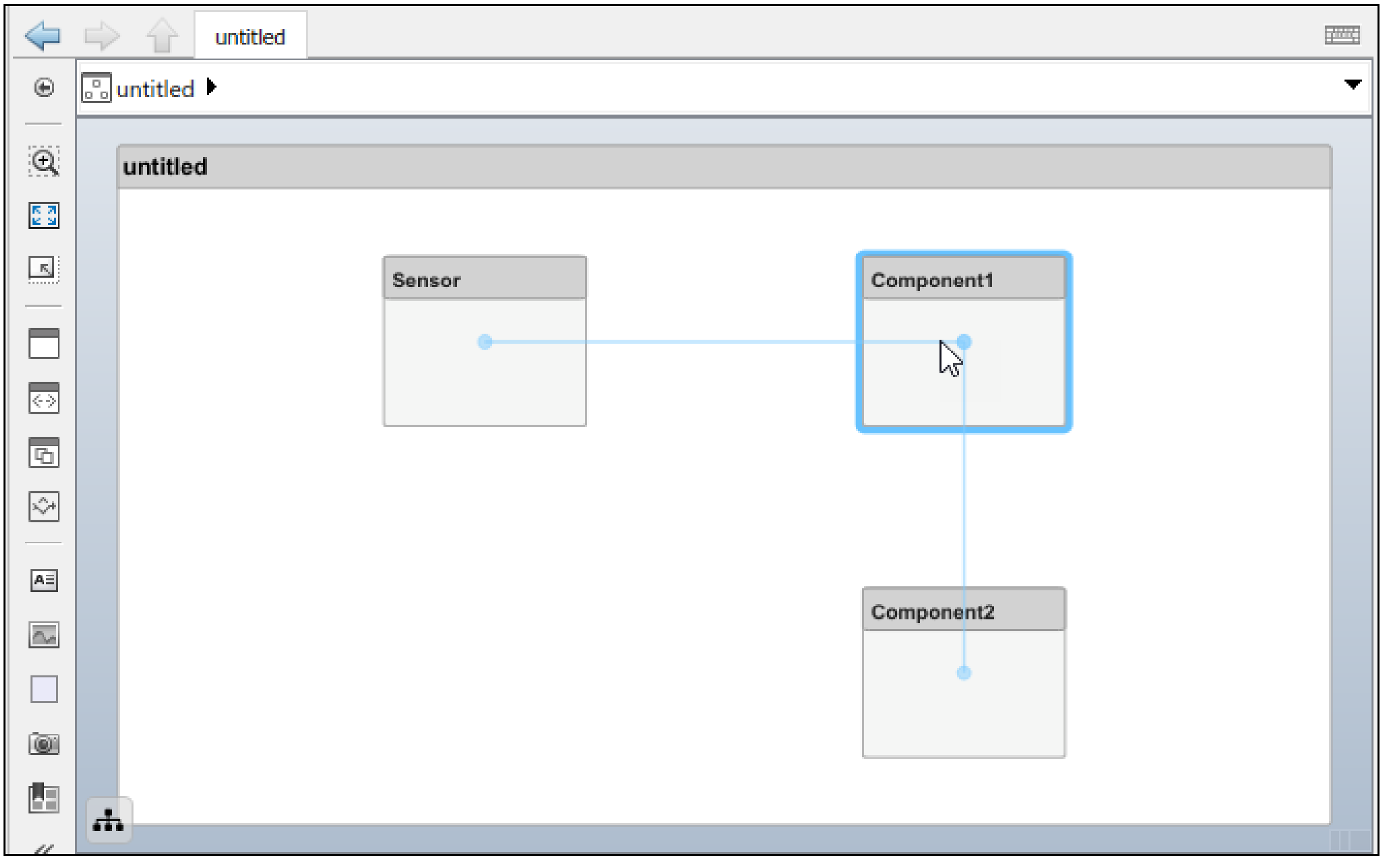
Each component must have a name that is unique within the same architecture level. The name of the component is highlighted upon creation so you can directly type the name. To change the name of a component, click the component and then click its name.





Move Component

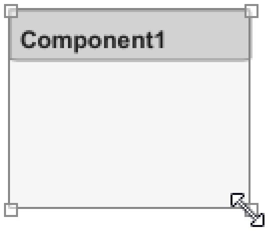
Move a component simply by clicking and dragging it. Blue guidelines may appear to help align the component with other components.



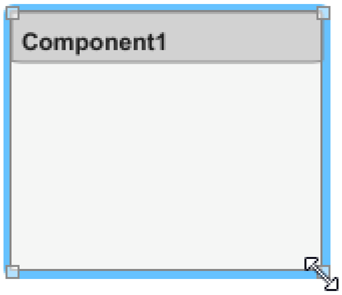
Resize Component

Resize a component by dragging corners.

1 Pause the pointer over a corner to see the double arrow.



2 Click the corner and drag while holding the mouse button down. If you want to resize the component proportionally, hold the **Shift** button as well.



3 Release the mouse button when the component reaches the size you want.

Delete Component

Click a component and press **Delete** to delete it. To delete multiple components, select them while holding the **Shift** key down, then press **Delete**.

Ports

A port is a node on a component or architecture that represents a point of interaction with its environment. A port permits the flow of information to and from other components or systems.

There are different types of ports:

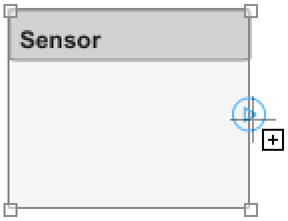
- *Component ports* are interaction points on the component to other components.
- *Architecture ports* are ports on the boundary of the system, whether the boundary is within a component or the overall architecture model.

For example, a sensor might have data ports to communicate with a motor and a controller. Its input port takes data from the motor, and the output port delivers data to the controller. You can specify data properties by defining an interface as described in “Define Port Interfaces Between Components” on page 3-2.

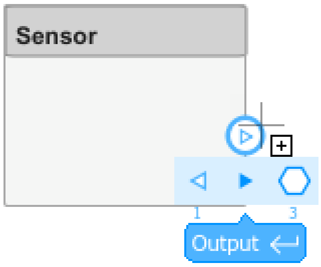
Add Component Port

Represent the relationship between components by defining directional interface ports. You can organize the diagram by positioning ports on any edge of the component, in any position.

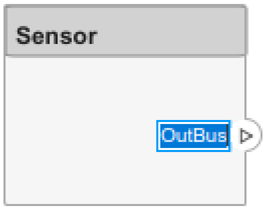
1 Pause over the side of a component. A + sign and a port outline appear.



2 Click the port outline. A set of options appear for an `Input`, `Output`, or `Physical` port.



3 Select `Output` to commit the port. You can also name the port at this point.

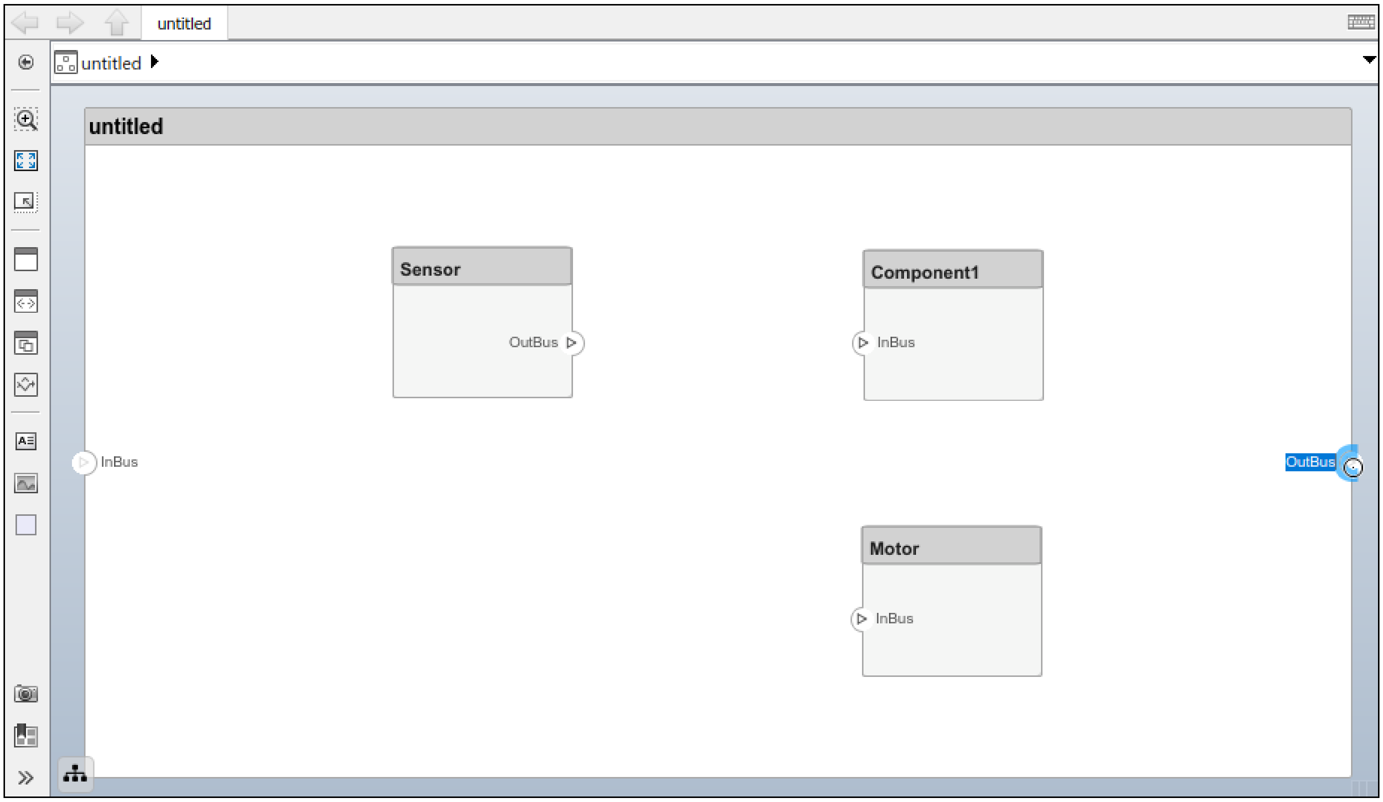


An output port is shown with the ▷ icon, an input port is shown with the ◁ icon, and a physical port is shown with the ⬡ icon and is nondirectional.

You can move any port to any component edge after creation.

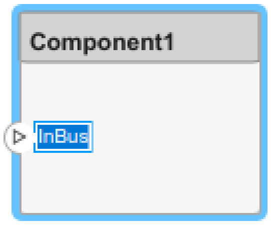
Add Architecture Port

You can also create a port for the architecture that contains components. These system ports carry the interface of the system with other systems. Pause on any edge of the system box and click when the + sign appears. Click the left side to create input ports and click the right side to create output ports.



Name Port

Every port is created with a name. To change the name, click it and edit.



Ports of a component must have unique names.

Move Port

You can move a port to any side of a component. Select the port and use arrow keys.

Arrow Key	Original Port Edge	Port Movement
Up	Left or right	If below other ports on the same edge, move up, if not, move to the top edge
	Top or bottom	No action

Arrow Key	Original Port Edge	Port Movement
Right	Top or bottom	If to the left of other ports on the same edge, move right, if not, move to the right edge
	Left or right	No action
Down	Left or right	If above other ports on the same edge, move down, if not, move to the bottom edge
	Top or bottom	No action
Left	Top or bottom	If to the right of other ports on the same edge, move left, if not, move to the left edge
	Left or right	No action

The spacing of the ports on one side is automatic. There can be a combination of input and output ports on the same edge.

Delete Port

Delete a port by selecting it and pressing the **Delete** button.

Change Port Type

You can change a port type after right-clicking a port and selecting `Conjugate port` from the context menu. An `Input` port is converted into an `Output` port, and an `Output` port is converted into an `Input` port.

Connections

Connectors are lines that provide connections between ports. Connectors describe how information flows between components or architectures.

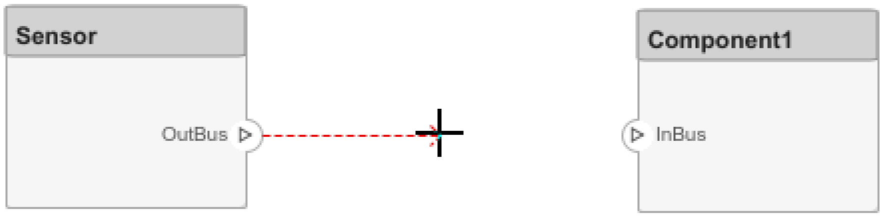
A connector allows two components to interact without defining the nature of the interaction. Set an interface on a port to define how the components interact.

Connections are visual representations of data flow from an output port to an input port. For example, a connection from a motor to a sensor carries positional information.

Connect Existing Ports

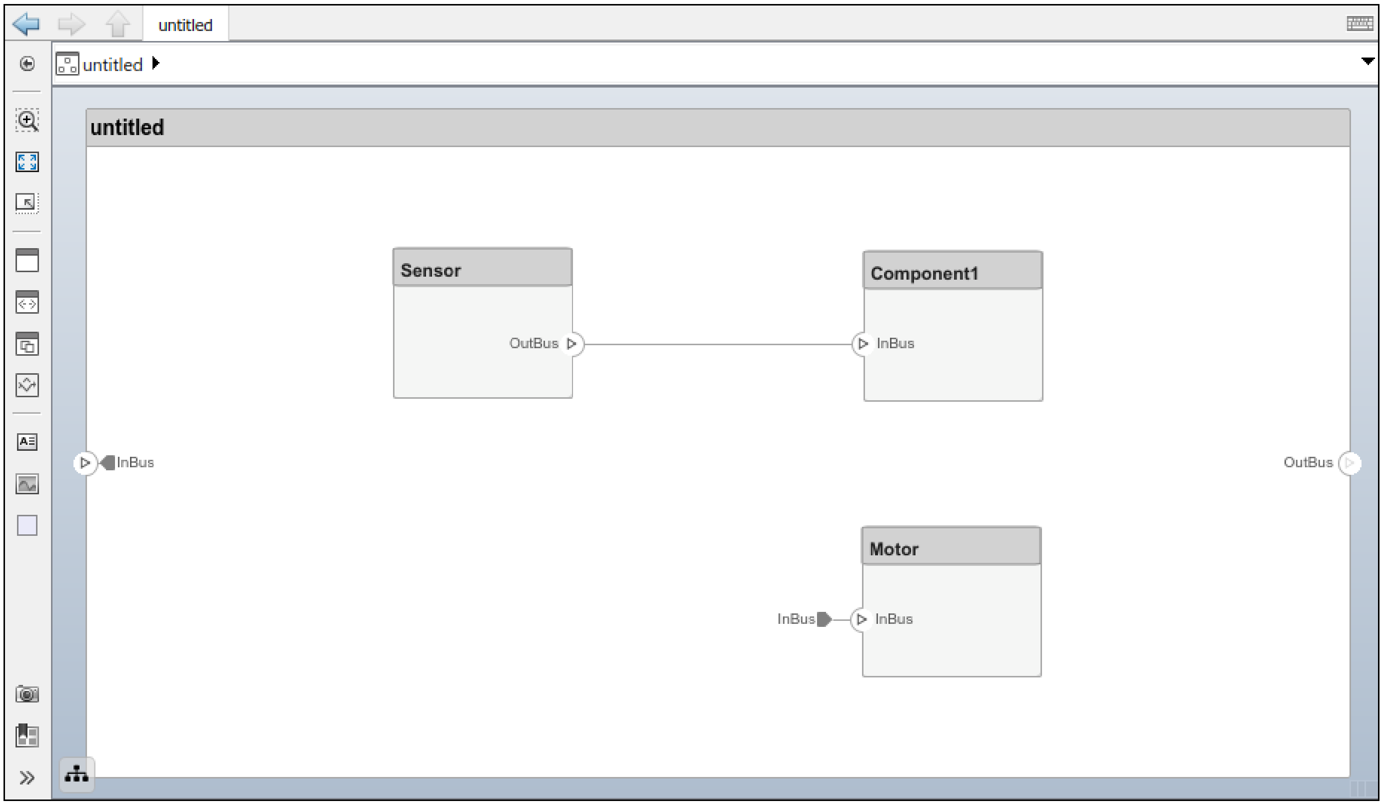
Connect two ports by dragging a line:

1. Click one of the ports.
2. Keep the mouse button down while dragging a line to the other port.
3. Release the mouse button at the destination port. A black line indicates the connection is complete. A red-dotted line appears if the connection is incomplete.



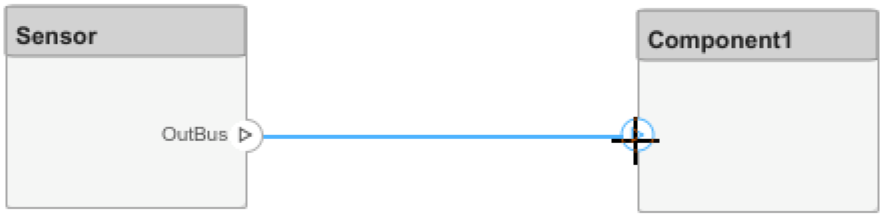
You can take these steps in both directions — input port to output port, or output port to input port. You cannot connect ports that have the same direction.

A connection between an architecture port and a component port is shown with tags instead of lines.



Connect Components Without Ports

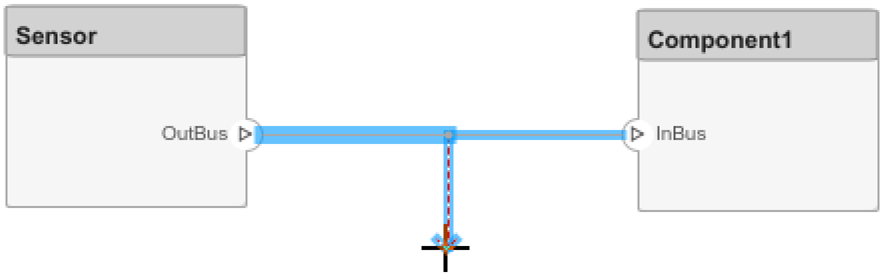
To quickly create ports and connections at the same time, drag a line from one component edge to another. The direction of this connection depends on which edges of the components are used - left and top edges are considered inputs, right and bottom edges are considered outputs. You can also perform this operation from an existing port to a component edge.



You can create a connection between an edge that is assumed to be an input only with an edge that is assumed to be an output. For example, you cannot connect a top edge, which is assumed to be an input, with another top edge, unless one of them already has an output port.

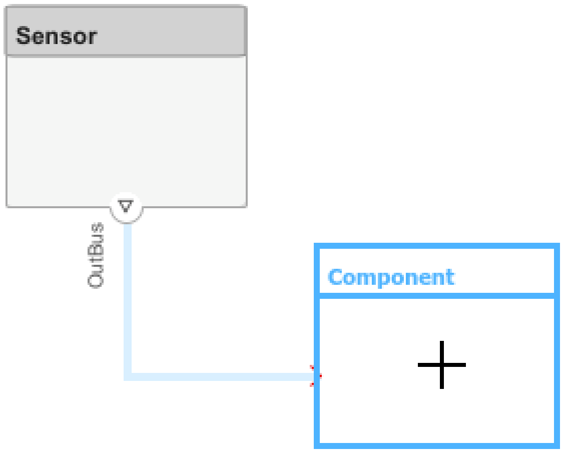
Branch Connections

Connect an output port to multiple input ports by branching a connection. To branch, right-click an existing connection and drag to an input port while holding the mouse button down. Release the button to commit the new connection.



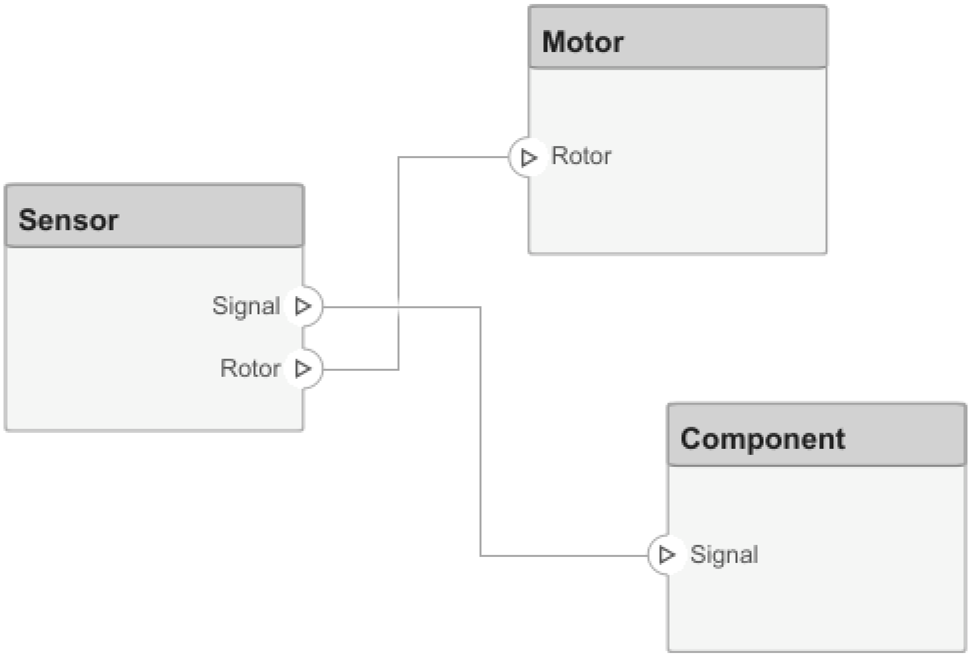
Create New Components Through Connections

If you start a connection from an output port and release the mouse button without a destination port, a new component tentatively appears. Accept the new component by clicking it.

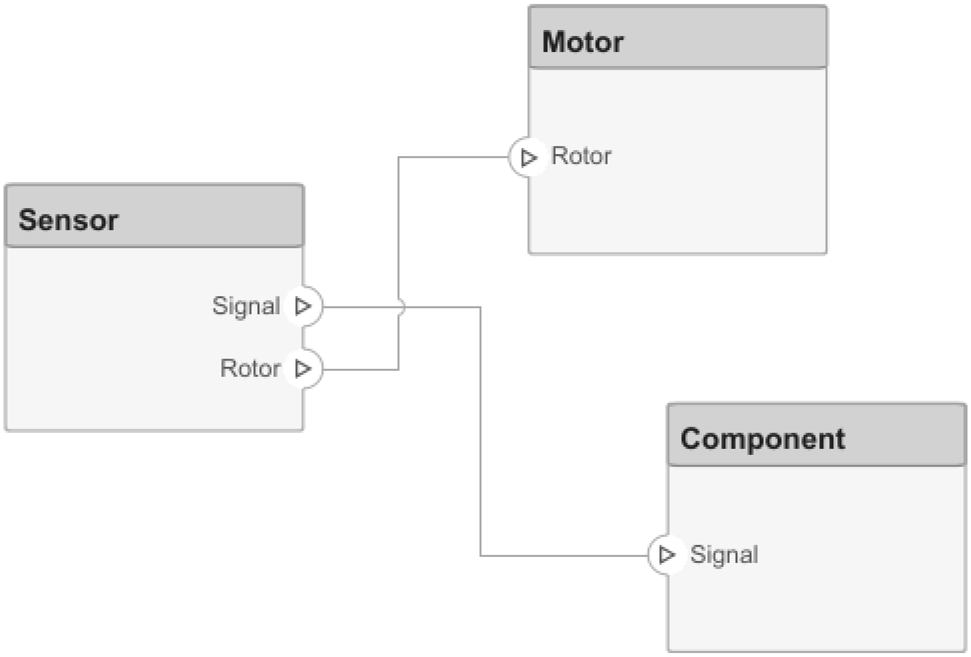


Change Line Crossing Style for Overlapping Connections

In complex architectural diagrams, connectors can overlap. You can improve the readability of your diagram by choosing another line crossing style. Navigate to **Modeling** > **Environment** > **Simulink Preferences**. In **Simulink Preferences**, select **Editor**, then select a **Line crossing style**. The default line crossing style, `Tunnel`, is shown below.



Another option, `Line Hop`, is shown below.



For more information on line crossing style parameters, see “Line crossing style”.

See Also

Functions
`createModel` | `addComponent` | `addPort` | `connect` | `exportModel` | `importModel`

Blocks
Component

More About

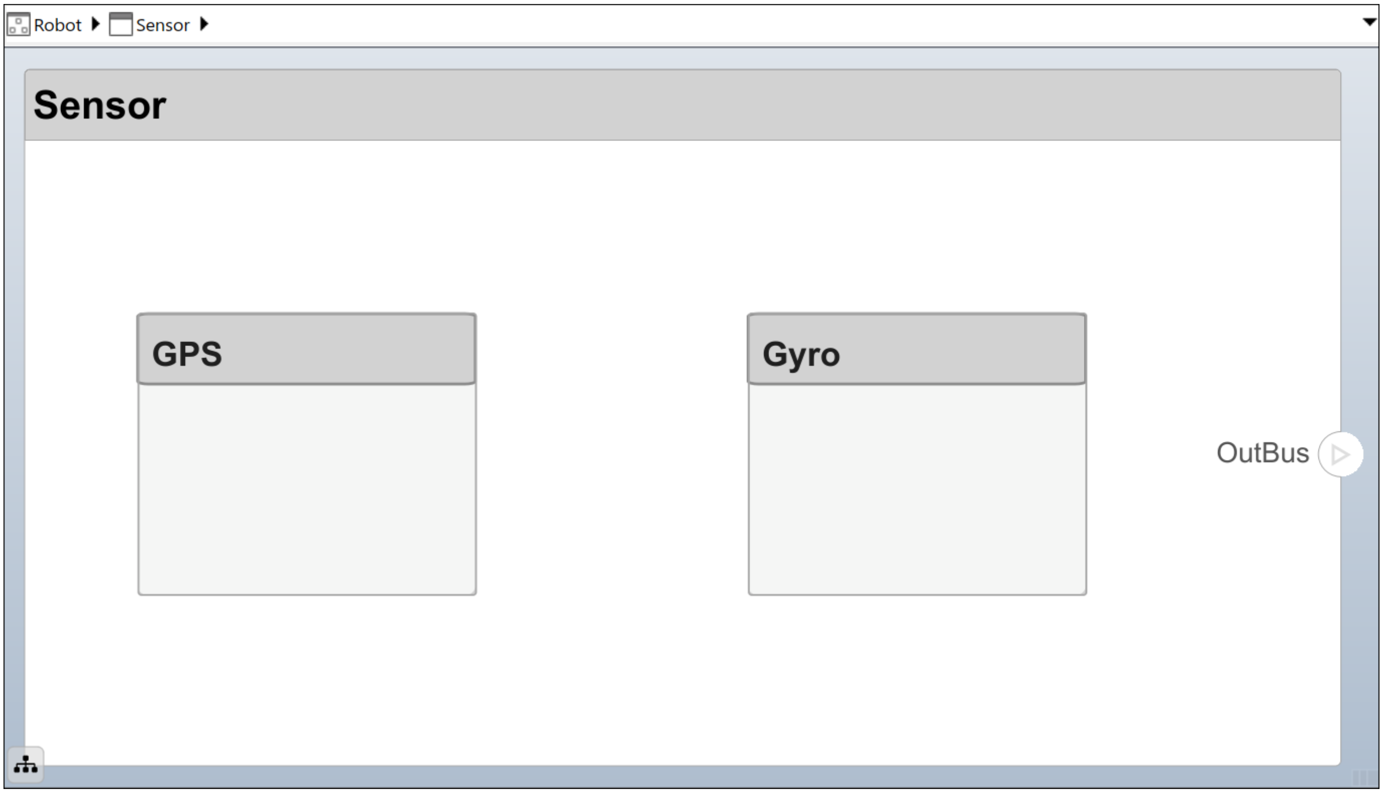
- “Decompose and Reuse Components” on page 1-17
- “Create Interfaces” on page 3-4
- “Author Parameters in System Composer Using Parameter Editor” on page 4-2
- “Describe System Behavior Using Sequence Diagrams” on page 6-2
- “Simulate Mobile Robot with System Composer Workflow” on page 5-20

Decompose and Reuse Components

Every component in an architecture model can have its own design, or even several design alternatives. These designs can be architectures modeled in System Composer or behaviors modeled in Simulink. Engineering systems often use the same component design in multiple places. A common component, such as power switch, can be part of all electrical components. You can reuse a component in System Composer within the same model as well as across architecture models.

Decompose Component

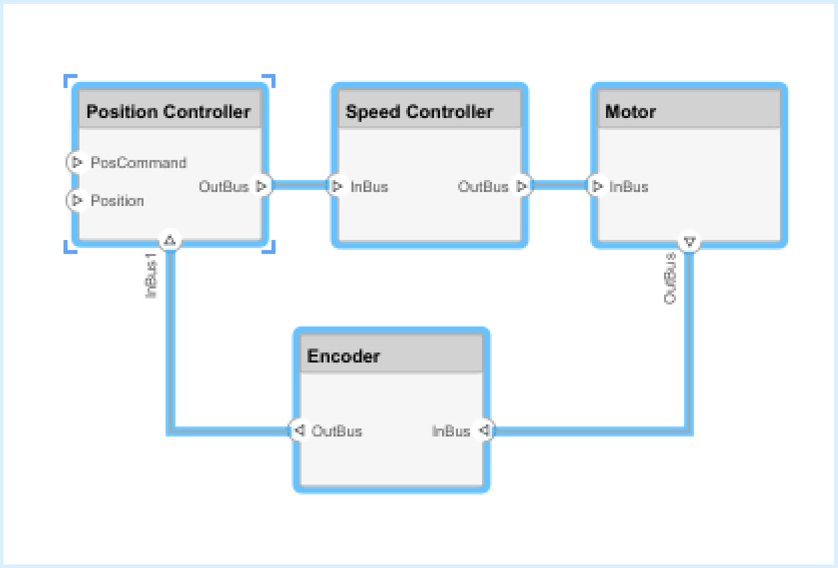
A component can have its own architecture. Double-click a component to view or edit its architecture. When you view the component at this level, its ports appear as architecture ports. Use the Model Browser to view component hierarchy.



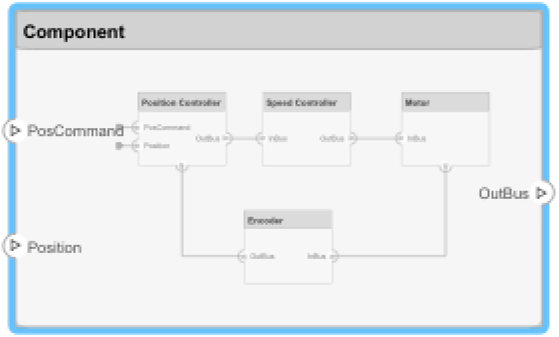
You can add components, ports, and connections at this level to define the architecture.

You can also make a new component from a group of components.

1. Select the components. Either click and drag a rectangle, or select multiple components by holding the **Shift** button down.



2 Create a component from the selected elements by right-clicking and selecting `Create Component from Selection`.



As a result, the new component has the selected components, their ports, and connections as part of its architecture. Any unconnected ports and connections to components outside of the selection become ports on the new component.

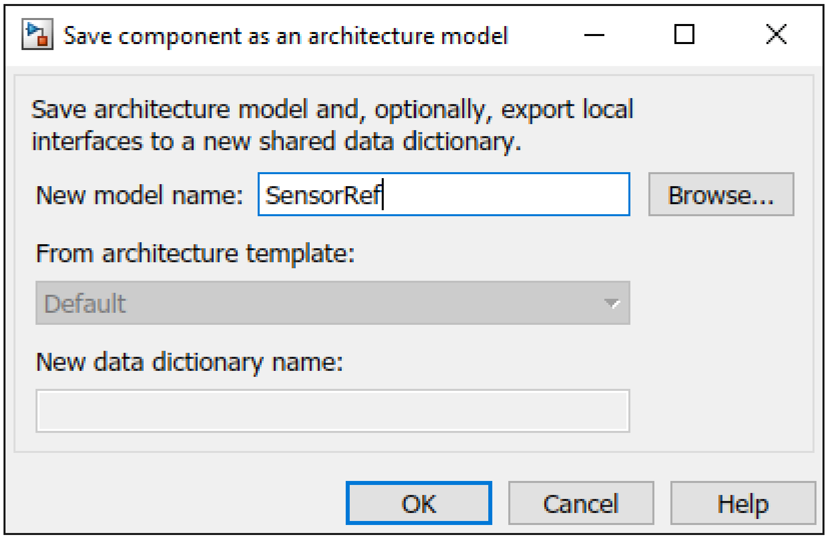
Any component that has its own architecture displays a preview of its contents.

Create Reference Architecture

Some projects use the same, detailed component in multiple places, and require the design of such a component to be tightly managed. You can create a reference architecture to reuse the architectural definition of a component in the same architecture model or across several architecture models. Create such a reference architecture using this procedure:

1 Right-click the `Sensor` component and select **Save as Architecture Model**.

2 Provide a name for the model. By default, the reference architecture is saved in the same folder as the architecture model. Browse for or type the full path if you want to save it in a different folder.



Save component as an architecture model

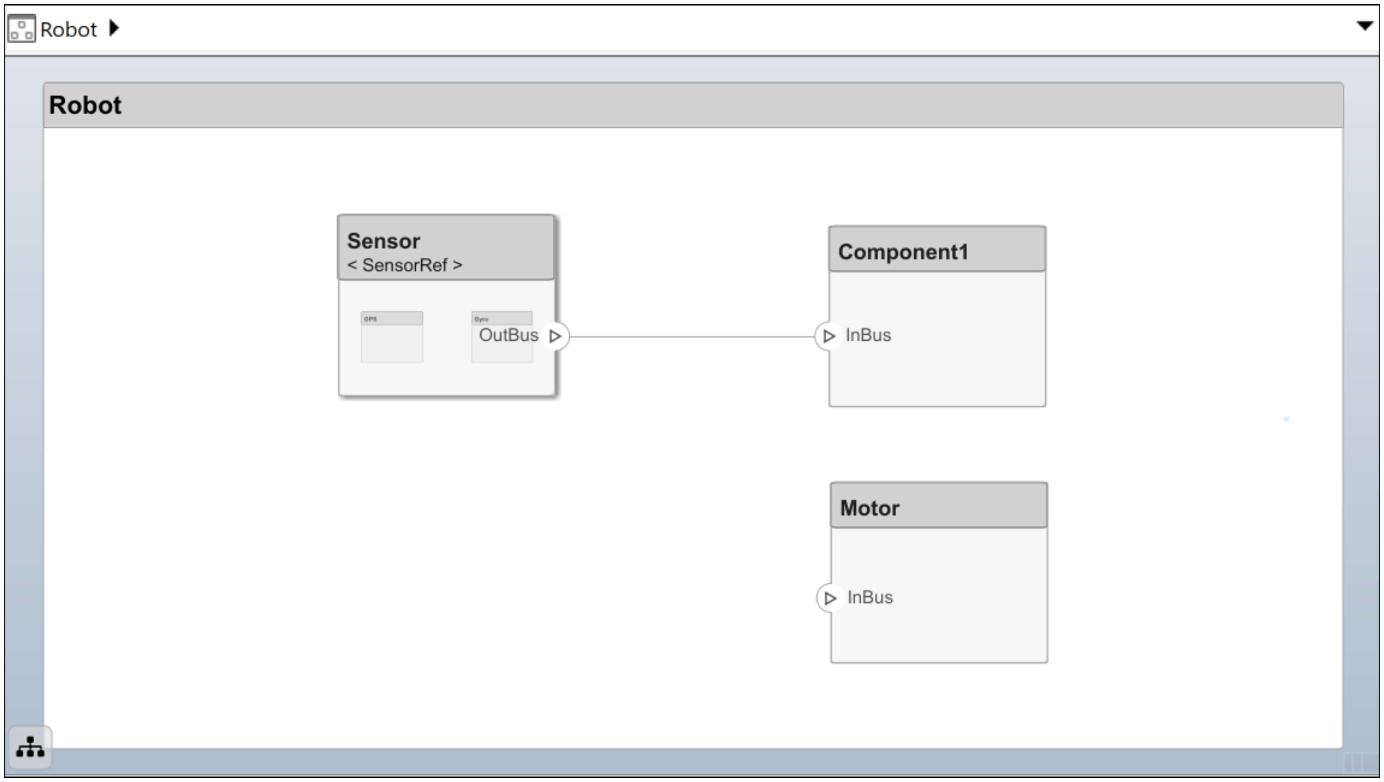
Save architecture model and, optionally, export local interfaces to a new shared data dictionary.

New model name: SensorRef

From architecture template: Default

New data dictionary name:

3 System Composer creates an architecture model with the provided name, and links the component to the new model. The linked model is indicated in the name of the component between the <> signs.



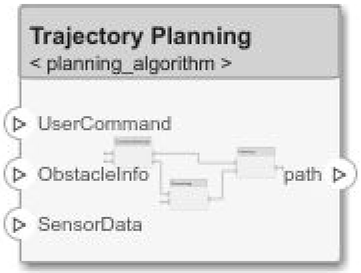
All architecture models can reference this new architecture model through linked components.

Use Reference Architecture

You can use a reference architecture, saved in a separate file, by linking to it from a component. Right-click the component and select **Link to Model**. You can also use the **Create Reference** option in the element palette directly to create a component that uses a reference architecture.

To link a selected component to an existing architecture model, right-click the `Trajectory Planning` component and select **Link to Model**.

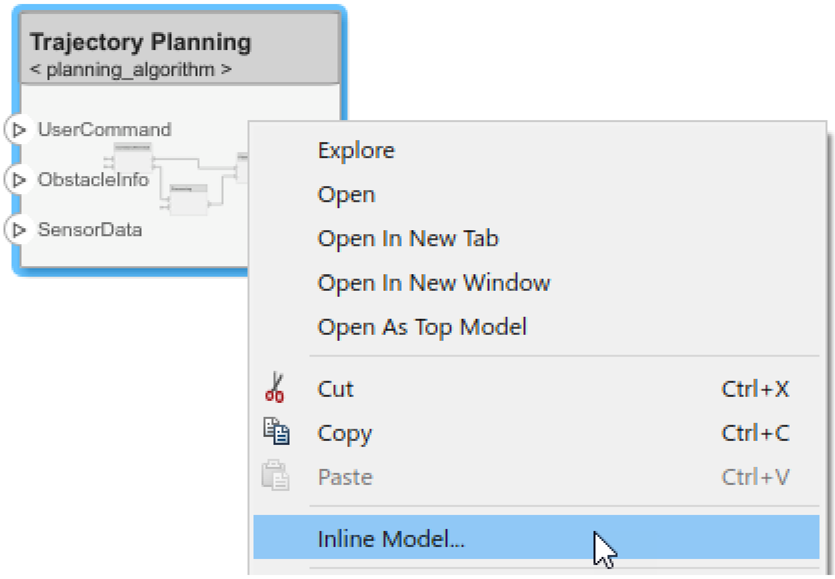
Provide the full path to the reference architecture. If the linked component has its own ports and components, this content is deleted during linking and replaced by that of the reference architecture. The ports of the linked component become the architecture ports in the reference architecture.



Any change made in a reference architecture is immediately reflected in the models that link to it. If you move or rename the reference architecture, the link becomes invalid and the linked component displays an error. Link the component to a valid reference architecture.

Remove Reference Architecture

In some cases, you have to deviate from the reference architecture for a single component. For example, a comprehensive sensor model, referenced from a local component, may include too many features for the motion control architecture at hand and require simplification for that architecture only. In this case, you can remove the reference architecture to make local changes possible. Right-click a linked component and select **Inline Model**.



This operation provides two options:

- Interface and subcomponents — Ports, interfaces, and subcomponents of the reference architecture are copied to the component.
- Interface only — The ports and designated interfaces of the reference architecture are reflected on the component, but the composition is blank.

Once the reference architecture is removed, you can start making changes without affecting other architectures. However, you cannot propagate local changes to the reference architecture. If you link to the reference architecture again, local changes are lost.

To remove a Stateflow® chart behavior, see “Remove Stateflow Chart Behavior from Component” on page 7-17.

Create Variants

A component can have multiple design alternatives, or variants.

A variant is one of many structural or behavioral choices in a variant component.

Use variants to quickly swap different architectural designs for a component while performing analysis.

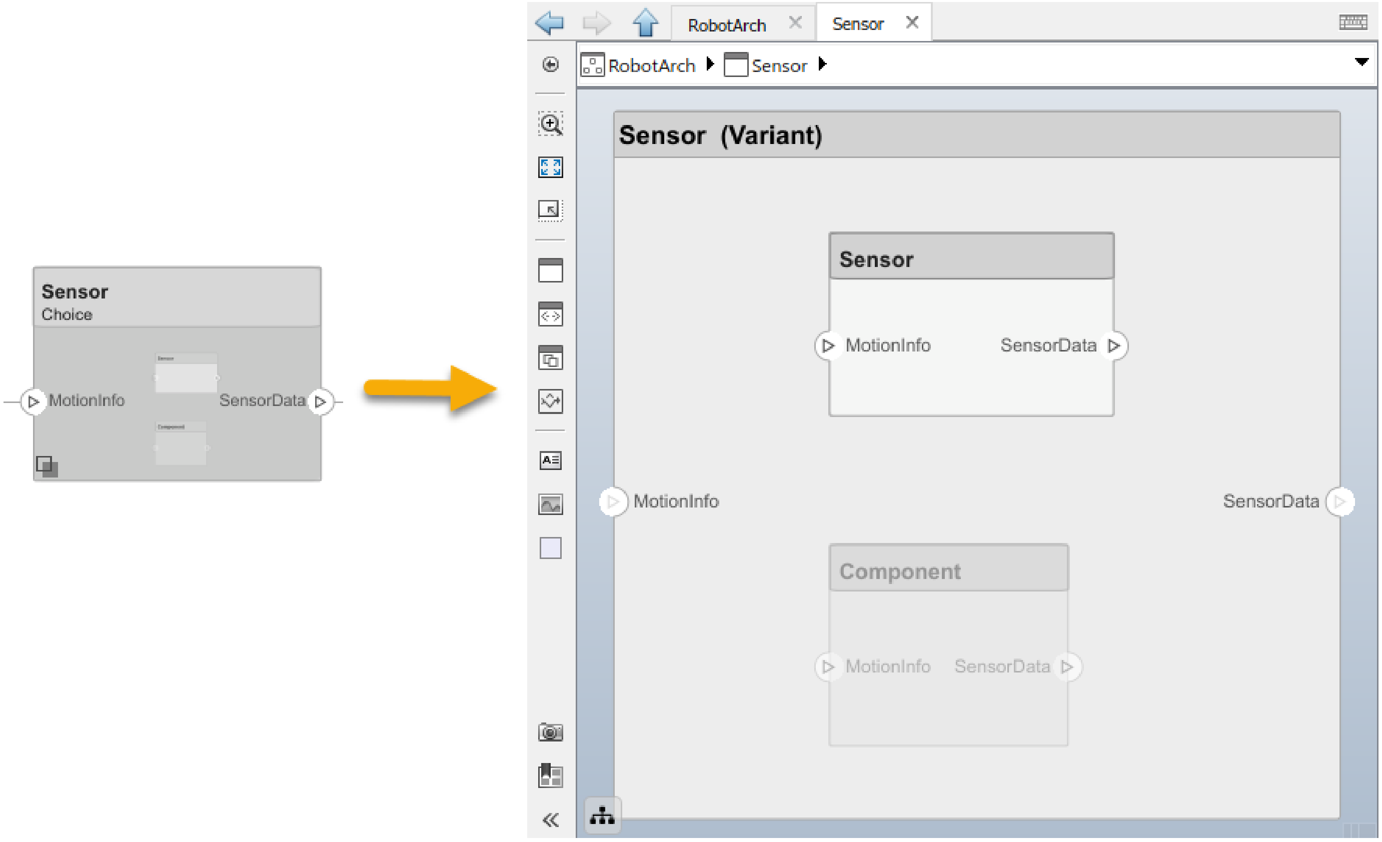
A variant control is a string that controls the active variant choice.

Set the variant control to programmatically control which variant is active.

You can model variations for any component in a single architecture model. You can define a mix of behaviors (defined in a Simulink model) and architectures (defined in a System Composer architecture model) as variant choices. For example, a component may have two variant options that represent two alternate structural decompositions.

Convert a Component to a Variant Component adding variant choices to the component. Right-click the `Sensor` component and select **Add Variant Choice**.

The badge on the component indicates that it is a variant, and a variant choice is added to the existing composition. Double-click the component to see variant choices.



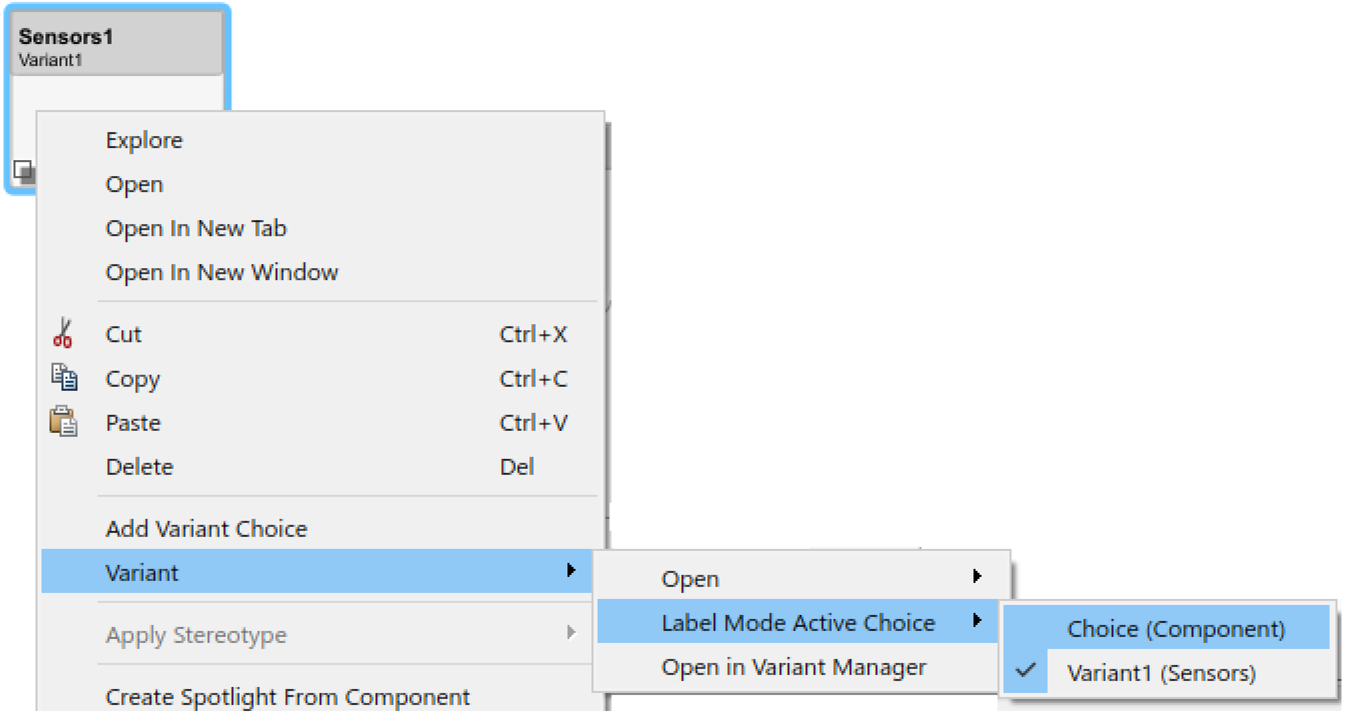
Add Variant Choices

You can add more variant choices to a variant component using the **Add Variant Choice** option.

Open and edit the variant by right-clicking and selecting **Variant** > **Open** > **Variant Name** from the component context menu.

You can also designate a component as a variant upon creation using the object in the toolstrip. This creates two variant choices by default.

Activate a specific variant choice using the context menu of the block. Right-click and select **Variant** > **Label Mode Active Choice** > **Choice (Component)**. The active choice is displayed in the header of the block.



Create Software Architecture from Component

You can create a software architecture model from a component in a System Composer architecture model and reference the software architecture model from the component. You can use software architectures to link Simulink export-function, rate-based, or JMAAB models to components in your architecture model to simulate and generate code. For more information, see “Create Software Architecture from Architecture Model Component” on page 10-5.

See Also

Functions
`createArchitectureModel` | `linkToModel` | `inlineComponent` | `addVariantComponent` | `makeVariant` | `addChoice` | `setActiveChoice`

Blocks
Reference Component | Variant Component

More About

- “Implement Component Behavior Using Simulink” on page 7-2
- “Implement Component Behavior Using Stateflow Charts” on page 7-14
- “Organize System Composer Files in Projects” on page 12-2
- “Simulate Mobile Robot with System Composer Workflow” on page 5-20

Build Architecture Models Programmatically

Build an architecture model programmatically using System Composer™.

Build Model

To build a model, add a data dictionary with data interfaces, data elements, a value type, and a physical interface, then add components, ports, and connections. Create a profile with stereotypes and properties and then apply those stereotypes to model elements. Assign an owned interface to a port. After the model is built, you can create custom views to focus on specific considerations. You can also query the model to collect different model elements according to criteria you specify.

Add Components, Ports, Connections, and Interfaces

Create a model and extract its architecture.

```
model = systemcomposer.createModel("mobileRobotAPI");
arch = model.Architecture;
```

Create an interface data dictionary and add a data interface. Add a data element to the data interface. Add a value type to the interface data dictionary. Assign the type of the data element to the value type. Add a physical interface and physical element with a physical domain type. Link the data dictionary to the model.

```
dictionary = systemcomposer.createDictionary("SensorInterfaces.sldd");
interface = dictionary.addInterface("GPSInterface");
element = interface.addElement("SignalStrength");
valueType = dictionary.addValueType("SignalStrengthType",Units="dB",Description="GPS Signal Stren
element.setType(valueType);
physicalInterface = dictionary.addPhysicalInterface("PhysicalInterface");
physicalElement = addElement(physicalInterface,"ElectricalElement",Type="electrical.electrical")
linkDictionary(model,"SensorInterfaces.sldd");
```

Save the changes to the interface data dictionary.

```
dictionary.save
```

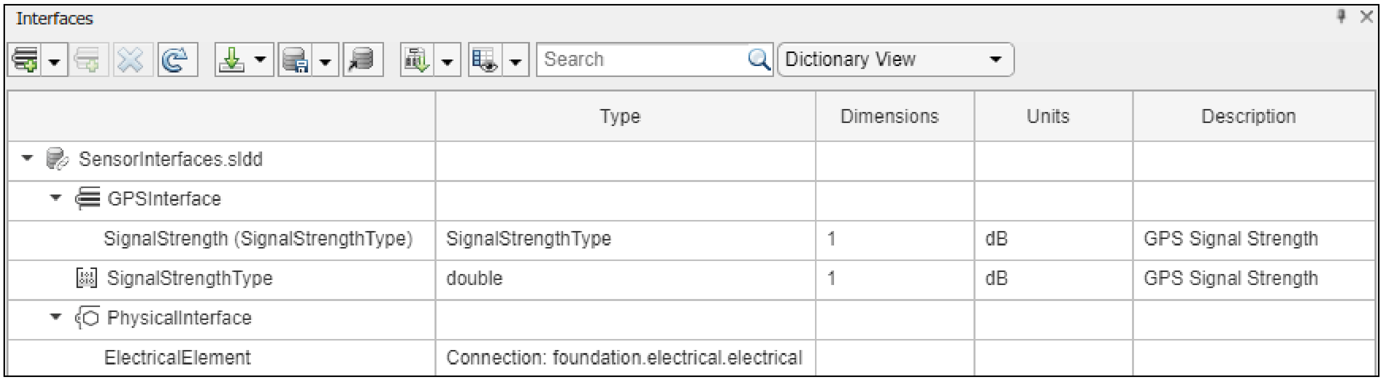
Save the model.

```
model.save
```

Open the model.

```
systemcomposer.openModel("mobileRobotAPI");
```

View the interfaces in the Interface Editor.



	Type	Dimensions	Units	Description
SensorInterfaces.sldd				
GPSInterface				
SignalStrength (SignalStrengthType)	SignalStrengthType	1	dB	GPS Signal Strength
SignalStrengthType	double	1	dB	GPS Signal Strength
PhysicalInterface				
ElectricalElement	Connection: foundation.electrical.electrical			

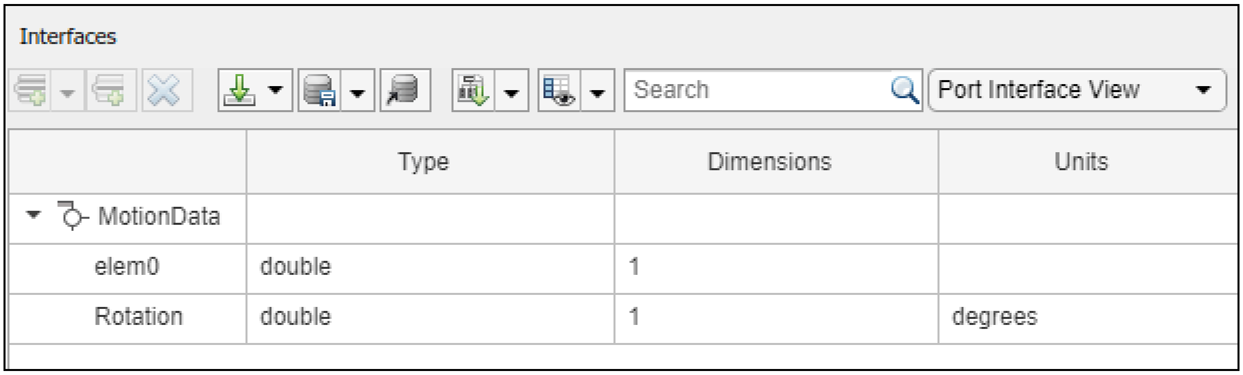
Add components, ports, and connections. Set the physical interface to the physical ports, which you will connect later.

```
componentSensor = addComponent(arch,"Sensor");
sensorPorts = addPort(componentSensor.Architecture,{'MotionData','SensorPower'},{'in','physical'
sensorPorts(2).setInterface(physicalInterface)

componentPlanning = addComponent(arch,"Planning");
planningPorts = addPort(componentPlanning.Architecture,{'Command','SensorPower1','MotionCommand'
planningPorts(2).setInterface(physicalInterface)

componentMotion = addComponent(arch,"Motion");
motionPorts = addPort(componentMotion.Architecture,{'MotionCommand','MotionData'},{'in','out'});
```

Create an owned interface on the `'MotionData'` port. Add an owned data element under the owned data interface. Assign the data element `"Rotation"` to a value type with units set to `degrees`.

```
ownedInterface = motionPorts(2).createInterface("DataInterface");
ownedElement = ownedInterface.addElement("Rotation");
subInterface = ownedElement.createOwnedType(Units="degrees");
```

View the interfaces in the Interface Editor. Select the `'MotionData'` port on the `Motion` component. In the Interface Editor, switch from **Dictionary View** to **Port Interface View**.



	Type	Dimensions	Units
MotionData			
elem0	double	1	
Rotation	double	1	degrees

Connect components with an interface rule and the default name rule. The interface rule connects ports on components that share the same interface. By default, the name rule connects ports on components that share the same name.

```
c_sensorData = connect(arch,componentSensor,componentPlanning,Rule="interface");
c_motionData = connect(arch,componentMotion,componentSensor);
c_motionCommand = connect(arch,componentPlanning,componentMotion);
```

Add and Connect Architecture Port

Add an architecture port on the architecture.

```
archPort = addPort(arch,"Command","in");
```

The `connect` command requires a component port as an argument. Obtain the component port, then connect.

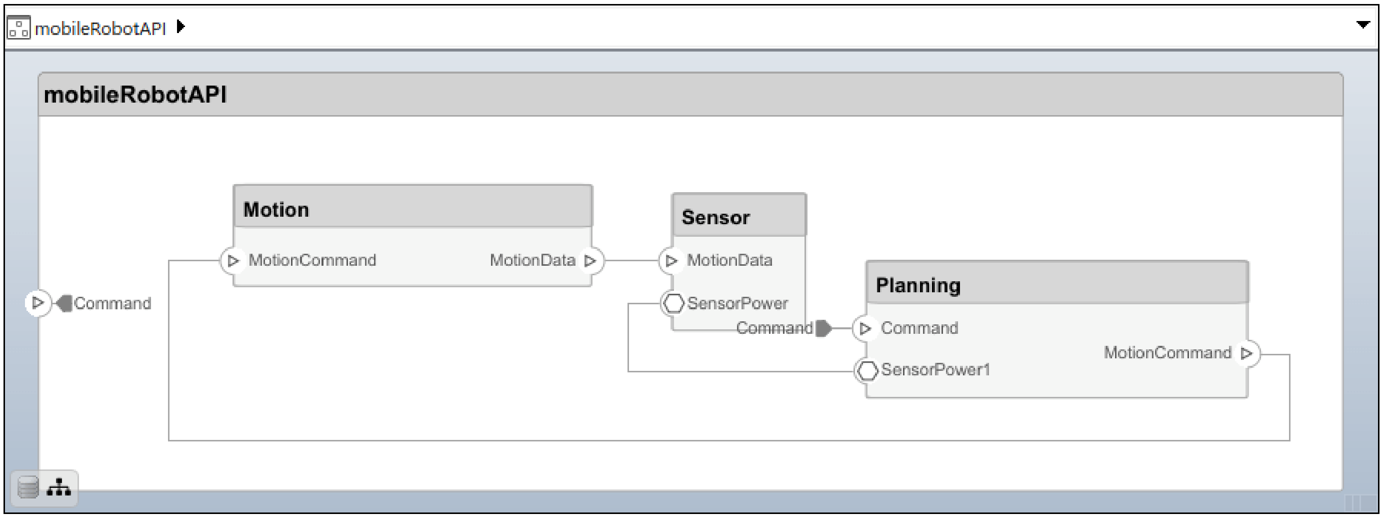
```
compPort = getPort(componentPlanning,"Command");
c_Command = connect(archPort,compPort);
```

Save the model.

```
model.save
```

Arrange the layout by pressing **Ctrl+Shift+A** or using this command.

```
Simulink.BlockDiagram.arrangeSystem("mobileRobotAPI");
```



Create and Apply Profile with Stereotypes

Profiles are XML files that can be applied to any model. You can add stereotypes with properties to profiles and then populate the properties with specific values. Along with the built-in analysis capabilities of System Composer, stereotypes help you optimize your system for performance, cost, and reliability.

Create Profile and Add Stereotypes

Create a profile.

```
profile = systemcomposer.createProfile("GeneralProfile");
```

Create a stereotype that applies to all element types.

```
elemSType = addStereotype(profile,"projectElement");
```

Create stereotypes for different types of components. You can select these types are based on your design needs.

```
pCompSType = addStereotype(profile,"physicalComponent",AppliesTo="Component");
sCompSType = addStereotype(profile,"softwareComponent",AppliesTo="Component");
```

Create a stereotype for connections.

```
sConnSType = addStereotype(profile,"standardConn",AppliesTo="Connector");
```

Add Properties

Add properties to the stereotypes. You can use properties to capture metadata for model elements and analyze nonfunctional requirements. These properties are added to all elements to which the stereotype is applied, in any model that imports the profile.

```
addProperty(elemSType,'ID',Type="uint8");
addProperty(elemSType,'Description',Type="string");
addProperty(pCompSType,'Cost',Type="double",Units="USD");
addProperty(pCompSType,'Weight',Type="double",Units="g");
addProperty(sCompSType,'develCost',Type="double",Units="USD");
addProperty(sCompSType,'develTime',Type="double",Units="hour");
addProperty(sConnSType,'unitCost',Type="double"',Units="USD");
addProperty(sConnSType,'unitWeight',Type="double",Units="g");
addProperty(sConnSType,'length',Type="double",Units="m");
```

Save Profile

```
profile.save;
```

Apply Profile to Model

Apply the profile to the model.

```
applyProfile(model,"GeneralProfile");
```

Apply stereotypes to components. Some components are physical components, while others are software components.

```
applyStereotype(componentPlanning,"GeneralProfile.softwareComponent")
applyStereotype(componentSensor,"GeneralProfile.physicalComponent")
applyStereotype(componentMotion,"GeneralProfile.physicalComponent")
```

Apply the connector stereotype to all connections.

```
batchApplyStereotype(arch,'Connector',"GeneralProfile.standardConn");
```

Apply the general element stereotype to all connectors and ports.

```
batchApplyStereotype(arch,'Component',"GeneralProfile.projectElement");
batchApplyStereotype(arch,'Connector',"GeneralProfile.projectElement");
```

Set properties for each component.

```
setProperty(componentSensor,'GeneralProfile.projectElement.ID','001');
setProperty(componentSensor,'GeneralProfile.projectElement.Description','''Central unit for all s
setProperty(componentSensor,'GeneralProfile.physicalComponent.Cost','200');
setProperty(componentSensor,'GeneralProfile.physicalComponent.Weight','450');
setProperty(componentPlanning,'GeneralProfile.projectElement.ID','002');
setProperty(componentPlanning,'GeneralProfile.projectElement.Description','''Planning computer''
setProperty(componentPlanning,'GeneralProfile.softwareComponent.develCost','20000');
setProperty(componentPlanning,'GeneralProfile.softwareComponent.develTime','300');
setProperty(componentMotion,'GeneralProfile.projectElement.ID','003');
setProperty(componentMotion,'GeneralProfile.projectElement.Description','''Motor and motor contro
setProperty(componentMotion,'GeneralProfile.physicalComponent.Cost','4500');
setProperty(componentMotion,'GeneralProfile.physicalComponent.Weight','2500');
```

Set the properties of connections to be identical.

```
connections = [c_sensorData c_motionData c_motionCommand c_Command];
for k = 1:length(connections)
    setProperty(connections(k),'GeneralProfile.standardConn.unitCost','0.2');
    setProperty(connections(k),'GeneralProfile.standardConn.unitWeight','100');
    setProperty(connections(k),'GeneralProfile.standardConn.length','0.3');
end
```

Add Hierarchy

Add two components named `Controller` and `Scope` inside the `Motion` component. Define the ports. Connect the components to the architecture and to each other, applying a connector stereotype. Hierarchy in an architecture diagram creates an additional level of detail that specifies how components behave internally.

```
motionArch = componentMotion.Architecture;

motionController = motionArch.addComponent('Controller');
controllerPorts = addPort(motionController.Architecture,{'controlIn','controlOut'},{'in','out'})
controllerCompPortIn = motionController.getPort('controlIn');
controllerCompPortOut = motionController.getPort('controlOut');

motionScope = motionArch.addComponent('Scope');
scopePorts = addPort(motionScope.Architecture,{'scopeIn','scopeOut'},{'in','out'});
scopeCompPortIn = motionScope.getPort('scopeIn');
scopeCompPortOut = motionScope.getPort('scopeOut');

c_planningController = connect(motionPorts(1),controllerCompPortIn);
```

For outport connections, the data element must be specified.

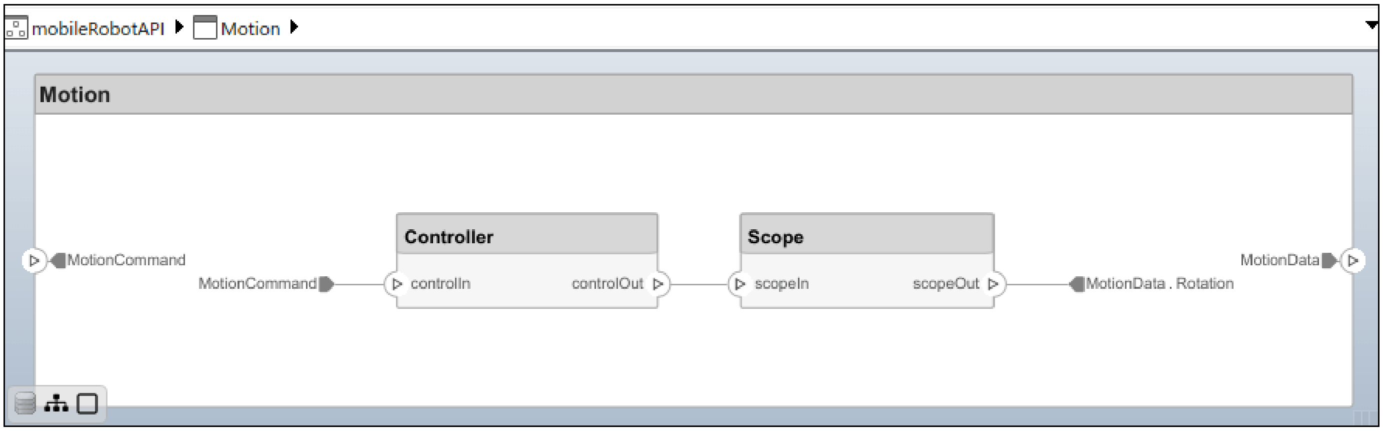
```
c_planningScope = connect(scopeCompPortOut,motionPorts(2),'DestinationElement',"Rotation");
c_planningConnect = connect(controllerCompPortOut,scopeCompPortIn,'GeneralProfile.standardConn')
```

Save the model.

```
model.save
```

Arrange the layout by pressing **Ctrl+Shift+A** or using this command.

```
Simulink.BlockDiagram.arrangeSystem('mobileRobotAPI/Motion');
```

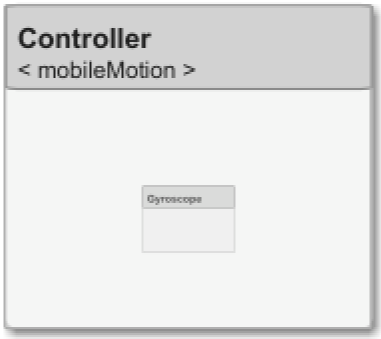


Create Model Reference

Model references can help you organize large models hierarchically and define architectures or behaviors once that you can then reuse. When a component references another model, any existing ports on the component are removed, and ports that exist on the referenced model will appear on the component.

Create a new System Composer model. Convert the `Controller` component into a reference component to reference the new model. To add additional ports on the `Controller` component, you must update the referenced model `"mobileMotion"`.

```
referenceModel = systemcomposer.createModel("mobileMotion");
referenceArch = referenceModel.Architecture;
newComponents = addComponent(referenceArch,"Gyroscope");
referenceModel.save

linkToModel(motionController,"mobileMotion");
```



Save the models.

```
referenceModel.save
model.save
```

Make Variant Component

You can convert the `Planning` component to a variant component using the `makeVariant` function. The original component is embedded within a variant component as one of the available variant choices. You can design other variant choices within the variant component and toggle the active choice. Variant components allow you to choose behavioral designs programmatically in an architecture model to perform trade studies and analysis.

```
[variantComp,choice1] = makeVariant(componentMotion);
```

Add an additional variant choice named MotionAlt. The second argument defines the name, and the third argument defines the label. The label identifies the choice. The active choice is controlled by the label.

```
choice2 = addChoice(variantComp,{'MotionAlt'},{'MotionAlt'});
```

Create the necessary ports on MotionAlt.

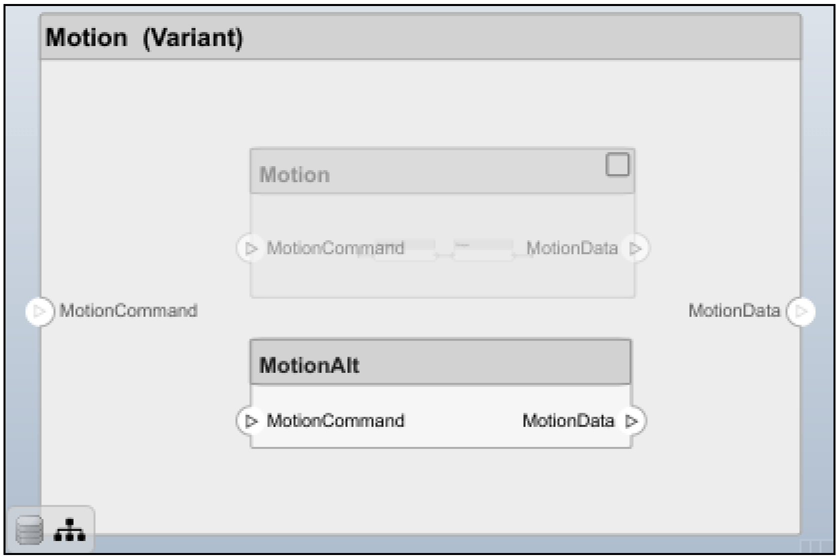
```
motionAltPorts = addPort(choice2.Architecture,{'MotionCommand','MotionData'},{'in','out'});
```

Make MotionAlt the active variant.

```
setActiveChoice(variantComp,'MotionAlt')
```

Arrange the layout by pressing **Ctrl+Shift+A** or using this command.

```
Simulink.BlockDiagram.arrangeSystem('mobileRobotAPI/Planning');
```



Save the model.

```
model.save
```

Clean Up

Run this script to remove generated artifacts before you run this example again.

```
cleanUpArtifacts
```

See Also

Functions

createModel | createDictionary | addInterface | addPhysicalInterface | addValueType | addElement | setType | createOwnedType | linkDictionary | addComponent | addPort |

`setInterface` | `connect` | `save` | `getPort` | `createProfile` | `addStereotype` | `addProperty` | `save` | `applyProfile` | `applyStereotype` | `batchApplyStereotype` | `setProperty` | `linkToModel` | `makeVariant` | `addChoice` | `setActiveChoice` | `closeAll`

Blocks
Component | Reference Component | Variant Component

More About

- “Compose Architectures Visually” on page 1-2
- “Define Profiles and Stereotypes” on page 5-2
- “Use Stereotypes and Profiles” on page 5-9
- “Decompose and Reuse Components” on page 1-17
- “Create Interfaces” on page 3-4
- “Organize System Composer Files in Projects” on page 12-2
- “Simulate Mobile Robot with System Composer Workflow” on page 5-20

Modeling System Architecture of Small UAV

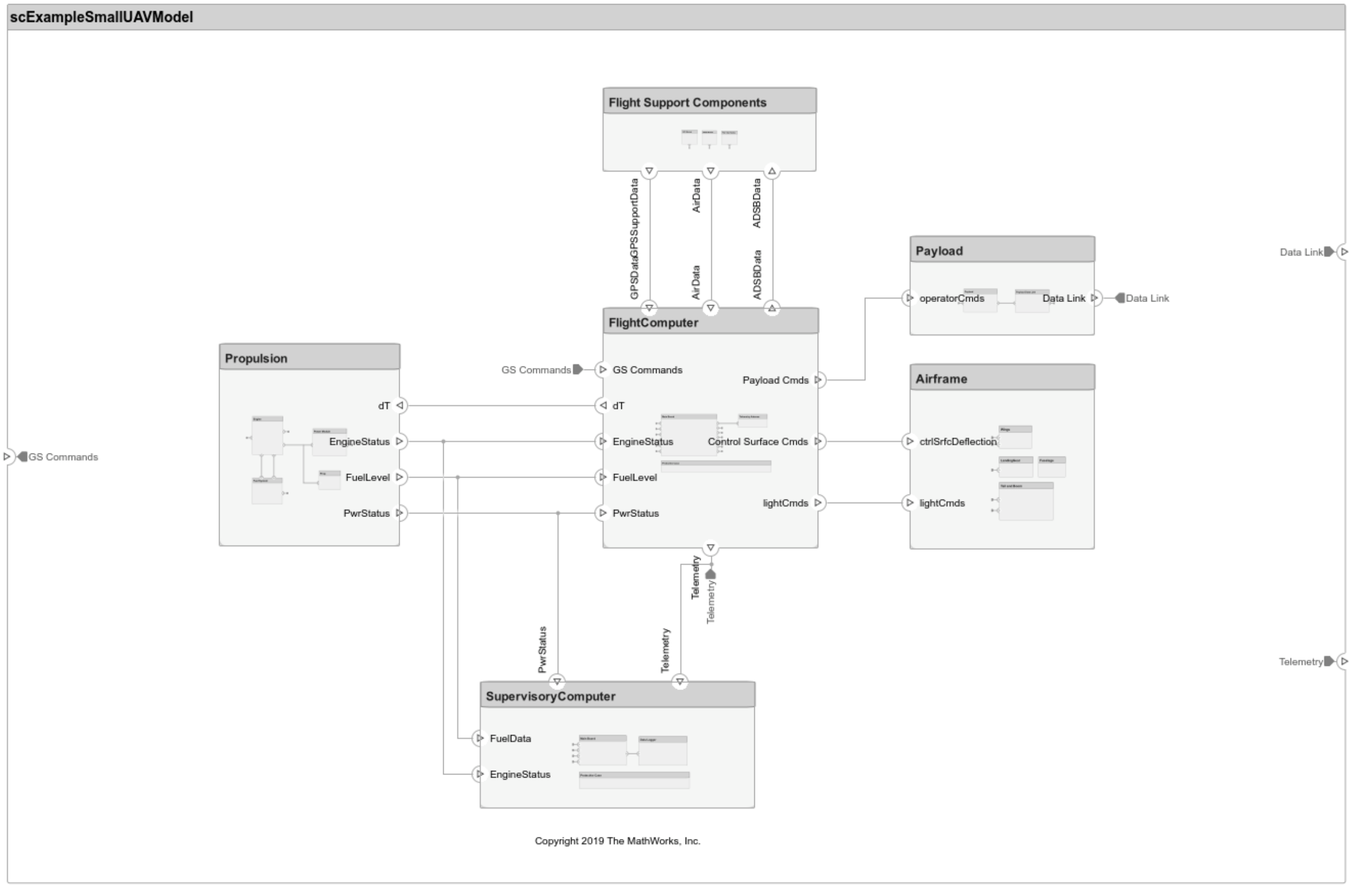
Overview

This example shows how to use System Composer™ to set up the architecture for a small unmanned aerial vehicle, composed of six top-level components. Learn how to refine your architecture design by authoring interfaces, inspect linked textual requirements, define profiles and stereotypes, and run a static analysis on such an architecture model.

Open the project.

```
>> scExampleSmallUAV
```

```
Starting: Simulink
```

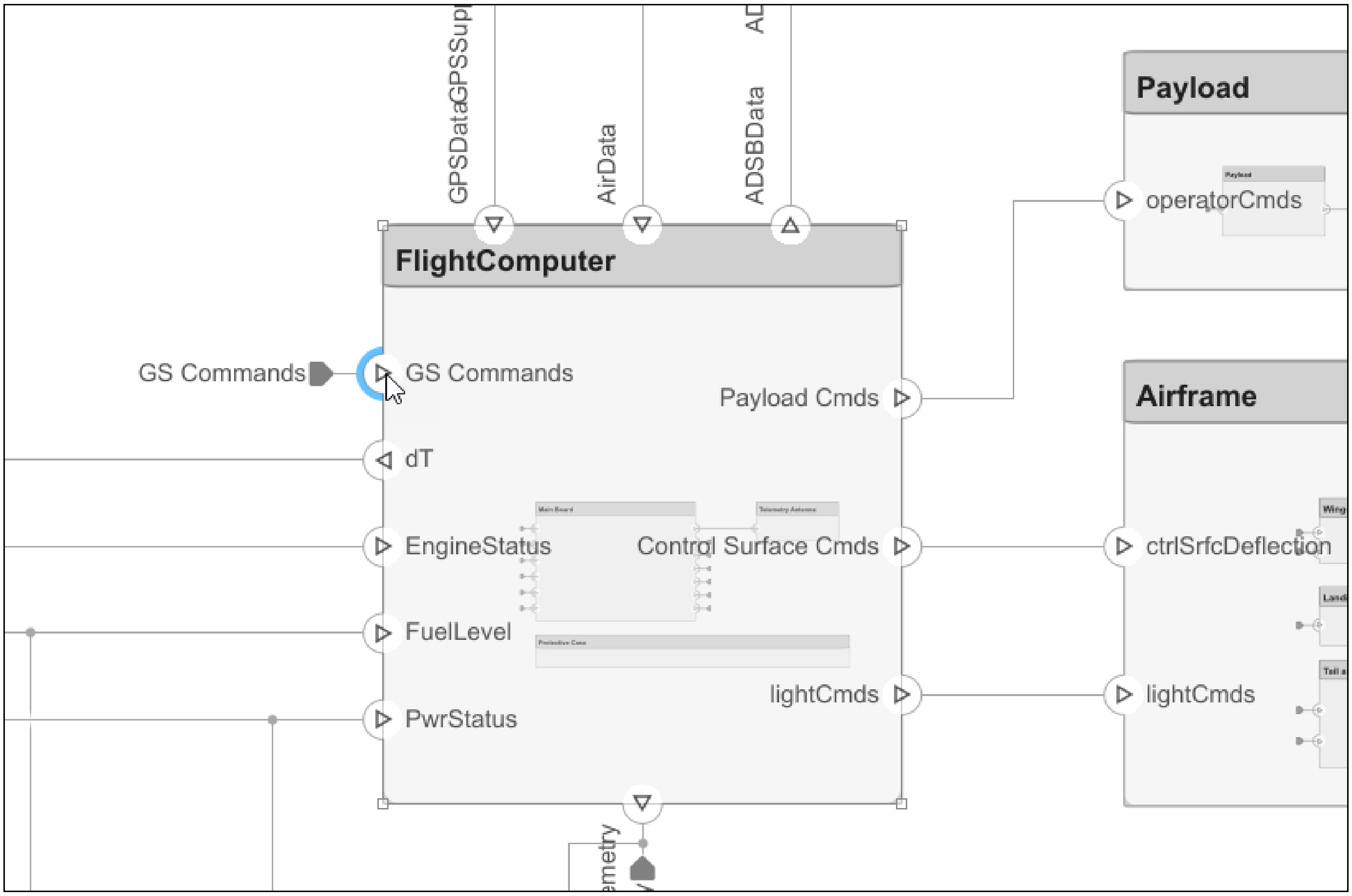


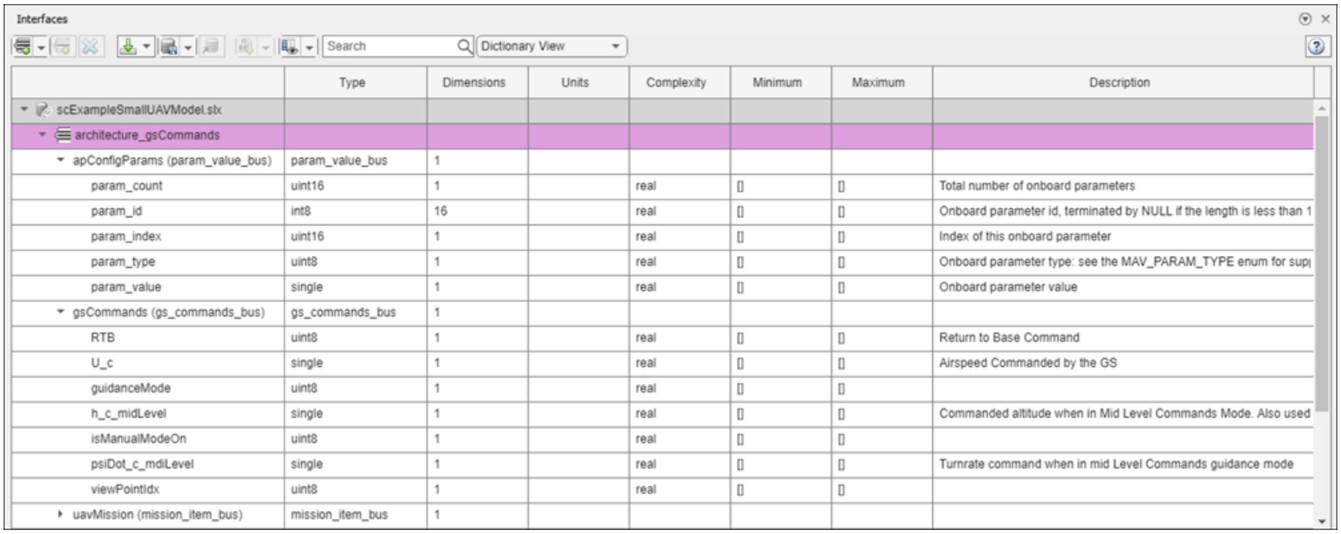
Each top-level component is decomposed into its subcomponents. Navigate through the hierarchy to view the composition for each component. The root component, `scExampleSmallUAVModel`, has input and output ports that represent data exchange between the system and its environment.

Author Interfaces

Define interfaces for domain-specific data between connections. The information shared between two ports defined by interface element property values further enhances the specification. To open the Interface Editor, in the **Modeling** tab in the toolstrip, click **Interface Editor**.

Click the **GS Commands** port on the architecture model to highlight the **architecture_gsCommands** interface and indicate the assignment of the interface.



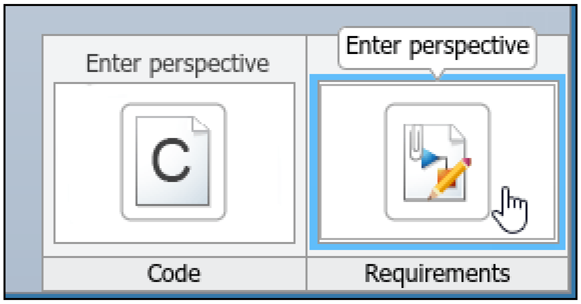


	Type	Dimensions	Units	Complexity	Minimum	Maximum	Description
scExampleSmallUAVModel.slx							
architecture_gsCommands							
apConfigParams (param_value_bus)	param_value_bus	1					
param_count	uint16	1		real	[]	[]	Total number of onboard parameters
param_id	int8	16		real	[]	[]	Onboard parameter id, terminated by NULL if the length is less than 1
param_index	uint16	1		real	[]	[]	Index of this onboard parameter
param_type	uint8	1		real	[]	[]	Onboard parameter type: see the MAV_PARAM_TYPE enum for sup
param_value	single	1		real	[]	[]	Onboard parameter value
gsCommands (gs_commands_bus)	gs_commands_bus	1					
RTB	uint8	1		real	[]	[]	Return to Base Command
U_c	single	1		real	[]	[]	Airspeed Commanded by the GS
guidanceMode	uint8	1		real	[]	[]	
h_c_midLevel	single	1		real	[]	[]	Commanded altitude when in Mid Level Commands Mode. Also used
isManualModeOn	uint8	1		real	[]	[]	
psiDot_c_mdiLevel	single	1		real	[]	[]	Turnrate command when in mid Level Commands guidance mode
viewPointIdx	uint8	1		real	[]	[]	
uavMission (mission_item_bus)	mission_item_bus	1					

Inspect Requirements

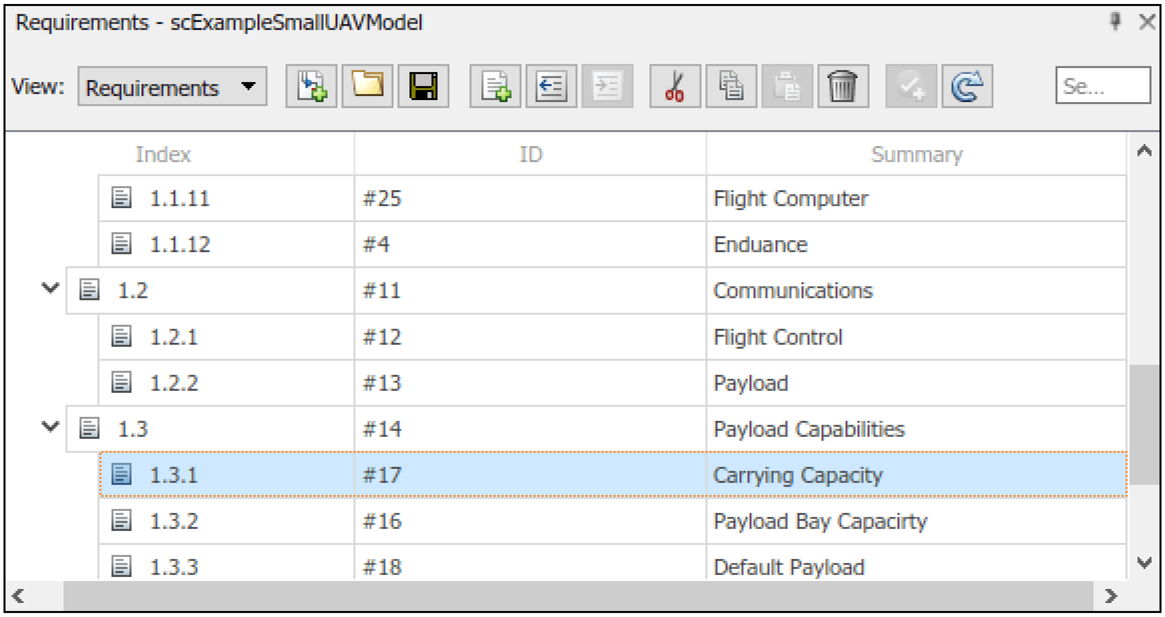
A Requirements Toolbox™ license is required to inspect requirements in a System Composer architecture model.

Components in the architecture model link to system requirements defined in `scExampleSmallUAVModel.slreqx`. Open the **Requirements Manager**. In the bottom right corner of the model pane, click **Show Perspectives views**. Then, click **Requirements**.



Select components on the model to see the requirement they link to, or, conversely, select items in the **Requirements** view to see which components implement them. Requirements can also be linked to connectors or ports to allow traceability throughout your design artifacts. To edit the requirements in `smallUAVReqs.slreqx`, select the Requirements Editor (Requirements Toolbox) from the menu.

The `Carrying Capacity` requirement highlights the total mass able to be carried by the aircraft. This requirement, along with the weight of the aircraft, is part of the mass rollup analysis performed for early verification and validation.



Index	ID	Summary
1.1.11	#25	Flight Computer
1.1.12	#4	Enduance
1.2	#11	Communications
1.2.1	#12	Flight Control
1.2.2	#13	Payload
1.3	#14	Payload Capabilities
1.3.1	#17	Carrying Capacity
1.3.2	#16	Payload Bay Capacirty
1.3.3	#18	Default Payload

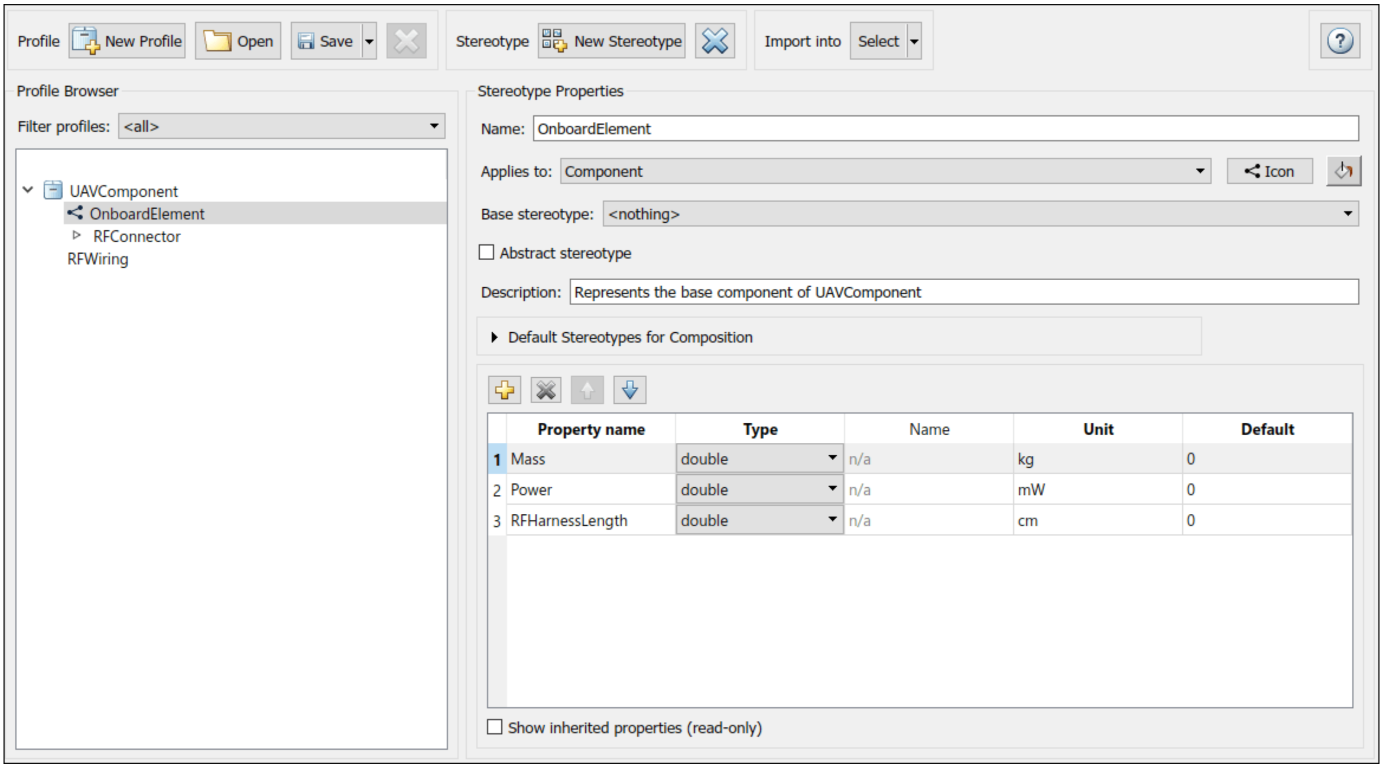
Define Profiles and Stereotypes

To complete specifications and enable analysis later in the design process, stereotypes add custom metadata to architecture model elements. This model has stereotypes for these elements:

- On-board element, applicable to components
- RF connector, applicable to ports
- RF wiring, applicable to connectors

Stereotypes are defined in XML files by using profiles. The profile `UAVComponent.xml` is attached to this model. Edit a profile by using the Profile Editor. On the **Modeling** tab, click **Profile Editor**.

The display appears below.



Name: OnboardElement

Applies to: Component

Base stereotype: <nothing>

☐ Abstract stereotype

Description: Represents the base component of UAVComponent

▸ Default Stereotypes for Composition

	Property name	Type	Name	Unit	Default
1	Mass	double	n/a	kg	0
2	Power	double	n/a	mW	0
3	RFHarnessLength	double	n/a	cm	0

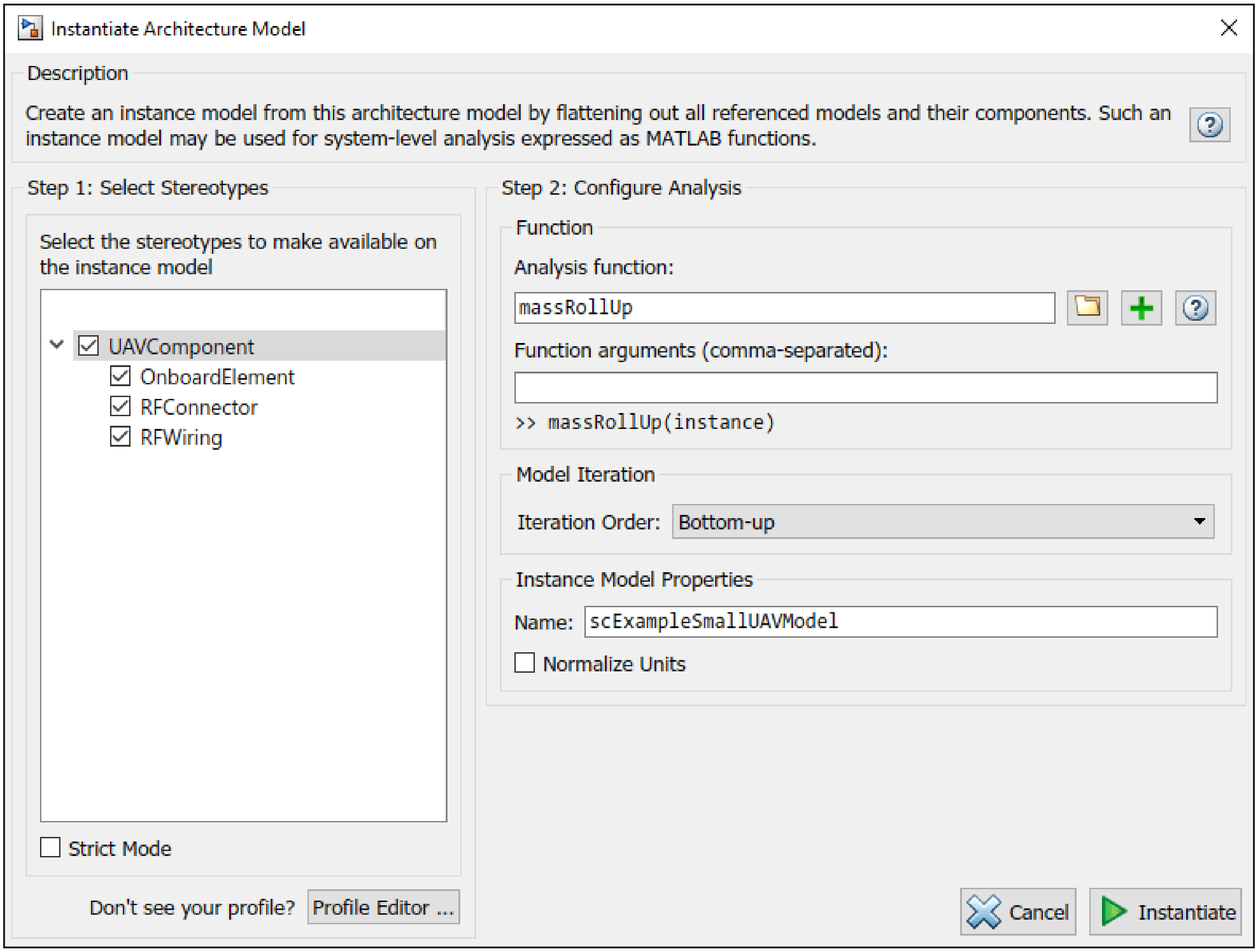
☐ Show inherited properties (read-only)

Analyze the Model

To run static analyses on your system, create an analysis model from your architecture model. An analysis model is a tree of instances generated from the elements of the architecture model in which all referenced models are flattened out, and all variants are resolved.

To open the Instantiate Architecture Model tool, click **Analysis Model** on the **Views** menu.

Run a mass rollup on this model. In the dialog, select the stereotypes that you want to include in your analysis. Select the analysis function by browsing to `utilities/massRollUp.m`. Set the model iteration mode to **Bottom-up**.



Instantiate Architecture Model

Description

Create an instance model from this architecture model by flattening out all referenced models and their components. Such an instance model may be used for system-level analysis expressed as MATLAB functions.

Step 1: Select Stereotypes

Select the stereotypes to make available on the instance model

- ☑ UAVComponent
  - ☑ OnboardElement
  - ☑ RFConnector
  - ☑ RFWiring

□ Strict Mode

Don't see your profile?

Step 2: Configure Analysis

Function

Analysis function: `massRollUp`

Function arguments (comma-separated):

```
>> massRollUp(instance)
```

Model Iteration

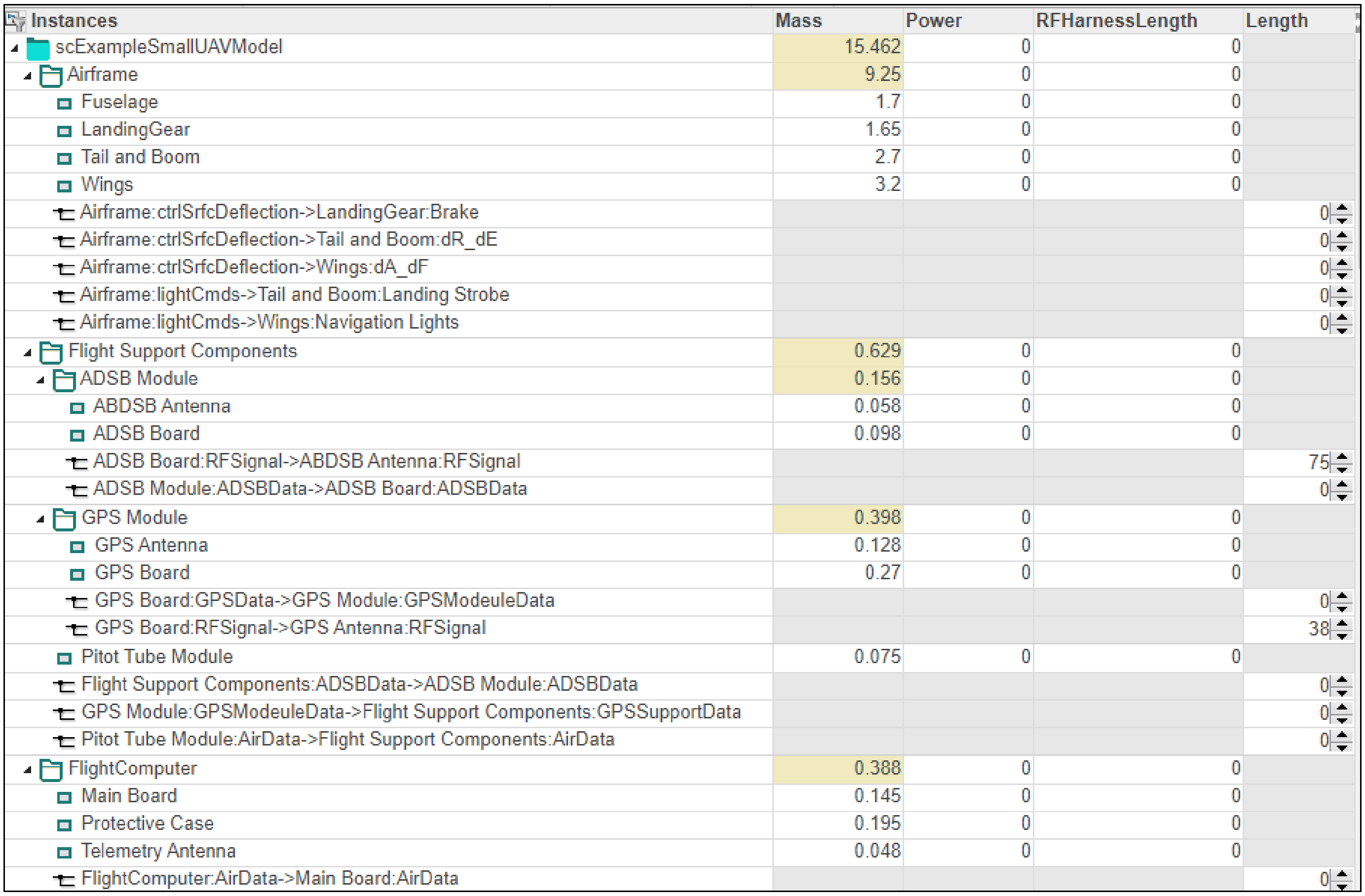
Iteration Order: Bottom-up

Instance Model Properties

Name: `scExampleSmallUAVModel`

□ Normalize Units

Uncheck `Strict Mode` so that all components can have a `Mass` property instantiated to facilitate calculation of total mass. Click **Instantiate** to generate an analysis.



Instances	Mass	Power	RFHarnessLength	Length
scExampleSmallUAVModel	15.462	0	0	
Airframe	9.25	0	0	
Fuselage	1.7	0	0	
LandingGear	1.65	0	0	
Tail and Boom	2.7	0	0	
Wings	3.2	0	0	
Airframe:ctrlSrfcDeflection->LandingGear:Brake				0
Airframe:ctrlSrfcDeflection->Tail and Boom:dR_dE				0
Airframe:ctrlSrfcDeflection->Wings:dA_dF				0
Airframe:lightCmds->Tail and Boom:Landing Strobe				0
Airframe:lightCmds->Wings:Navigation Lights				0
Flight Support Components	0.629	0	0	
ADSB Module	0.156	0	0	
ABDSB Antenna	0.058	0	0	
ADSB Board	0.098	0	0	
ADSB Board:RFSignal->ABDSB Antenna:RFSignal				75
ADSB Module:ADSBData->ADSB Board:ADSBData				0
GPS Module	0.398	0	0	
GPS Antenna	0.128	0	0	
GPS Board	0.27	0	0	
GPS Board:GPSData->GPS Module:GPSModeuleData				0
GPS Board:RFSignal->GPS Antenna:RFSignal				38
Pitot Tube Module	0.075	0	0	
Flight Support Components:ADSBData->ADSB Module:ADSBData				0
GPS Module:GPSModeuleData->Flight Support Components:GPSSupportData				0
Pitot Tube Module:AirData->Flight Support Components:AirData				0
FlightComputer	0.388	0	0	
Main Board	0.145	0	0	
Protective Case	0.195	0	0	
Telemetry Antenna	0.048	0	0	
FlightComputer:AirData->Main Board:AirData				0

Once on the Analysis Viewer screen, click **Analyze**. The analysis function iterates through model elements bottom up, assigning the `Mass` property of each component as a sum of the `Mass` properties of its subcomponents. The overall weight of the system is assigned to the `Mass` property of the top level component, `scExampleSmallUAVModel`.

See Also

`setInterface` | `createProfile` | `addStereotype` | `addProperty` | `applyStereotype` | `instantiate`

More About

- “Create Interfaces” on page 3-4
- “Manage Requirements” on page 2-8
- “Define Profiles and Stereotypes” on page 5-2
- “Analyze Architecture” on page 9-2
- “Model-Based Systems Engineering for Space-Based Applications” on page 1-38
- “Organize System Composer Files in Projects” on page 12-2

Model-Based Systems Engineering for Space-Based Applications

This example provides an overview of the **CubeSat Model-Based System Engineering Project** template, available from the Simulink® start page, under Aerospace Blockset™. It demonstrates how to model a space mission architecture in Simulink with System Composer™ and Aerospace Blockset for a 1U CubeSat in low Earth orbit (LEO). The CubeSat's mission is to image MathWorks Headquarters in Natick, Massachusetts at least once per day. The project references the Aerospace Blockset *CubeSat Simulation Project*, reusing the vehicle dynamics, environment models, data dictionaries, and flight control system models defined in that project.

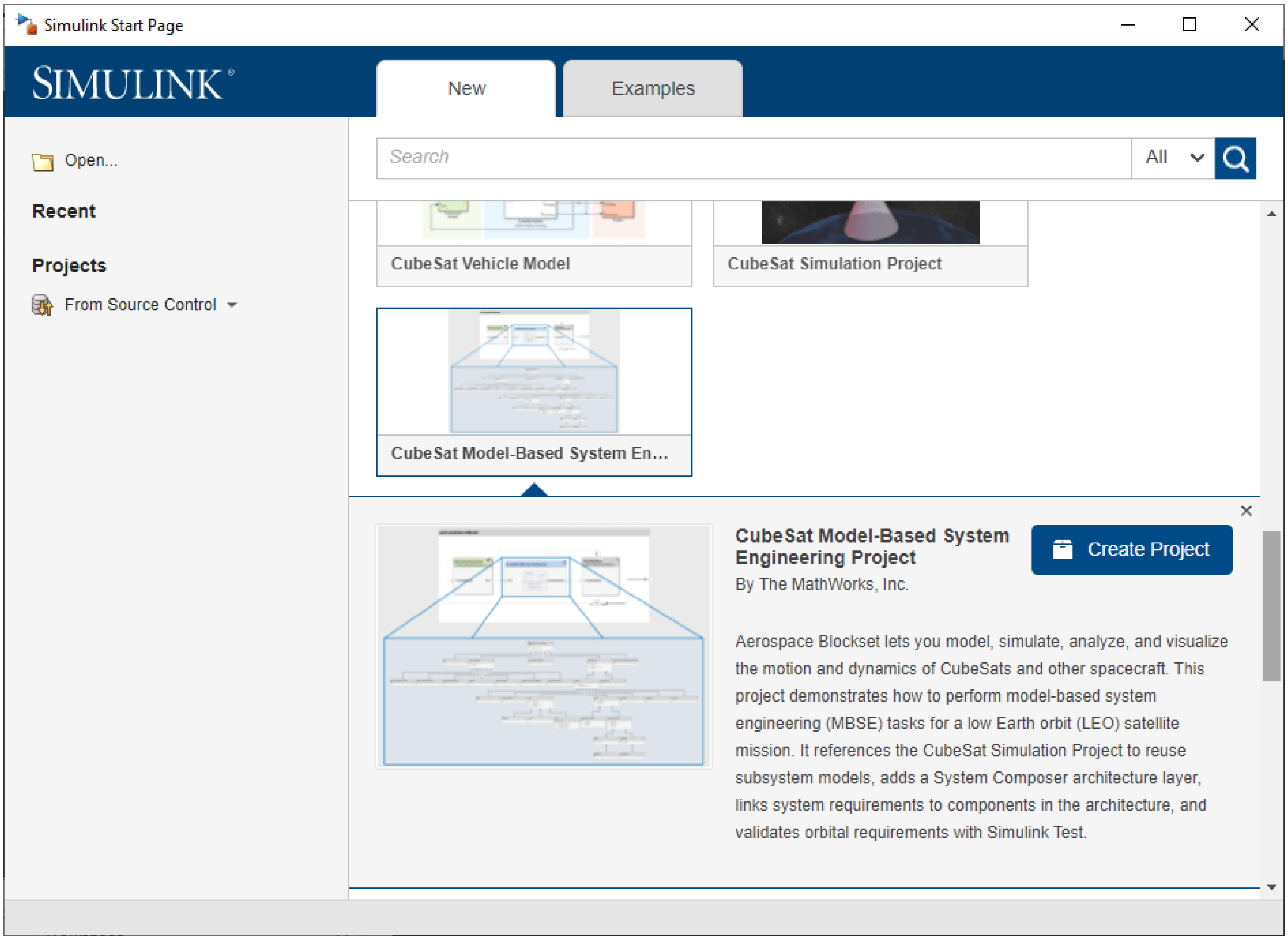
This project demonstrates how to:

- Define system level requirements for a CubeSat mission in Simulink
- Compose a system architecture for the mission in System Composer
- Link system-level requirements to components in the architecture with Requirements Toolbox™
- Model vehicle dynamics and flight control systems with Aerospace Blockset
- Validate orbital requirements using mission analysis tools and Simulink Test™

Open the Project

To create a new instance of the **CubeSat Model-Based System Engineering Project**, select **Create Project** in the Simulink start page**.** When the project is loaded, an architecture model for the CubeSat opens.

```
open("asbCubeSatMBSEProject.sltx");
```



Aerospace Blockset lets you model, simulate, analyze, and visualize the motion and dynamics of CubeSats and other spacecraft. This project demonstrates how to perform model-based system engineering (MBSE) tasks for a low Earth orbit (LEO) satellite mission. It references the CubeSat Simulation Project to reuse subsystem models, adds a System Composer architecture layer, links system requirements to components in the architecture, and validates orbital requirements with Simulink Test.

Define System-level Requirements

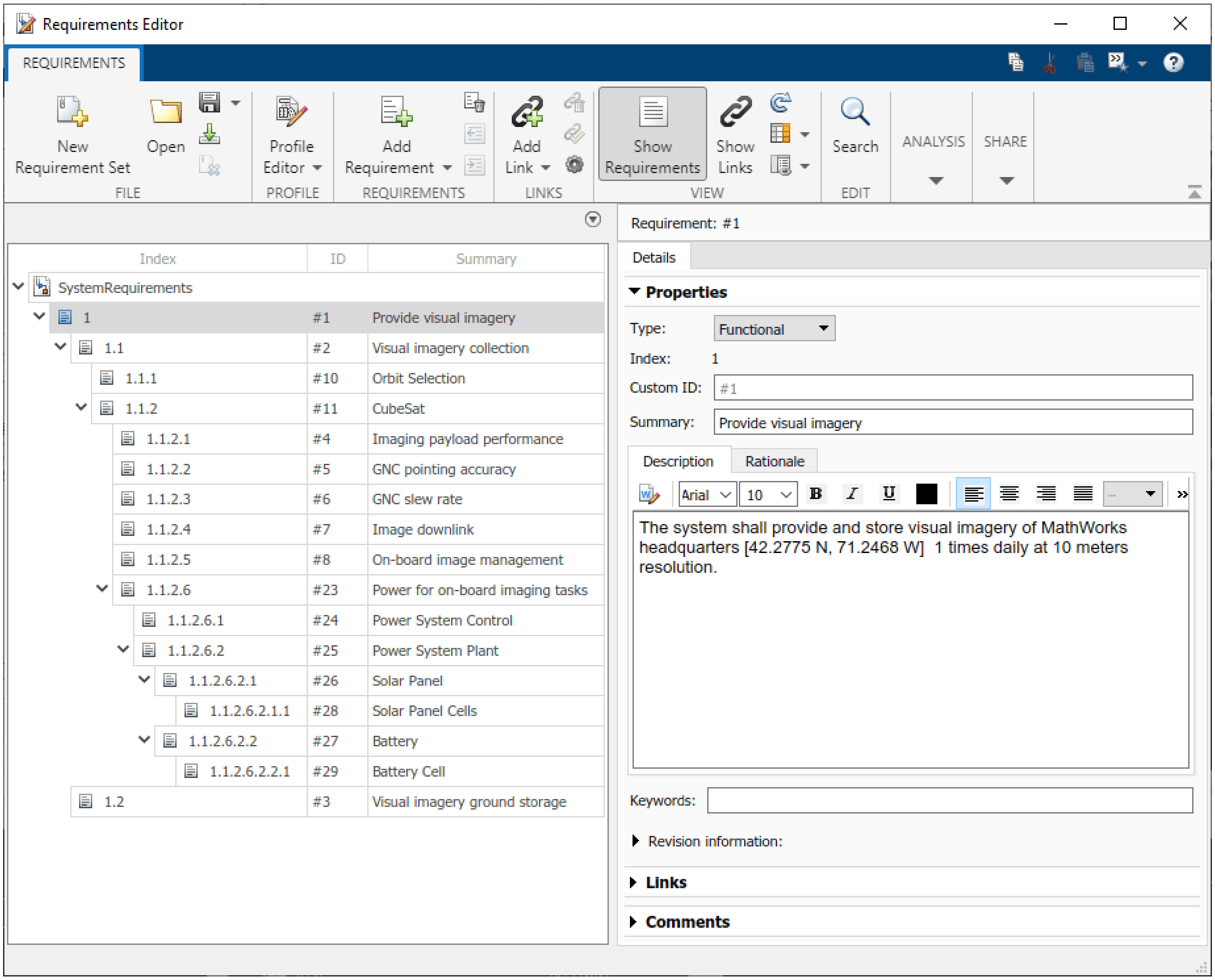
Define a set of system-level requirements for the mission. You can import these requirements from third-party requirement management tools such as ReqIF (Requirements Interchange Format) files or author them directly in the Requirements Editor.

This example contains a set of system-level requirements stored in *SystemRequirements.slreqx*. Open this requirement specification file in the **Requirements Editor**. Access the **Requirements Editor** from the **Apps** tab or by double-clicking on *SystemRequirements.slreqx* in the project folder browser.

Our top level requirement for this mission is:

1 The system shall provide and store visual imagery of MathWorks headquarters [42.2775 N, 71.2468 W] once daily at 10 meters resolution.

Additional requirements are decomposed from this top-level requirement to create a hierarchy of requirements for the architecture.



Index	ID	Summary
SystemRequirements		
1	#1	Provide visual imagery
1.1	#2	Visual imagery collection
1.1.1	#10	Orbit Selection
1.1.2	#11	CubeSat
1.1.2.1	#4	Imaging payload performance
1.1.2.2	#5	GNC pointing accuracy
1.1.2.3	#6	GNC slew rate
1.1.2.4	#7	Image downlink
1.1.2.5	#8	On-board image management
1.1.2.6	#23	Power for on-board imaging tasks
1.1.2.6.1	#24	Power System Control
1.1.2.6.2	#25	Power System Plant
1.1.2.6.2.1	#26	Solar Panel
1.1.2.6.2.1.1	#28	Solar Panel Cells
1.1.2.6.2.2	#27	Battery
1.1.2.6.2.2.1	#29	Battery Cell
1.2	#3	Visual imagery ground storage

Requirement: #1

Type: Functional

Index: 1

Custom ID: #1

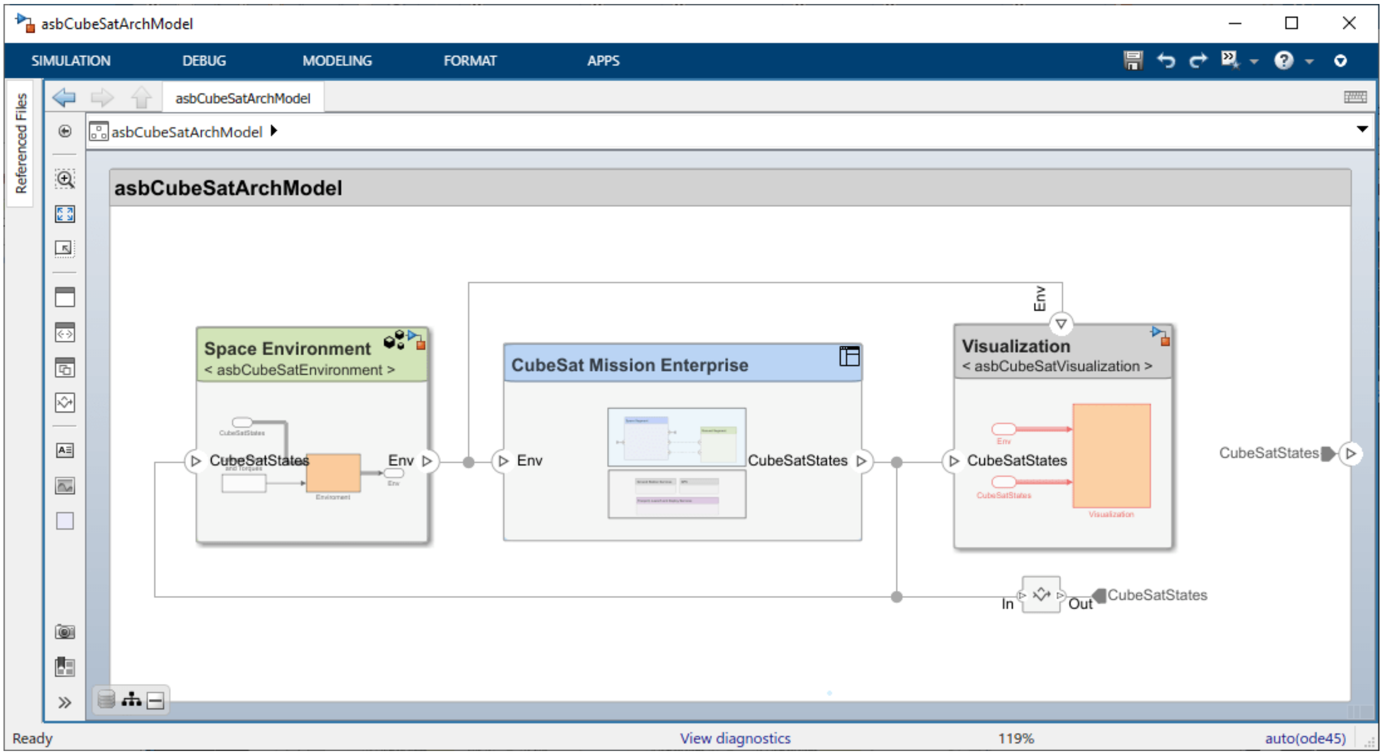
Summary: Provide visual imagery

The system shall provide and store visual imagery of MathWorks headquarters [42.2775 N, 71.2468 W] 1 times daily at 10 meters resolution.

Keywords:

Compose a System Architecture

System Composer enables the specification and analysis of architectures for model-based systems engineering. Use the system-level requirements defined above to guide the creation of an architecture model in System Composer. The architecture in this example is based on *CubeSat Reference Model (CRM)* developed by the International Council on Systems Engineering (INCOSE) Space Systems Working Group (SSWG) [1].



The architecture is composed of components, ports, and connectors. A component is a part of a system that fulfills a clear function in the context of the architecture. It defines an architectural element, such as a system, subsystem, hardware, software, or other conceptual entity.

Ports are nodes on a component or architecture that represent a point of interaction with its environment. A port permits the flow of information to and from other components or systems. Connectors are lines that provide connections between ports. Connectors describe how information flows between components in an architecture.

Extend the Architecture with Stereotypes and Interfaces

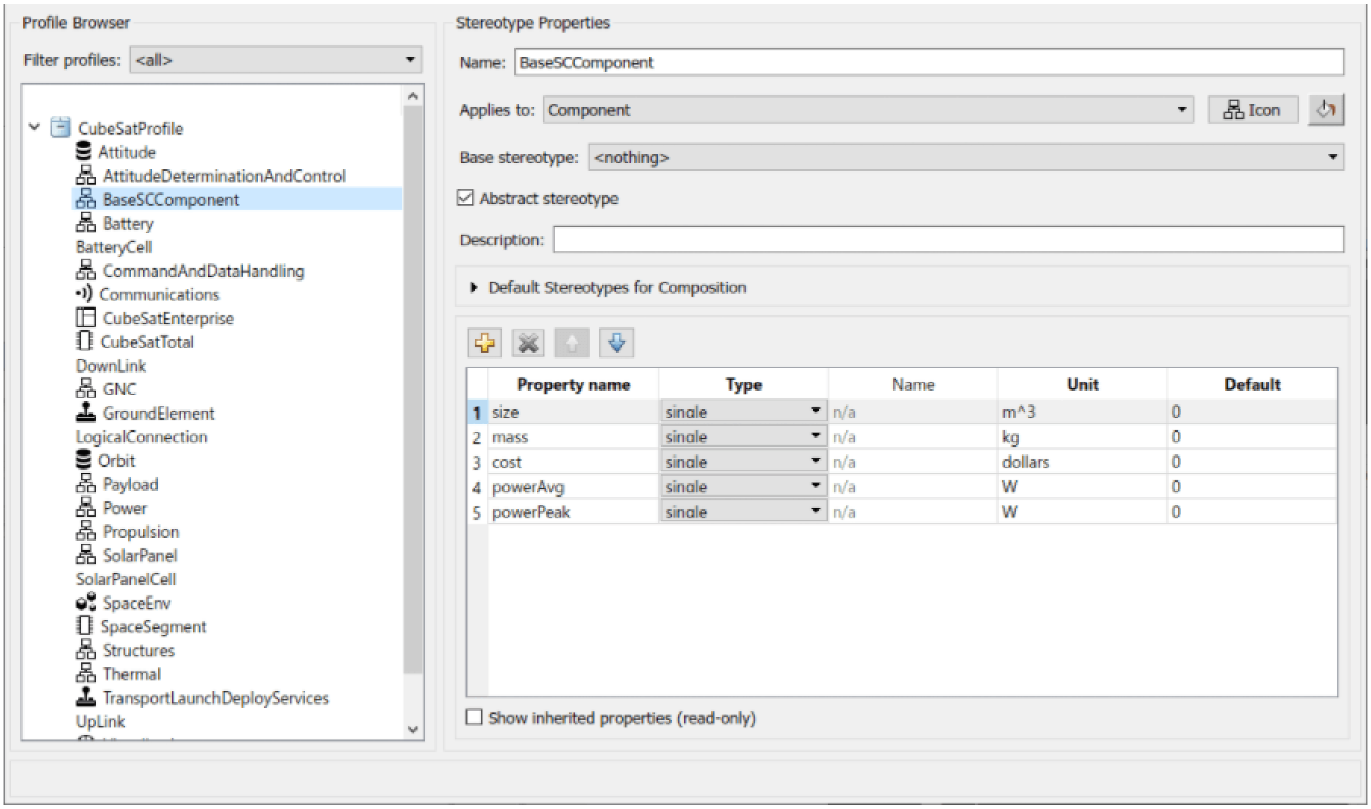
You can add additional levels of detail to an architecture using stereotypes and interfaces.

Stereotypes

Stereotypes extend the architectural elements by adding domain-specific metadata to each element. Stereotypes are applied to components, connectors, ports, and other architectural elements to provide these elements with a common set of properties such as mass, cost, power, etc.

Packages of stereotypes used by one or more architectures are stored in profiles. This example includes a profile of stereotypes called *CubeSatProfile.xml*. To view, edit, or add new stereotypes to the profile, open this profile in the **Profile Editor** from the **Modeling** Tab.

This profile defines a set of stereotypes that are applied to components and connectors in the CubeSat architecture.



Name: BaseSCComponent

Applies to: Component

Base stereotype: <nothing>

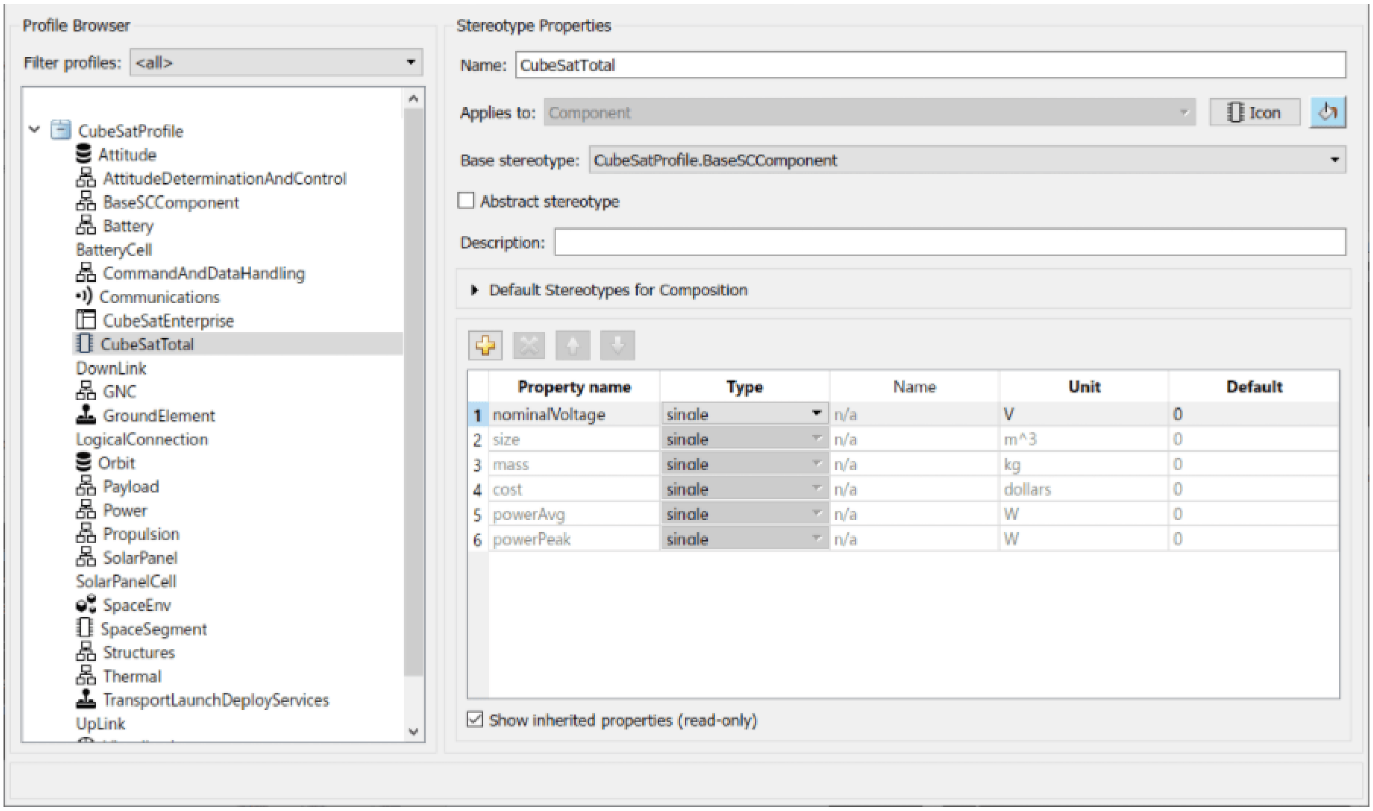
☑ Abstract stereotype

Description:

	Property name	Type	Name	Unit	Default
1	size	single	n/a	m^3	0
2	mass	single	n/a	kg	0
3	cost	single	n/a	dollars	0
4	powerAvg	single	n/a	W	0
5	powerPeak	single	n/a	W	0

□ Show inherited properties (read-only)

Stereotypes can also inherit properties from abstract base stereotypes. For example, `BaseSCComponent` in the profile above contains properties for size, mass, cost, and power demand. We can add another stereotype to the profile, `CubeSatTotal`, and define `BaseSCComponent` as its base stereotype. `CubeSatTotal` adds in its own property, nominalVoltage, but also inherits properties from its base stereotype.



Profile Browser

Filter profiles: <all>

- CubeSatProfile
  - Attitude
  - AttitudeDeterminationAndControl
  - BaseSCComponent
  - Battery
  - BatteryCell
  - CommandAndDataHandling
  - Communications
  - CubeSatEnterprise
  - CubeSatTotal
  - DownLink
  - GNC
  - GroundElement
  - LogicalConnection
  - Orbit
  - Payload
  - Power
  - Propulsion
  - SolarPanel
  - SolarPanelCell
  - SpaceEnv
  - SpaceSegment
  - Structures
  - Thermal
  - TransportLaunchDeployServices
  - UpLink

Stereotype Properties

Name: CubeSatTotal

Applies to: Component

Base stereotype: CubeSatProfile.BaseSCComponent

□ Abstract stereotype

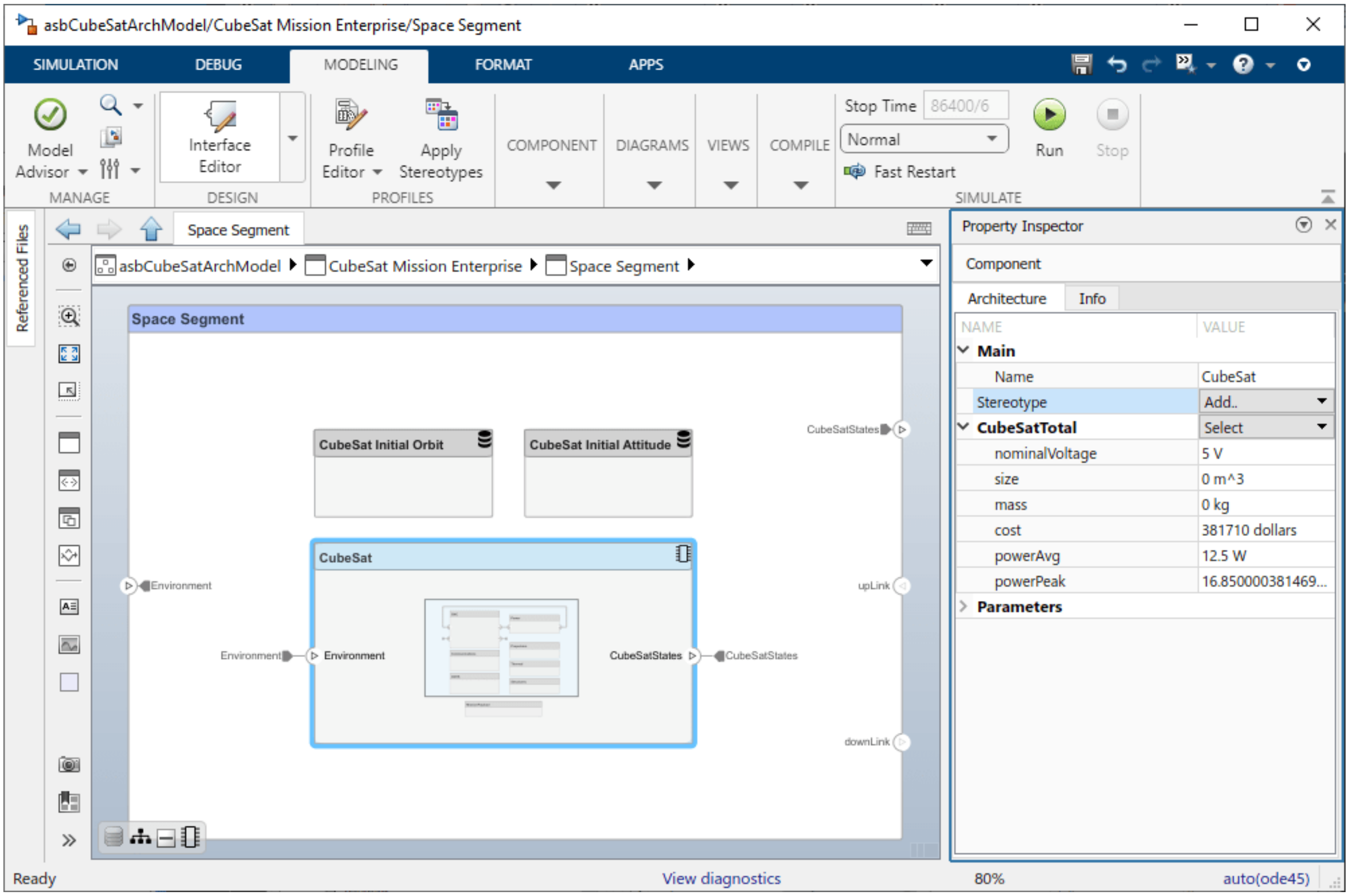
Description:

Default Stereotypes for Composition

	Property name	Type	Name	Unit	Default
1	nominalVoltage	single	n/a	V	0
2	size	single	n/a	m^3	0
3	mass	single	n/a	kg	0
4	cost	single	n/a	dollars	0
5	powerAvg	single	n/a	W	0
6	powerPeak	single	n/a	W	0

☑ Show inherited properties (read-only)

In the architecture model, apply the `CubeSatTotal` stereotype to CubeSat system component (`asbCubeSatArchModel/CubeSat Mission Enterprise/Space Segment/CubeSat`). Select the component in the model. In the Property Inspector, select the desired stereotype from the drop-down window. Next, set property values for the CubeSat component.



Property Inspector

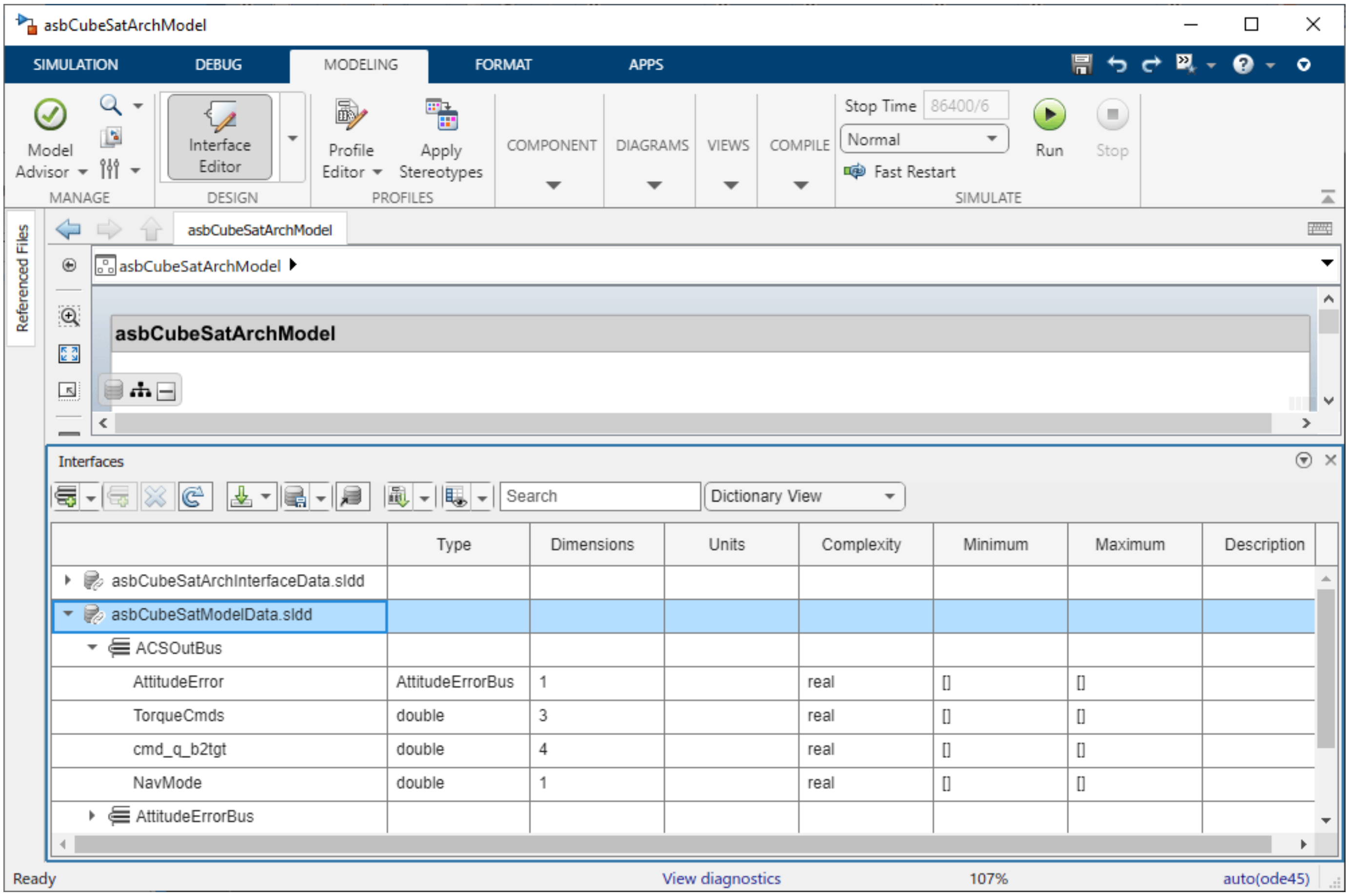
Component

Architecture | Info

NAME	VALUE
Main	
Name	CubeSat
Stereotype	Add..
CubeSatTotal	Select
nominalVoltage	5 V
size	0 m^3
mass	0 kg
cost	381710 dollars
powerAvg	12.5 W
powerPeak	16.850000381469...
Parameters	

Interfaces

Data interfaces define the kind of information that flows through a port. The same interface can be assigned to multiple ports. A data interface can be composite, meaning that it can include data elements that describe the properties of an interface signal. Create and manage interfaces from the **Interface Editor**. Existing users of Simulink can draw a parallel between interfaces in System Composer and buses in Simulink. In fact, buses can be used to define interfaces (and vice versa). For example, the data dictionary *asbCubeSatModelData.sldd* contains several bus definitions, including `ACSOutBus`, that can be viewed in the **Interface Editor** and applied to architecture ports.

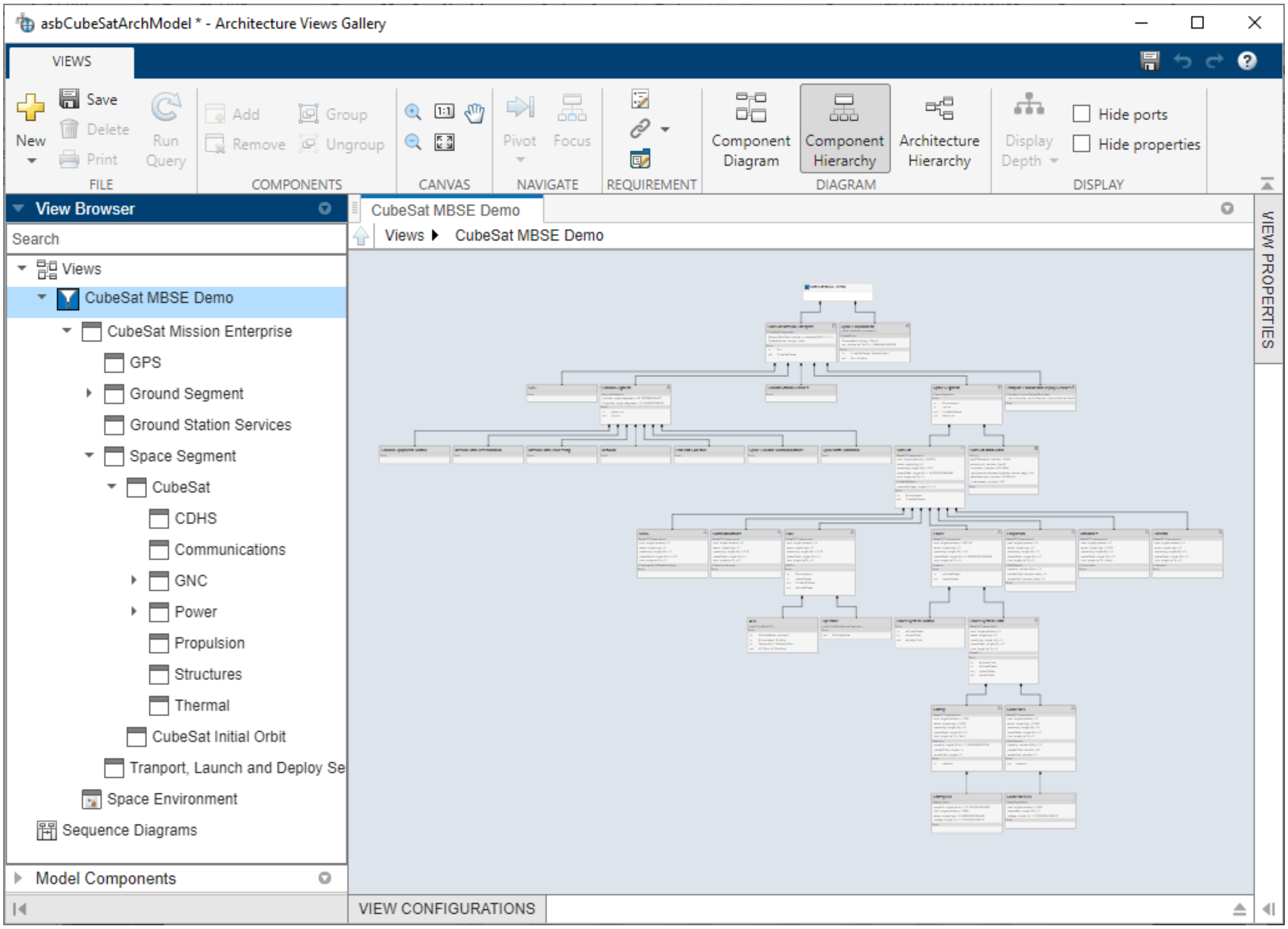


	Type	Dimensions	Units	Complexity	Minimum	Maximum	Description
asbCubeSatArchInterfaceData.sldd							
asbCubeSatModelData.sldd							
ACSOutBus							
AttitudeError	AttitudeErrorBus	1		real	[]	[]	
TorqueCmds	double	3		real	[]	[]	
cmd_q_b2tgt	double	4		real	[]	[]	
NavMode	double	1		real	[]	[]	
AttitudeErrorBus							

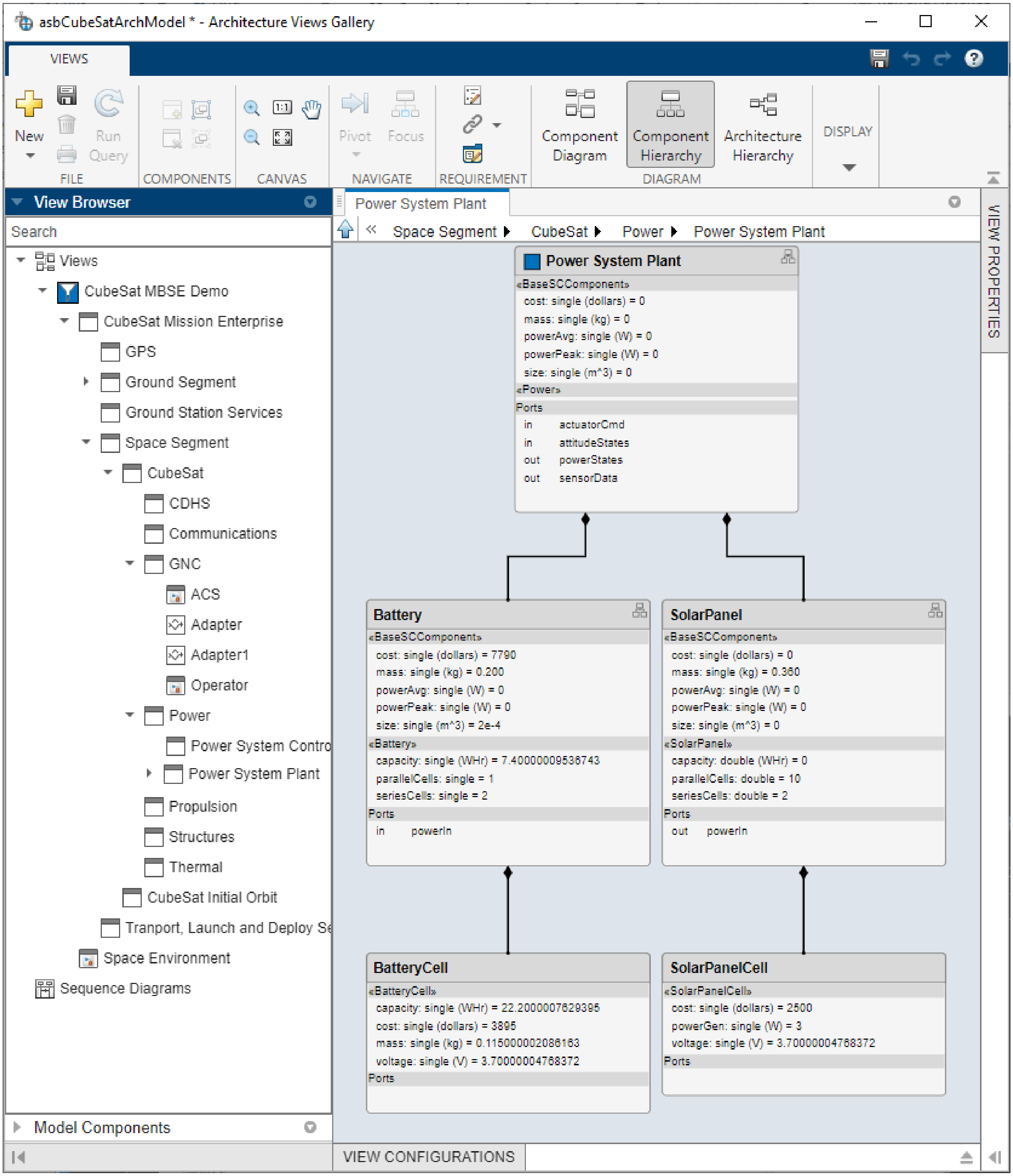
Visualize the System with Architecture Views

Now that we have implemented our architecture using components, stereotypes, ports, and interfaces, we can visualize our system with an architecture view. In the **Modeling** Tab, select **Views**.

Use the **Component Hierarchy** view to show our system component hierarchy. Each component also lists its stereotype property values and ports.



You can also view the hierarchy at different depths of the architecture. For example, navigate to the `Power System Plant` component of the architecture by double-clicking the component in the **View Browser**.



Power System Plant

«BaseSCComponent»
cost: single (dollars) = 0
mass: single (kg) = 0
powerAvg: single (W) = 0
powerPeak: single (W) = 0
size: single (m^3) = 0
«Power»
Ports
in actuatorCmd
in attitudeStates
out powerStates
out sensorData

Battery

«BaseSCComponent»
cost: single (dollars) = 7790
mass: single (kg) = 0.200
powerAvg: single (W) = 0
powerPeak: single (W) = 0
size: single (m^3) = 2e-4
«Battery»
capacity: single (WHr) = 7.40000009536743
parallelCells: single = 1
seriesCells: single = 2
Ports
in powerIn

SolarPanel

«BaseSCComponent»
cost: single (dollars) = 0
mass: single (kg) = 0.360
powerAvg: single (W) = 0
powerPeak: single (W) = 0
size: single (m^3) = 0
«SolarPanel»
capacity: double (WHr) = 0
parallelCells: double = 10
seriesCells: double = 2
Ports
out powerIn

BatteryCell

«BatteryCell»
capacity: single (WHr) = 22.2000007629395
cost: single (dollars) = 3895
mass: single (kg) = 0.115000002086163
voltage: single (V) = 3.70000004768372
Ports

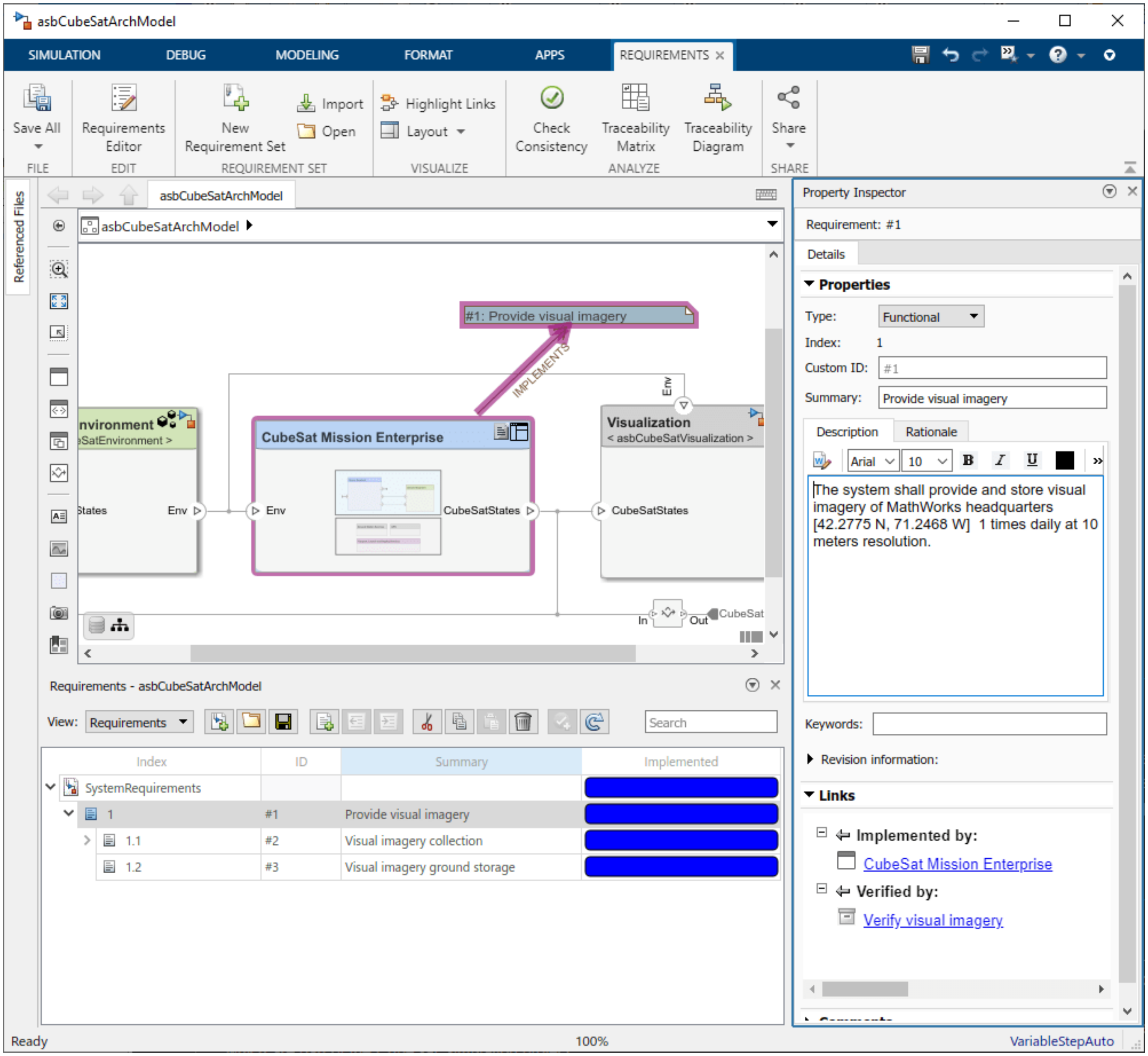
SolarPanelCell

«SolarPanelCell»
cost: single (dollars) = 2500
powerGen: single (W) = 3
voltage: single (V) = 3.70000004768372
Ports

)

Link Requirements to Architecture Components

To link requirements to the architectural elements that implement them, use the **Requirements Manager.** Drag the requirement onto the corresponding component, port, or interface. Using this linking mechanism, we can identify how requirements are met in the architecture model. The column labeled "Implemented" in the **Requirements Manager** shows whether a textual requirement has been linked to a component in the given model. For example, our top-level requirement "Provide visual imagery" is linked to our top-level component `CubeSat Mission Enterprise` with decomposed requirements linked to respective decomposed architectural components.



Requirements - asbCubeSatArchModel

View: Requirements

Index	ID	Summary	Implemented
SystemRequirements			🟦
1	#1	Provide visual imagery	🟦
1.1	#2	Visual imagery collection	🟦
1.2	#3	Visual imagery ground storage	🟦

Requirement: #1

Type: Functional

Index: 1

Custom ID: #1

Summary: Provide visual imagery

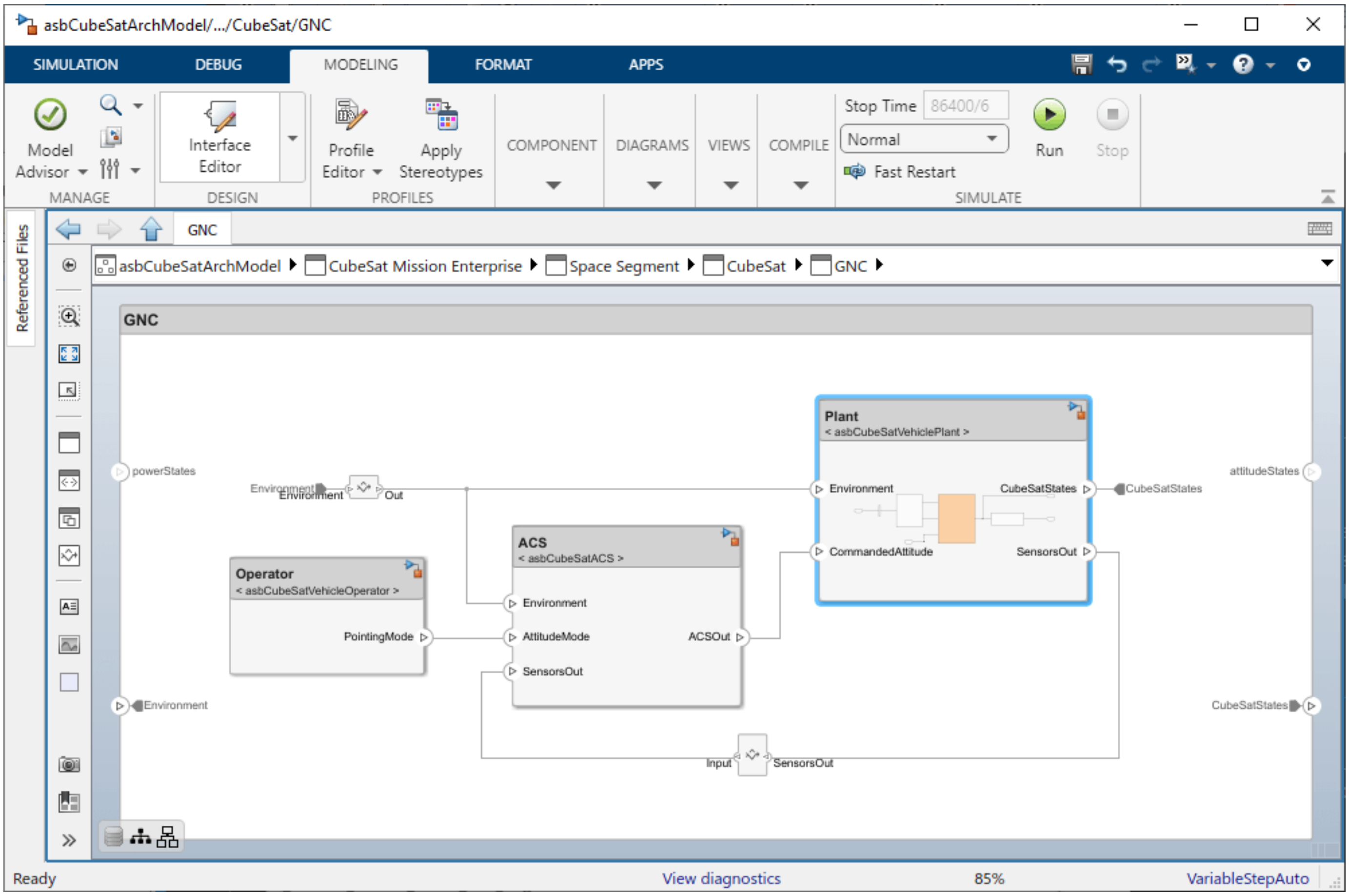
The system shall provide and store visual imagery of MathWorks headquarters [42.2775 N, 71.2468 W] 1 times daily at 10 meters resolution.

Implemented by:
CubeSat Mission Enterprise

Verified by:
Verify visual imagery

Connecting the Architecture to Design Models

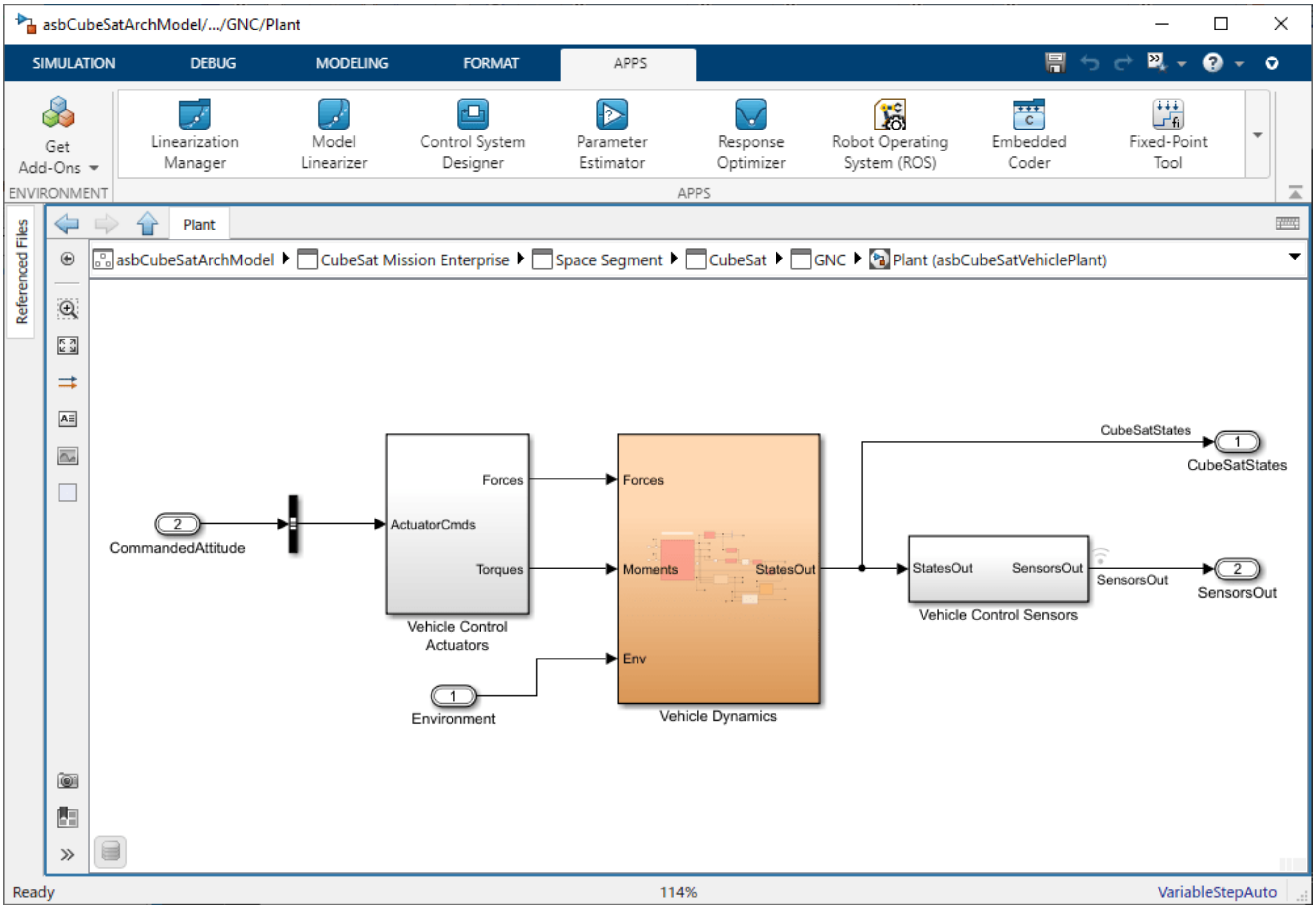
As the design process matures through analysis and other systems engineering processes, we can begin to populate our architecture with dynamics and behavior models. System Composer is built as a layer on top of Simulink, which enables Simulink models to be directly referenced from the components we have created. We can then simulate our architecture model as a Simulink model and generate results for analysis. For example, the `GNC subsystem` component contains 3 Simulink model references that are part of the *CubeSat Simulation Project*.



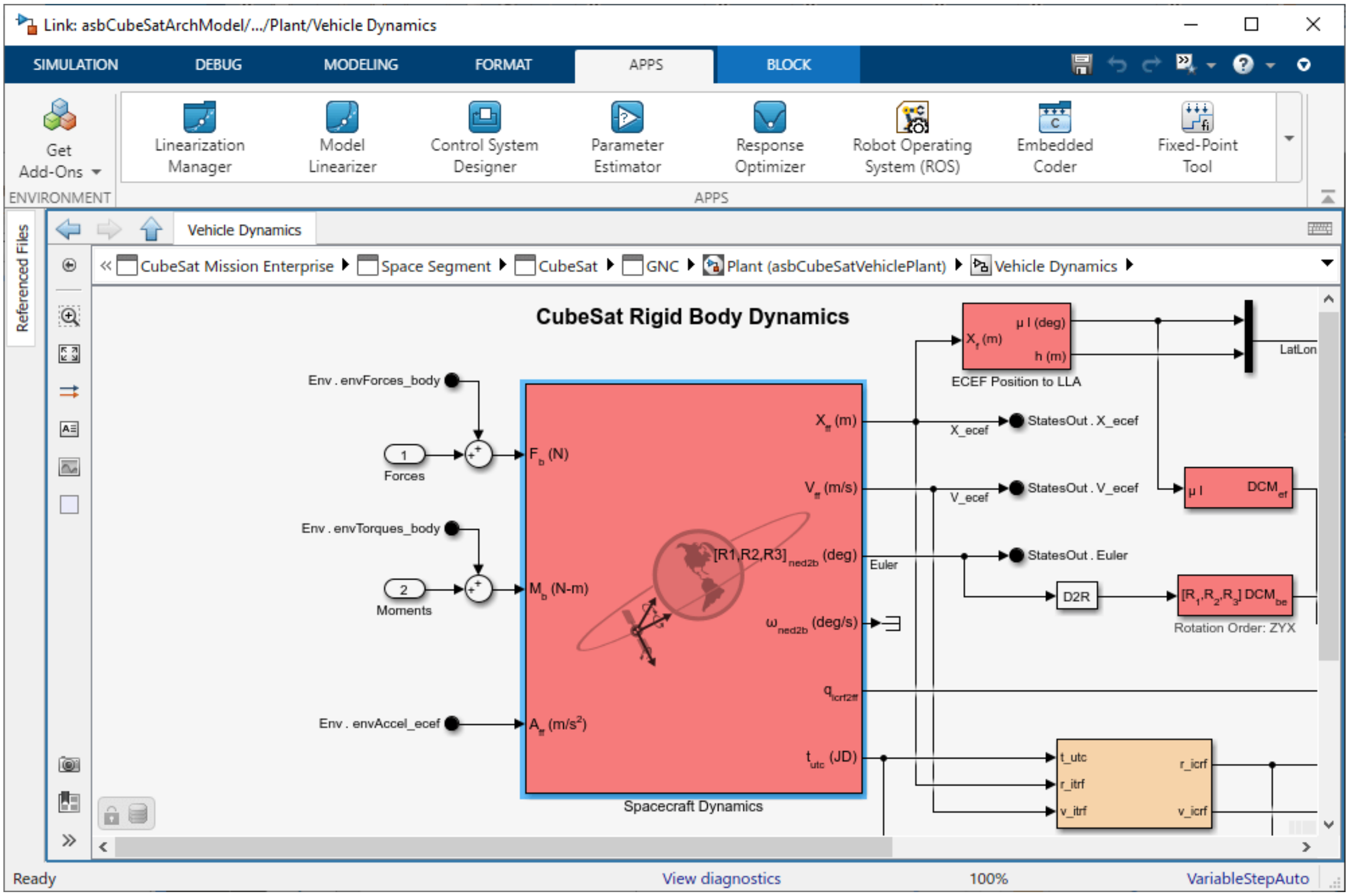
Stop Time 86400/6

Normal

Double-click these reference components to open the underlying Simulink models. Notice that the interfaces defined in the architecture map to bus signals in the Simulink model.

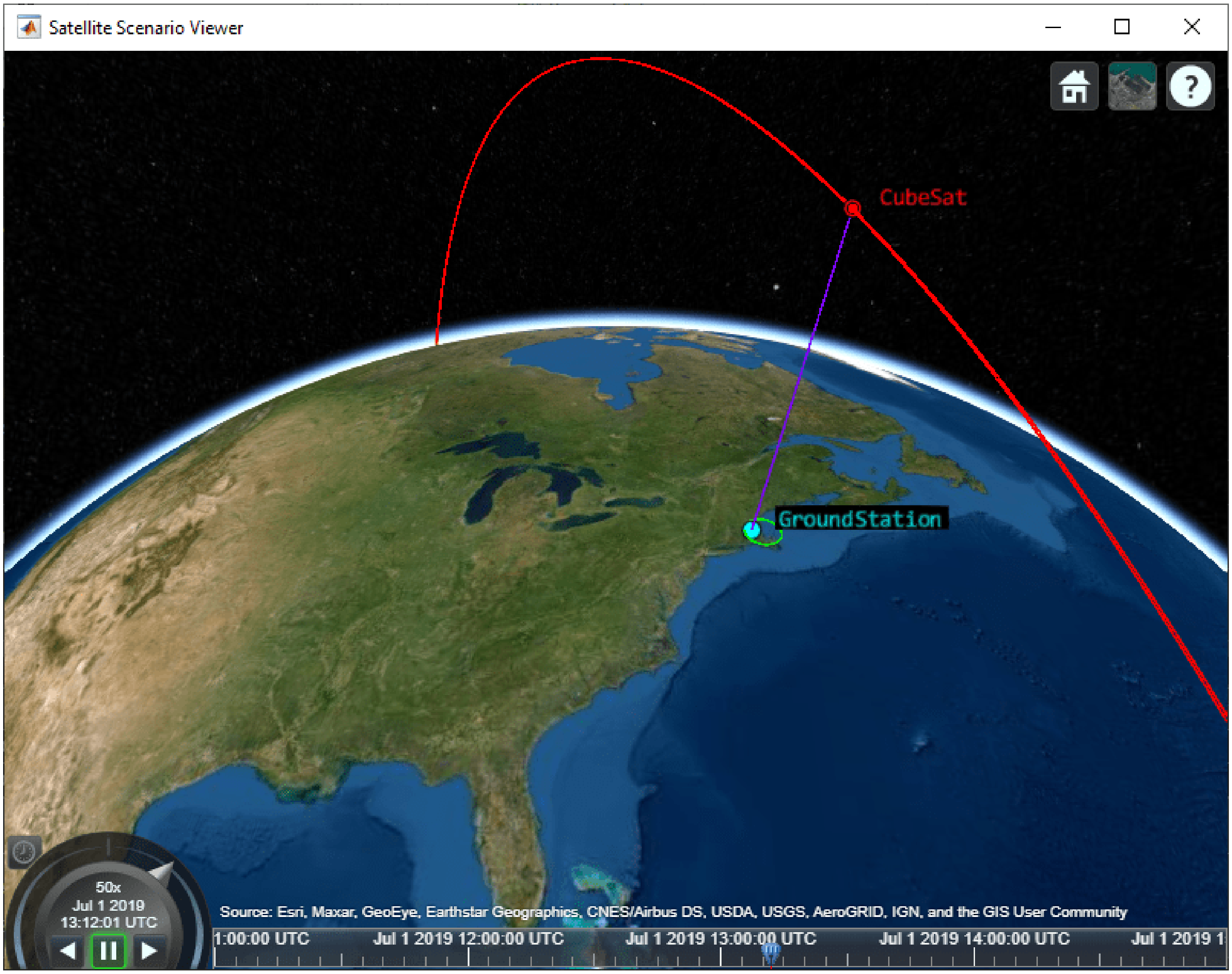


This example uses the **Spacecraft Dynamics** block from Aerospace Blockset to propagate the CubeSat orbit and rotational states.



Simulate System Architecture to Validate Orbital Requirements

We can use simulation to verify our system-level requirements. In this scenario, our top level requirement states that the CubeSat onboard camera captures an image of MathWorks Headquarters at [42.2775 N, 71.2468 W] once daily at 10 meters resolution. We can manually validate this requirement with various mission analysis tools. For examples of these analyses, click on the project shortcuts *Analyze with Mapping Toolbox* and *Analyze with Satellite Scenario.*

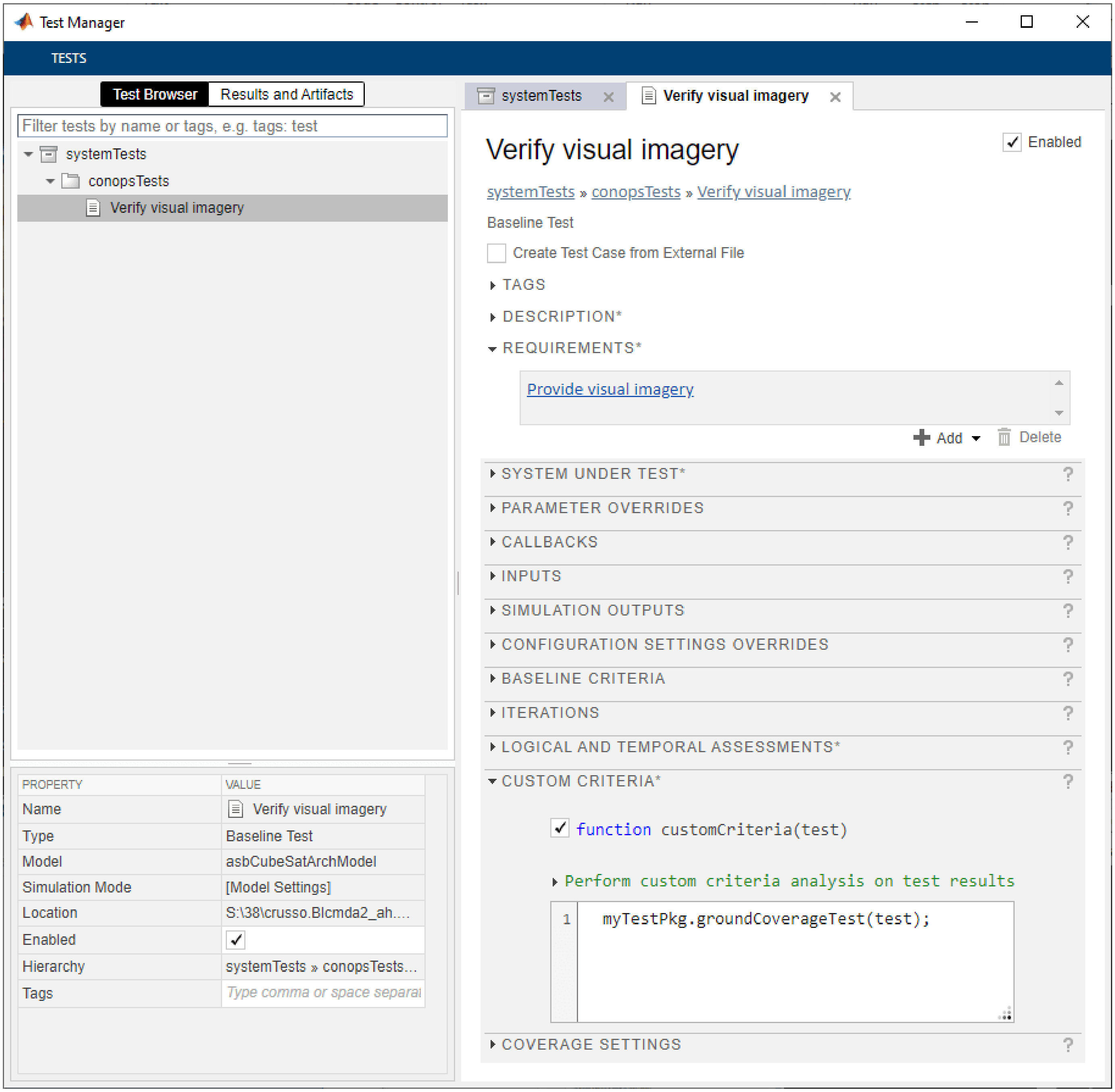

Satellite Scenario Viewer
CubeSat
GroundStation
50x
Jul 1 2019
13:12:01 UTC
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
1:00:00 UTC
Jul 1 2019 12:00:00 UTC
Jul 1 2019 13:00:00 UTC
Jul 1 2019 14:00:00 UTC
Jul 1 2019 1

The satellite scenario created in the *Analyze with Satellite Scenario* shortcut example is shown above.

Validate Orbital Requirements using Simulink Test

Although we can use MATLAB to visualize and analyze the CubeSat behavior, we can also use Simulink Test to build test cases. This test case automates the requirements-based testing process by using the testing framework to test whether our CubeSat orbit and attitude meet our high-level requirement. The test case approach enables us to create a scalable, maintainable, and flexible testing infrastructure based on our textual requirements.

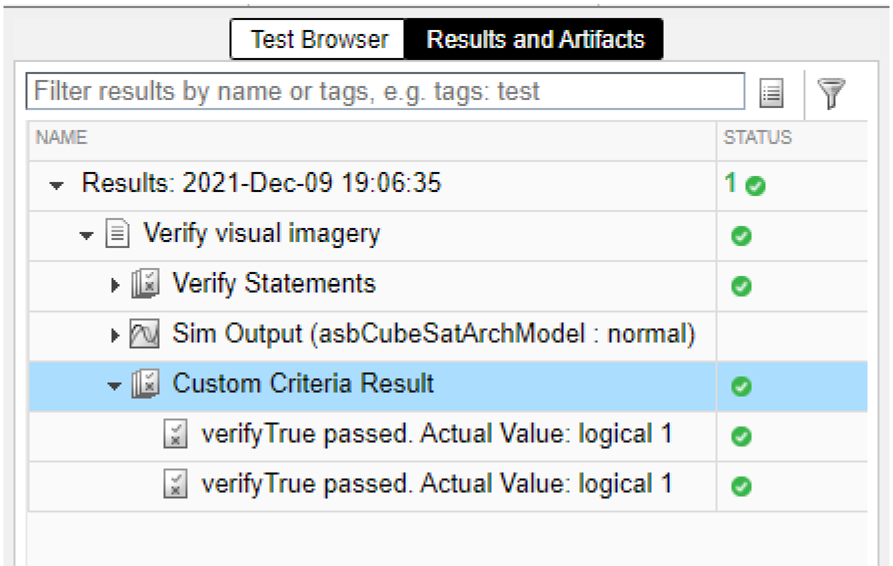
This example contains a test file *systemTests.mldatx*. Double-click this file in the project folder browser to view it in the **Test Manager**. Our test file contains a test to verify our top-level requirement. The "Verify visual imagery" testpoint is mapped to the requirement "Provide visual imagery" and defines a MATLAB function to use as custom criteria for the test. While this test case is not a comprehensive validation of our overall mission, it is useful during early development to confirm our initial orbit selection is reasonable, allowing us to continue refining and adding detail to our architecture.



PROPERTY	VALUE
Name	Verify visual imagery
Type	Baseline Test
Model	asbCubeSatArchModel
Simulation Mode	[Model Settings]
Location	S:\38\crusso.Blcmda2_ah....
Enabled	✓
Hierarchy	systemTests » conopsTests...
Tags	Type comma or space separat

```
☑ function customCriteria(test)

Perform custom criteria analysis on test results
myTestPkg.groundCoverageTest(test);
```

Run the test point in the **Test Manager** and confirm that the test passes. Passing results indicate that the CubeSat onboard camera as visibility to the imaging target during the simulation window.



NAME	STATUS
Results: 2021-Dec-09 19:06:35	1 ✓
Verify visual imagery	✓
Verify Statements	✓
Sim Output (asbCubeSatArchModel : normal)	
Custom Criteria Result	✓
verifyTrue passed. Actual Value: logical 1	✓
verifyTrue passed. Actual Value: logical 1	✓

References

[1] “Space Systems Working Group.” INCOSE, 2019, https://www.incose.org/incose-member-resources/working-groups/Application/space-systems.

See Also

Orbit Propagator | Spacecraft Dynamics | Attitude Profile

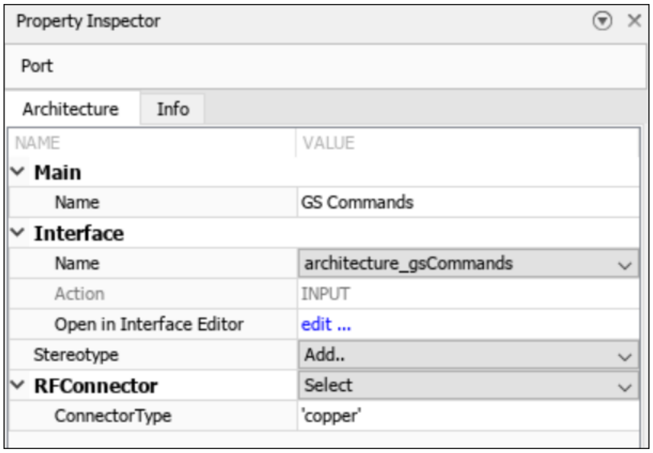
Related Examples

- “Compose Architectures Visually” on page 1-2
- “Define Profiles and Stereotypes” on page 5-2
- “Manage Requirements” on page 2-8

Use Property Inspector in System Composer

The **Property Inspector** allows you to access and edit properties for different elements in System Composer.

To open the tool, from the System Composer toolstrip, navigate to **Modeling** > **Property Inspector**. Alternatively, press **Ctrl+Shift+I**. On a macOS, use the **command** key instead of **Ctrl**.



Property Inspector

Port

NAME	VALUE
Main	
Name	GS Commands
Interface	
Name	architecture_gsCommands
Action	INPUT
Open in Interface Editor	edit ...
Stereotype	Add..
RFConnector	Select
ConnectorType	'copper'

Use the **Property Inspector** to inspect properties based on context. When you select a component, port, connector, interface, function, or requirement, the structure of the **Property Inspector** adapts to accommodate the given element.

Property Inspector Modes

This table explains where to find more information about authoring properties.

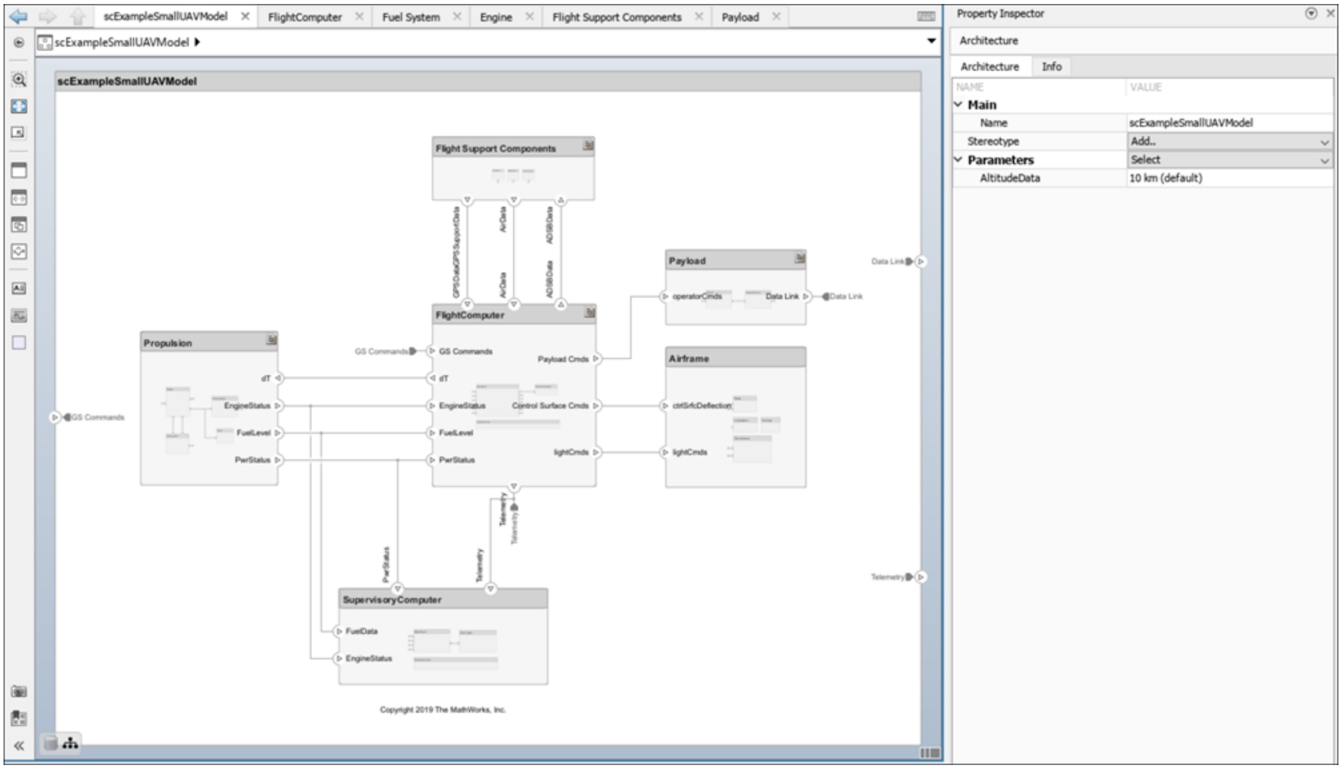
Property	Tool
Stereotypes	**Profile Editor**
Parameters	**Parameter Editor**
Interfaces	**Interface Editor**
Requirements	**Requirements Editor**
Functions	**Functions Editor**

View and Edit Stereotypes and Parameters

Launch the small unmanned aerial vehicle (UAV) project.

```
scExampleSmallUAV
```

In the **Property Inspector**, on the root architecture layer of the architecture model, you can view and edit stereotypes and parameters.



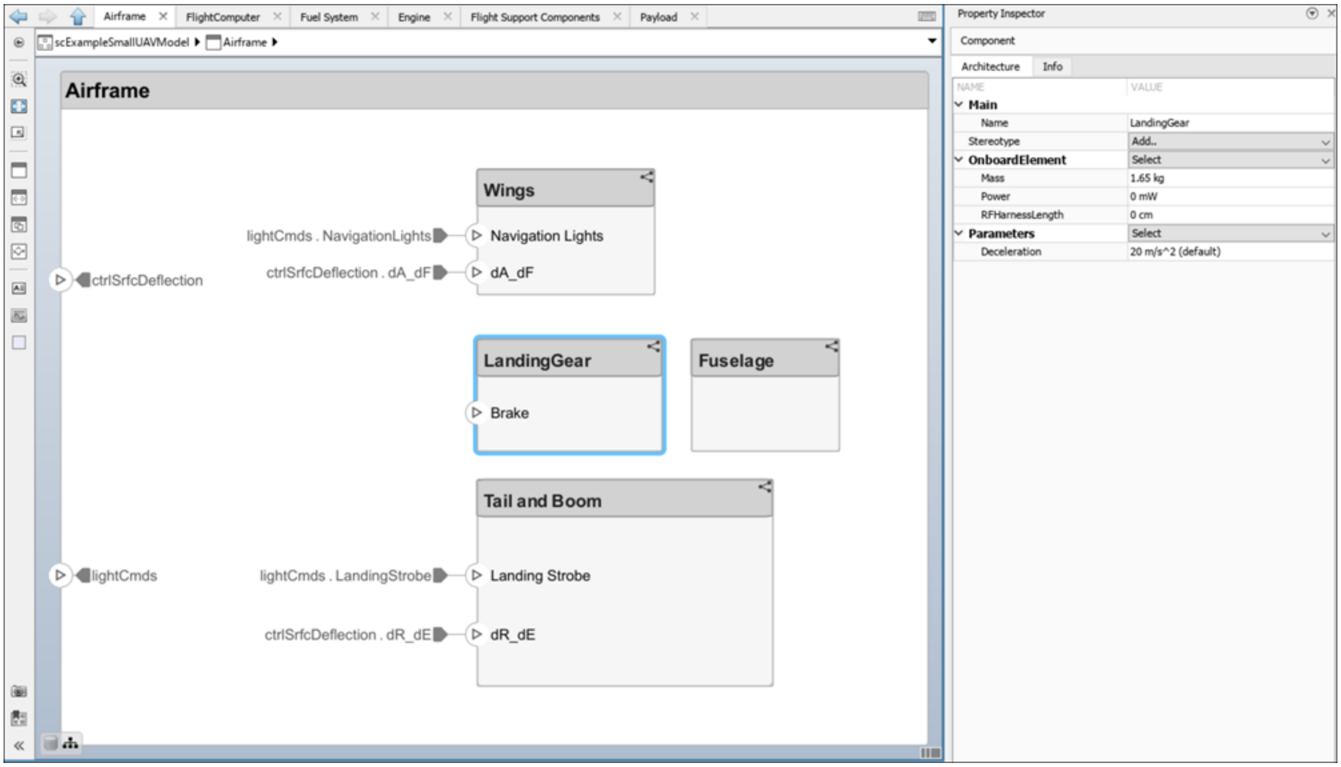
Property Inspector

Architecture

Architecture | Info

NAME	VALUE
Main	
Name	scExampleSmallUAVModel
Stereotype	Add..
Parameters	Select
AltitudeData	10 km (default)

When you select a component, you can view and edit the stereotypes or parameters assigned to the component.



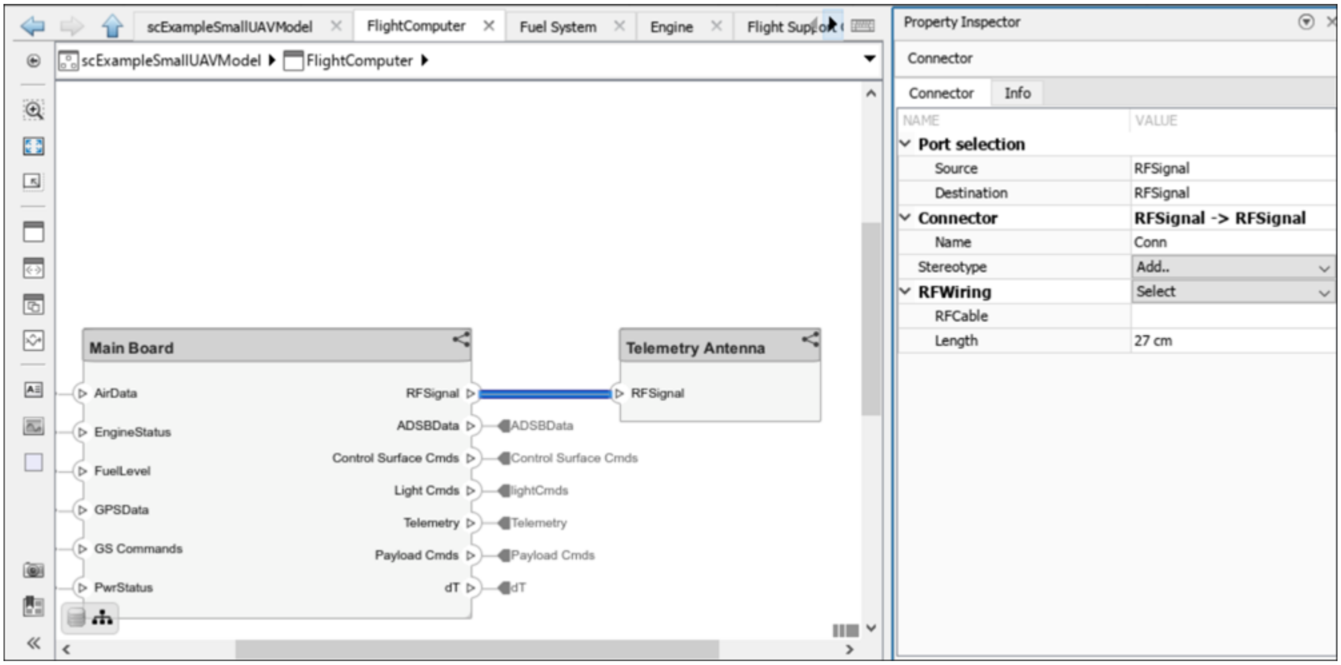
Property Inspector

Component

Architecture | Info

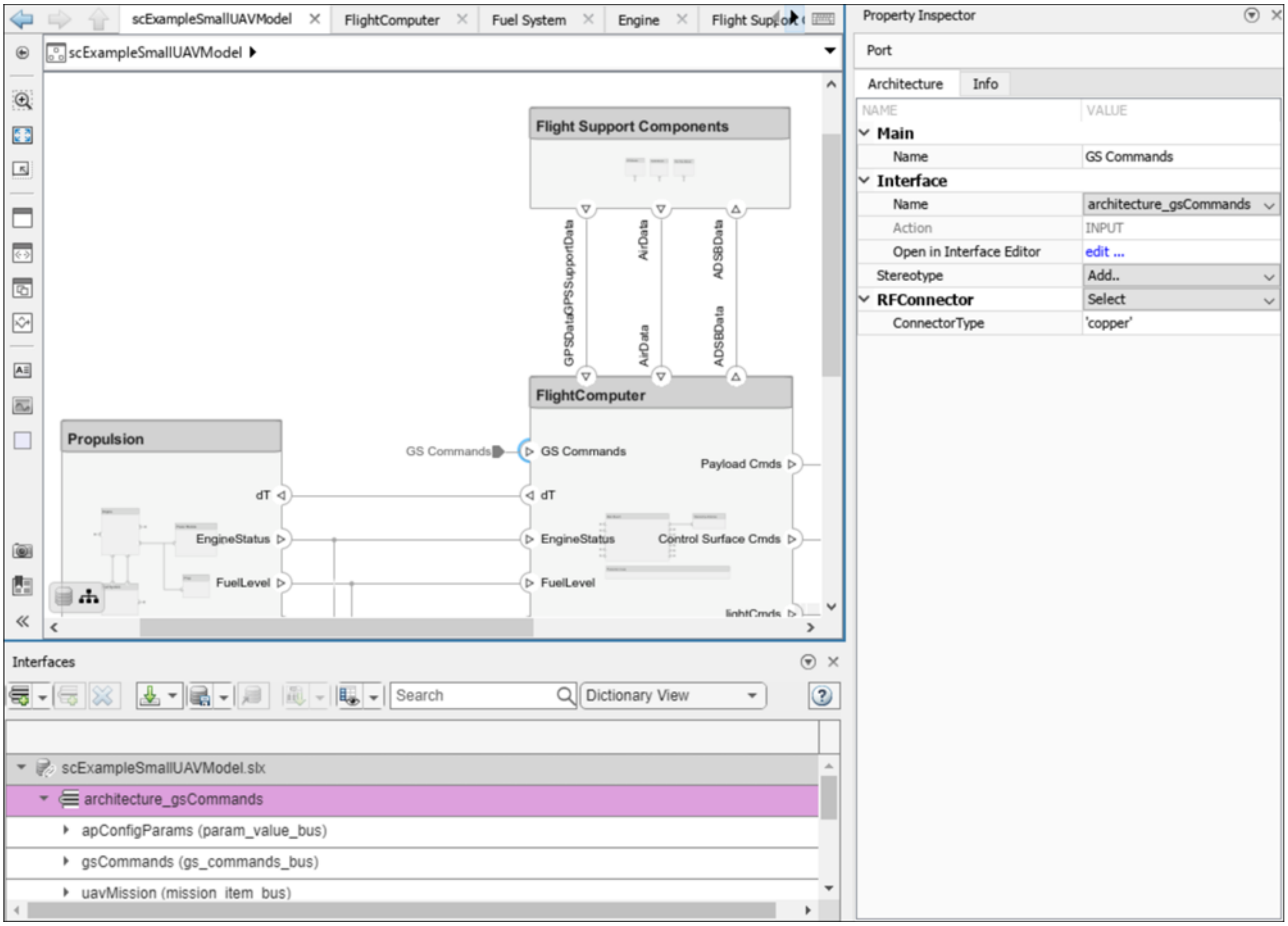
NAME	VALUE
Main	
Name	LandingGear
Stereotype	Add..
OnboardElement	Select
Mass	1.65 kg
Power	0 mW
RFHarnessLength	0 cm
Parameters	Select
Deceleration	20 m/s^2 (default)

When you select a connector, you can view and edit the stereotypes assigned to the connector.



NAME	VALUE
Port selection	
Source	RFSignal
Destination	RFSignal
Connector	RFSignal -> RFSignal
Name	Conn
Stereotype	Add..
RFWiring	Select
RFCable	
Length	27 cm

When you select a port, you can view and edit the stereotypes or interfaces assigned to the port.



NAME	VALUE
Main	
Name	GS Commands
Interface	
Name	architecture_gsCommands
Action	INPUT
Open in Interface Editor	edit ...
Stereotype	Add..
RFConnector	Select
ConnectorType	'copper'

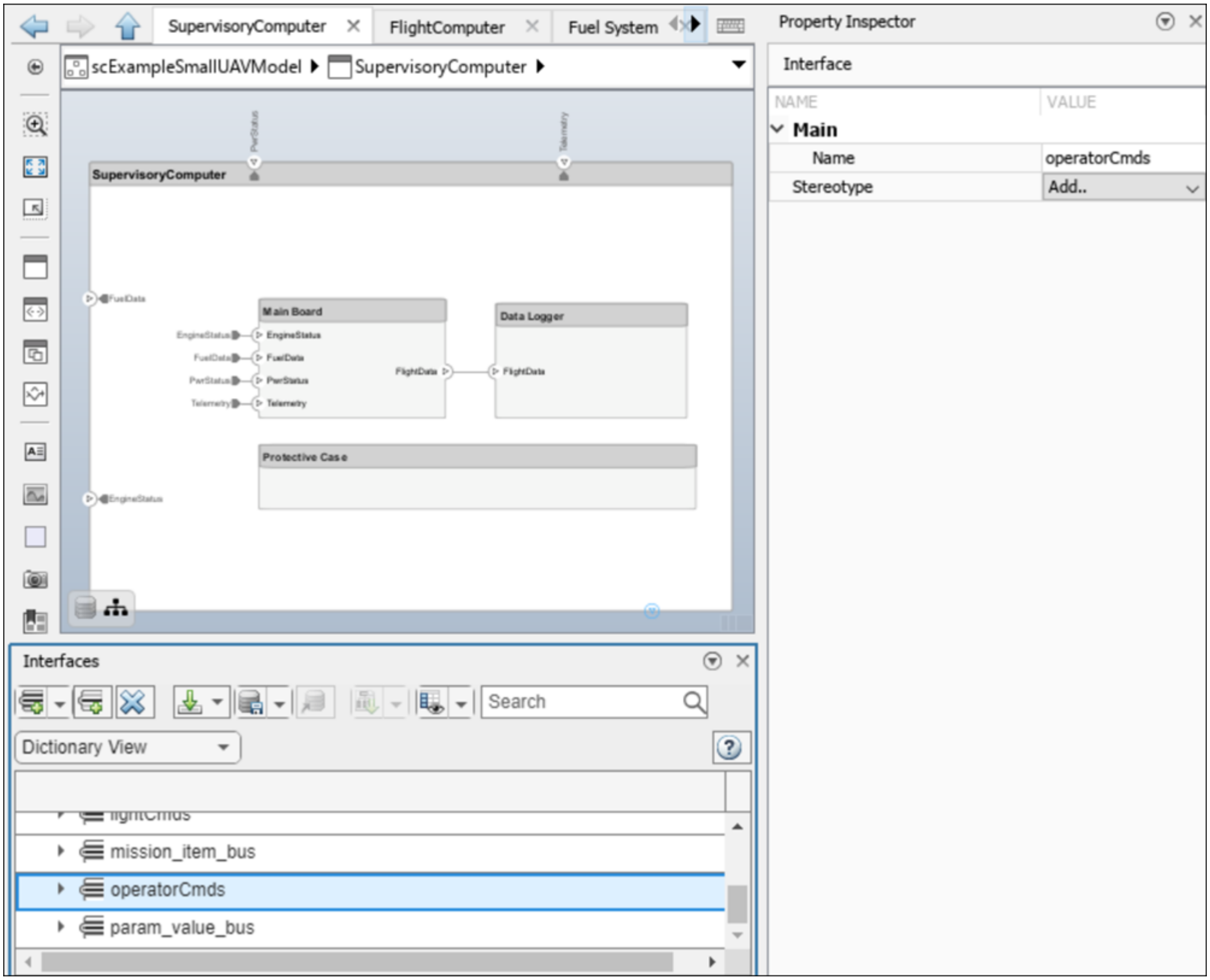
From the Stereotype list, choose an option to apply a stereotype to the model element. Select the fully qualified name of a stereotype, <profile>.<stereotype>, or create or edit new stereotypes in the **Profile Editor**. Use <Add/Edit> when no stereotypes are applied or <New/Edit> when at least one stereotype is applied. Choose <Remove All> from the Stereotype list to remove all stereotypes from a model element.

Once you choose a stereotype, select from the list next to the stereotype name. Options include Remove to remove the stereotype from the element and Reset to default values to reset the values of the stereotype properties to their defaults. Expand the stereotype to view and edit its property values.

Use the Parameters list to open the **Parameter Editor** using the Open Editor option. Reset a specific parameter to its default value using the Reset to default option. Find the source of the parameter using Highlight source of parameter. Since parameters can be promoted to higher parts of the hierarchy, the source of the parameter is not always clear.

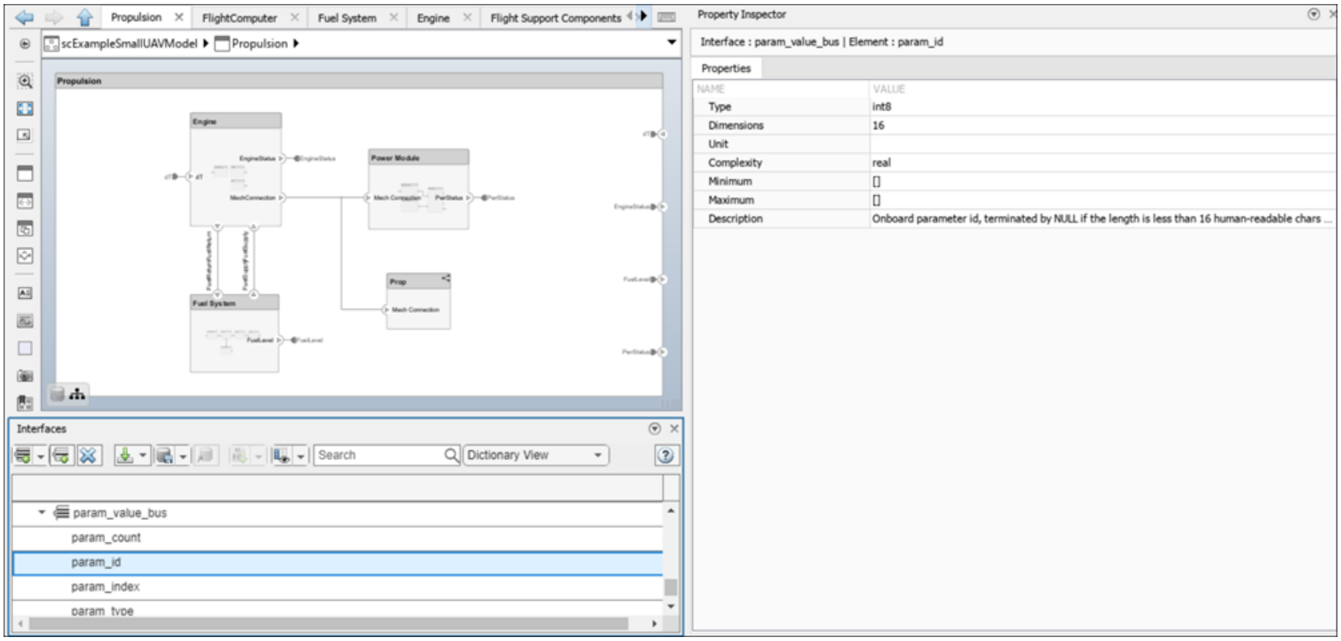
View and Edit Interfaces

When you select a data interface on the **Interface Editor**, you can view and edit the stereotypes in the **Property Inspector**.



Select the `edit` hyperlink to open the interface in the **Interface Editor**.

When you select a data element on the **Interface Editor**, you can view and edit the type, dimension, unit, complexity, minimum, maximum, and description in the **Property Inspector**.

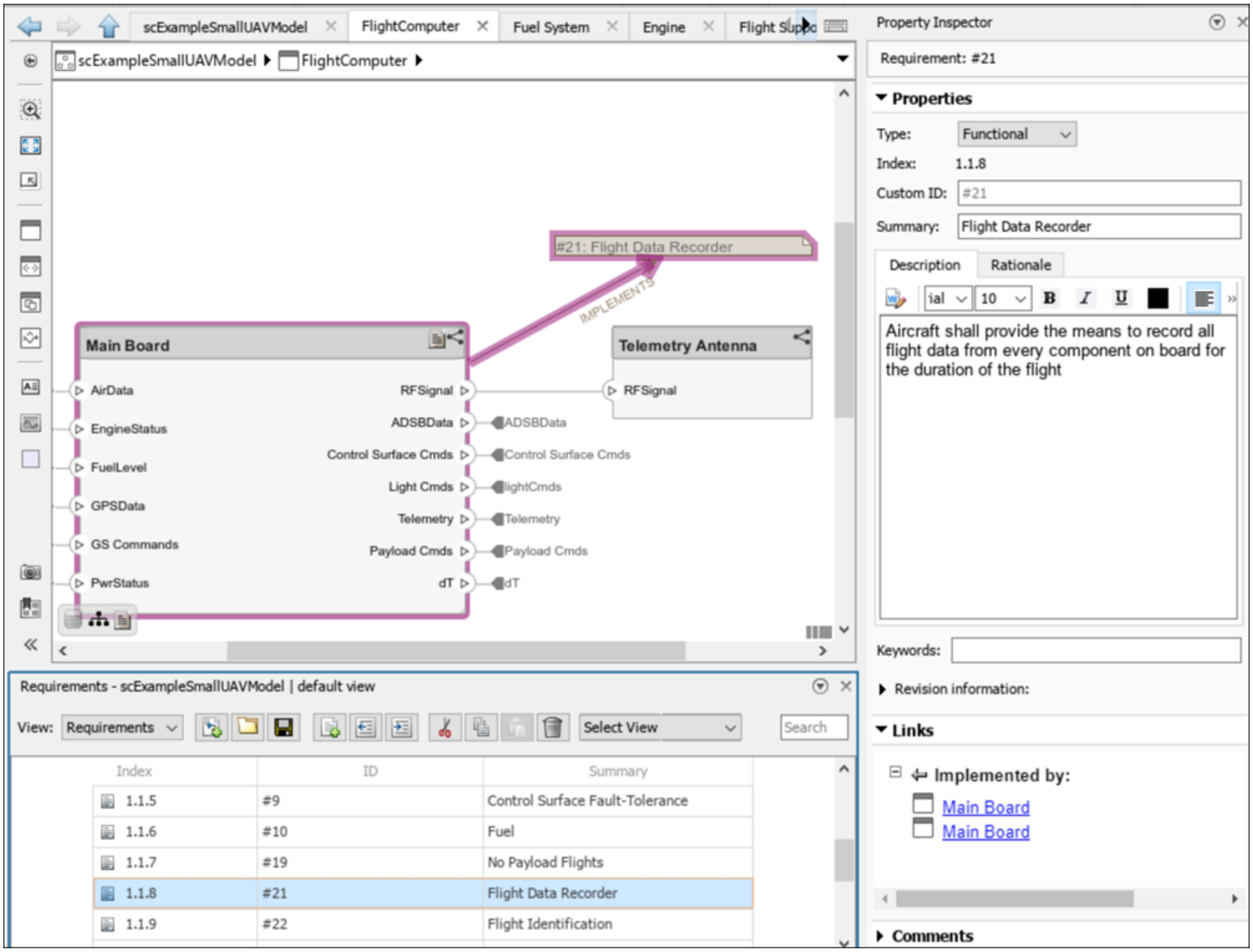


Interface : param_value_bus | Element : param_id

NAME	VALUE
Type	int8
Dimensions	16
Unit	
Complexity	real
Minimum	[]
Maximum	[]
Description	Onboard parameter id, terminated by NULL if the length is less than 16 human-readable chars ...

View and Edit Requirements

When you select a requirement with the Requirements Perspective open, you can view and edit the type, summary, description, and links for the requirement in the **Property Inspector**.



Requirement: #21

Properties

Type: Functional

Index: 1.1.8

Custom ID: #21

Summary: Flight Data Recorder

Description:

Aircraft shall provide the means to record all flight data from every component on board for the duration of the flight

Keywords:

Links

Implemented by:

- Main Board
- Main Board

View: Requirements

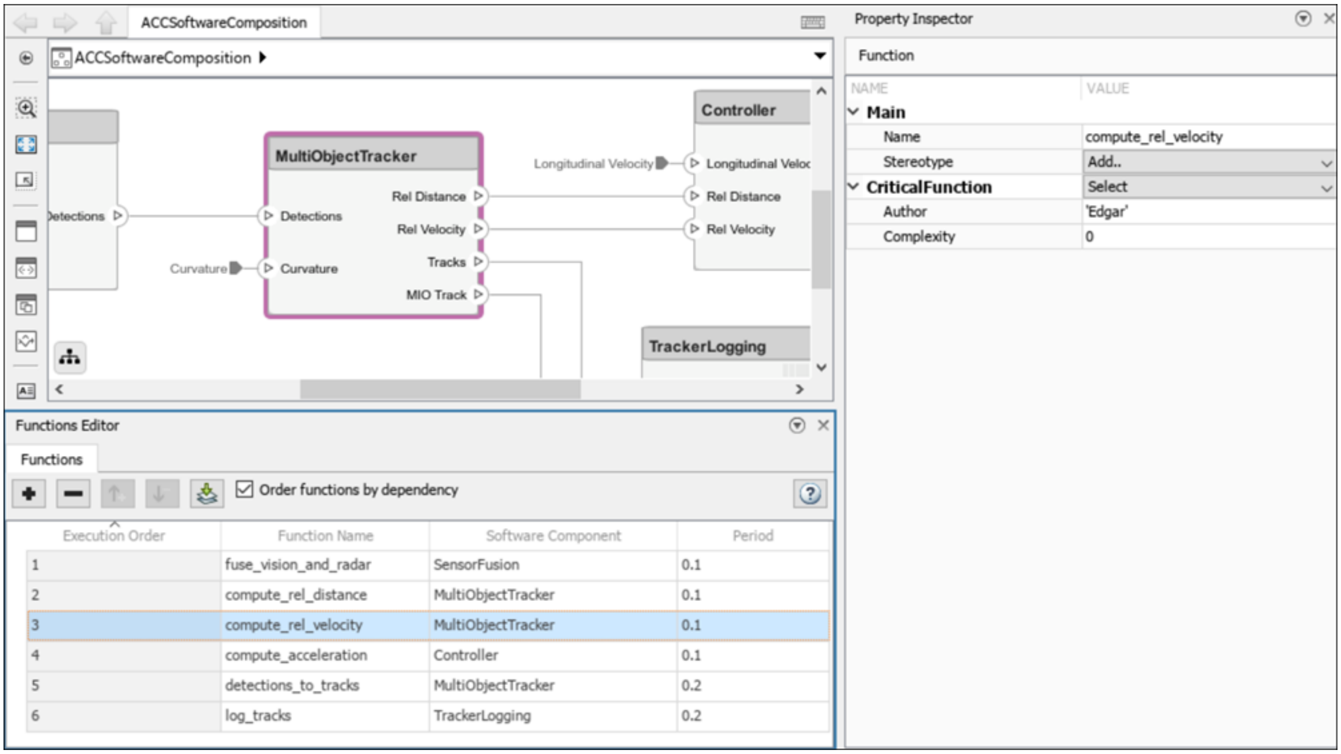
Index	ID	Summary
1.1.5	#9	Control Surface Fault-Tolerance
1.1.6	#10	Fuel
1.1.7	#19	No Payload Flights
1.1.8	#21	Flight Data Recorder
1.1.9	#22	Flight Identification

View and Edit Functions

Launch the adaptive cruise control example.

```
openExample('systemcomposer/ACCSoftwareCompositionExample')
```

When you select a function on the **Functions Editor**, you can view and edit the stereotypes for the function in the **Property Inspector**.



☑ Order functions by dependency

Execution Order	Function Name	Software Component	Period
1	fuse_vision_and_radar	SensorFusion	0.1
2	compute_rel_distance	MultiObjectTracker	0.1
3	compute_rel_velocity	MultiObjectTracker	0.1
4	compute_acceleration	Controller	0.1
5	detections_to_tracks	MultiObjectTracker	0.2
6	log_tracks	TrackerLogging	0.2

Property Inspector

Function

NAME	VALUE
Main	
Name	compute_rel_velocity
Stereotype	Add..
CriticalFunction	Select
Author	'Edgar'
Complexity	0

See Also

`applyStereotype` | `removeStereotype` | `createInterface` | `setInterface` | `addFunction` | **Property Inspector**

Related Examples

- “Modeling System Architecture of Small UAV” on page 1-32
- “Authoring Functions for Software Components of an Adaptive Cruise Control” on page 10-34
- “Define Profiles and Stereotypes” on page 5-2
- “Define Port Interfaces Between Components” on page 3-2
- “Manage Requirements” on page 2-8

Requirements

Link and Trace Requirements

This example shows how to work with requirements in an architecture model.

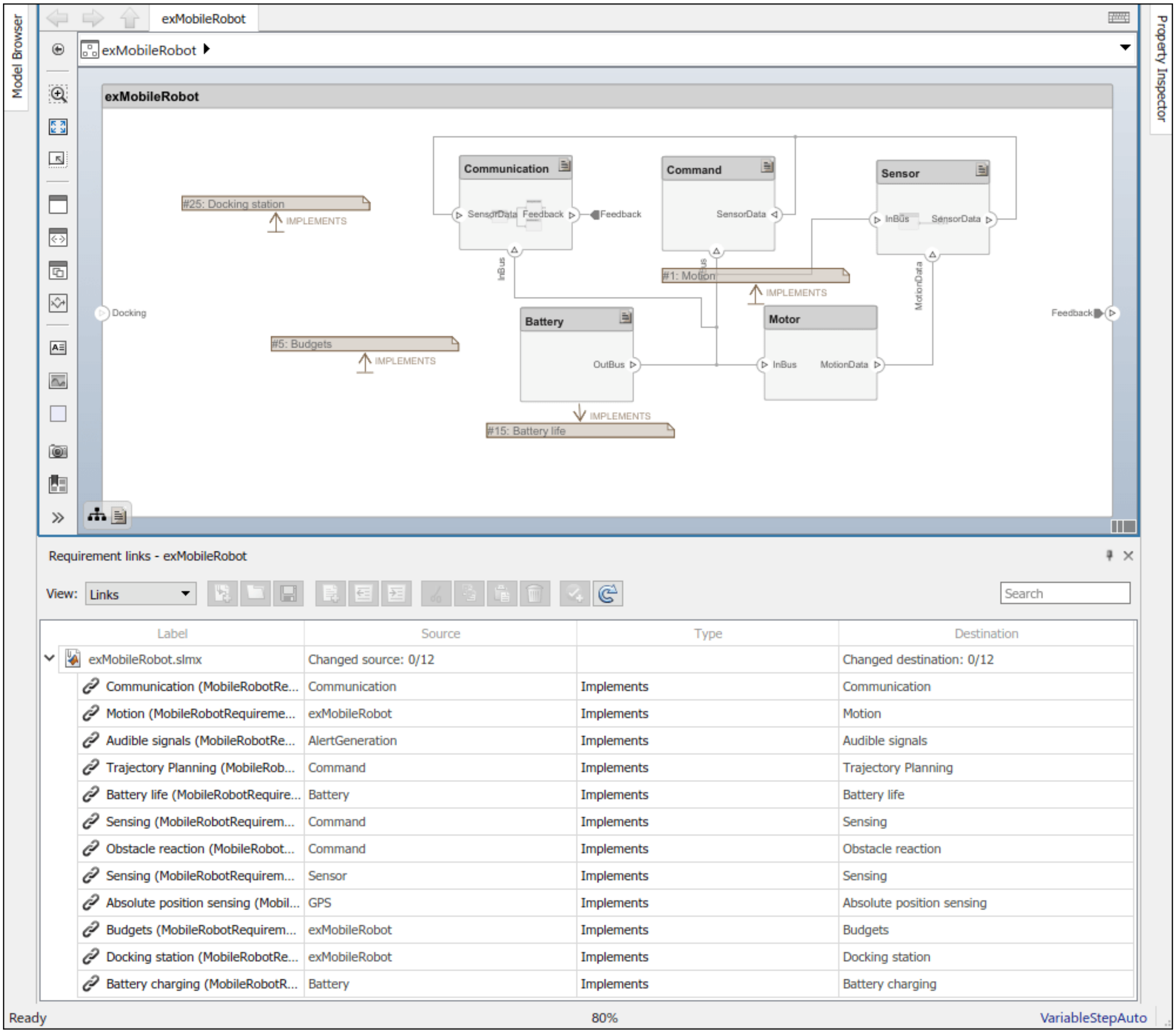
Allocate functional requirements to components to establish traceability. By creating a link between a component and the related requirement, you can track whether all requirements are represented in the architecture. You can also keep requirements and design in sync, for example, if a requirement changes or if the design warrants a revision of the requirements. You can link components to requirements in Requirements Toolbox™, test cases in Simulink® Test™, or selections in MATLAB®, Microsoft® Excel®, or Microsoft Word.

A Requirements Toolbox license is required to link, trace, and manage requirements in System Composer™.

Open the model `exMobileRobot`.

```
systemcomposer.openModel("exMobileRobot");
```

Manage requirements and architecture together in the **Requirements Manager** from Requirements Toolbox. Navigate to **Apps** > **Requirements Manager**. You are now in the Requirements Perspective in System Composer.



Requirement links - exMobileRobot

View: Links

Search

Label	Source	Type	Destination
exMobileRobot.slmx	Changed source: 0/12		Changed destination: 0/12
Communication (MobileRobotRe...	Communication	Implements	Communication
Motion (MobileRobotRequireme...	exMobileRobot	Implements	Motion
Audible signals (MobileRobotRe...	AlertGeneration	Implements	Audible signals
Trajectory Planning (MobileRob...	Command	Implements	Trajectory Planning
Battery life (MobileRobotRequire...	Battery	Implements	Battery life
Sensing (MobileRobotRequirem...	Command	Implements	Sensing
Obstacle reaction (MobileRobot...	Command	Implements	Obstacle reaction
Sensing (MobileRobotRequirem...	Sensor	Implements	Sensing
Absolute position sensing (Mobil...	GPS	Implements	Absolute position sensing
Budgets (MobileRobotRequirem...	exMobileRobot	Implements	Budgets
Docking station (MobileRobotRe...	exMobileRobot	Implements	Docking station
Battery charging (MobileRobotR...	Battery	Implements	Battery charging

Ready 80% VariableStepAuto

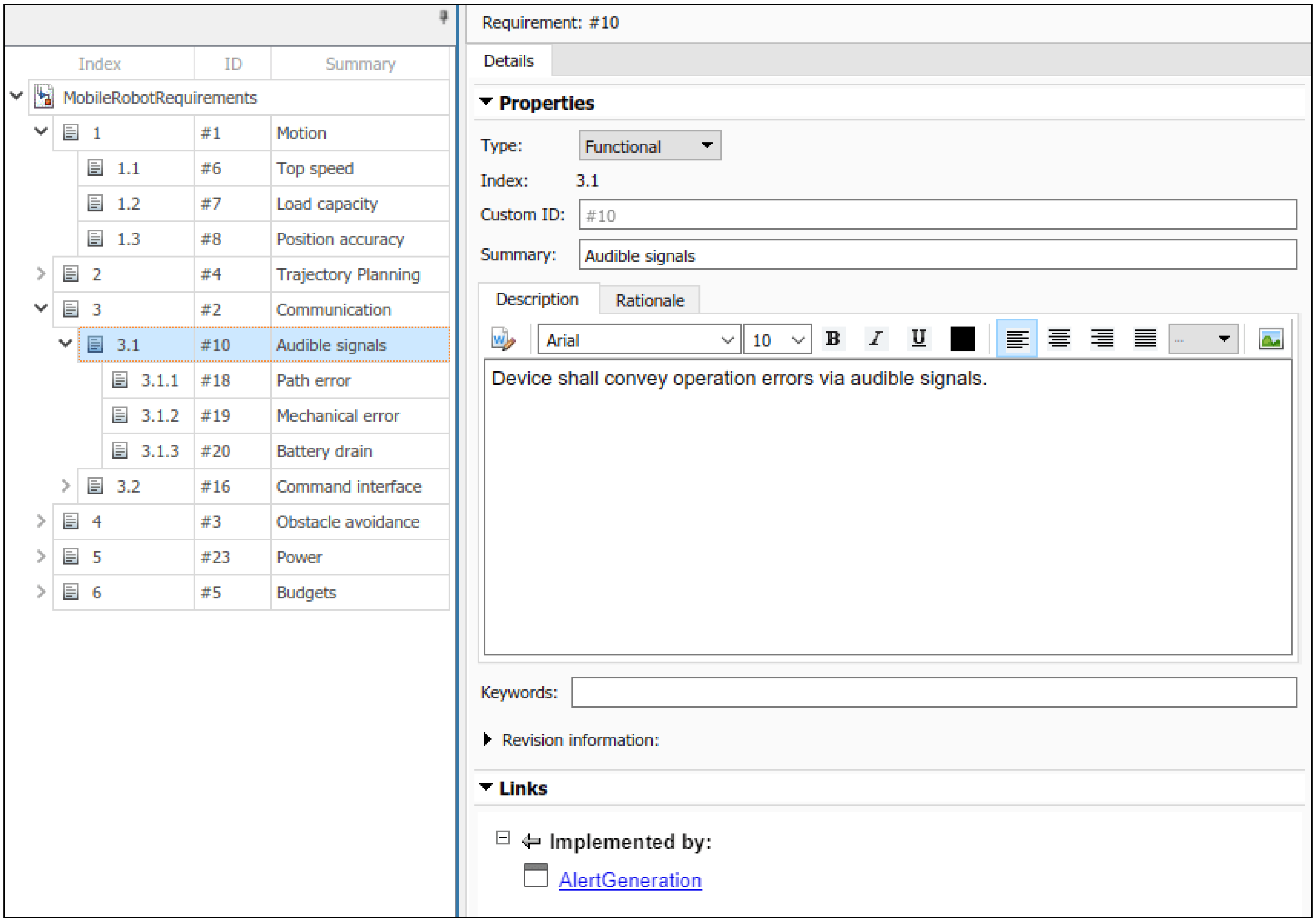
Links can be created and managed through the Requirements Perspective. For more information, see “Manage Requirements” on page 2-8. This example shows an alternative approach using the Requirements Editor.

Open the requirements in the Requirements Editor (Requirements Toolbox).

```
slreq.load('MobileRobotRequirements');
```

```
slreq.editor
```

Select the requirement to be linked.



Index	ID	Summary
MobileRobotRequirements		
1	#1	Motion
1.1	#6	Top speed
1.2	#7	Load capacity
1.3	#8	Position accuracy
2	#4	Trajectory Planning
3	#2	Communication
3.1	#10	Audible signals
3.1.1	#18	Path error
3.1.2	#19	Mechanical error
3.1.3	#20	Battery drain
3.2	#16	Command interface
4	#3	Obstacle avoidance
5	#23	Power
6	#5	Budgets

Requirement: #10

Details

Properties

Type: Functional

Index: 3.1

Custom ID: #10

Summary: Audible signals

Device shall convey operation errors via audible signals.

Keywords:

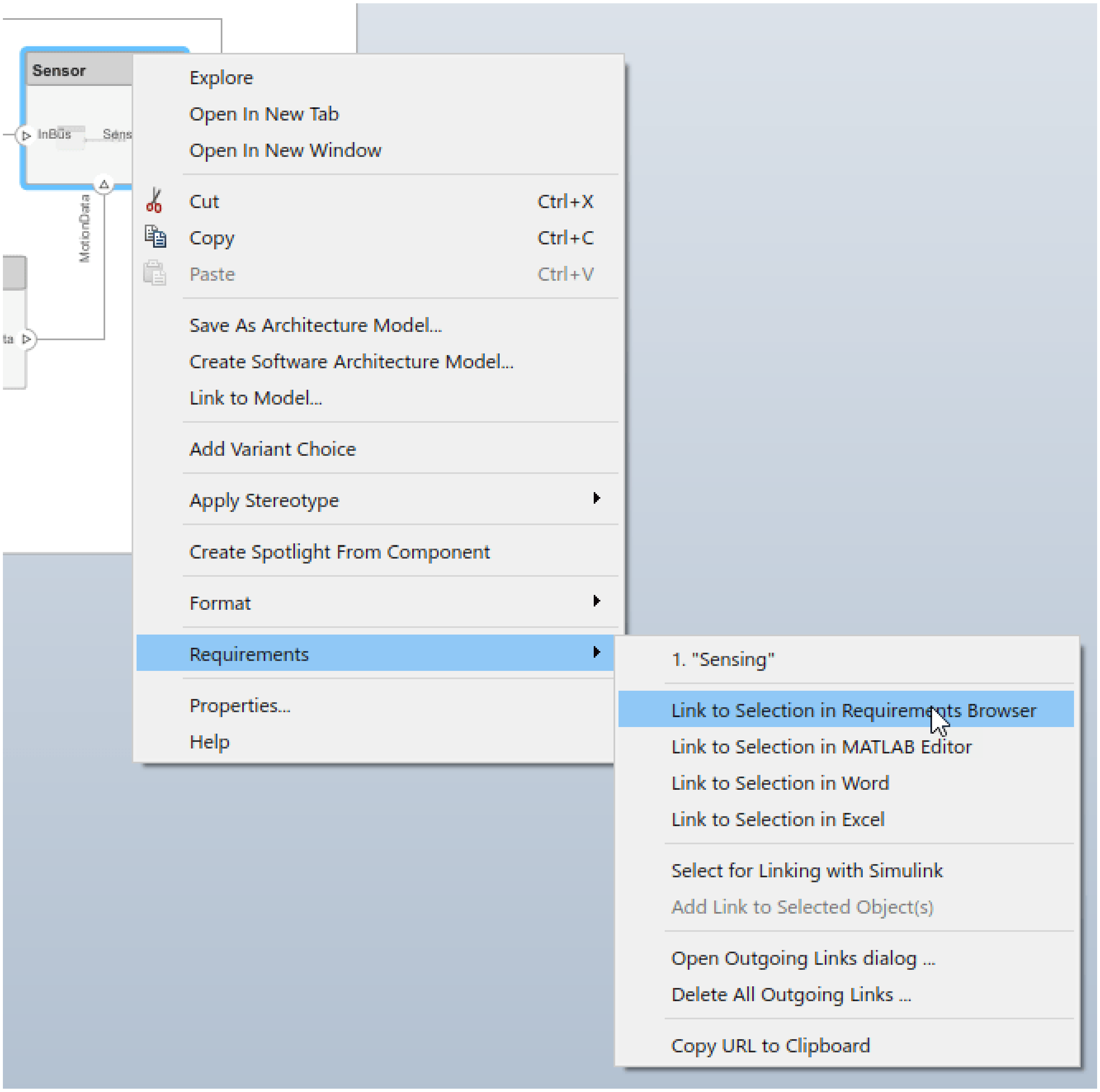
Revision information:

Links

Implemented by:

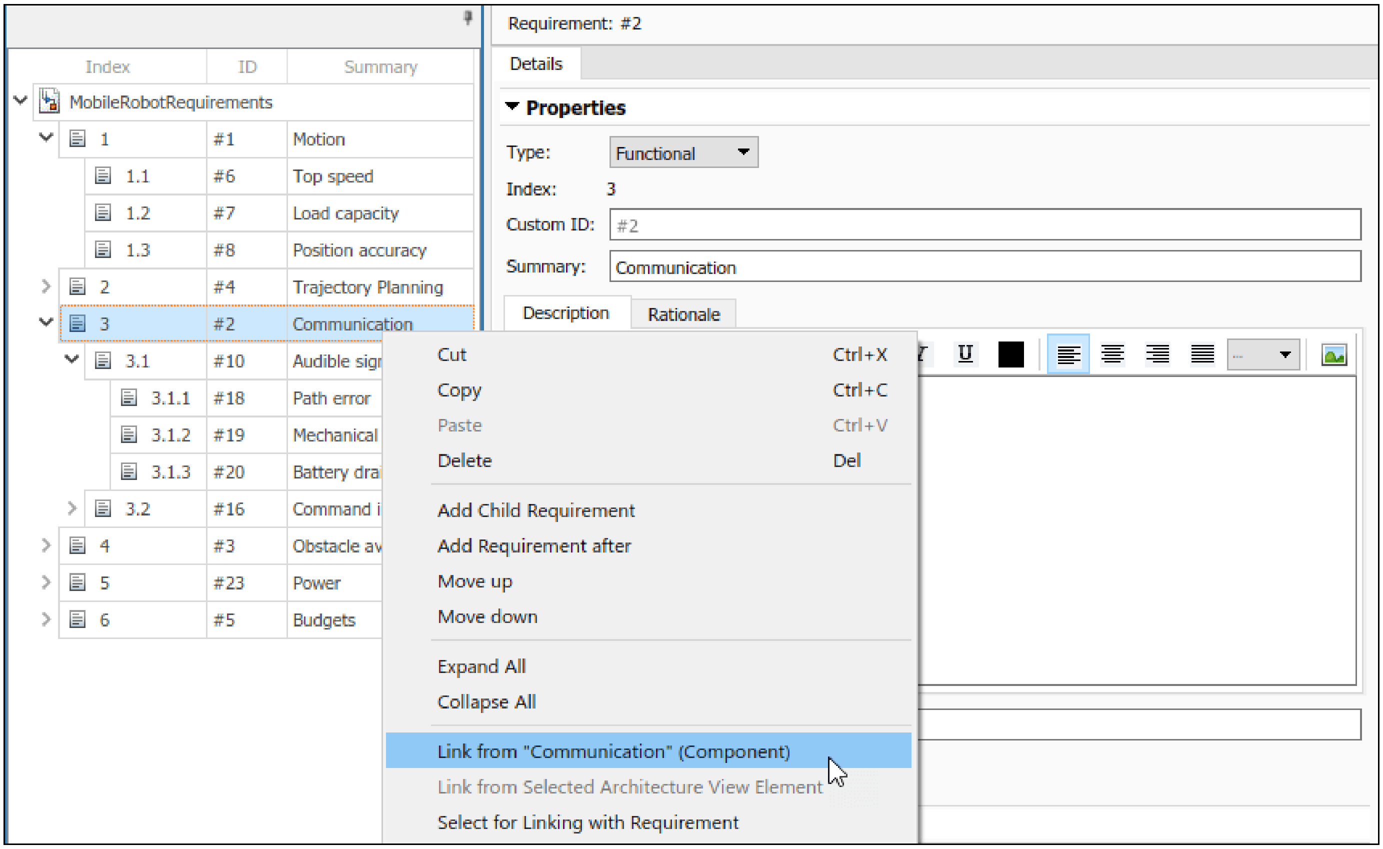
AlertGeneration

Select the component to be linked in the architecture model. Right-click and select **Requirements > Link to Selection in Requirements Browser**.


Sensor
InBus
Sens
MotionData
ta
Explore
Open In New Tab
Open In New Window
Cut Ctrl+X
Copy Ctrl+C
Paste Ctrl+V
Save As Architecture Model...
Create Software Architecture Model...
Link to Model...
Add Variant Choice
Apply Stereotype
Create Spotlight From Component
Format
Requirements
Properties...
Help
1. "Sensing"
Link to Selection in Requirements Browser
Link to Selection in MATLAB Editor
Link to Selection in Word
Link to Selection in Excel
Select for Linking with Simulink
Add Link to Selected Object(s)
Open Outgoing Links dialog ...
Delete All Outgoing Links ...
Copy URL to Clipboard

When you first link a requirement in an architecture model, a link set file with extension `.slmx` is created to store requirement links. The **Requirements** context menu displays the linked requirements.

You can also create a link using the Requirements Editor. First, select the component in the architecture model. Then, in the Requirements Editor (Requirements Toolbox), right-click the requirement and select **Link from "<Component Name>" (Component)**.



Index	ID	Summary
MobileRobotRequirements		
1	#1	Motion
1.1	#6	Top speed
1.2	#7	Load capacity
1.3	#8	Position accuracy
2	#4	Trajectory Planning
3	#2	Communication
3.1	#10	Audible sigr
3.1.1	#18	Path error
3.1.2	#19	Mechanical
3.1.3	#20	Battery drai
3.2	#16	Command i
4	#3	Obstacle av
5	#23	Power
6	#5	Budgets

Requirement: #2

Type: Functional

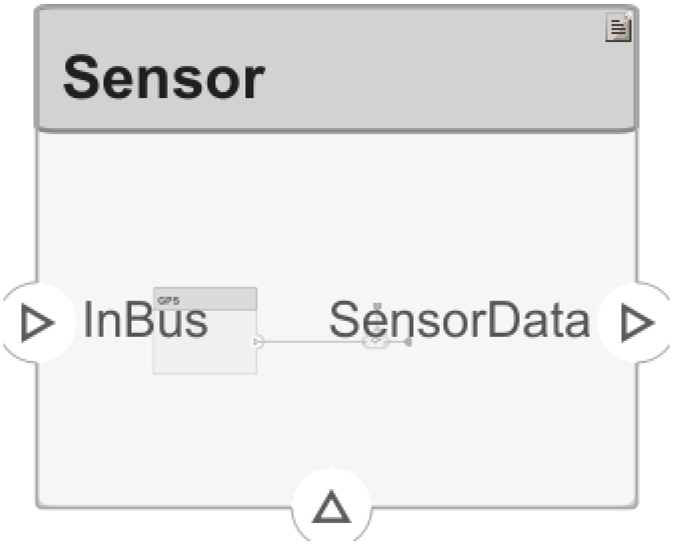
Index: 3

Custom ID: #2

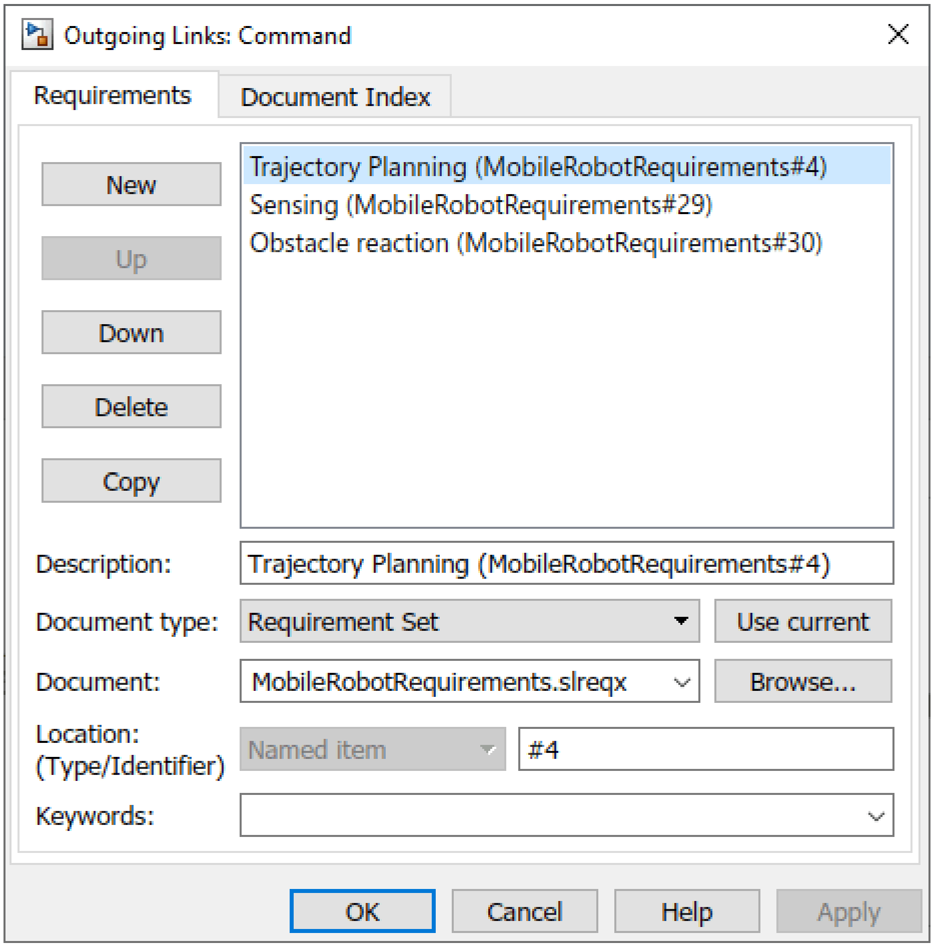
Summary: Communication

You can also create requirement links with blocks and subsystems in Simulink models. For more information, see “Link Blocks and Requirements” (Requirements Toolbox).

The 🗎 badge on a component indicates that it is linked to a requirement. This badge also shows at the lower-left corner of the architecture model.



To trace requirement links to a component, right-click the `Command` component and select **Requirements > Open Outgoing Links dialog**. Here, you can create new requirements, delete existing ones, and change their order.



Outgoing Links: Command

Trajectory Planning (MobileRobotRequirements#4)
Sensing (MobileRobotRequirements#29)
Obstacle reaction (MobileRobotRequirements#30)

Description: Trajectory Planning (MobileRobotRequirements#4)
Document type: Requirement Set
Document: MobileRobotRequirements.slreqx
Location: (Type/Identifier) Named item #4
Keywords:

See Also

More About

- “Manage Requirements” on page 2-8
- “Organize System Composer Files in Projects” on page 12-2
- “View Requirements Toolbox Links Associated with Model Elements”
- “Design Insulin Infusion Pump Using Model-Based Systems Engineering” on page 9-23
- “Simulate Mobile Robot with System Composer Workflow” on page 5-20

Manage Requirements

Requirements are a collection of statements describing the desired behavior and characteristics of a system. Requirements ensure system design integrity and are achievable, verifiable, unambiguous, and consistent with each other. Each level of design should have appropriate requirements.

A Requirements Toolbox™ license is required to link, trace, and manage requirements in System Composer.

To enhance traceability of requirements, link system, functional, customer, performance, or design requirements to components and ports. Link requirements to each other to represent derived or allocated requirements. Manage requirements from the Requirements Manager on an architecture model or through custom views. Assign test cases to requirements using the **Test Manager** for verification and validation.

A Simulink Test™ license is required to use the Test Manager and to create test harnesses for components in System Composer.

A requirement set is a collection of requirements. You can structure the requirements hierarchically and link them to components or ports.

Use the **Requirements Editor** to edit and refine requirements in a requirement set. Requirement sets are stored in SLREQX files. You can create a new requirement set and author requirements using Requirements Toolbox, or import requirements from supported third-party tools.

A link is an object that relates two model-based design elements. A requirement link is a link where the destination is a requirement. You can link requirements to components or ports.

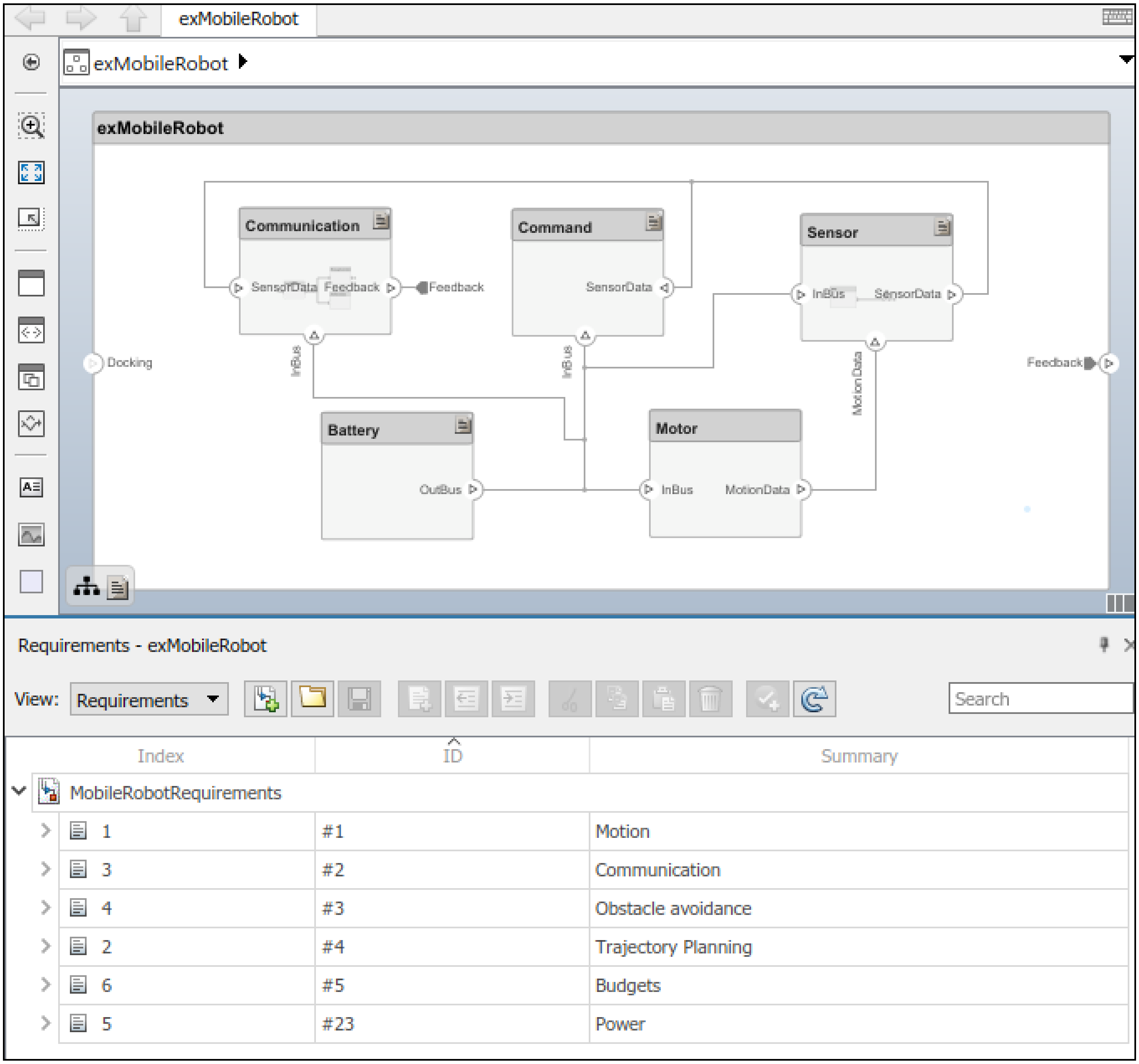
View links using the Requirements Perspective in System Composer. Select a requirement in the Requirements Browser to highlight the component or the port to which the requirement is assigned. Links are stored externally as SLMX files.

Mobile Robot Architecture Model

This example shows a mobile robot platform architecture.

Manage Requirements

Manage requirements and architecture together in the **Requirements Manager** from Requirements Toolbox. Navigate to **Apps** > **Requirements Manager**. You are now in the Requirements Perspective in System Composer.



Requirements - exMobileRobot

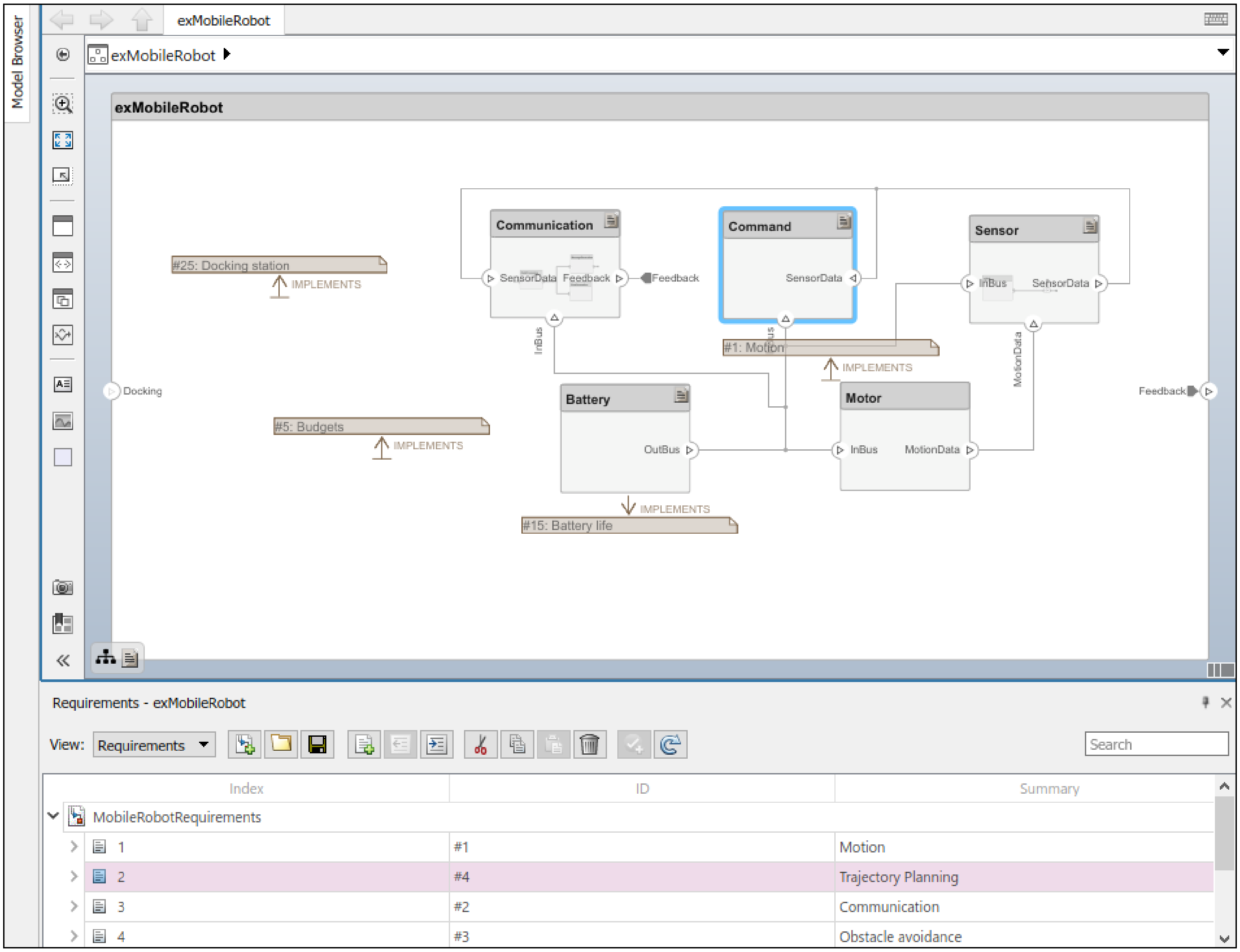
View: Requirements

Search

Index	ID	Summary
MobileRobotRequirements		
1	#1	Motion
3	#2	Communication
4	#3	Obstacle avoidance
2	#4	Trajectory Planning
6	#5	Budgets
5	#23	Power

Trace Requirements

When you click a component in the Requirements Perspective, linked requirements are highlighted. Conversely, when you click a requirement, the linked components are shown.



Requirements - exMobileRobot

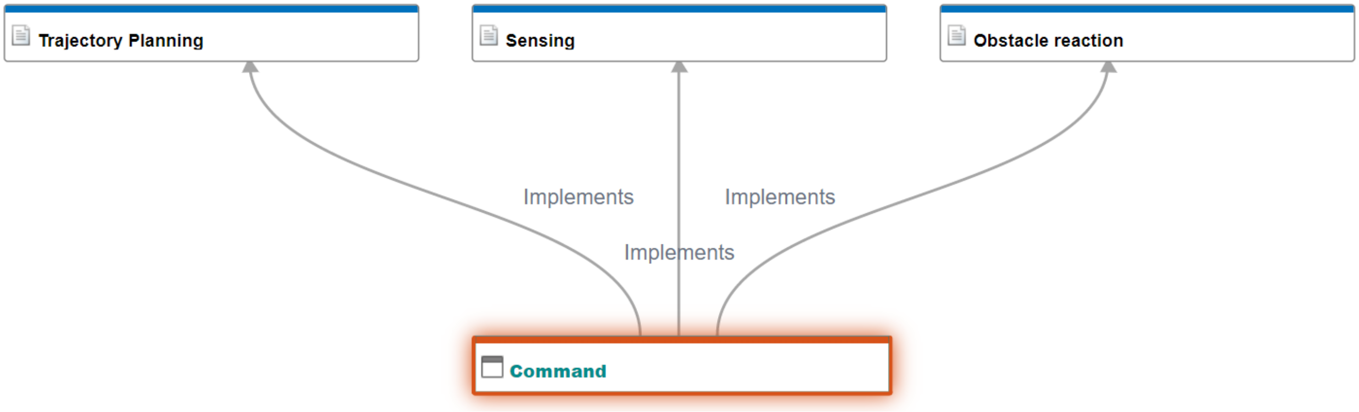
View: Requirements

Index	ID	Summary
MobileRobotRequirements		
1	#1	Motion
2	#4	Trajectory Planning
3	#2	Communication
4	#3	Obstacle avoidance

Use Requirements Traceability Diagram

Visualize traceability of requirements and how they are related using a traceability diagram.

Change the **View** option on the Requirements Manager from `Requirements` to `Links`. Right-click the `Trajectory Planning` requirement link and select `View Traceability Diagram`.



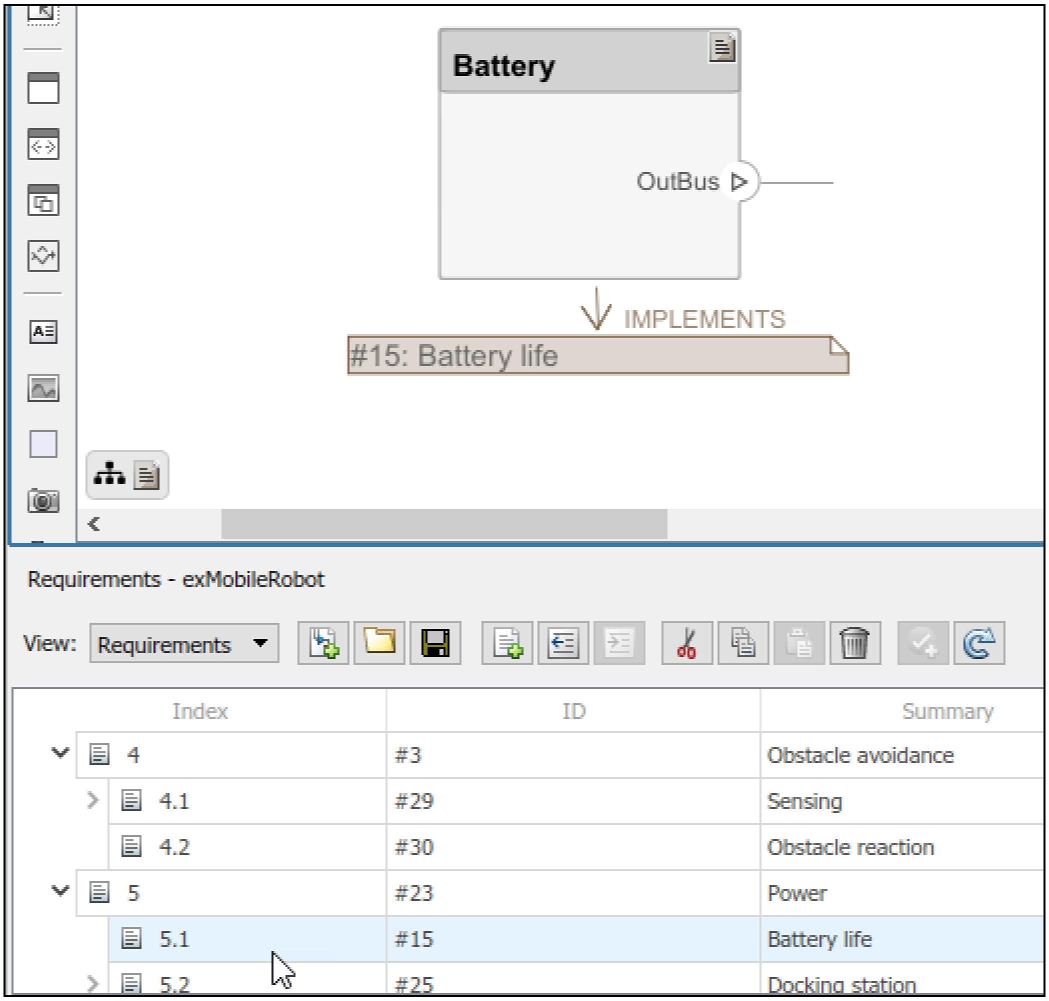
According to this traceability diagram, the `Command` component implements the three requirements `Trajectory Planning`, `Sensing`, and `Obstacle reaction`.

Change the **View** option on the Requirements Manager from `Links` back to `Requirements`.

For more information, see “Visualize Links with a Traceability Diagram” (Requirements Toolbox).

Link Requirements

To directly create a link, drag a requirement onto a component or port.



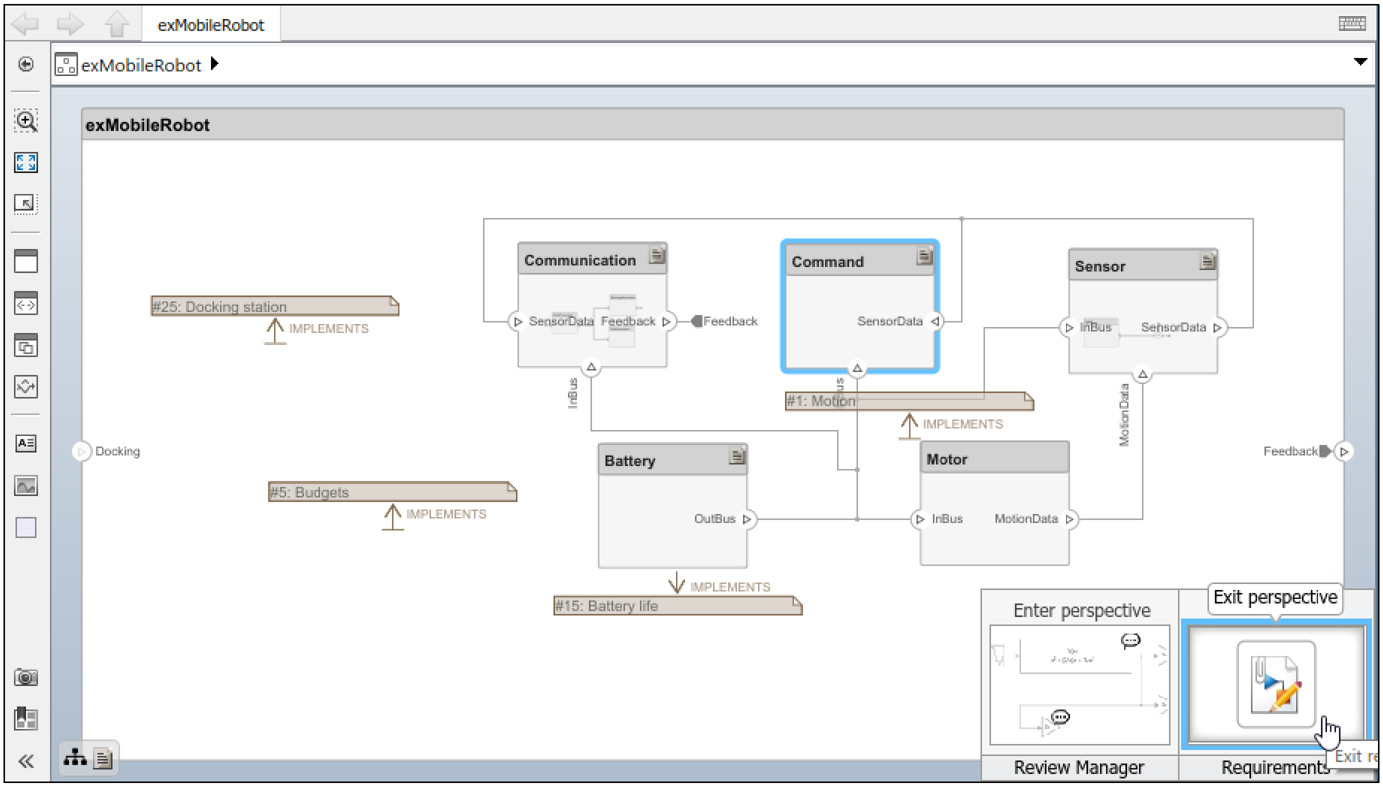
Requirements - exMobileRobot

View: Requirements

Index	ID	Summary
4	#3	Obstacle avoidance
4.1	#29	Sensing
4.2	#30	Obstacle reaction
5	#23	Power
5.1	#15	Battery life
5.2	#25	Docking station

You can close the annotation that shows the link as necessary. This action does not delete the link.

You can exit the Requirements perspective by clicking the perspectives menu on the lower-right corner of the architecture model and selecting **Exit perspective**.



For more information on managing requirements from external documents, see “Manage Navigation Backlinks in External Requirements Documents” (Requirements Toolbox). To integrate the requirement links to the model, see “Update Reference Requirement Links from Imported File”.

Verify and Validate Requirements Using Test Harnesses

A test harness is a model that isolates the component under test with inputs, outputs, and verification blocks configured for testing scenarios. You can create a test harness for a model component or for a full model. A test harness gives you a separate testing environment for a model or a model component.

For more information, see “Create a Test Harness” (Simulink Test).

Create a test harness for a System Composer component to validate simulation results and verify design. The **Interface Editor** is accessible in System Composer test harness models to enable behavior testing and implementation-independent interface testing.

Use Simulink Test to perform requirement-based testing workflows that include inputs, expected outputs, and acceptance criteria. For more information on using Simulink Test with Requirements Toolbox, see “Link to Test Cases from Requirements” (Requirements Toolbox).

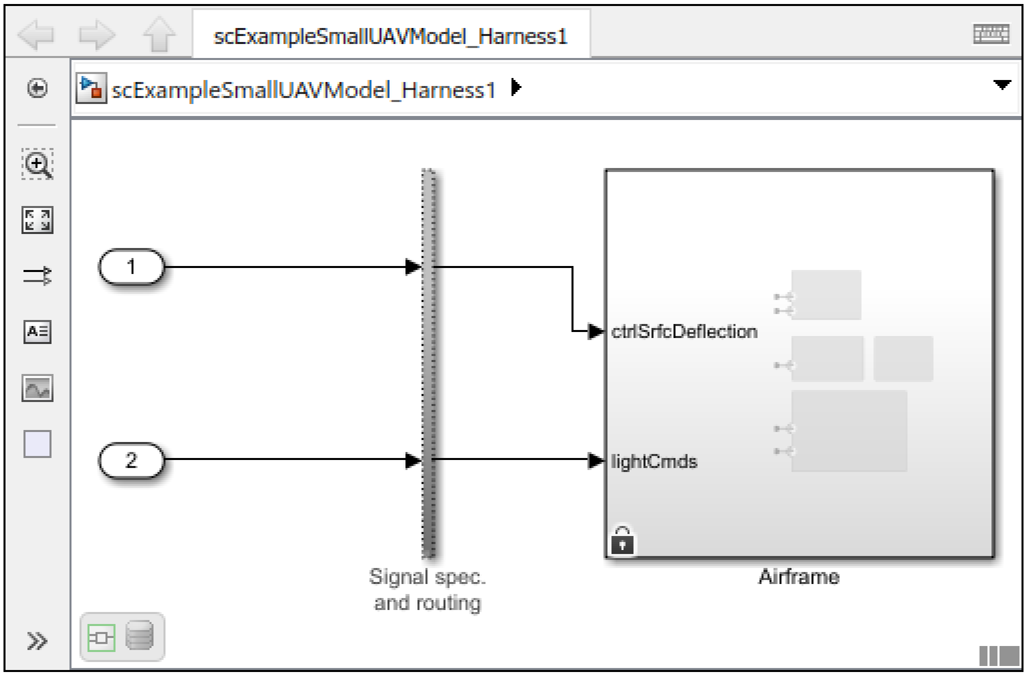
Note Test harnesses are not supported for Adapter blocks in architecture models or Component blocks that contain a Reference Component in software architecture models.

This example uses the architecture model for an unmanned aerial vehicle (UAV) to create a test harness for a System Composer component. In the MATLAB Command Window, enter this command.

```
scExampleSmallUAV
```

To create a test harness for the `Airframe` component, right-click the component and select `Test Harness > Create for 'Airframe'`. In the Create Test Harness dialog box, specify the name of your test harness and click **OK**. Your test harness opens in a new window, and the **Harness** menu is available in the toolstrip.

Tip If the model component is not fully wired and in an early step in the design process, you can select the **Advanced Properties** tab in the Create Test Harness dialog box and select **Create without compiling the model**.


scExampleSmallUAVModel_Harness1
scExampleSmallUAVModel_Harness1
1
2
ctrlSrfcDeflection
lightCmds
Signal spec.
and routing
Airframe

Use the **Test Manager** with the test harness to create test files and test cases. For more information, see “Test Harness and Model Relationship” (Simulink Test) and “Create Test Harnesses and Select Properties” (Simulink Test).

See Also

More About

- “Link and Trace Requirements” on page 2-2
- “Import and Export Architectures” on page 13-2
- “Compose Architectures Visually” on page 1-2
- “Organize System Composer Files in Projects” on page 12-2
- “Design Insulin Infusion Pump Using Model-Based Systems Engineering” on page 9-23

Update Reference Requirement Links from Imported File

After importing requirement links from a file, update links to reference requirements for the model to make full use of the Requirements Toolbox™ functionality.

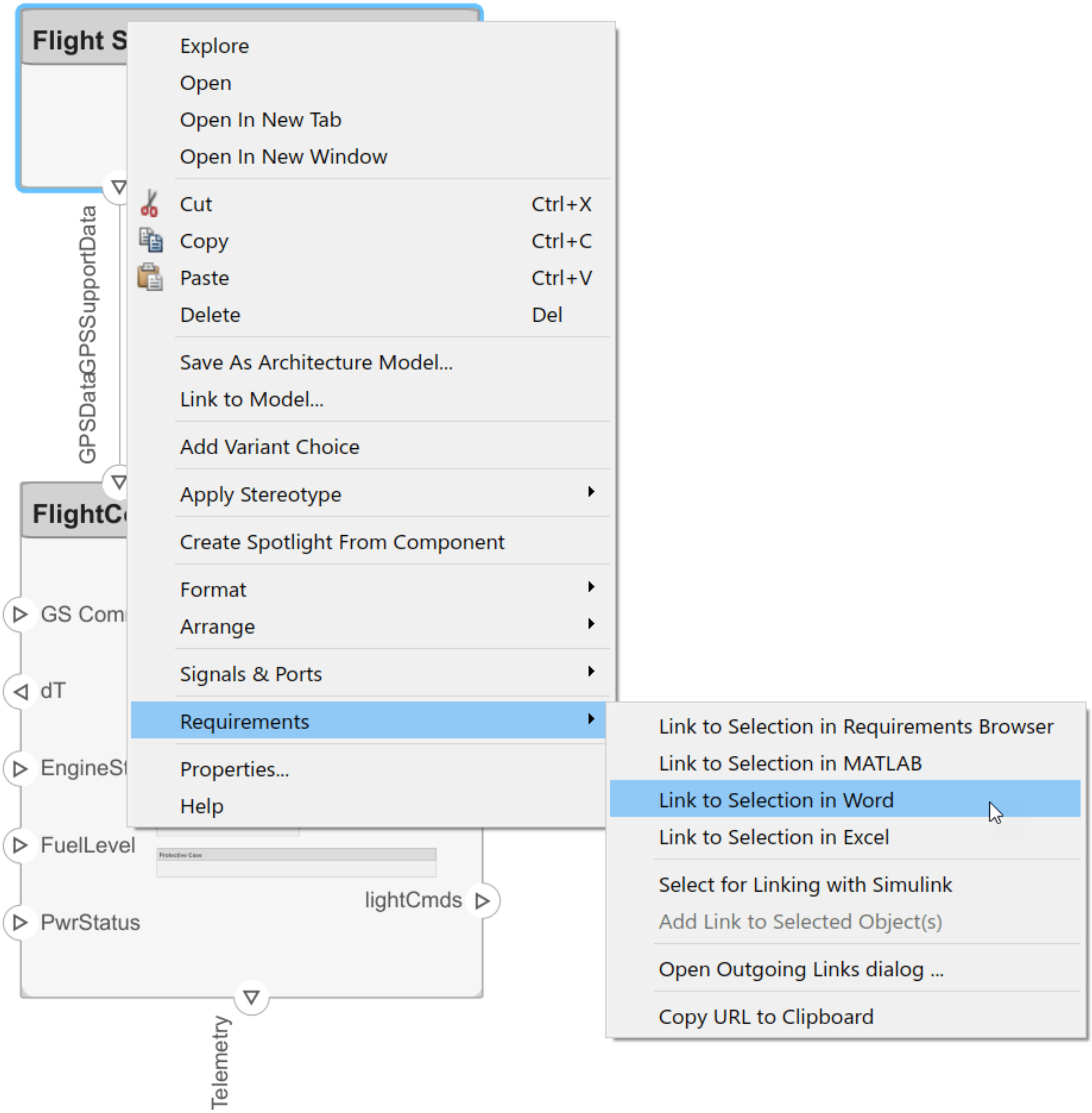
```
model = systemcomposer.openModel("reqImportExample");
```

Note: Importing or linking requirements may not work with a web-based Microsoft® Office file stored in SharePoint or OneDrive. Use a local copy of the file.

Import Requirement Links from Word File

Open the Microsoft® Word file `Functional_Requirements.docx` with the requirements listed. Highlight the requirement to link.

In the model, select the component to which to link the requirement. Right-click the component and select **Requirements > Link to Selection in Word**.



Export Model and Save to External File

Export the model and save to an external file.

```
exportedSet = systemcomposer.exportModel("reqImportExample");
SaveToExcel("exportedModel",exportedSet);
```

Import Requirement Links from File and Import to Model

Use the external file to import requirement links into another model.

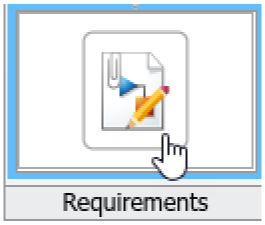
```
structModel = ImportModelFromExcel("exportedModel.xls","Components","Ports", ...
"Connections","PortInterfaces","RequirementLinks");
structModel.readTableFromExcel

systemcomposer.importModel("reqNewExample",structModel.Components, ...
structModel.Ports,structModel.Connections,structModel.Interfaces,structModel.RequirementLinks);
```

Update Links to Reference Requirements

To integrate the requirement links to the model, update references within the model.

```
systemcomposer.updateLinksToReferenceRequirements("reqNewExample","linktype_rmi_word","Functiona
```

Open the **Requirements** perspective from the bottom right corner of the model palette to view the requirements.



See Also

`importModel` | `exportModel` | `updateLinksToReferenceRequirements`

More About

- “Link and Trace Requirements” on page 2-2
- “Manage Requirements” on page 2-8
- “Import and Export Architecture Models” on page 13-5
- “Custom Link Types” (Requirements Toolbox)

Interface Management

Define Port Interfaces Between Components

A systems engineering solution in System Composer includes a formal definition of the interfaces between components. A connection shows that two components have an output-to-input relationship, and an interface defines the type, dimensions, units, and structure of the data.

A data interface defines the kind of information that flows through a port. The same interface can be assigned to multiple ports. A data interface can be composite, meaning that it can include data elements that describe the properties of an interface signal.

Data interfaces represent the information that is shared through a connector and enters or exits a component through a port. Use the **Interface Editor** to create and manage data interfaces and data elements and store them in an interface data dictionary for reuse between models.

A data element describes a portion of an interface, such as a communication message, a calculated or measured parameter, or other decomposition of that interface.

Data interfaces are decomposed into data elements:

- Pins or wires in a connector or harness.
- Messages transmitted across a bus.
- Data structures shared between components.

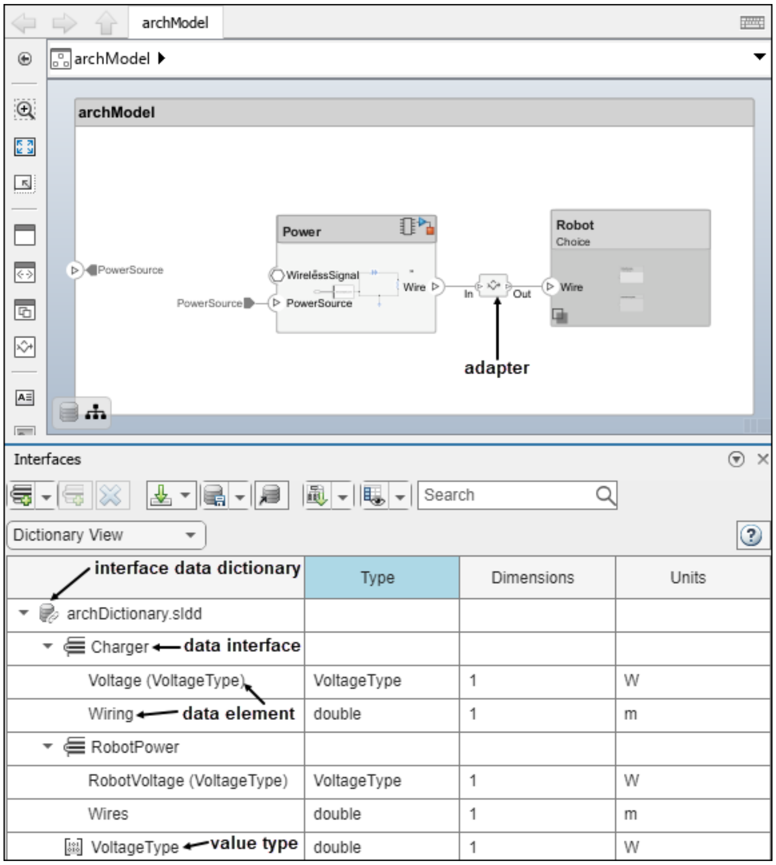
A value type can be used as a port interface to define the atomic piece of data that flows through that port and has a top-level type, dimension, unit, complexity, minimum, maximum, and description.

You can also assign the type of data elements in data interfaces to value types. Add value types to data dictionaries using the **Interface Editor** so that you can reuse the value types as interfaces or data elements.

Use interfaces to describe information transmitted across connections through ports between components.

- “Create Interfaces” on page 3-4: Design interfaces and nested interfaces in the **Interface Editor** with data interfaces, data elements, and value types.
- “Assign Interfaces to Ports” on page 3-9: Assign data interfaces and data elements to ports. Define owned interfaces local to ports.
- “Manage Interfaces with Data Dictionaries” on page 3-21: Save external interface data dictionaries to reuse between different models, link data dictionaries to architecture models, and delete data interfaces from data dictionaries.
- “Reference Data Dictionaries” on page 3-23: Reference data dictionaries so you can selectively share interface definitions among models. Manage referenced data dictionaries in the **Model Explorer**.
- “Interface Adapter” on page 3-16: Use an Adapter block to help connect two components with incompatible port interfaces by mapping between the two interfaces. Use the Interface Adapter dialog by double-clicking the Adapter block to map between interfaces, apply an interface conversion that breaks algebraic loops with unit delays, insert a rate transition for different sample time rates, or use the Adapter block as a Merge block to merge message lines for architecture models or both message and signal lines for software architecture models. When output interfaces are undefined, you can use input interfaces in bus creation mode of the Interface Adapter to author owned output interfaces as you work.

The architecture model below represents an adapter, an interface data dictionary, a data interface, a data element, and a value type.



	Type	Dimensions	Units
archDictionary.sldd			
Charger			
Voltage (VoltageType)	VoltageType	1	W
Wiring	double	1	m
RobotPower			
RobotVoltage (VoltageType)	VoltageType	1	W
Wires	double	1	m
VoltageType	double	1	W

Note System Composer interfaces mirror Simulink interfaces that use buses and value types. For more information, see “Simplify Subsystem and Model Interfaces with Bus Element Ports”, “Specify Application-Specific Signal Properties”, and “Implement Component Behavior Using Simulink” on page 7-2.

See Also

More About

- “Specify Physical Interfaces on Ports” on page 7-24
- “Author Service Interfaces for Client-Server Communication” on page 10-41
- “Modeling System Architecture of Small UAV” on page 1-32
- “Modeling System Architecture of Keyless Entry System” on page 11-25

Create Interfaces

In this section...

You can create interfaces between components in System Composer to structure transmitted data. Use composite data interfaces with data elements or value types to manage data defined on ports. Assign a data interface or value type to a data element so the data element inherits attributes and reuses data. Use the model below as a starting point before adding interfaces using the **Interface Editor**. For interfaces terminology, see "Define Port Interfaces Between Components" on page 3-2.

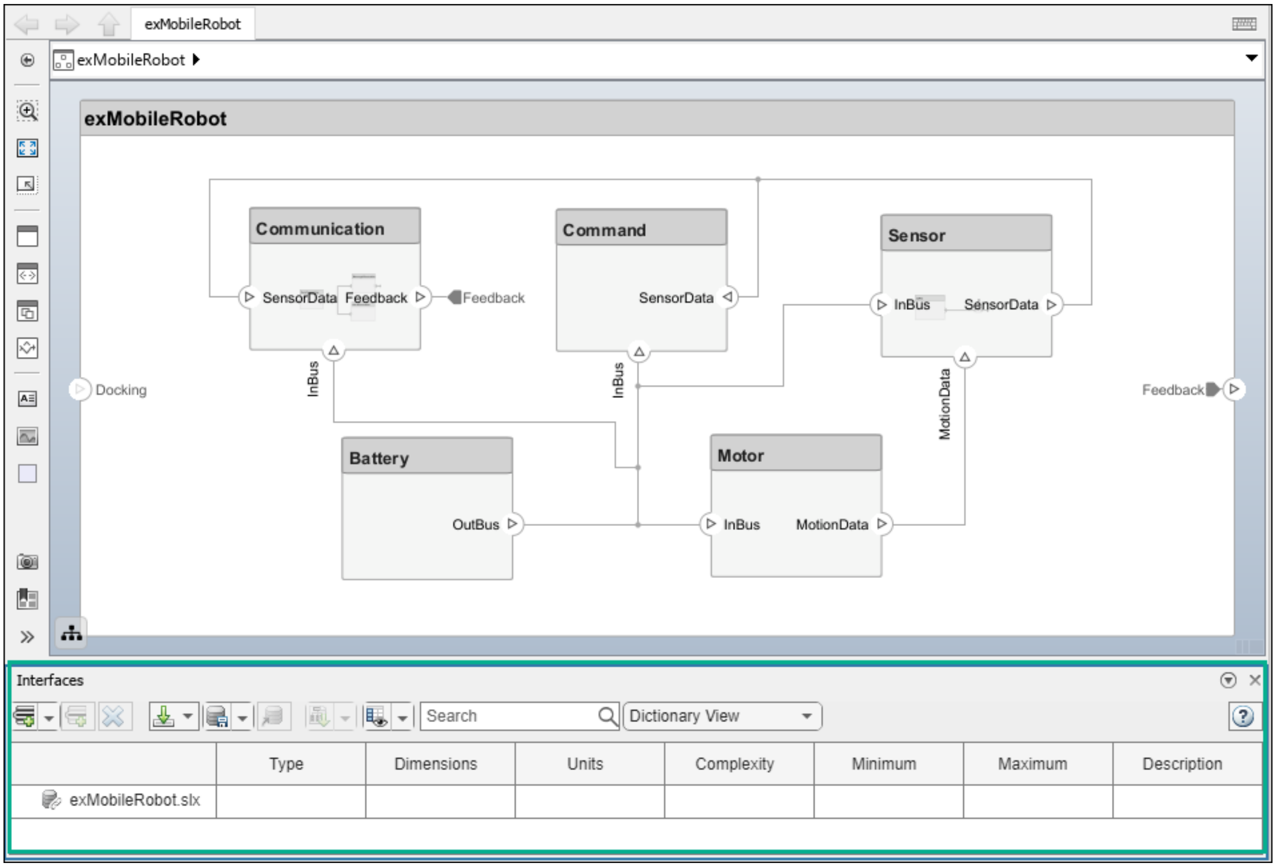
To manage interfaces shared between models in data dictionaries, see "Manage Interfaces with Data Dictionaries" on page 3-21. For information on physical interfaces, see "Specify Physical Interfaces on Ports" on page 7-24.

Mobile Robot Architecture Model

This example shows a mobile robot platform architecture.

Open Interface Editor

To open the **Interface Editor**, navigate to **Modeling > Interface Editor**. The **Interface Editor** will open at the bottom of the canvas.

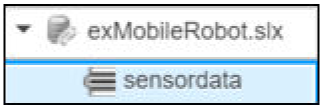


	Type	Dimensions	Units	Complexity	Minimum	Maximum	Description
exMobileRobot.slx							

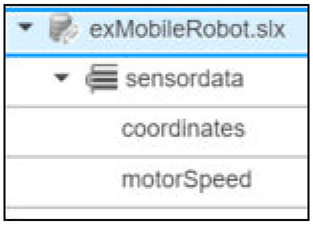
Note The System Composer **Interface Editor** is a web-based widget and might appear blank when you first launch it. If this occurs, save the model and relaunch MATLAB with the command line option `-cefdisablegpu`.

Create Composite Data Interfaces

To add a new data interface definition, click the icon. Name the data interface `sensordata`.

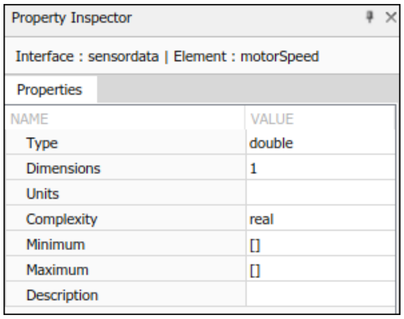


To add a data element to the data interface, click the icon. Data interface and data element names must be valid MATLAB variable names.



You can delete data interfaces and data elements in the **Interface Editor** using the ☒ button.

You can view and edit the properties of an element in the **Property Inspector**. Right-click the data element and select **Inspect Properties**. For data interfaces, use the **Property Inspector** to apply stereotypes.



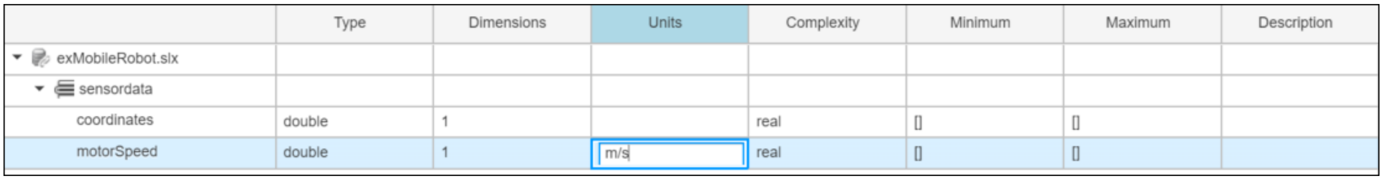
Property Inspector

Interface : sensordata | Element : motorSpeed

Properties

NAME	VALUE
Type	double
Dimensions	1
Units	
Complexity	real
Minimum	[]
Maximum	[]
Description	

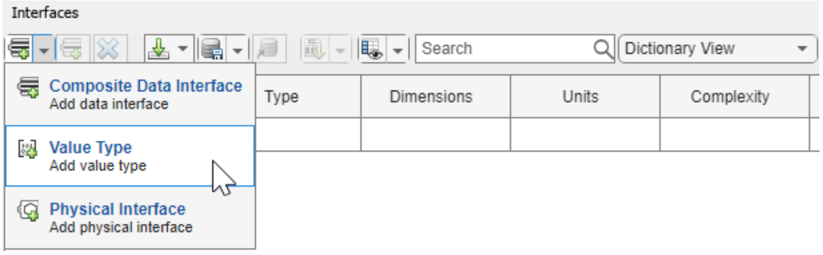
For a comparative view, you can edit data element properties from the relevant Interface Editor columns.



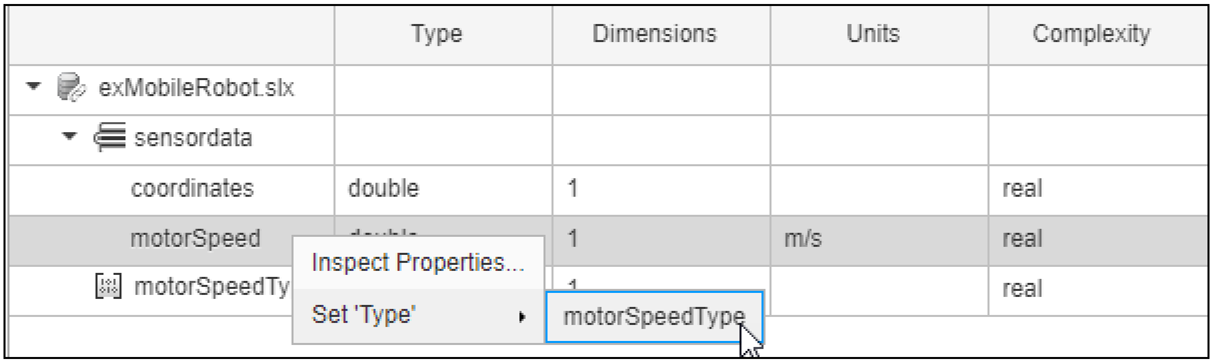
	Type	Dimensions	Units	Complexity	Minimum	Maximum	Description
exMobileRobot.slx							
sensordata							
coordinates	double	1		real	[]	[]	
motorSpeed	double	1	m/s	real	[]	[]	

Create Value Types as Interfaces

To add a value type in the **Interface Editor**, select the down arrow next to the ▤ icon and select **Value Type**. Name the value type `motorSpeedType`. Value type names must be valid MATLAB variable names.



Right-click the `motorSpeed` data element and select **Set 'Type' > motorSpeedType**. The data element `motorSpeed` is assigned to the value type `motorSpeedType`.



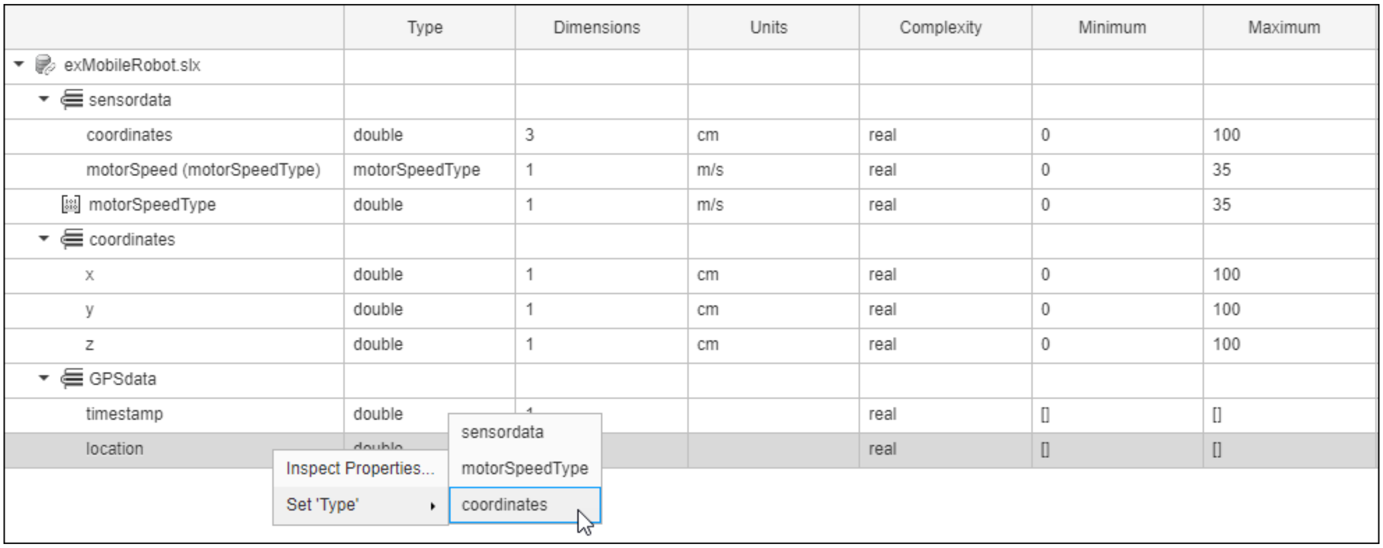
	Type	Dimensions	Units	Complexity
exMobileRobot.slx				
sensordata				
coordinates	double	1		real
motorSpeed	double	1	m/s	real
motorSpeedTy		1		real

Any data changes on the `motorSpeedType` value type is propagated to the `motorSpeed` data element. You can reuse value types any number of times. Data changes on a value type will propagate to each data element that uses the value type.

Nest Interfaces to Reuse Data

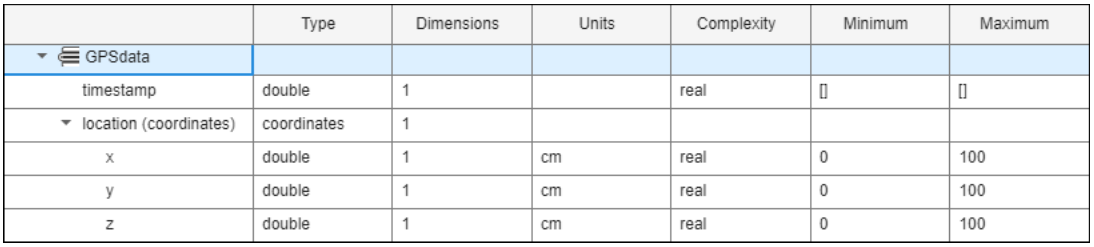
A nested interface contains another data interface. Create a nested data interface by assigning a data interface as the type of a data element. For information about the corresponding buses, see “Create Bus Objects Using Type Editor”.

For example, let `coordinates` be a data interface that consists of `x`, `y`, and `z` coordinates. The `GPSdata` data interface includes `location` and a `timestamp`. If the `location` data element is in the same format as the `coordinates` interface, you can set its type to `coordinates`. Right-click `location` and select **Set 'Type'** > **coordinates**. The available interface options include all value types and all data interfaces in the model, except the parent of the data element.



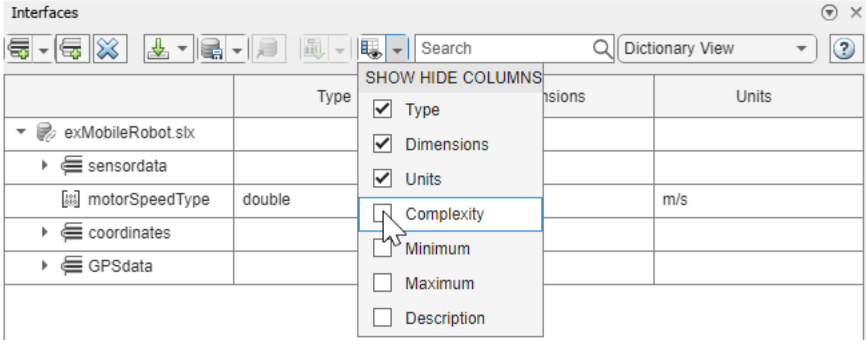
	Type	Dimensions	Units	Complexity	Minimum	Maximum
exMobileRobot.slx						
sensordata						
coordinates	double	3	cm	real	0	100
motorSpeed (motorSpeedType)	motorSpeedType	1	m/s	real	0	35
motorSpeedType	double	1	m/s	real	0	35
coordinates						
x	double	1	cm	real	0	100
y	double	1	cm	real	0	100
z	double	1	cm	real	0	100
GPSdata						
timestamp	double	1		real	[]	[]
location	double			real	[]	[]

The nested data interface displays the inherited data elements.



	Type	Dimensions	Units	Complexity	Minimum	Maximum
GPSdata						
timestamp	double	1		real	[]	[]
location (coordinates)	coordinates	1				
x	double	1	cm	real	0	100
y	double	1	cm	real	0	100
z	double	1	cm	real	0	100

Note To change the number of columns that display in the **Interface Editor**, click the icon. Select or clear the desired columns to show or hide them.



SHOW HIDE COLUMNS

- ☑ Type
- ☑ Dimensions
- ☑ Units
- □ Complexity
- □ Minimum
- □ Maximum
- □ Description

	Type	...nsions	Units
exMobileRobot.slx			
sensordata			
motorSpeedType	double		m/s
coordinates			
GPSdata			

See Also

Functions

addInterface | removeInterface | addElement | removeElement | connect | setInterface | addValueType

Blocks

Component

More About

- “Define Port Interfaces Between Components” on page 3-2
- “Specify Physical Interfaces on Ports” on page 7-24
- “Modeling System Architecture of Small UAV” on page 1-32

Assign Interfaces to Ports

In this section...

A port interface describes the data that can be passed between ports in a System Composer architecture model. Data elements within the interface describe characteristics of the data transmitted across the interface. Data elements can describe the composition of a data interface, messages transmitted, or data structures shared between components. For interfaces terminology, see “Define Port Interfaces Between Components” on page 3-2.

This topic will show you how to:

- Use the **Property Inspector** to assign data interfaces to one port at a time or the **Interface Editor** to assign data interfaces to multiple ports.
- Manage owned interfaces that are local to a port and not shared in a data dictionary.
- Assign interfaces to multiple ports at the same time.
- Connect components through ports and specify the source element or the destination element for the connection.
- Use the interface compatibility edit-time check.

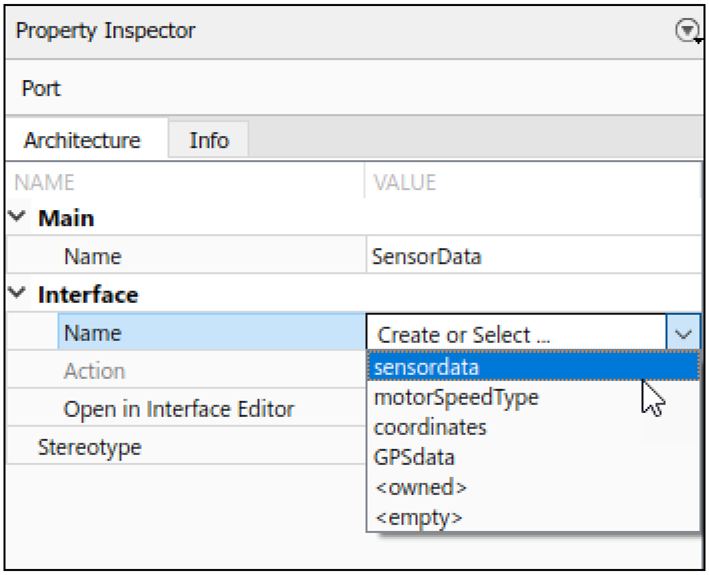
Incompatible data interfaces on either end of a connection can be reconciled with an Adapter block using the “Interface Adapter” on page 3-16. To manage interfaces shared between models in data dictionaries, see “Manage Interfaces with Data Dictionaries” on page 3-21. For information on physical interfaces, see “Specify Physical Interfaces on Ports” on page 7-24.

Mobile Robot Architecture Model with Interfaces

This example shows a mobile robot hardware architecture with interfaces defined.

Associate Ports with Interfaces in Property Inspector

To assign data interfaces or value types to one port at a time, use the **Property Inspector**. To open the **Property Inspector**, navigate to **Modeling** > **Property Inspector**. To show the `SensorData` port properties, select the port in the model. Expand **Interface**, and from the **Name** list, select `sensordata` to associate the `sensordata` interface with the `SensorData` port.



Assign Interfaces to Ports Using the Context Menu

After you select an interface from the **Interface Editor**, right-click a port. If the selected interface is compatible with the port, select `Apply selected interface: <interface name>` to assign the interface to the port. If a port already has an interface assigned, when you right click the port, you can select `Clear interface: <interface name>` to remove the interface.

After you select a port from the architecture canvas, right-click an interface on the **Interface Editor**. To assign the interface to the port, select `Assign to Selected Port(s)`.

Define Owned Interfaces Local to Ports

You can select a value type or data interface from the model data dictionary in the **Property Inspector**, or you can create an owned interface.

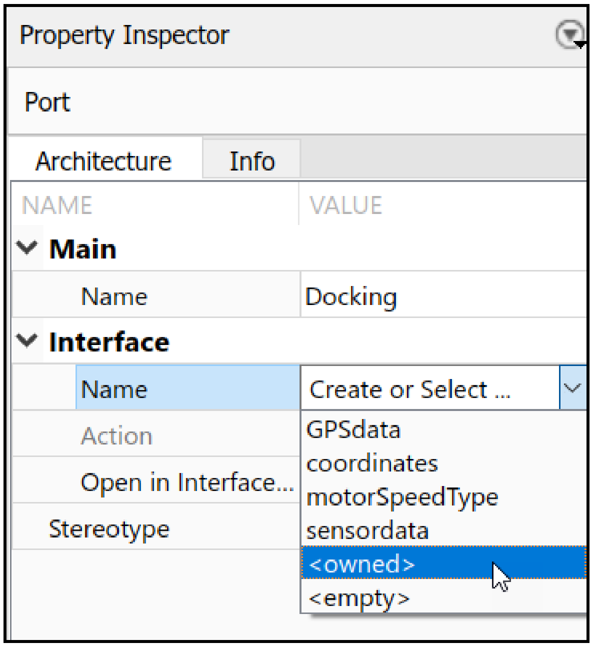
An owned interface is an interface that is local to a specific port and not shared in a data dictionary or the model dictionary.

Create an owned interface to represent a value type or data interface that is local to a port.

Note Owned interfaces and value types do not have their own names because they are local to a port and not shared. The name of the owned interface is derived from the port name.

Manage Owned Interfaces Using Property Inspector

You can edit the data for the owned interface in the **Property Inspector**. Select the `Docking` architecture port. In the **Property Inspector**, under **Interface**, from the **Name** list, select <owned>.

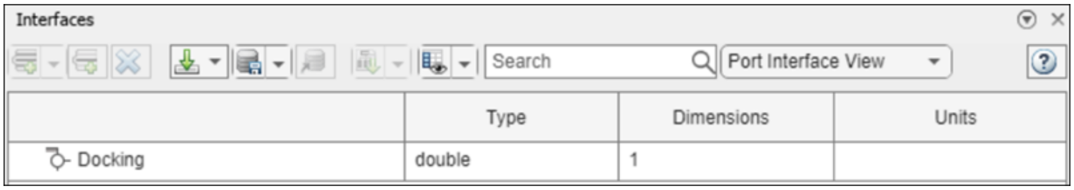


Property Inspector

Port

NAME	VALUE
Main	
Name	Docking
Interface	
Name	Create or Select ...
Action	
Open in Interface...	
Stereotype	

By default, the owned interface `Docking` becomes an owned value type. Edit interface attributes directly in the **Property Inspector**, or select `Open in Interface Editor` to edit the owned value type interface.



Interfaces

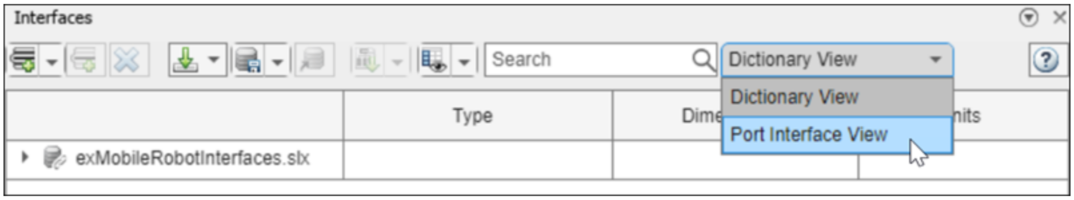
Port Interface View

	Type	Dimensions	Units
Docking	double	1	

To convert the owned value type into an owned data interface, click to add a data element.

Manage Owned Interfaces Using Interface Editor

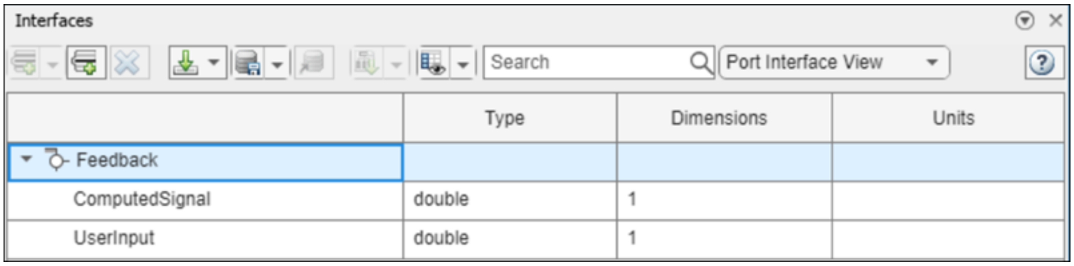
You can also work exclusively from the **Interface Editor**. Select the component port named `Feedback`. In the **Interface Editor**, change from `Dictionary View` to `Port Interface View`.



Interfaces

Dictionary View

Click to add data elements to the owned data interface.



	Type	Dimensions	Units
Feedback			
ComputedSignal	double	1	
UserInput	double	1	

To convert the owned data interface to an owned value type, change the **Type** for `Feedback` to a valid MATLAB data type, such as `double`.

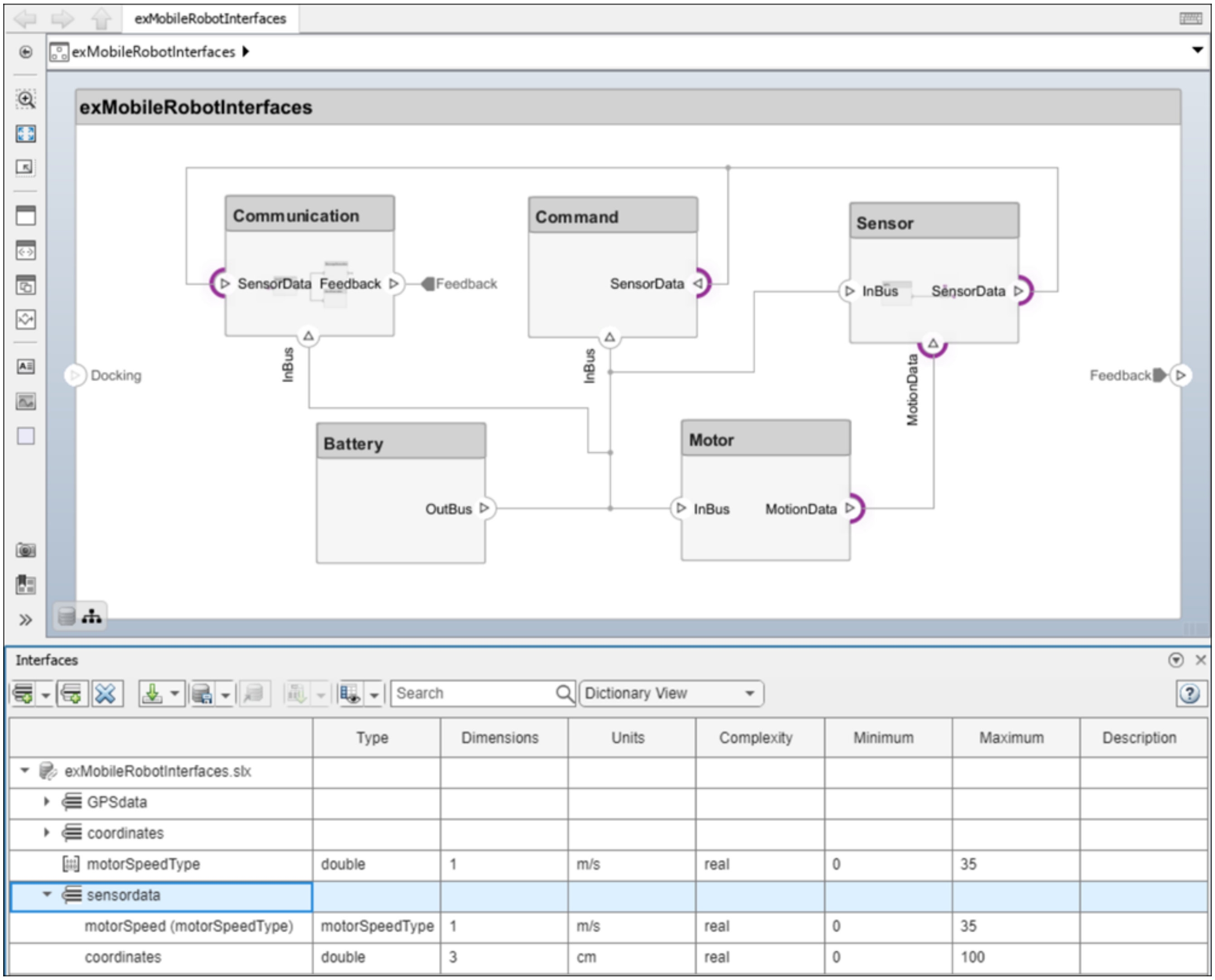
Make Owned Interfaces into Shared Interfaces

To convert an owned interface into a shared interface, right-click the port with the owned interface and select `Convert to shared interface`. Alternatively, use the `makeOwnedInterfaceShared` function.

Select Multiple Ports and Assign Data Interface

Multiple ports, whether they are connected or not, can use the same data interface definition. When you assign a data interface to a port, the interface is automatically propagated to connected ports, provided they do not already have assignments. To simplify batch assignments, select multiple ports, right-click the data interface, and select `Assign to Selected Port(s)`.

Highlight the ports that use a data interface definition by clicking the interface name in the **Interface Editor**.

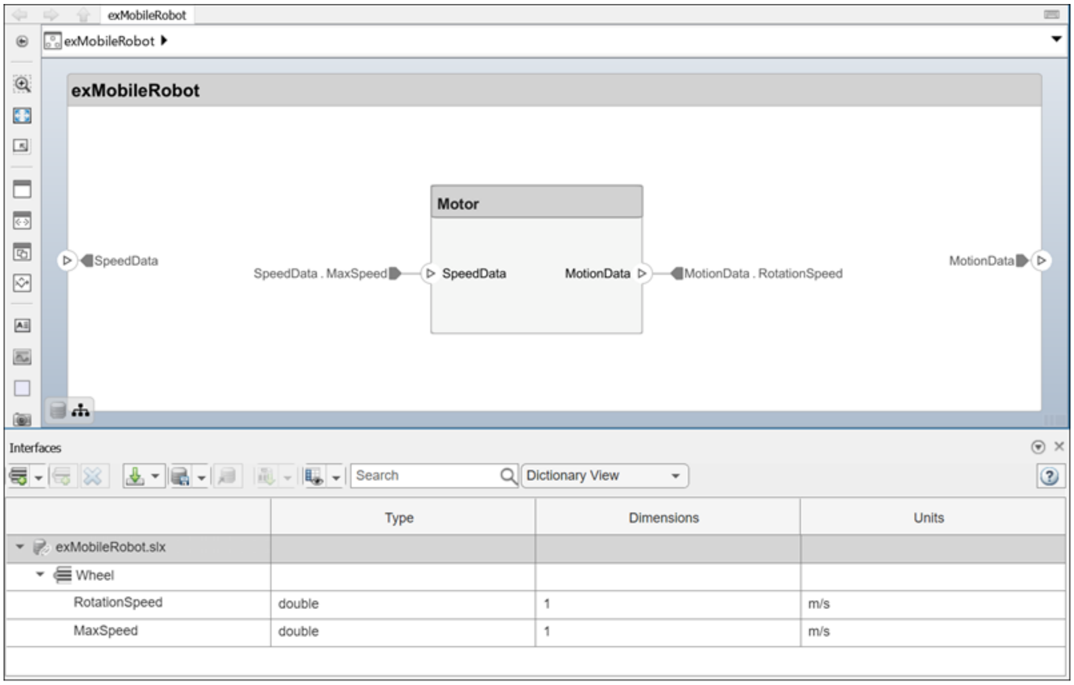


	Type	Dimensions	Units	Complexity	Minimum	Maximum	Description
exMobileRobotInterfaces.slx							
GPSdata							
coordinates							
motorSpeedType	double	1	m/s	real	0	35	
sensordata							
motorSpeed (motorSpeedType)	motorSpeedType	1	m/s	real	0	35	
coordinates	double	3	cm	real	0	100	

Specify Source Element or Destination Element for Ports

For connections between the root architecture and a component within the architecture model, you can add a source element or destination element to the ports.

1. Create a component called `Motor` and connect it to the root architecture with ports named `MotionData` and `SpeedData`.
2. Define the data interface `Wheel` with the data elements `RotationSpeed` and `MaxSpeed`.
3. Assign the `Wheel` data interface to the ports on the connection.
4. Select the `MotionData` port name on the component. A dot and a list of data elements appear. From the list, select the source element `RotationSpeed`.
5. Assign the `MaxSpeed` destination element to the `SpeedData` port.



	Type	Dimensions	Units
exMobileRobot.slx			
Wheel			
RotationSpeed	double	1	m/s
MaxSpeed	double	1	m/s

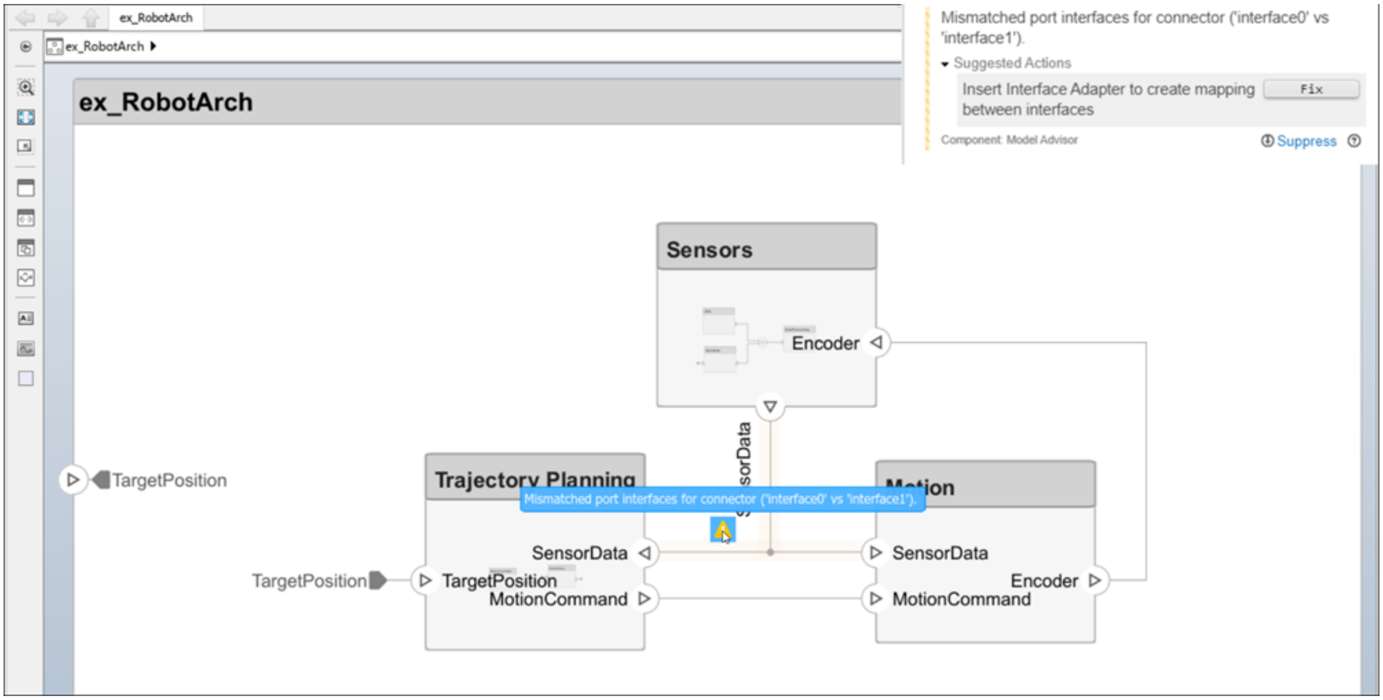
Enable Interface Compatibility Edit-Time Check

Edit-time checks report warnings as you build the model and require a Simulink Check™ license. Types of warnings for interface compatibility include:

- Shared interfaces defined in an interface data dictionary are incompatible across ports on a connection if different interfaces are assigned to different ports.
- Owned interfaces defined locally on ports are incompatible across ports on a connection if the value type or data elements do not have the same structure.

To enable edit-time checks on your architecture model, navigate to **Modeling > Model Advisor > Edit-Time Checks**. Select the **Edit-Time Checks** check box.

Connectors highlighted in yellow signify an interface mismatch between different ports on the same connector. If you click the warning symbol, you see the edit-time check message and a suggestion for what to do.



Mismatched port interfaces for connector ('interface0' vs 'interface1').

Suggested Actions

Insert Interface Adapter to create mapping between interfaces

Component: Model Advisor

Mismatched port interfaces for connector ('interface0' vs 'interface1').

For incompatible interfaces on different ports on the same connection, such as different data interfaces, you can fix the problem by adding an Adapter block to define interface mappings.

See Also

Functions
`connect` | `getDestinationElement` | `getSourceElement` | `createOwnedType` | `createInterface` | `makeOwnedInterfaceShared`

Blocks
Component | Adapter

More About

- “Define Port Interfaces Between Components” on page 3-2
- “Specify Physical Interfaces on Ports” on page 7-24
- “Modeling System Architecture of Small UAV” on page 1-32

Interface Adapter

A source port and its destination port may be defined by different data interfaces. Such a connection can represent an intermediate point in design, where components from different sources come together. To connect components with different data interfaces, use an Adapter block and the Interface Adapter dialog. For interfaces terminology, see “Define Port Interfaces Between Components” on page 3-2.

An *adapter* helps connect two components with incompatible port interfaces by mapping between the two interfaces. Use the Adapter block to implement an adapter. Open the Interface Adapter by double-clicking an Adapter block on the connection between the ports.

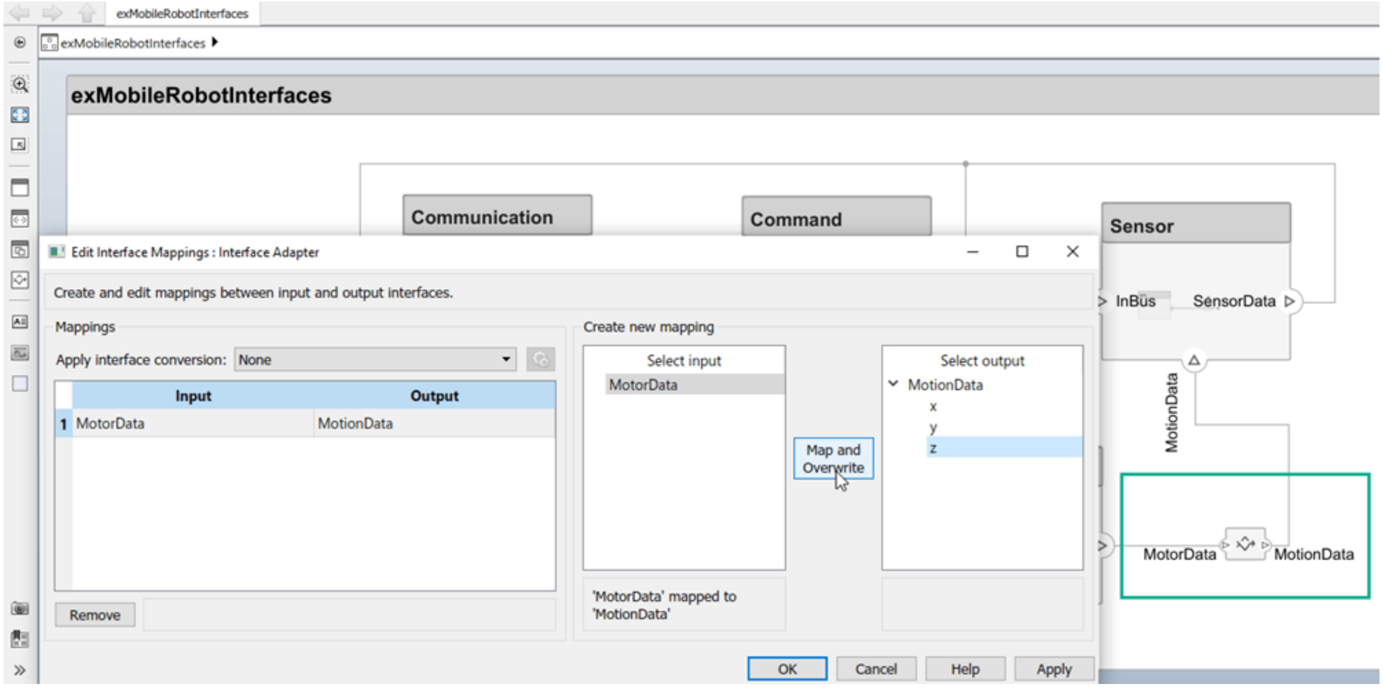
Use the Interface Adapter in System Composer™ to map interface elements between two ports. You can also use the Interface Adapter to apply an interface conversion that breaks algebraic loops with unit delays, inserts a rate transition for different sample time rates, or merges two or more message or signal lines. When output interfaces are undefined, you can use input interfaces in bus creation mode of the Interface Adapter to author owned output interfaces.

```
systemcomposer.openModel("exMobileRobotInterfaces");
```

Map Incompatible Interfaces

When two connected components with Simulink® behaviors have incompatible interfaces, use an Adapter block and the Interface Adapter to define the port connections.

1 Add an Adapter block on the connection between the two components.
2 Double-click the block to open the Interface Adapter dialog box.
3 In the **Select input** box, select a data element. In the **Select output** box, select a data element.
4 Click the **Map and Overwrite** button.



Edit Interface Mappings : Interface Adapter

Create and edit mappings between input and output interfaces.

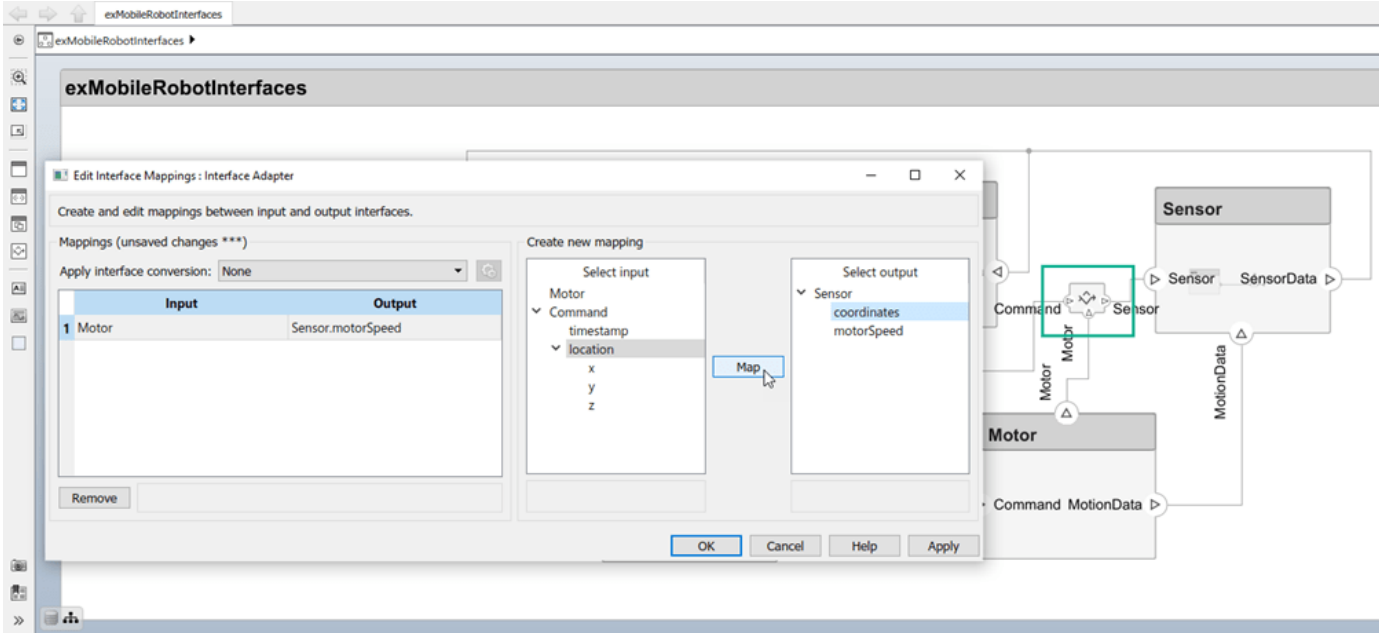
Apply interface conversion: None

	Input	Output
1	MotorData	MotionData

'MotorData' mapped to 'MotionData'

You can use an Adapter block to map similar interfaces for an `N:1` connection, which is an Adapter with more than one input port and a single output port. A data element from each input connection maps to the output connection data elements.

Change the number of input ports on an Adapter block in the same way you add and remove component ports. For more information, see “Compose Architectures Visually” on page 1-2.



exMobileRobotInterfaces

Edit Interface Mappings : Interface Adapter

Create and edit mappings between input and output interfaces.

Mappings (unsaved changes ***)

Apply interface conversion: None

	Input	Output
1	Motor	Sensor.motorSpeed

Use Unit Delay to Break Algebraic Loop

When connecting two components with port connections in both directions, an algebraic loop can occur. To break the algebraic loop, use an Adapter block to insert a unit delay between the components.

1. Add an Adapter block on the connection between the two components.
2. Double-click the block to open the Interface Adapter dialog box.
3. From the **Apply interface conversion** list, select `UnitDelay`.

Use Rate Transition Between Simulink Behaviors

When connecting two reference components, the Simulink models the components reference can have different sample time rates. For compatibility, use an Adapter block to insert a rate transition between the components.

1. Add an Adapter block on the connection between the two components.
2. Double-click the block to open the Interface Adapter dialog box.
3. From the **Apply interface conversion** list, select `RateTransition`.

Use Adapter Block as Merge Block

Use an Adapter block as a Merge block to merge multiple message lines for system architecture models or merge multiple signal and message lines for software architecture models.

1 Add an Adapter block on the connection between the two components.
2 Double-click the block to open the Interface Adapter dialog box.
3 From the **Apply interface conversion** list, select `Merge`.

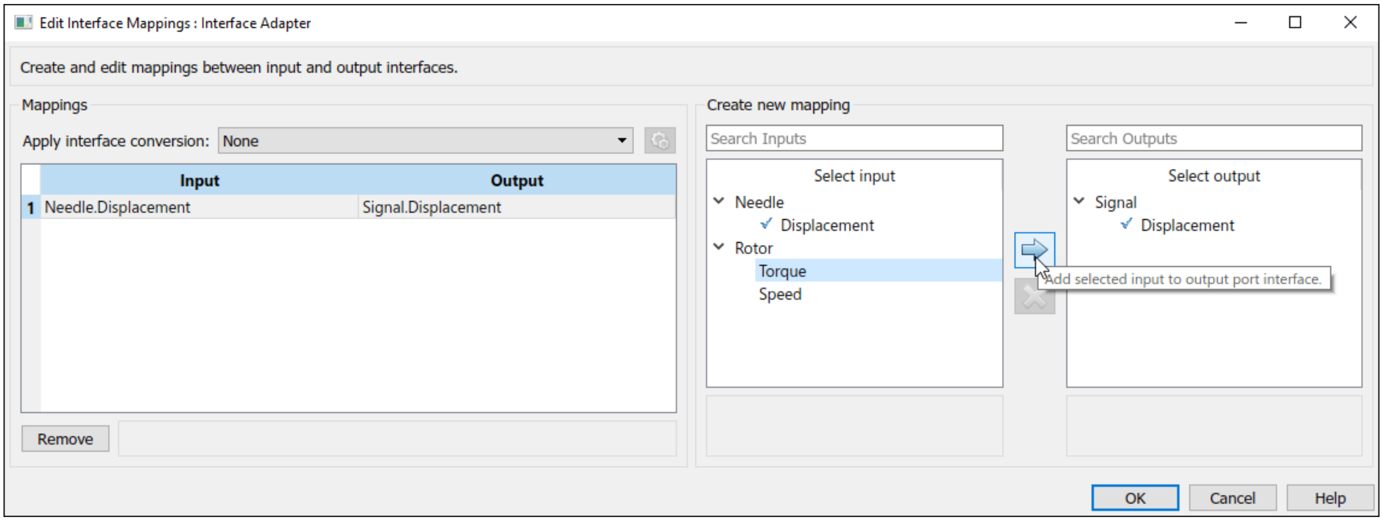
Use Bus Creation Mode to Author Owned Interfaces

When input ports for an Adapter block are typed by interfaces from incoming connections and no interfaces are defined on the output ports of the Adapter, you can use these interface elements to author owned interfaces for outgoing connections. Instead of pre-defining interface structures, you can create the bus structure.

```
systemcomposer.openModel("SewingMachine");
```

1. Double-click the Adapter block to open the Interface Adapter dialog in bus creation mode.

2. Click the ⇨ button to add the input data element `Torque` to the output port interface for the port named `Signal`.



Edit Interface Mappings : Interface Adapter

Create and edit mappings between input and output interfaces.

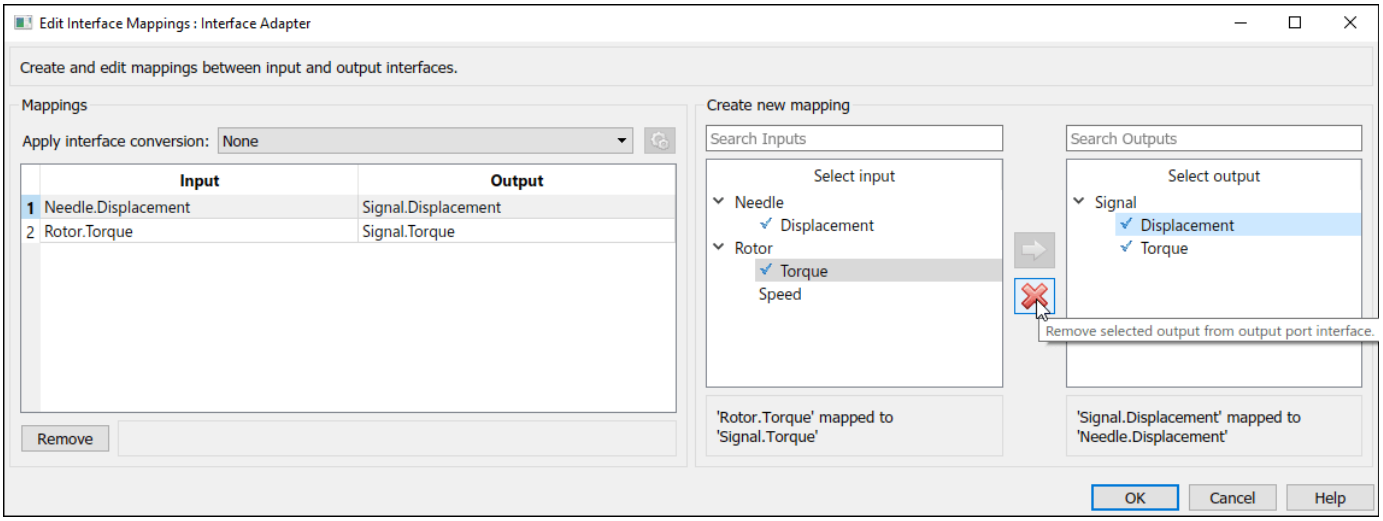
Mappings

Apply interface conversion: None

	Input	Output
1	Needle.Displacement	Signal.Displacement

Create new mapping

3. Click the ✖ button to remove the output data element `Displacement` from the output port interface for the port named `Signal`.



Create and edit mappings between input and output interfaces.

Apply interface conversion: None

	Input	Output
1	Needle.Displacement	Signal.Displacement
2	Rotor.Torque	Signal.Torque

Select input:
- Needle
  - ✓ Displacement
- Rotor
  - ✓ Torque
  - Speed

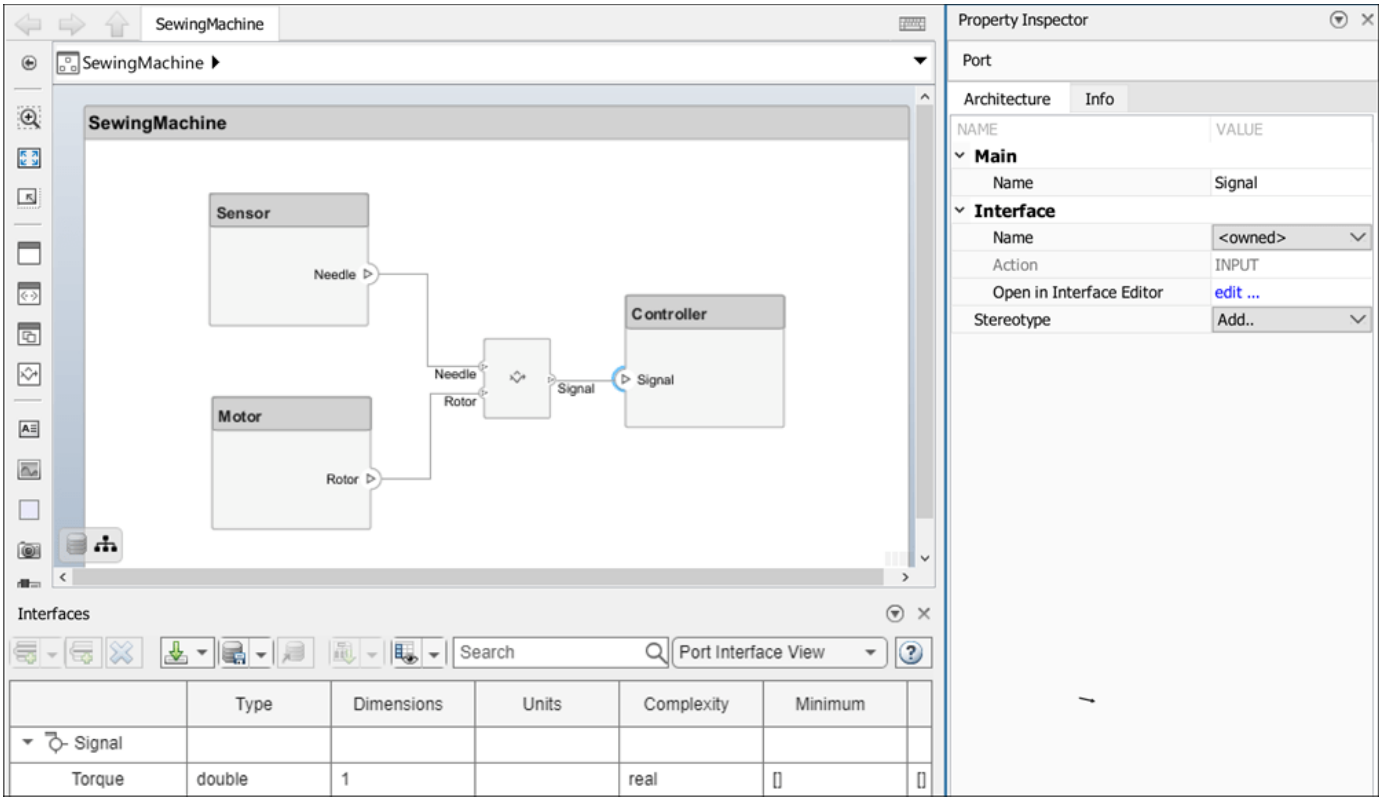
Select output:
- Signal
  - ✓ Displacement
  - ✓ Torque

Remove selected output from output port interface.

'Rotor.Torque' mapped to 'Signal.Torque'

'Signal.Displacement' mapped to 'Needle.Displacement'

4. Click **OK** to apply the changes.



NAME	VALUE
Main	
Name	Signal
Interface	
Name	<owned>
Action	INPUT
Open in Interface Editor	edit ...
Stereotype	Add..

	Type	Dimensions	Units	Complexity	Minimum	
Signal						
Torque	double	1		real	[]	[]

The owned interface on the output port of the Adapter block propagates to the connected input port `Signal` on the `Controller` component. The owned interface contains one element, `Torque`.

To convert an owned interface into a shared interface, right-click the port with the owned interface and select `Convert to shared interface`.

See Also

Blocks
Adapter | `makeOwnedInterfaceShared`

More About

- “Define Port Interfaces Between Components” on page 3-2
- “Merge Message Lines for Architectures Using Adapter Block” on page 7-29
- “Merge Message Lines Using Adapter Block” on page 10-32

Manage Interfaces with Data Dictionaries

Engineering systems often share interface definitions across multiple components or subsystems. Data interfaces in System Composer can be stored either locally in a model or in a data dictionary, depending on the maturity of your system. For interfaces terminology, see "Define Port Interfaces Between Components" on page 3-2.

An interface data dictionary is a consolidated list of all the interfaces and value types in an architecture and where they are used.

Local interfaces on a System Composer model can be saved in an interface data dictionary using the **Interface Editor**. You can reuse interface dictionaries between models that need to use a given set of interfaces, elements, and value types. Linked data dictionaries are stored in separate SLDD files.

For more advanced dictionary referencing techniques, see "Reference Data Dictionaries" on page 3-23.

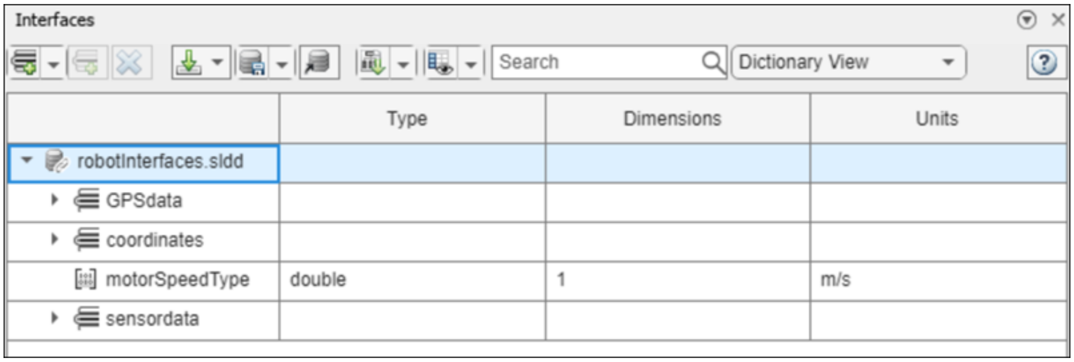
Mobile Robot Architecture Model with Interfaces

This example shows a mobile robot hardware architecture with interfaces defined.

Save, Link, and Delete Interfaces

By default, interfaces are stored within the architecture model and are not visible outside the model. If you are in the initial stages of building a system model, store interfaces locally to limit the number of files that need to be managed. However, if your model is mature to the point of leveraging componentization workflows like reference architectures and behaviors, storing interfaces in a data dictionary gives you the ability to share interface definitions across the model hierarchy.

Use the 🗄 menu to save a data interface to a new or existing data dictionary. To create a new data dictionary, select **Save to new dictionary**. Provide a dictionary name.



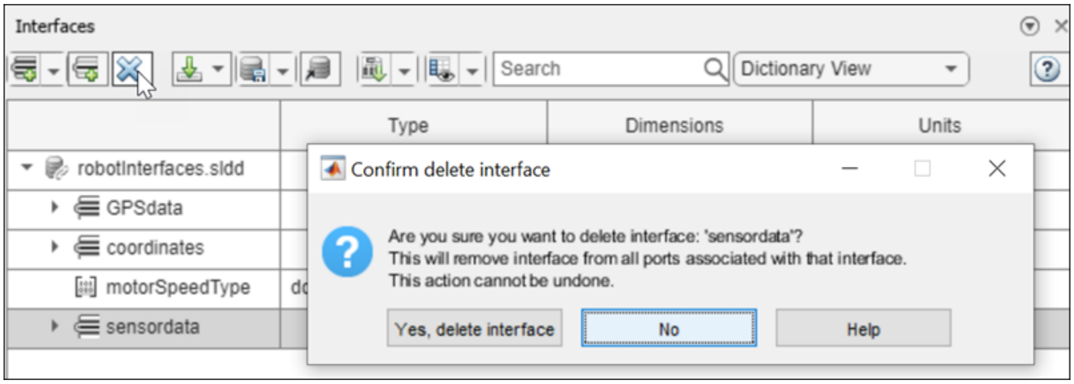
	Type	Dimensions	Units
robotInterfaces.sldd			
GPSdata			
coordinates			
motorSpeedType	double	1	m/s
sensordata			

You can also add the interface definitions in the model to an existing data dictionary by selecting **Link existing dictionary**.

Use the button to import interface definitions from a Simulink bus object, either from a MAT-file or the workspace.

Delete a data interface from a dictionary using the button. If the data interface is already being used by ports in a currently open model, the software returns a warning message. The data interface is then removed from any ports in the open model that are associated with the data interface.

If a data interface is deleted from a dictionary upon opening another model that shares the dictionary, a warning will be presented on startup if the deleted interface is used by ports in that model. The Diagnostic Viewer offers an option to remove the deleted interface from all ports that are still using it. You can also select ports individually and delete their missing interfaces.



Are you sure you want to delete interface: 'sensordata'?
This will remove interface from all ports associated with that interface.
This action cannot be undone.

A System Composer model and a data dictionary are separate artifacts. Even when the data dictionary is linked to the model, changes to the data dictionary (a `.sldd` file) must be saved separately from changes to the model (a `.slx` file). To save changes to a linked data dictionary, use the button and select `Save dictionary`. Once a data dictionary is saved, other models can use its interface definitions by linking to the data dictionary, allowing multiple models to share the same interface definitions.

See Also

`createDictionary` | `openDictionary` | `saveToDictionary` | `linkDictionary` | `unlinkDictionary` | `makeOwnedInterfaceShared`

More About

- “Specify Physical Interfaces on Ports” on page 7-24
- “Define Port Interfaces Between Components” on page 3-2

Reference Data Dictionaries

In this section...

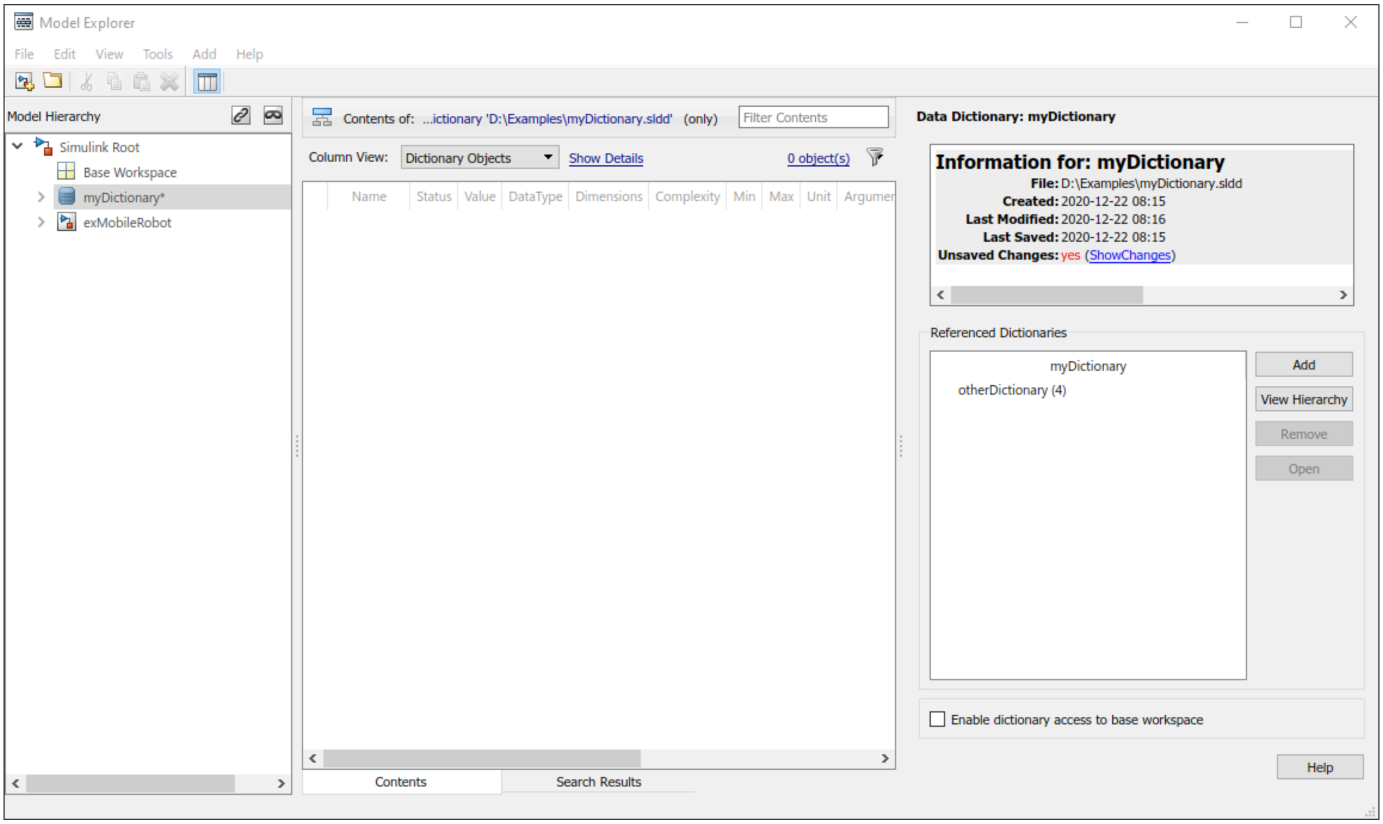
Referenced dictionaries in System Composer may be useful when multiple models need to share some, but not all, interface definitions. and to allow communication between the models. A data dictionary can reference one or more other data dictionaries. The interface definitions in the referenced dictionaries are visible in the parent dictionary and can be used by a model that is linked to the parent dictionary. For interfaces terminology, see “Define Port Interfaces Between Components” on page 3-2.

To create a data dictionary from interfaces in a model dictionary, see “Manage Interfaces with Data Dictionaries” on page 3-21.

Add Referenced Data Dictionaries

To add a dictionary reference, open the **Model Explorer** by clicking , or by navigating to **Modeling** > **Model Explorer**.

On the right side of the **Model Explorer** app, click **Add**, then select the file name of the data dictionary to add as a referenced dictionary. To remove a dictionary reference, highlight the referenced dictionary, then click **Remove**.



Data Dictionary: myDictionary

Information for: myDictionary

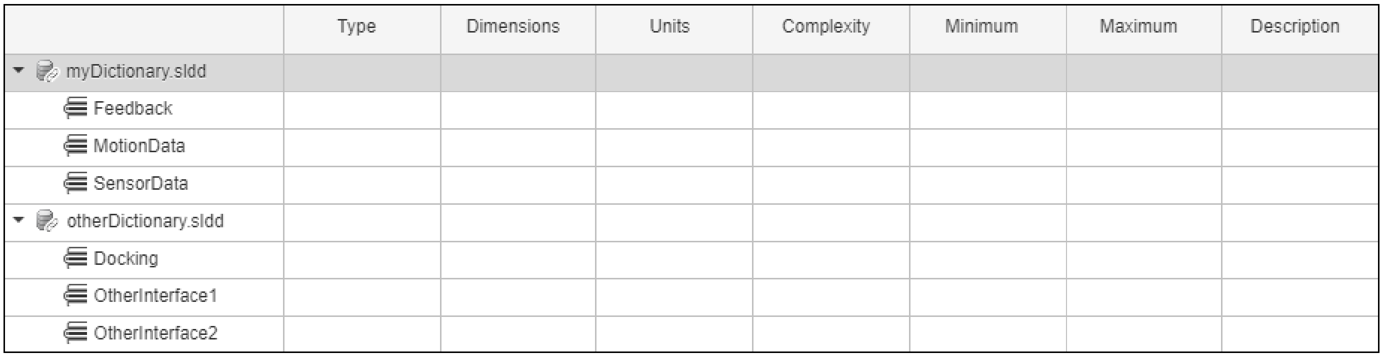
File: D:\Examples\myDictionary.sldd
Created: 2020-12-22 08:15
Last Modified: 2020-12-22 08:16
Last Saved: 2020-12-22 08:15
Unsaved Changes: yes (ShowChanges)

Referenced Dictionaries:

myDictionary
otherDictionary (4)

☐ Enable dictionary access to base workspace

The **Interface Editor** shows all interfaces accessible to a model, grouped based on their data dictionary files. In this example, `myDictionary.sldd` is the data dictionary linked to the model, and `otherDictionary.sldd` is a referenced dictionary.



	Type	Dimensions	Units	Complexity	Minimum	Maximum	Description
▾ myDictionary.sldd							
Feedback							
MotionData							
SensorData							
▾ otherDictionary.sldd							
Docking							
OtherInterface1							
OtherInterface2							

The model can use any of the interfaces listed. You can modify the contents of referenced dictionaries in the **Interface Editor**.

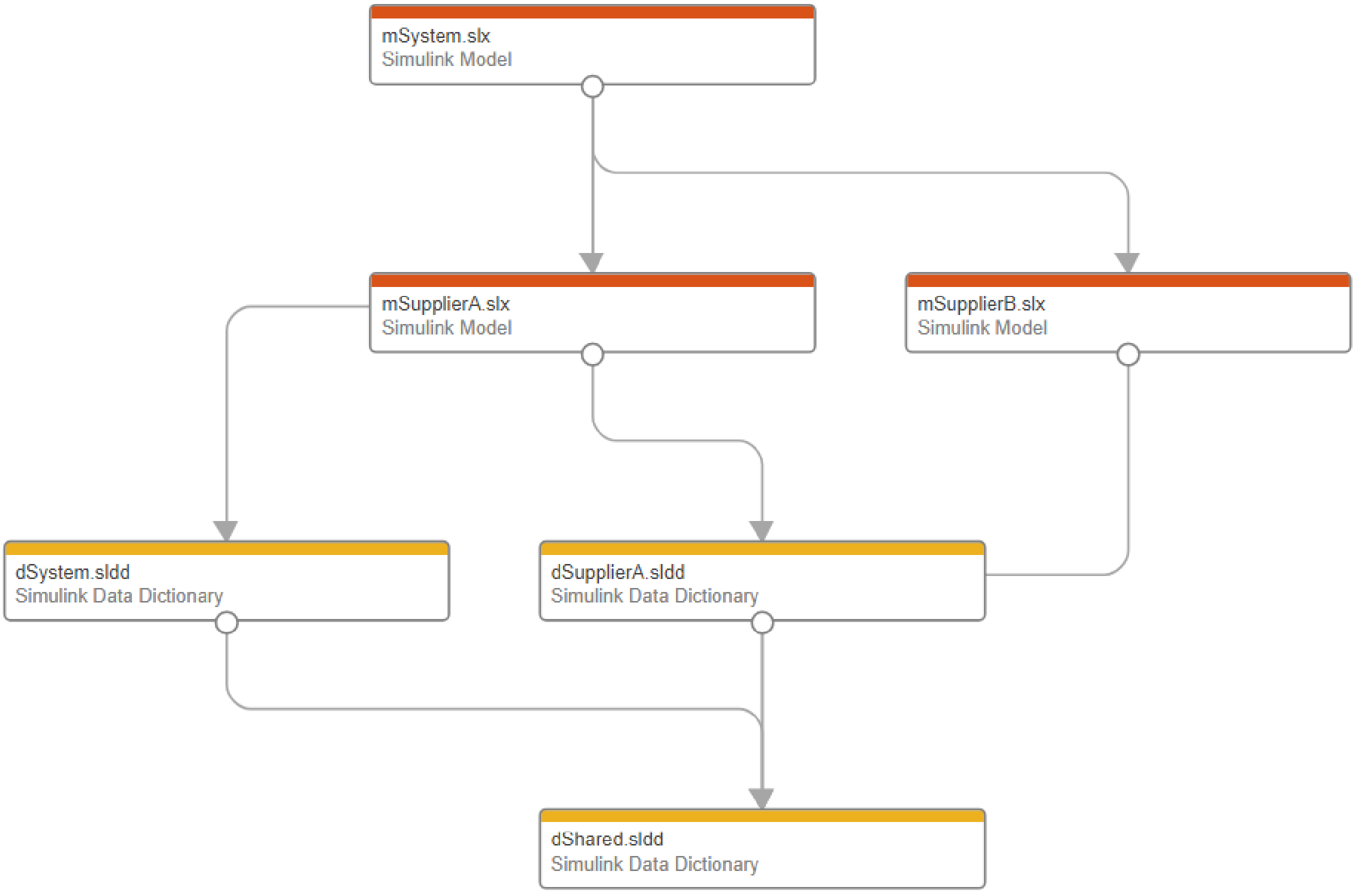
Note Referenced dictionaries can reference other data dictionaries. A model that links to a dictionary has access to all interface definitions in referenced dictionaries, including indirectly referenced dictionaries.

Use Referenced Data Dictionaries for Projects with Multiple Models

A project may contain multiple models, and it may be useful for the models to share interface definitions that are relevant to data flows and other communications between models. For more information, see “Organize System Composer Files in Projects” on page 12-2,

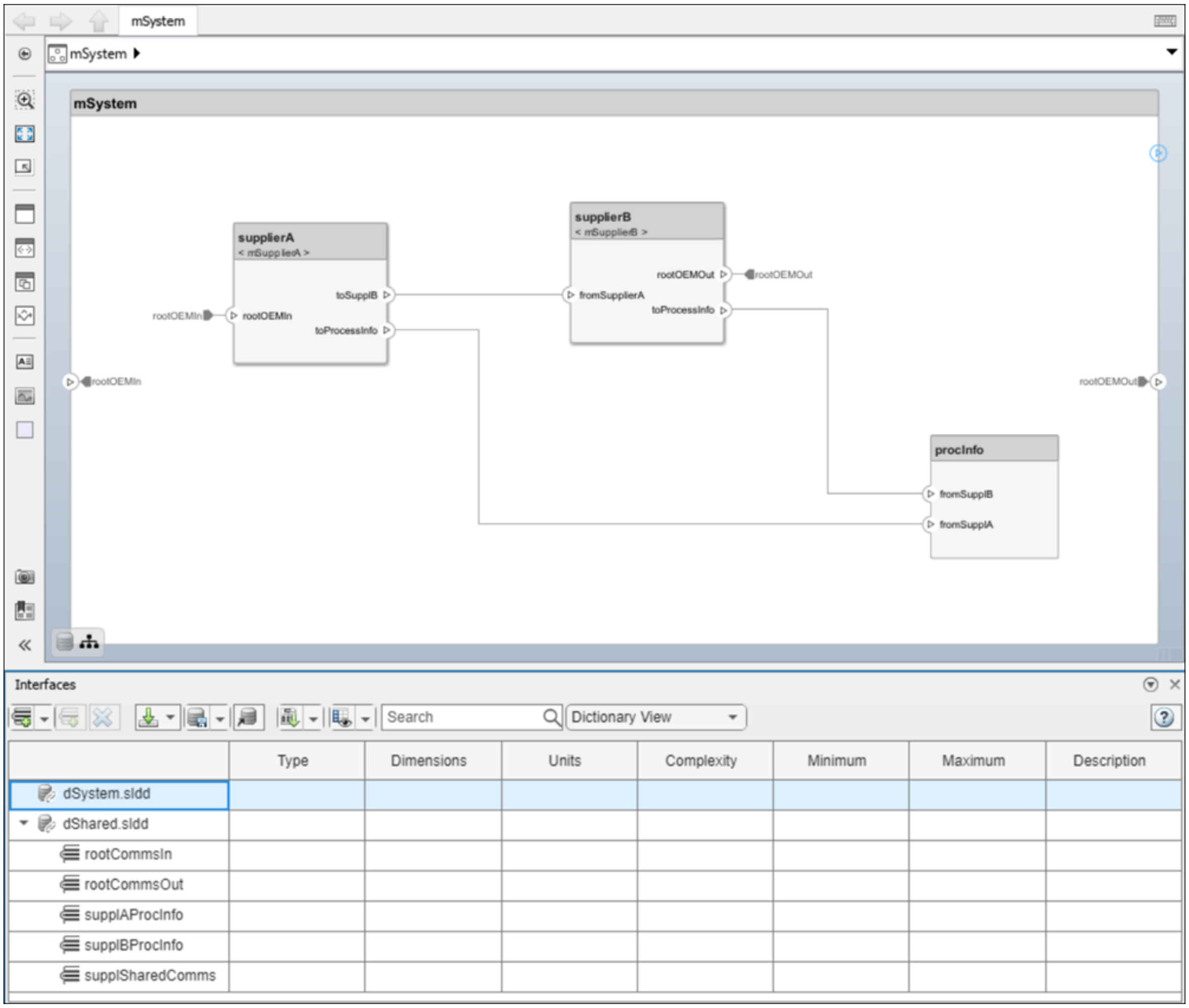
At the same time, each model may have interface definitions that are relevant only to its internal operations. For example, different components of a system may be represented by different models, with different teams or different suppliers working on each model, with a system integrator working on the "top" model that incorporates the various components. Referenced data dictionaries provide a way for models to share some but not all interface definitions.

In such a multiple-team project, set up a "shared artifacts" data dictionary to store interface definitions that will be shared by different teams, then set up a data dictionary for each model within the project to store its own interface definitions. Each data dictionary can then add the shared data dictionary as a referenced data dictionary. Alternatively, if a model does not need its own interface definitions, that model can link directly to the shared data dictionary.



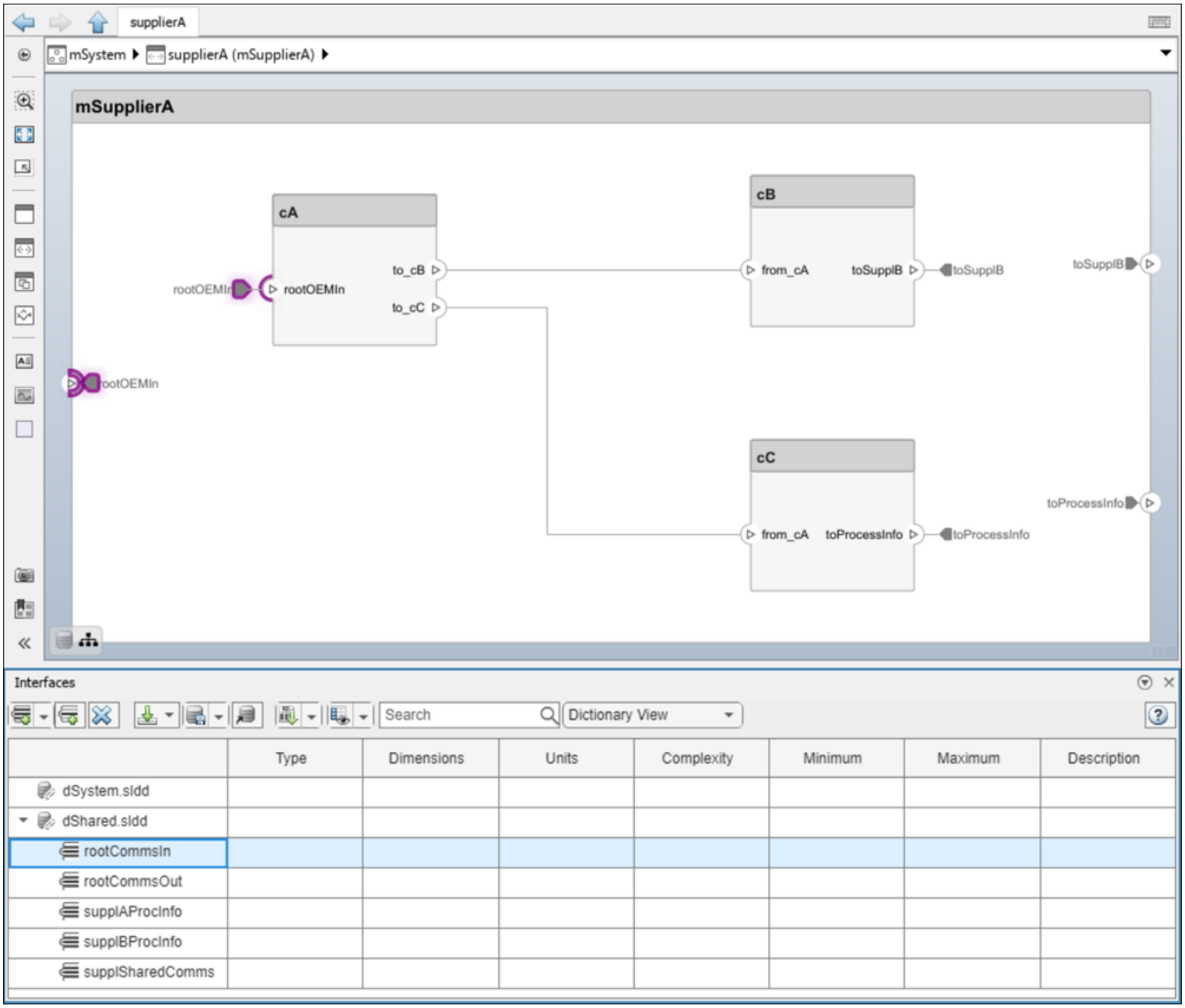
The above diagram depicts a project with three models. The model `mSystem.slx` represents a system integration model, and `mSupplierA.slx` and `mSuppierB.slx` represent supplier models. The data dictionary `dShared.sldd` contains interface definitions shared by all the models. The system integration model is linked to the data dictionary `dSystem.sldd`, and the Supplier A model is linked to the data dictionary `dSupplierA.sldd`; each data dictionary contains interface definitions relevant to the corresponding model's internal workflow. The data dictionaries `dSystem.sldd` and `dSupplierA.sldd` both reference the shared dictionary `dShared.sldd`. The `mSuppierB.slx` model, by contrast, is linked directly to the shared dictionary `dShared.sldd`. In this way, all three models have access to the interface definitions in `dShared.sldd`.

The following diagrams show the system integration model `mSystem`, along with the **Interface Editor**. Interface definitions contained in the referenced dictionary `dShared` are associated with the ports used to communicate between the models `mSupplierA` and `mSupplierB` and the rest of the system integration model.



	Type	Dimensions	Units	Complexity	Minimum	Maximum	Description
dSystem.sldd							
▾ dShared.sldd							
rootCommsIn							
rootCommsOut							
supplAProcInfo							
supplBProcInfo							
supplSharedComms							

The following diagrams show the supplier model `mSupplierA`, along with the **Interface Editor**. Interface definitions contained in the referenced dictionary `dShared` are associated with the ports used to communicate externally, while interface definitions in the private dictionary `dSupplierA` are associated with ports whose use is internal to the `mSupplierA` model.



	Type	Dimensions	Units	Complexity	Minimum	Maximum	Description
dSystem.sldd							
dShared.sldd							
rootCommsIn							
rootCommsOut							
supplAProcInfo							
supplBProcInfo							
supplSharedComms							

See Also

`addReference` | `removeReference`

More About

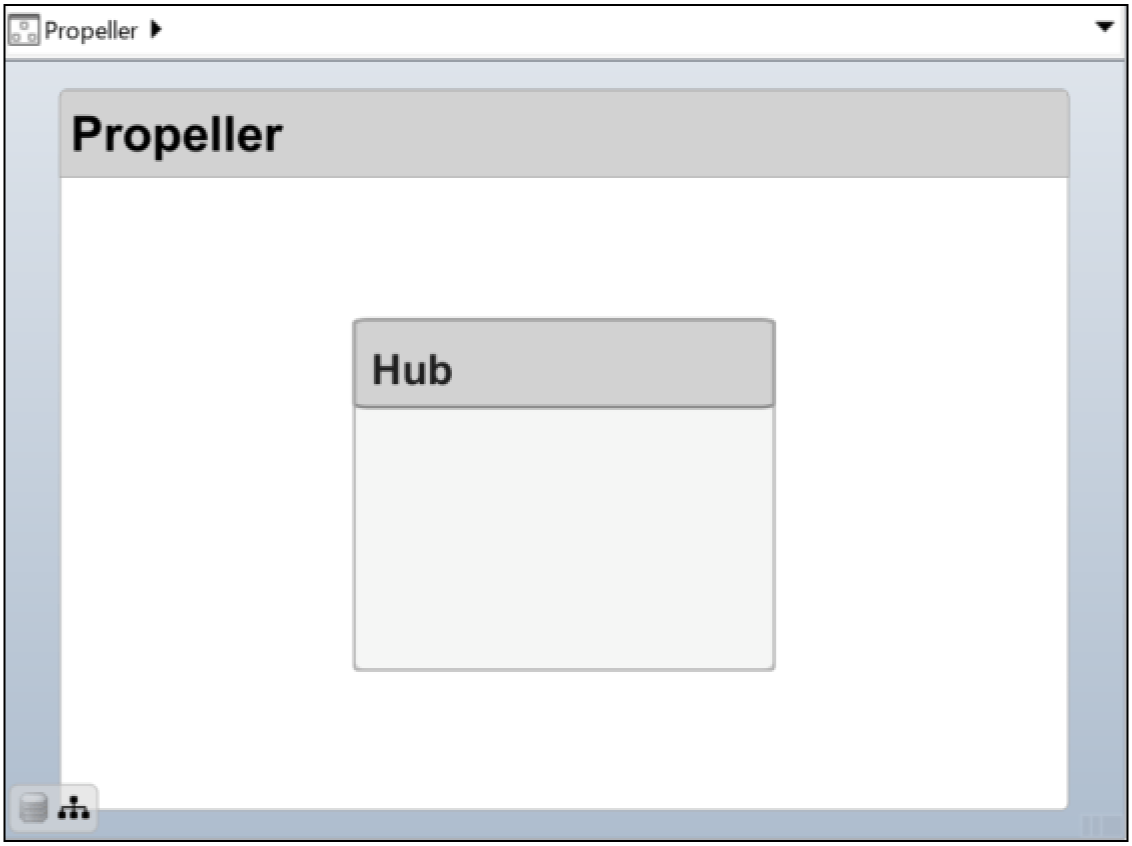
- “Define Port Interfaces Between Components” on page 3-2
- “Specify Physical Interfaces on Ports” on page 7-24
- “Organize System Composer Files in Projects” on page 12-2

Define Parameters

Author Parameters in System Composer Using Parameter Editor

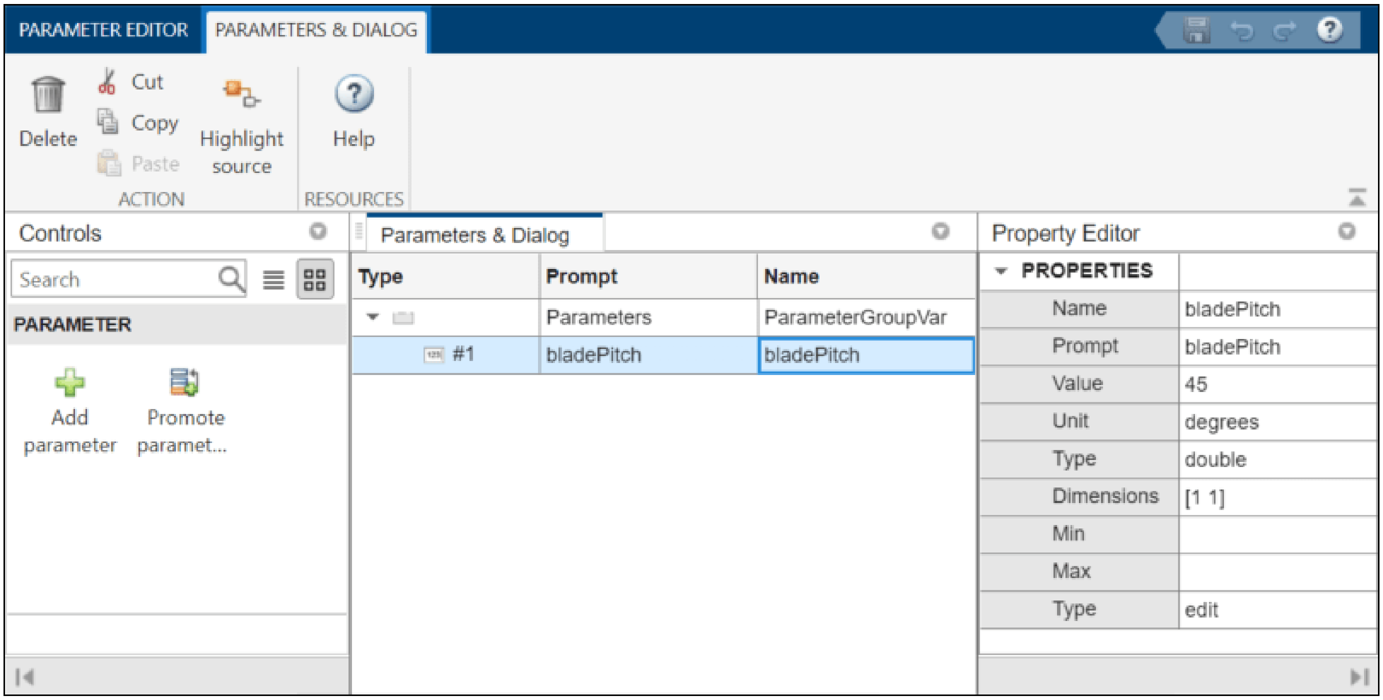
This example shows how to add and modify parameters for a System Composer™ architecture model of a propeller by using a top-down authoring workflow available in the Parameter Editor. System Composer parameters synchronize with Simulink® for seamless simulation and code generation.

1. Create an architecture model called Propeller. Add a component called Hub to the model.



2. Click the Hub component, then open the Property Inspector. Pin the **Property Inspector** for easy access. To open the **Parameter Editor**, go to the Parameters list on the **Property Inspector** and select Open Editor from the drop-down list.

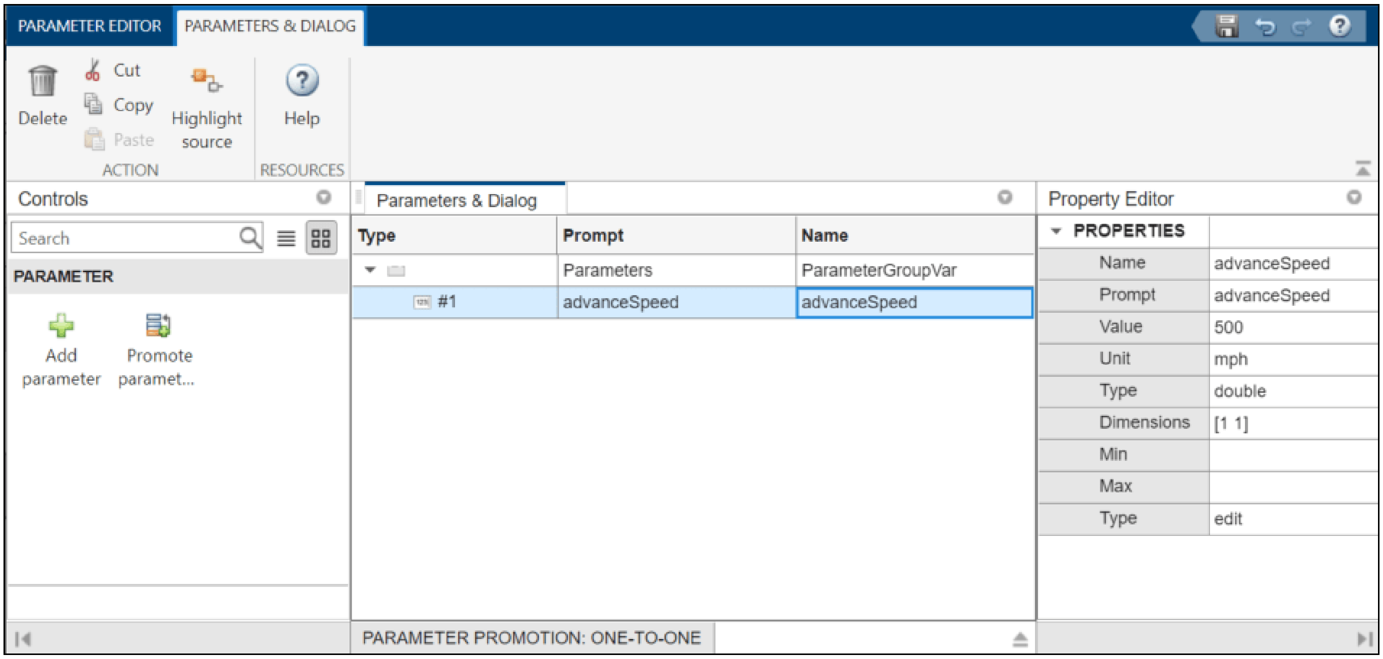
3. Click **Add parameter**. Define the bladePitch parameter with default value 45 and unit degrees.



Type	Prompt	Name
	Parameters	ParameterGroupVar
#1	bladePitch	bladePitch

PROPERTIES	
Name	bladePitch
Prompt	bladePitch
Value	45
Unit	degrees
Type	double
Dimensions	[1 1]
Min	
Max	
Type	edit

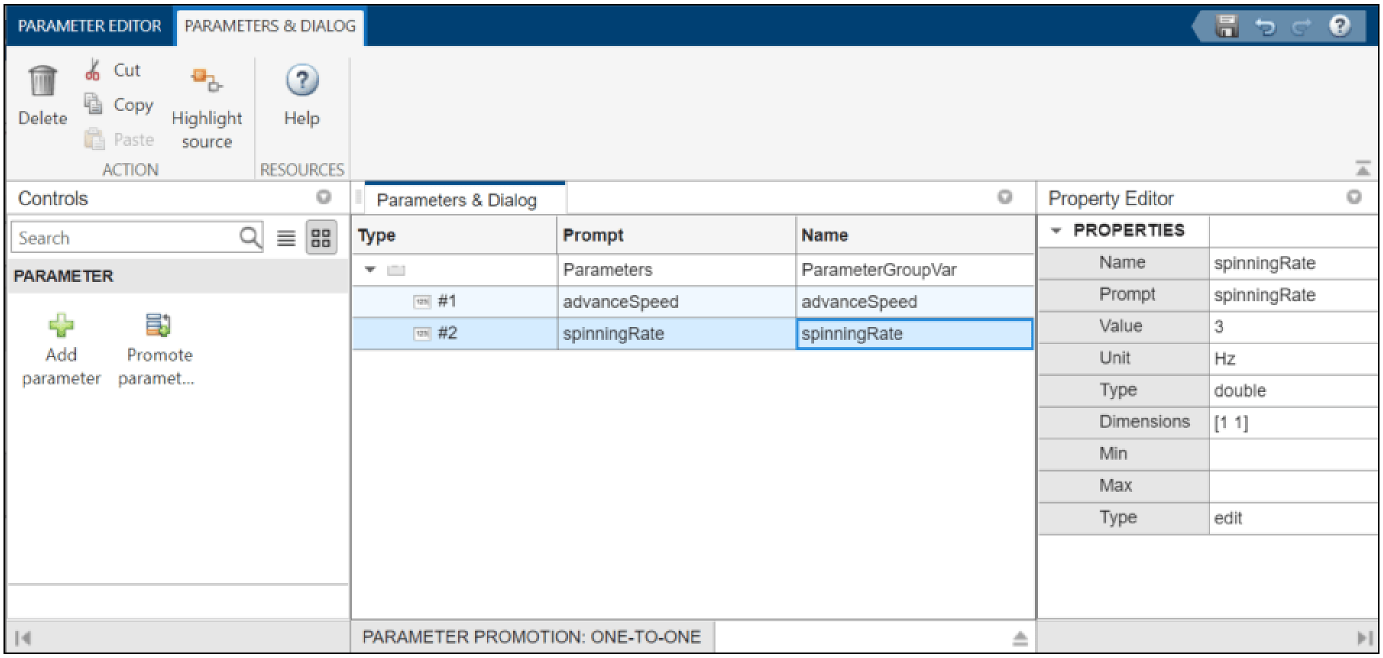
4. Click the `Propeller` root architecture. Open the **Parameter Editor**. Add a parameter named `advanceSpeed`. Set **Value** as `500`, and **Unit** as `mph`.



Type	Prompt	Name
	Parameters	ParameterGroupVar
#1	advanceSpeed	advanceSpeed

PROPERTIES	
Name	advanceSpeed
Prompt	advanceSpeed
Value	500
Unit	mph
Type	double
Dimensions	[1 1]
Min	
Max	
Type	edit

5. Define a parameter named `spinningRate`. Set **Value** as `3`, and **Unit** as `Hz`.

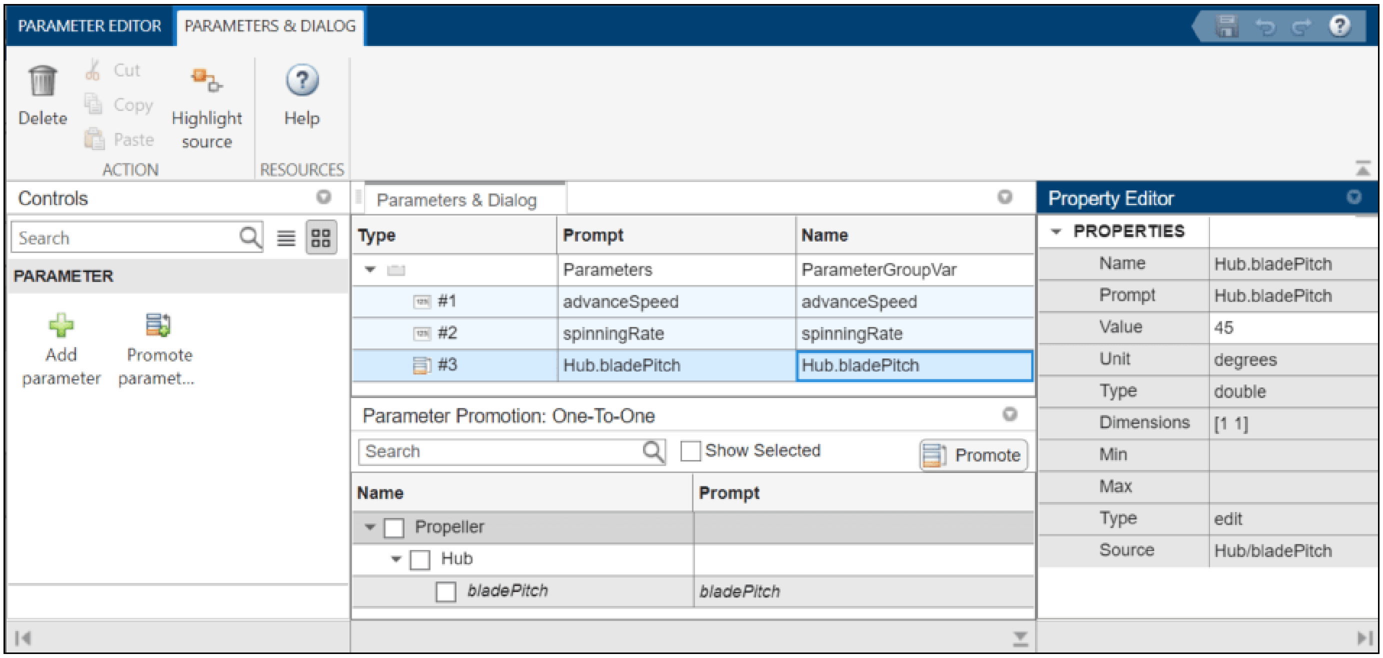


Type	Prompt	Name
	Parameters	ParameterGroupVar
#1	advanceSpeed	advanceSpeed
#2	spinningRate	spinningRate

PROPERTIES	
Name	spinningRate
Prompt	spinningRate
Value	3
Unit	Hz
Type	double
Dimensions	[1 1]
Min	
Max	
Type	edit

6. Click **Promote parameter** to open the **Parameter Promotion: One-To-One** section. Under the component `Hub`, select the `bladePitch` parameter. Click **Promote** to promote the parameter.

Parameter promotion enables easy access to parameter values and preserves distinct parameter values inside the model during simulation or code generation. Parameter promotion also removes unnecessary duplication of parameters defined on lower levels of an architectural hierarchy.

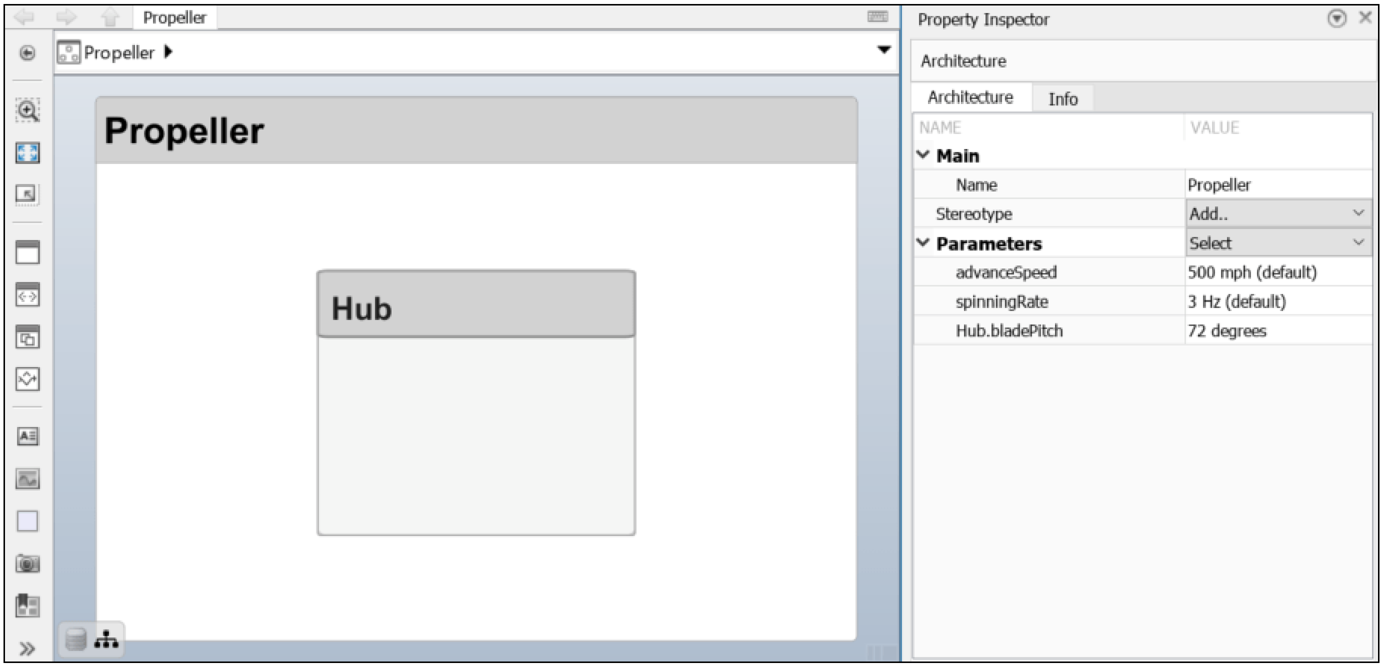


Type	Prompt	Name
	Parameters	ParameterGroupVar
#1	advanceSpeed	advanceSpeed
#2	spinningRate	spinningRate
#3	Hub.bladePitch	Hub.bladePitch

Name	Prompt
□ Propeller	
□ Hub	
□ *bladePitch*	*bladePitch*

PROPERTIES	
Name	Hub.bladePitch
Prompt	Hub.bladePitch
Value	45
Unit	degrees
Type	double
Dimensions	[1 1]
Min	
Max	
Type	edit
Source	Hub/bladePitch

7. Change the default value of the promoted parameter `bladePitch` from the source component `Hub` to `72`. The new value of the `bladePitch` parameter now appears for the architecture `Propeller`.



NAME	VALUE
Main	
Name	Propeller
Stereotype	Add..
Parameters	Select
advanceSpeed	500 mph (default)
spinningRate	3 Hz (default)
Hub.bladePitch	72 degrees

See Also

`systemcomposer.arch.Parameter` | `addParameter` | `getParameter` | `resetToDefault` | `getParameterPromotedFrom` | `getEvaluatedParameterValue` | `getParameterNames` | `getParameterValue` | `setParameterValue` | `setUnit` | `resetParameterToDefault`

More About

- “Use Parameters to Store Instance Values with Components” on page 4-6
- “Use Property Inspector in System Composer” on page 1-55
- “Promote Block Parameters on a Mask”
- “Compose Architectures Visually” on page 1-2
- “Simulate Mobile Robot with System Composer Workflow” on page 5-20

Use Parameters to Store Instance Values with Components

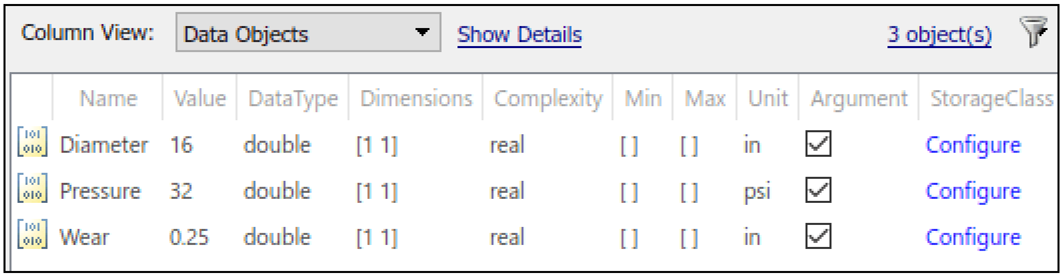
This example shows how to add value types as model arguments to a System Composer™ architecture model of a wheel, `mWheelArch.slx`, using the Model Explorer. Then, on the System Composer architecture model `mAxleArch.slx`, these model arguments are exposed as instance-specific parameter values that can be changed independently across each component that references `mWheelArch`.

Use Model Explorer to Add MATLAB Variables as Model Arguments

Open the `mWheelArch` model.

```
systemcomposer.openModel("mWheelArch");
```

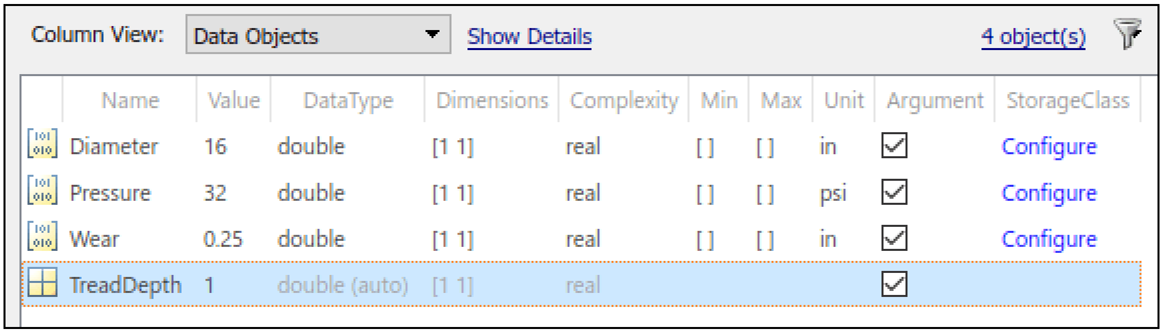
Navigate to **Modeling** > **Model Explorer** or enter **Ctrl+H**. The Model Explorer opens. Expand the `mWheelArch` model and select `Model Workspace`. View the contents of the model workspace. The workspace contains three Simulink Parameters named `Diameter`, `Pressure`, and `Wear`.



Column View: Data Objects | Show Details | 3 object(s)

Name	Value	DataType	Dimensions	Complexity	Min	Max	Unit	Argument	StorageClass
Diameter	16	double	[1 1]	real	[ ]	[ ]	in	☑	Configure
Pressure	32	double	[1 1]	real	[ ]	[ ]	psi	☑	Configure
Wear	0.25	double	[1 1]	real	[ ]	[ ]	in	☑	Configure

To add a new MATLAB® variable to the model workspace, on the toolstrip menu, click ⊞. You can rename your variable from the default name `Var` and set its starting value. If you select the **Argument** check box, the MATLAB variable becomes a model argument. As a model argument, the variable can later be exposed as an instance-specific parameter value in an architecture model. Rename the variable to `TreadDepth` and set its value to `1`, then select it as a model argument.

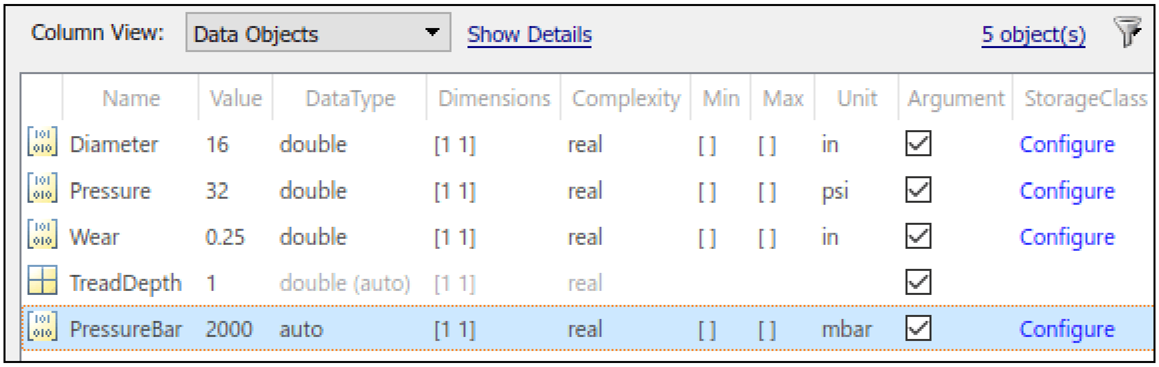


Column View: Data Objects | Show Details | 4 object(s)

Name	Value	DataType	Dimensions	Complexity	Min	Max	Unit	Argument	StorageClass
Diameter	16	double	[1 1]	real	[ ]	[ ]	in	☑	Configure
Pressure	32	double	[1 1]	real	[ ]	[ ]	psi	☑	Configure
Wear	0.25	double	[1 1]	real	[ ]	[ ]	in	☑	Configure
TreadDepth	1	double (auto)	[1 1]	real				☑	

Use Model Explorer to Add Simulink Parameters as Model Arguments

In the Model Explorer, you can also add Simulink parameters as model arguments. To add a new Simulink parameter to the model workspace, on the toolstrip menu, click 101 010. You can edit the attributes of a Simulink parameter including: `Name`, `Value`, `DataType`, `Dimensions`, `Complexity`, `Min`, `Max`, and `Unit`. These attributes contribute to the parameter definition when the parameter is specified as a model argument. Select the **Argument** check box to specify a parameter as a model argument. Rename the variable to `PressureBar`, set its value to `2000`, set its units to `mbar`, then select it as a model argument.



Column View: Data Objects | Show Details | 5 object(s)

Name	Value	DataType	Dimensions	Complexity	Min	Max	Unit	Argument	StorageClass
Diameter	16	double	[1 1]	real	[ ]	[ ]	in	☑	Configure
Pressure	32	double	[1 1]	real	[ ]	[ ]	psi	☑	Configure
Wear	0.25	double	[1 1]	real	[ ]	[ ]	in	☑	Configure
TreadDepth	1	double (auto)	[1 1]	real				☑	
PressureBar	2000	auto	[1 1]	real	[ ]	[ ]	mbar	☑	Configure

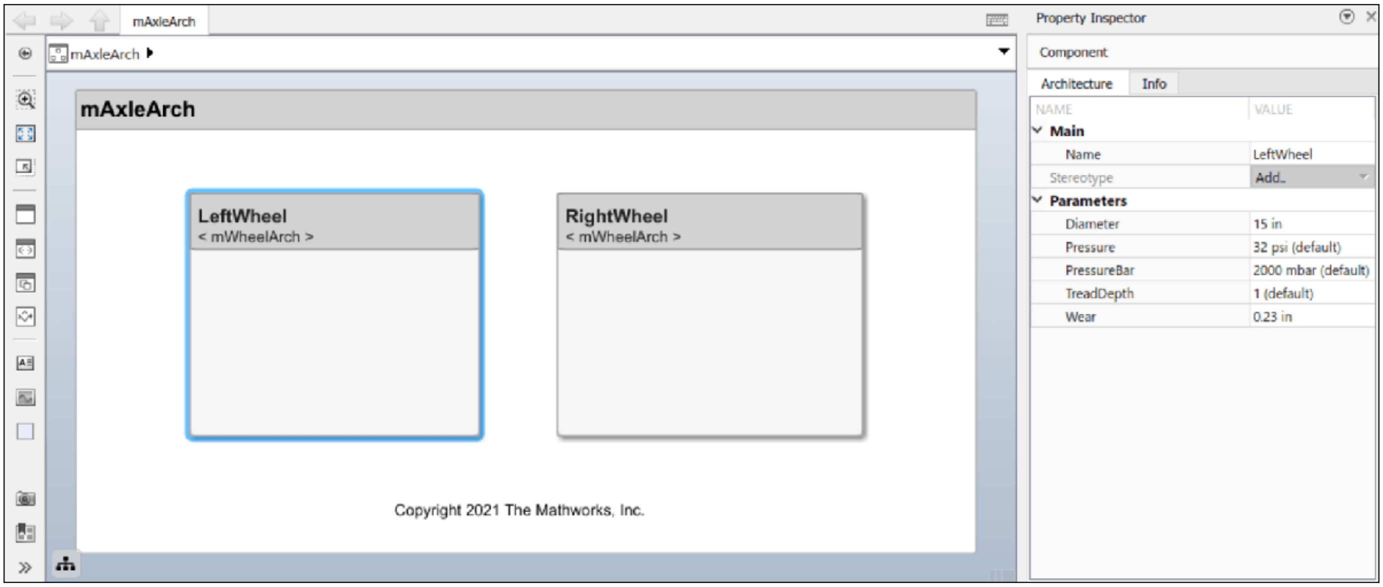
Right-click the `mWheel` model in the **Model Explorer**. Save these changes to the model workspace, then close the **Model Explorer**.

View and Edit Parameters on Components in Architecture Model

Open the `mAxleArch` architecture model.

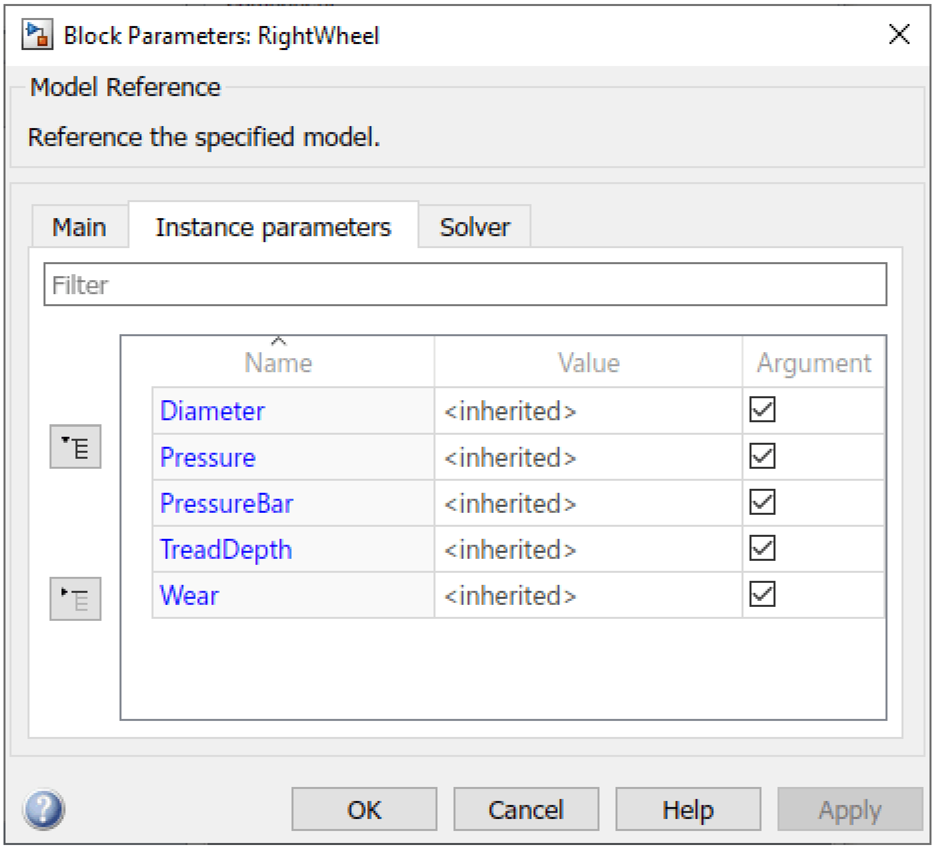
```
systemcomposer.openModel("mAxleArch");
```

Select the `LeftWheel` component that references the `mWheel` model. The parameters appear on the Property Inspector with default values.



NAME	VALUE
Main	
Name	LeftWheel
Stereotype	Add..
Parameters	
Diameter	15 in
Pressure	32 psi (default)
PressureBar	2000 mbar (default)
TreadDepth	1 (default)
Wear	0.23 in

You can expose these parameters as model arguments and then edit the parameters as instance-specific parameters independently for each component that references the same model. Right-click the `RightWheel` component and select `Block Parameters (Model Reference)`. Click the **Instance parameters** tab and select the **Argument** check box for the new parameters `Pressure` and `TreadDepth`.



Block Parameters: RightWheel

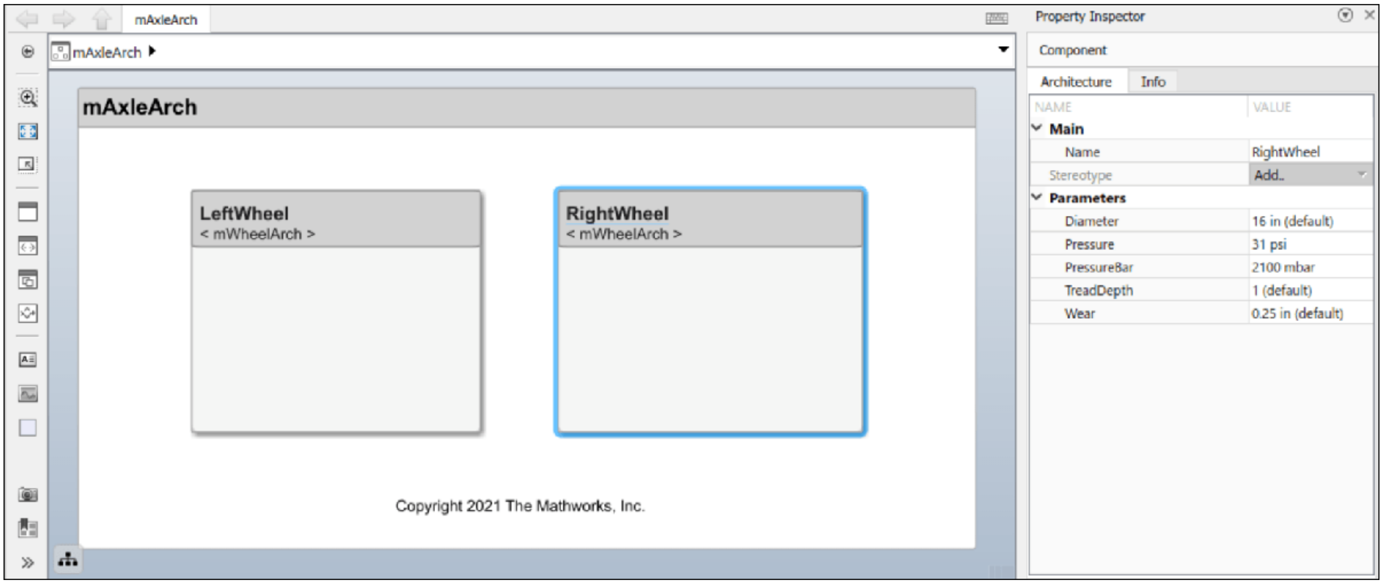
Model Reference

Reference the specified model.

Name	Value	Argument
Diameter	<inherited>	☑
Pressure	<inherited>	☑
PressureBar	<inherited>	☑
TreadDepth	<inherited>	☑
Wear	<inherited>	☑

Once selected, these parameters are treated as model arguments of the mAxleArch model and can be changed independently for each instance the model.

Edit the parameters for the RightWheel component so that Pressure and PressureBar are now 31 psi and 2100 mbar, respectively.



NAME	VALUE
Main	
Name	RightWheel
Stereotype	Add..
Parameters	
Diameter	16 in (default)
Pressure	31 psi
PressureBar	2100 mbar
TreadDepth	1 (default)
Wear	0.25 in (default)

The corresponding parameter values for the `LeftWheel` component remain unchanged.

See Also

`systemcomposer.arch.Parameter` | `addParameter` | `getParameter` | `resetToDefault` | `getParameterPromotedFrom` | `getEvaluatedParameterValue` | `getParameterNames` | `getParameterValue` | `setParameterValue` | `setUnit` | `resetParameterToDefault`

More About

- “Author Parameters in System Composer Using Parameter Editor” on page 4-2
- “Specify Instance-Specific Parameter Values for Reusable Referenced Model” (Simulink Coder)
- “Implement Component Behavior Using Simulink” on page 7-2
- “Compose Architectures Visually” on page 1-2
- “Simulate Mobile Robot with System Composer Workflow” on page 5-20

Define Architectural Properties

Define Profiles and Stereotypes

To verify structural and functional requirements, you must capture nonfunctional properties on elements in a System Composer architecture model. To capture these properties, use stereotyping.

For example, if there is a limit on the total power consumption of a system, the model must be able to capture the power rating of each electrical component. To define component-specific property values requires extending built-in model element types with properties corresponding to requirements. In this case, an electrical component type as an extension of components is a stereotype. By extending the definition of regular components, you introduce a custom modeling language and framework that includes specific concepts and terminologies important for the architecture model. Capturing the individual properties also sets the scene for early parametric analyses and to define custom views.

A stereotype is a custom extension of the modeling language. Stereotypes provide a mechanism to extend the architecture language elements by adding domain-specific metadata.

Apply stereotypes to model elements such as root-level architecture, component architecture, connectors, ports, data interfaces, value types, functions, requirements, and links. Functions only apply to software architectures. You must have a Requirements Toolbox license to apply stereotypes to requirements and links. A model element can have multiple stereotypes. Stereotypes provide model elements with a common set of property fields, such as mass, cost, and power.

A property is a field in a stereotype. You can specify property values for each element to which the stereotype is applied.

Use properties to store quantitative characteristics, such as weight or speed, that are associated with a model element. Properties can also be descriptive or represent a status. You can view and edit the properties of each element in the architecture model using the **Property Inspector**.

Open the **Property Inspector** by navigating to **Modeling** > **Property Inspector**.

A profile is a package of stereotypes that you can use to create a self-consistent domain of element types.

Author profiles and apply profiles to a model using the **Profile Editor**. You can store stereotypes for a project in one or several profiles. When you save profiles, they are stored in XML files.

In this topic, you will learn how to:

1. Create a profile and define stereotypes with properties.
2. Define default stereotypes in a profile to be added to any new element in a model with that applied profile.
3. Use stereotype-based styling that enhances the appearance of the model based upon specific features each element represents.

Create a Profile and Add Stereotypes

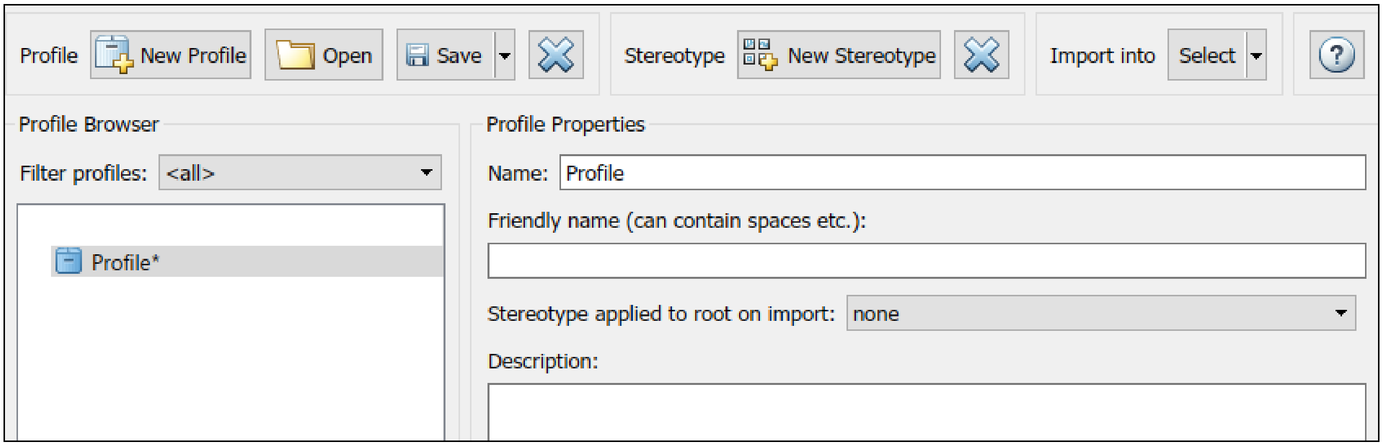
Create a profile to define a set of component, port, and connection types to be used in an architecture model. For example, a profile for an electromechanical system, such as a robot, could consist of these types.

- Component types

    - Electrical component
    - Mechanical component
    - Software component
- Connection types
    - Analog signal connection
    - Data connection
- Port types
    - Data port

Define a profile using the **Profile Editor** by navigating to **Modeling** > **Profile Editor**. Click **New Profile**. Select the new profile to start editing.

Note Before you move, copy, or rename a profile to a different directory, you must close the profile in the **Profile Editor** or by using the `close` function. If you rename a profile, follow the example for the `renameProfile` function.



Filter profiles: <all>

Name: Profile

Stereotype applied to root on import: none

Name the profile and provide a description. Add stereotypes by clicking **New Stereotype**. You can delete stereotypes and profiles by clicking the ✖ button in their respective menus.

Note To create requirement or link stereotypes, you need a Requirements Toolbox license. For more information, see "Customize Requirements and Links by Using Stereotypes" (Requirements Toolbox).

Save the profile. The file name is the same as the profile name.

Add Properties with Stereotypes

Select a stereotype in a profile to define it:

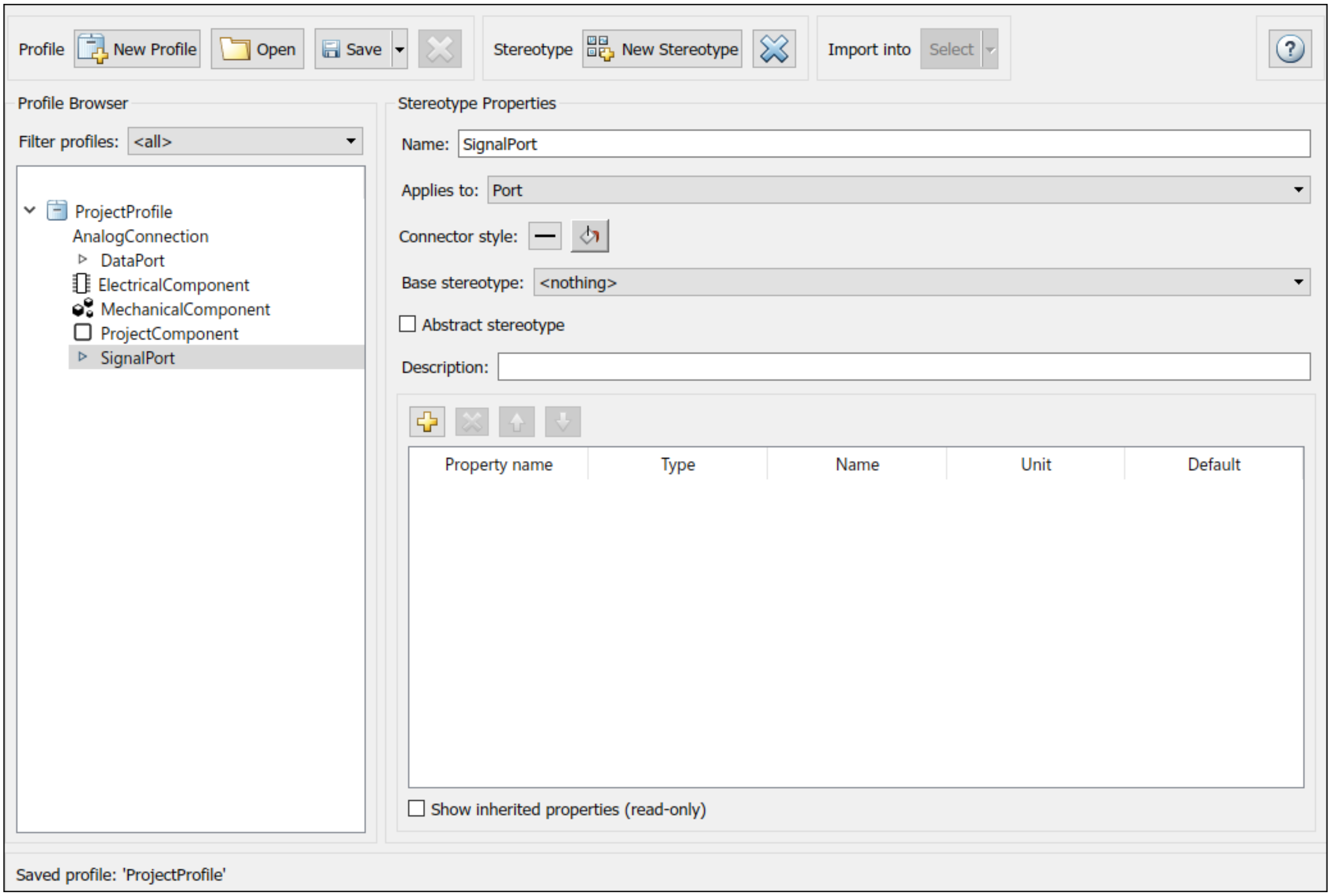
- **Name** — The name of the stereotype, for example, `ElectricalComponent`.
- **Applies to** — The model element type to which the stereotype applies. This option can be `<all>`, `Component`, `Port`, `Connector`, `Interface`, `Function`, `Requirement`, or `Link`. You can apply

this stereotype only to a model element of this type. The model element type `Function` is only available for software architecture models. For more information, see “Apply Stereotypes to Functions of Software Architectures” on page 10-29. The model element types `Requirement` and `Link` require a Requirements Toolbox license.

- **Icon** — Icon to be shown on the model element with color, if applicable.
- **Connector Style** — Line style of the connector to be shown on the model with color, if applicable.
- **Base stereotype** — Other stereotype on which this stereotype is based. This option can be empty.
- **Abstract stereotype** — A stereotype that is not intended to be applied directly to a model element. You can use abstract stereotypes only as the base stereotype for other stereotypes.

Add properties to a stereotype using the ✚ button. Define these fields for each property:

- Property name — Valid variable name
- Type — Numeric, string, or enumeration data type
- Name — Name of the enumerated type, if applicable
- Unit — Value units as a string
- Default — Default value



Filter profiles: <all>

- ProjectProfile
  - AnalogConnection
  - DataPort
  - ElectricalComponent
  - MechanicalComponent
  - ProjectComponent
  - SignalPort

Name: SignalPort

Applies to: Port

Base stereotype: <nothing>

☐ Abstract stereotype

Description:

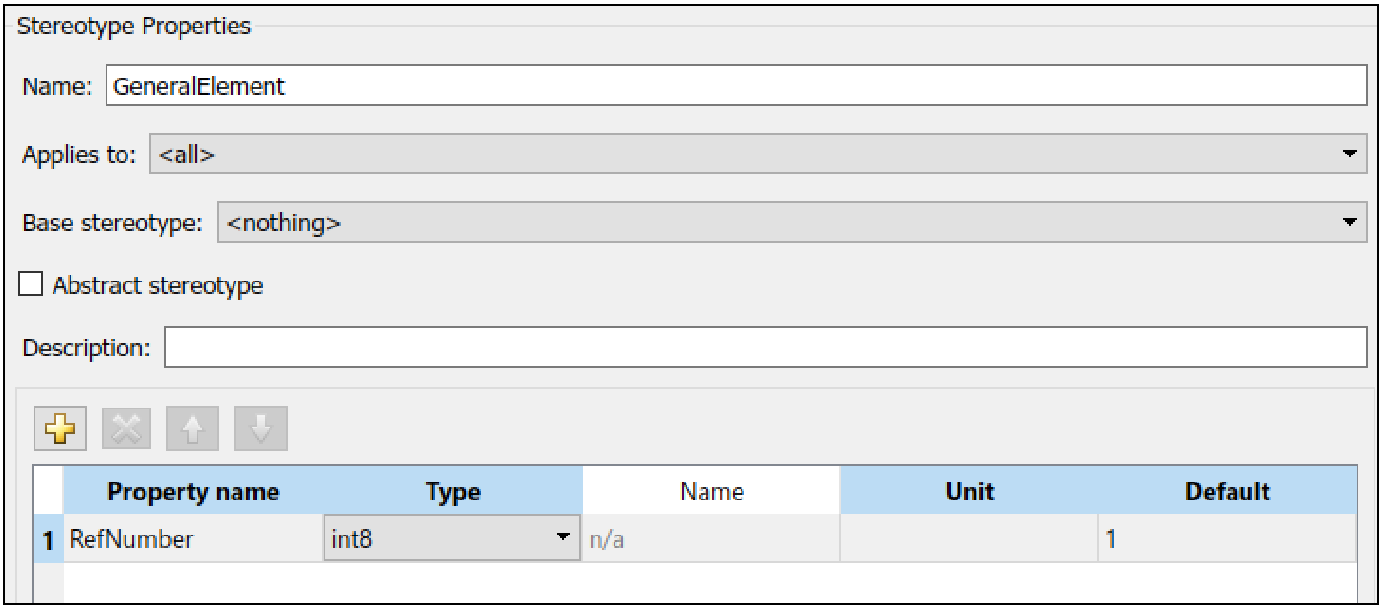
Property name	Type	Name	Unit	Default

☐ Show inherited properties (read-only)

Saved profile: 'ProjectProfile'

Add, delete, and reorder properties using the property toolstrip: ✚ ✖ ⇧ ⇩

You can create a stereotype that applies to all model element types by setting the **Applies to** field to **<all>**. With these stereotypes, you can add properties to elements regardless of whether they are components, ports, connectors, interfaces, functions, requirements, or links.



Stereotype Properties

Name: GeneralElement

Applies to: <all>

Base stereotype: <nothing>

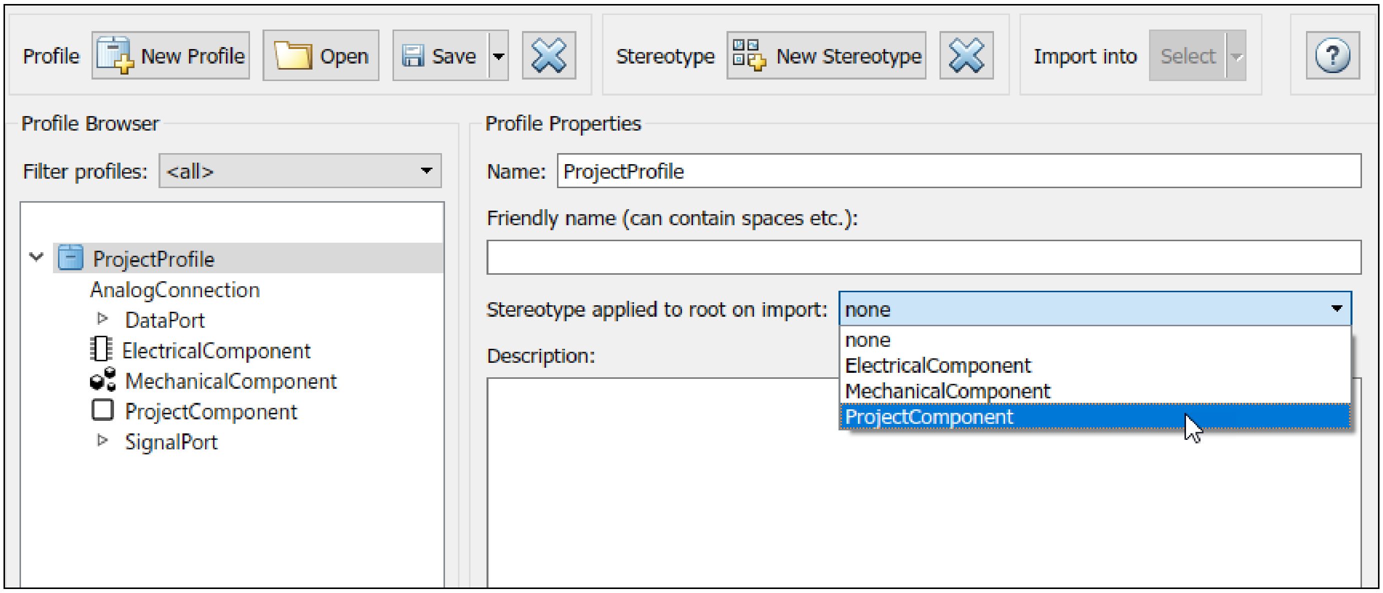
□ Abstract stereotype

Description:

	Property name	Type	Name	Unit	Default
1	RefNumber	int8	n/a		1

Define Default Stereotypes

Each profile can have a set of default stereotypes. Use default stereotypes when each new element of a certain type must assume the same stereotype. System Composer applies a default stereotype to the root architecture when you import the profile. You can set this default as `ProjectComponent` in the **Profile Editor** using the **Stereotype applied to root on import** field.



Filter profiles: <all>

Profile Properties

Name: ProjectProfile

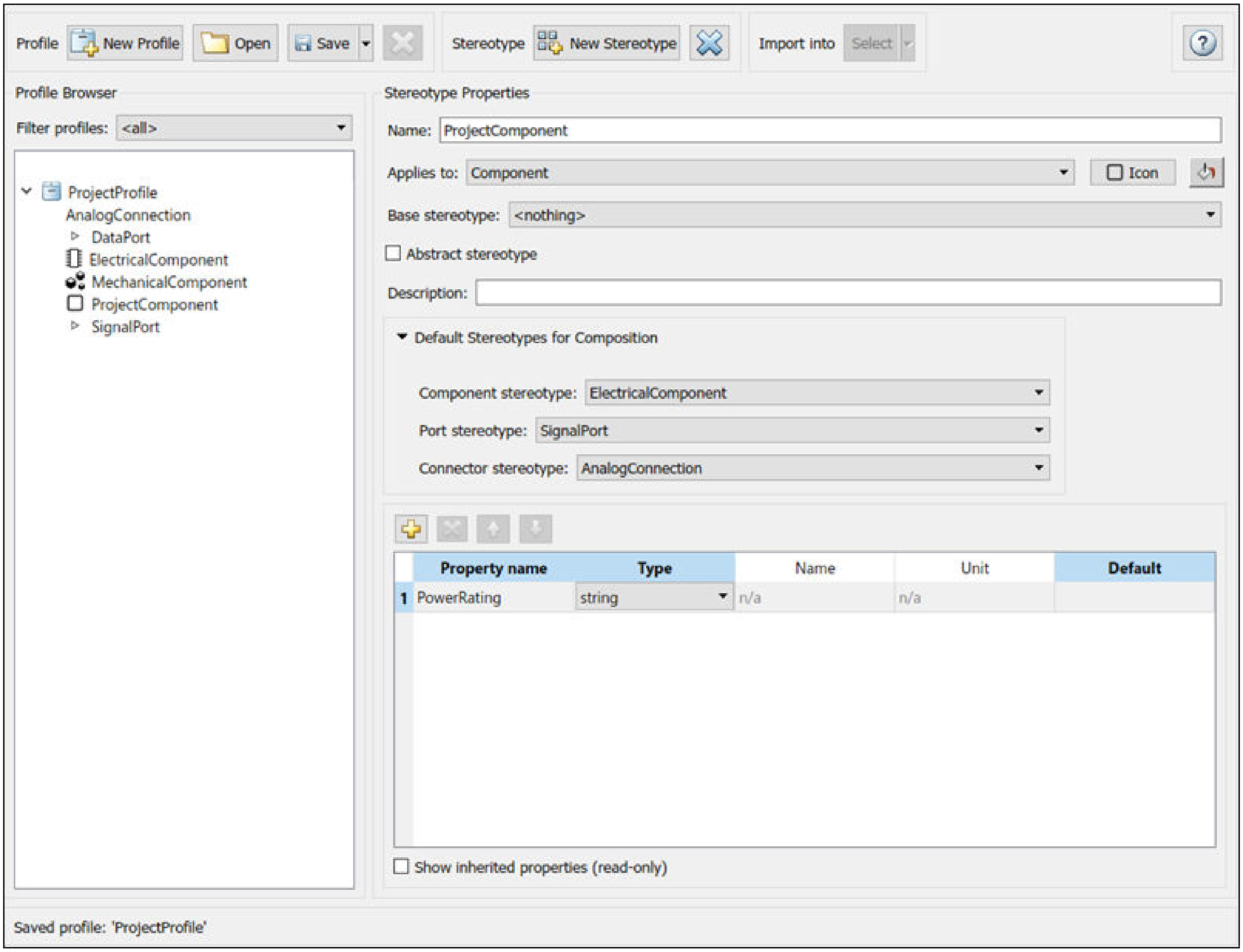
Friendly name (can contain spaces etc.):

Stereotype applied to root on import: none

Description:

This default stereotype is for the top-level architecture. If a model imports multiple profiles, the default component stereotype for all profiles apply to the architecture.

Each component stereotype can also have defaults for the components, ports, and connections added to its architecture. For example, if you want all new connections in a project component to be analog connections, set `AnalogConnection` as a default stereotype for the `ProjectComponent` stereotype.



Filter profiles: <all>

- ProjectProfile
  - AnalogConnection
  - DataPort
  - ElectricalComponent
  - MechanicalComponent
  - ProjectComponent
  - SignalPort

Name: ProjectComponent

Applies to: Component

Base stereotype: <nothing>

☐ Abstract stereotype

Description:

Default Stereotypes for Composition

Component stereotype: ElectricalComponent

Port stereotype: SignalPort

Connector stereotype: AnalogConnection

	Property name	Type	Name	Unit	Default
1	PowerRating	string	n/a	n/a	

☐ Show inherited properties (read-only)

Saved profile: 'ProjectProfile'

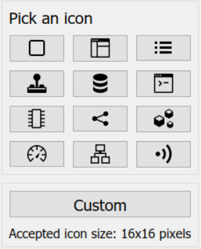
When you import the profile `ProjectProfile` into a model:

- The `ProjectComponent` stereotype is automatically applied to the root architecture.
- The `ElectricalComponent` stereotype is automatically applied to all new components in the architecture model.
- The `SignalPort` stereotype is automatically applied to all new ports.
- The `AnalogConnection` stereotype is automatically applied to all new connections.

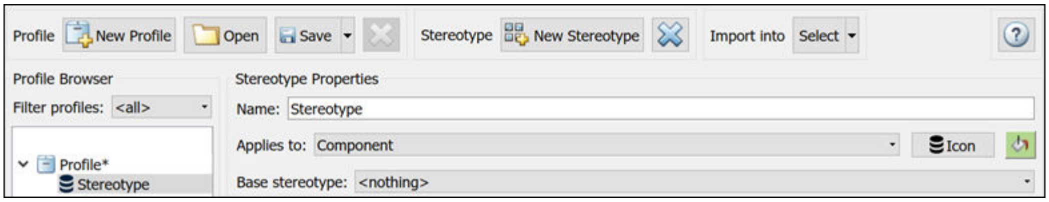
Use Stereotype-Based Styling

Profiles and stereotypes are used to apply custom metadata on the architecture model elements. Element styling is an additional visual cue that indicates applied stereotypes.

You can use provided icons for the component stereotypes or use you own custom icon images. Custom icons support `.png`, `.jpeg`, or `.svg` image files of size 16-by-16 pixels. The custom icons are displayed as badges on the components for which the stereotypes are applied.



You can associate a color with component stereotypes. Element styling is an additional visual cue that indicates applied stereotypes.



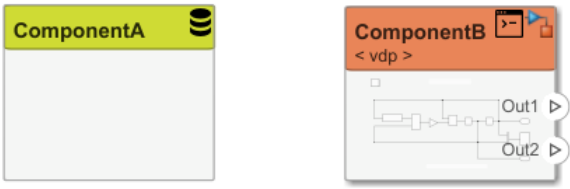
Filter profiles: <all>

Name: Stereotype

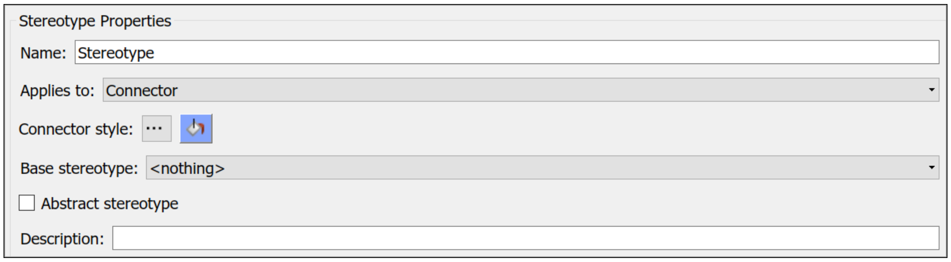
Applies to: Component

Base stereotype: <nothing>

Use a preconfigured set of color options for component stereotypes to style the architecture component headers. See “Use Stereotypes and Profiles” on page 5-9 to learn how to use stereotypes in your model.



Similarly, you can style architecture connectors using the stereotype settings. You can style connectors by using connector, port, or port interface stereotypes. Customize styling provides various color and line style choices. Connector styles are also reflected in architecture and spotlight views.



Name: Stereotype

Applies to: Connector

Connector style: ⋯

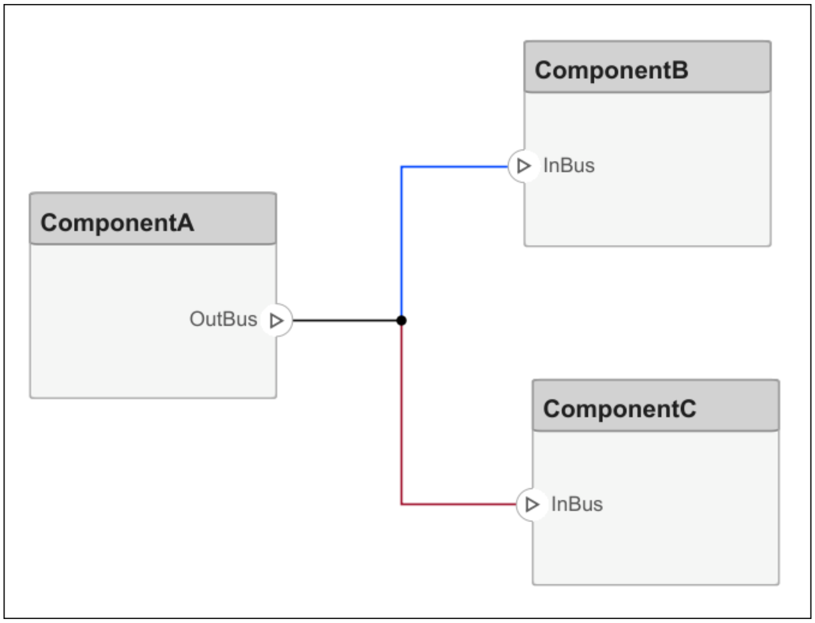
Base stereotype: <nothing>

☐ Abstract stereotype

Description:

Connector styling is sourced from the highest-priority stereotype that defines style information. Connector stereotypes have the highest priority, followed by port stereotypes and then interface stereotypes.

When two connectors with different styling merge, if the styling is incompatible, the resulting connector is displayed in black.



See Also

`hasStereotype` | `hasProperty` | `editor` | `systemcomposer.profile.Profile` | `systemcomposer.profile.Property` | `systemcomposer.profile.Stereotype`

More About

- “Use Stereotypes and Profiles” on page 5-9
- “Analyze Architecture” on page 9-2
- “Analysis Function Constructs” on page 9-9
- “Modeling System Architecture of Small UAV” on page 1-32
- “Simulate Mobile Robot with System Composer Workflow” on page 5-20

Use Stereotypes and Profiles

Use profiles to add properties to components, ports, and connectors in System Composer. Import an existing profile, apply stereotypes, and add property values. To create a profile, see “Define Profiles and Stereotypes” on page 5-2.

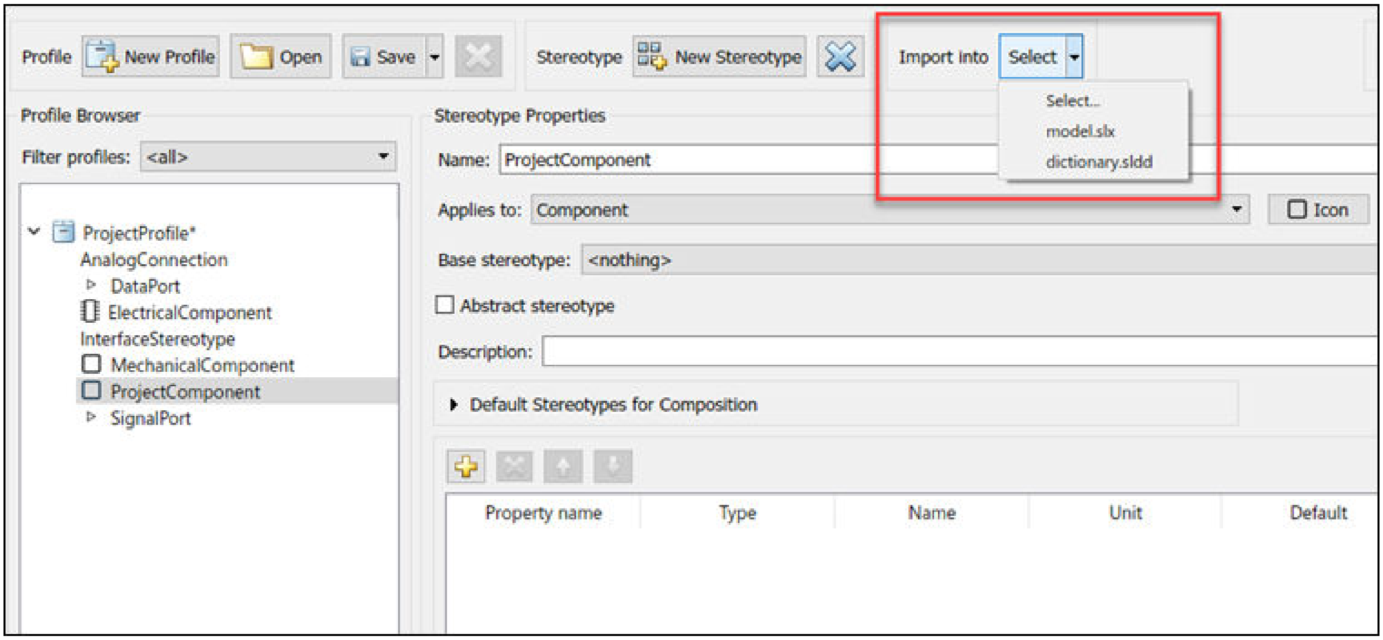
In this topic, you will learn how to:

1. Import profiles into a model or a dictionary.
2. Apply a stereotype to a model element and add property values.
3. Remove stereotypes using the **Property Inspector**.
4. Extend stereotypes with other stereotypes to include their properties through an inherited mechanism. For example, a `UserInterface` stereotype can be an extension of a `SoftwareComponent` stereotype, and add a property called `ScreenResolution`.

Import Profiles

The **Profile Editor** is independent from the model that opens it, so you must explicitly import a new profile into a model. The profile must first be saved with an `.xml` extension. Navigate to **Modeling** > **Profiles** > **Import**. Select the profile to import. An architecture model can use multiple profiles at once.

Alternatively, open the **Profile Editor** by navigating to **Modeling** > **Profile Editor**. You can import a profile into any open dictionaries or models.



Filter profiles: <all>

- ProjectProfile*
  - AnalogConnection
  - DataPort
  - ElectricalComponent
  - InterfaceStereotype
  - MechanicalComponent
  - ProjectComponent
  - SignalPort

Name: ProjectComponent

Applies to: Component

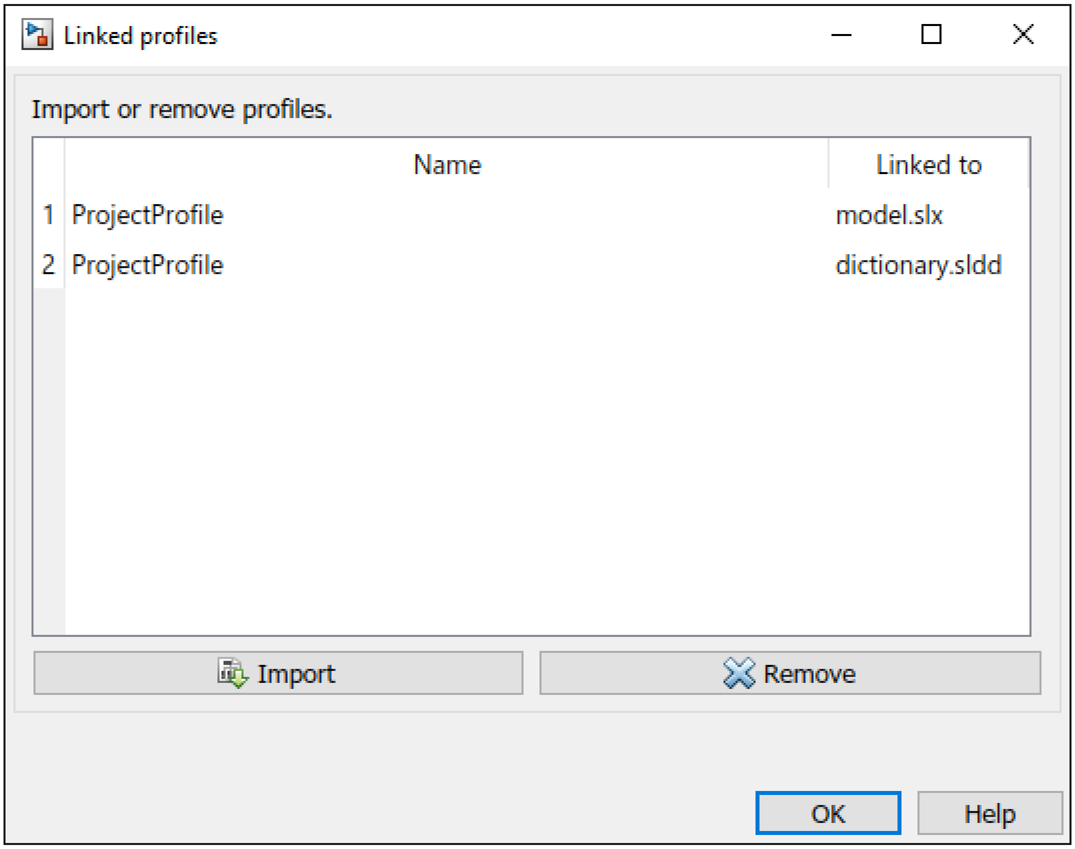
Base stereotype: <nothing>

□ Abstract stereotype

Description:

Note For a System Composer component that is linked to a Simulink behavior model, the profile must be imported into the Simulink model before applying a stereotype from it to the component. Since the **Property Inspector** on the Simulink side does not display stereotypes, this workflow is not finalized.

To manage profiles after they have been imported, navigate to **Modeling** > **Profiles** > **Manage** .



Linked profiles

Import or remove profiles.

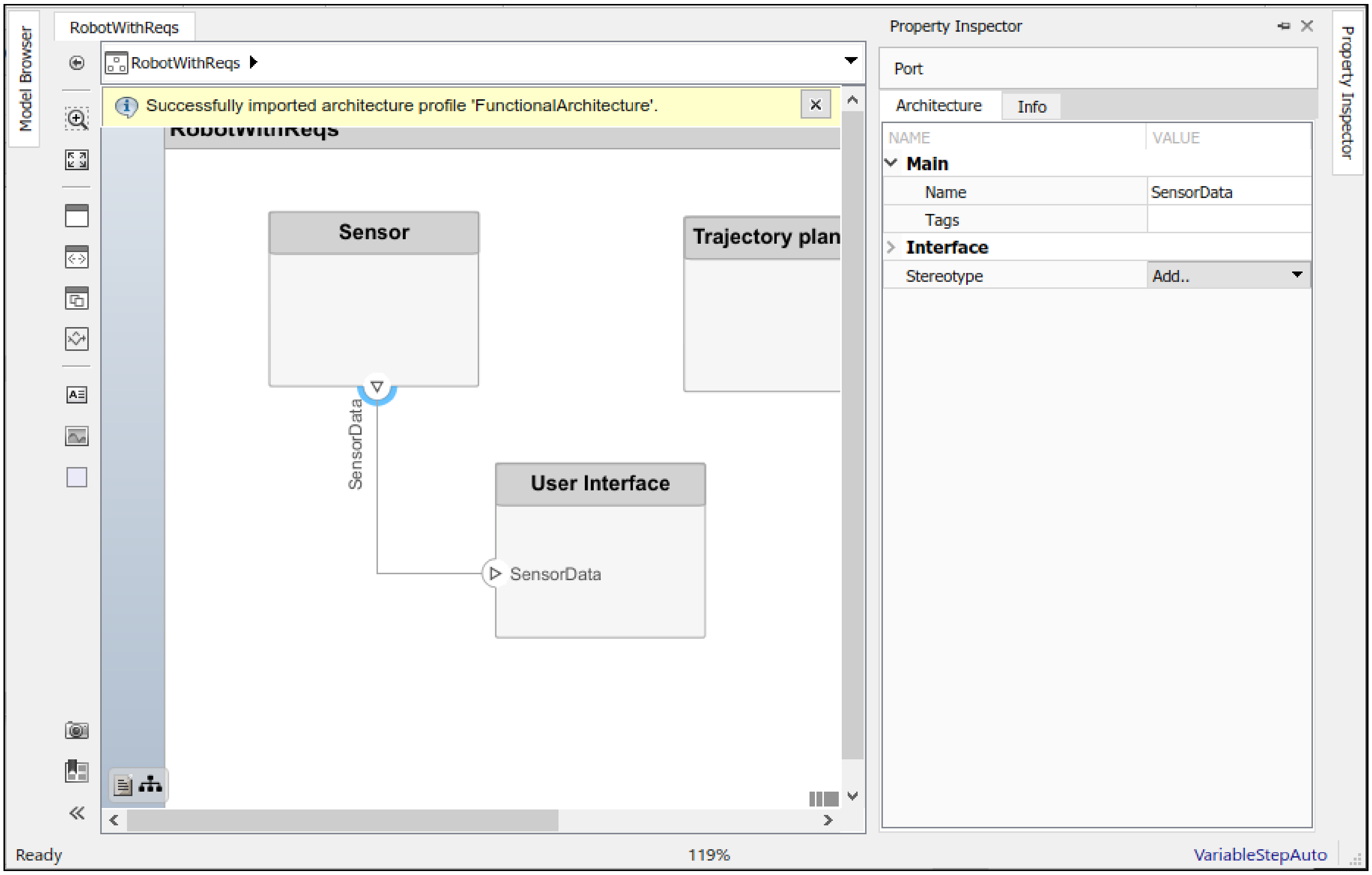
	Name	Linked to
1	ProjectProfile	model.slx
2	ProjectProfile	dictionary.sldd

Apply Stereotypes

Apply stereotypes to architecture model elements using the **Property Inspector** or the Apply Stereotypes dialog. You can also quick-insert a new component with the stereotype applied. For information about applying stereotypes to functions in software architectures, see “Apply Stereotypes to Functions of Software Architectures” on page 10-29.

Apply Stereotype Using Property Inspector

Once the profile is available in the model, open the **Property Inspector** by navigating to **Modeling** > **Property Inspector**. Select a model element.



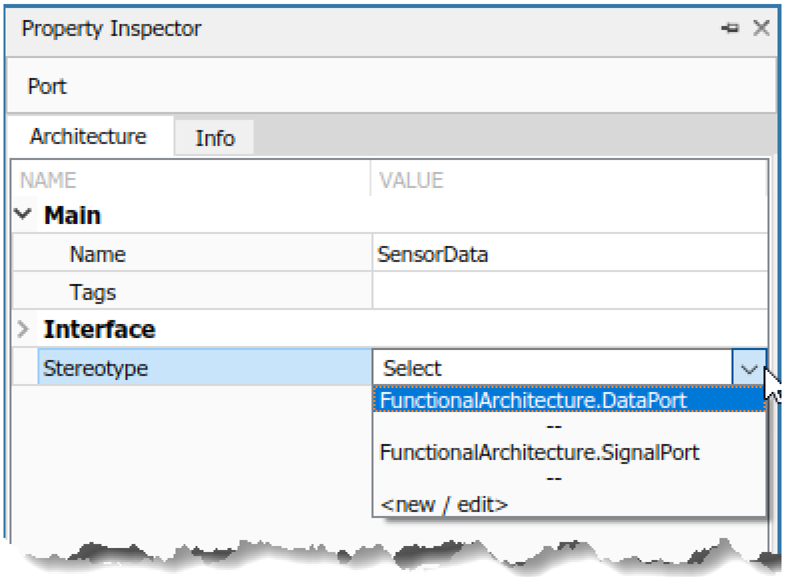
Successfully imported architecture profile 'FunctionalArchitecture'.

Property Inspector

Port

NAME	VALUE
Main	
Name	SensorData
Tags	
Interface	
Stereotype	Add..

In the **Stereotype** field, use the drop-down to select the stereotype. Only the stereotypes that apply to the current element type (for example, a port) are available for selection. If no stereotype exists, you can use the **<new / edit>** option to open the **Profile Editor** and create one.



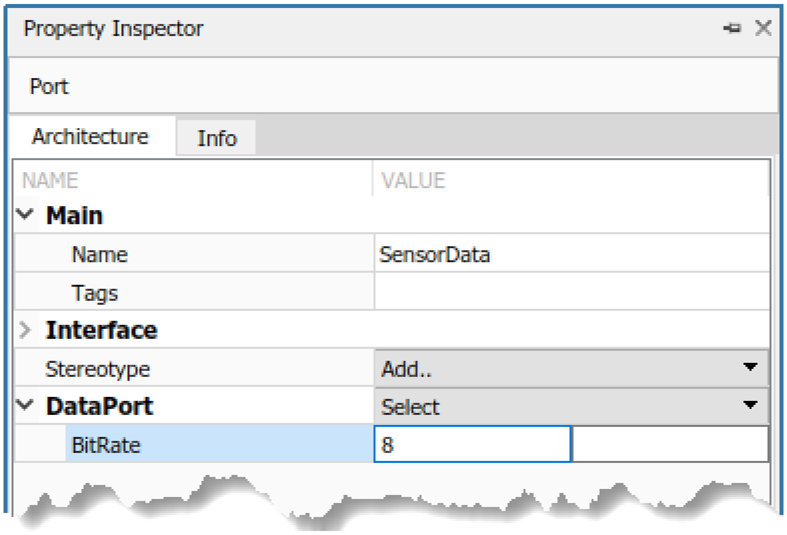
Property Inspector

Port

NAME	VALUE
Main	
Name	SensorData
Tags	
Interface	
Stereotype	Select

```
FunctionalArchitecture.DataPort
--
FunctionalArchitecture.SignalPort
--
<new / edit>
```

When you apply a stereotype to an element, a new set of properties appears in the **Property Inspector** under the name of the stereotype. To edit the properties, expand this set.

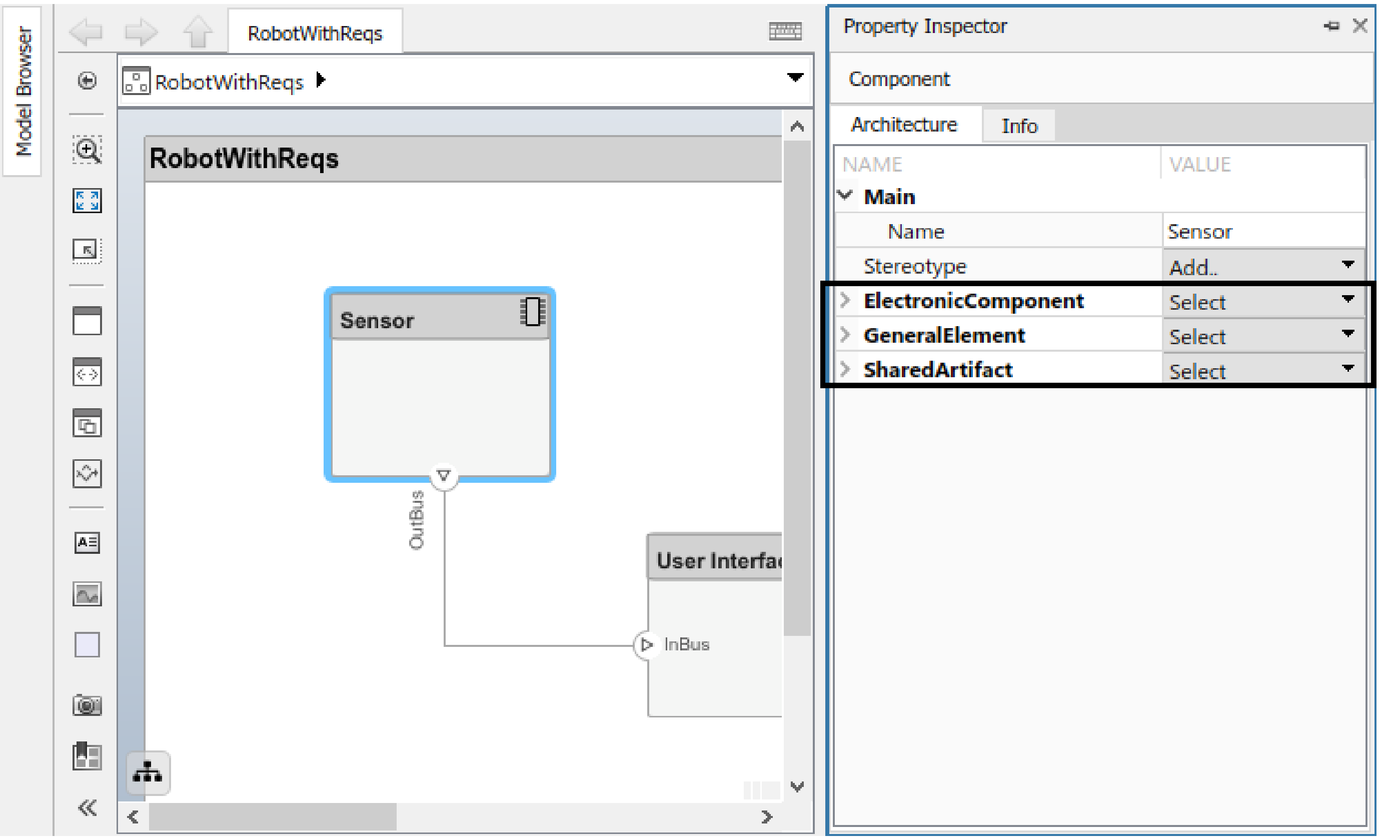


Property Inspector

Port

NAME	VALUE
Main	
Name	SensorData
Tags	
Interface	
Stereotype	Add..
DataPort	Select
BitRate	8

You can set multiple stereotypes for each element.



Property Inspector

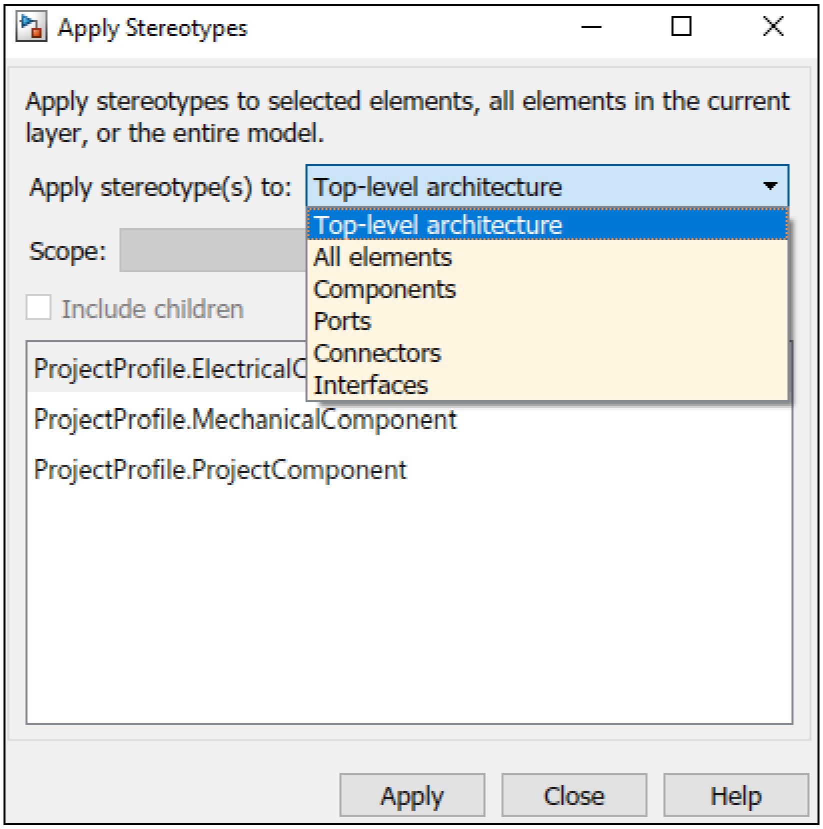
Component

NAME	VALUE
Main	
Name	Sensor
Stereotype	Add..
ElectronicComponent	Select
GeneralElement	Select
SharedArtifact	Select

Use Apply Stereotypes Dialog to Batch Apply Stereotypes

You can also apply component, port, connector, and interface stereotypes to all applicable elements at the same architecture level. Navigate to **Modeling** > **Apply Stereotypes**. In Apply Stereotypes, from **Apply stereotype(s) to**, select `Top-level architecture`, `All elements`, `Components`, `Ports`, `Connectors`, or `Interfaces`.

Note The `Interfaces` option is only available if interfaces are defined in the **Interface Editor**. For more information, see “Create Interfaces” on page 3-4.



Apply Stereotypes

Apply stereotypes to selected elements, all elements in the current layer, or the entire model.

Apply stereotype(s) to: Top-level architecture

Scope:

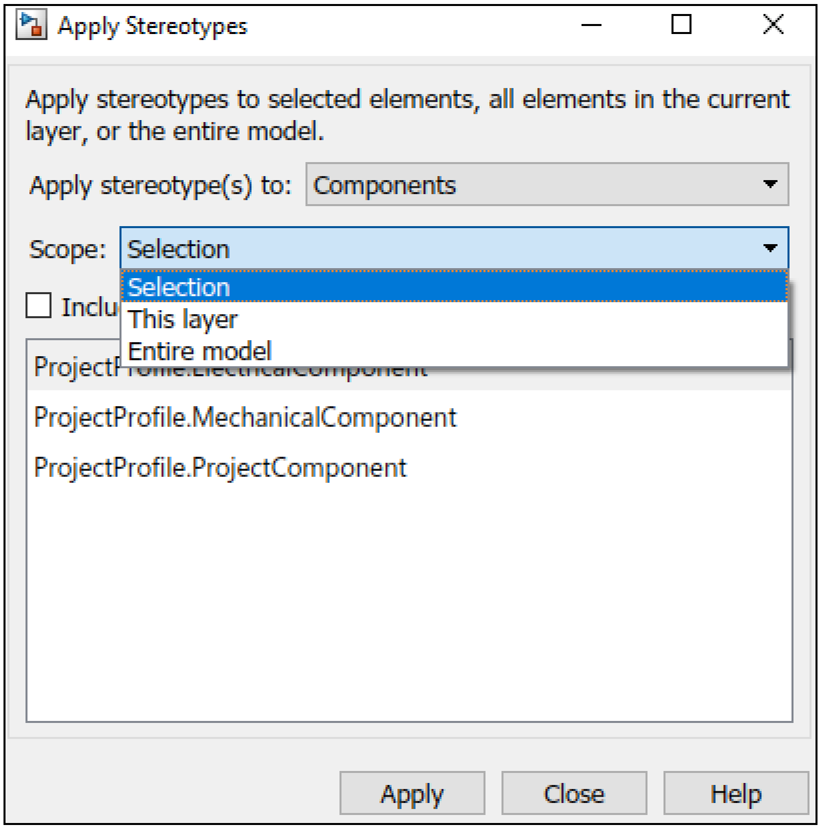
□ Include children

ProjectProfile.ElectricalC

ProjectProfile.MechanicalComponent

ProjectProfile.ProjectComponent

You can also apply stereotypes by selecting a single model element. From **Scope**, select `Selection`, `This layer`, or `Entire model`.


Apply Stereotypes

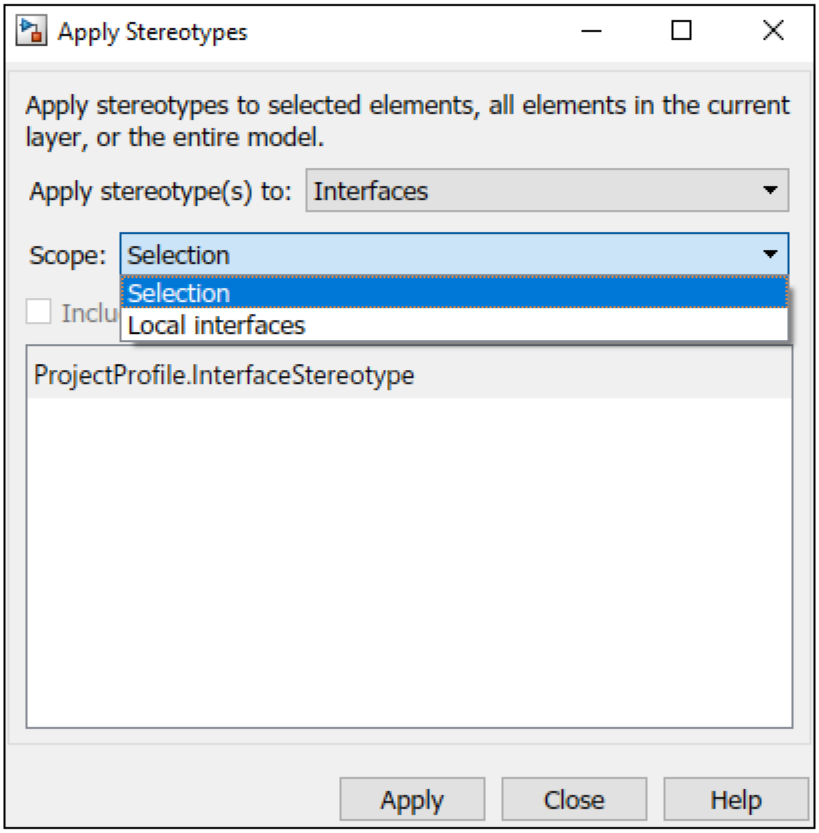
Apply stereotypes to selected elements, all elements in the current layer, or the entire model.

Apply stereotype(s) to: Components

Scope: Selection

Selection
This layer
Entire model
□ Inclu
ProjectProfile.ElectricalComponent
ProjectProfile.MechanicalComponent
ProjectProfile.ProjectComponent
Apply
Close
Help

You can also apply stereotypes to data interfaces or value types. When interfaces are locally defined and you select one or more interfaces in the **Interface Editor**, the options for **Scope** are `Selection` and `Local interfaces`.



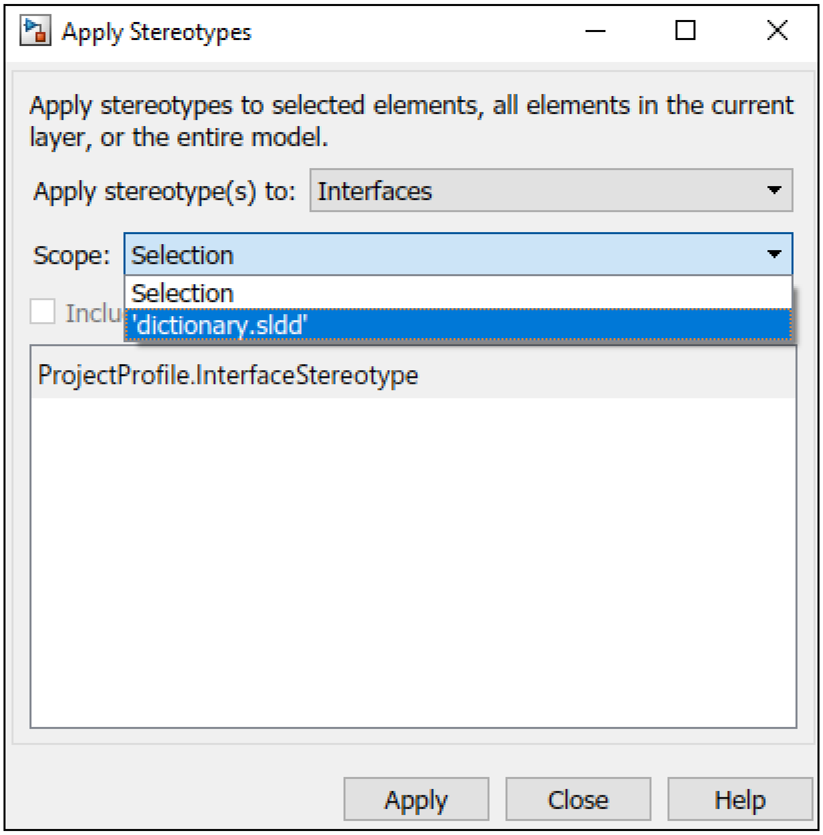
Apply Stereotypes

Apply stereotypes to selected elements, all elements in the current layer, or the entire model.

Apply stereotype(s) to: Interfaces

Scope: Selection

When interfaces are stored and shared across a data dictionary and you select one or more interfaces in the **Interface Editor**, the options for **Scope** are `Selection` and either `dictionary.sldd` or the name of the dictionary currently in use.



Apply stereotypes to selected elements, all elements in the current layer, or the entire model.

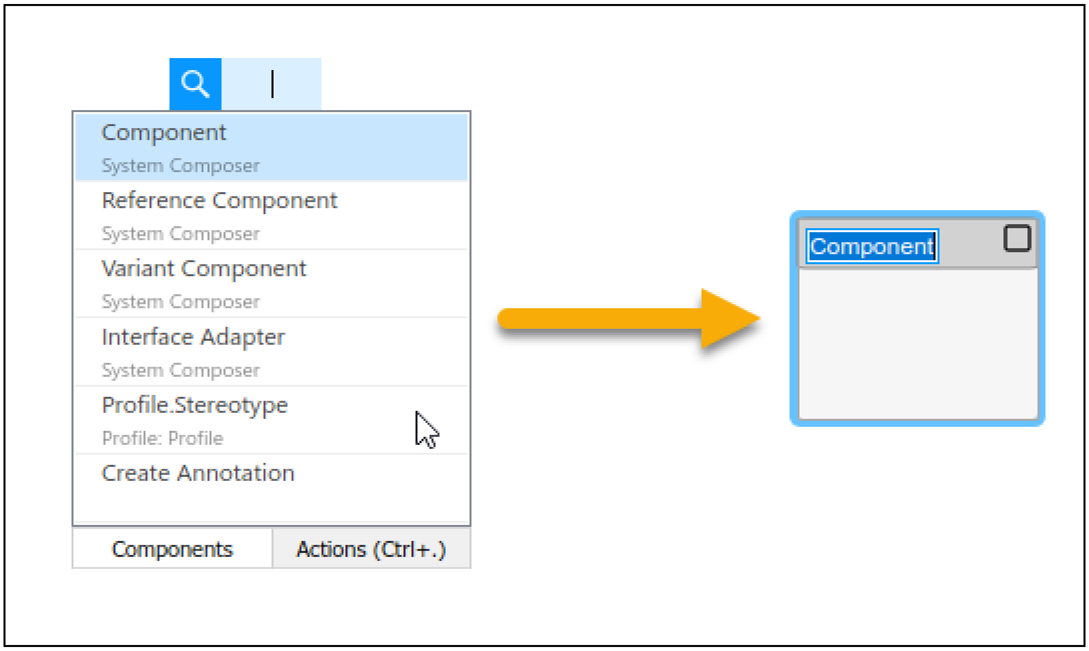
Apply stereotype(s) to: Interfaces

Scope: Selection

Note For the stereotypes to display for interfaces in a dictionary, in the Apply Stereotypes dialog box, the profile must be imported into the dictionary.

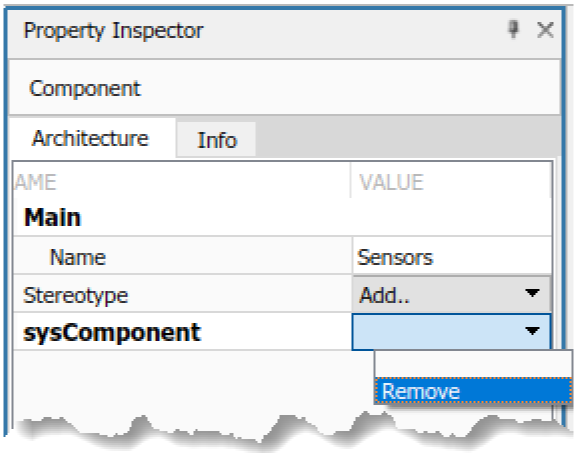
Quick-Insert New Component With Stereotype Applied

You can also create a new component with an applied stereotype using the quick-insert menu. Select the stereotype as a fully qualified name. A component with that stereotype is created.



Remove Stereotypes

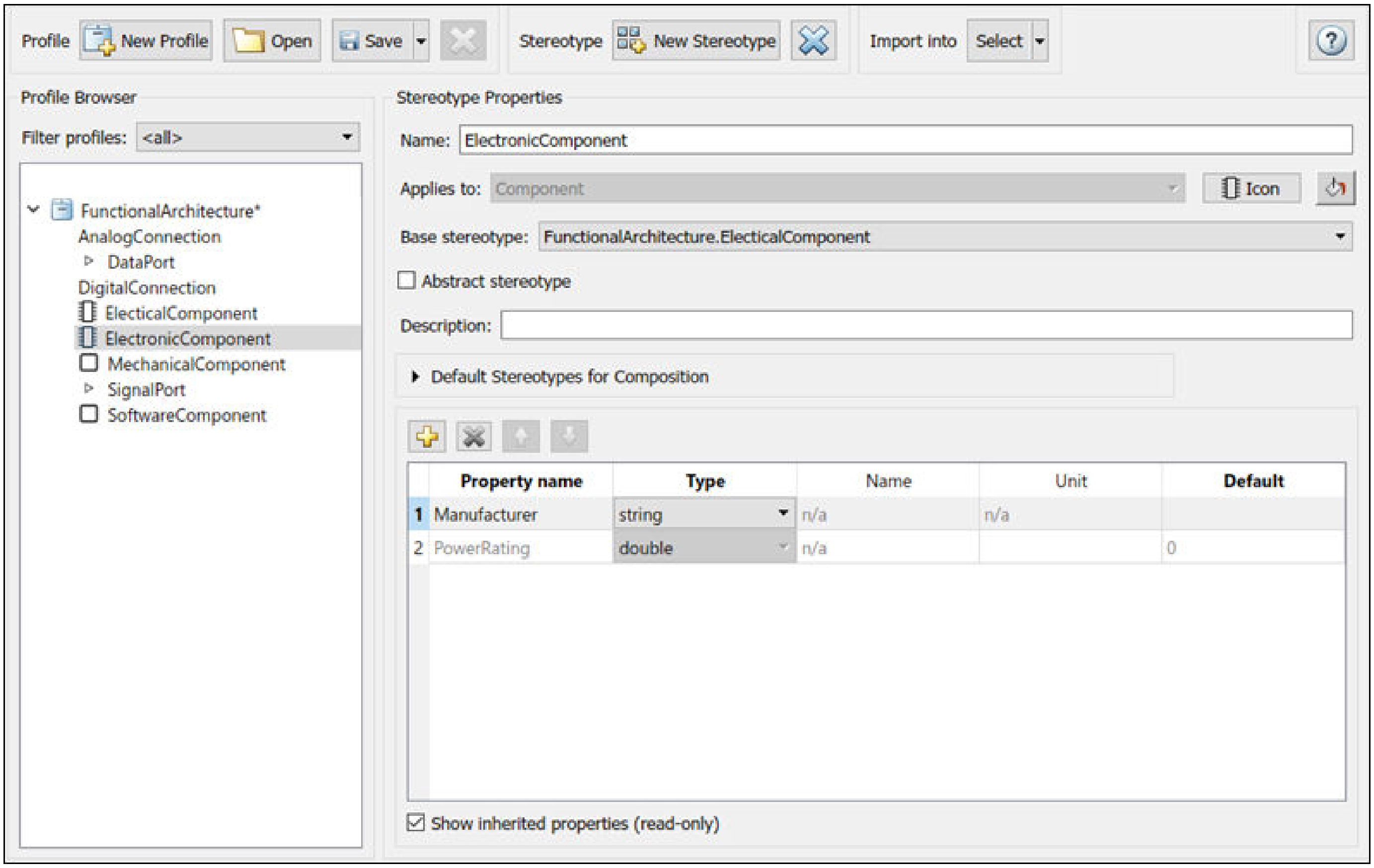
If a stereotype is no longer required for an element, remove it using the **Property Inspector**. Click **Select** next to the stereotype and choose **Remove**.



Extend Stereotypes

You can extend a stereotype by creating a new stereotype based on the existing one, allowing you to control properties in a structural manner. For example, all components in a project may have a part number, but only electrical components have a power rating, and only electronic components — a subset of electrical components — have manufacturer information. You can use an abstract stereotype to serve solely as a base for other stereotypes and not as a stereotype for any architecture model elements.

For example, create a new stereotype called `ElectronicComponent` in the **Profile Editor**. Select its base stereotype as `FunctionalArchitecture.ElectricalComponent`. Define properties you are adding to those of the base stereotype. Check **Show inherited properties** at the bottom of the property list to show the properties of the base stereotype. You can edit only the properties of the selected stereotype, not the base stereotype.



Filter profiles: <all>

- FunctionalArchitecture*
  - AnalogConnection
    - DataPort
  - DigitalConnection
  - ElecticalComponent
  - ElectronicComponent
  - MechanicalComponent
    - SignalPort
  - SoftwareComponent

Name: ElectronicComponent

Applies to: Component

Base stereotype: FunctionalArchitecture.ElecticalComponent

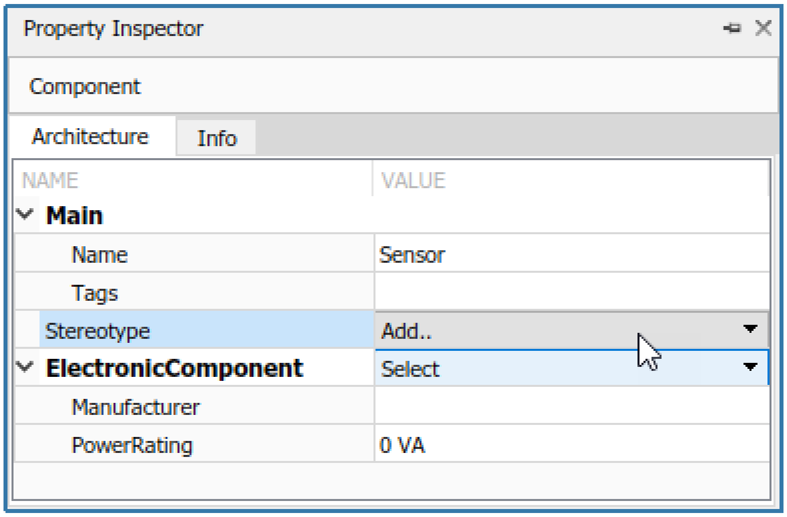
☐ Abstract stereotype

Description:

	Property name	Type	Name	Unit	Default
1	Manufacturer	string	n/a	n/a	
2	PowerRating	double	n/a		0

☑ Show inherited properties (read-only)

When you apply the new stereotype, it carries its defined properties in addition to those of its base stereotype.



NAME	VALUE
Main	
Name	Sensor
Tags	
Stereotype	Add..
ElectronicComponent	Select
Manufacturer	
PowerRating	0 VA

See Also

`editor` | `hasStereotype` | `hasProperty` | `systemcomposer.profile.Profile` | `systemcomposer.profile.Property` | `systemcomposer.profile.Stereotype`

More About

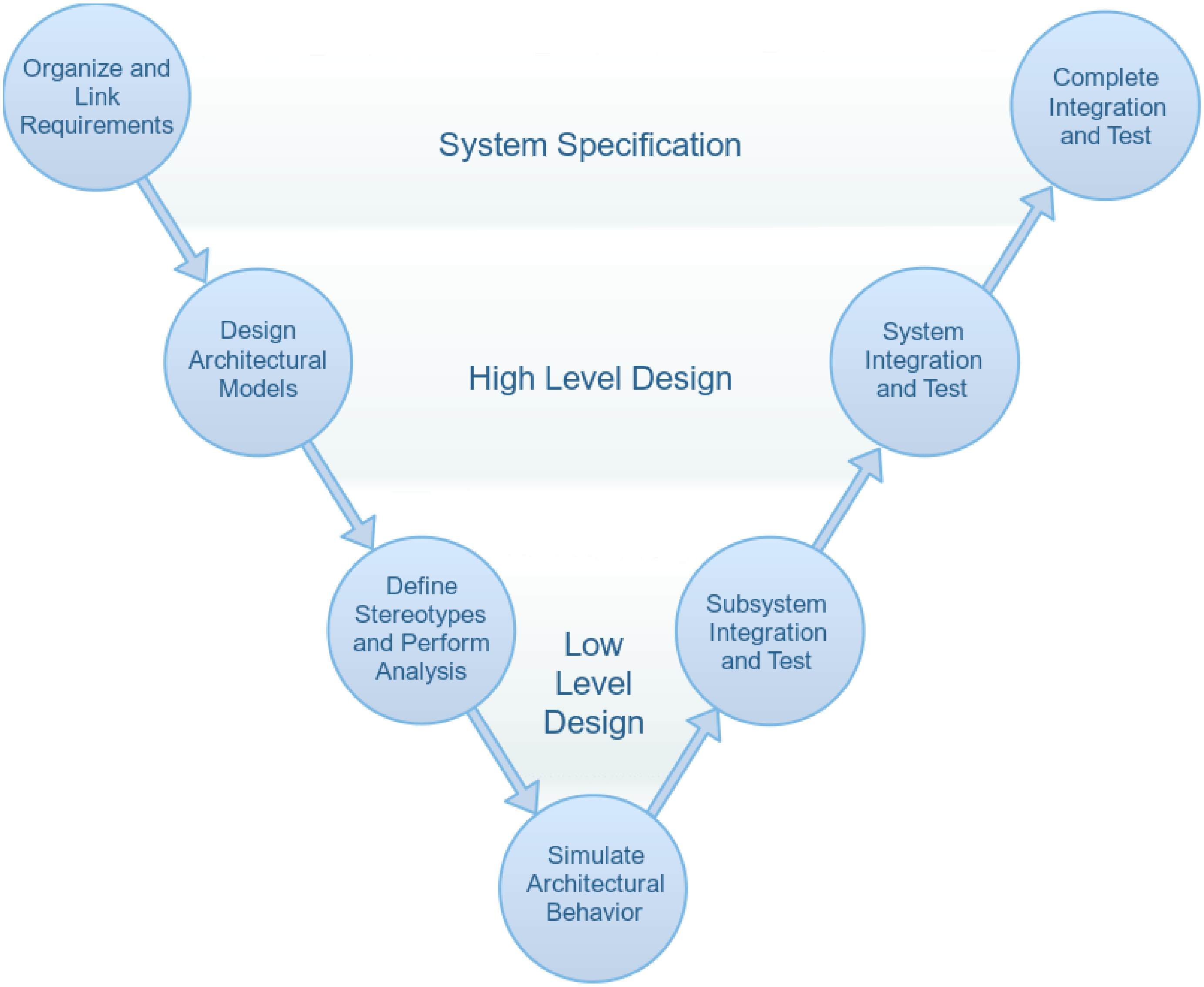
- "Define Profiles and Stereotypes" on page 5-2
- "Analyze Architecture" on page 9-2
- "Analysis Function Constructs" on page 9-9
- "Apply Stereotypes to Functions of Software Architectures" on page 10-29
- "Simulate Mobile Robot with System Composer Workflow" on page 5-20

Simulate Mobile Robot with System Composer Workflow

Along with other tools, System Composer™ can help you organize and link requirements, design and allocate architecture models, analyze the system, and implement the design in Simulink®. Follow this tutorial for the early phase of development of an autonomous mobile robot.

1. “Organize and Link Requirements” on page 5-22: Set up the requirements based on market research using Requirements Toolbox™.
2. “Design Architecture Models” on page 5-25: Create architecture models to help organize algorithms and hardware.
3. “Define Stereotypes and Perform Analysis” on page 5-32: Define stereotypes and perform system analysis to ensure that the life expectancy of the durable components in the robot meets the customer-specified mean time before repair.
4. “Simulate Architectural Behavior” on page 5-41: Create a Simulink model to simulate realistic behavior of the mobile robot.

This workflow is represented by the left side of the model-based systems engineering (MBSE) design diagram.


Organize and Link Requirements
System Specification
Complete Integration and Test
Design Architectural Models
High Level Design
System Integration and Test
Define Stereotypes and Perform Analysis
Low Level Design
Subsystem Integration and Test
Simulate Architectural Behavior

See Also

More About

- "Model-Based Design with Simulink"
- "Organize System Composer Files in Projects" on page 12-2

Organize and Link Requirements

The first step in model-based systems engineering (MBSE) design using System Composer is to set up requirements. This functionality requires a Requirements Toolbox license.

Requirements are a collection of statements describing the desired behavior and characteristics of a system. Requirements ensure system design integrity and are achievable, verifiable, unambiguous, and consistent with each other. Each level of design should have appropriate requirements. This mobile robot example has three sets of requirements.

1. *Stakeholder needs*—A set of end-user needs. Stakeholders are interested in attributes of the mobile robot associated with endurance, payload, speed, autonomy, and reliability.
2. *System requirements*—A set of requirements that are linked closely with system-level design. System requirements include the derived requirements that describe how the system responds to stakeholder needs.
3. *Implementation requirements*—A set of requirements that specify subsystems in the model. Implementation requirements include specifications for the battery, structure, propulsion, path generation, position, controller, and component life for individual subsystems.

By linking one requirement set to another, each high-level requirement can be traced to implementation. As the MBSE design evolves, you can use iterative requirements analysis to enhance requirement traceability and coverage. You can use the traceability diagram to visualize requirement traceability. See “Visualize Links with a Traceability Diagram” (Requirements Toolbox).

Note This example uses Simscape™ blocks. If you do not have a Simscape license, you can open and simulate the model but can only make basic changes, such as modifying block parameters.

Link Stakeholder Requirements to System Requirements

The mobile robot example includes a functional, logical, and physical architecture that fulfill stakeholder needs, system requirements, and implementation requirements.

Load these systems in memory to view their requirement links:

- Functional architecture model
- Logical architecture model
- Physical architecture model

```
systemcomposer.loadModel("RobotFunctionalArchitecture");
systemcomposer.loadModel("scMobileRobotLogicalArchitecture_SS");
systemcomposer.loadModel("scMobileRobotHardwareArchitecture");
```

Load these requirement sets into memory:

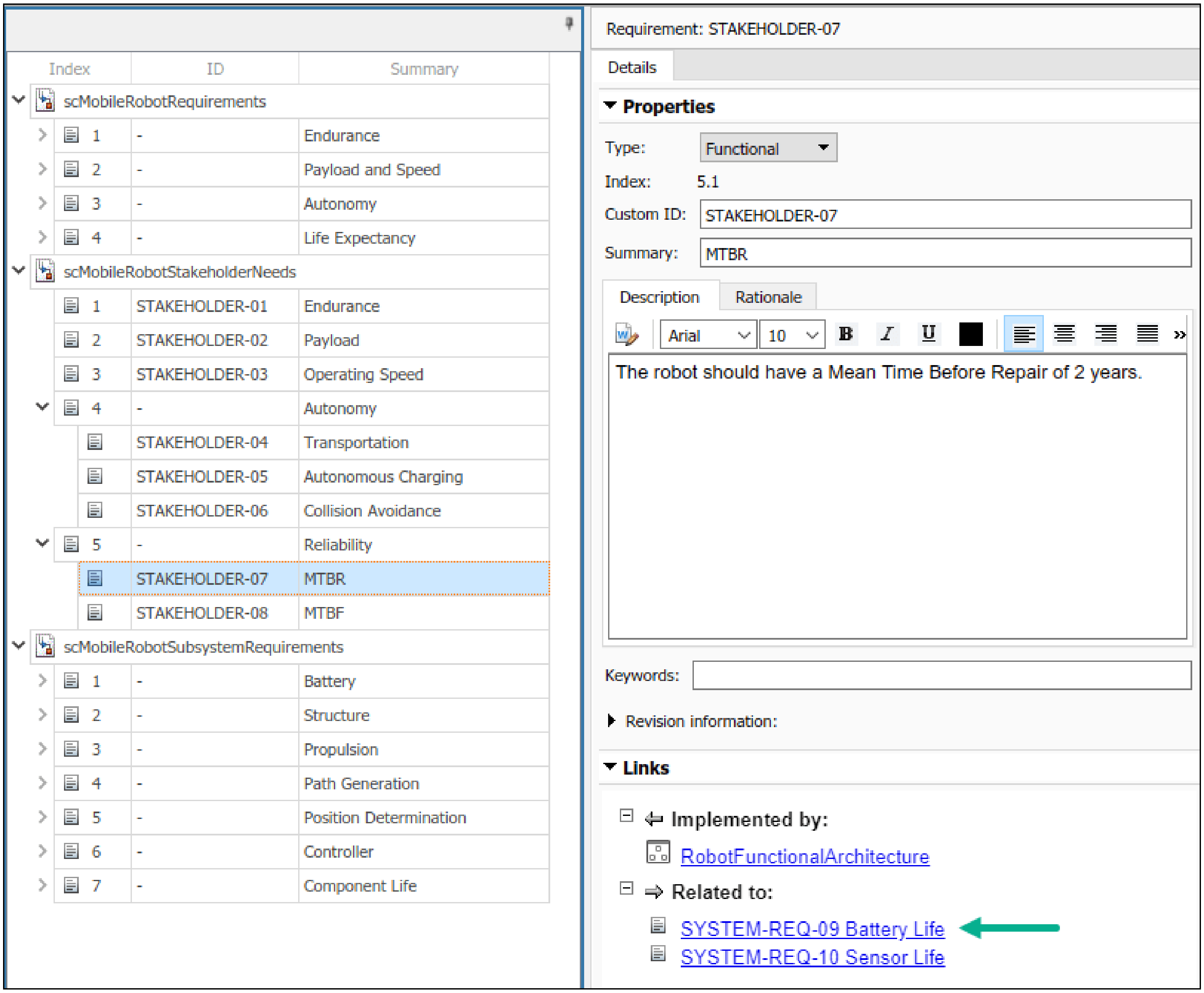
- Stakeholder needs
- System requirements
- Implementation requirements

```
slreq.load("scMobileRobotStakeholderNeeds");
slreq.load("scMobileRobotRequirements");
slreq.load("scMobileRobotSubsystemRequirements");
```

Open the Requirements Editor (Requirements Toolbox).

```
slreq.editor
```

You can link stakeholder needs to derived requirements to keep track of high-level goals. The Mean Time Before Repair (MTBR) requirement, `STAKEHOLDER-07`, is refined by the Battery Life requirement, `SYSTEM-REQ-09`.



Index	ID	Summary
scMobileRobotRequirements		
1	-	Endurance
2	-	Payload and Speed
3	-	Autonomy
4	-	Life Expectancy
scMobileRobotStakeholderNeeds		
1	STAKEHOLDER-01	Endurance
2	STAKEHOLDER-02	Payload
3	STAKEHOLDER-03	Operating Speed
4	-	Autonomy
	STAKEHOLDER-04	Transportation
	STAKEHOLDER-05	Autonomous Charging
	STAKEHOLDER-06	Collision Avoidance
5	-	Reliability
	STAKEHOLDER-07	MTBR
	STAKEHOLDER-08	MTBF
scMobileRobotSubsystemRequirements		
1	-	Battery
2	-	Structure
3	-	Propulsion
4	-	Path Generation
5	-	Position Determination
6	-	Controller
7	-	Component Life

Requirement: STAKEHOLDER-07

Properties

Type: Functional

Index: 5.1

Custom ID: STAKEHOLDER-07

Summary: MTBR

The robot should have a Mean Time Before Repair of 2 years.

Keywords:

Links

Implemented by:

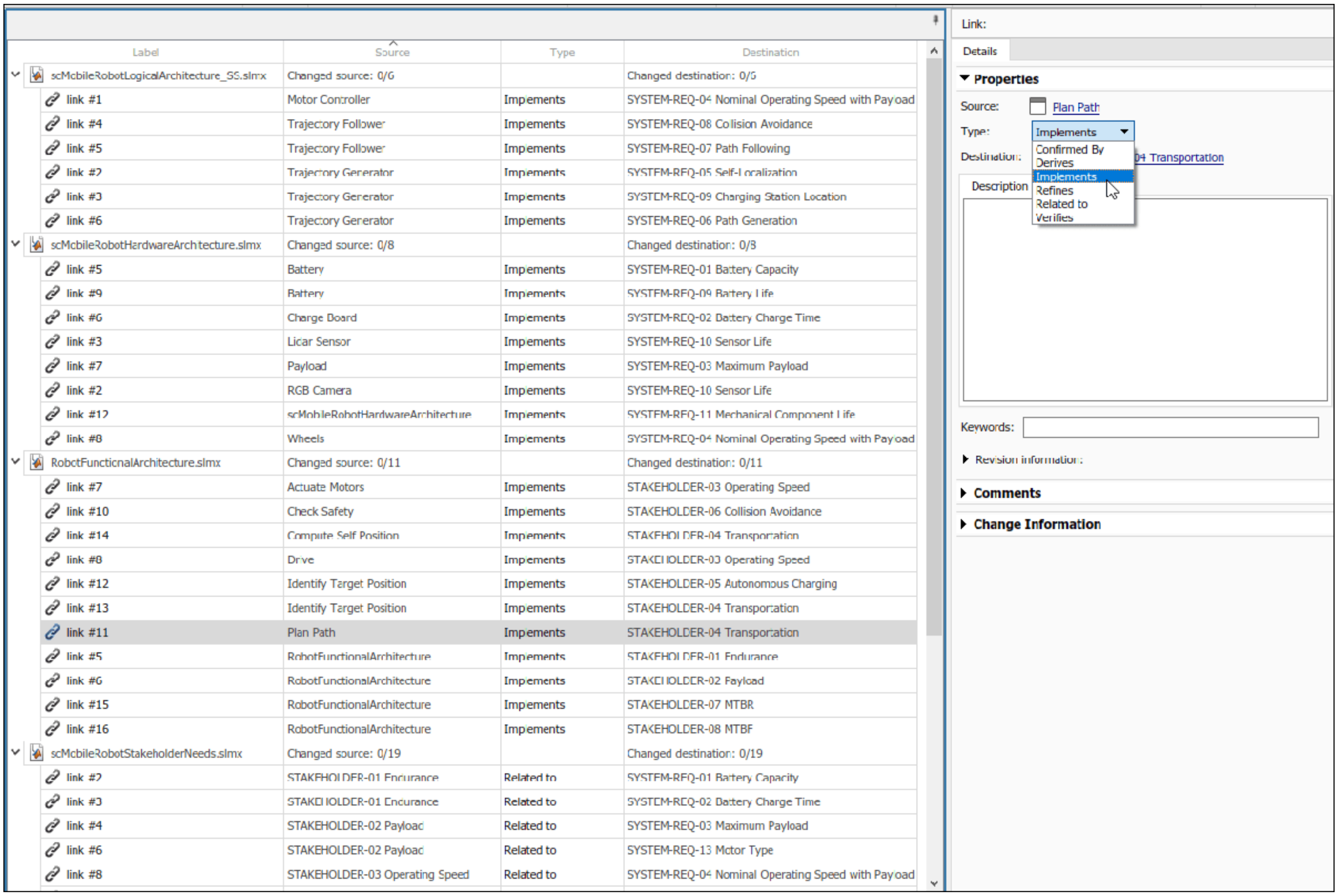
RobotFunctionalArchitecture

Related to:

SYSTEM-REQ-09 Battery Life

SYSTEM-REQ-10 Sensor Life

You can set a specific link type. To change link types, in the Requirements Editor (Requirements Toolbox), select **Show Links**. For more information, see “Create and Store Links” (Requirements Toolbox).



Label	Source	Type	Destination
scMobileRobotLogicalArchitecture_SS.slmx	Changed source: 0/6		Changed destination: 0/6
link #1	Motor Controller	Implements	SYSTEM-REQ-04 Nominal Operating Speed with Payload
link #4	Trajectory Follower	Implements	SYSTEM-REQ-08 Collision Avoidance
link #5	Trajectory Follower	Implements	SYSTEM-REQ-07 Path Following
link #2	Trajectory Generator	Implements	SYSTEM-REQ-05 Self-Localization
link #3	Trajectory Generator	Implements	SYSTEM-REQ-09 Charging Station Location
link #6	Trajectory Generator	Implements	SYSTEM-REQ-06 Path Generation
scMobileRobotHardwareArchitecture.slmx	Changed source: 0/8		Changed destination: 0/8
link #5	Battery	Implements	SYSTEM-REQ-01 Battery Capacity
link #9	Battery	Implements	SYSTEM-REQ-09 Battery Life
link #6	Charge Board	Implements	SYSTEM-REQ-02 Battery Charge Time
link #3	Lidar Sensor	Implements	SYSTEM-REQ-10 Sensor Life
link #7	Payload	Implements	SYSTEM-REQ-03 Maximum Payload
link #2	RGB Camera	Implements	SYSTEM-REQ-10 Sensor Life
link #12	scMobileRobotHardwareArchitecture	Implements	SYSTEM-REQ-11 Mechanical Component Life
link #8	Wheels	Implements	SYSTEM-REQ-04 Nominal Operating Speed with Payload
RobotFunctionalArchitecture.slmx	Changed source: 0/11		Changed destination: 0/11
link #7	Actuate Motors	Implements	STAKEHOLDER-03 Operating Speed
link #10	Check Safety	Implements	STAKEHOLDER-06 Collision Avoidance
link #14	Compute Self Position	Implements	STAKEHOLDER-04 Transportation
link #8	Drive	Implements	STAKEHOLDER-03 Operating Speed
link #12	Identify Target Position	Implements	STAKEHOLDER-05 Autonomous Charging
link #13	Identify Target Position	Implements	STAKEHOLDER-04 Transportation
link #11	Plan Path	Implements	STAKEHOLDER-04 Transportation
link #5	RobotFunctionalArchitecture	Implements	STAKEHOLDER-01 Endurance
link #6	RobotFunctionalArchitecture	Implements	STAKEHOLDER-02 Payload
link #15	RobotFunctionalArchitecture	Implements	STAKEHOLDER-07 MTBR
link #16	RobotFunctionalArchitecture	Implements	STAKEHOLDER-08 MTBF
scMobileRobotStakeholderNeeds.slmx	Changed source: 0/19		Changed destination: 0/19
link #2	STAKEHOLDER-01 Endurance	Related to	SYSTEM-REQ-01 Battery Capacity
link #3	STAKEHOLDER-01 Endurance	Related to	SYSTEM-REQ-02 Battery Charge Time
link #4	STAKEHOLDER-02 Payload	Related to	SYSTEM-REQ-03 Maximum Payload
link #6	STAKEHOLDER-02 Payload	Related to	SYSTEM-REQ-13 Motor Type
link #8	STAKEHOLDER-03 Operating Speed	Related to	SYSTEM-REQ-04 Nominal Operating Speed with Payload

Link:

Details

Properties

Source: Plan Path

Type: Implements

Destination: 04 Transportation

Description

Keywords:

To return to interacting with requirements, in the Requirements Editor (Requirements Toolbox), select **Show Requirements**. The Transportation stakeholder needs requirement, `STAKEHOLDER-04`, will be implemented by the Localization system requirement, `SYSTEM-REQ-05`. The robot must be able to determine its current position with a specified tolerance. Right-click `SYSTEM-REQ-05` and select `Select for Linking with Requirement`. Then, right-click `STAKEHOLDER-04` and select `Create a link from SYSTEM-REQ-05 to STAKEHOLDER-04`.

See Also

`slreq.editor` | `slreq.load` | `systemcomposer.loadModel`

More About

- “Manage Requirements” on page 2-8
- “Link and Trace Requirements” on page 2-2
- “Design Insulin Infusion Pump Using Model-Based Systems Engineering” on page 9-23

Design Architecture Models

Architecture models in System Composer describe a system at different levels of abstraction. This mobile robot example presents three architectures:

1. *Functional architecture* describes high-level functions and the relationships between them.
2. *Logical architecture* describes data exchange between electronic hardware and software components in each subsystem.
3. *Physical architecture* describes the physical hardware or platform needed for the robot.

Note This example uses Simscape blocks. If you do not have a Simscape license, you can open and simulate the model but can only make basic changes, such as modifying block parameters.

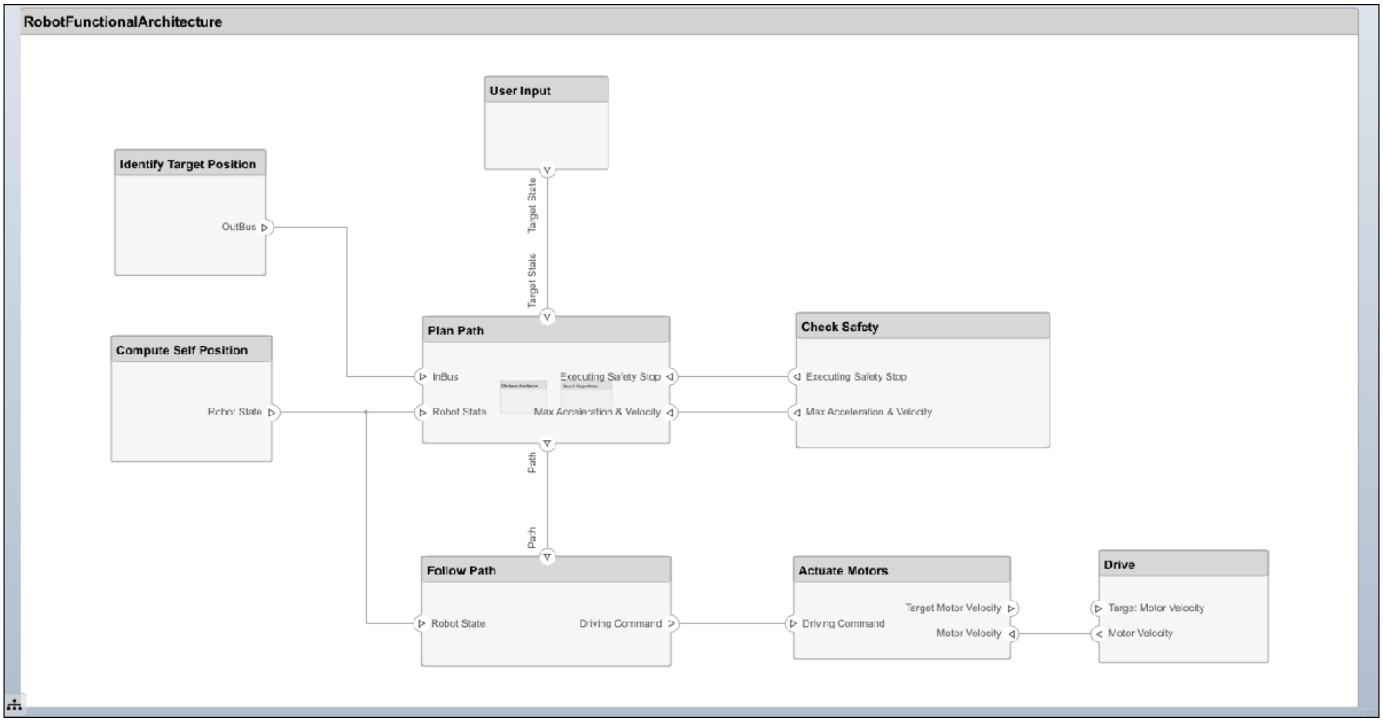
Design, Specify, and Allocate Architecture Models

The mobile robot example includes a functional, logical, and physical architecture with requirements linked to components and model-to-model allocations defined.

Functional Architecture Model for Mobile Robot

The functional architecture model describes functional dependencies: controlling a mobile robot autonomously, localization, path-planning, and path-following. To open the functional architecture model, double-click the file or run this command.

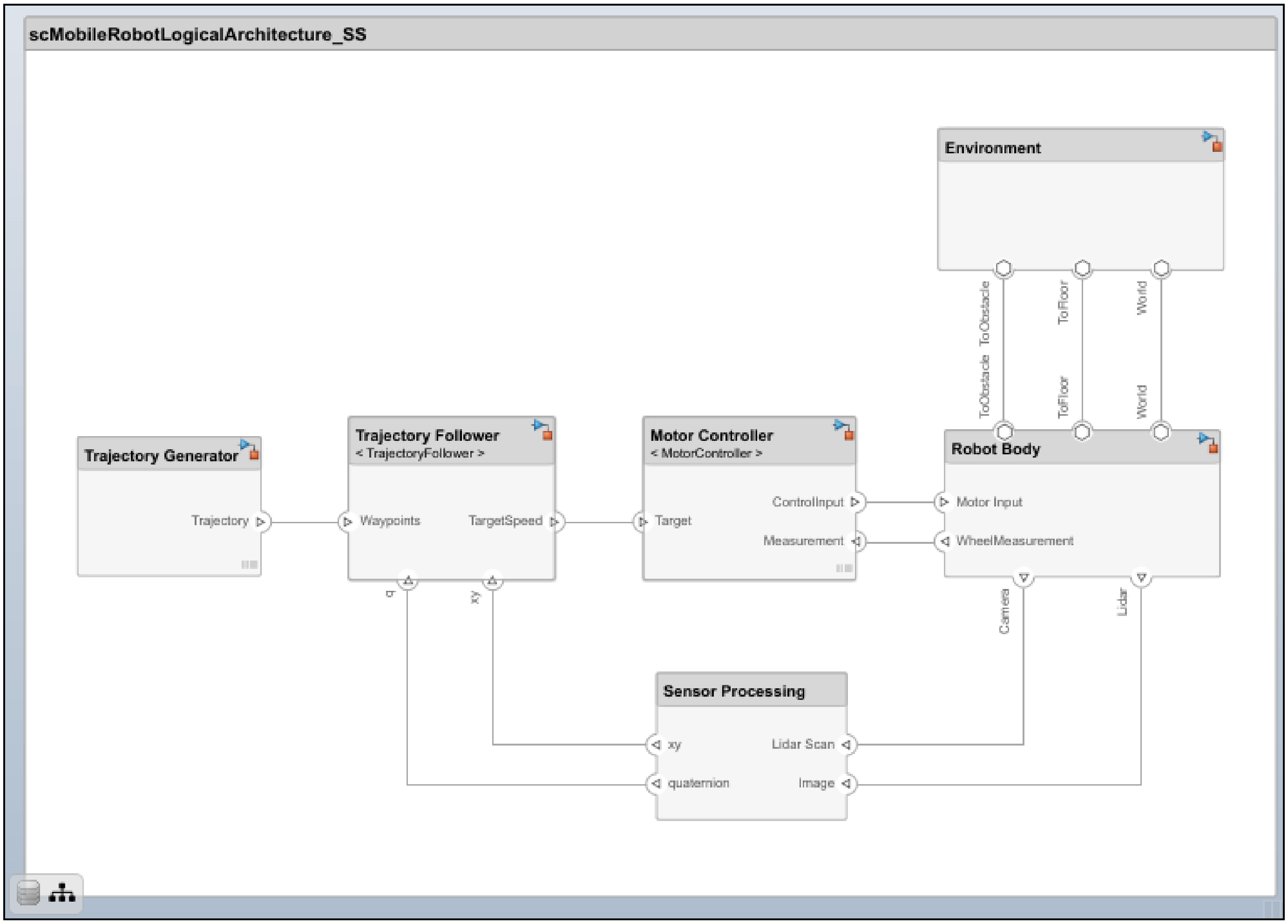
```
systemcomposer.openModel("RobotFunctionalArchitecture");
```



Logical Architecture Model for Mobile Robot

The logical architecture model describes the behavior of the mobile robot system for simulation: trajectory generator, trajectory follower, motor controller, sensor algorithm, and robot and environment. The connections represent the interactions in the system. To open the logical architecture model, double-click the file or run this command.

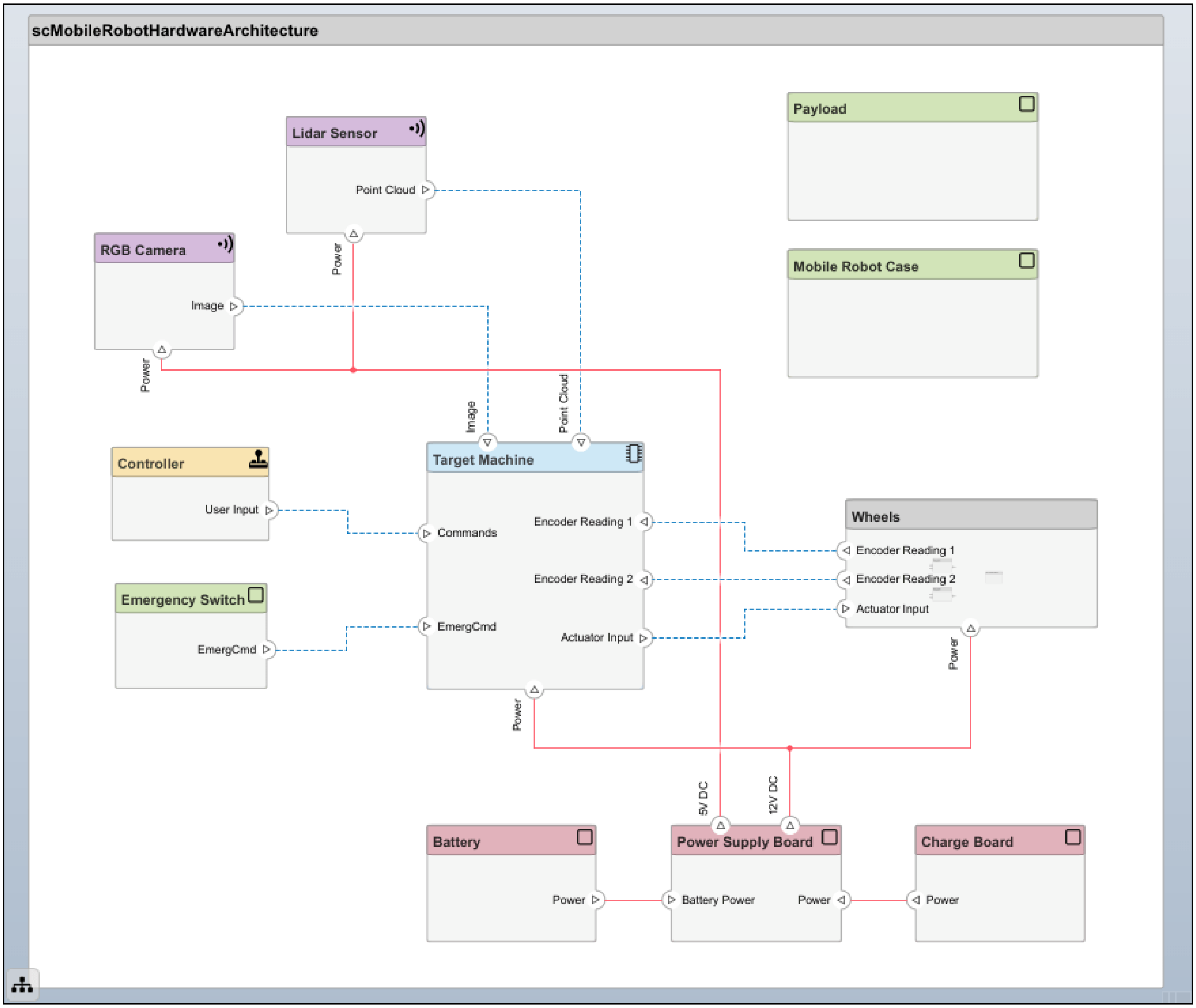
```
systemcomposer.openModel("scMobileRobotLogicalArchitecture_SS");
```



Physical Architecture Model for Mobile Robot

The physical architecture model describes the hardware components and their connections: the sensor, actuators, and embedded processor. The colors and icons indicate the stereotypes used for each element. To open the physical architecture model, double-click the file or run this command.

```
systemcomposer.openModel("scMobileRobotHardwareArchitecture");
```

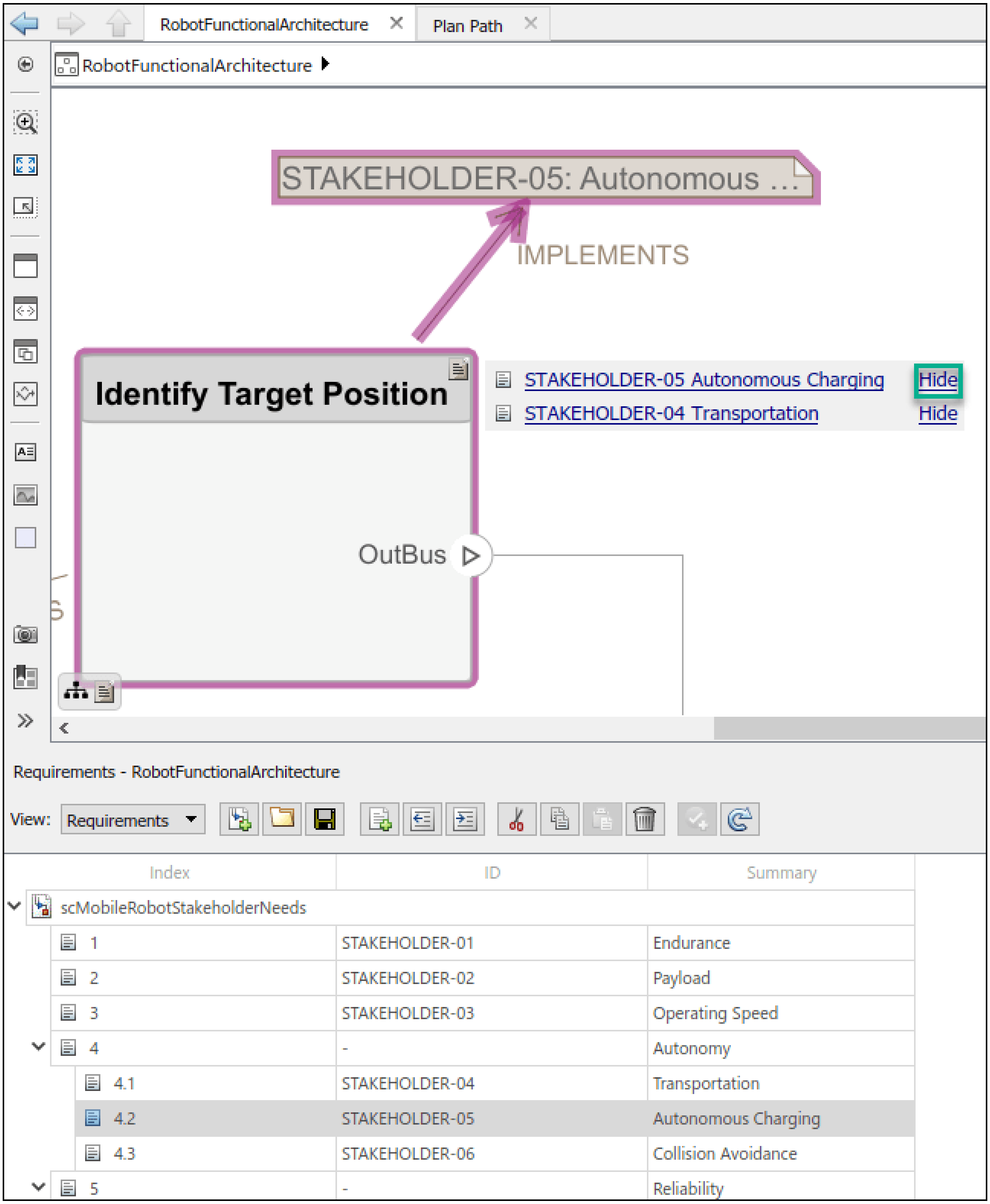


Link Requirements to Components

Requirement traceability involves linking technical requirements to components and ports in architecture models, thereby allowing the connection between an early requirements phase and system-level design. You can easily track whether a requirement is met by connecting components back to stakeholder needs. You can add requirement links by dragging requirements to a component.

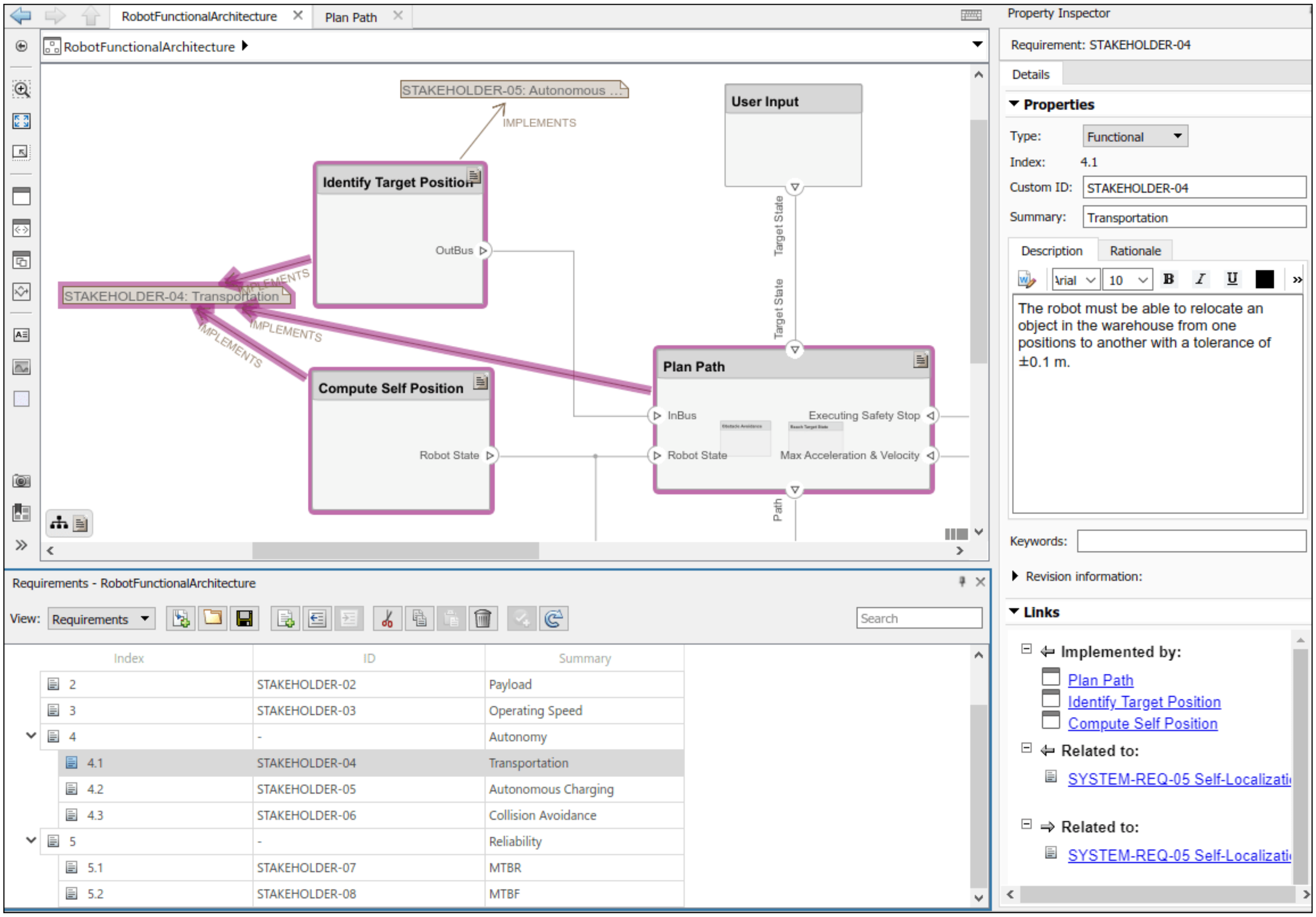
To view requirements, open the Requirements Manager by navigating to **Apps** > **Requirements Manager**.

The `Identify Target Position` component in the functional architecture model implements the Autonomous Charging requirement, `STAKEHOLDER-05`. To show or hide linked requirements, click the requirement icon on the top-right corner of a component.


RobotFunctionalArchitecture
Plan Path
RobotFunctionalArchitecture
STAKEHOLDER-05: Autonomous …
IMPLEMENTS
Identify Target Position
OutBus
STAKEHOLDER-05 Autonomous Charging
Hide
STAKEHOLDER-04 Transportation
Hide
Requirements - RobotFunctionalArchitecture
View:
Requirements

Index	ID	Summary
scMobileRobotStakeholderNeeds		
1	STAKEHOLDER-01	Endurance
2	STAKEHOLDER-02	Payload
3	STAKEHOLDER-03	Operating Speed
4	-	Autonomy
4.1	STAKEHOLDER-04	Transportation
4.2	STAKEHOLDER-05	Autonomous Charging
4.3	STAKEHOLDER-06	Collision Avoidance
5	-	Reliability

You can view the requirements linked to the hardware architecture model in the Requirements Browser. After selecting `STAKEHOLDER-04`, only components related to the Transportation requirement are shown.



Index	ID	Summary
2	STAKEHOLDER-02	Payload
3	STAKEHOLDER-03	Operating Speed
4	-	Autonomy
4.1	STAKEHOLDER-04	Transportation
4.2	STAKEHOLDER-05	Autonomous Charging
4.3	STAKEHOLDER-06	Collision Avoidance
5	-	Reliability
5.1	STAKEHOLDER-07	MTBR
5.2	STAKEHOLDER-08	MTBF

Requirement: STAKEHOLDER-04

Properties

Type: Functional

Index: 4.1

Custom ID: STAKEHOLDER-04

Summary: Transportation

The robot must be able to relocate an object in the warehouse from one positions to another with a tolerance of ±0.1 m.

Keywords:

Links

Implemented by:
- Plan Path
- Identify Target Position
- Compute Self Position

Related to:
- SYSTEM-REQ-05 Self-Localizati

Related to:
- SYSTEM-REQ-05 Self-Localizati

Allocate Architectures

You can allocate functional components to physical components using model-to-model allocations. To open the Allocation Editor, navigate to **Modeling** > **Allocation Editor**, or run this command.

```
systemcomposer.allocation.editor
```

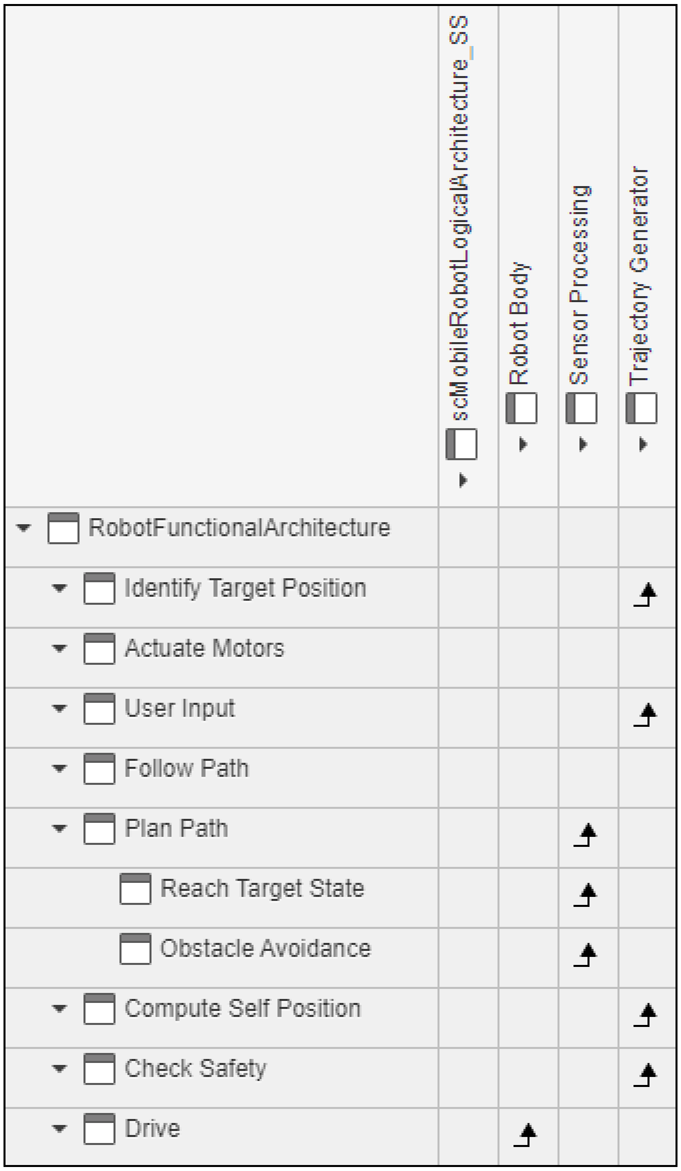
Load the allocation sets.

```
allocSetFunc = systemcomposer.allocation.load("FunctionalAllocation");
allocSetPhys = systemcomposer.allocation.load("PhysicalAllocation");
```

Allocate Functional to Physical Architectures

Click `Scenario 1` under the `FunctionalAllocation` allocation set.

Select the **Component** in the **Row Filter** and **Column Filter** sections. The Allocation Editor tool allows you to link components between different architecture models to establish traceability for your project. Double-click the boxes in the allocation matrix to allocate or deallocate two elements.

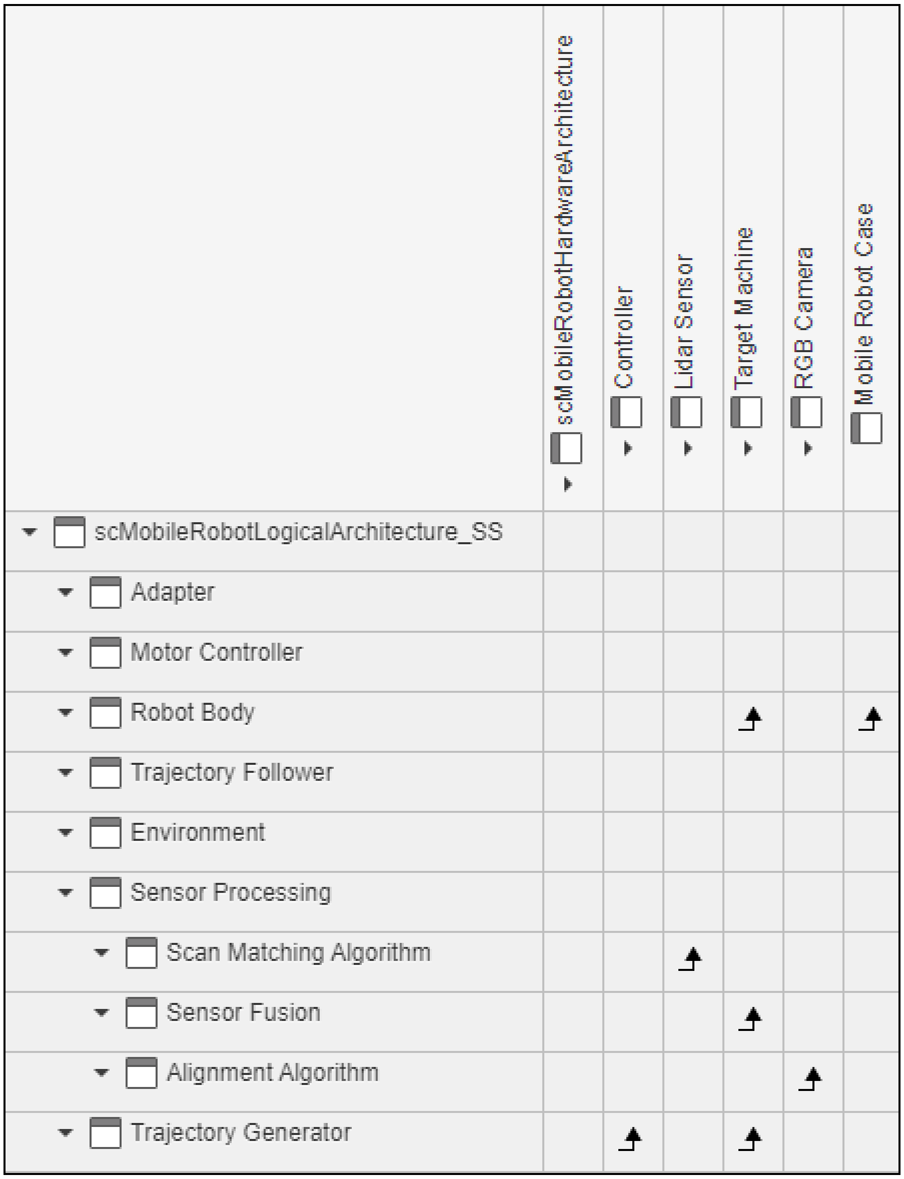


	scMobileRobotLogicalArchitecture_SS	Robot Body	Sensor Processing	Trajectory Generator
RobotFunctionalArchitecture				
Identify Target Position				↑
Actuate Motors				
User Input				↑
Follow Path				
Plan Path			↑	
Reach Target State			↑	
Obstacle Avoidance			↑	
Compute Self Position				↑
Check Safety				↑
Drive		↑		

In the functional architecture, the trajectory generator requires components such as `Identify Target Postion`, `User Input`, and `Compute Self Position`, so these components are allocated to the `Trajectory Generator` component in the logical architecture.

Allocate Logical to Physical Architectures

Click `Scenario 1` under the `PhysicalAllocation` allocation set.



	scMobileRobotHardwareArchitecture	Controller	Lidar Sensor	Target Machine	RGB Camera	Mobile Robot Case
scMobileRobotLogicalArchitecture_SS						
Adapter						
Motor Controller						
Robot Body				↑		↑
Trajectory Follower						
Environment						
Sensor Processing						
Scan Matching Algorithm			↑			
Sensor Fusion				↑		
Alignment Algorithm					↑	
Trajectory Generator		↑		↑		

The autonomy of a vehicle is mostly handled by a target machine, which is an embedded computer responsible for processing sensor readings to calculate control inputs. Therefore, many functional components like `Robot Body`, `Sensor Fusion`, and `Trajectory Generator` are allocated to the `Target Machine` component in the physical architecture model.

See Also

`allocate` | `addComponent` | `addPort` | `connect`

More About

- "Compose Architectures Visually" on page 1-2
- "Link and Trace Requirements" on page 2-2
- "Create and Manage Allocations Programmatically" on page 8-8

Define Stereotypes and Perform Analysis

Stereotypes add an additional layer of metadata to components, ports, and connectors in System Composer. A stereotype is a custom extension of the modeling language. Stereotypes provide a mechanism to extend the architectural language elements by adding domain-specific metadata. The hardware architecture model provides a basis to understand the stereotypes applied to model elements, create filtered views based on the stereotypes, and perform an analysis on the model.

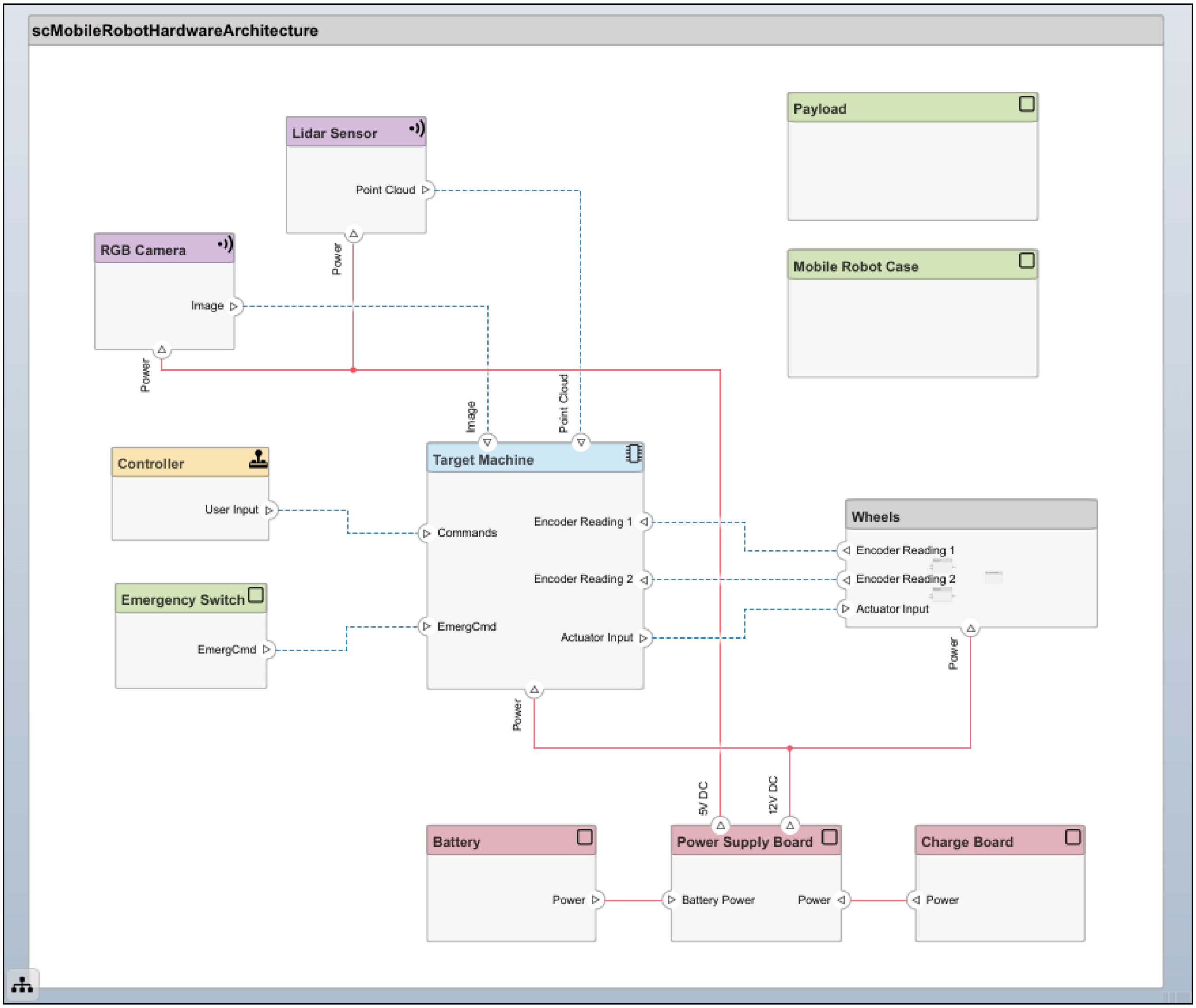
Define Stereotypes and Perform Analysis

This mobile robot example includes a profile applied to a physical architecture with stereotypes and properties defined. You can use views to display stakeholder concerns. Perform a remaining useful life (RUL) analysis on the life expectancy of the hardware components.

Hardware Architecture Model for Mobile Robot

The hardware architecture model describes the hardware components and their connections: the sensor, actuators, and embedded processor. The colors and icons indicate the stereotypes used for each element. To open the hardware architecture model, double-click the file or run this command.

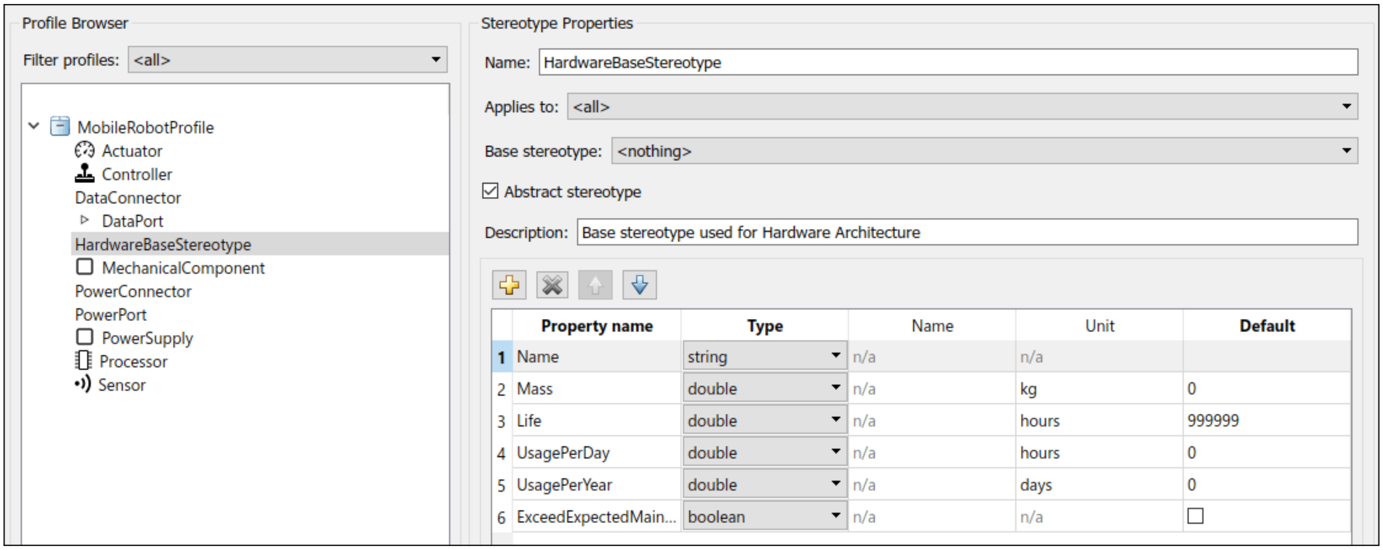
```
systemcomposer.openModel("scMobileRobotHardwareArchitecture");
```



View Stereotypes and Properties in Profile Editor

In this example, the `HardwareBaseStereotype` stereotype is defined as an abstract stereotype and is extended to connector and component stereotypes. For example, a `DataConnector` stereotype is a connector stereotype that inherits the `HardwareBaseStereotype`.

To focus on expected time before first maintenance, define properties such as `UsagePerDay`, `UsagePerYear`, and `Life`. Setting these properties allows you to analyze each hardware component to make sure the mobile robot will last until first expected year of maintenance. To open the Profile Editor, navigate to **Modeling** > **Profile Editor**.



Profile Browser

Filter profiles: <all>

MobileRobotProfile
Actuator
Controller
DataConnector
DataPort
HardwareBaseStereotype
MechanicalComponent
PowerConnector
PowerPort
PowerSupply
Processor
Sensor

Stereotype Properties

Name: HardwareBaseStereotype

Applies to: <all>

Base stereotype: <nothing>

☑ Abstract stereotype

Description: Base stereotype used for Hardware Architecture

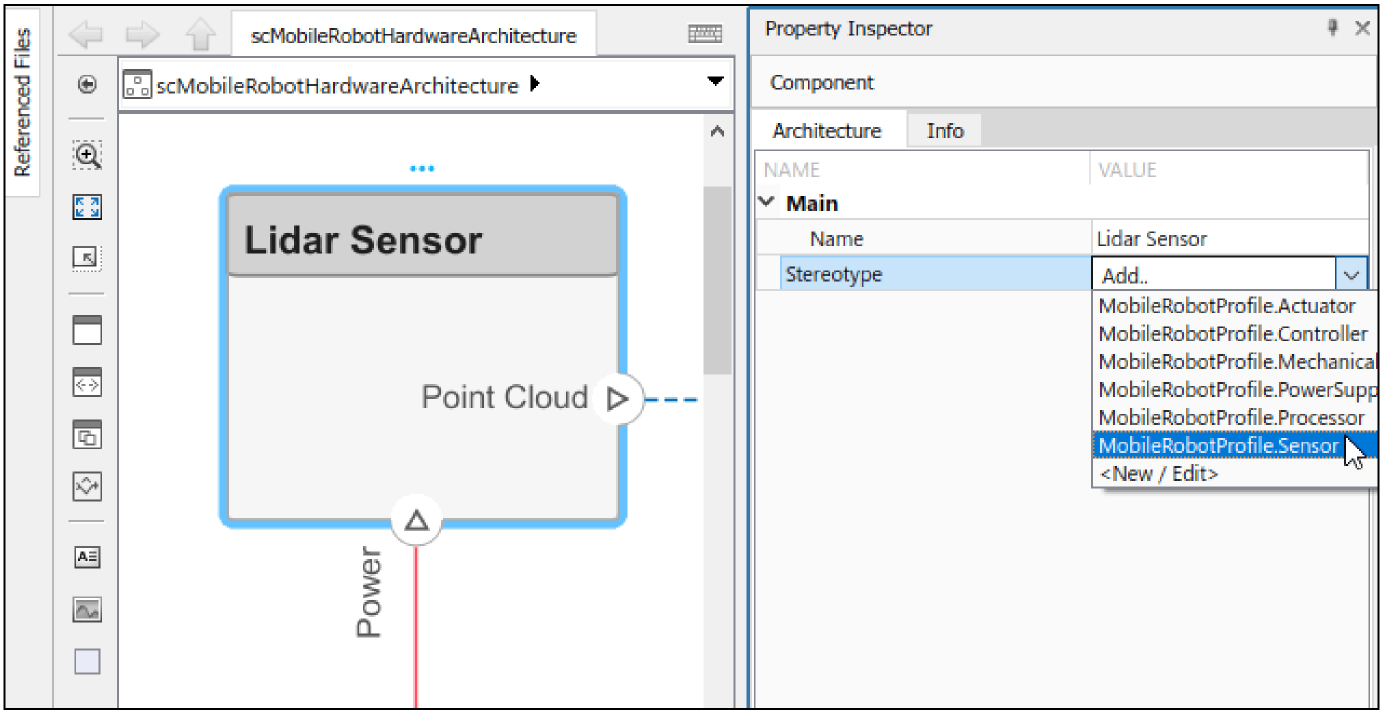
	Property name	Type	Name	Unit	Default
1	Name	string	n/a	n/a	
2	Mass	double	n/a	kg	0
3	Life	double	n/a	hours	999999
4	UsagePerDay	double	n/a	hours	0
5	UsagePerYear	double	n/a	days	0
6	ExceedExpectedMain...	boolean	n/a	n/a	□

In addition to properties like name and mass, the `DataConnector` stereotype has a property of enumeration type, `TypeOfConnection`, that describes which of the three connection types it uses: RS232, Ethernet, or USB. To generate custom data types, create a script simlar to `ConnectorType.m`. For more information, see “Simulink Enumerations”.

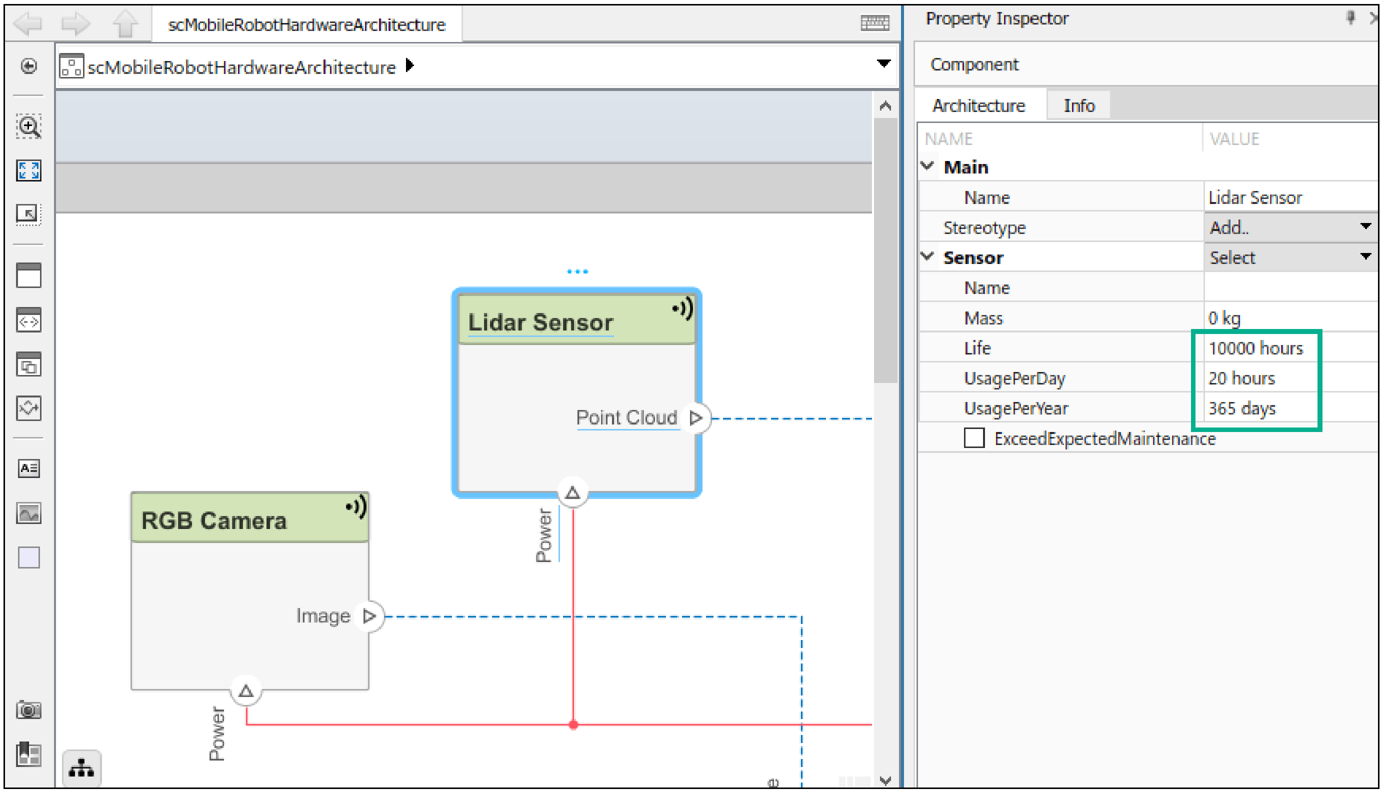
Apply Stereotypes to Elements in Model

Once you define stereotypes in the Profile Editor, you can apply them to components, ports, and connectors. Apply stereotypes using the Property Inspector. To open the Property Inspector, navigate to **Modeling** > **Property Inspector**.

To add stereotypes to elements, select the element in the diagram. In the Property Inspector, select **Main** > **Stereotype**. You can apply multiple stereotypes to the same element. Apply the `MobileRobotProfile.Sensor` stereotype to the `Lidar Sensor` component to add properties.


Referenced Files
scMobileRobotHardwareArchitecture
scMobileRobotHardwareArchitecture ▸
Lidar Sensor
Point Cloud
Power
Property Inspector
Component
Architecture
Info
NAME
VALUE
Main
Name
Lidar Sensor
Stereotype
Add..
MobileRobotProfile.Actuator
MobileRobotProfile.Controller
MobileRobotProfile.Mechanical
MobileRobotProfile.PowerSupp
MobileRobotProfile.Processor
MobileRobotProfile.Sensor
<New / Edit>

Some components remain in use for longer periods of time than others. The `Lidar Sensor` component is used for obstacle avoidance in this scenario, so it is always in use except when it is charging. The `RGB Camera` only aligns the robot to the charging station, so it is in use for a shorter period per day. You can change values for the `UsagePerDay`, `UsagePerYear`, and `Life` properties to determine the expected maintenance time for components that are each used with different frequency.



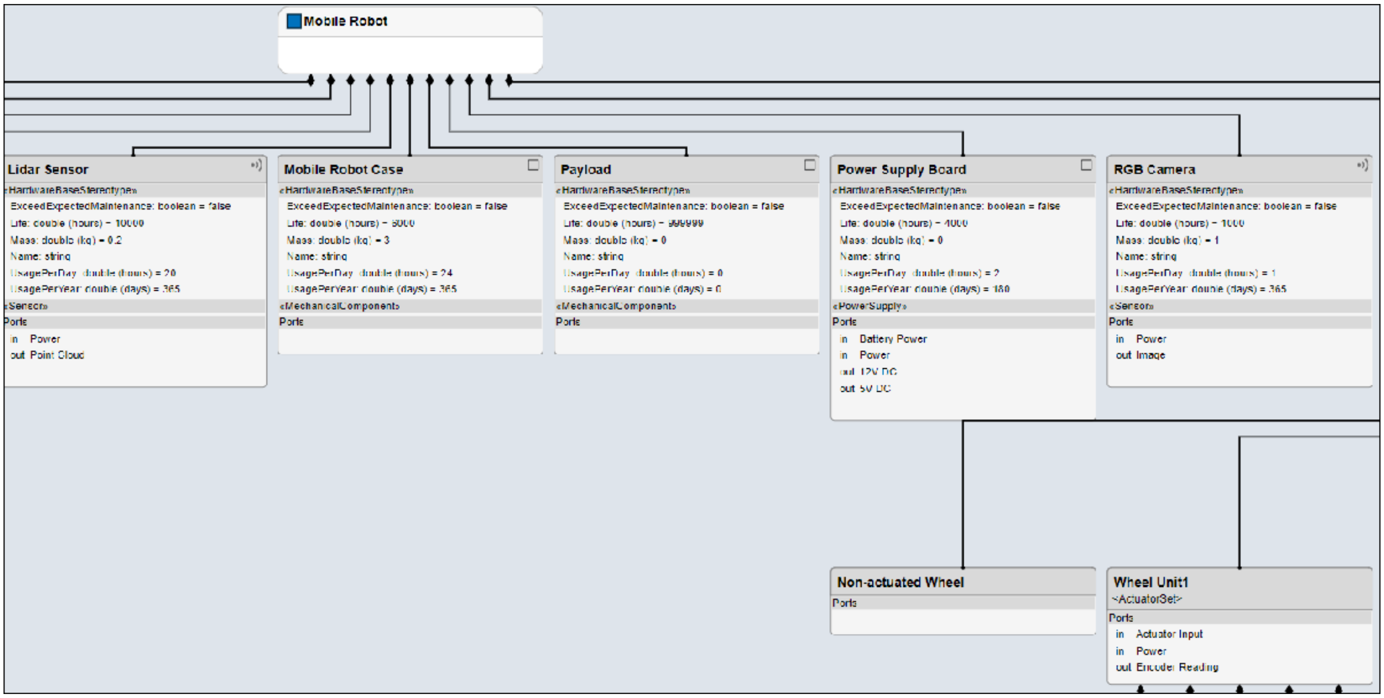
NAME	VALUE
Main	
Name	Lidar Sensor
Stereotype	Add..
Sensor	Select
Name	
Mass	0 kg
Life	10000 hours
UsagePerDay	20 hours
UsagePerYear	365 days
□ ExceedExpectedMaintenance	

The property `ExceedExpectedMaintenance` is set to false by default. This property will update when you run your analysis.

Architecture Views for Hardware Architecture Model

Use the Architecture Views Gallery to review changes you make in the architecture model. Architecture views allow you to create filtered views and thereby focus on few elements of the model, which enables you to navigate a complex model more easily.

1. To open the Architecture Views Gallery, navigate to **Modeling** > **Architecture** Views.
2. Select **New** > **View** to create a new view.
3. Name the view in the **View Properties** pane on the right.
4. In the bottom pane, under **View Configurations** > **Filter**, select from the list **Add Component Filter** > **Select All Components** to show all components in the view. Select **Apply** ✓.
5. Select the **Component Hierarchy** view. The hierarchy of the components is flattened to show all subcomponents in one view.



Lidar Sensor
«HardwareBaseStereotype»
ExceedExpectedMaintenance: boolean = false
Life: double (hours) = 10000
Mass: double (kg) = 0.2
Name: string
UsagePerDay: double (hours) = 20
UsagePerYear: double (days) = 365
«Sensor»
Ports
in Power
out Point Cloud

Mobile Robot Case
«HardwareBaseStereotype»
ExceedExpectedMaintenance: boolean = false
Life: double (hours) = 5000
Mass: double (kg) = 3
Name: string
UsagePerDay: double (hours) = 24
UsagePerYear: double (days) = 365
«MechanicalComponent»
Ports

Payload
«HardwareBaseStereotype»
ExceedExpectedMaintenance: boolean = false
Life: double (hours) = 999999
Mass: double (kg) = 0
Name: string
UsagePerDay: double (hours) = 0
UsagePerYear: double (days) = 0
«MechanicalComponent»
Ports

Power Supply Board
«HardwareBaseStereotype»
ExceedExpectedMaintenance: boolean = false
Life: double (hours) = 4000
Mass: double (kg) = 0
Name: string
UsagePerDay: double (hours) = 2
UsagePerYear: double (days) = 180
«PowerSupply»
Ports
in Battery Power
in Power
out 12V DC
out 5V DC

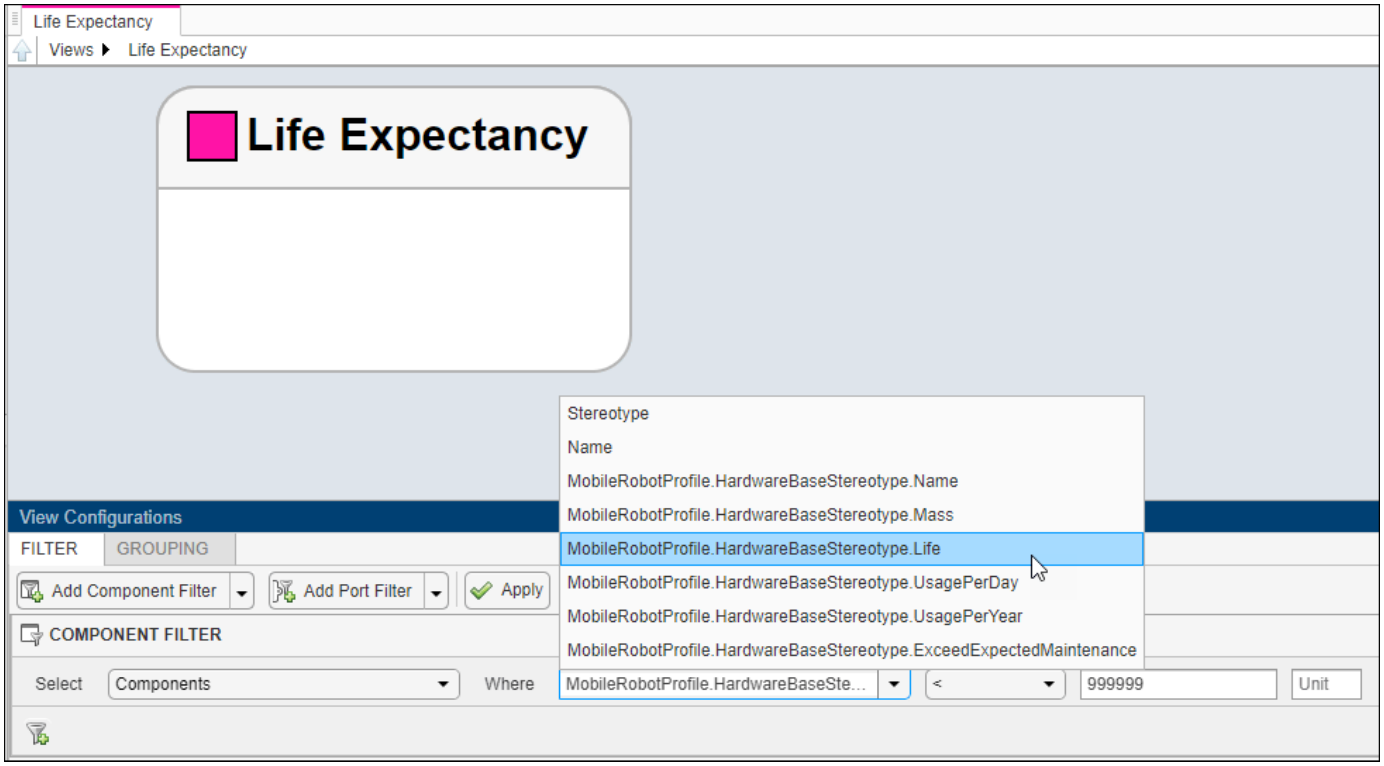
RGB Camera
«HardwareBaseStereotype»
ExceedExpectedMaintenance: boolean = false
Life: double (hours) = 1000
Mass: double (kg) = 1
Name: string
UsagePerDay: double (hours) = 1
UsagePerYear: double (days) = 365
«Sensor»
Ports
in Power
out Image

Non-actuated Wheel
Ports

Wheel Unit1
<ActuatorSet>
Ports
in Actuator Input
in Power
out Encoder Reading

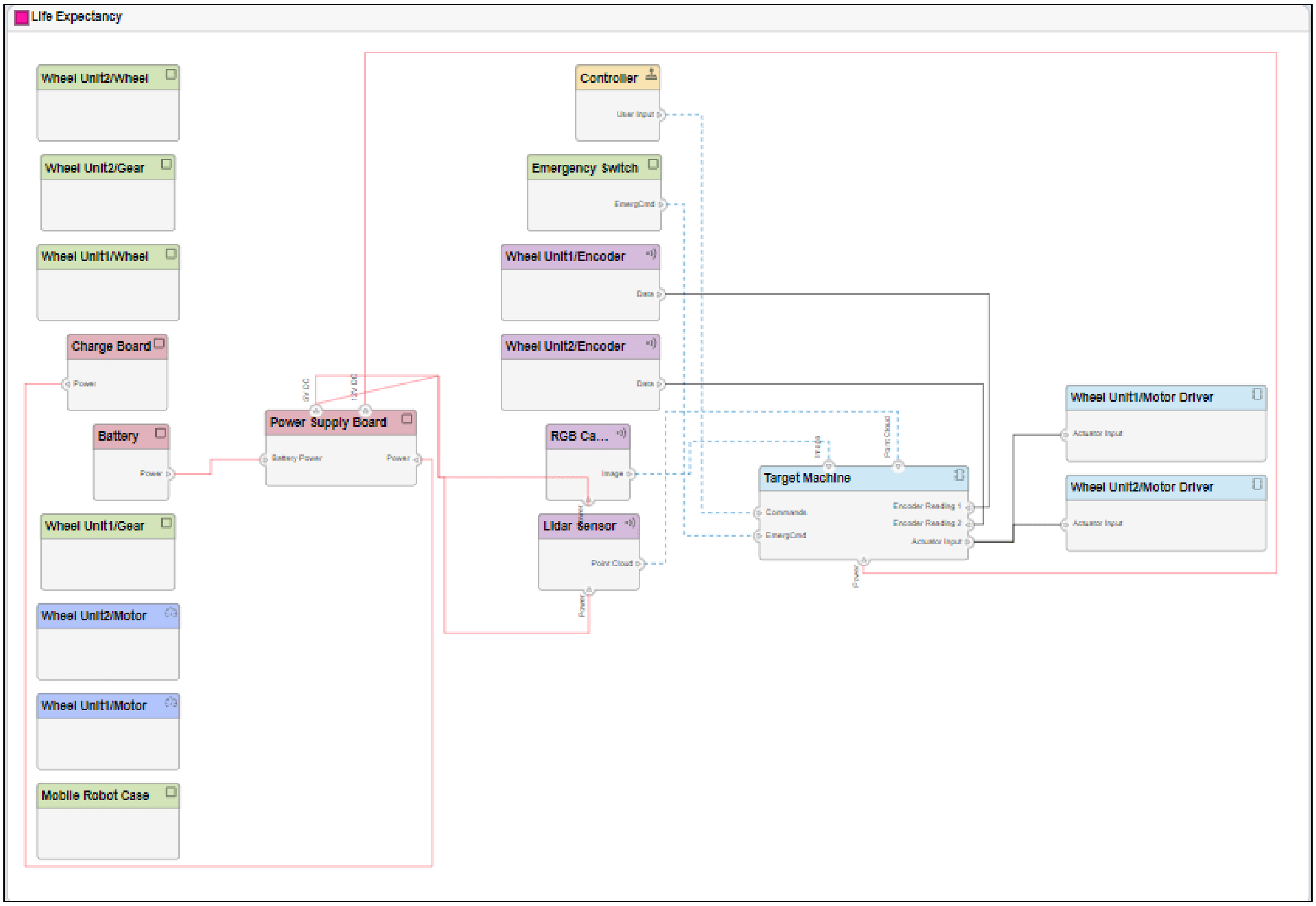
7 You can apply a filter to view components with the Life Expectancy requirement. Select **New > View** and name the view in the **View Properties** pane on the right.

8 In the bottom pane under **View Configurations > Filter**, select **Add Component Filter**.


Life Expectancy
Views ▸ Life Expectancy
Life Expectancy
View Configurations
FILTER
GROUPING
Add Component Filter
Add Port Filter
Apply
COMPONENT FILTER
Stereotype
Name
MobileRobotProfile.HardwareBaseStereotype.Name
MobileRobotProfile.HardwareBaseStereotype.Mass
MobileRobotProfile.HardwareBaseStereotype.Life
MobileRobotProfile.HardwareBaseStereotype.UsagePerDay
MobileRobotProfile.HardwareBaseStereotype.UsagePerYear
MobileRobotProfile.HardwareBaseStereotype.ExceedExpectedMaintenance

Select Components Where MobileRobotProfile.HardwareBaseSte... < 999999 Unit

10 Select **Apply** ✓. Observe the components with the `Life` property defined.

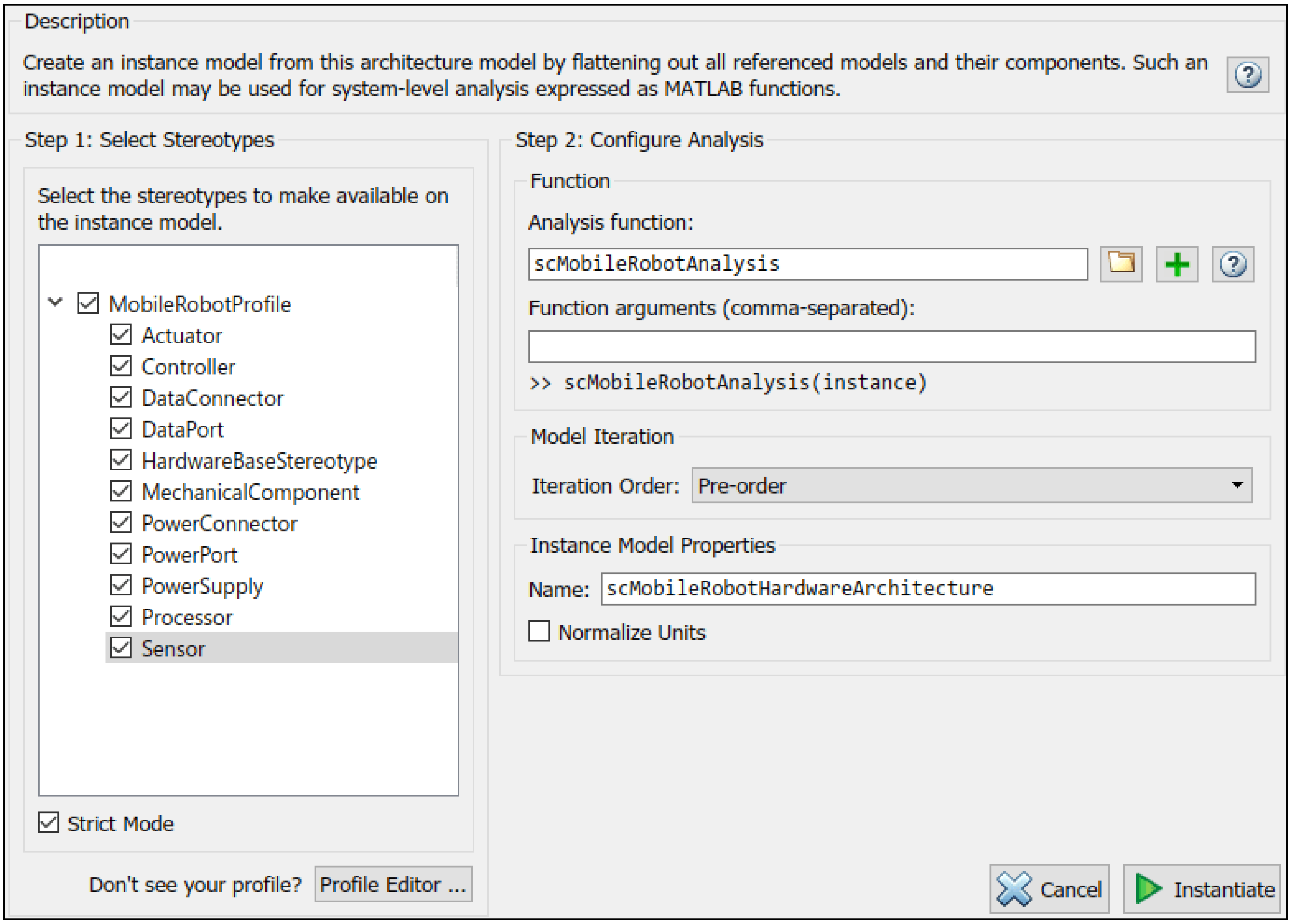


The components with the `Life` property defined are components for which expected time before first maintenance is a concern.

Analyze Hardware Components for Life Expectancy

Analyze the system to check if the components and connectors will last longer than the expected time before first maintenance. This value is set to two years in the analysis function. Navigate to **Modeling** > **Analysis Model** to open the Instantiate Architecture Model tool.

Select all stereotypes to make them available on the instance model. Select `scMobileRobotAnalysis.m` as the analysis function. The iteration order determines in what order the component hierarchy is analyzed. However, since each component is analyzed separately, the order does not matter. Select the default iteration order `Pre-order`.



Description

Create an instance model from this architecture model by flattening out all referenced models and their components. Such an instance model may be used for system-level analysis expressed as MATLAB functions.

Step 1: Select Stereotypes

Select the stereotypes to make available on the instance model.

- ☑ MobileRobotProfile
  - ☑ Actuator
  - ☑ Controller
  - ☑ DataConnector
  - ☑ DataPort
  - ☑ HardwareBaseStereotype
  - ☑ MechanicalComponent
  - ☑ PowerConnector
  - ☑ PowerPort
  - ☑ PowerSupply
  - ☑ Processor
  - ☑ Sensor

☑ Strict Mode

Don't see your profile? Profile Editor ...

Step 2: Configure Analysis

Function

Analysis function: `scMobileRobotAnalysis`

Function arguments (comma-separated):

```
>> scMobileRobotAnalysis(instance)
```

Model Iteration

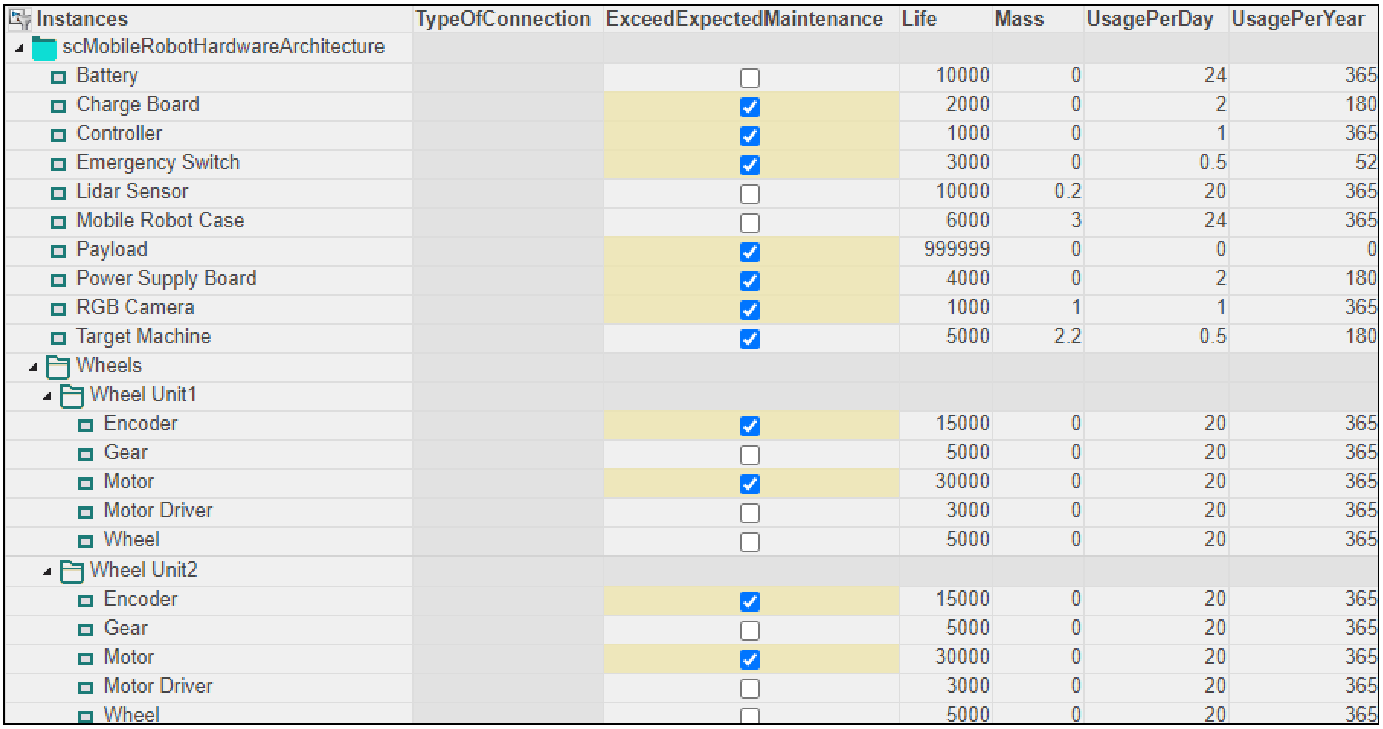
Iteration Order: Pre-order

Instance Model Properties

Name: `scMobileRobotHardwareArchitecture`

□ Normalize Units

Click **Instantiate** to instantiate the model and open the Analysis Viewer tool. Relevant components and connectors with stereotypes are shown. Since all stereotypes are selected, all elements with stereotypes are shown in the instance model. Model analysis will calculate which components and connectors will last longer than the expected two years. Click **Analyze** to perform the calculation.



Instances	TypeOfConnection	ExceedExpectedMaintenance	Life	Mass	UsagePerDay	UsagePerYear
scMobileRobotHardwareArchitecture						
Battery		☐	10000	0	24	365
Charge Board		☑	2000	0	2	180
Controller		☑	1000	0	1	365
Emergency Switch		☑	3000	0	0.5	52
Lidar Sensor		☐	10000	0.2	20	365
Mobile Robot Case		☐	6000	3	24	365
Payload		☑	999999	0	0	0
Power Supply Board		☑	4000	0	2	180
RGB Camera		☑	1000	1	1	365
Target Machine		☑	5000	2.2	0.5	180
Wheels						
Wheel Unit1						
Encoder		☑	15000	0	20	365
Gear		☐	5000	0	20	365
Motor		☑	30000	0	20	365
Motor Driver		☐	3000	0	20	365
Wheel		☐	5000	0	20	365
Wheel Unit2						
Encoder		☑	15000	0	20	365
Gear		☐	5000	0	20	365
Motor		☑	30000	0	20	365
Motor Driver		☐	3000	0	20	365
Wheel		☐	5000	0	20	365

The components for which usage is not defined are components that last significantly longer than the expected time and are therefore excluded from analysis. The analysis function calculates whether the time before first maintenance for each component and connector will exceed `Life`, which is set to two years. The unchecked boxes indicate that components and connectors will need maintenance within two years.

To refresh the instance model in the Analysis Viewer, select **Overwrite**, then click **Refresh**. This action will retrieve the values back from the source model, in this case, the hardware architecture model. Since `ExceedExpectedMaintenance` was the only property changed, it reverts back to its default value. Conversely, when you click **Update** the property values in the hardware architecture source update according to the instance model.

See Also

`applyProfile` | `applyStereotype` | `openViews` | `instantiate`

More About

- “Define Profiles and Stereotypes” on page 5-2
- “Create Architecture Views Interactively” on page 11-5
- “Analyze Architecture” on page 9-2
- “Analysis Function Constructs” on page 9-9

Simulate Architectural Behavior

To simulate the mobile robot logical architecture, link Simulink models to the components or add Simulink subsystem components. For details, see “Implement Component Behavior Using Simulink” on page 7-2. These models act as Simulink behaviors and can be simulated in System Composer by clicking **Run**. The simulation shows how well the mobile robot follows a trajectory created by a controller to avoid an obstacle.

Note This example uses Simscape blocks. If you do not have a Simscape license, you can open and simulate the model but can only make basic changes, such as modifying block parameters.

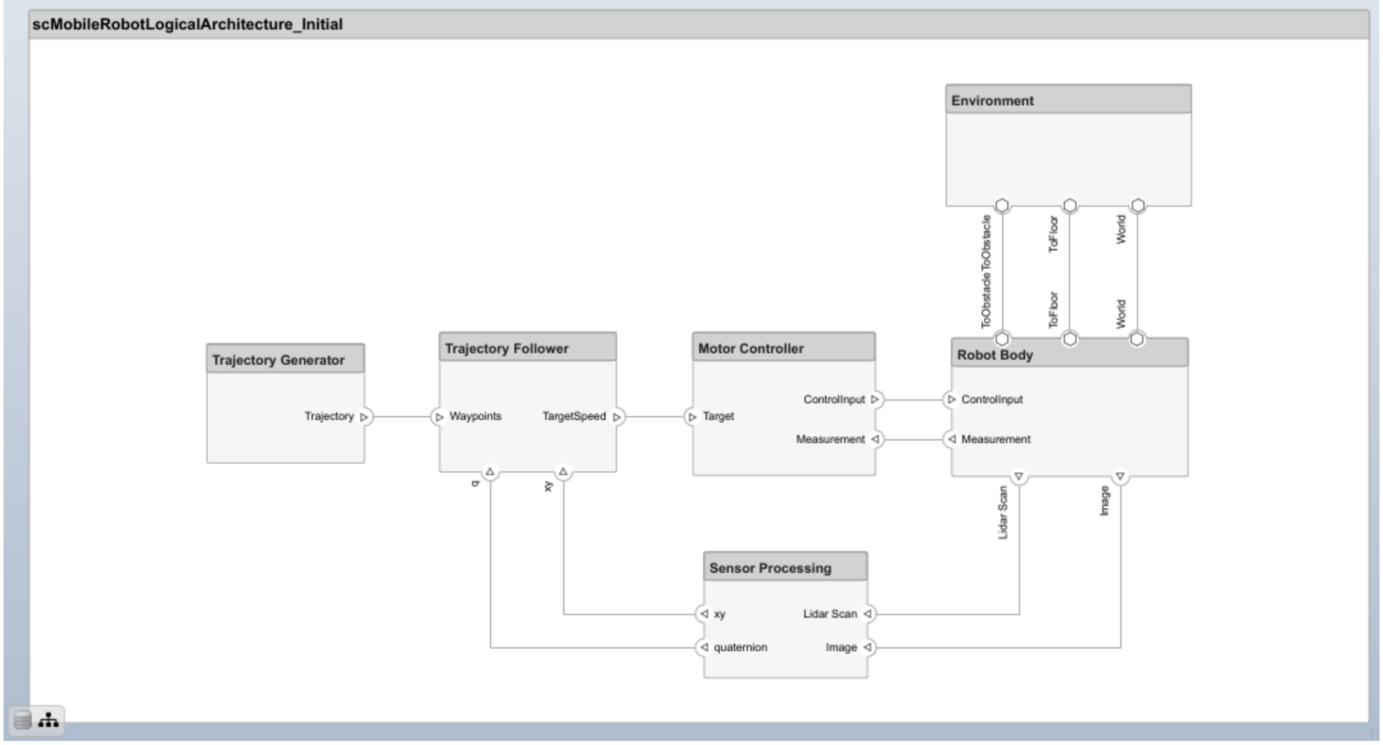
Simulate Architectural Behavior

The mobile robot example includes a logical architecture with component behaviors defined. You can run the simulation to watch the mobile robot avoid an obstacle.

Add Behavior to Logical Architecture

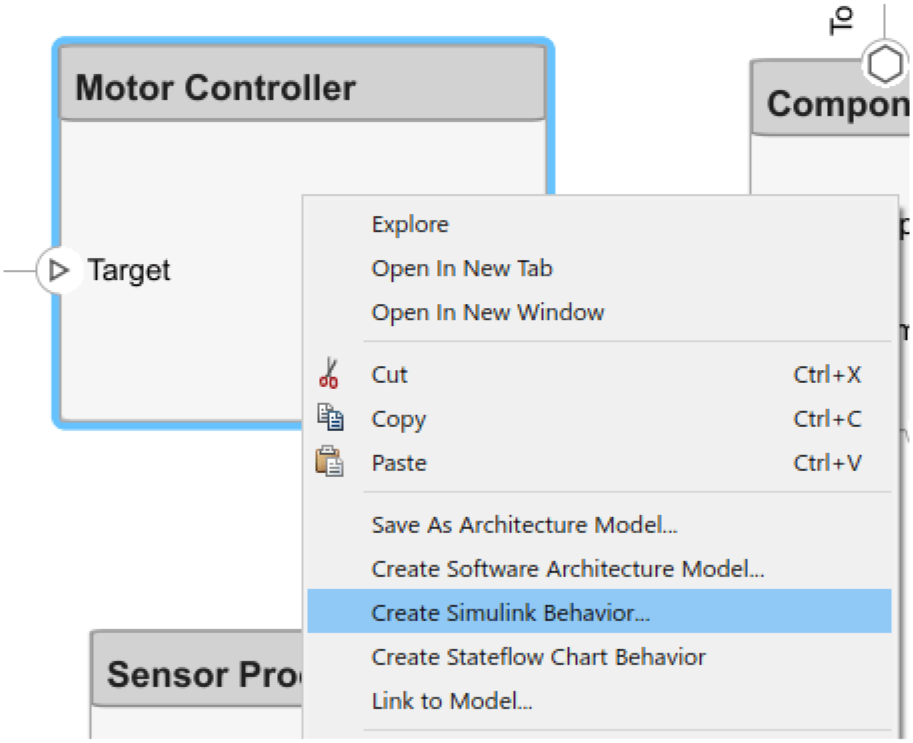
The logical architecture model describes the behavior of the mobile robot system for simulation: trajectory generator, trajectory follower, motor controller, sensor algorithm, and robot and environment. The connections represent the interactions in the system. Open the logical architecture model without any behaviors, double-click the file or run this command.

```
systemcomposer.openModel("scMobileRobotLogicalArchitecture_Initial");
```



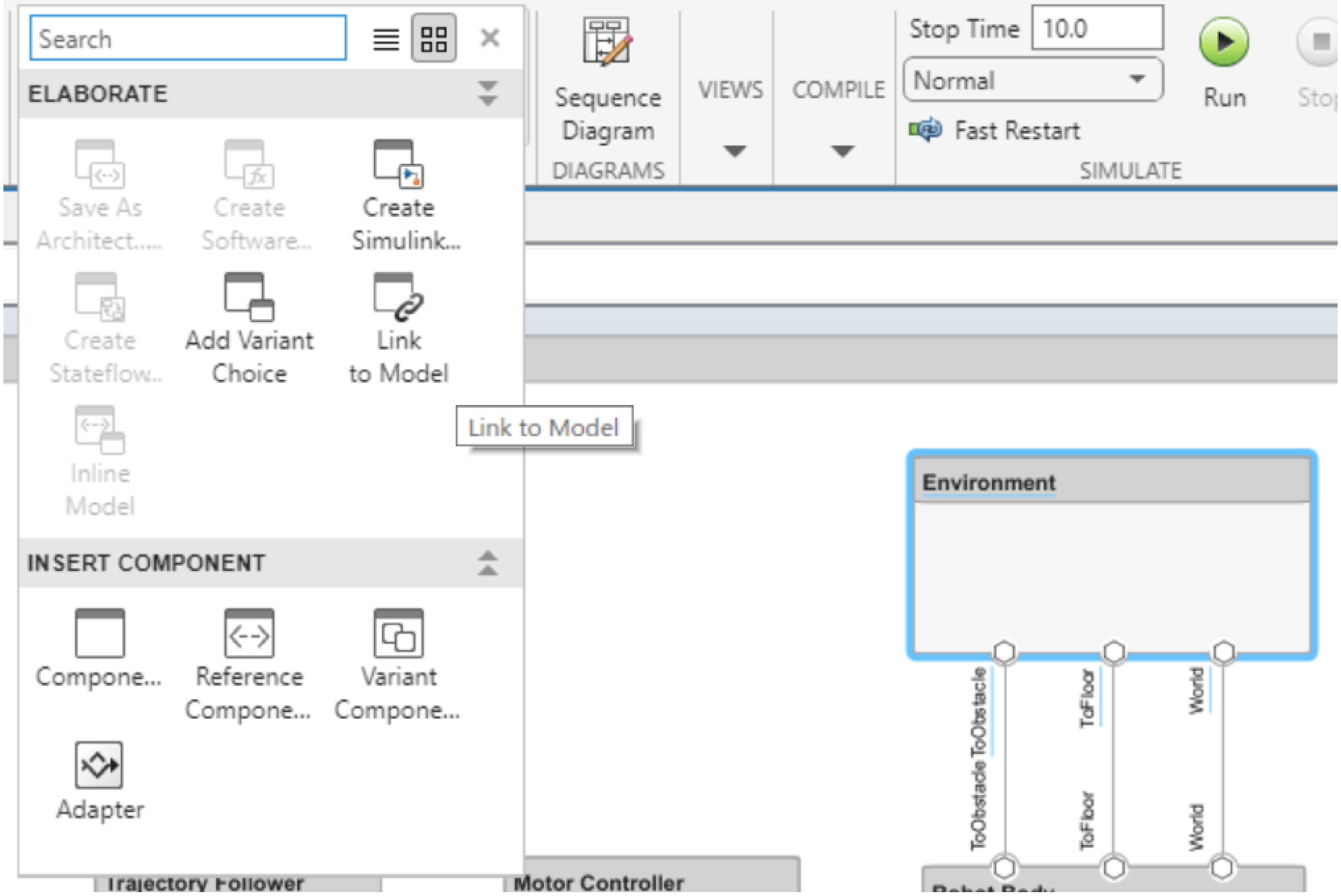
The architecture model describes the behavior of the robot, but no behavior is actually added to the architecture yet. By adding Simulink or Stateflow® behavior, the logical architecture can also be simulated.

Create a new behavior based on the interface of a component. If a model or subsystem file already exists for the behavior, use `Link To Model` to link to the exisiting model or subsystem. To create new subsystem reference behavior for the `Motor Controller` component, right-click and select `Create Simulink Behavior`, or, on the toolstrip, click **Create Simulink Behavior**. For more information, see "Implement Component Behavior Using Simulink" on page 7-2.



You can create Simulink behaviors using mulitiple methods: `Subsystem`, `Subsystem Reference`, and `Model Reference`. Use `Subsystem` to create a subsystem component behavior that is part of the parent architecture model. Use the `Subsystem Reference` or `Model Reference` option to save the behavior as a separate artifact and reuse the behavior. Physical ports can only cross subsystem boundaries, so for physical systems, `Subsystem Reference` or `Subsystem` are recommended.

If you already have a behavior defined in a model file or subsystem file, use `Link To Model` to link a component to the corresponding file. On the toolstrip, click `Link to Model`, or right-click the `Environment` component and select `Link to Model` to link to the `Environment.slx` subsystem file.



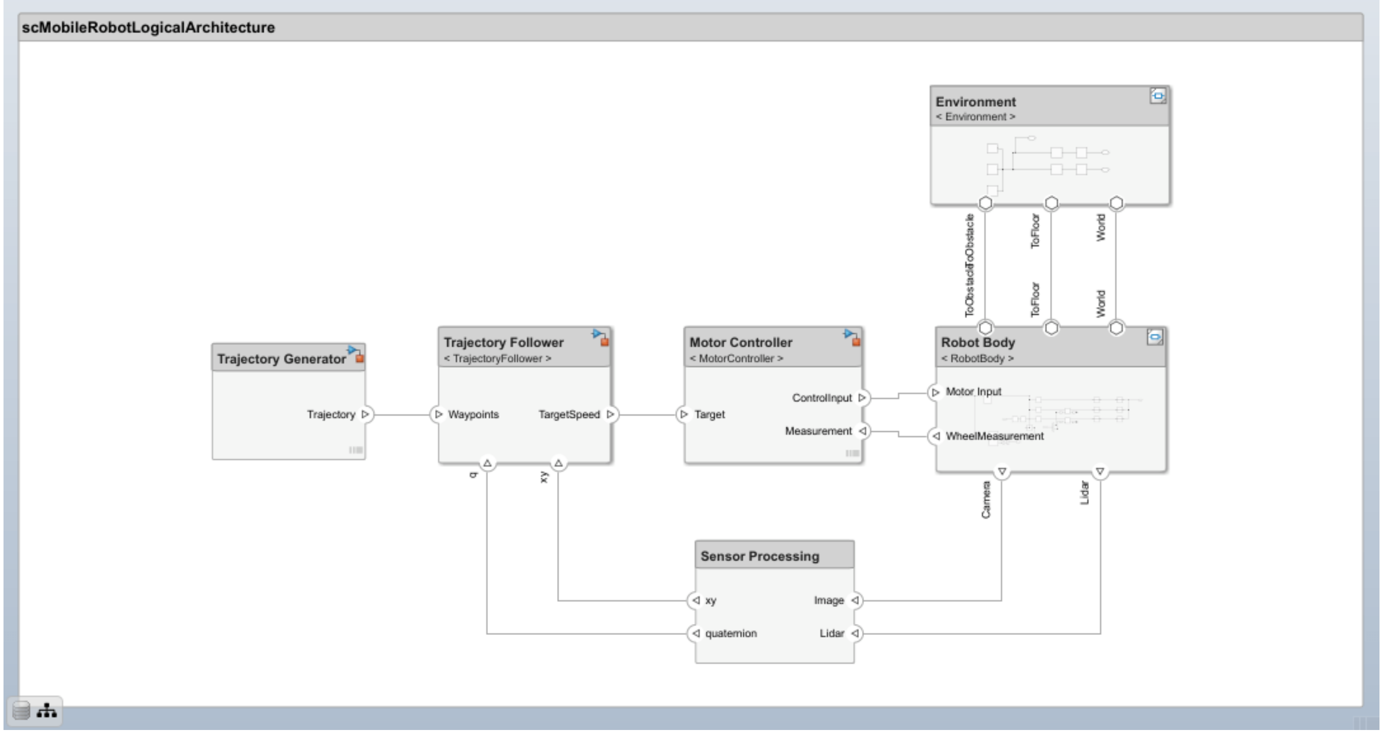
Logical Architecture Model for Mobile Robot

Open the final logical architecture where behavior is added to all the components.

```
systemcomposer.openModel("scMobileRobotLogicalArchitecture");
```

The `Robot Body` and `Environment` are Simulink subsystem reference components that support physical ports. The `Trajectory Generator` is a Simulink subsystem component that also supports physical ports. The `Trajectory Follower` and `Motion Controller` components are represented as Simulink models linked to the components as referenced models.

A behavior algorithm is created based on port information only. When designing a logical architecture, you can set the interface of the port to define the information in more detail. For example, if you know that 800 x 600 RGB images captured at 24 frames per second are transferred from the camera sensor, then you can set the corresponding port interfaces accordingly to ensure efficient data transfer. For more information about setting interfaces, see “Define Port Interfaces Between Components” on page 3-2.

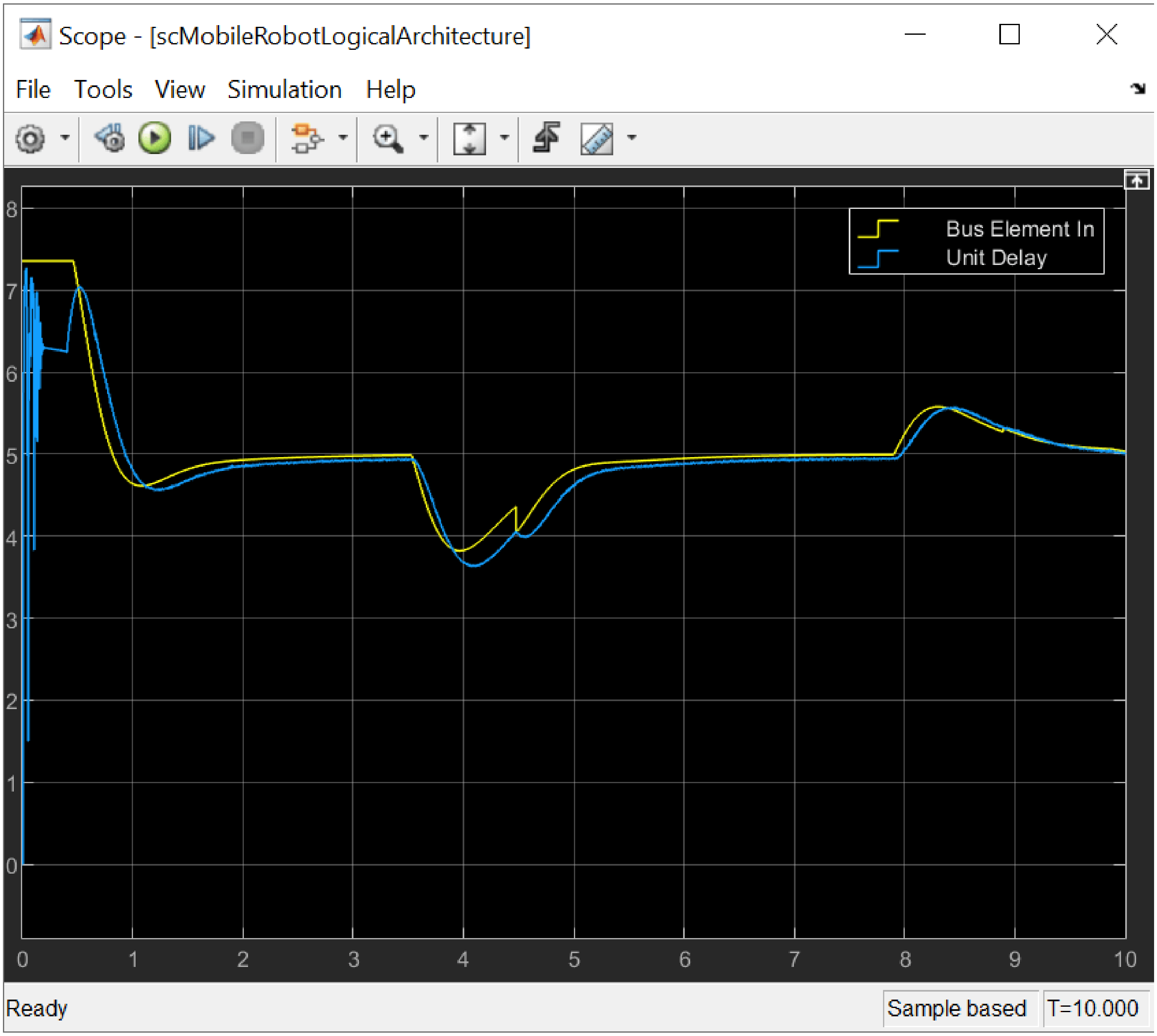


Run Simulation Using Logical Architecture

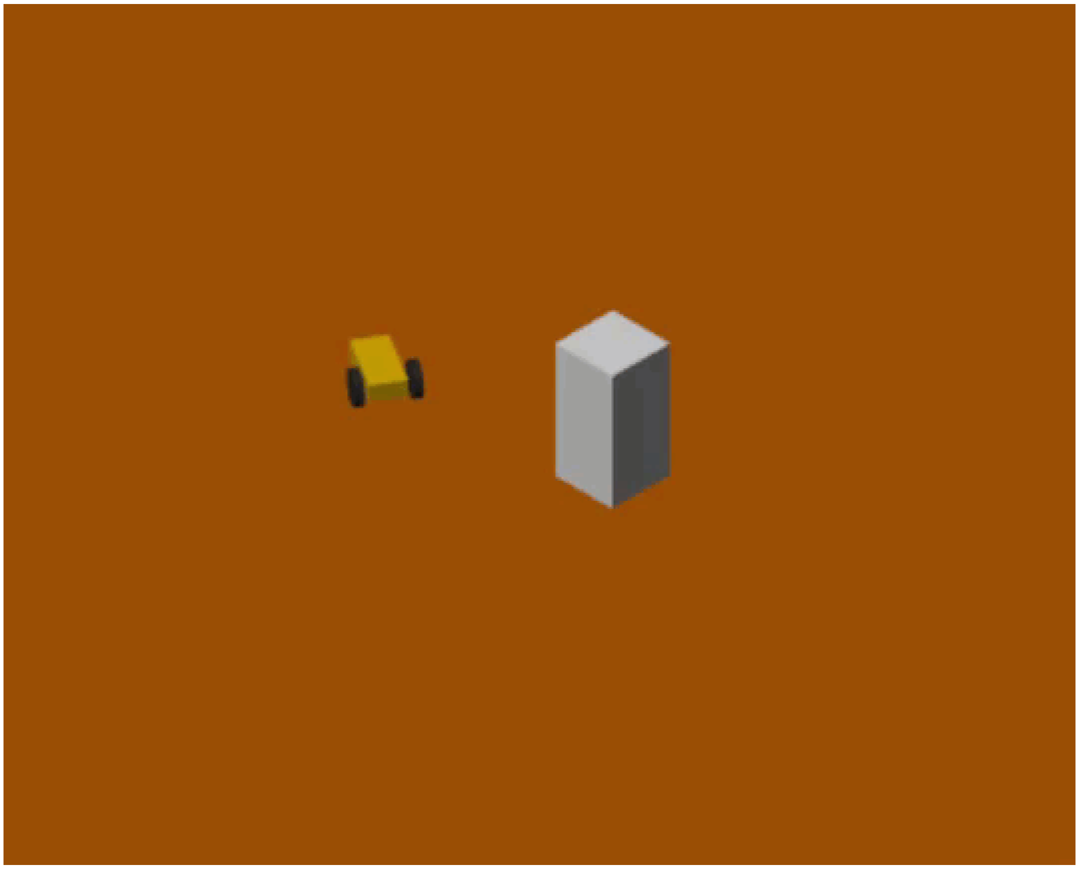
Once behavior models are linked, you can simulate the architecture model just like any other Simulink model by clicking **Run**. Simulation verifies requirements such as `Transportation`, `Collision Avoidance`, and `Path Generation`.

```
sim scMobileRobotLogicalArchitecture;
```

The scope from the `MotorController` component behavior shows how a simple P-gain controller performs to follow the reference velocity for one of the wheels on the robot.



In the Mechanics Explorer (Simscape Multibody), switch to the isometric view by selecting . Watch the mobile robot avoid an obstacle.



See Also

`createSimulinkBehavior`

More About

- “Define Port Interfaces Between Components” on page 3-2
- “Explore Simulink Bus Capabilities”
- “Implement Component Behavior Using Simulink” on page 7-2

Describe System Behavior with Diagrams

Describe System Behavior Using Sequence Diagrams

A sequence diagram represents the expected interaction between structural elements of an architecture as a sequence of message exchanges.

Use sequence diagrams to describe how the parts of a system interact.

Sequence diagrams are integrated with architecture models in System Composer.

- “Author Sequence Diagram for Traffic Light Example” on page 6-4: Interactively create and edit a sequence diagram and learn terminology.
- “Author Sequence Diagram Fragments” on page 6-29: Learn how to implement fragments and more about fragment semantics.
- “Use Sequence Diagrams with Architecture Models” on page 6-16: Create and use sequence diagrams with architecture models.
- “Synchronize Sequence Diagrams and Architecture Models” on page 6-40: Learn how to synchronize sequence diagrams with architecture models.

A lifeline is represented by a head and a timeline that proceeds down a vertical dotted line.

The head of a lifeline represents a component in an architecture model.

A message sends information from one lifeline to another. Messages are specified with a message label.

A message label has a trigger and a constraint. A trigger determines whether the message occurs. A constraint determines whether the message is valid.

An annotation describes the elements of a sequence diagram.

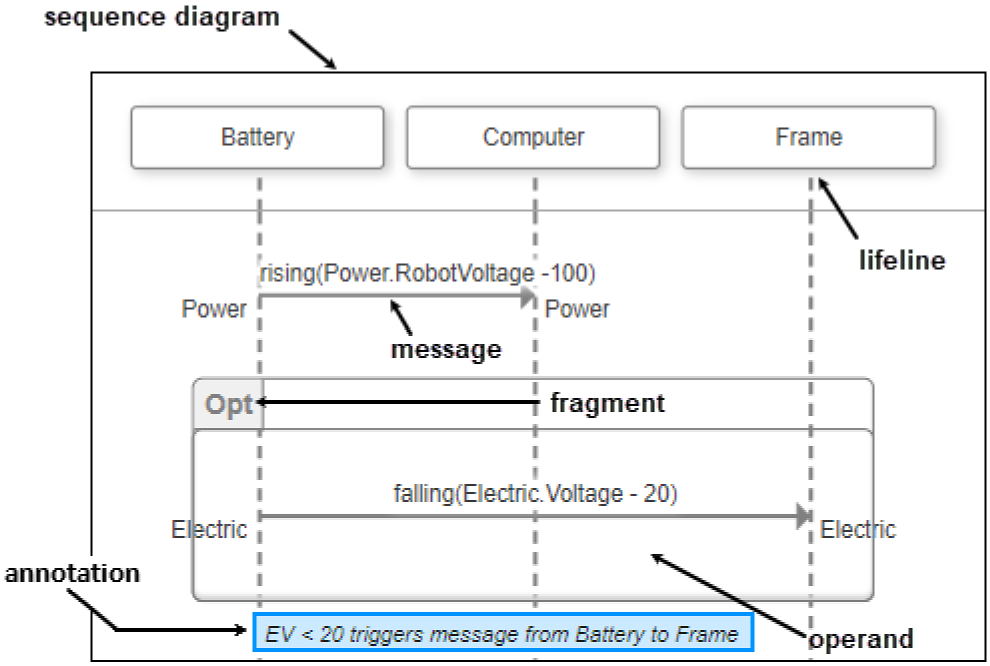
Use annotations to provide detailed explanations of elements or workflows captured by sequence diagrams.

A fragment indicates how a group of messages within it execute or interact.

A fragment is used to model complex sequences, such as alternatives, in a sequence diagram.

An operand is a region in a fragment. Fragments have one or more operands depending on the kind of fragment. Operands can contain messages and additional fragments.

Each operand can include a constraint to specify whether the messages inside the operand execute. You can express the precondition of an operand as a MATLAB Boolean expression using the input signal of any lifeline.


sequence diagram
Battery
Computer
Frame
lifeline
rising(Power.RobotVoltage -100)
Power
Power
message
Opt
fragment
falling(Electric.Voltage - 20)
Electric
Electric
annotation
EV < 20 triggers message from Battery to Frame
operand

See Also

More About

- “Simulate Sequence Diagrams for Traffic Light Example” on page 6-44
- “Compose Architectures Visually” on page 1-2
- “Implement Component Behavior Using Simulink” on page 7-2
- “Implement Component Behavior Using Stateflow Charts” on page 7-14

Author Sequence Diagram for Traffic Light Example

You can create, edit, and simulate sequence diagrams in System Composer by accessing the **Architecture Views Gallery**. You will learn about the basic terminology and functions of a sequence diagram in two stages.

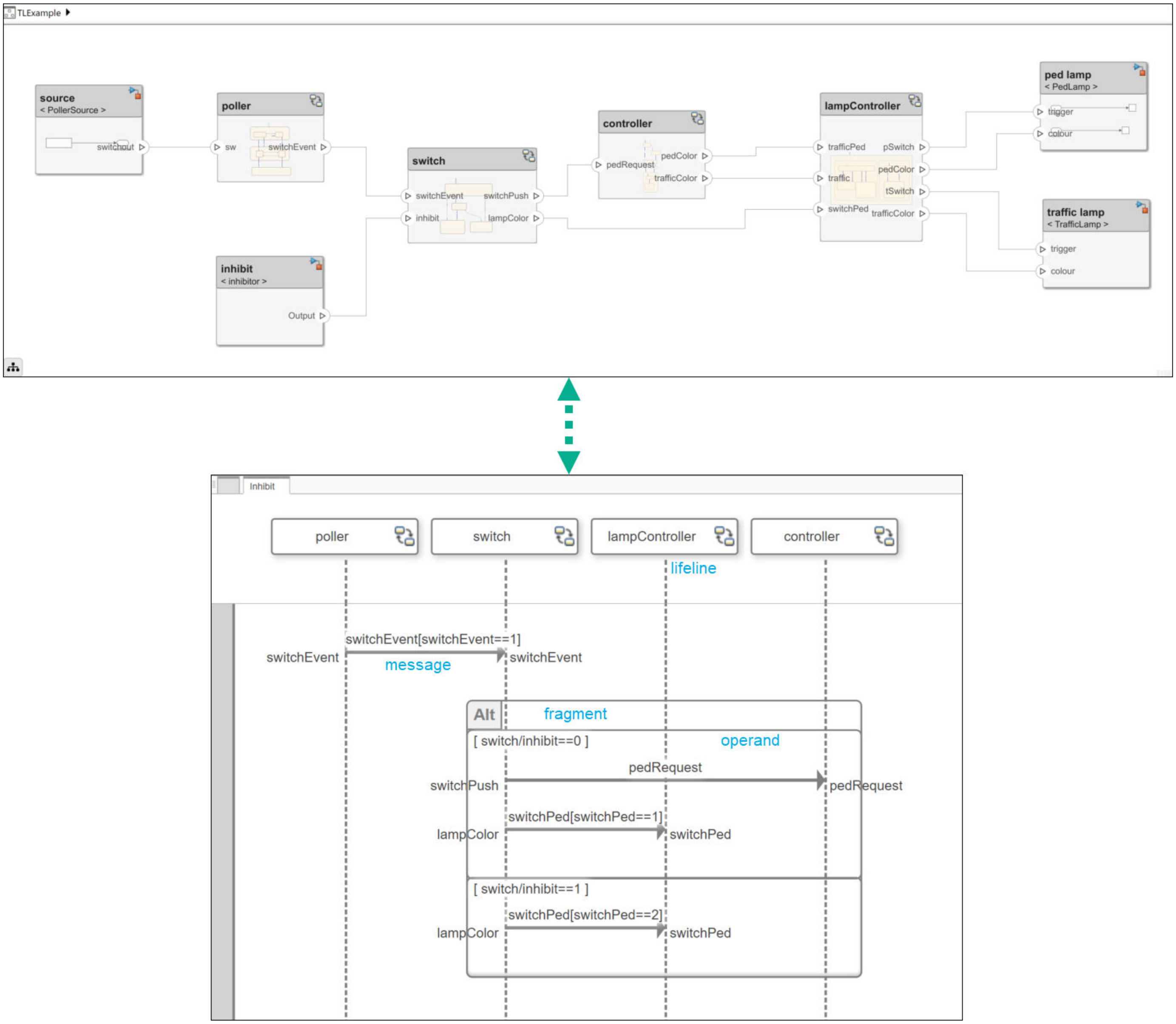
- Add lifelines and messages with message labels including triggers and constraints to represent interactions.
- Include fragments and operands with constraints to further specify the behavior of the interaction.

A lifeline in a sequence diagram represents a component in the architecture. A message represents a communication across a path between the source lifeline and destination lifeline. The path for a message must consist of at least two ports and one connector from the architecture model. With nested messages, the path is more complex due to the hierarchy to be navigated.

For a roadmap of the sequence diagram topics, see “Describe System Behavior Using Sequence Diagrams” on page 6-2.

This figure shows a traffic light architecture model and a corresponding sequence diagram that describes one operative scenario. The traffic light model describes a cycling traffic light, the pedestrian crossing button being pressed, and the lights changing so pedestrians can cross.

To learn how to execute this sequence diagram to simulate the model, see “Simulate Sequence Diagrams for Traffic Light Example” on page 6-44.



Note This example uses Stateflow blocks. If you do not have a Stateflow license, you can open and simulate the model but can only make basic changes, such as modifying block parameters.

Traffic Light Example

This traffic light example contains sequence diagrams to describe pedestrians crossing an intersection. The model describes these steps:

1. The traffic signal cycles from red to green to yellow.
2. When the pedestrian crossing button is pressed, if the traffic signal is green, the traffic signal transitions from yellow to red for a limited time.

3 The pedestrians cross while the walk signal is active.

Open the System Composer model that contains the sequence diagrams.

```
model = systemcomposer.openModel('TLExample');
```

Open the Architecture Views Gallery to view the sequence diagrams.

```
openViews(model)
```

Add Lifelines and Messages

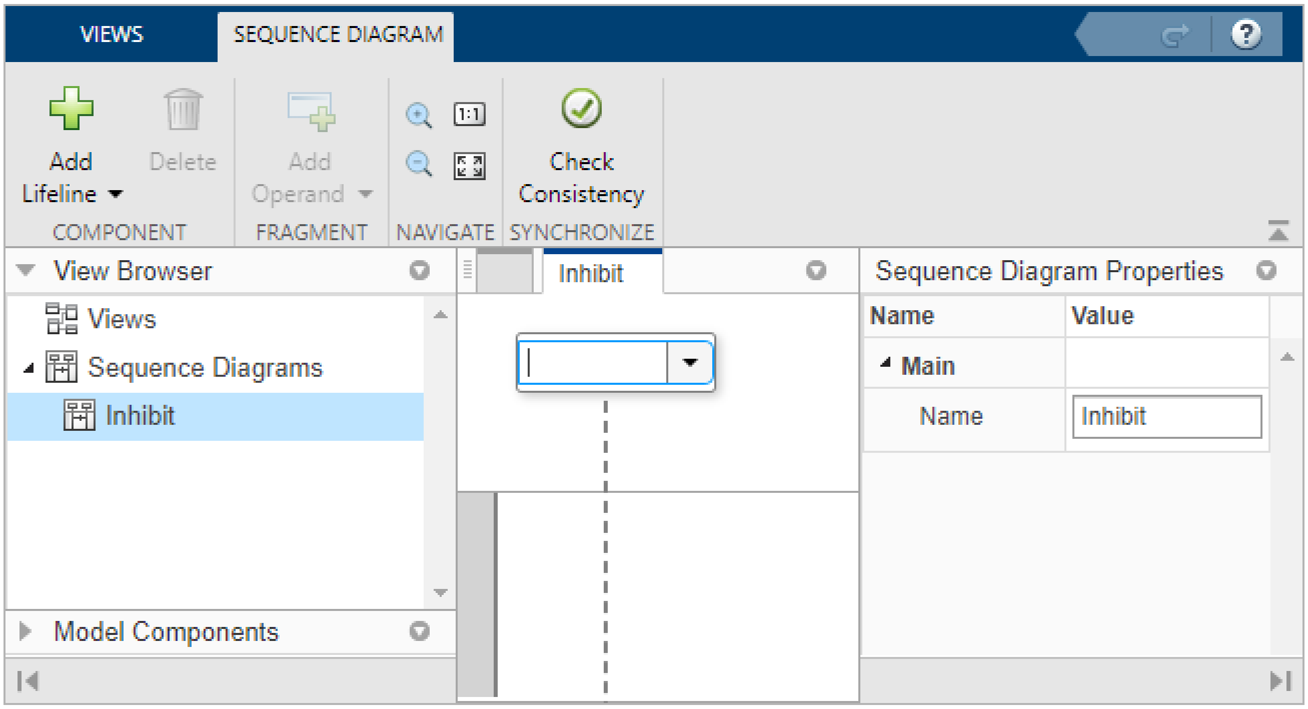
A lifeline is represented by a head and a timeline that proceeds down a vertical dotted line.

The head of a lifeline represents a component in an architecture model.

A message sends information from one lifeline to another. Messages are specified with a message label.

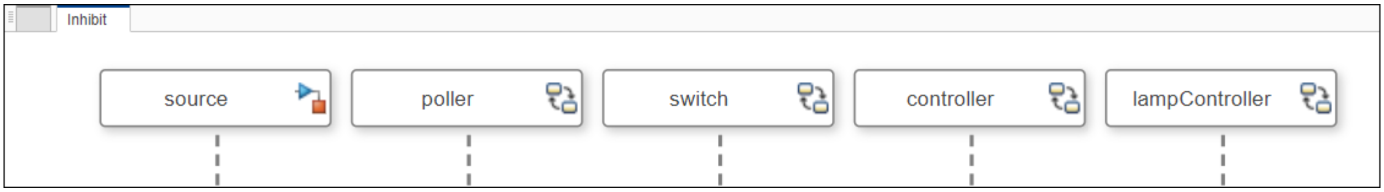
A message label has a trigger and a constraint. A trigger determines whether the message occurs. A constraint determines whether the message is valid.

1 Navigate to **Modeling** > **Sequence Diagram** to open sequence diagrams in the **Architecture Views Gallery**.
2 To create a new sequence diagram, click **New** > **Sequence Diagram**.
3 A new sequence diagram called `SequenceDiagram1` is created in the View Browser, and the **Sequence Diagram** tab becomes active. Under **Sequence Diagram Properties**, rename the sequence diagram `Inhibit`.
4 Select **Component** > **Add Lifeline** to add a lifeline. A new lifeline with no name is created and is indicated by a dotted line.

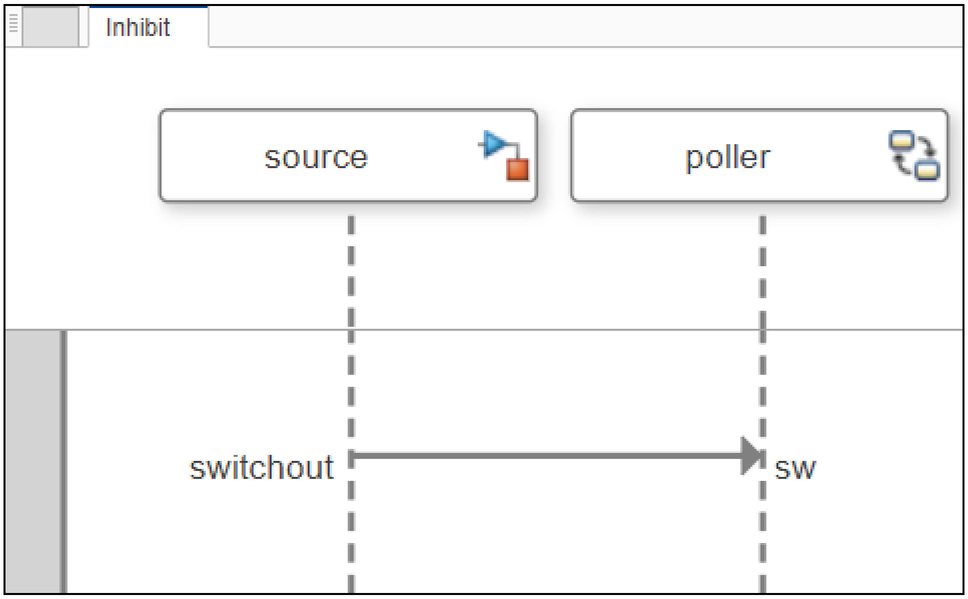


Name	Value
Main	
Name	Inhibit

5 Click the down arrow and select `source`. The `source` lifeline detects when the pedestrian presses the crossing button. Add four more lifelines using the down arrow named `poller`, `switch`, `controller`, and `lampController`. The `poller` lifeline checks if the pedestrian crossing button has been pressed, `switch` processes the signal, `controller` determines which color the pedestrian lamp and traffic light should display, and `lampController` changes the traffic light colors.



6 Draw a line from the `source` lifeline to the `poller` lifeline. Start to type `sw` in the **To** box, which will automatically fill in as you type. Once the text has filled in, select `sw`.



Since the `switchout` port and `sw` port are connected in the model, a message is created from the `switchout` port to the `sw` port in the sequence diagram.

7 A message label has a trigger and a constraint. A trigger determines whether the message occurs, and a constraint determines whether the message is valid. For signal messages, the trigger is called an edge.

You can enter a condition that specifies a triggering edge with a direction and an expression. You can also optionally add a constraint in square brackets to the message. Constraints consist of a MATLAB Boolean expression acting on the inputs of the destination lifeline.

```
direction(signalPort(+|-)positiveReal)[booleanExpression]
```

There are three directions for edges:

- `crossing` — The edge expression is either rising or falling past zero.
- `rising` — The edge expression is rising from strictly below zero to a value equal to or greater than zero.

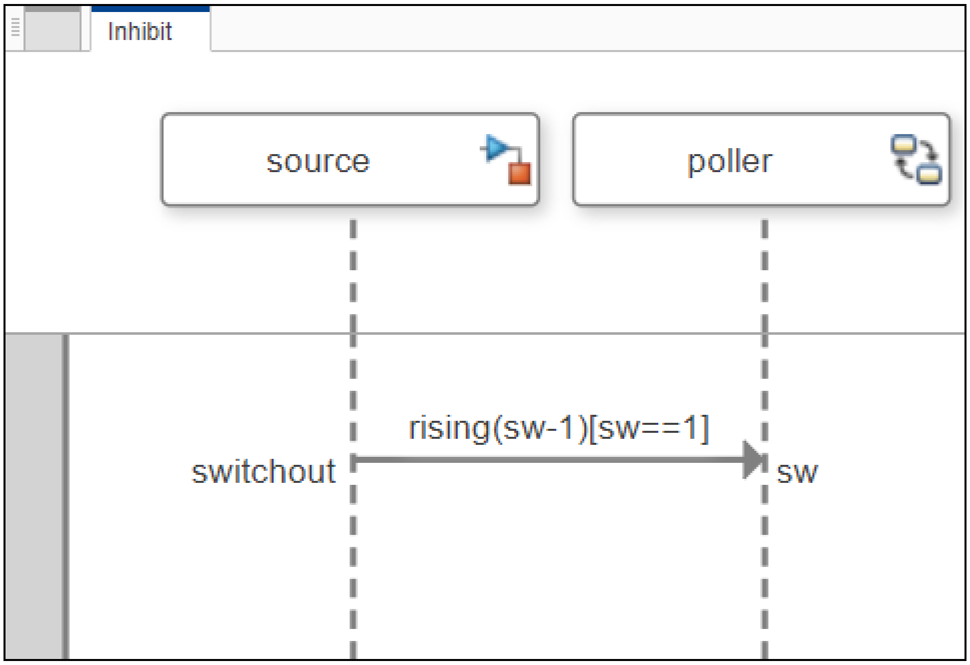
- `falling` — The edge expression is falling from strictly above zero to a value equal to or less than zero.

Click on the message and double-click on the empty message label that appears. Enter this condition and constraint.

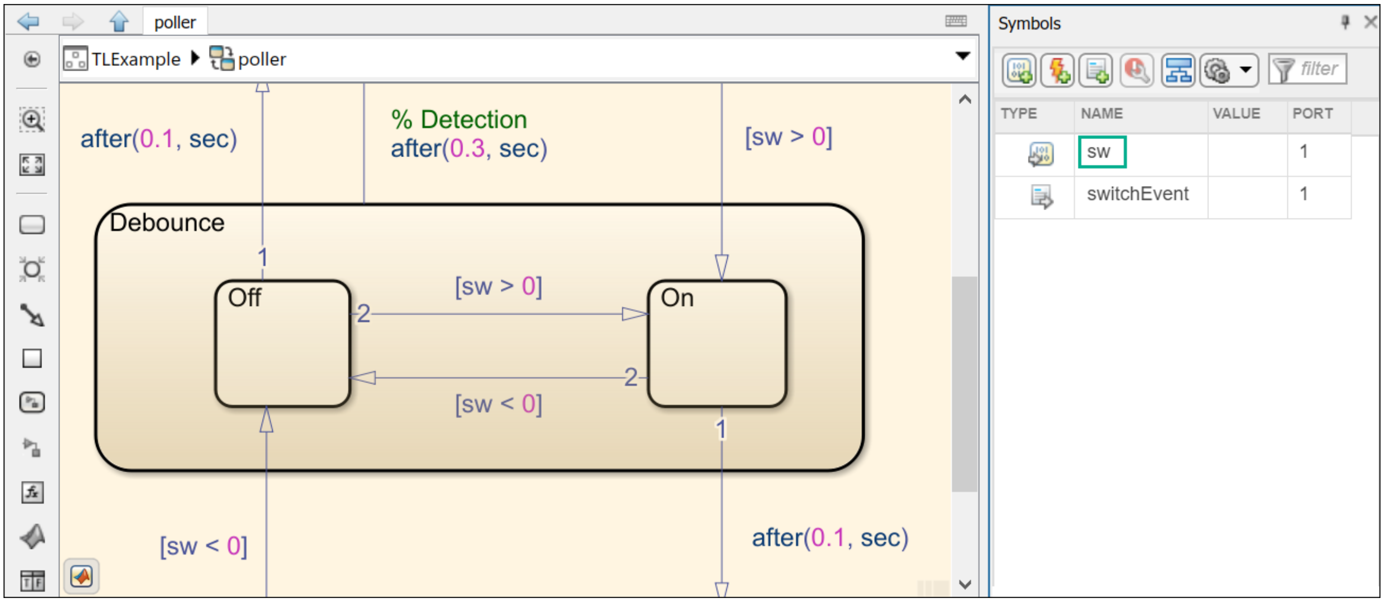
```
rising(sw-1)[sw==1]
```

The message will be triggered when the `sw` signal rises from below `1` to a value of `1` or above. The constraint in square brackets indicates that if `sw` is not equal to `1`, the message is invalid.

Note Only destination elements are supported for message labels. In this example, `switchout` is a source element and cannot be included.



The signal name `sw` is valid input data on the port for a Stateflow chart behavior. The `poller` component with state chart behavior has `sw` in the **Symbols** pane.

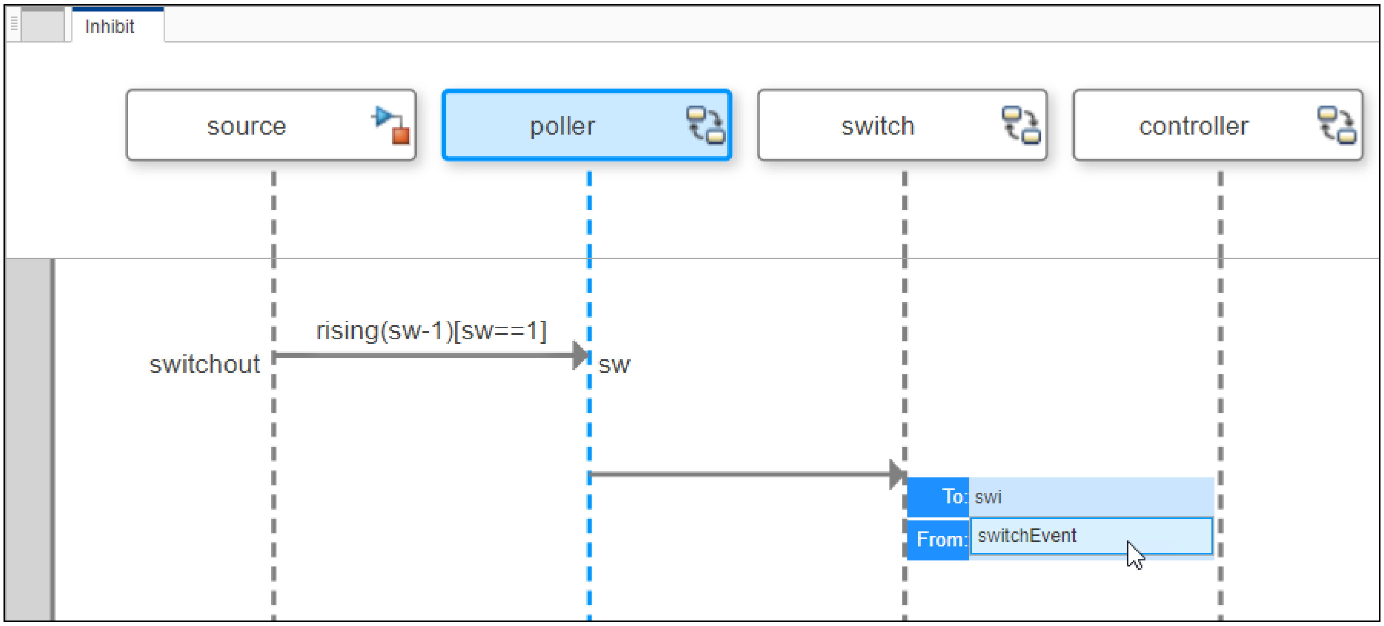


TYPE	NAME	VALUE	PORT
	sw		1
	switchEvent		1

Note The signal name can also be a data element on a data interface on a port. Enter **Tab** to autocomplete the port and data element names. For more information, see “Represent System Interaction Using Sequence Diagrams”.

In this example, when the `sw` signal becomes `1`, the pedestrian crossing button has been pressed, and a message to the `poller` lifeline is recognized.

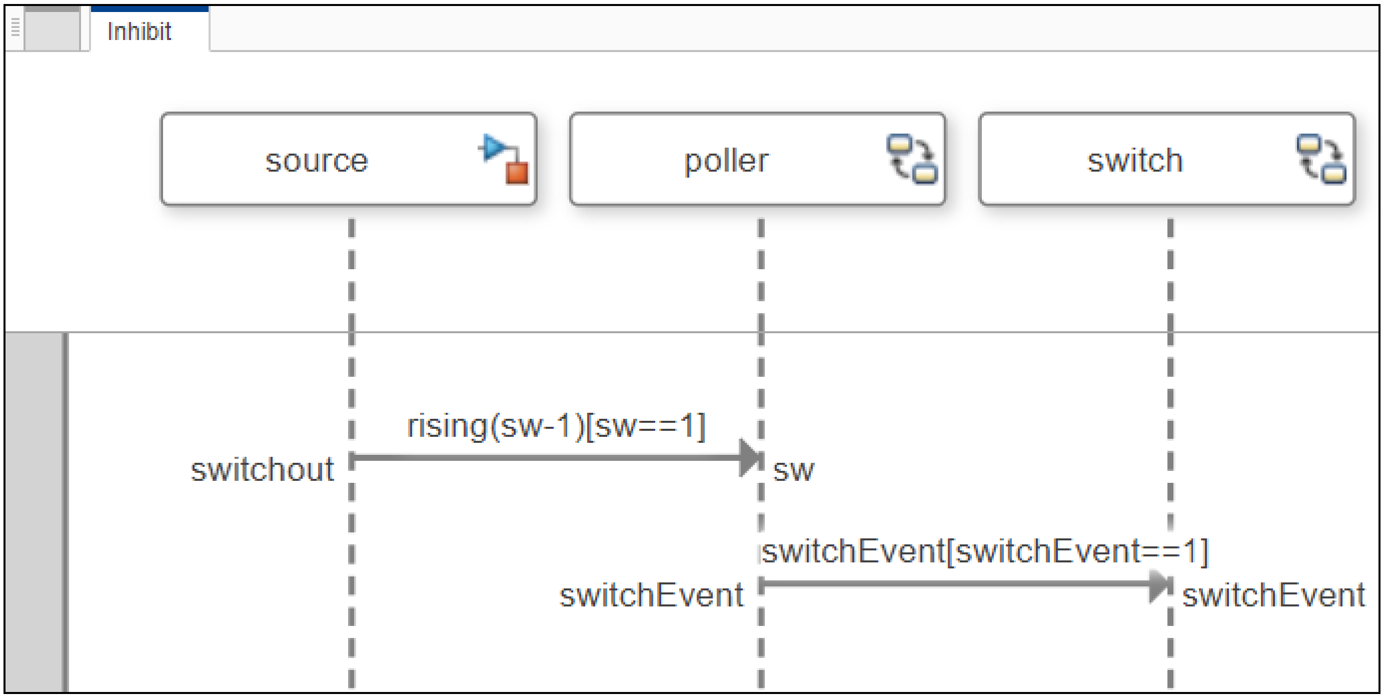
8 In addition to signal events, sequence diagrams also support message events. Create a message by drawing a line from the `poller` lifeline to the `switch` lifeline. Start typing `switchEvent` in the **To** box until `switchEvent` is available to select.



Since there is an existing connection in the architecture model, a message is created from source port `switchEvent`.

9 Click the message and double-click the empty message label that appears. Enter this condition representing the port and constraint.

```
switchEvent[switchEvent==1]
```



When the message `switchEvent` is received and its value is `1`, the message has occurred and is valid.

Add Fragments and Operands

A fragment indicates how a group of messages within it execute or interact.

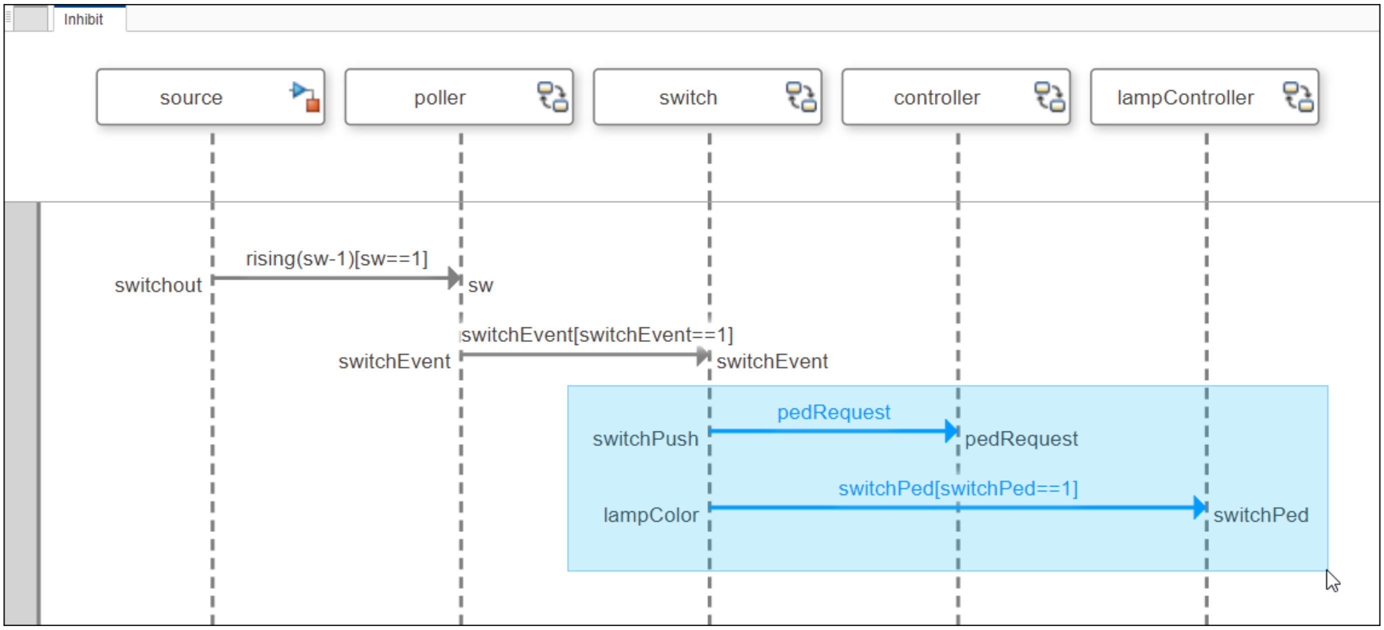
A fragment is used to model complex sequences, such as alternatives, in a sequence diagram.

An operand is a region in a fragment. Fragments have one or more operands depending on the kind of fragment. Operands can contain messages and additional fragments.

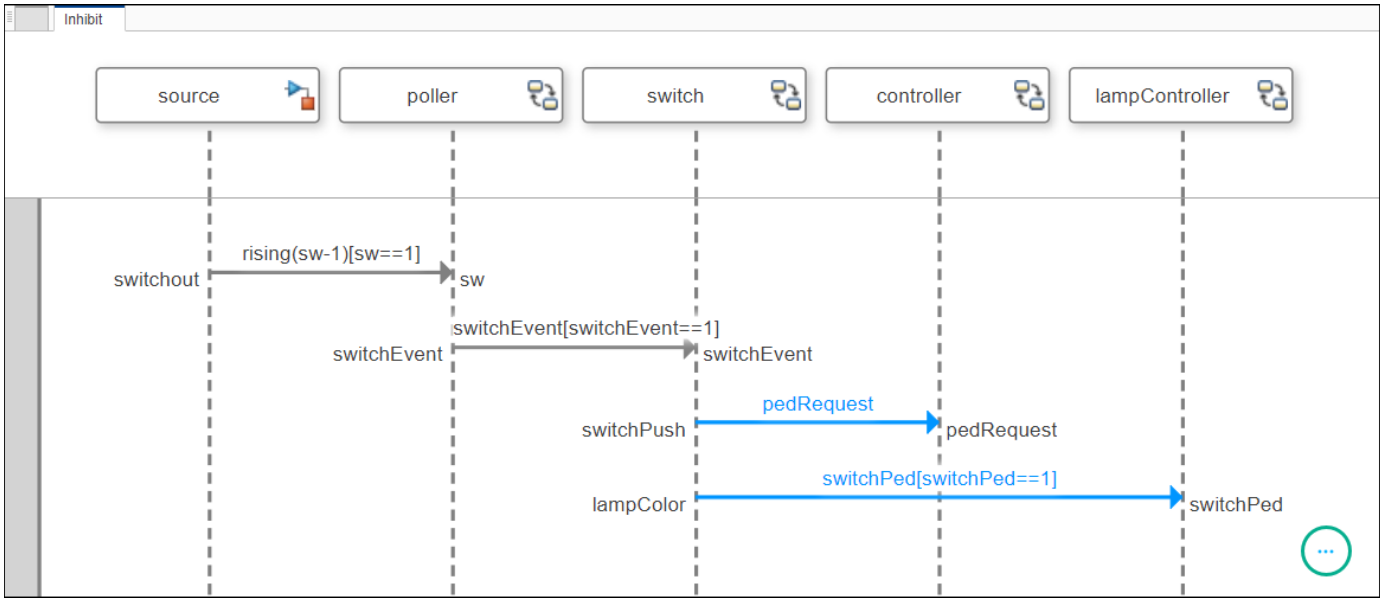
Each operand can include a constraint to specify whether the messages inside the operand execute. You can express the precondition of an operand as a MATLAB Boolean expression using the input signal of any lifeline.

To access the menu of fragments:

1 Click and drag to select two messages.



2 Pause on the ellipsis (...) that appears to access the action bar.

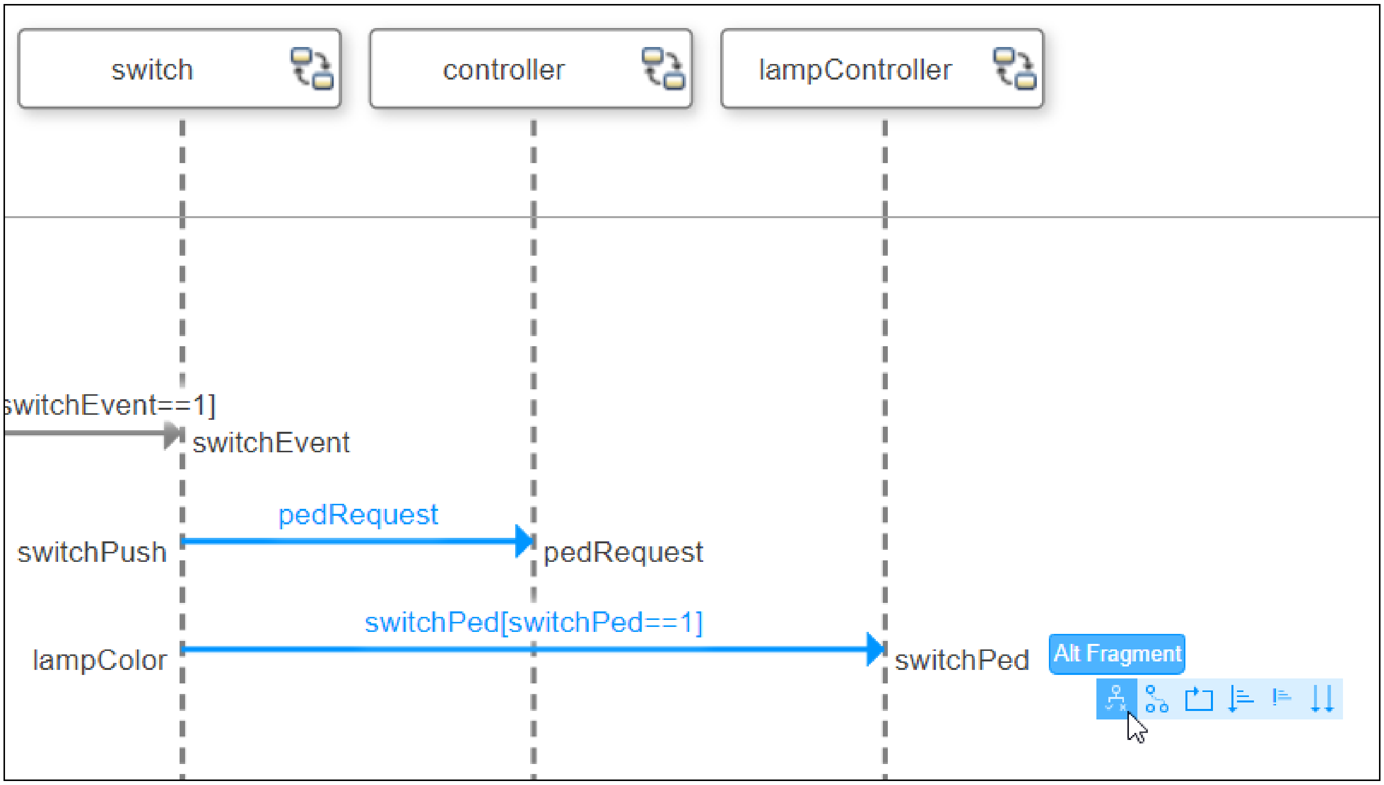


3 A list of fragments appears:

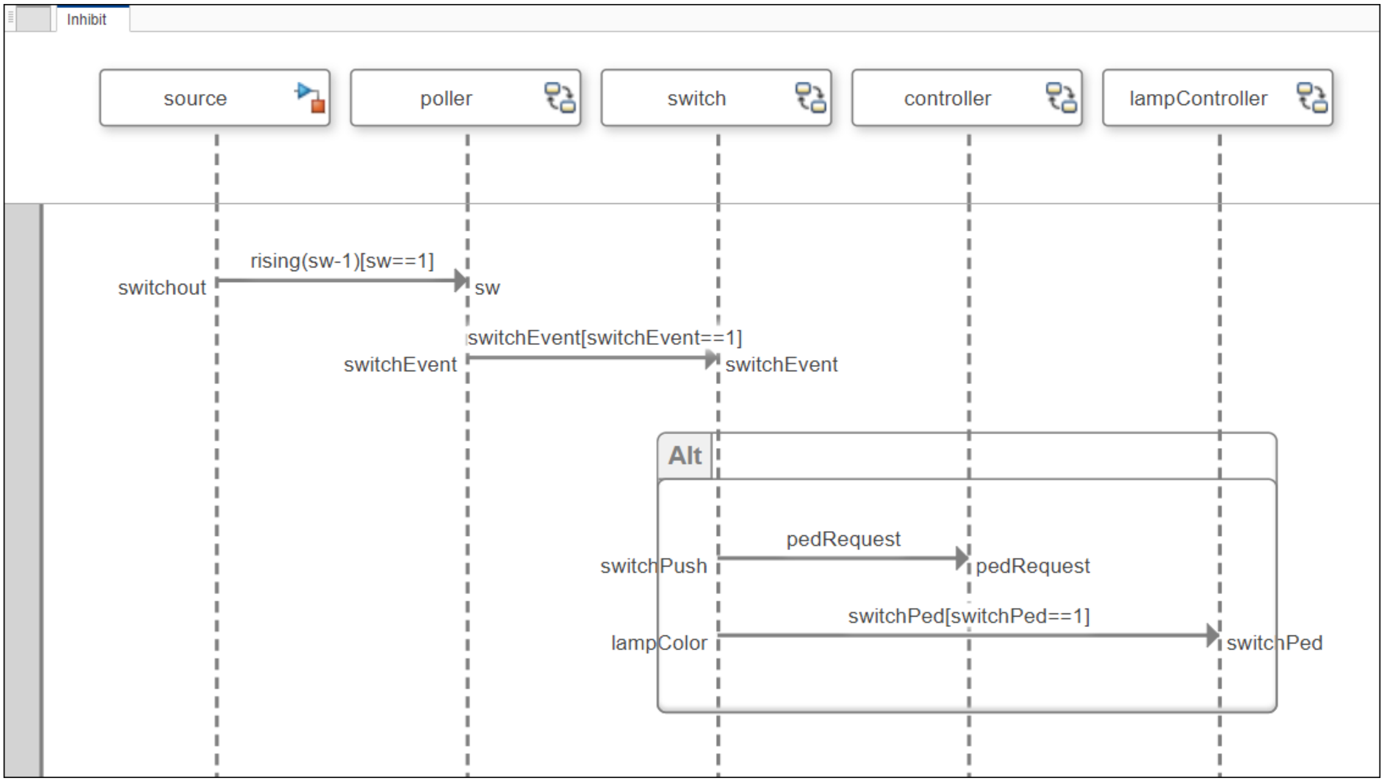
- Alternative (`Alt`) fragment
- Optional (`Opt`) fragment
- Loop (`Loop`) fragment
- Weak sequencing (`Seq`) fragment
- Strict sequencing (`Strict`) fragment
- Parallel (`Par`) fragment

For more information, see “Author Sequence Diagram Fragments” on page 6-29.

Select the “Alt Fragment” on page 6-35 fragment.



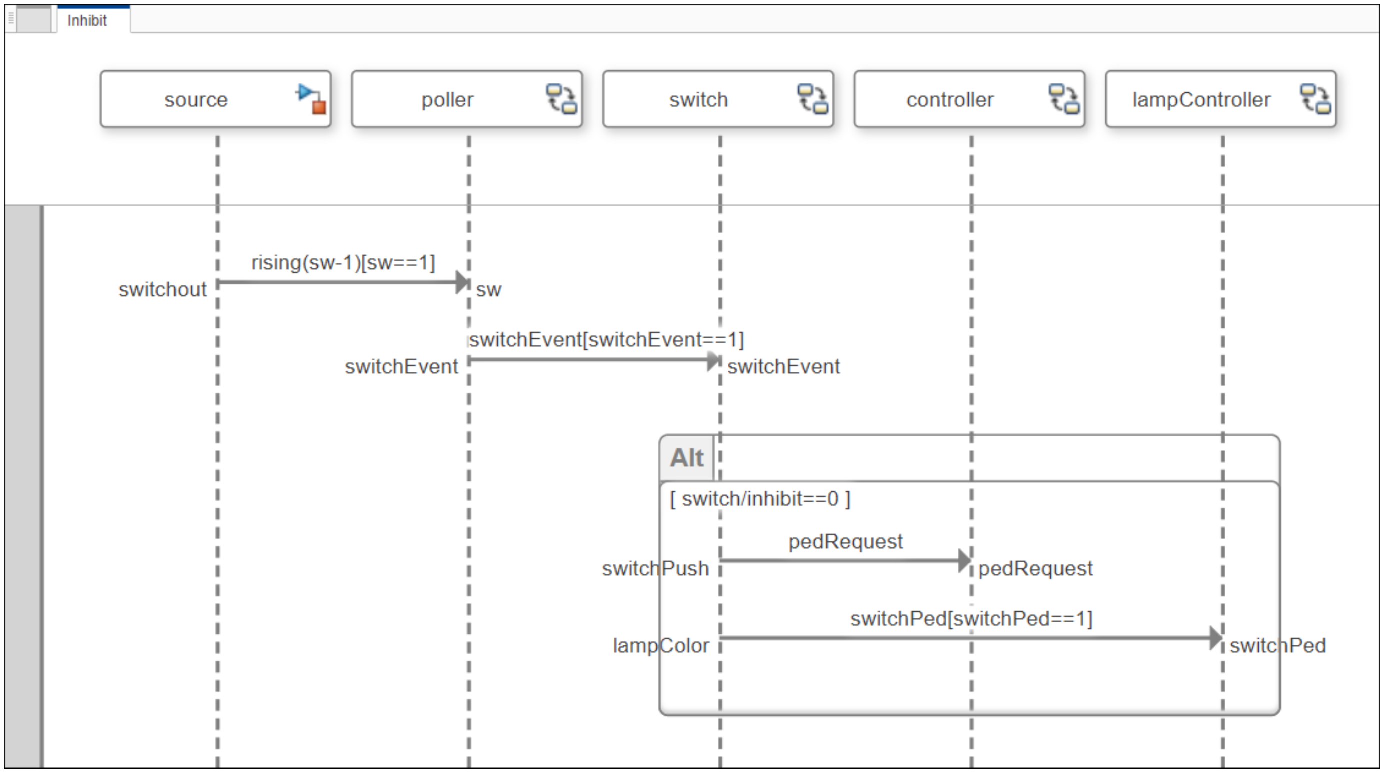
4 The “Alt Fragment” on page 6-35 fragment is added to the sequence diagram with a single operand that contains the selected messages.



5 Select the fragment to enter an operand condition. Choose a fully qualified name for input data and use a constraint condition relation.

```
switch/inhibit==0
```

This constraint is a precondition that determines when the operand is active. This constraint specifies that the `inhibit` flag is set to `0`. Thus, pedestrian crossing is allowed at this intersection using a pedestrian lamp.



The messages inside an operand can only be executed if the constraint condition is true.

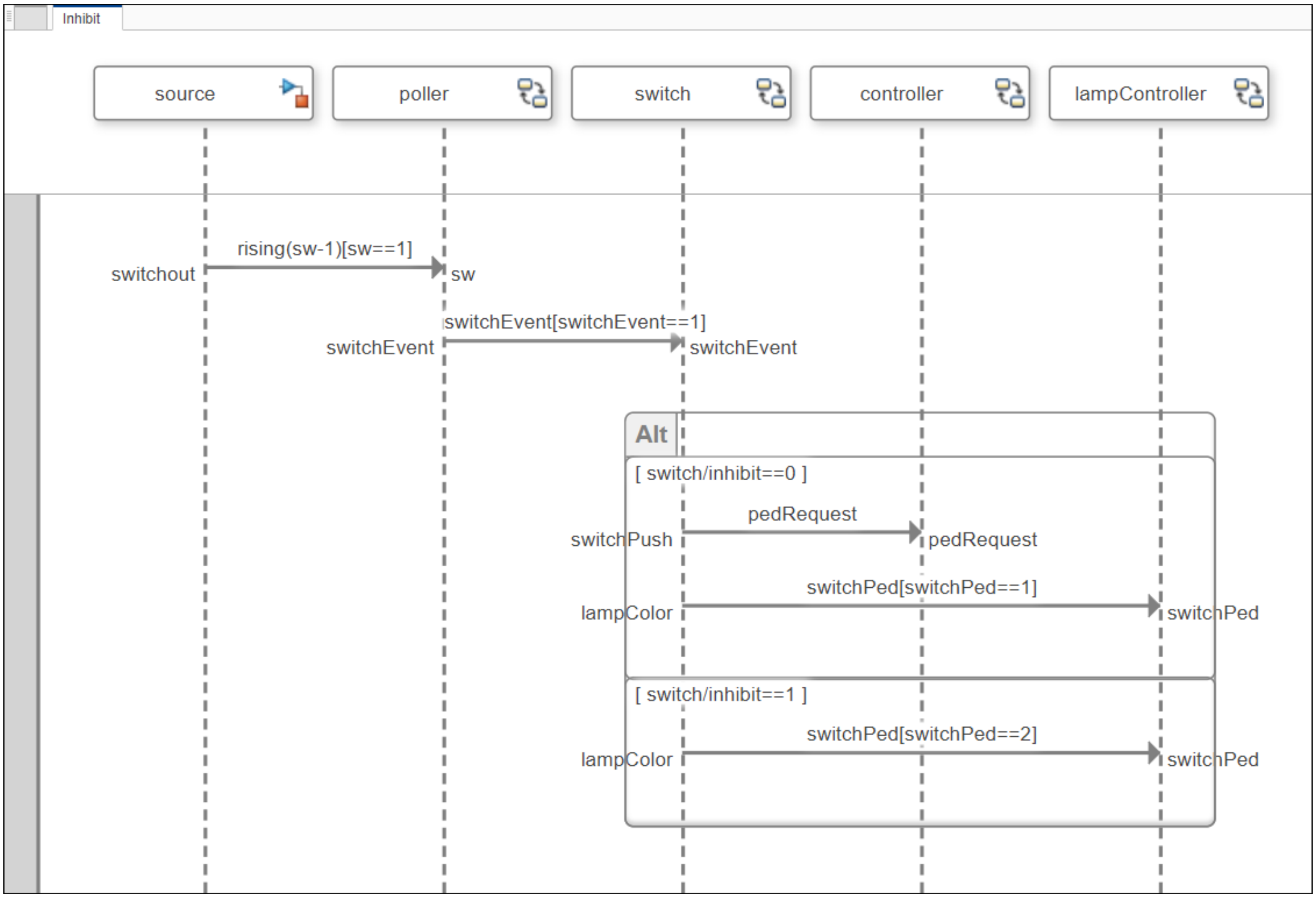
6 Highlight the first operand under the “Alt Fragment” on page 6-35 fragment and select from the toolstrip **Fragment** > **Add Operand** > **Insert After**. A second operand is added.

Add a constraint condition relation to the second operand. The second operand in an “Alt Fragment” on page 6-35 fragment represents an `elseif` condition for which the message will be executed.

```
switch/inhibit==1
```

This constraint represents when the `inhibit` flag is set to `1`. Thus, pedestrian crossing is not controlled by a walk signal on that intersection.

Create a message with a message label inside the second operand.



For the first operand in the “Alt Fragment” on page 6-35 fragment, since the `inhibit` flag is set to `0`, the first message to the `controller` lifeline is recognized when the `pedRequest` message is valid. Then, when the `switchPed` message value is `1`, the `lampController` component behavior allows pedestrians to cross.

For the second operand in the “Alt Fragment” on page 6-35 fragment, since the `inhibit` flag is set to `1`, the `switch` bypasses the `controller`. The message `switchPed` with a value of `2` goes directly to the `lampcontroller` which does not affect the traffic signal. Pedestrian crossing is not specifically supported in this traffic intersection.

See Also

More About

- “Describe System Behavior Using Sequence Diagrams” on page 6-2
- “Compose Architectures Visually” on page 1-2
- “Implement Component Behavior Using Simulink” on page 7-2
- “Implement Component Behavior Using Stateflow Charts” on page 7-14
- “Define Port Interfaces Between Components” on page 3-2

Use Sequence Diagrams with Architecture Models

You can author sequence diagrams to describe expected system behavior as a sequence of interactions between components of a System Composer architecture model. Lifelines correspond to components in an architecture model, and messages correspond to the connectors between the components. You can create multiple sequence diagrams to represent different operational scenarios of the system. Sequence diagrams are integrated into the **Architecture Views Gallery** in System Composer.

For a roadmap of the sequence diagram topics, see “Describe System Behavior Using Sequence Diagrams” on page 6-2.

This traffic light example will show you how to:

- Create a sequence diagram.
- Add child lifelines in a sequence diagram.
- Interact with root architecture ports in a sequence diagram using gates.
- Co-create components and keep the architecture model and the sequence diagram in sync.
- Create messages in a sequence diagram.
- Use the model browser to add components.

Note This example uses Stateflow blocks. If you do not have a Stateflow license, you can open and simulate the model but can only make basic changes, such as modifying block parameters.

Traffic Light Example with Hierarchy for Sequence Diagrams

This traffic light example contains sequence diagrams to describe pedestrians crossing an intersection. The model describes these steps:

1. The traffic signal cycles from green to yellow to red.
2. When the pedestrian crossing button is pressed, if the traffic signal is green, the traffic signal transitions from yellow to red for a limited time.
3. The pedestrians cross while the walk signal is active.

Open the System Composer model that contains the sequence diagrams.

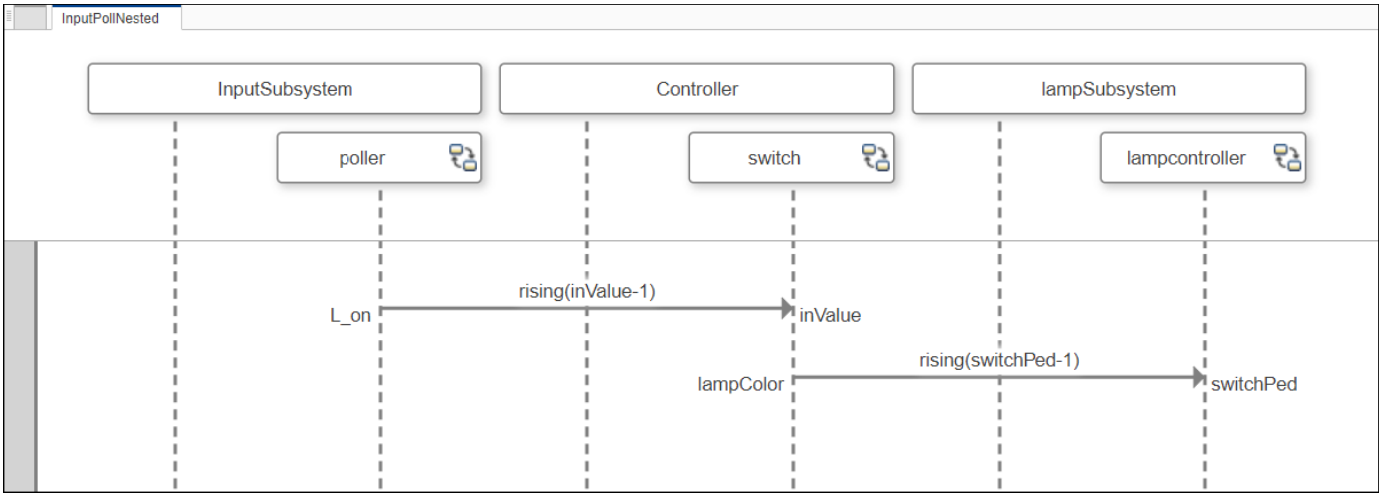
```
model = systemcomposer.openModel("TrafficLight");
```

Open the Architecture Views Gallery to view the sequence diagrams.

```
openViews(model)
```

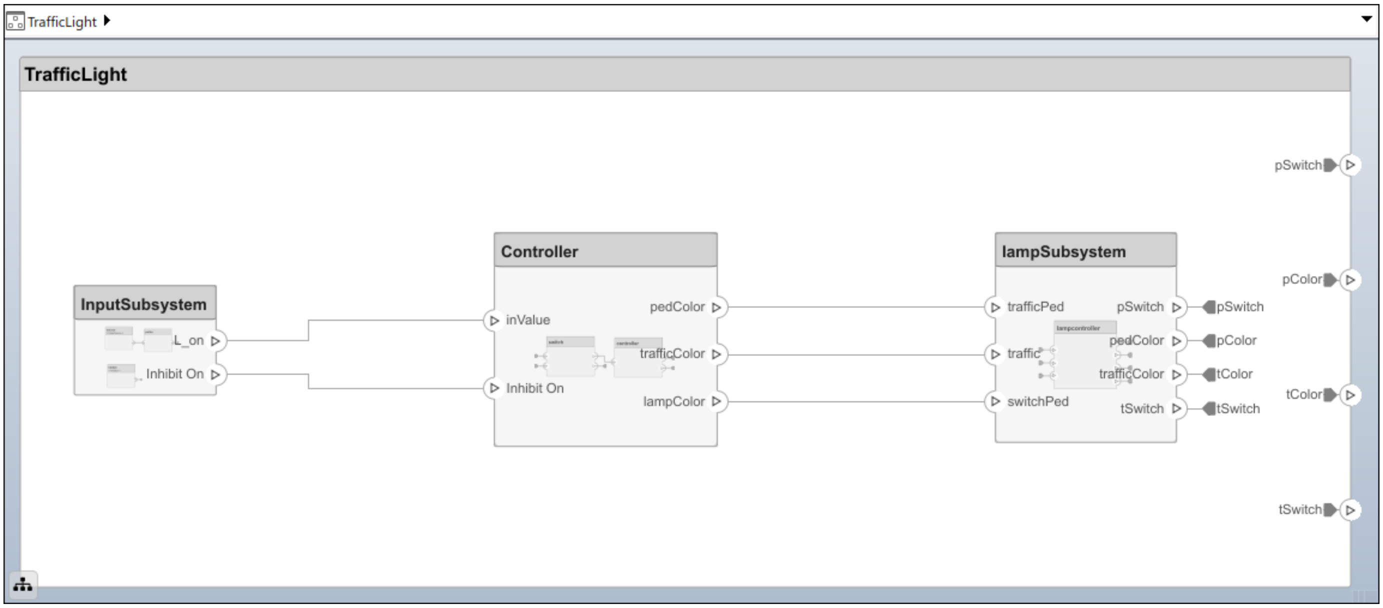
The sequence diagram in this example represents an operative scenario in the architecture model.

`InputPollNested` sequence diagram: When the `poller` recognizes a signal event as `inValue` rises to `1`, the pedestrian crossing button is pressed. Next, the `switch` lifeline recognizes a signal event to `lampcontroller` as `switchPed` rises to `1`, which activates the pedestrian crossing signal.



Create Sequence Diagram

Use an architecture model in System Composer to represent a traffic light example.



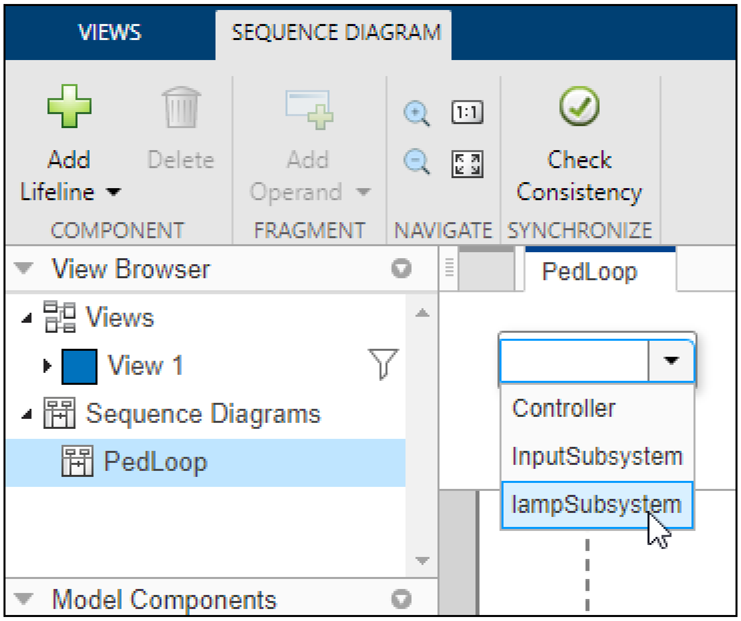
1 Navigate to **Modeling** > **Sequence Diagram** to open sequence diagrams in the **Architecture Views Gallery**.

2 To create a new sequence diagram, click **New** > **Sequence Diagram**.

3 In **Sequence Diagram Properties** on the right, enter the name `PedLoop`.

4 Select **Component** > **Add Lifeline** from the menu. A box with a vertical dotted line appears on the canvas. This is the new lifeline.

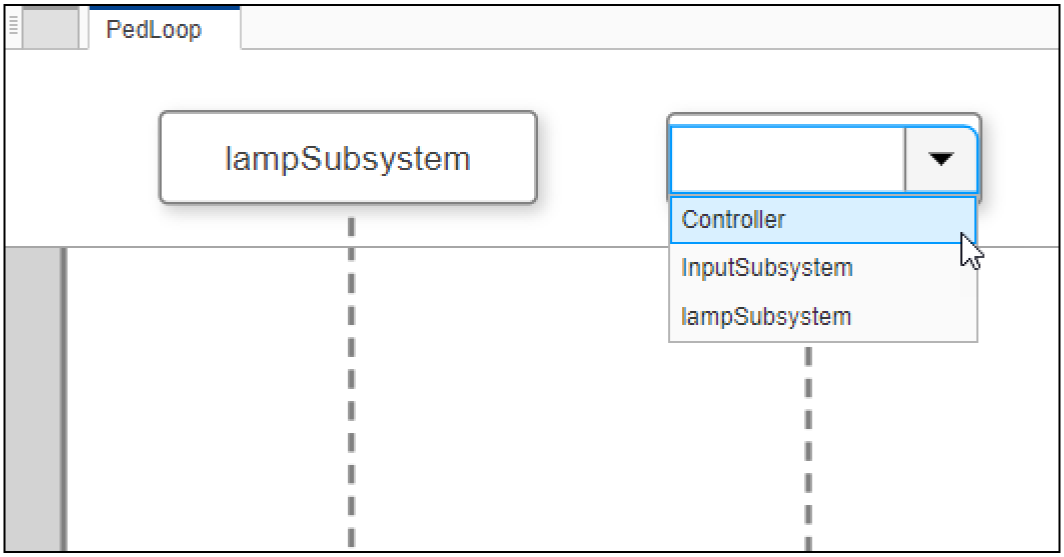
5 Click the down arrow on the lifeline to view available options. Select the component named `lampSubsystem` to be represented by the lifeline.



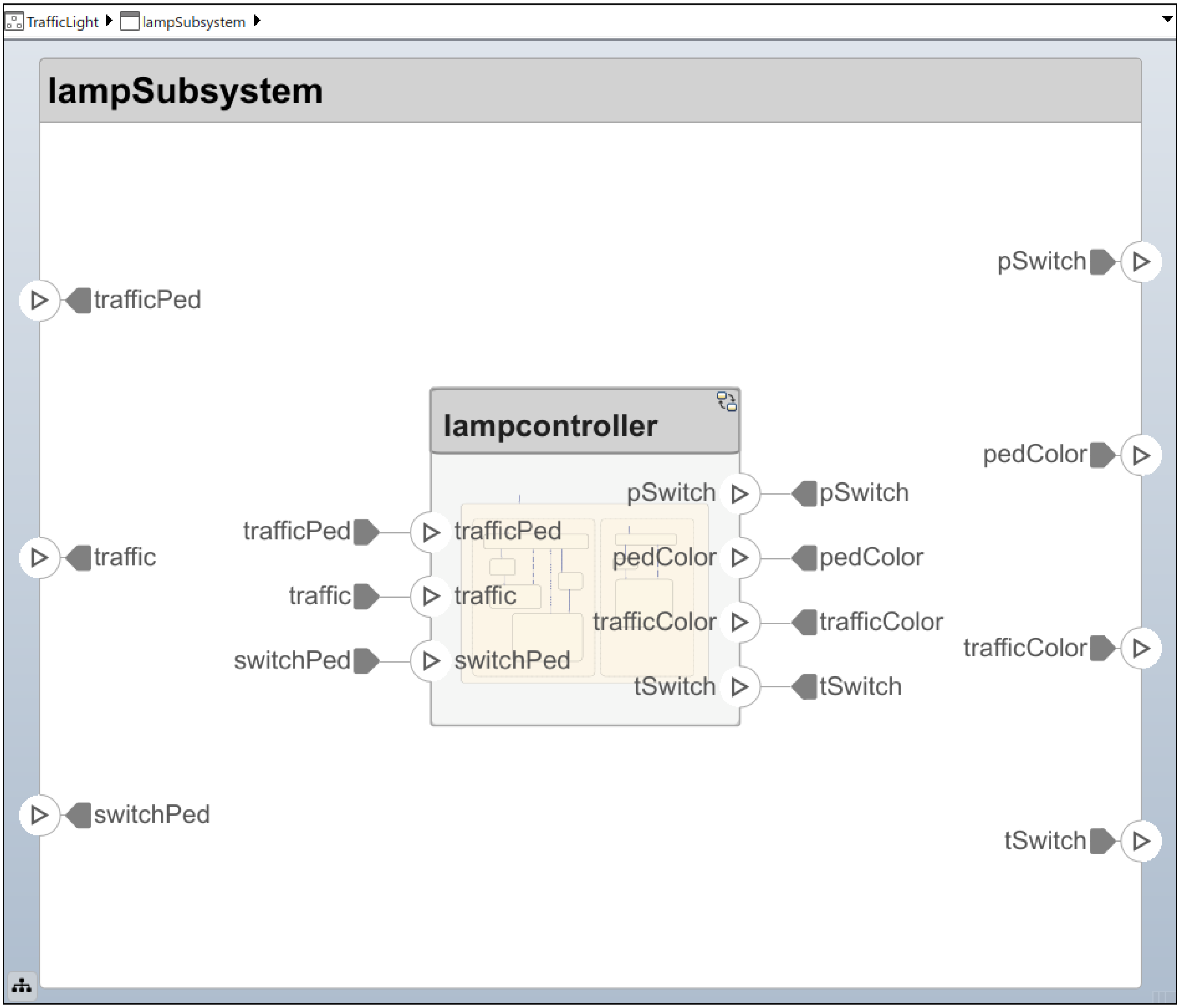
Add Child Lifelines to Sequence Diagram

You can add child lifelines to a sequence diagram to represent model hierarchy and describe the interactions between lifelines.

1 From the menu, select **Component** > **Add Lifeline**. From the list that appears, select the `Controller` component.

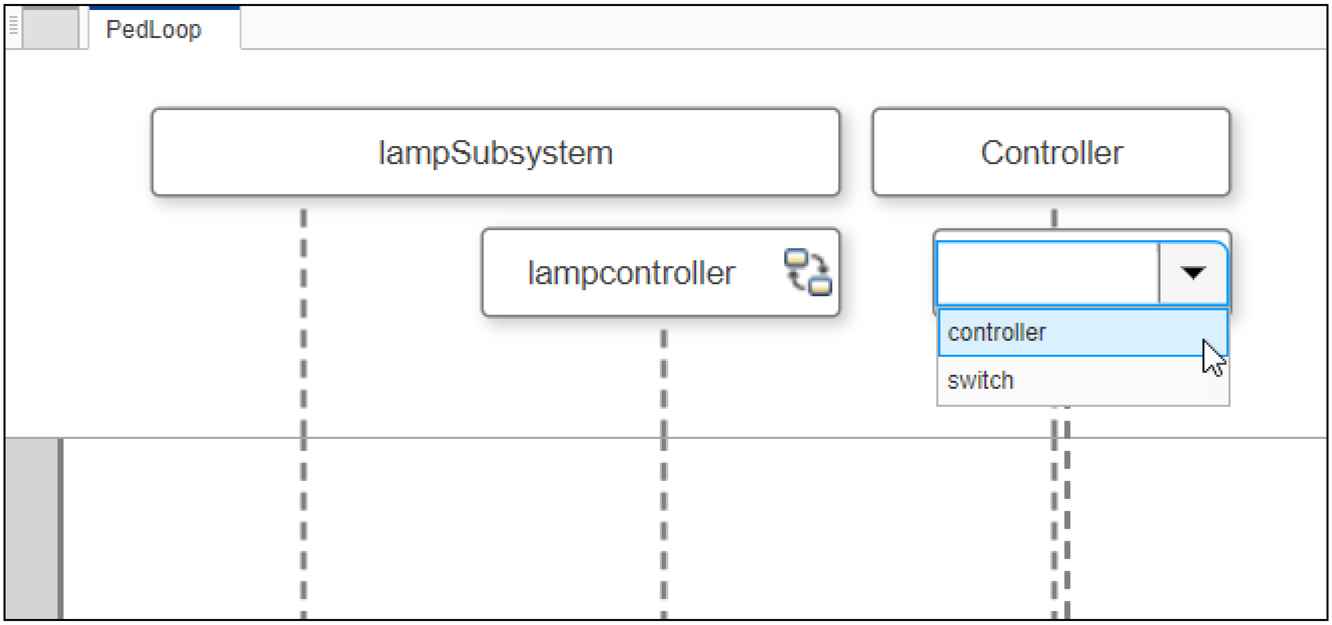


2 Child components called `lampcontroller` and `controller` are located inside the `lampSubsystem` and `Controller` components, respectively.



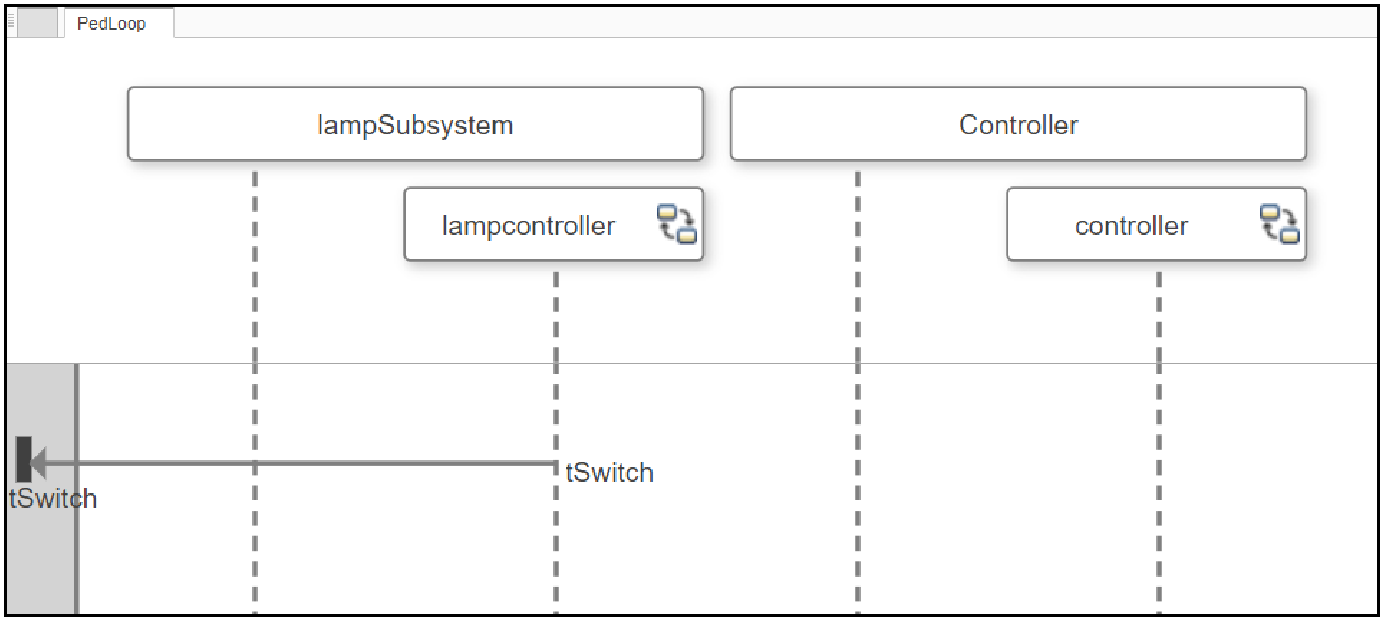
3 Select the `lampSubsystem` lifeline. Navigate to **Component** > **Add Lifeline** > **Add Child Lifeline**. Select `lampcontroller`. The `lampcontroller` child lifeline is now situated below `lampSubsystem` in the hierarchy.

4 Repeat these steps for the `Controller` lifeline to add the `controller` child lifeline.

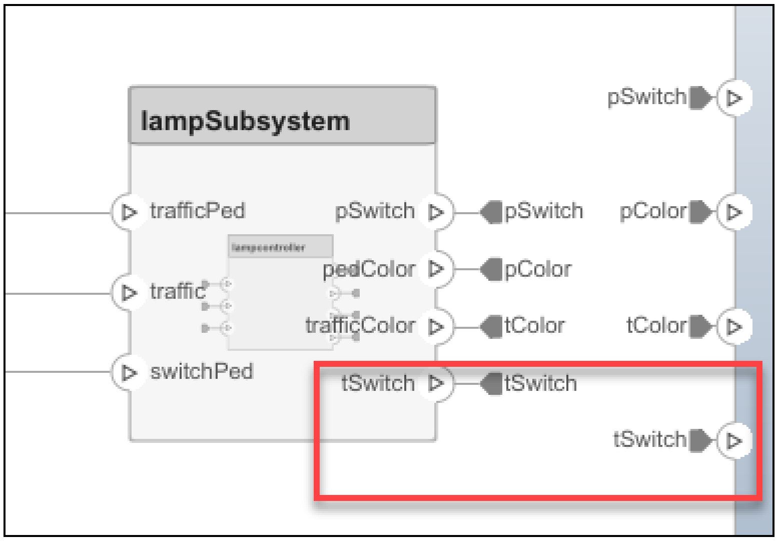


Create Sequence Diagram Gates

1 Select the `lampcontroller` lifeline, then click and drag it to the gutter region. Start typing `tSwitch` into the **To** box and select `tSwitch` from the list. See that a gate called `tSwitch` has been created with a message from the `lampcontroller` lifeline at the port `tSwitch`.



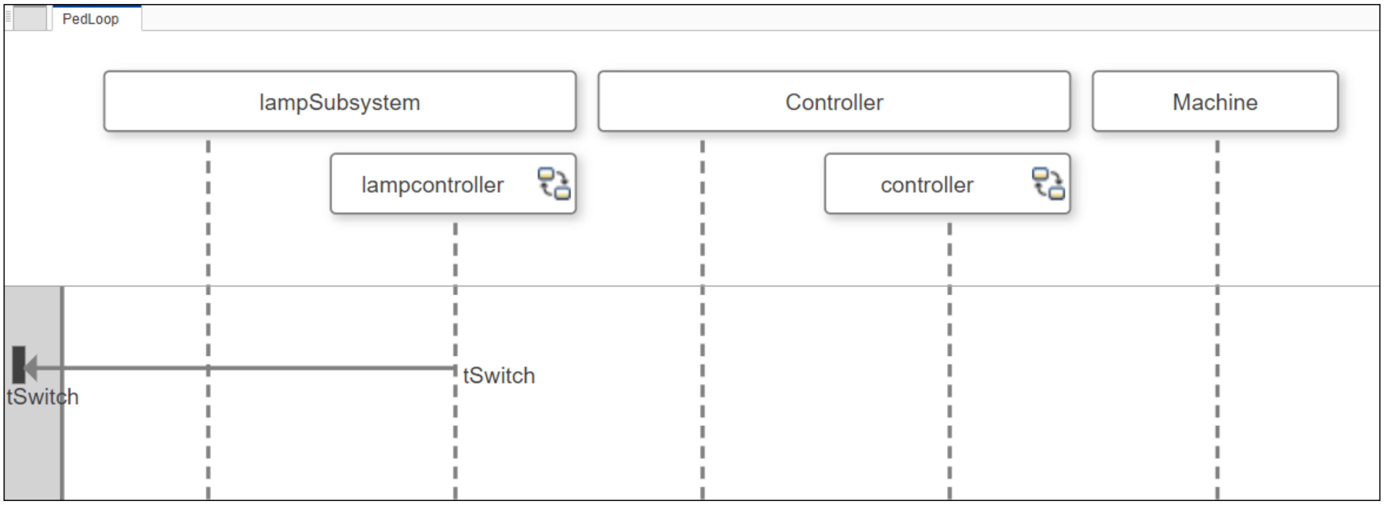
2 Return to the architecture diagram. Observe that `tSwitch` is a root architecture port connected to the `lampcontroller` component in the hierarchy through the `lampSubsystem` component.



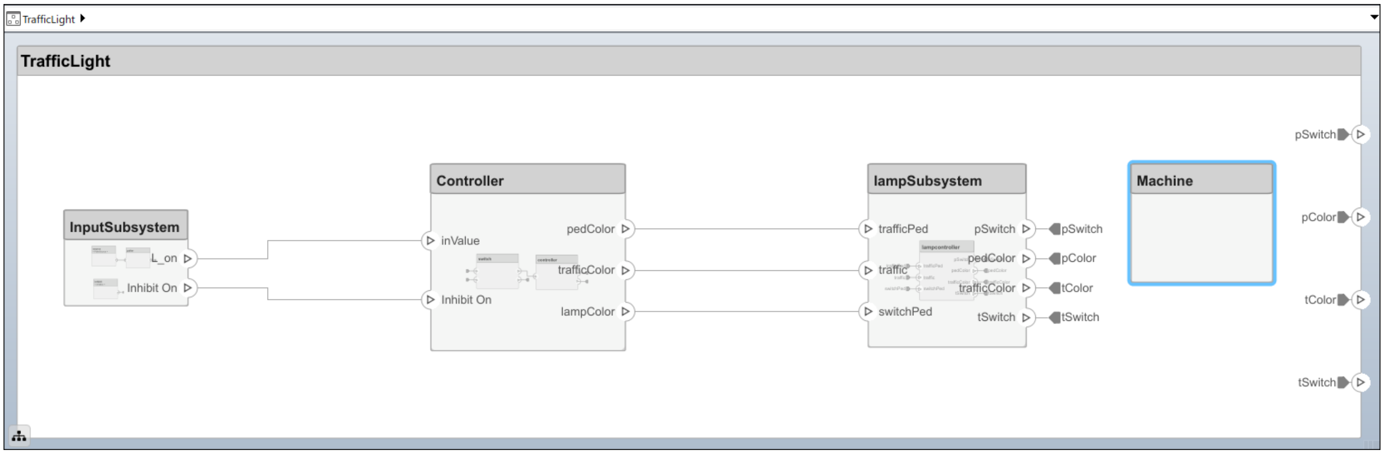
Co-Create Components

The co-creation workflow between the sequence diagram and the architecture model keeps the model synchronized as you make changes to the sequence diagram. Adding both lifelines and messages in a sequence diagram results in updates to the architecture model. This example shows component co-creation.

1 From the toolstrip menu, select **Component** > **Add Lifeline**. Another box with a vertical dotted line appears on the canvas to represent a lifeline. In the box, enter the name of a new component named `Machine`.

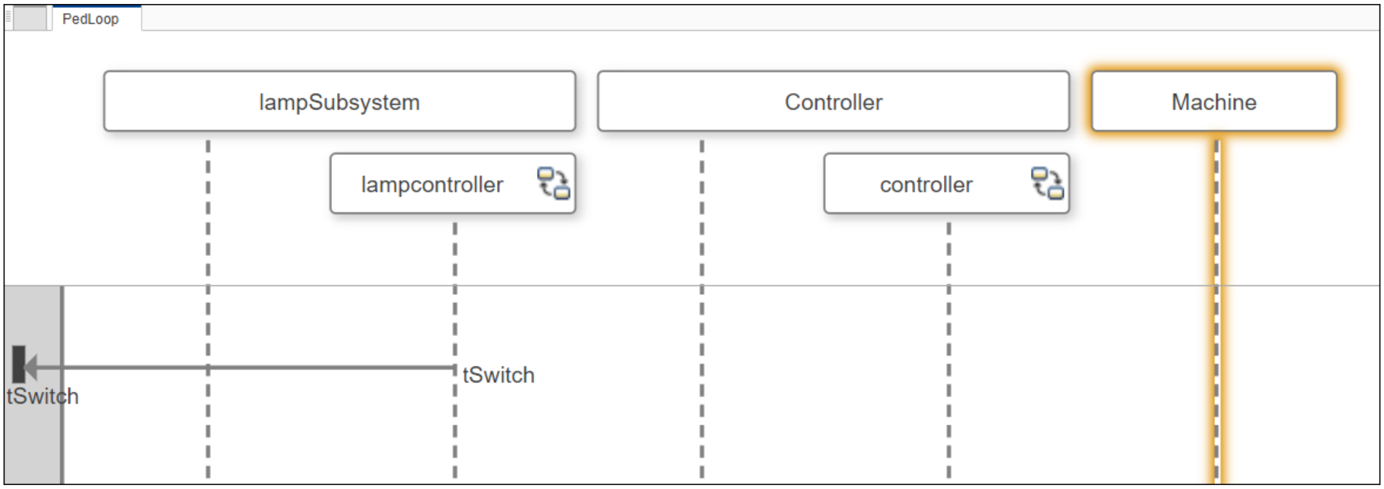


2 Observe that the `Machine` component is co-created in the architecture diagram.



Synchronize Sequence Diagram and Model

1. Remove the `Machine` component from the architecture diagram.
2. Return to the sequence diagram and select **Synchronize** > **Check Consistency**. See that the `Machine` lifeline is highlighted, as it does not correspond to a component.



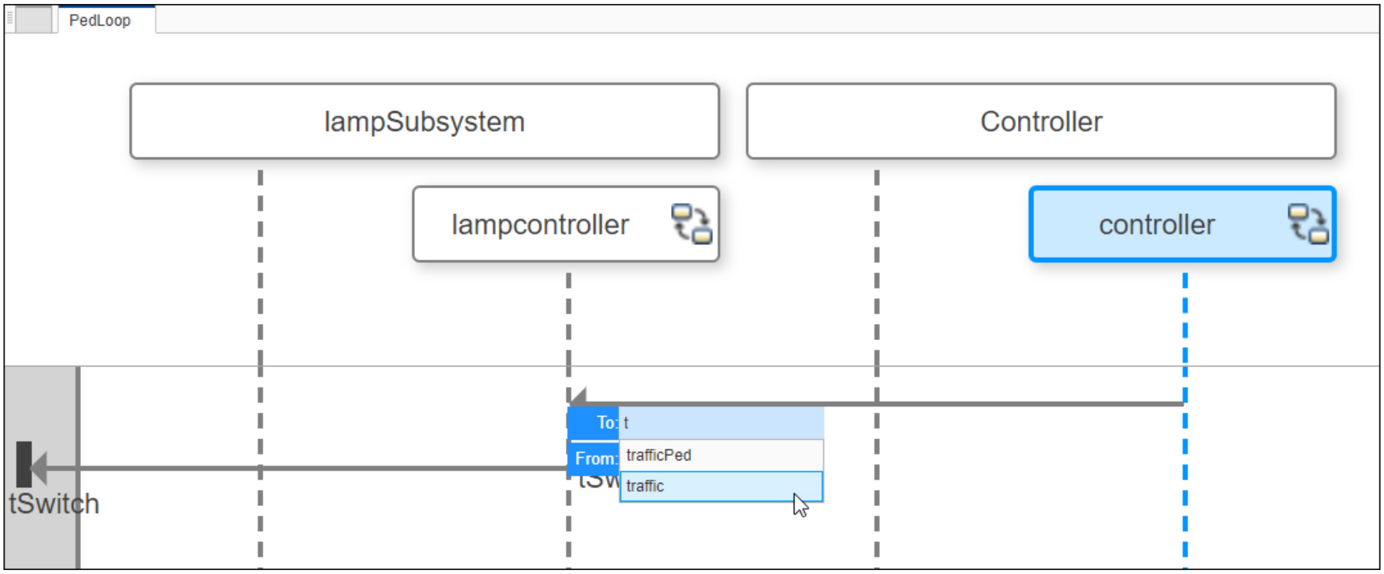
3. To restore consistency, either remove the `Machine` lifeline or click **Undo** in the architecture model to restore the `Machine` component.
4. Click **Check Consistency** again.

For advanced sequence diagram synchronization techniques, see “Synchronize Sequence Diagrams and Architecture Models” on page 6-40.

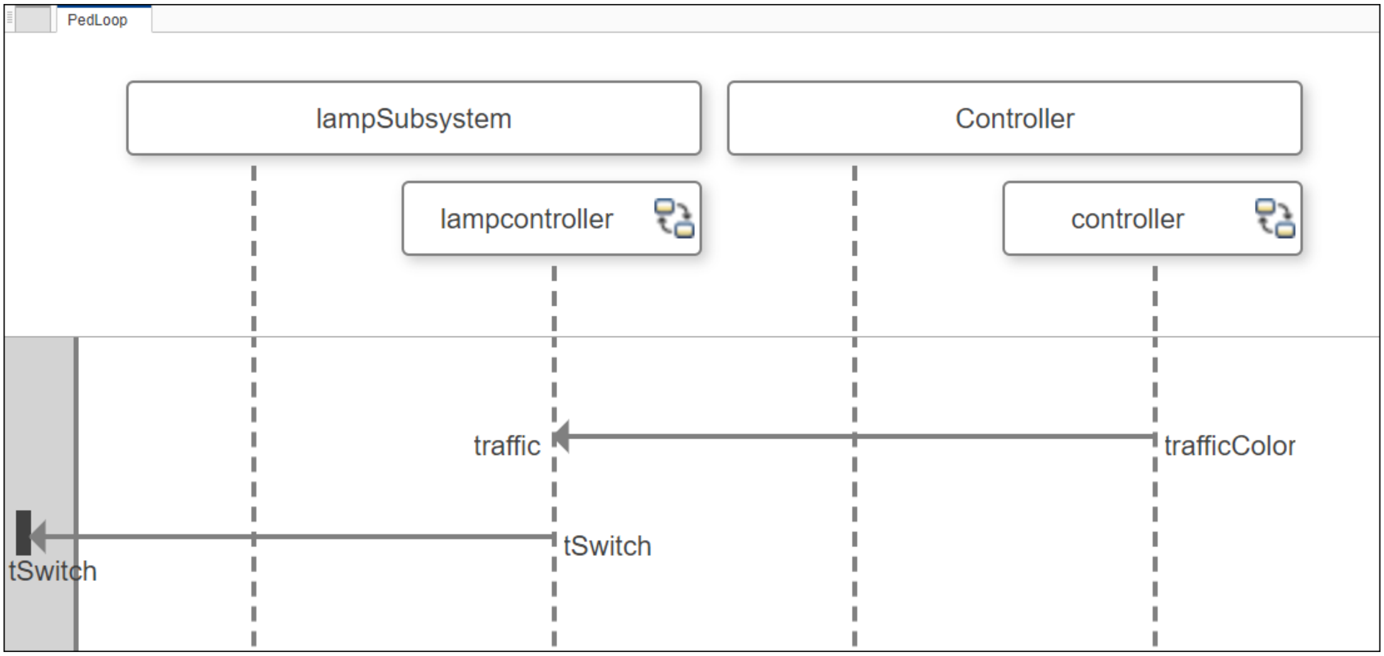
Create Messages in Sequence Diagram

You can create a message from an existing connection.

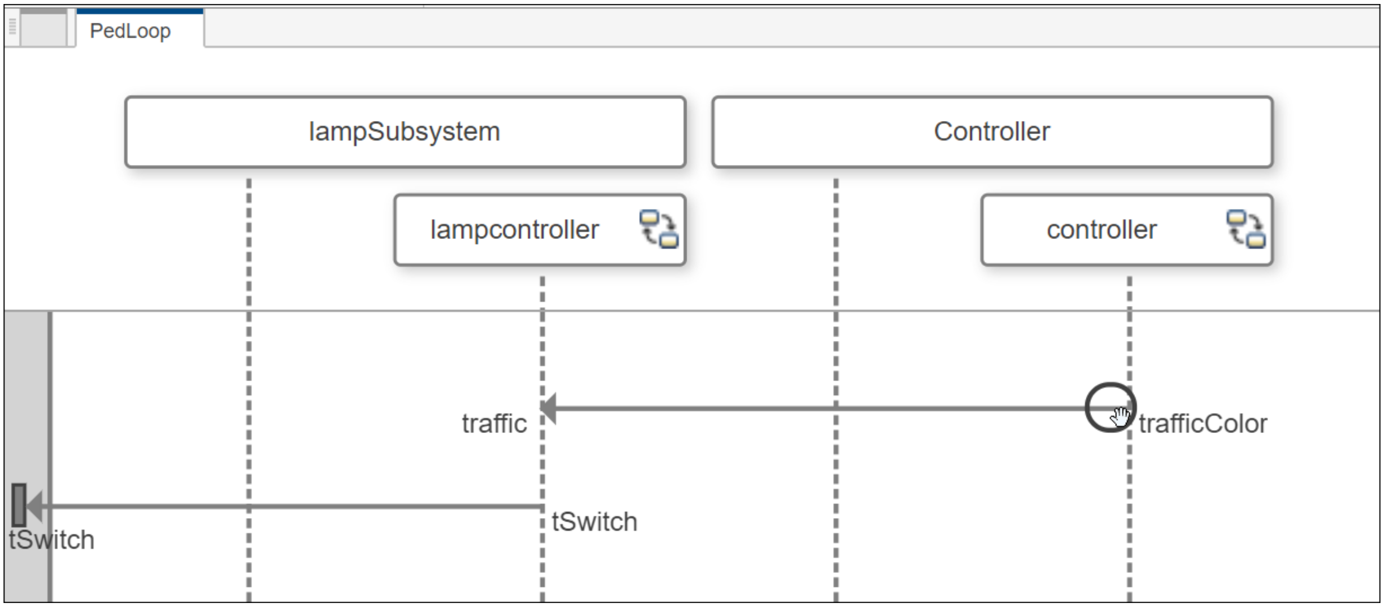
1. Draw a line from the `controller` lifeline to the `lampcontroller` lifeline. Start to type `traffic` in the **To** box, which fills in automatically as you type. Once the text fills in, select `traffic`.



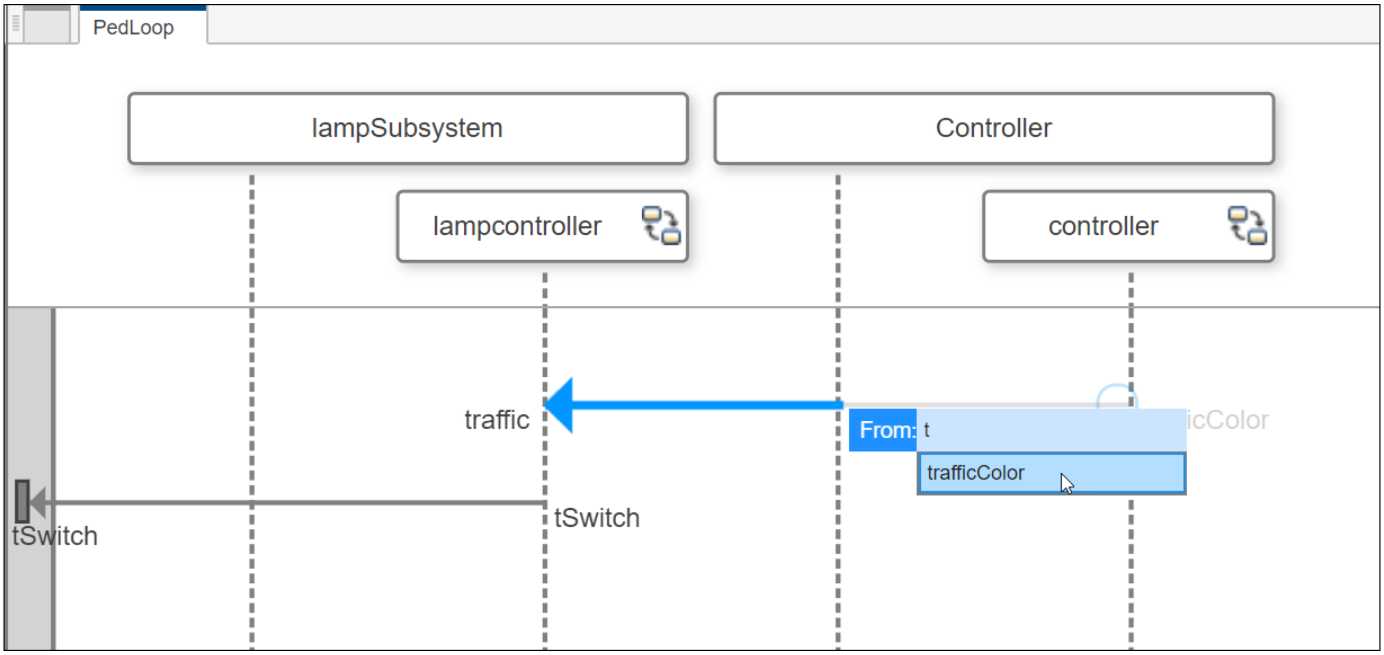
2 Since the `trafficColor` port and `traffic` port are connected in the model, a message is created from the `traffic` port to the `trafficColor` port in the sequence diagram.



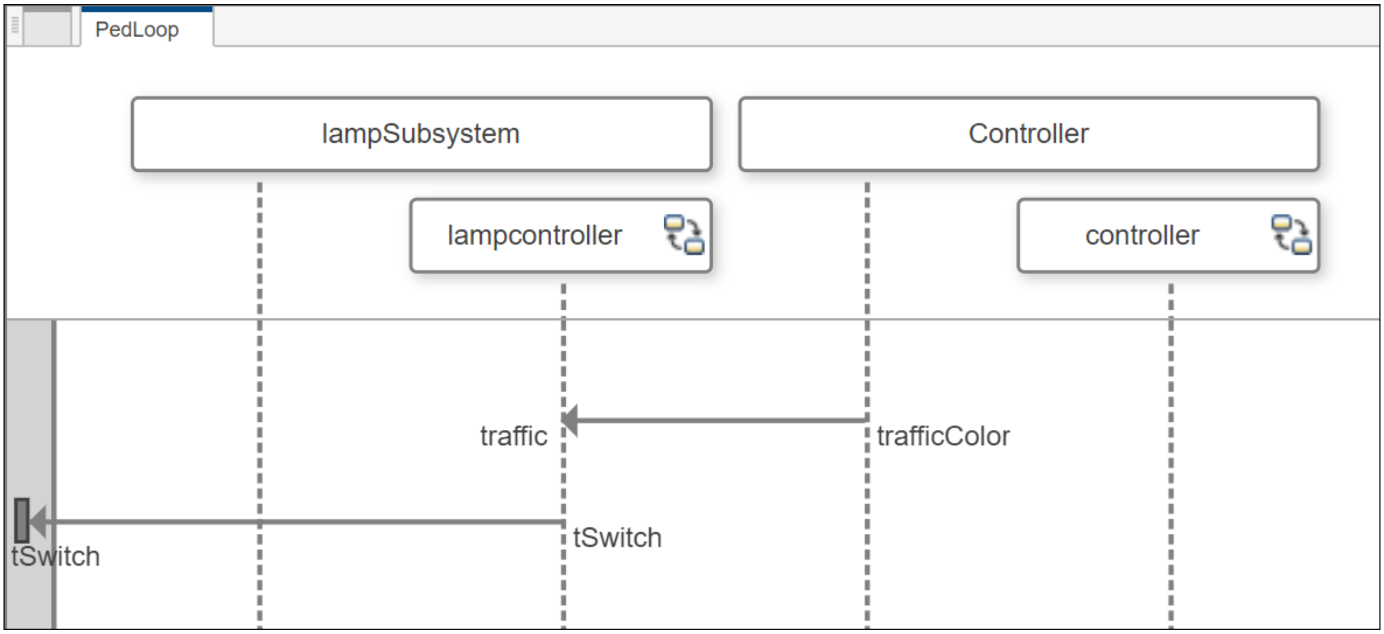
3 You can modify the source and destination of a message after the message has been created. Click the `trafficColor` message end to select it.



4 Click and drag the `trafficColor` message end to the `Controller` parent lifeline, then select the `trafficColor` port.



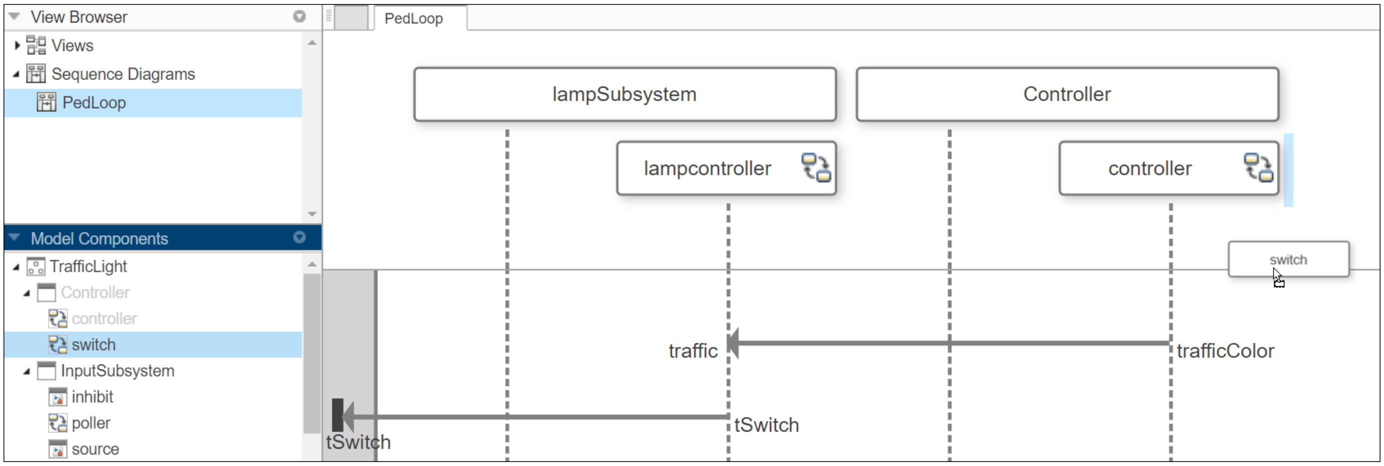
5 Once the `trafficColor` port is selected, the message end moves from the `controller` child lifeline to the `Controller` parent lifeline.



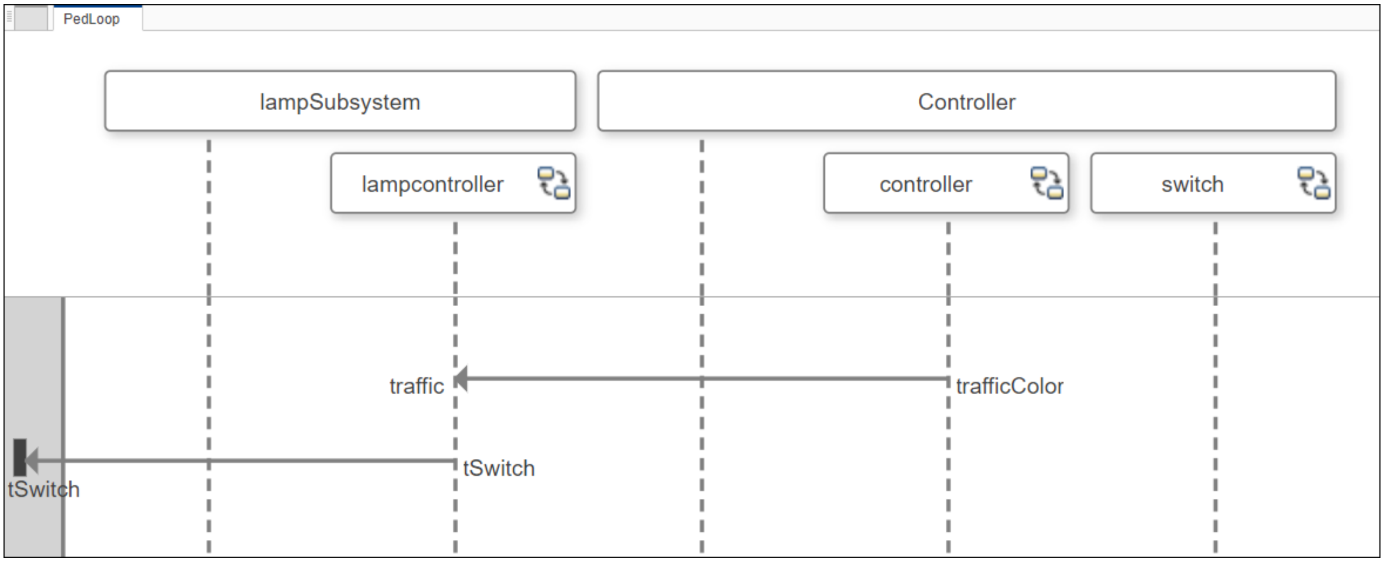
You can also rename message ends and the associated ports by double-clicking the name of a message end.

Modify Sequence Diagram Using Model Browser

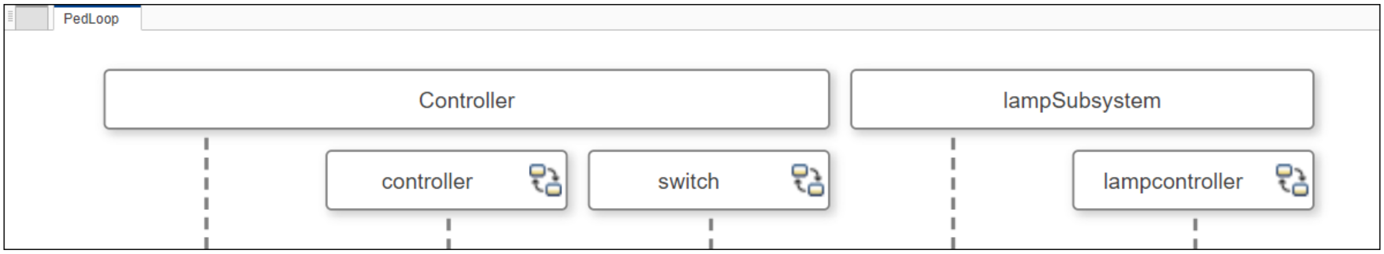
1 The Views Gallery model browser located on the bottom left of the canvas is called **Model Components**. Click and drag the `switch` child component into the sequence diagram.



2 The sequence diagram is updated with a new lifeline.



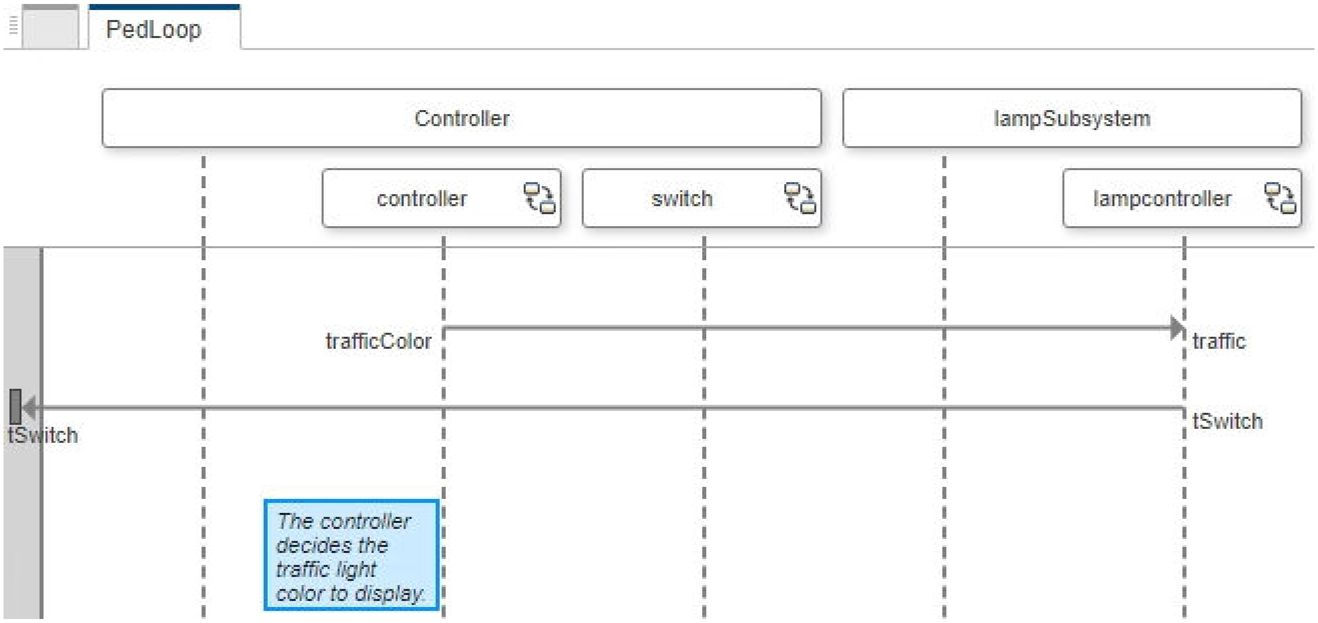
3 Click and drag to reorder the `lampSubsystem` and the `Controller` lifelines.



Use Annotations to Describe Elements of Sequence Diagram

You can add plain-text annotations to a sequence diagram to describe elements, such as lifelines, messages, and fragments.

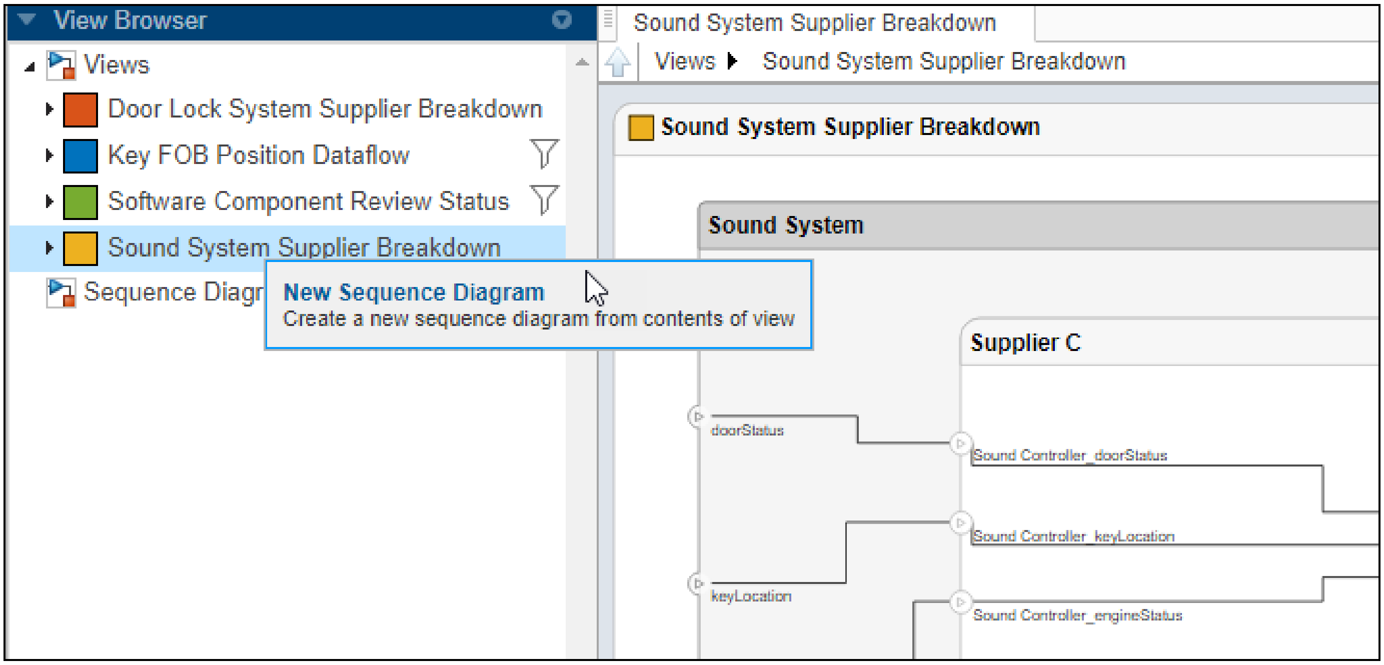
To create an annotation, double-click the canvas at the desired location. Then, enter the annotation text in the text box that appears on the canvas.



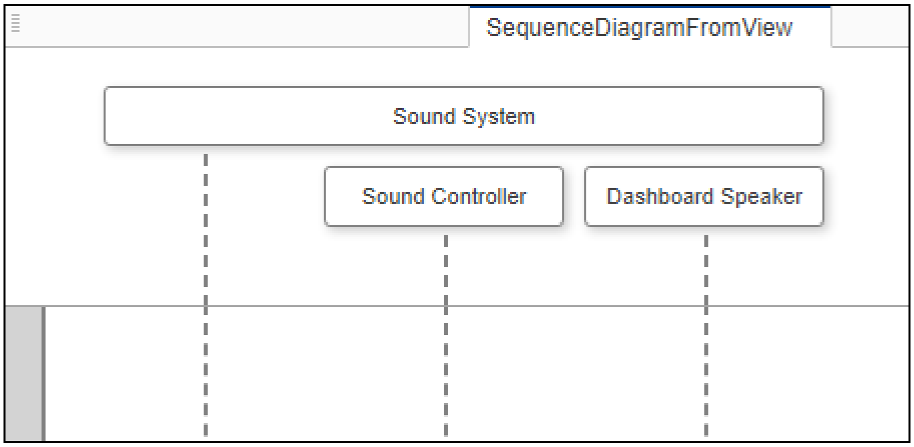
Press **Esc** or click anywhere outside the text box to apply the changes.

Create Sequence Diagram from View

1. In the MATLAB Command Window, enter `scKeylessEntrySystem`. The architecture model opens in the Simulink Editor.
2. To open the **Architecture Views Gallery** for the model, navigate to **Modeling** > **Views** > **Architecture Views**.
3. Right-click the `Sound System Supplier Breakdown` view and select **New Sequence Diagram**.


View Browser
Views
Door Lock System Supplier Breakdown
Key FOB Position Dataflow
Software Component Review Status
Sound System Supplier Breakdown
Sequence Diagr
New Sequence Diagram
Create a new sequence diagram from contents of view
Sound System Supplier Breakdown
Views ▶ Sound System Supplier Breakdown
Sound System Supplier Breakdown
Sound System
Supplier C
doorStatus
keyLocation
Sound Controller_doorStatus
Sound Controller_keyLocation
Sound Controller_engineStatus

4 A new sequence diagram of lifelines is created with all the components from the view.



See Also

More About

- “Describe System Behavior Using Sequence Diagrams” on page 6-2
- “Compose Architectures Visually” on page 1-2
- “Implement Component Behavior Using Simulink” on page 7-2
- “Implement Component Behavior Using Stateflow Charts” on page 7-14
- “Define Port Interfaces Between Components” on page 3-2

Author Sequence Diagram Fragments

A sequence diagram describes an expected order of the events logged during execution of a Simulink model. There are four event types:

1. Signal read
2. Signal write
3. Message send
4. Message receive

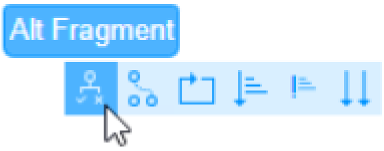
These four events cover the two interaction styles described by sequence diagrams: signals and messages. You can specify events using messages between lifelines. Each message describes a pair of events. For signals, the pair of events is write followed by read. For messages, the pair of events is send followed by receive.

To learn more about simulating sequence diagrams, see “Simulate Sequence Diagrams for Traffic Light Example” on page 6-44.

A fragment indicates how a group of messages within it execute or interact.

A fragment is used to model complex sequences, such as alternatives, in a sequence diagram.

To add a fragment to a sequence diagram, click and drag around a group of messages or other fragments. A blue box appears. Pause on the ellipsis (...) menu to select from a list of possible fragments.



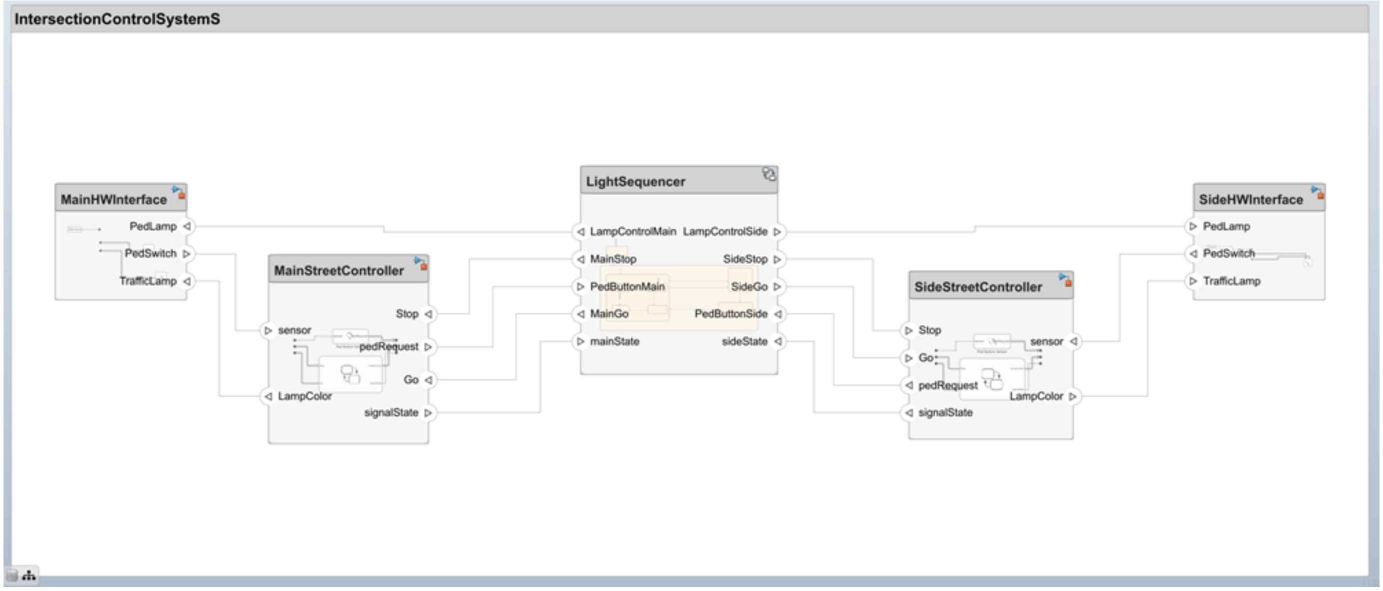
The fragment you select is added in the sequence diagram. For more information, see “Add Fragments and Operands” on page 6-10.

Sequence Diagram Fragments

This example shows an intersection control system to demonstrate how composite fragments are used in sequence diagrams.

Open the System Composer model that contains the sequence diagrams.

```
model = systemcomposer.openModel("IntersectionControlSystemS");
```



Open the Architecture Views Gallery to view the sequence diagrams.

```
openViews(model)
```

Fragment Semantics

Fragments in a sequence diagram execute messages in a specific order based on the kind of fragment. The following fragments are supported:

- Alternative (`Alt`) fragment
- Optional (`Opt`) fragment
- Loop (`Loop`) fragment
- Weak sequencing (`Seq`) fragment
- Strict sequencing (`Strict`) fragment
- Parallel (`Par`) fragment

An operand is a region in a fragment. Fragments have one or more operands depending on the kind of fragment. Operands can contain messages and additional fragments.

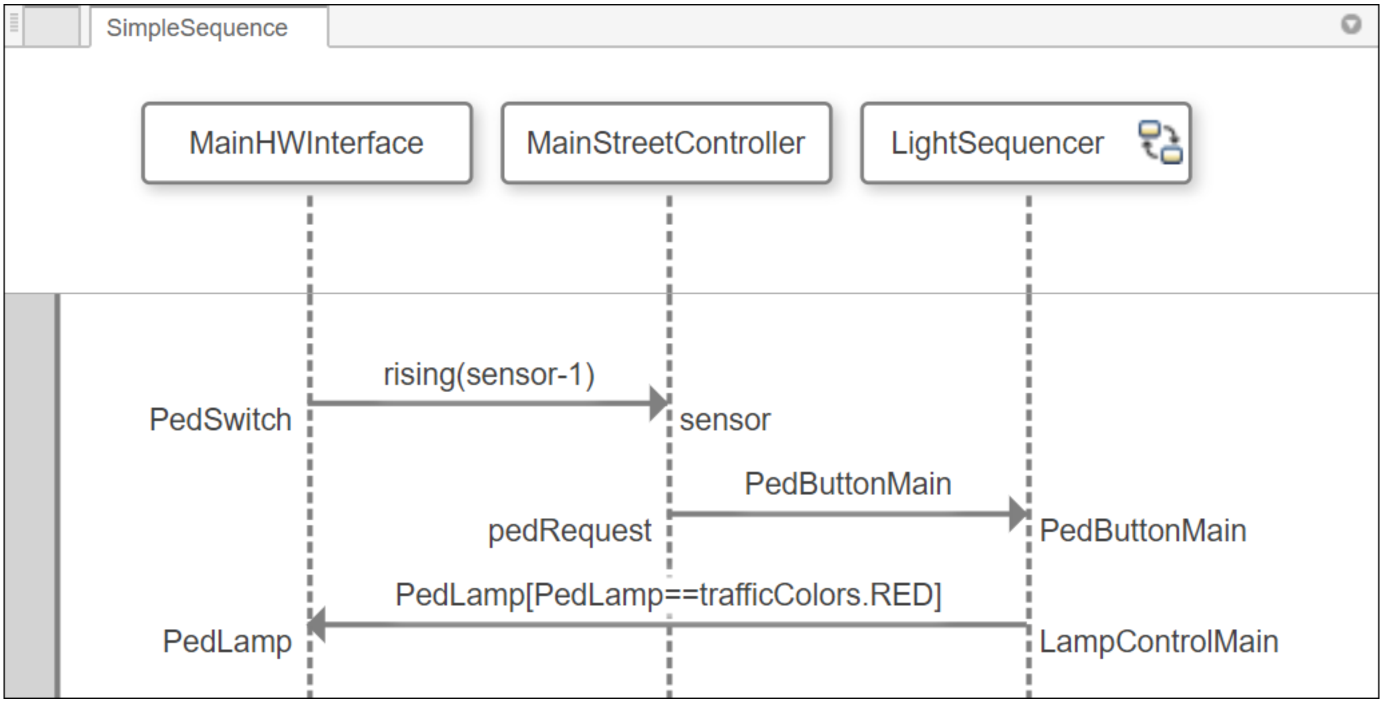
Each operand can include a constraint to specify whether the messages inside the operand execute. You can express the precondition of an operand as a MATLAB Boolean expression using the input signal of any lifeline.

Seq Fragment

The `Seq` fragment contains one operand and represents weak sequencing. The `Seq` fragment specifies the same ordering constraints as a sequence of messages with no fragment.

Weak sequencing means that the sequence of events on each lifeline is respected, but the sequencing of events between lifelines can differ from the order shown in the operand.

- On any given lifeline, any event must occur after the event immediately above it on the lifeline. If a message send or write event occurs from the same lifeline, the order is determined by from how far down the lifeline the event occurs.
- The send or write event for a message must occur before the corresponding receive or read event.
- If two different message send and receive events or write and read events occur on the same lifeline, then the first message can be received before or after the second message is sent.

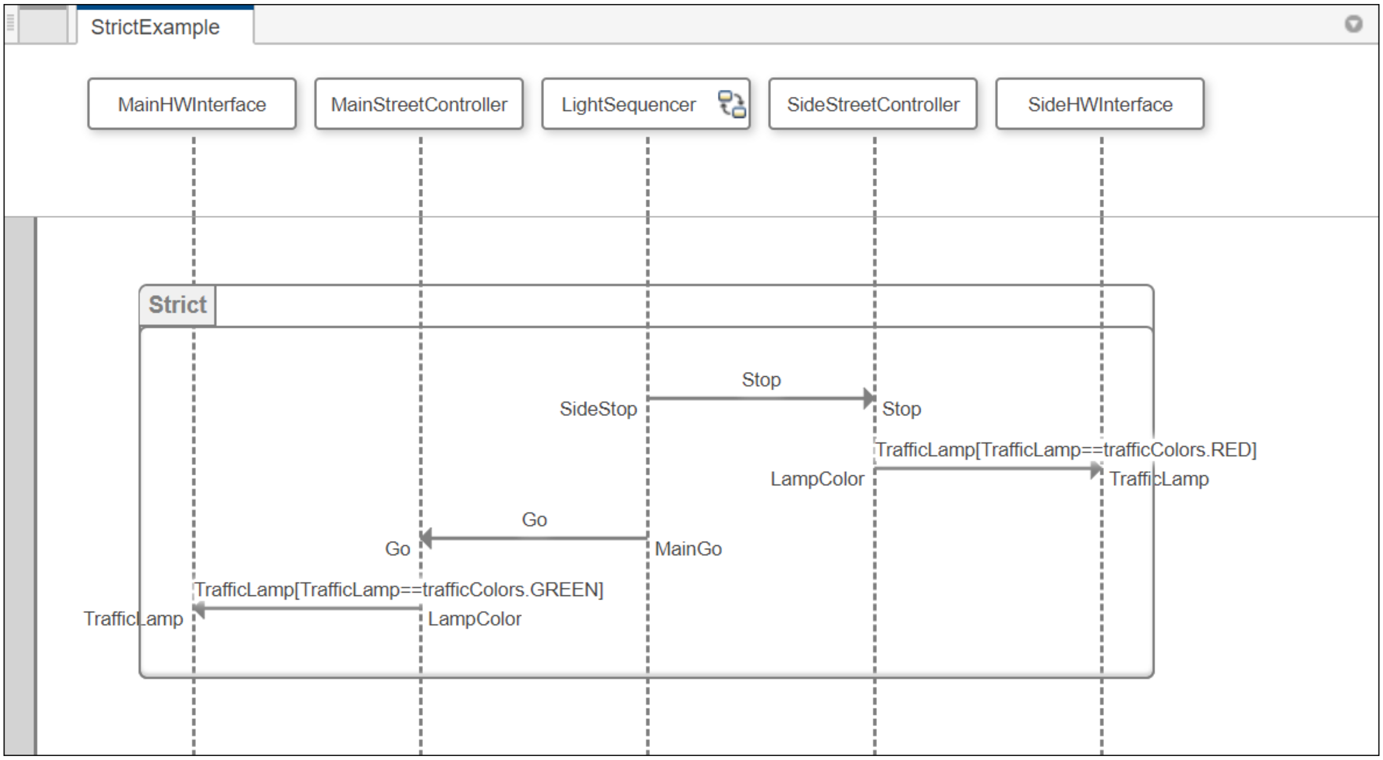


This sequence diagram specifies that after the `sensor` signal from its hardware interface rises through `1`, the `MainStreetController` sends a `PedButtonMain` message to `LightSequencer`, which controls the intersection. `LightSequencer` then tells the hardware interface to turn the pedestrian lamp red, indicating that pedestrians should wait.

Strict Fragment

The `Strict` fragment contains one operand and represents strict sequencing.

Strict sequencing follows the weak sequencing found in a “Seq Fragment” on page 6-30 with the additional constraint that the order of the events in the operand be followed exactly. If messages are sent from the same lifeline, the order is determined by from how far down the lifeline they are sent. Messages are received in the order on the operand regardless of which lifeline receives them.



This sequence diagram is an example of strict sequencing for an intersection controller. The traffic lights on the side street should be set to red before the traffic lights on the main street are set to green. Without strict sequencing, the order in which the street controllers perform their tasks would be undefined.

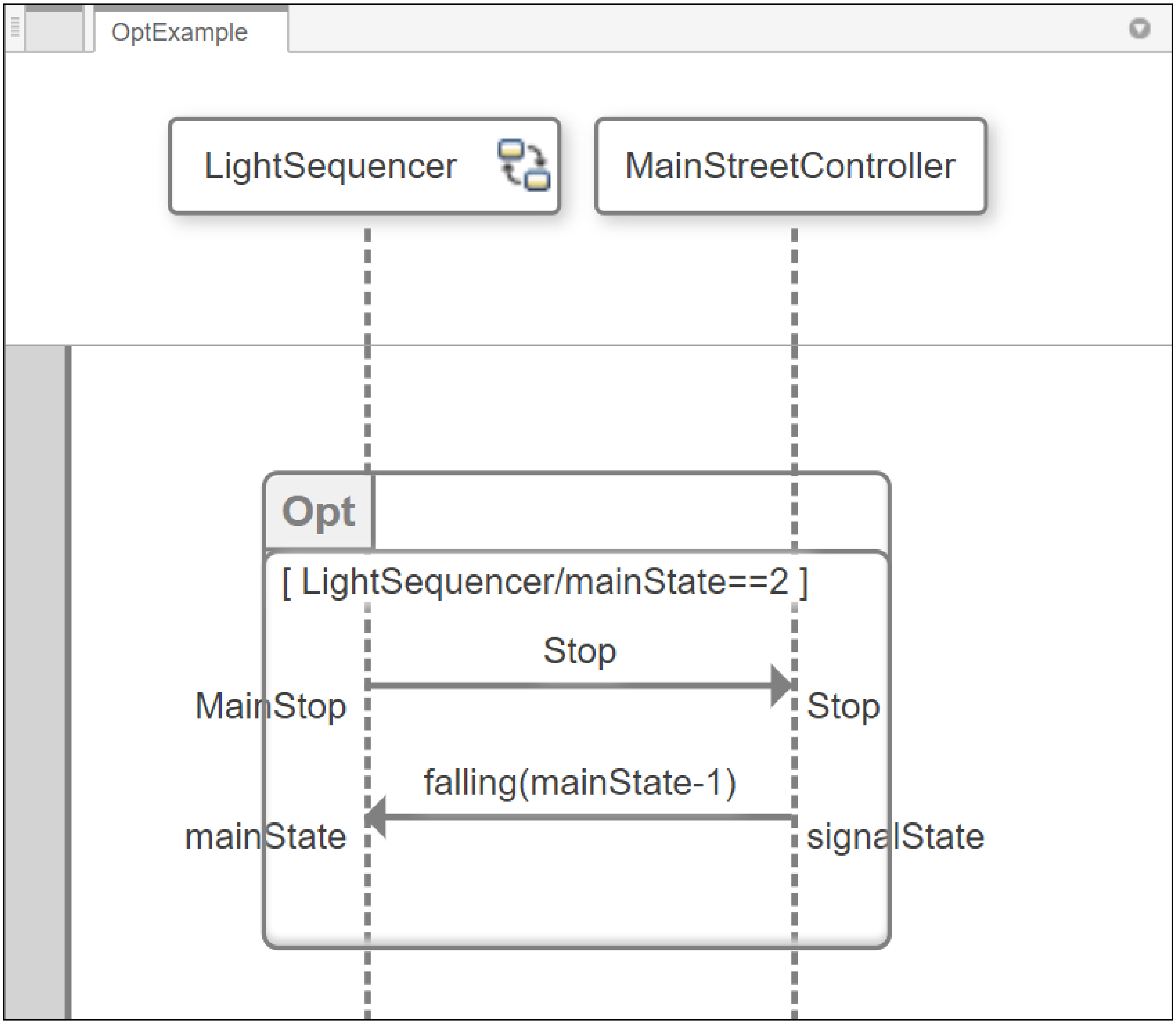
You can use the “Seq Fragment” on page 6-30 for a subset of the messages in a `Strict` fragment if all the messages do not require strict ordering.

Opt Fragment

The `Opt` fragment includes a single operand and indicates that the events described might occur or not. A constraint determines whether the group of messages are valid. If the group of messages are valid, they can execute, otherwise, this fragment is skipped. If no constraint is specified, the messages in the `Opt` fragment are executed only if the messages become valid.

The events in an `Opt` fragment occur if all of these conditions are met:

- The current event is a valid first event for the operand.
- The condition expressed by the operand constraint evaluates to `true`.



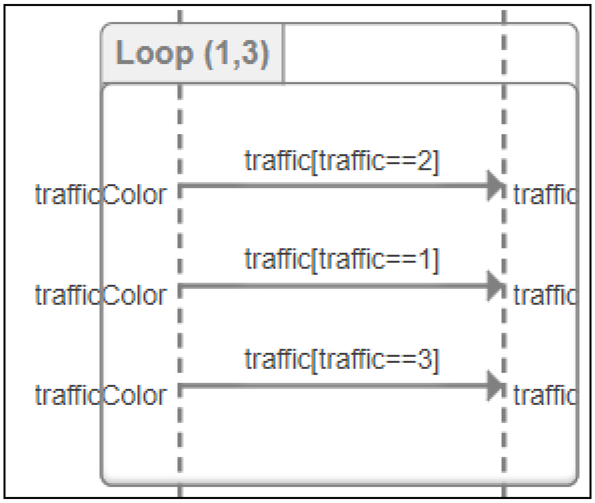
In this sequence diagram, the LightSequencer knows the state of each controller due to the state signal. The LightSequencer issues a Stop command to a controller if it is in the flowing (Green) state, which is indicated by the value 2. The operand in the Opt fragment is executed only if a Stop command is present and its mainState signal has the value 2. After the Stop command, the mainState signal falls to 1, indicating a stopping (Yellow) state.

Loop Fragment

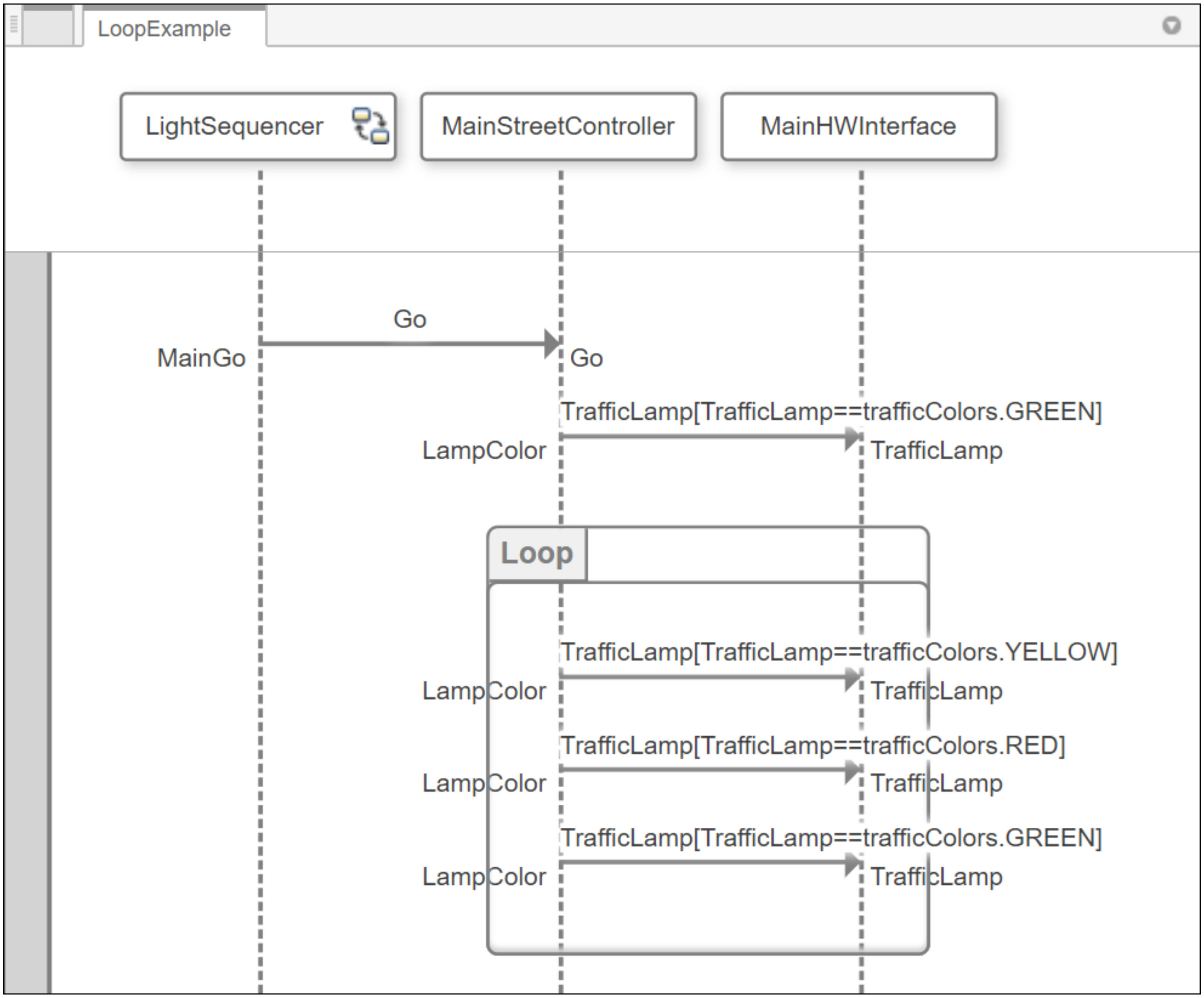
A Loop fragment has a single operand with a constraint and an expression describing the minimum (lower bound) and maximum (upper bound) number of times that the operand repeats. The upper bound can be *, indicating that there is no maximum. The lower bound can be 0, indicating that the operand is optional. The default is a lower bound of 0 and an upper bound of *. With the default lower and upper bounds, the Loop fragment repeats a certain number of times according to the simulation time or the lower and upper bounds of the architecture model.

The single operand in the Loop fragment repeats if all of these conditions are met:

- The current event is a valid first event for the operand.
- The condition expressed by the operand constraint evaluates to true.
- The number of iterations is less than or equal to the upper bound.



The lower bound (1) is the minimum number of iterations of the loop. The upper bound (3) is the maximum. You can also define a constraint on a Loop fragment operand that determines whether the loop executes. When the Boolean expression is false, the loop is skipped.


LoopExample
LightSequencer
MainStreetController
MainHWInterface
Go
MainGo
Go
TrafficLamp[TrafficLamp==trafficColors.GREEN]
LampColor
TrafficLamp
Loop
TrafficLamp[TrafficLamp==trafficColors.YELLOW]
LampColor
TrafficLamp
TrafficLamp[TrafficLamp==trafficColors.RED]
LampColor
TrafficLamp
TrafficLamp[TrafficLamp==trafficColors.GREEN]
LampColor
TrafficLamp

This sequence diagram describes the default cycle of the main street traffic lamps. The `LightSequencer` issues a `Go` command so that the `MainStreetController` tells the `MainHWInterface` to turn the green lamps on. The controller then cycles the lights repeatedly through yellow, red, and green lamps, as indicated by the `Loop` fragment. The lower and upper bounds of the loop fragment are the default values of `0` and `*`, respectively, indicating that it allows any number of iterations.

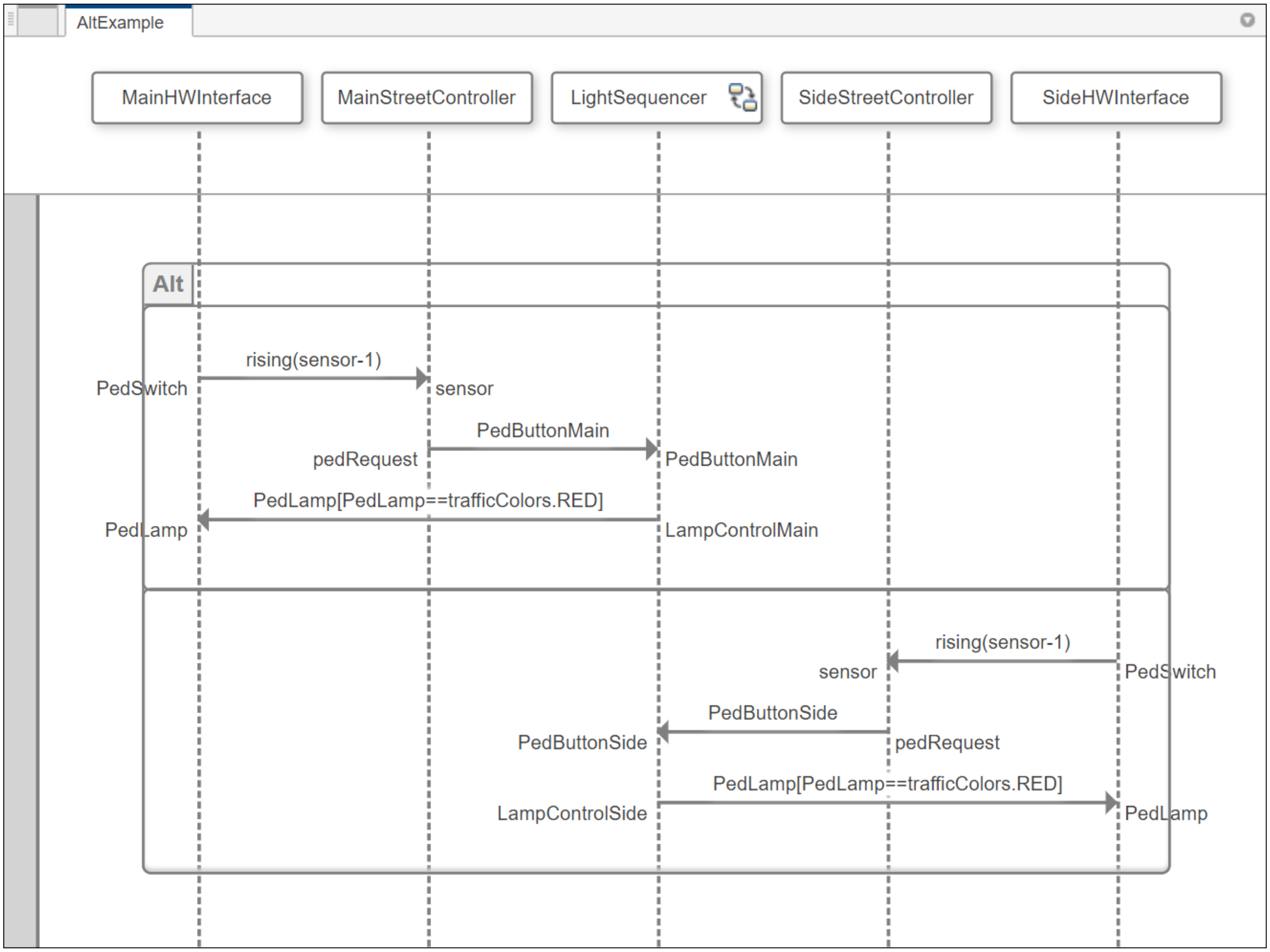
Alt Fragment

The `Alt` fragment is like an “Opt Fragment” on page 6-32 except that it has two or more operands, each describing a different message order.

The events for each operand in an `Alt` fragment occur if all of these conditions are met:

- The current event is a valid first event for the operand.

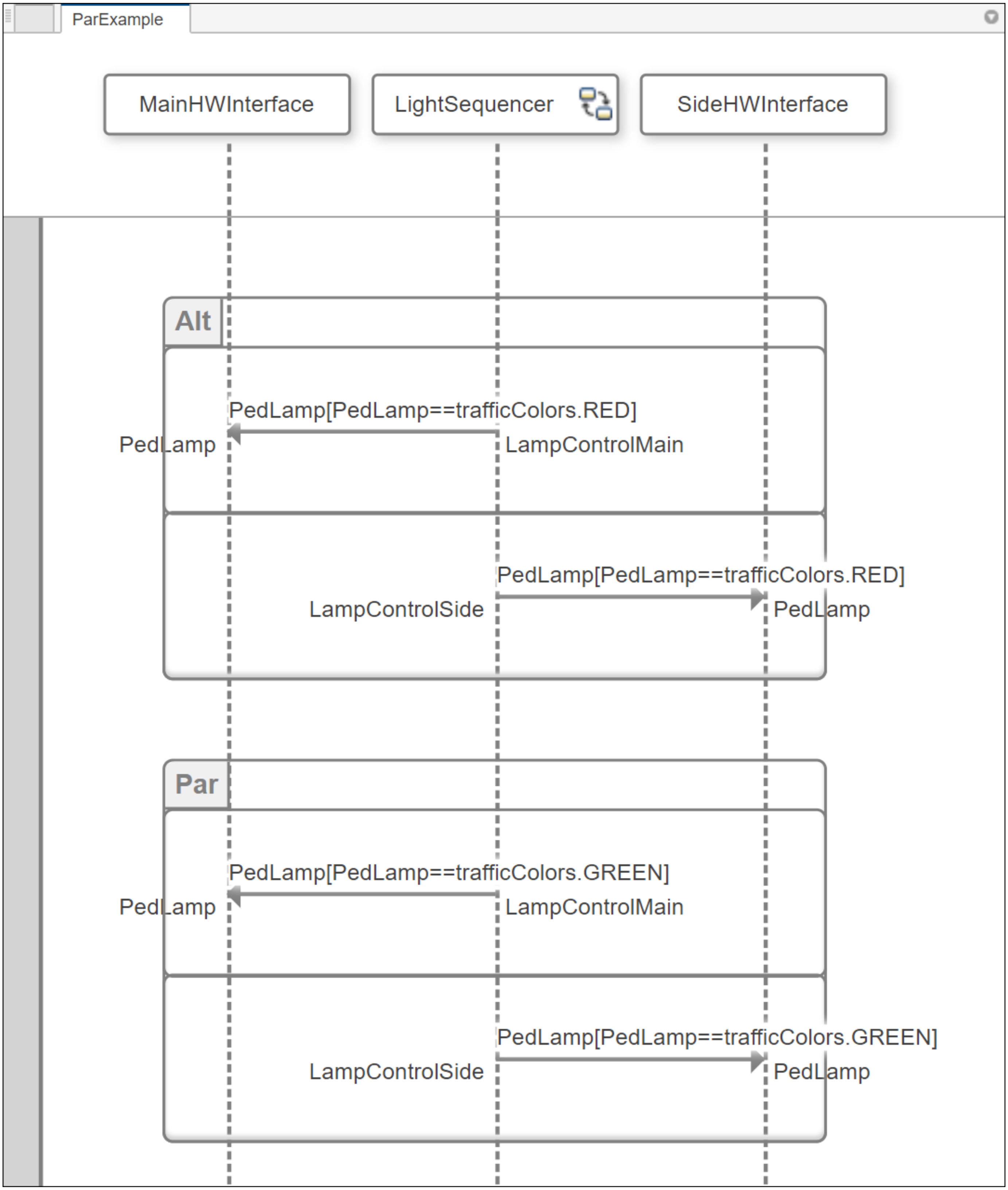
- The condition expressed by the operand constraint evaluates to `true`.



This sequence diagram shows that there are crossing buttons on the main street and the side street and either may be pressed. For a description of the first operand, see the sequence diagram for the “Seq Fragment” on page 6-30.

Par Fragment

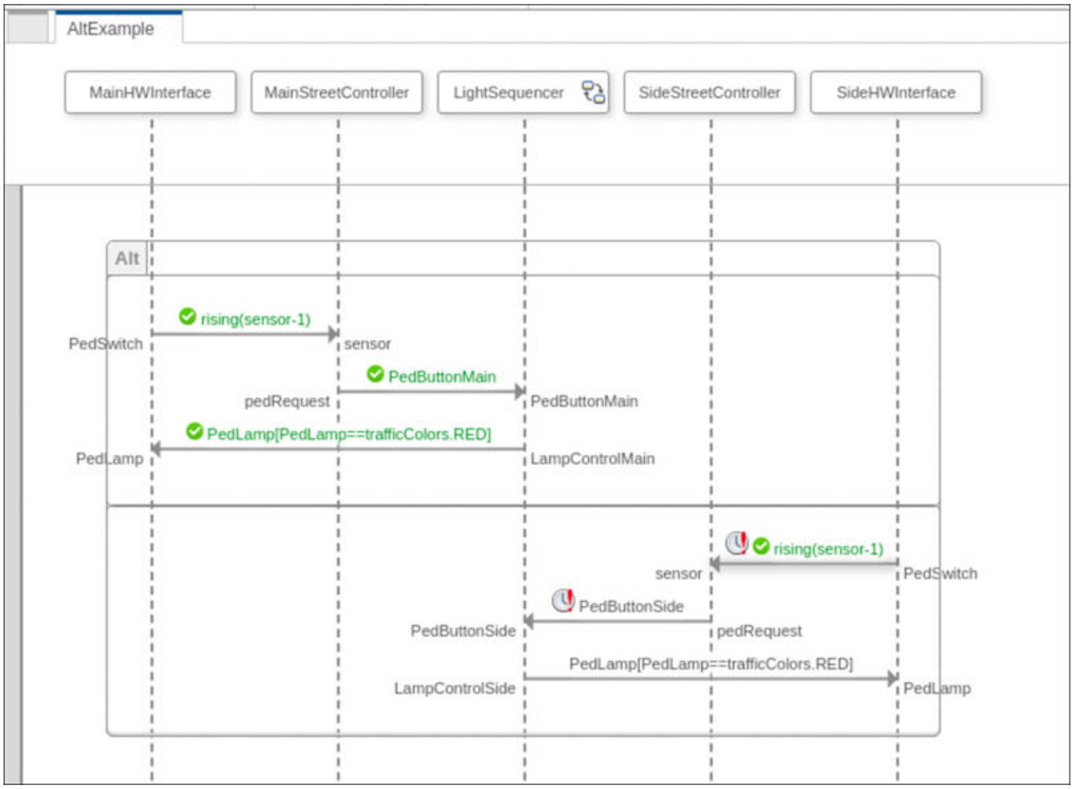
`Par` stands for parallel. A `Par` fragment can have two or more operands. In a `Par` fragment, the order of events in each operand is enforced, but there is no constraint on the order of events in different operands. You should use `Par` fragments wherever order between messages is not important because this fragment imposes few constraints on system design.


ParExample
MainHWInterface
LightSequencer
SideHWInterface
Alt
PedLamp[PedLamp==trafficColors.RED]
PedLamp
LampControlMain
PedLamp[PedLamp==trafficColors.RED]
LampControlSide
PedLamp
Par
PedLamp[PedLamp==trafficColors.GREEN]
PedLamp
LampControlMain
PedLamp[PedLamp==trafficColors.GREEN]
LampControlSide
PedLamp

No matter which crossing button the pedestrian presses, the controller stops traffic on both streets. This sequence diagram specifies this state using an `Alt` fragment for the red lamp color. The green light that indicates safety in crossing, is shown on both streets. The `Par` fragment indicates that both the main and side streets show the green color, but order does not matter.

Messages with Ambiguous Order

Due to the nature of signal semantics in block diagrams, predicting the ordering between signal edges and other events that occur in the same simulation step can be difficult. Signal edges are where a signal value passes through a threshold indicated by the rising, falling, or crossing keywords. Small changes to the architecture model can change the order of signal events represented by sequence diagrams. When a signal edge occurs in the same simulation step as another event, both messages are marked with an ⏱ symbol . You can examine both the sequence diagram and underlying architecture model for potential ambiguity.



To specify that these messages may occur in any order within the same time step, place each message in separate operands of a “Par Fragment” on page 6-36. The simulation interprets these messages to occur in any order. Alternatively, change the behavior of the underlying system so these events happen on different time steps.

See Also

More About

- “Describe System Behavior Using Sequence Diagrams” on page 6-2
- “Implement Component Behavior Using Simulink” on page 7-2
- “Implement Component Behavior Using Stateflow Charts” on page 7-14
- “Implement Component Behavior Using Simscape” on page 7-23
- “Define Port Interfaces Between Components” on page 3-2

Synchronize Sequence Diagrams and Architecture Models

This example shows how to maintain consistency between sequence diagrams and an architecture model.

Open the model.

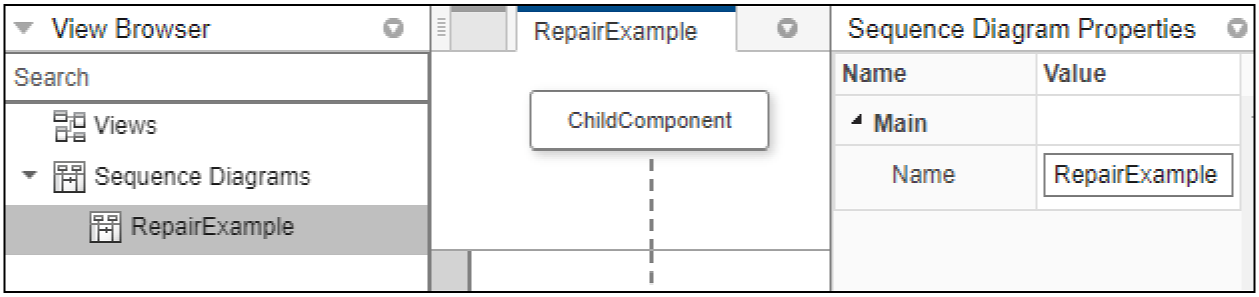
```
model = systemcomposer.openModel("mRetargetElements");
```

Open the Architecture Views Gallery.

```
openViews(model)
```

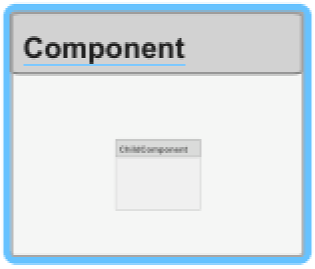
Pull Changes from Architecture Model to Sequence Diagram

1. In the **View Browser**, select the `RepairExample` sequence diagram. Inspect the lifeline named `ChildComponent`.

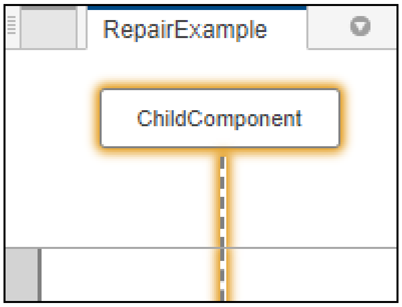


Name	Value
Main	
Name	RepairExample

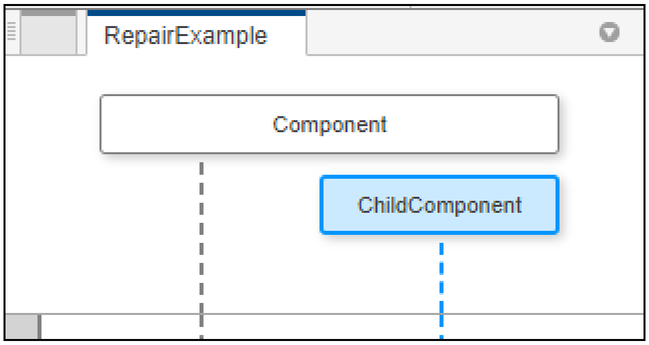
2. Return to the model canvas. Marquee select the `ChildComponent` component. Pause on the ellipses (...) menu and select `Create Subsystem`. Specify the name of the new component as `Component`. The `ChildComponent` component is now the child of the `Component` component.



3. Click **Check Consistency** on the sequence diagram `RepairExample`. The sequence diagram has become inconsistent and the `ChildComponent` lifeline is highlighted because it is no longer at the root level of the diagram.

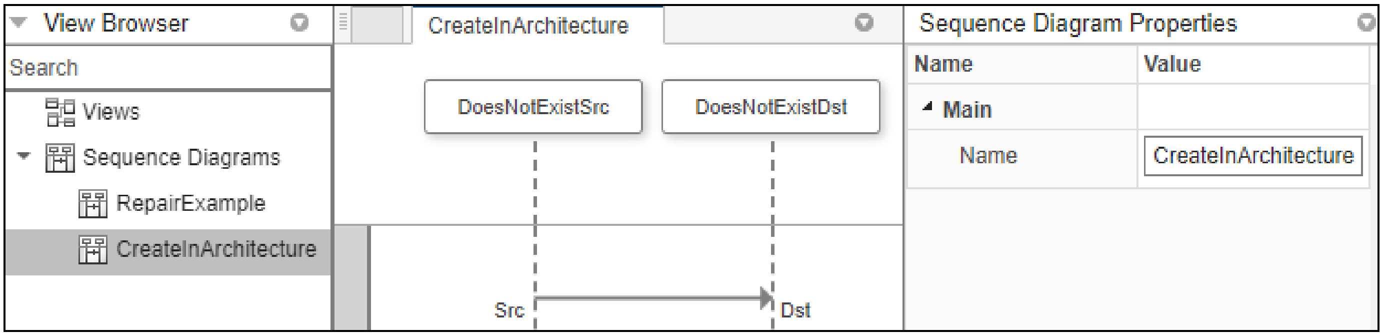


4. Select the `ChildComponent` lifeline and, on the toolstrip, click **Repair**. The sequence diagram `RepairExample` is updated after changes are pulled from the architecture model `mRetargetElements`.



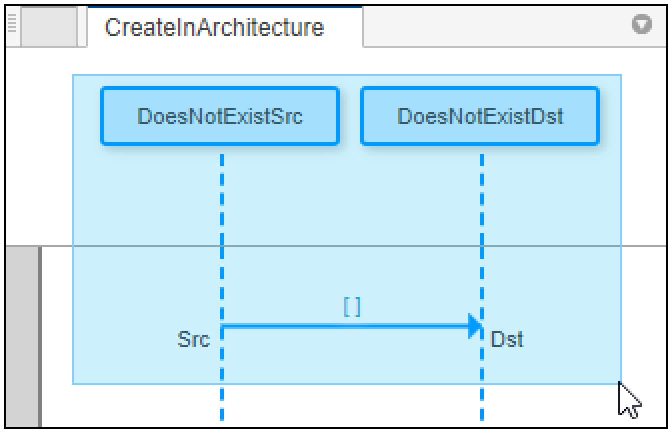
Push Changes from Sequence Diagram to Architecture Model

1. In the **View Browser**, select the `CreateInArchitecture` sequence diagram.

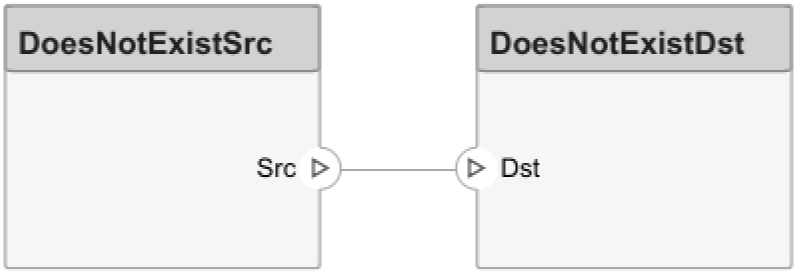


Name	Value
Main	
Name	CreateInArchitecture

2. Marquee select the contents of the sequence diagram, including the two lifelines and the message.

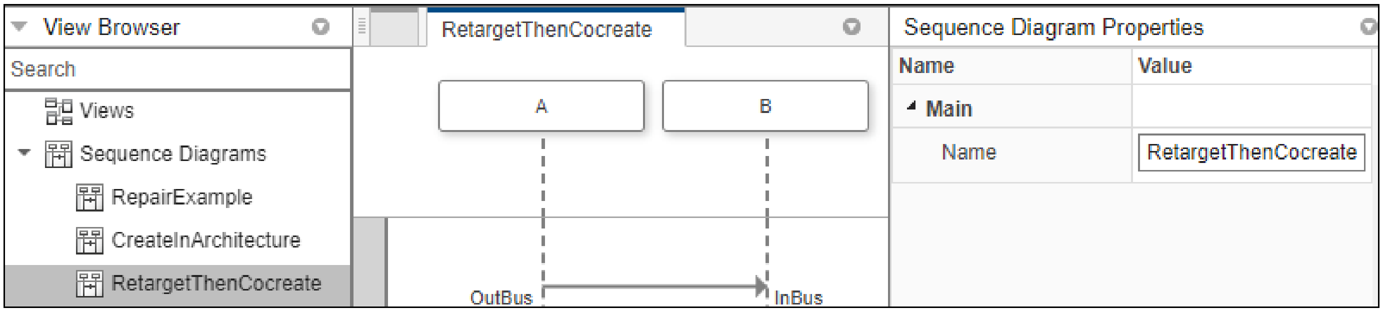


3. In the toolstrip, click **Create in Architecture**. The architecture model `mRetargetElements` is updated after changes are pushed from the sequence diagram.



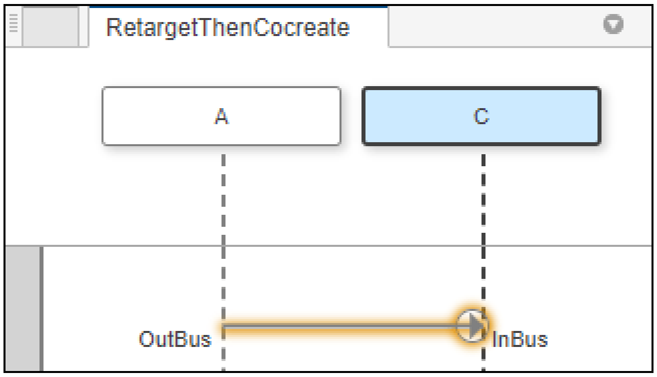
Retarget Lifeline and Create New Connection in Architecture Model

1. In the **View Browser**, select the `RetargetThenCocreate` sequence diagram.

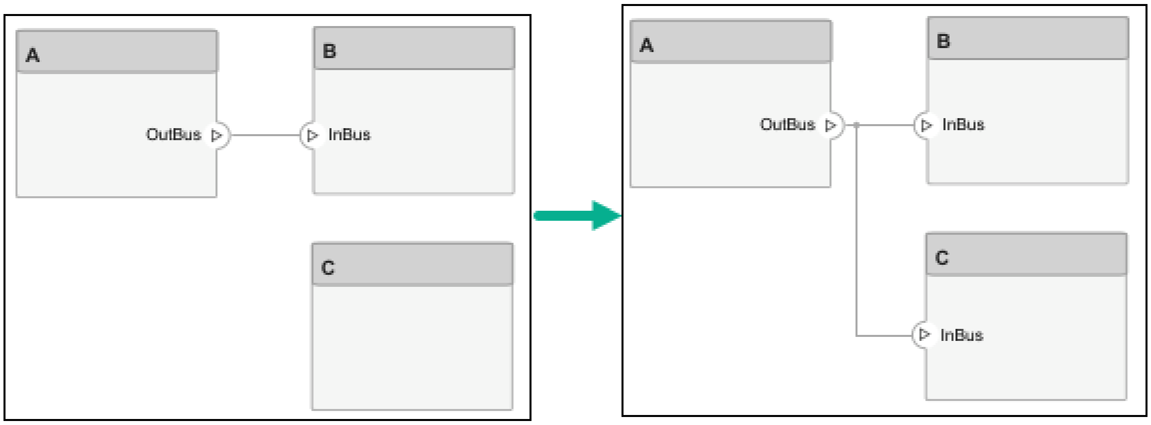


Name	Value
Main	
Name	RetargetThenCocreate

2. Select the `B` lifeline on the sequence diagram and, from the **Architecture Element** menu, select `C` from the list. The sequence diagram becomes inconsistent, and the message is highlighted.



3. Select the message and, in the toolstrip, click **Create in Architecture**. A new connection is created in the architecture model `mRetargetElements`.



See Also

More About

- "Describe System Behavior Using Sequence Diagrams" on page 6-2
- "Compose Architectures Visually" on page 1-2
- "Implement Component Behavior Using Simulink" on page 7-2
- "Implement Component Behavior Using Stateflow Charts" on page 7-14

Simulate Sequence Diagrams for Traffic Light Example

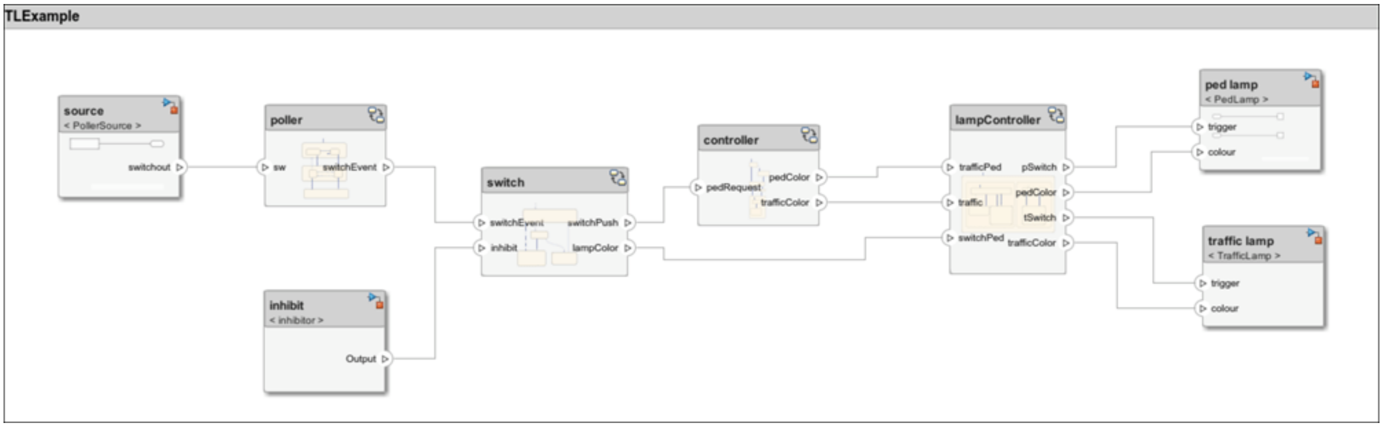
This demonstrates how to simulate a System Composer™ architecture model of a traffic light and verify that the model simulation results match the interactions within the sequence diagrams of the model. The example model uses blocks from Stateflow®. If you do not have a Stateflow license, you can open and simulate the model but only make basic changes such as modifying block parameters.

This traffic light example uses sequence diagrams to describe the process of pedestrians crossing an intersection.

1. The traffic signal cycles from red to green to yellow.
2. When the pedestrian crossing button is pressed, if the traffic signal is green, the traffic signal transitions from yellow to red for a limited time.
3. The pedestrians cross while the walk signal is active.

Open the model.

```
model = systemcomposer.openModel("TLExample");
```

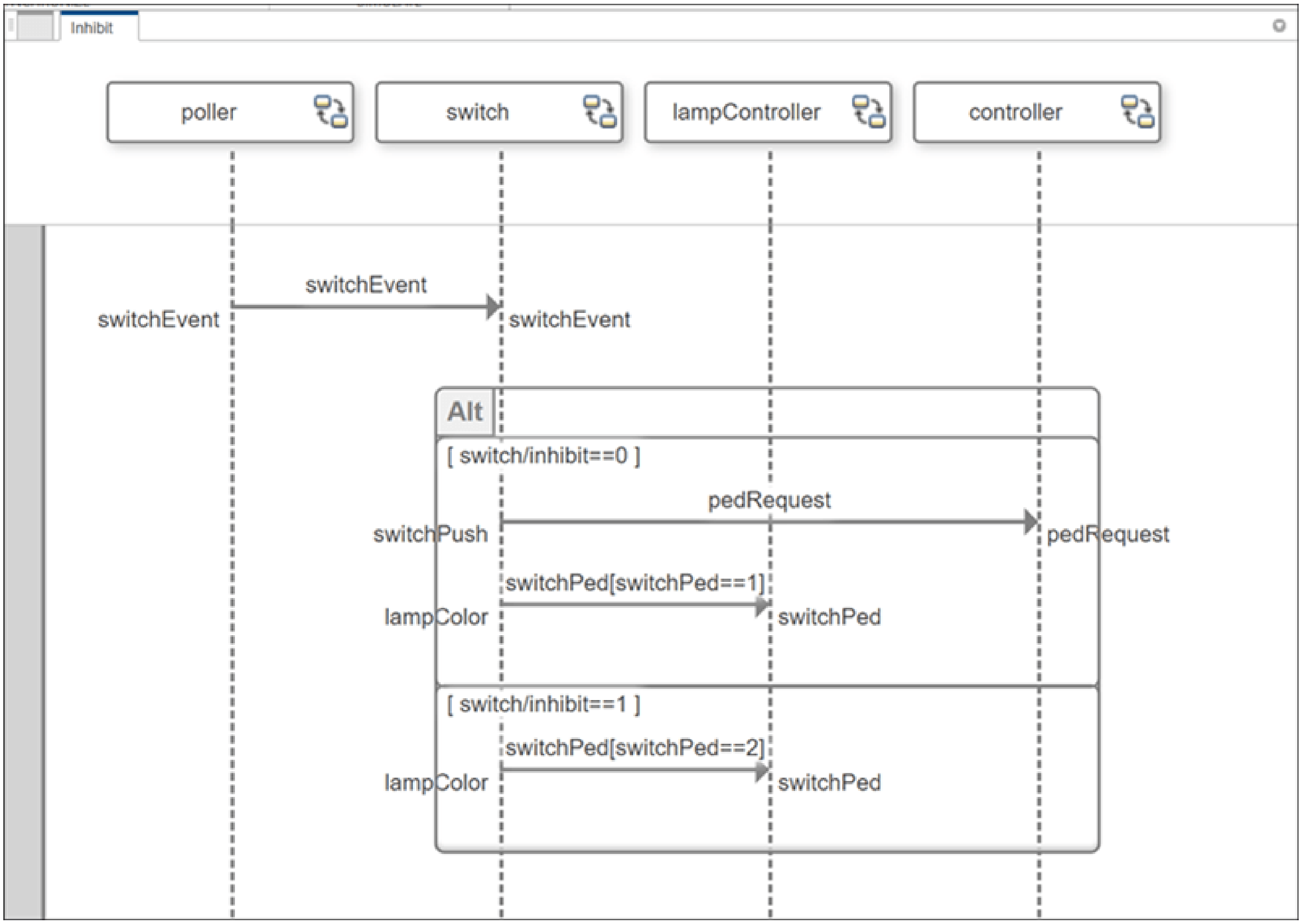


Open the Architecture Views Gallery to view the sequence diagrams.

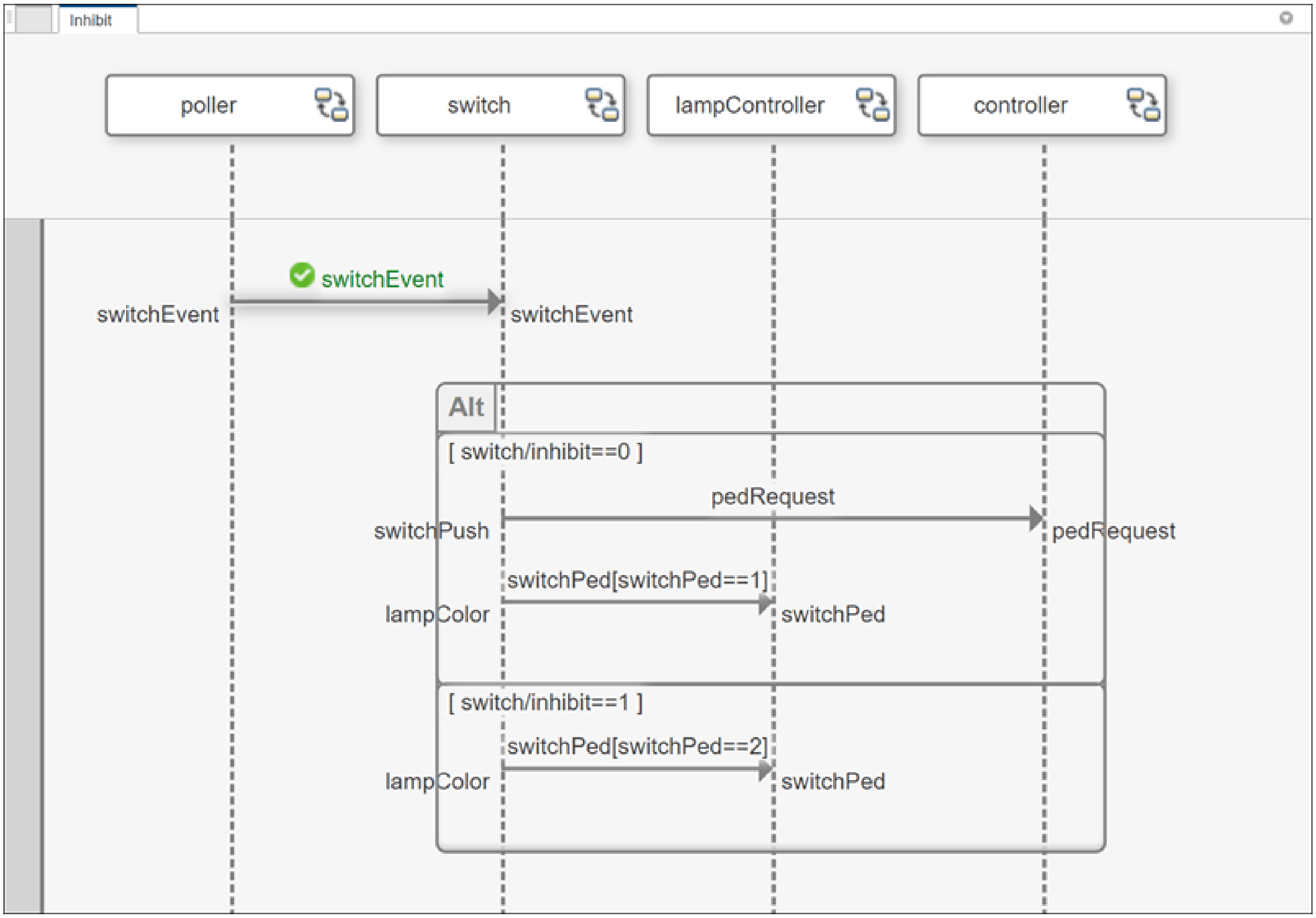
```
openViews(model)
```

Simulate `Inhibit` Sequence Diagram

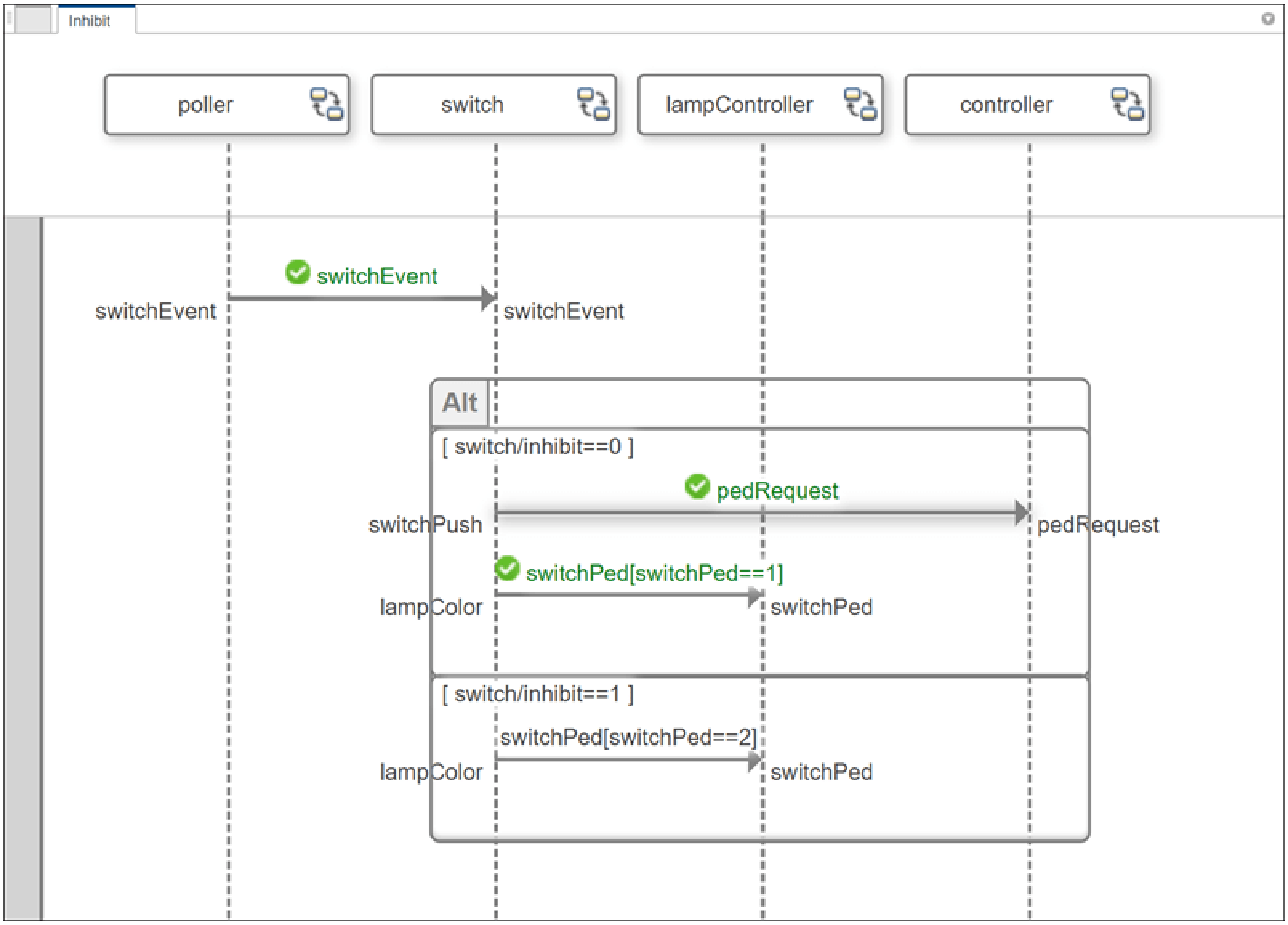
In the **View Browser**, select the `Inhibit` sequence diagram. For more information on how to construct this sequence diagram, see “Author Sequence Diagram for Traffic Light Example” on page 6-4.



To simulate the sequence diagram until the next message, select the **Next Message** option in the toolstrip. When the message event `switchEvent` occurs, the `switch` lifeline activates.



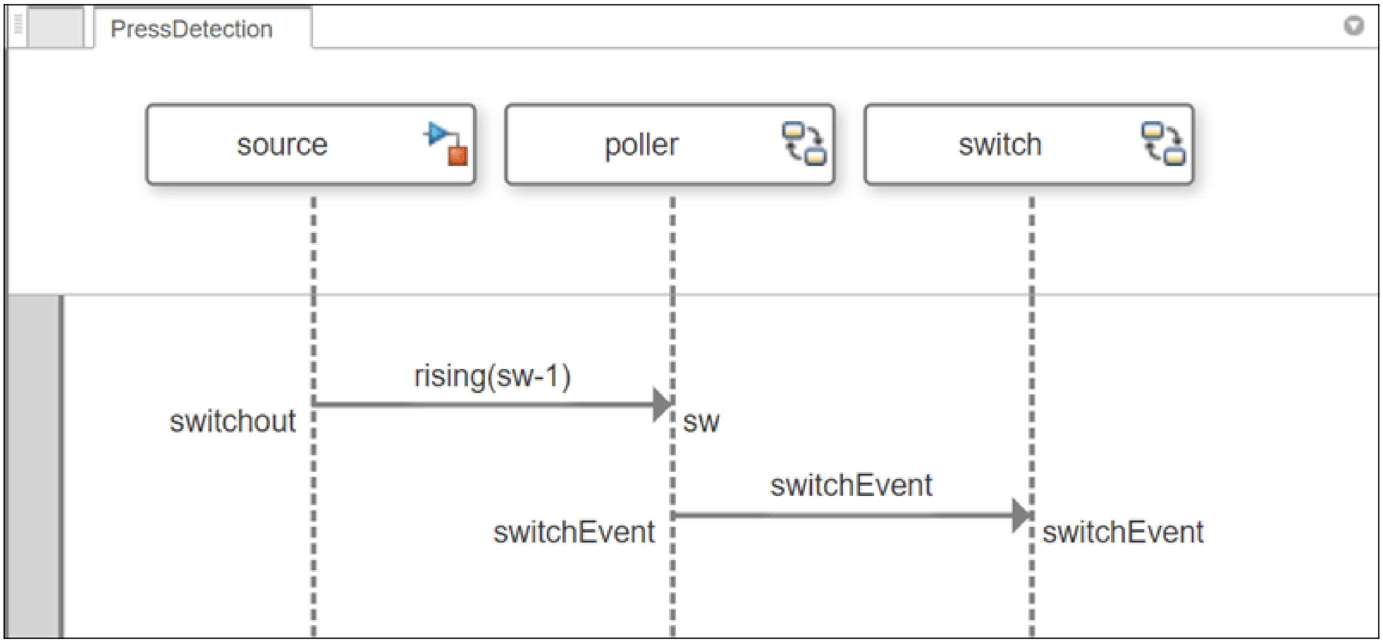
Select **Continue** to continue until the end. Since the `inhibit` flag is equal to 0, the first operand of the `Alt` fragment activates. For more information on the `Alt` fragment, see “Author Sequence Diagram Fragments” on page 6-29. The `switch` lifeline sends a message to the `controller` lifeline to change the traffic lamp via the `lampcontroller` lifeline to stop traffic and allow the pedestrians to cross the intersection.



If the `inhibit` flag is set to 1, the `switch` lifeline bypasses the controller and sends the signal directly to the `lampcontroller` lifeline. This action means that pedestrian crossing is not controlled by a walk signal on this intersection.

Simulate `PressDetection` Sequence Diagram

In the **View Browser**, select the `PressDetection` sequence diagram.

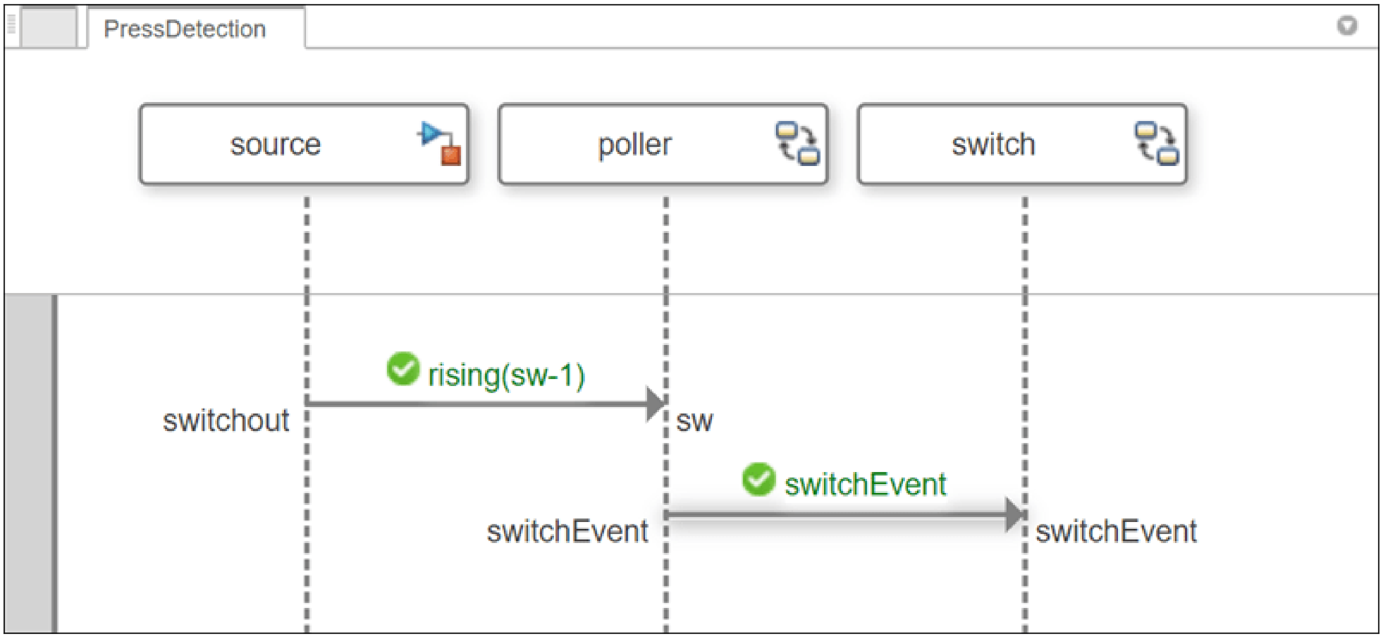


Observe the `PressDetection` sequence diagram during model simulation using a `Simulink.SimulationInput` object for the `sim` function. The `ObservedSequenceDiagrams` model configuration parameter specifies which sequences diagram to observe. Use `sim` to set `ObservedSequenceDiagrams` for just the simulation.

```
simIn = Simulink.SimulationInput("TLExample");
simIn = setModelParameter(simIn,"ObservedSequenceDiagrams","PressDetection","ObservedSequenceDiag
simOut = sim(simIn);
sequenceDiagramOut = simOut.sequenceDiagramOutput
```

```
sequenceDiagramOut = struct with fields:
         Name: 'PressDetection'
    Completed: 1
    NumErrors: 0
```

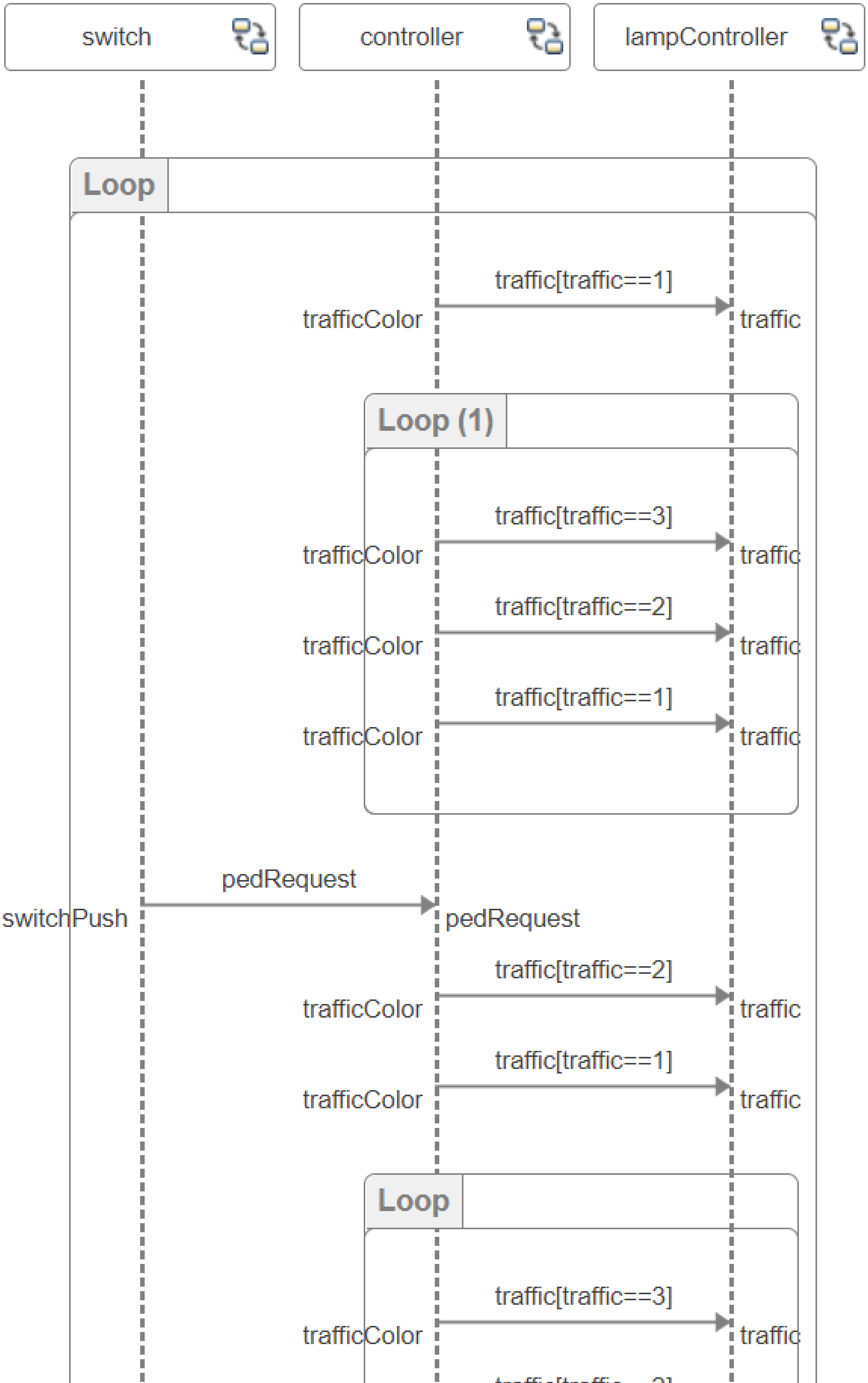
Messages where the conditions are met turn green with a checkmark.



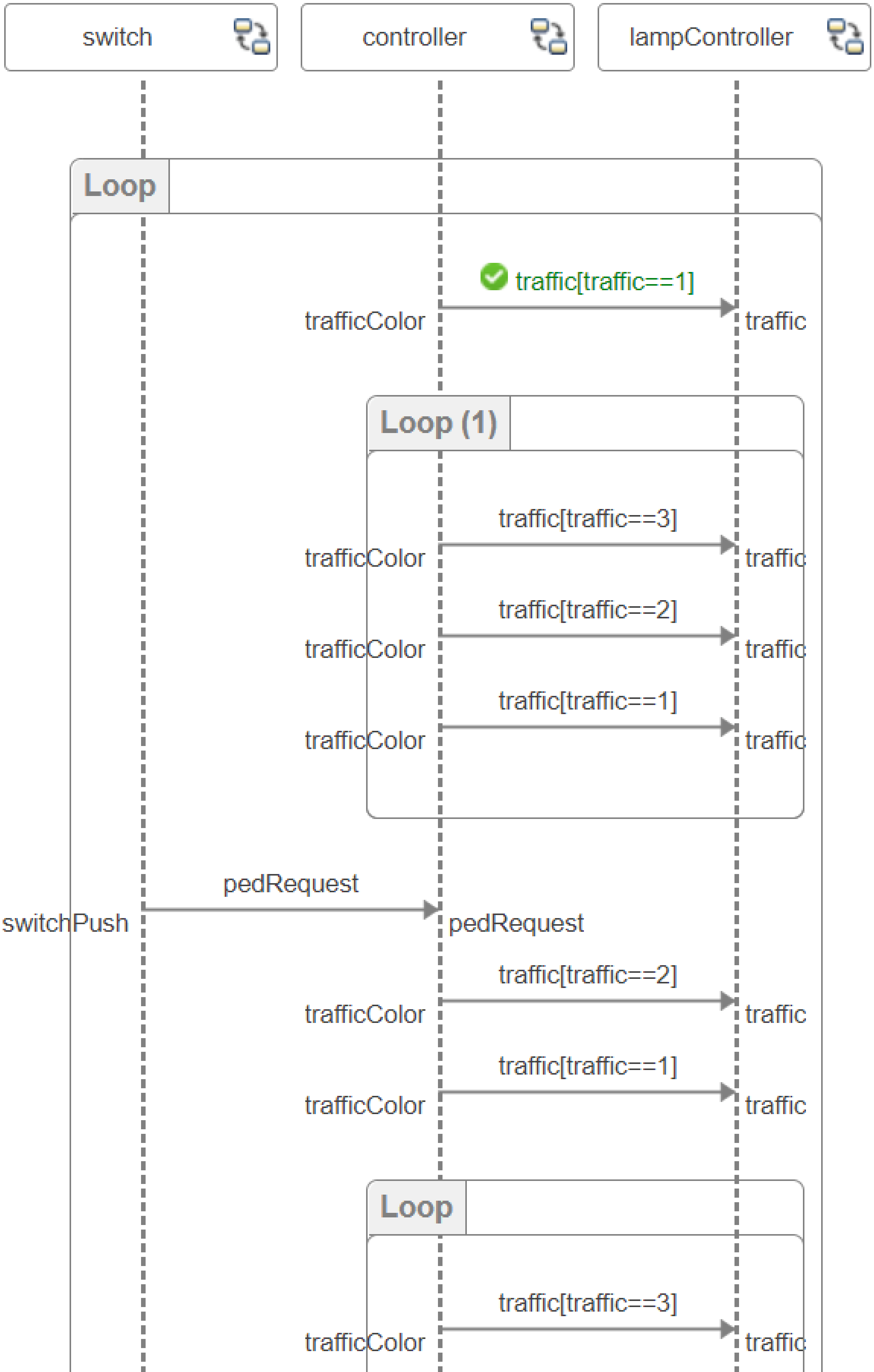
When a pedestrian presses the crossing button, the value of the signal sw rises to 1. When this action happens, the poller lifeline sends the message switchEvent to the switch lifeline. This action alerts the switch lifeline that a pedestrian is waiting so the switch lifeline can alert the controller lifeline. The traffic light then turns red to stop traffic, and the walk signal turns on.

Simulate PedestrianCross Sequence Diagram

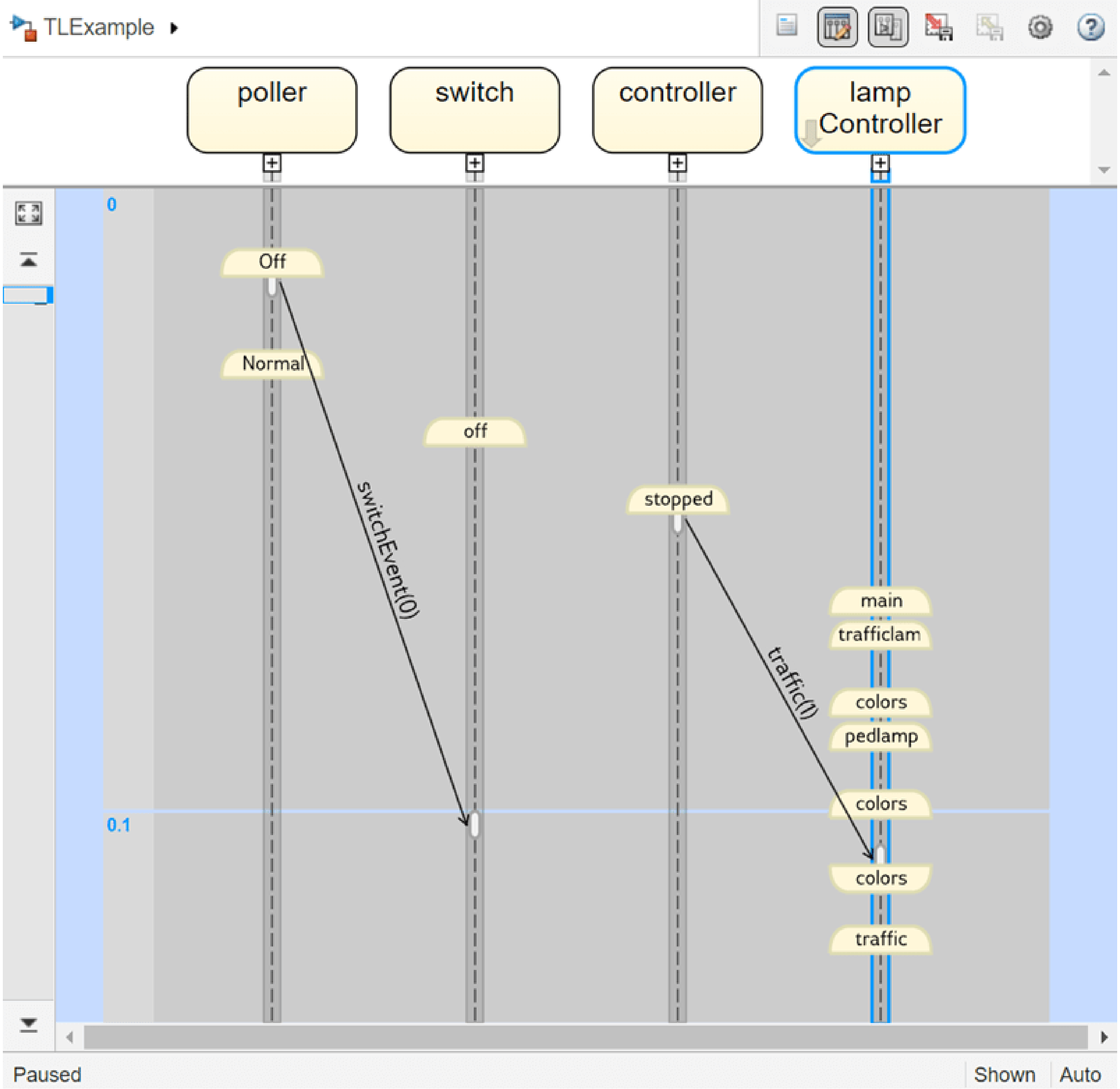
In the **View Browser**, select the PedestrianCross sequence diagram.


switch
controller
lampController
Loop
traffic[traffic==1]
trafficColor
traffic
Loop (1)
traffic[traffic==3]
trafficColor
traffic
traffic[traffic==2]
trafficColor
traffic
traffic[traffic==1]
trafficColor
traffic
pedRequest
switchPush
pedRequest
traffic[traffic==2]
trafficColor
traffic
traffic[traffic==1]
trafficColor
traffic
Loop
traffic[traffic==3]
trafficColor
traffic

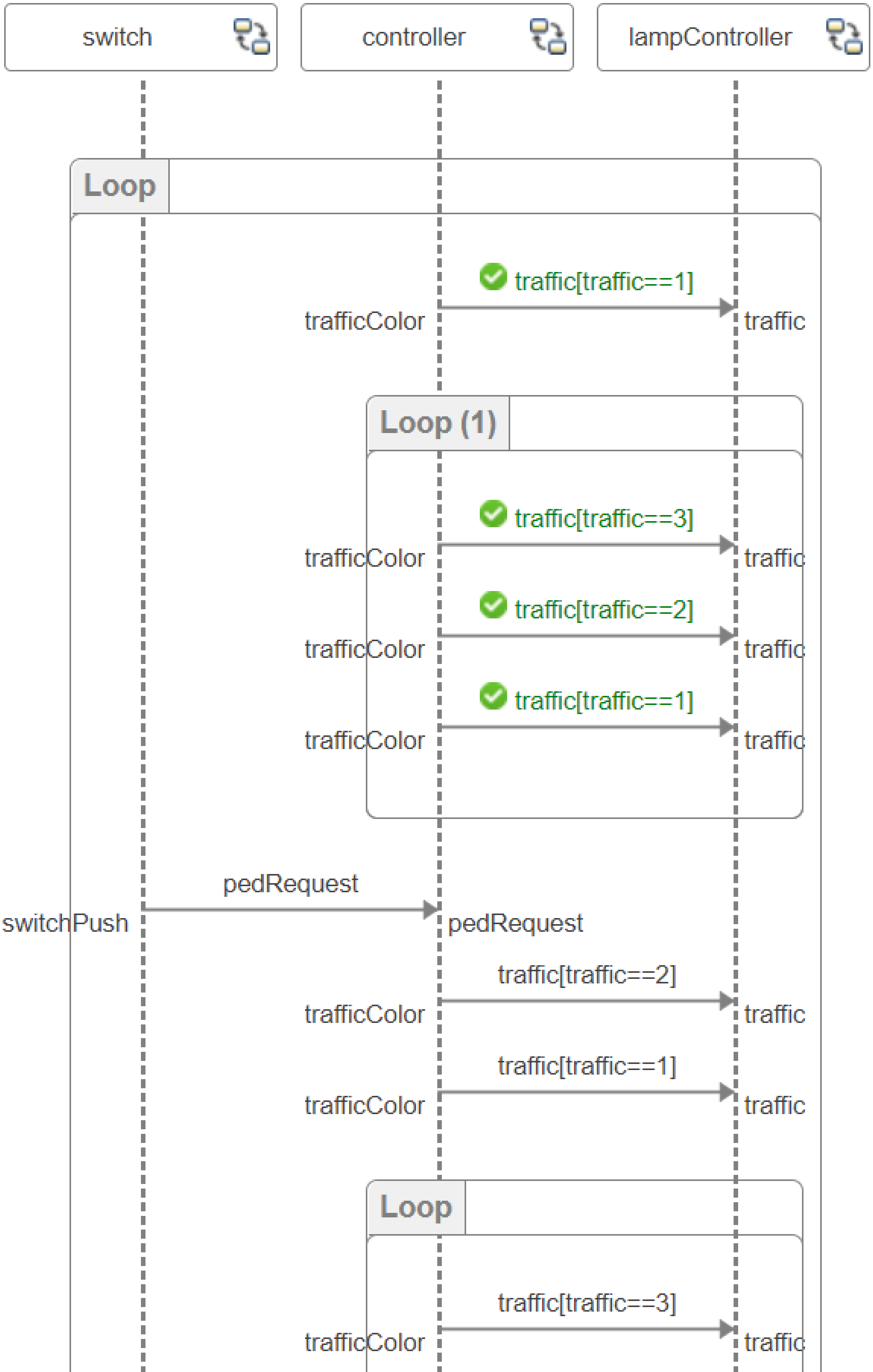
To simulate the sequence diagram until the next message, select the **Next Message** option in the toolstrip. The value of the message `traffic` is `1`, which indicates that the traffic light color is red.


switch
controller
lampController
Loop
traffic[traffic==1]
trafficColor
traffic
Loop (1)
traffic[traffic==3]
trafficColor
traffic
traffic[traffic==2]
trafficColor
traffic
traffic[traffic==1]
trafficColor
traffic
pedRequest
switchPush
pedRequest
traffic[traffic==2]
trafficColor
traffic
traffic[traffic==1]
trafficColor
traffic
Loop
traffic[traffic==3]
trafficColor
traffic

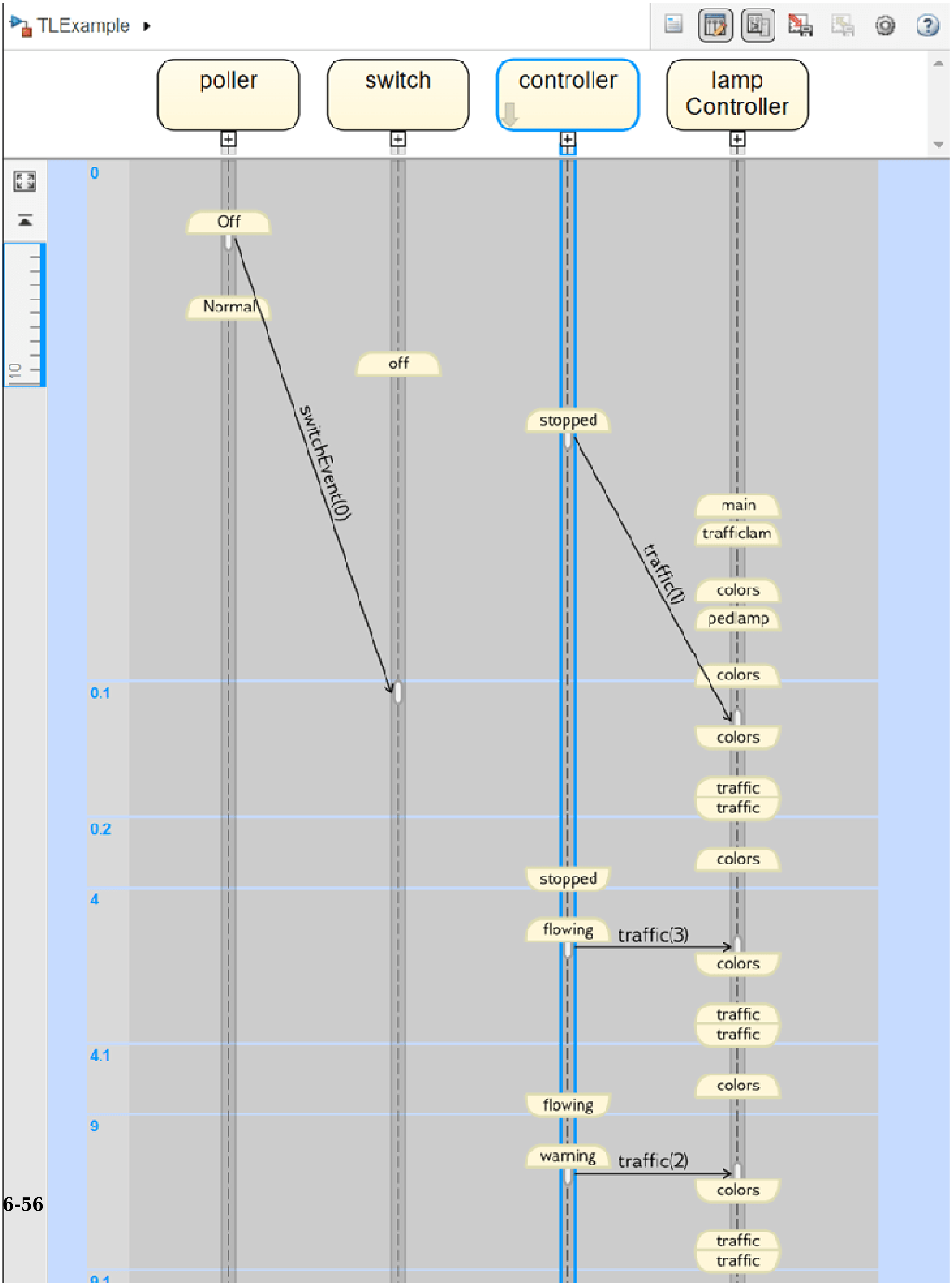
The Sequence Viewer describes the simulation events as they occur in the model as the sequence diagram describes what is expected to occur. On the toolstrip, in the **Simulation** tab, select **Log Events**, then launch the **Sequence Viewer** from the same location. See that the simulation pauses when `traffic` is 1.



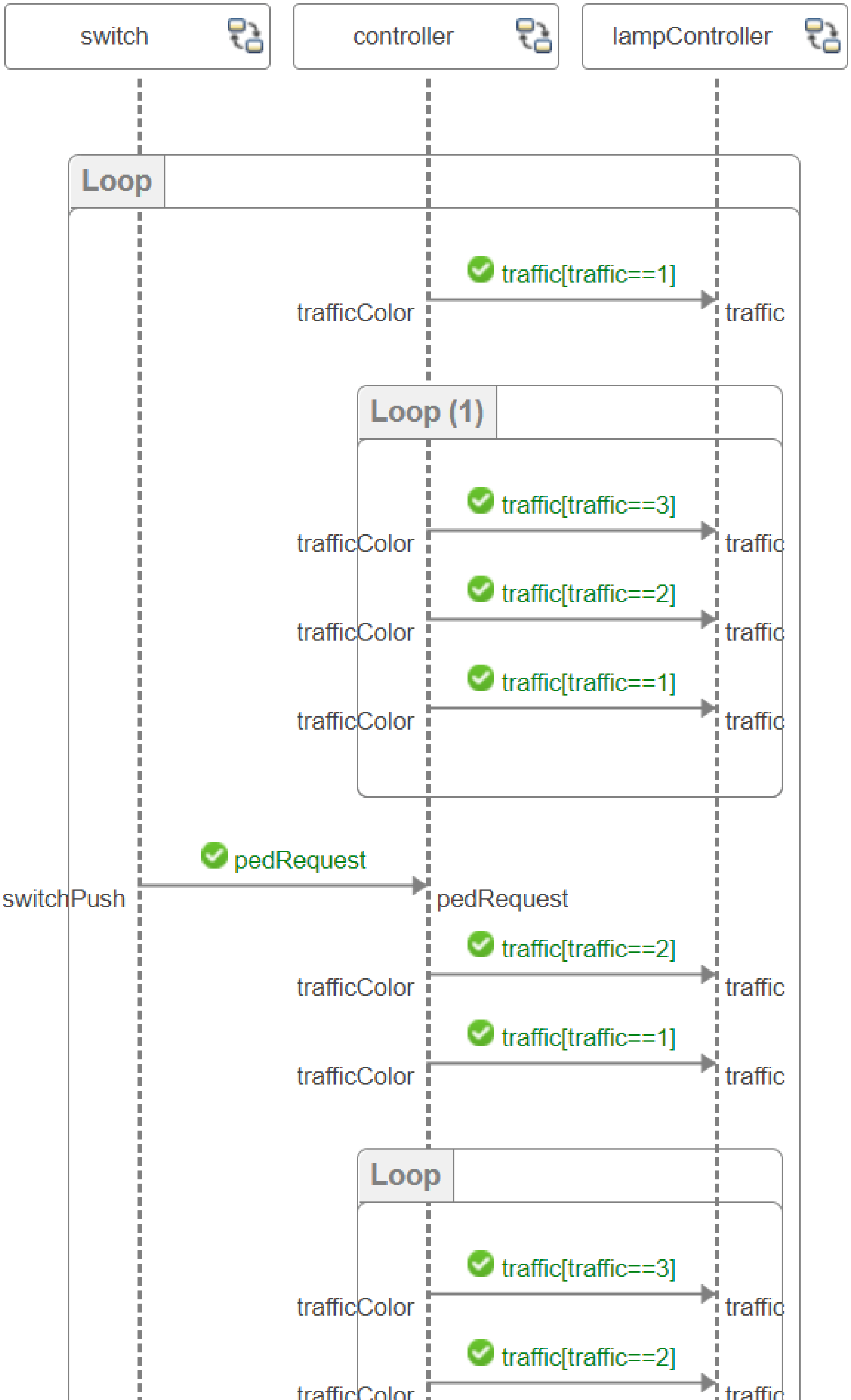
Select **Next Message** three more times to simulate until the traffic light completes one loop from green to yellow to red again. For more information on the `Loop` fragment, see “Author Sequence Diagram Fragments” on page 6-29.


switch
controller
lampController
Loop
✓ traffic[traffic==1]
trafficColor
traffic
Loop (1)
✓ traffic[traffic==3]
trafficColor
traffic
✓ traffic[traffic==2]
trafficColor
traffic
✓ traffic[traffic==1]
trafficColor
traffic
pedRequest
switchPush
pedRequest
traffic[traffic==2]
trafficColor
traffic
traffic[traffic==1]
trafficColor
traffic
Loop
traffic[traffic==3]
trafficColor
traffic

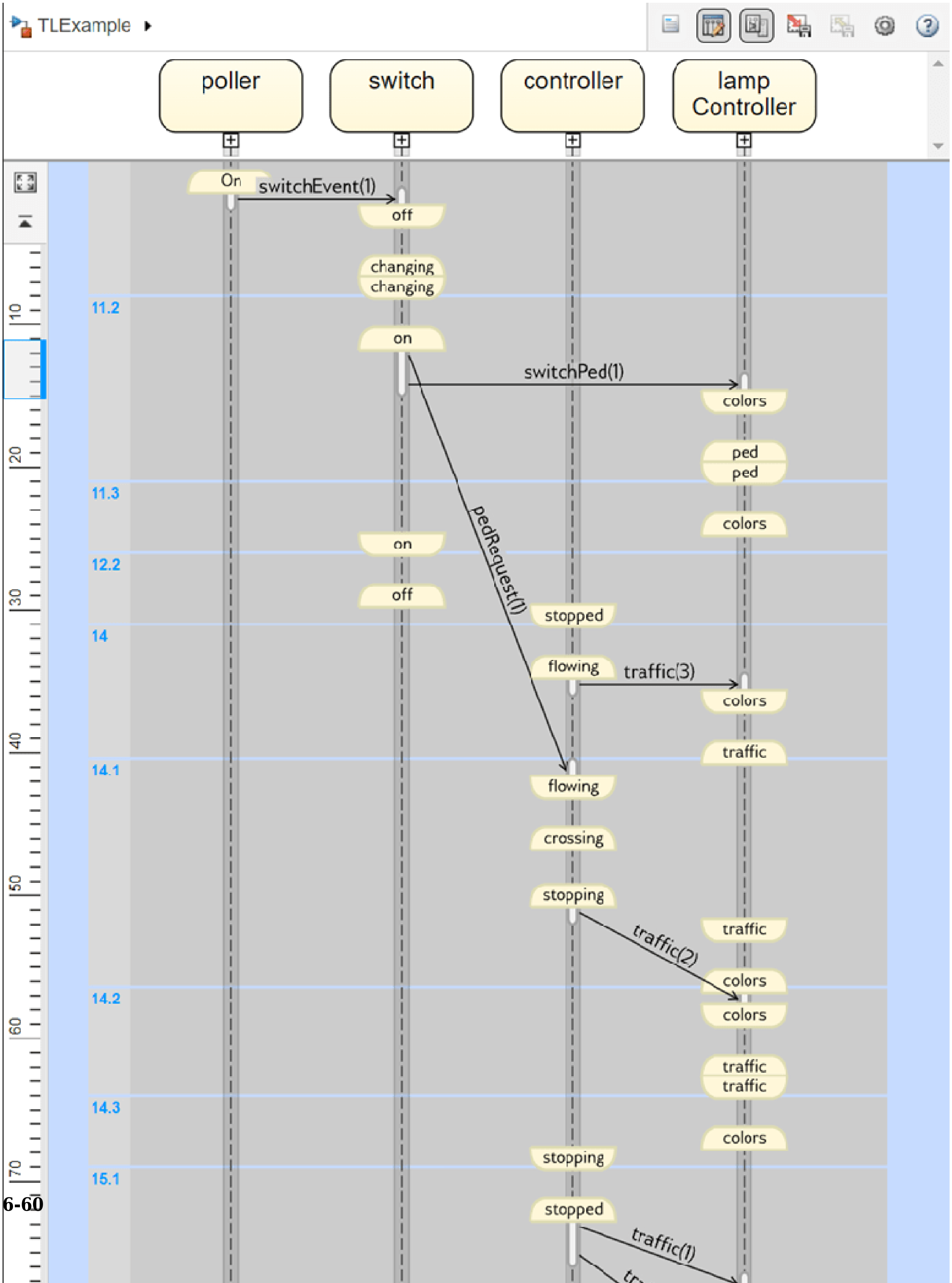
View the corresponding message events in the Sequence Viewer.


TLExample
poller
switch
controller
lamp Controller
0
Off
Normal
off
stopped
switchEvent(0)
traffic(1)
main
trafficlam
colors
pedlamp
colors
0.1
colors
traffic
traffic
0.2
colors
stopped
4
flowing
traffic(3)
colors
traffic
traffic
4.1
colors
flowing
9
warning
traffic(2)
colors
traffic
traffic
9.1
10

Select **Continue** to continue until the end. The pedestrian crossing signal allows the pedestrians cross by turning the traffic light red. Then, the traffic light continues its cycle.

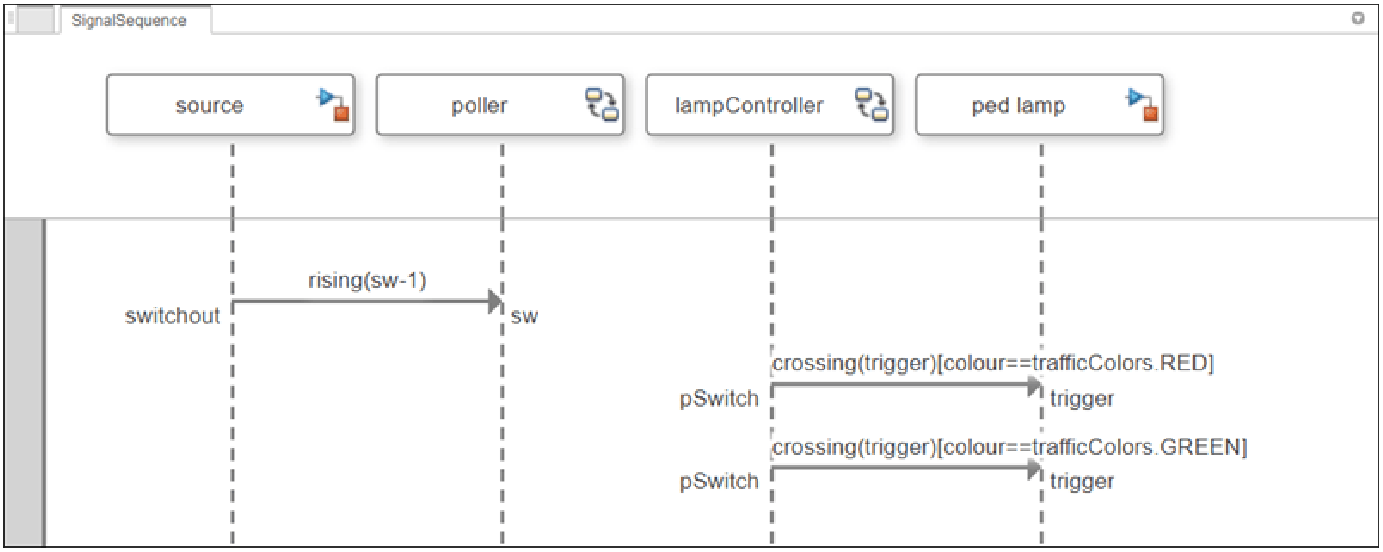

switch
controller
lampController
Loop
traffic[traffic==1]
trafficColor
traffic
Loop (1)
traffic[traffic==3]
trafficColor
traffic
traffic[traffic==2]
trafficColor
traffic
traffic[traffic==1]
trafficColor
traffic
pedRequest
switchPush
pedRequest
traffic[traffic==2]
trafficColor
traffic
traffic[traffic==1]
trafficColor
traffic
Loop
traffic[traffic==3]
trafficColor
traffic
traffic[traffic==2]
trafficColor
traffic

View the corresponding message events for the pedestrian crossing messages in the Sequence Viewer.

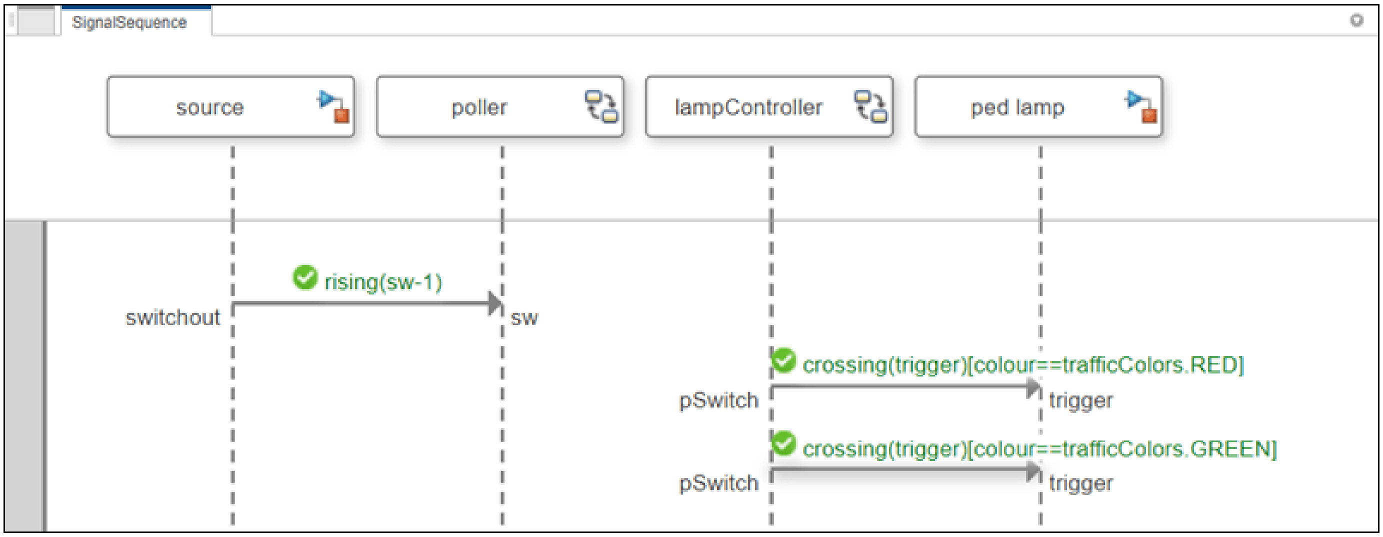

TLExample
poller
switch
controller
lamp Controller
On
switchEvent(1)
off
changing
changing
11.2
on
switchPed(1)
colors
ped
ped
11.3
colors
on
12.2
off
pedRequest(1)
stopped
14
flowing
traffic(3)
colors
traffic
14.1
flowing
crossing
stopping
traffic
traffic(2)
colors
14.2
colors
traffic
traffic
14.3
colors
stopping
15.1
stopped
traffic(1)
10
20
30
40
50
60
70

Simulate and Detect Errors with SignalSequence Sequence Diagram

In the **View Browser**, select the SignalSequence sequence diagram.

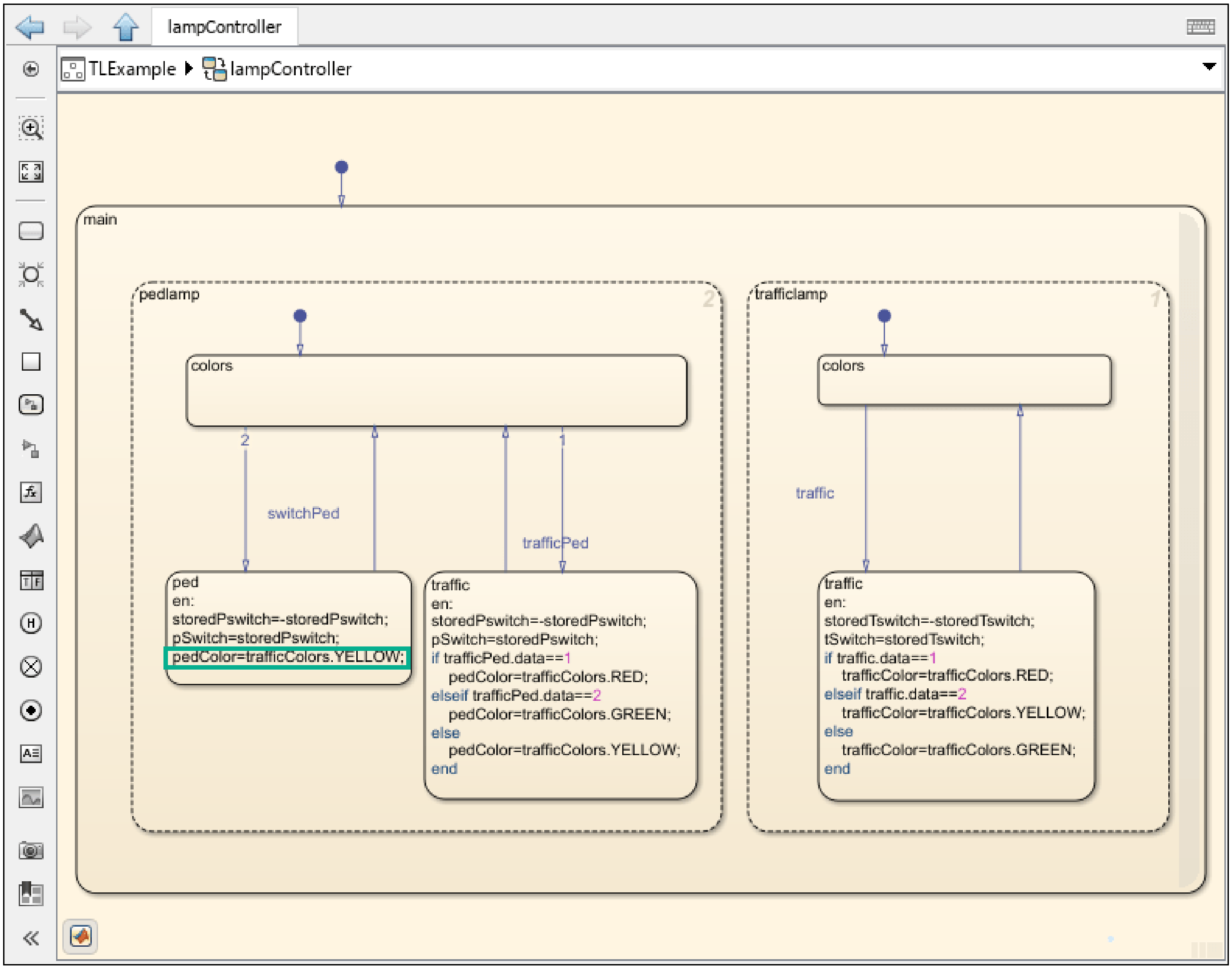


Click **Run** to simulate the sequence diagram to the end. Messages where the conditions are met turn green with a checkmark.



This step requires a Stateflow license.

Return to the TLExample model. Double-click the lampController component to view the state chart. In the ped subchart, introduce an error into model execution by changing pedColor=trafficColors.RED to pedColor=trafficColors.YELLOW. Save the TLExample model.

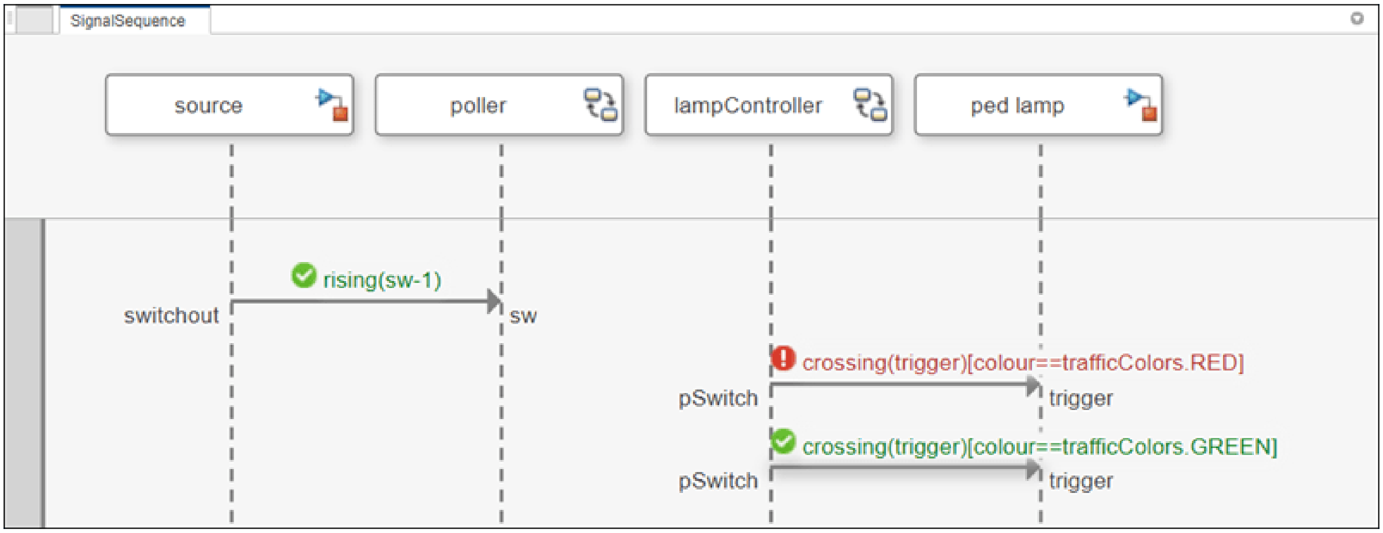


```
ped
en:
storedPswitch=-storedPswitch;
pSwitch=storedPswitch;
pedColor=trafficColors.YELLOW;
```

```
traffic
en:
storedPswitch=-storedPswitch;
pSwitch=storedPswitch;
if trafficPed.data==1
   pedColor=trafficColors.RED;
elseif trafficPed.data==2
   pedColor=trafficColors.GREEN;
else
   pedColor=trafficColors.YELLOW;
end
```

```
traffic
en:
storedTswitch=-storedTswitch;
tSwitch=storedTswitch;
if traffic.data==1
   trafficColor=trafficColors.RED;
elseif traffic.data==2
   trafficColor=trafficColors.YELLOW;
else
   trafficColor=trafficColors.GREEN;
end
```

Return to the **View Browser**. For the `SignalSequence` sequence diagram, click **Clear Results** to clear the green checkmarks and reset sequence diagram simulation. Click **Run** to simulate the `SignalSequence` sequence diagram again.



For the first message from the `lampController` lifeline to the `ped lamp` lifeline, the constraints specified by the sequence diagram are not met by the model execution.

See Also

`sim` | `Simulink.SimulationInput` | `Simulink.SimulationOutput`

More About

- “Describe System Behavior Using Sequence Diagrams” on page 6-2
- “Compose Architectures Visually” on page 1-2
- “Implement Component Behavior Using Simulink” on page 7-2
- “Implement Component Behavior Using Stateflow Charts” on page 7-14

Use Simulink Models with System Composer

Implement Component Behavior Using Simulink

System design and architecture definitions can involve a behavior definition for some components, such as the algorithm for a data processing component. Define components in System Composer architecture models as behaviors using Simulink subsystem components that are part of the parent model, or referenced behaviors by linking components to Simulink models or subsystems.

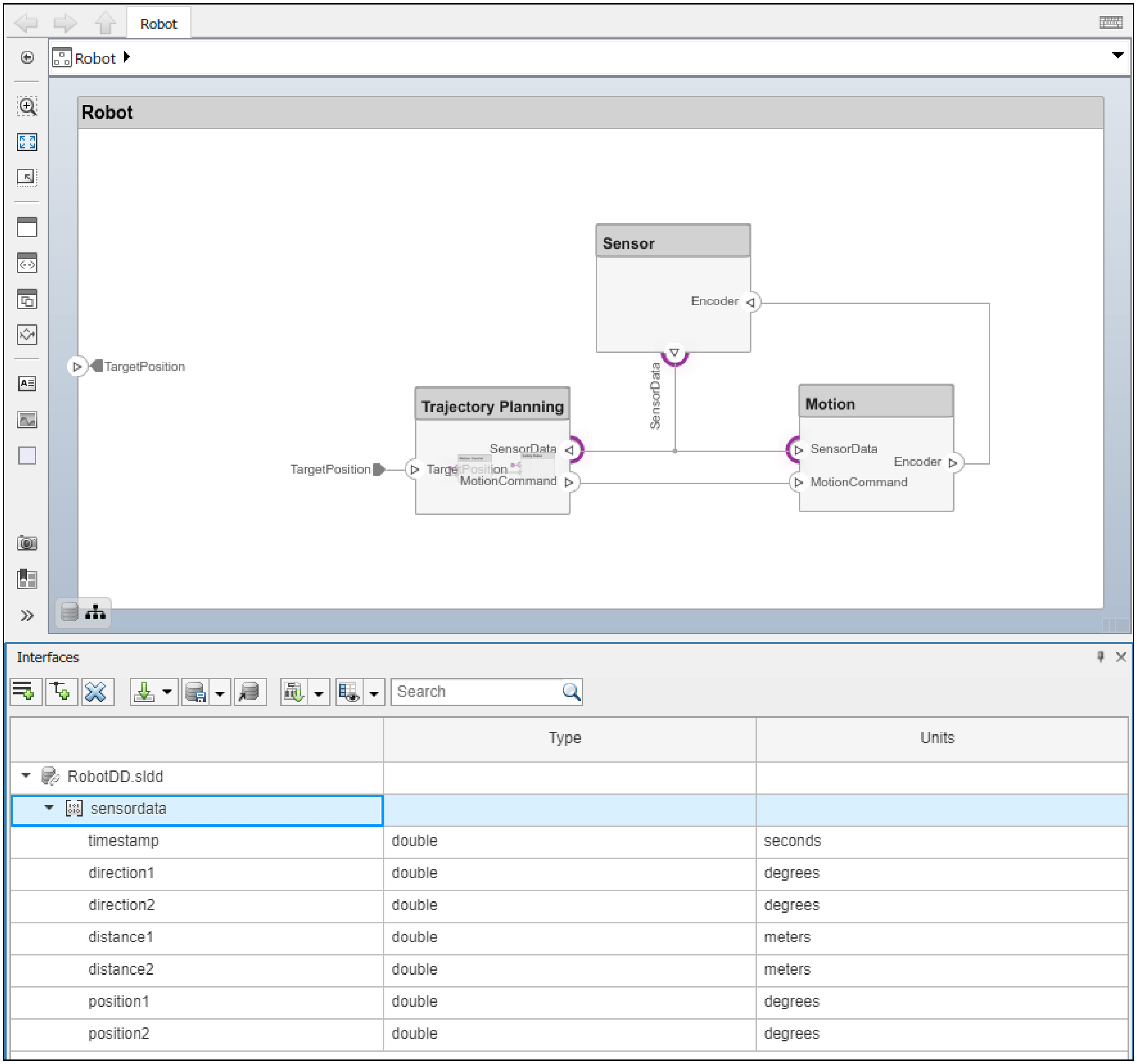
You can simulate the Simulink component implementations in System Composer. Use the **Simulation Data Inspector** to view and compare simulation results between model designs.

Create Simulink Behavior with Robot Arm Model

This example shows how to use a robot arm model to create Simulink® behavior from the `Motion` component.

1. Open the `Robot.slx` model.

```
model = systemcomposer.openModel('Robot');
```



	Type	Units
RobotDD.sldd		
sensordata		
timestamp	double	seconds
direction1	double	degrees
direction2	double	degrees
distance1	double	meters
distance2	double	meters
position1	double	degrees
position2	double	degrees

The `Robot` model has an interface `sensordata` applied on the ports `SensorData`.

2. Look up the `Motion` component.

```
motionComp = lookup(model,'Path','Robot/Motion');
```

3. Create a Simulink behavior.

```
motionComp.createSimulinkBehavior('MotionSimulink');
```

Create Referenced Simulink Behavior Model

When a component does not require decomposition from an architecture standpoint, you can design and define the behavior of the component in Simulink. When you link to a Simulink behavior, the Component block becomes a Reference Component block.

A reference component is a component whose definition is a separate architecture model, Simulink behavior model, or Simulink subsystem behavior. A reference component represents a logical hierarchy of other compositions.

You can reuse compositions in the model using reference components. There are three types of reference components:

- *Model references* are Simulink models.
- *Subsystem references* are Simulink subsystems.
- *Architecture references* are System Composer architecture models.

In this section, you will create a model reference and a subsystem reference. For more information on architecture references, see “Create Reference Architecture” on page 1-18.

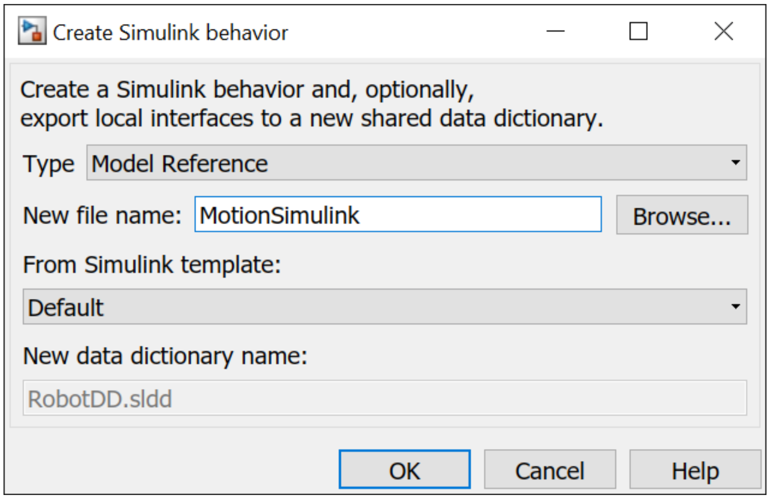
Referenced or linked models are useful for collaborative design with version control using Simulink projects. For more information, see “Organize System Composer Files in Projects” on page 12-2.

Create Reusable Simulink Behavior Using Model Reference Component

Use Simulink model references to describe the implementation of System Composer components.

1 Navigate to **Modeling** > **Create Simulink Behavior**. Alternatively, right-click the `Motion` component and select `Create Simulink Behavior`.

2 From the **Type** list, select `Model Reference`. Provide the model name `MotionSimulink`. The default name is the name of the component.



Create a Simulink behavior and, optionally, export local interfaces to a new shared data dictionary.

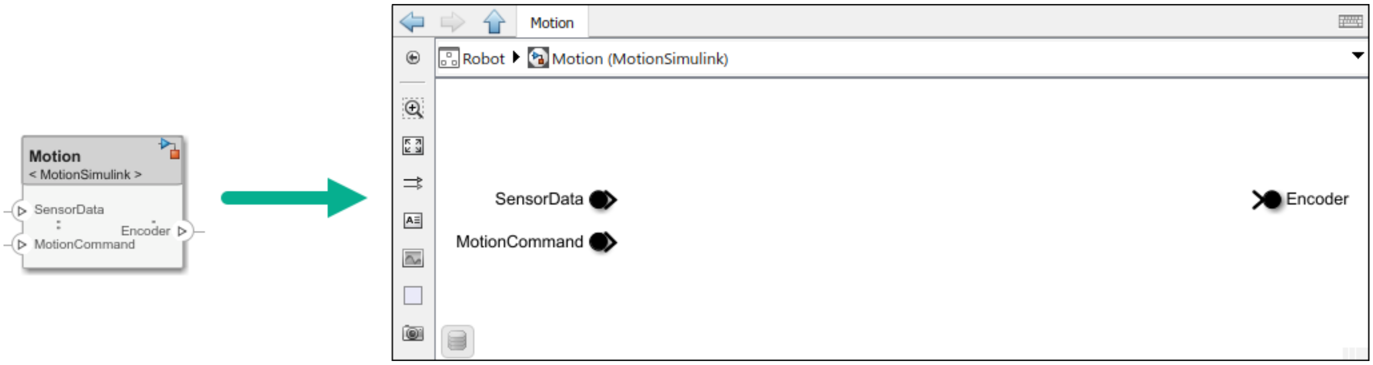
Type: Model Reference

New file name: MotionSimulink

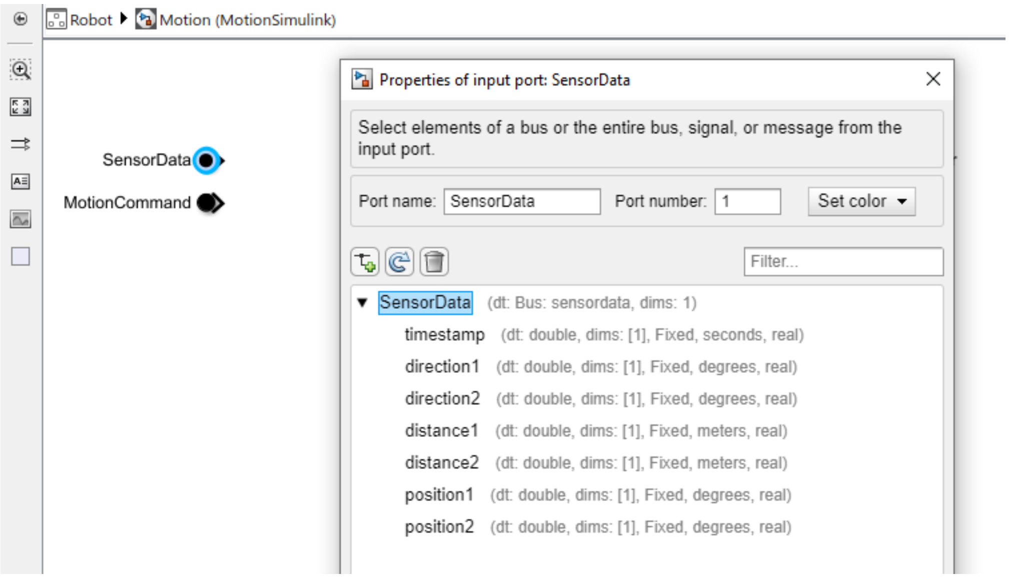
From Simulink template: Default

New data dictionary name: RobotDD.sldd

3 A new Simulink model file with the provided name is created in the current folder. The root-level ports of the Simulink model reflect the ports of the component. The component in the architecture model is linked to the Simulink model. The icon on the component indicates that the component has a Simulink behavior.



4 To view the interfaces on the **SensorData** port converted into Simulink bus elements, double-click the port in Simulink.



Properties of input port: SensorData

Select elements of a bus or the entire bus, signal, or message from the input port.

Port name: SensorData Port number: 1 Set color

Filter...

- SensorData (dt: Bus: sensordata, dims: 1)
  - timestamp (dt: double, dims: [1], Fixed, seconds, real)
  - direction1 (dt: double, dims: [1], Fixed, degrees, real)
  - direction2 (dt: double, dims: [1], Fixed, degrees, real)
  - distance1 (dt: double, dims: [1], Fixed, meters, real)
  - distance2 (dt: double, dims: [1], Fixed, meters, real)
  - position1 (dt: double, dims: [1], Fixed, degrees, real)
  - position2 (dt: double, dims: [1], Fixed, degrees, real)

5 To remove model behavior, right-click the linked `Motion` component and select **Inline Model**.

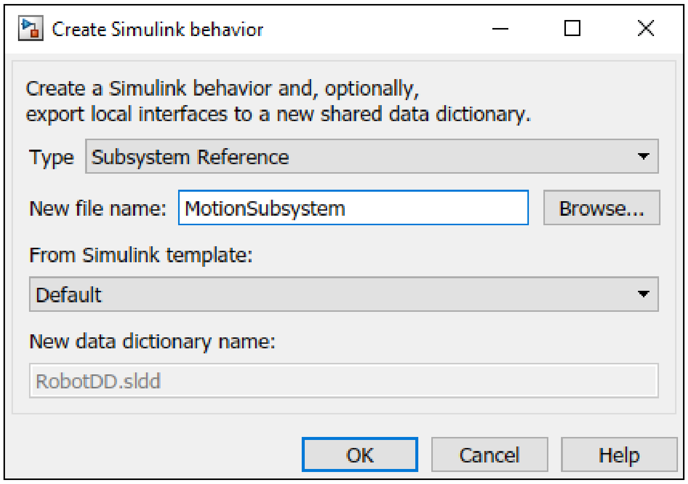
For more information on removing referenced behaviors, see “Remove Reference Architecture” on page 1-20.

Create Reusable Simulink Subsystem Behavior Using Subsystem Reference Component

Use subsystem references to author Simulink or Simscape behaviors with physical ports, connections, and blocks. For more information, see “Implement Component Behavior Using Simscape” on page 7-23.

1 Navigate to **Modeling** > **Create Simulink Behavior**. Alternatively, right-click the `Motion` component and select `Create Simulink Behavior`. Alternatively,

2 From the **Type** list, select `Subsystem Reference`. Provide the model name `MotionSubsystem`. The default name is the name of the component.



Create Simulink behavior

Create a Simulink behavior and, optionally, export local interfaces to a new shared data dictionary.

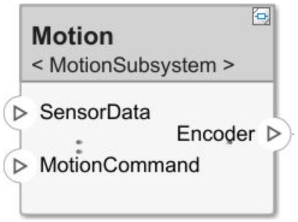
Type: Subsystem Reference

New file name: MotionSubsystem

From Simulink template: Default

New data dictionary name: RobotDD.sldd

3 A new Simulink subsystem file with the provided name is created in the current folder. The root-level ports of the Simulink subsystem reflect the ports of the component. The component in the architecture model is linked to the Simulink subsystem. The icon on the component indicates that the component has a Simulink subsystem behavior.



You can access and edit referenced Simulink models and subsystems by double-clicking the Reference Component in the architecture model. When you save the architecture model, all unsaved referenced Simulink behaviors are also saved, and all linked components are updated.

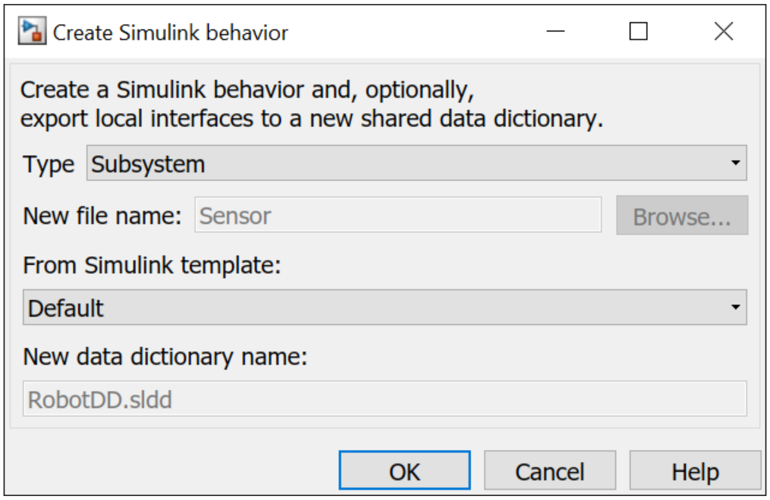
Create Simulink Subsystem Behavior Using Subsystem Component

A subsystem component is a Simulink subsystem that is part of the parent System Composer architecture model.

Add Simulink subsystem behavior to a component to author a subsystem component in System Composer. You cannot synchronize and reuse subsystem components as Reference Component blocks because the component is part of the parent model.

1 Right-click the `Sensor` component and select `Create Simulink Behavior`. Alternatively, navigate to **Modeling** > **Create Simulink Behavior**.

2 From the **Type** list, select `Subsystem`.



Create Simulink behavior

Create a Simulink behavior and, optionally, export local interfaces to a new shared data dictionary.

Type: Subsystem

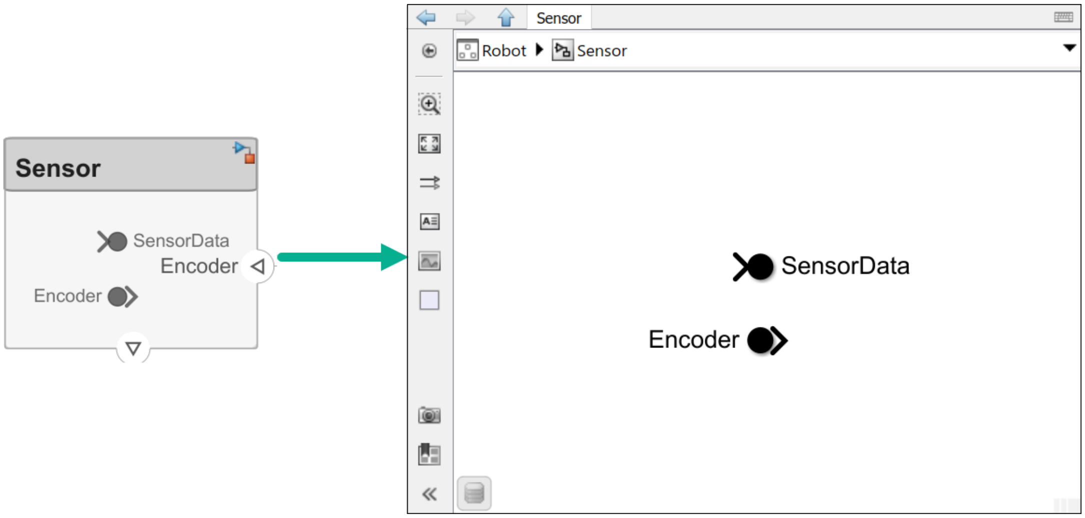
New file name: Sensor

From Simulink template: Default

New data dictionary name: RobotDD.sldd

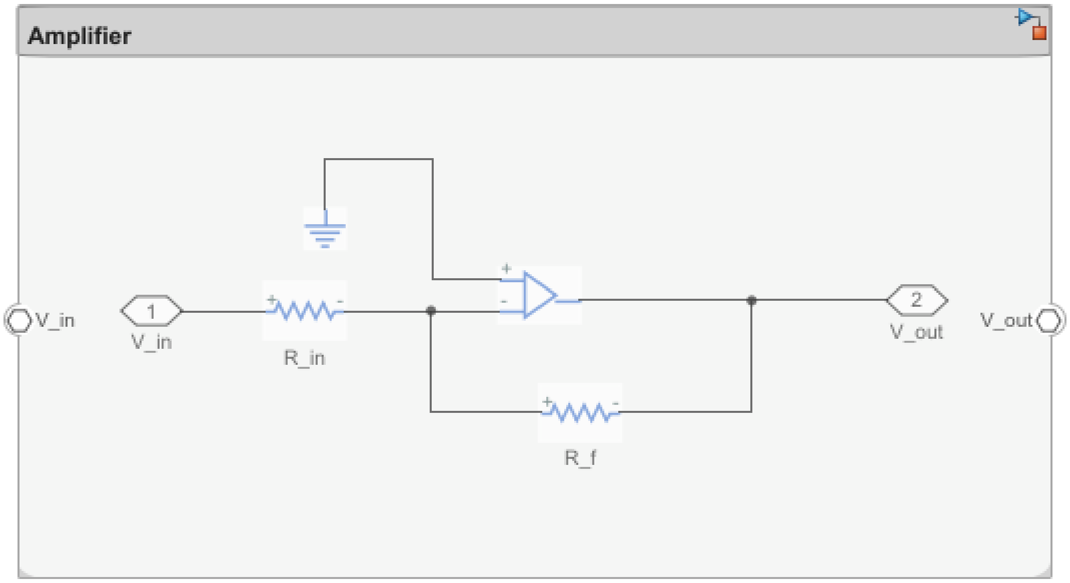
3 The `Sensor` component is now a Simulink subsystem of the same name that is part of the parent System Composer architecture model.

The root-level ports of the Simulink model reflect the ports of the component. The icon on the component indicates that the component has a Simulink subsystem behavior.



4 You can continue to provide specific dynamics and algorithms in the Simulink subsystem behavior model. Adding root-level ports in the subsystem behavior creates additional ports on the subsystem component.

5 You can use subsystem components to author Simscape component behaviors with physical ports, connections, and blocks. For example, this amplifier physical system uses electrical domain blocks inside a subsystem component in a System Composer architecture model.

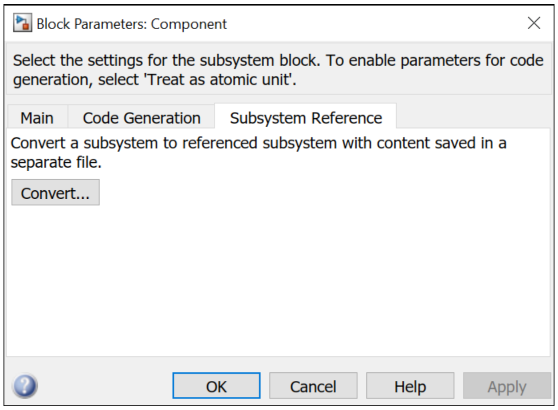


Convert Simulink Subsystem Component to Subsystem Reference Component

You can convert existing Simulink subsystem components that are part of the parent System Composer model to subsystem reference components. The subsystem reference components are saved separately as a reusable artifact.

1 Right-click the subsystem component block and select `Block Parameters (Subsystem)`.

2 Click the **Subsystem Reference** tab.

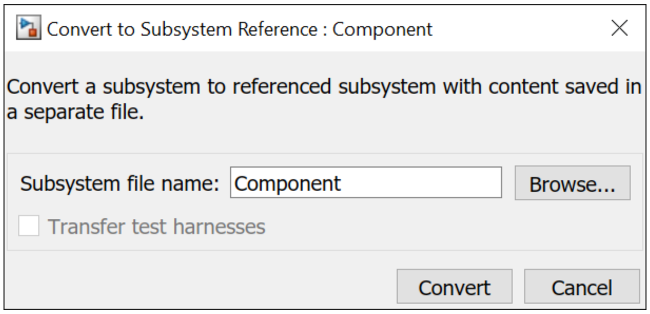

Block Parameters: Component

Select the settings for the subsystem block. To enable parameters for code generation, select 'Treat as atomic unit'.

Convert a subsystem to referenced subsystem with content saved in a separate file.

3 Click **Convert** to open the **Convert to Subsystem Reference** dialog.

4 Choose a name for the new subsystem file. Optionally, select **Transfer test harnesses** to transfer test harnesses. Click **Convert** to complete the conversion.



Convert to Subsystem Reference : Component

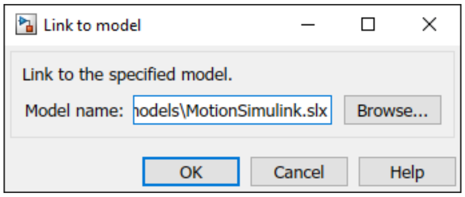
Convert a subsystem to referenced subsystem with content saved in a separate file.

Subsystem file name: Component

To convert a subsystem component to a subsystem reference programmatically, use the `createSimulinkBehavior` function.

Link to Existing Simulink Behavior Model

You can link to an existing Simulink behavior model or subsystem from a System Composer component, provided that the component is not already linked to a reference architecture. Right-click the component and select **Link to Model**. Type in or browse for the name of a Simulink model or subsystem.



Link to model

Link to the specified model.

Model name: nodels\MotionSimulink.slx

Any subcomponents and ports in the components are deleted when the component links to a Simulink model or subsystem. A prompt displays to continue and lose subcomponents and ports.

Note Linking a System Composer component to a Simulink model with root-level enable or trigger ports is not supported.

You can link protected Simulink models (`.slxp`) to create component behaviors. You can also convert an already linked Simulink behavior model to a protected model. The change is reflected when you refresh the model.

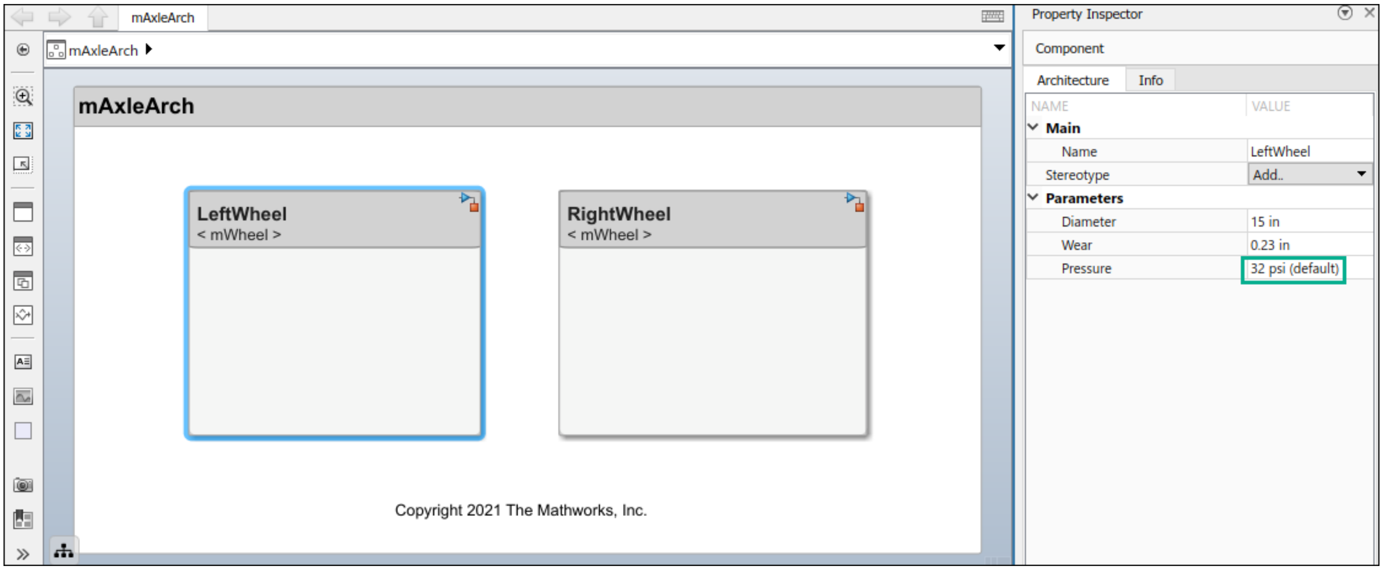
Access Model Arguments as Parameters on Reference Components

System Composer exposes instance-specific parameter values for reusable referenced models.

A parameter is an instance-specific value of a value type.

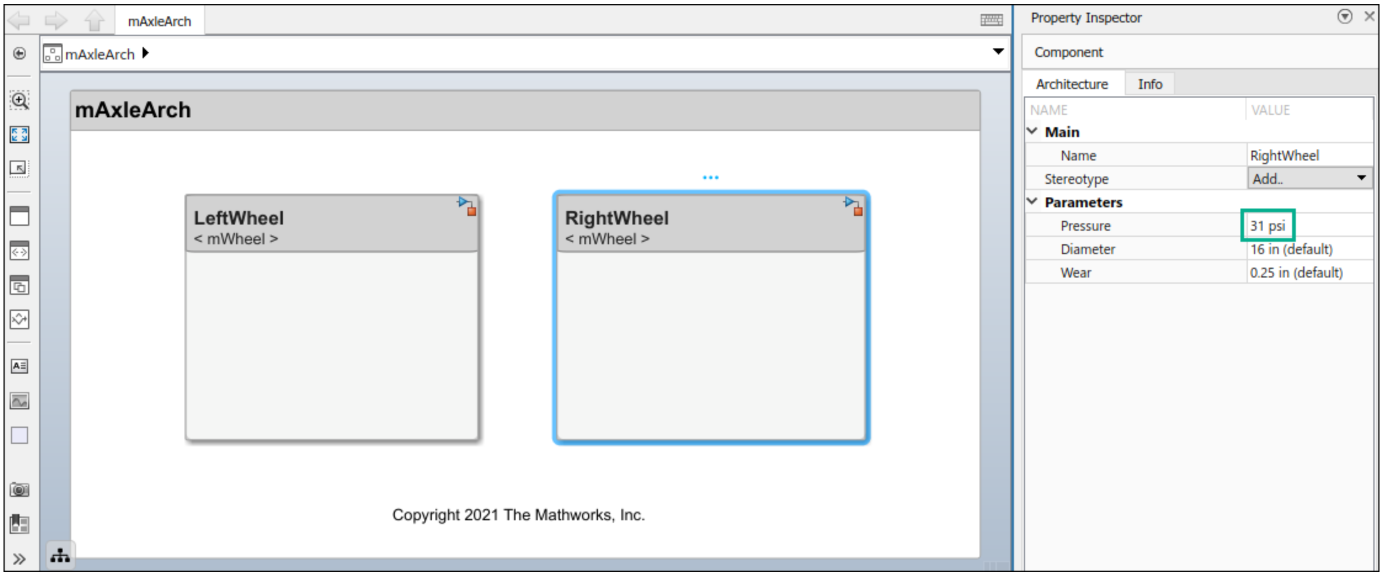
Parameters are available for inlined architectures and components. Parameters are also available for components linked to model references or architecture references that specify model arguments. You can specify independent values for a parameter on each component.

Instance-specific parameter values are visible on the component level. View and edit these values using the **Property Inspector**.



NAME	VALUE
Main	
Name	LeftWheel
Stereotype	Add..
Parameters	
Diameter	15 in
Wear	0.23 in
Pressure	32 psi (default)

Each parameter value can be specified independently for each component that references the model.



NAME	VALUE
Main	
Name	RightWheel
Stereotype	Add..
Parameters	
Pressure	31 psi
Diameter	16 in (default)
Wear	0.25 in (default)

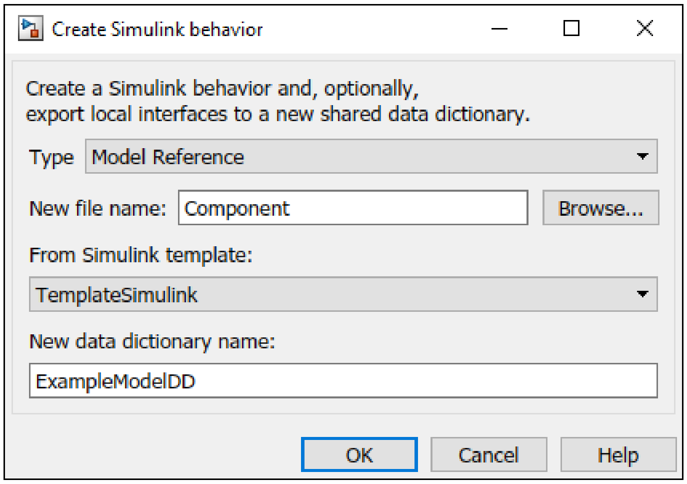
For more information, see “Use Parameters to Store Instance Values with Components” on page 4-6.

To add or modify parameters for architectures or components using the **Parameter Editor**, see “Author Parameters in System Composer Using Parameter Editor” on page 4-2.

Create Simulink Behavior from Template for Component

To create user-defined templates for Simulink models, see “Create Template from Model”.

After creating and saving a user-defined template, you can link the template to a Simulink behavior. Right-click the component and select `Create Simulink Behavior`, or, navigate to **Modeling** > **Create Simulink Behavior**.



Create Simulink behavior

Create a Simulink behavior and, optionally, export local interfaces to a new shared data dictionary.

Type: Model Reference

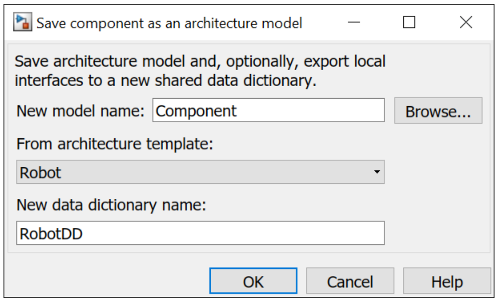
New file name: Component

From Simulink template: TemplateSimulink

New data dictionary name: ExampleModelDD

On the **Create Simulink behavior** dialog, choose the template and enter a new data dictionary name if local interfaces are defined. Click **OK**. The component exhibits a Simulink behavior according to the template with shared interfaces, if present. Blocks and lines in the template are excluded, and only configuration settings are preserved. Configuration settings include annotations and styling.

Note that you can use architecture templates by right-clicking a component and selecting `Save As Architecture Model`, or navigating to **Modeling** > **Save As Architecture Model**.



Save component as an architecture model

Save architecture model and, optionally, export local interfaces to a new shared data dictionary.

New model name: Component

From architecture template: Robot

New data dictionary name: RobotDD

See Also

Functions

`createSimulinkBehavior` | `linkToModel` | `createArchitectureModel` | `systemcomposer.parameter.ParameterDefinition`

Blocks

Reference Component

More About

- "Decompose and Reuse Components" on page 1-17
- "Implement Component Behavior Using Stateflow Charts" on page 7-14
- "Implement Component Behavior Using Simscape" on page 7-23
- "Describe System Behavior Using Sequence Diagrams" on page 6-2
- "Organize System Composer Files in Projects" on page 12-2

Extract Architecture of Simulink Model Using System Composer

Export an existing Simulink® model to a System Composer™ architecture model. The algorithmic sections of the original model are removed and structural information is preserved during this process. Requirements links, if present, are also preserved.

Convert Simulink Model to System Composer Architecture

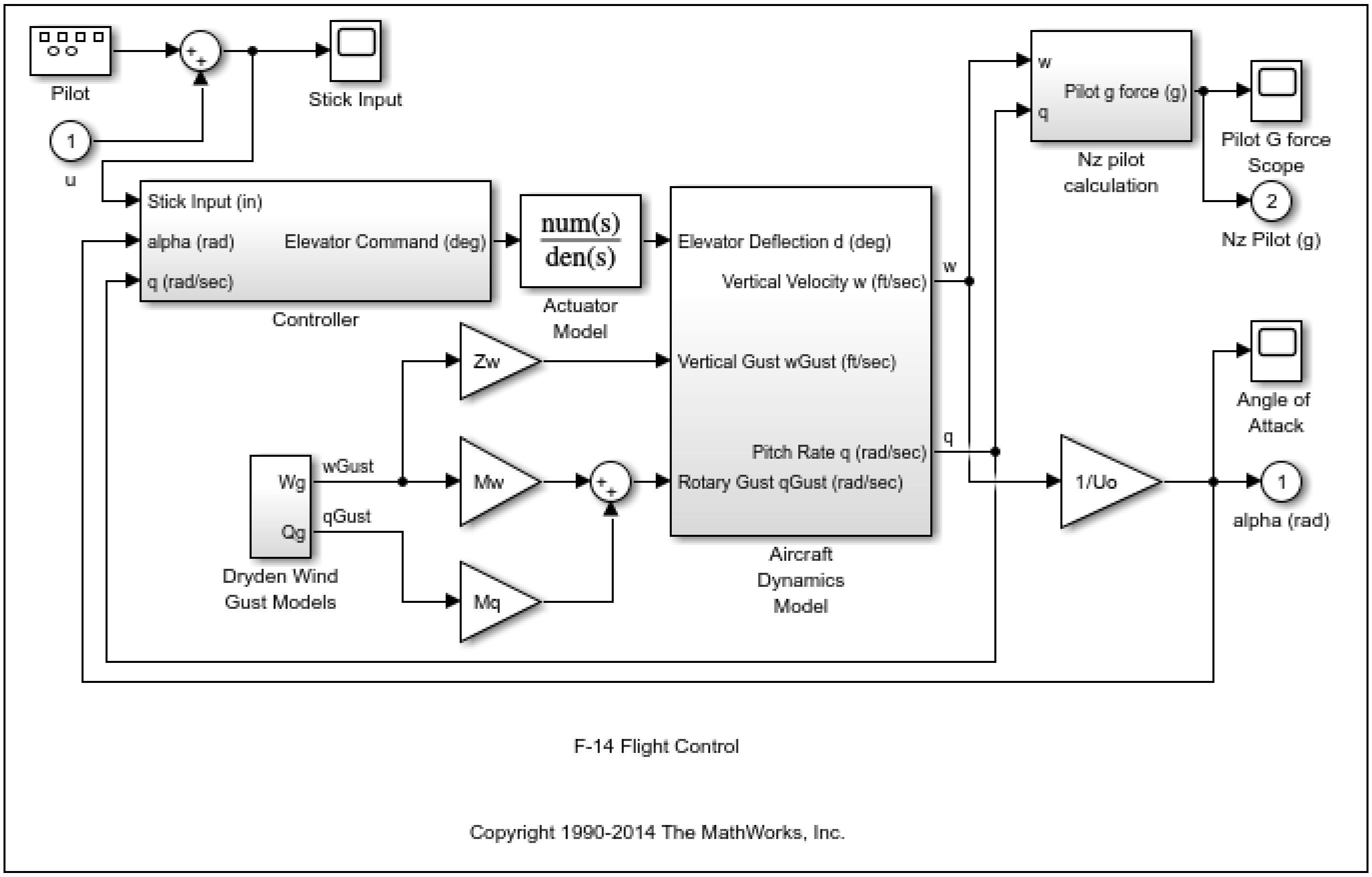
System Composer converts structural constructs in a Simulink model to equivalent architecture model constructs:

- Subsystems to components
- Variant subsystems to variant components
- Bus objects to interfaces
- Referenced models to reference components

Open Model

Open the Simulink model of F-14 Flight Control.

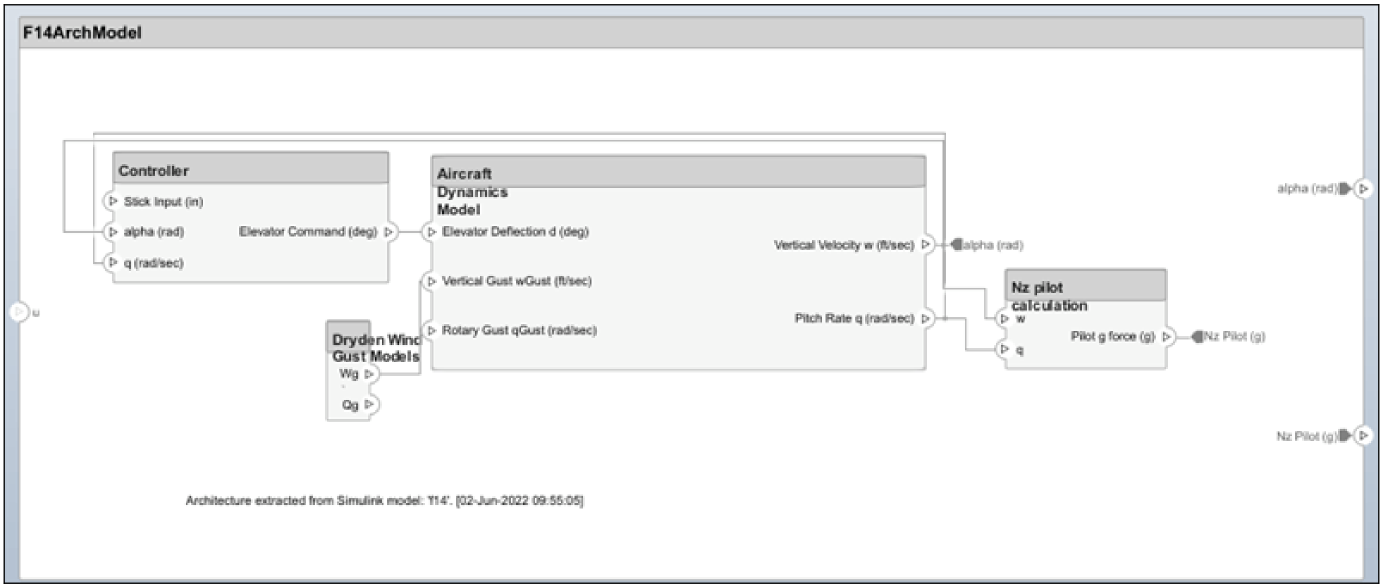
```
f14
```



Export Model

Extract an architecture model from the original model.

```
systemcomposer.extractArchitectureFromSimulink('f14','F14ArchModel');
Simulink.BlockDiagram.arrangeSystem('F14ArchModel');
systemcomposer.openModel('F14ArchModel');
```



See Also

`extractArchitectureFromSimulink`

More About

- “Extract Architecture from Simulink Model” on page 7-19
- “Compose Architectures Visually” on page 1-2
- “Implement Component Behavior Using Simulink” on page 7-2
- “Simulate Mobile Robot with System Composer Workflow” on page 5-20
- “Modeling System Architecture of Small UAV” on page 1-32

Implement Component Behavior Using Stateflow Charts

A state chart diagram demonstrates the state-dependent behavior of a component throughout its state lifecycle and the events that can trigger a transition between states.

Add Stateflow chart behavior to describe a component using state machines. You cannot synchronize and reuse Stateflow chart behaviors as Reference Component blocks because the component is part of the parent model.

You can simulate the Stateflow component implementations in System Composer. Use the **Simulation Data Inspector** to view and compare simulation results between model designs.

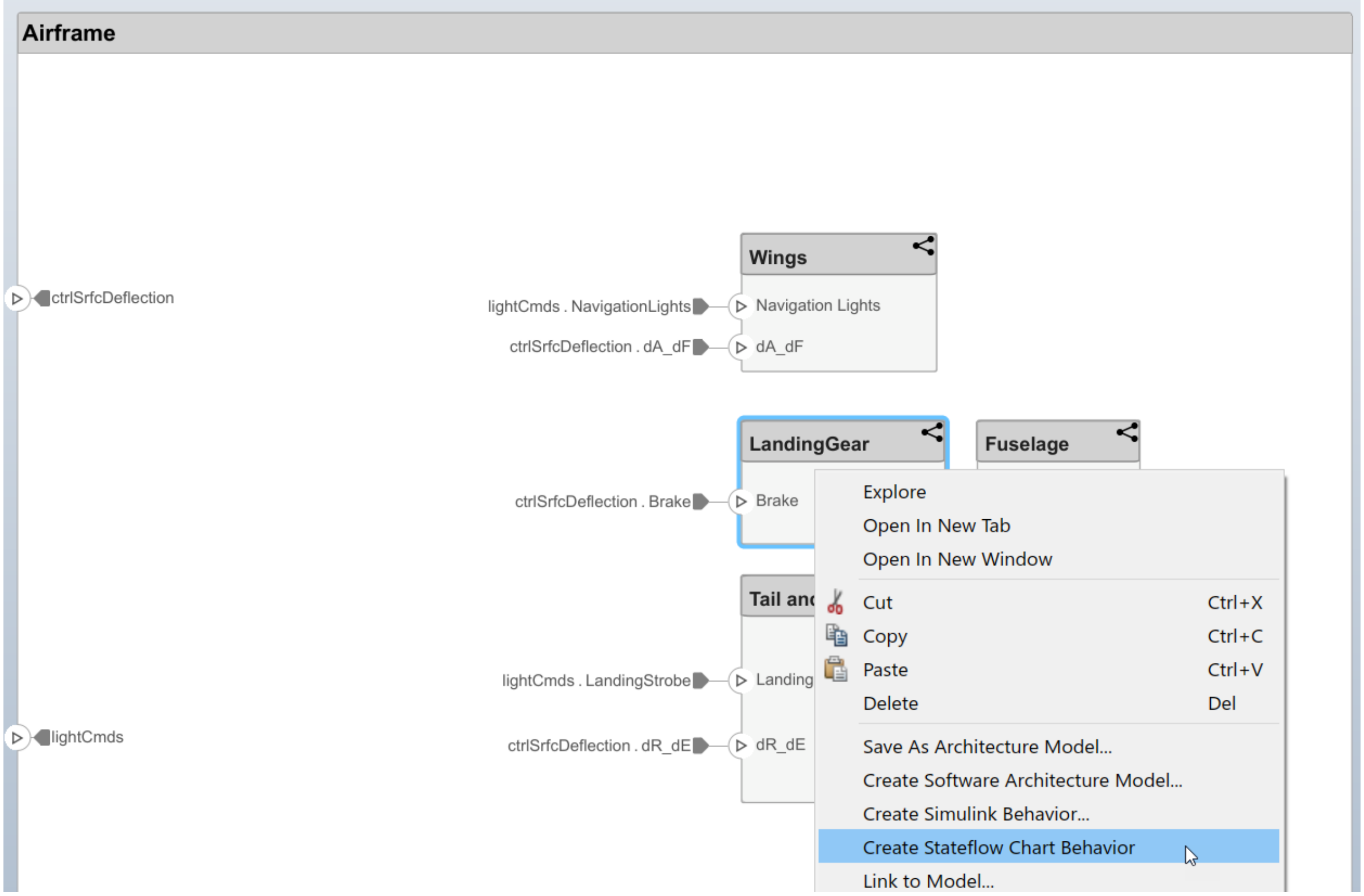
State charts consist of a finite set of states with transitions between them to capture the modes of operation for the component. Charts allow you to design for different modes, internal states, and event-based logic of a system. You can also use charts as stubs to mock a complex component implementation during top-down integration testing. This functionality requires a Stateflow license. For more information, see “Stateflow”.

Add State Chart Behavior to Component

A System Composer component with stereotypes, interfaces, requirement links, and ports, is preserved when you add Stateflow Chart behavior.

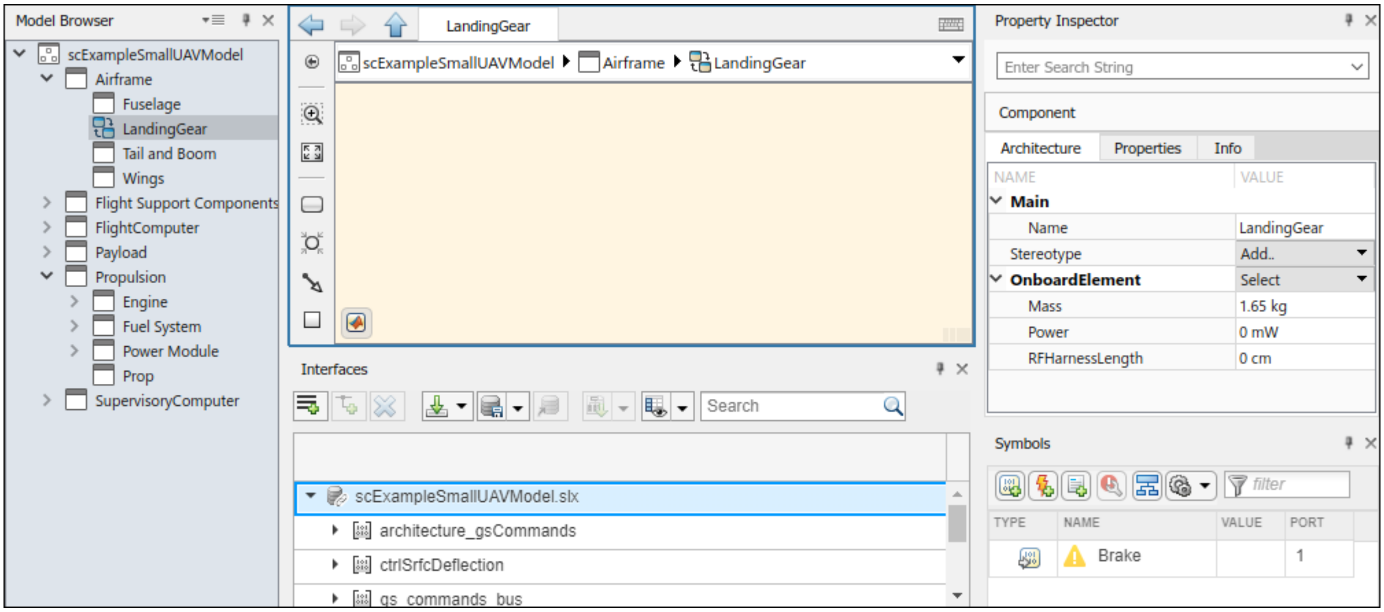
1. This example uses the architecture model for an unmanned aerial vehicle (UAV) to add state chart behavior to a component. In the MATLAB Command Window, enter the following command:

   ```
   scExampleSmallUAV
   ```
2. Double-click the `Airframe` component. Select the `LandingGear` component on the System Composer composition editor.
3. Select the `Brake` port. Open the **Interface Editor** from the toolstrip **Modeling** > **Interface Editor**. Right-click the interface `operatorCmds` and select **Assign to Selected Port(s)**.
4. Right-click the `LandingGear` component and select `Create Stateflow Chart Behavior`. Alternatively, navigate to **Modeling** > **Create Stateflow Chart Behavior**.


Airframe
ctrlSrfcDeflection
lightCmds
Wings
lightCmds . NavigationLights
ctrlSrfcDeflection . dA_dF
Navigation Lights
dA_dF
LandingGear
ctrlSrfcDeflection . Brake
Brake
Fuselage
Tail and
lightCmds . LandingStrobe
Landing
ctrlSrfcDeflection . dR_dE
dR_dE
Explore
Open In New Tab
Open In New Window
Cut Ctrl+X
Copy Ctrl+C
Paste Ctrl+V
Delete Del
Save As Architecture Model...
Create Software Architecture Model...
Create Simulink Behavior...
Create Stateflow Chart Behavior
Link to Model...

5 Double-click `LandingGear`, which has the Stateflow icon. Navigate to **Modeling** > **Design Data** > **Symbols Pane** to view the Stateflow symbols. The input port `Brake` appears as input data in the symbols pane.

Note Some Stateflow objects remain local to Stateflow charts. Input and output event ports are not supported in System Composer. Only local events are supported.

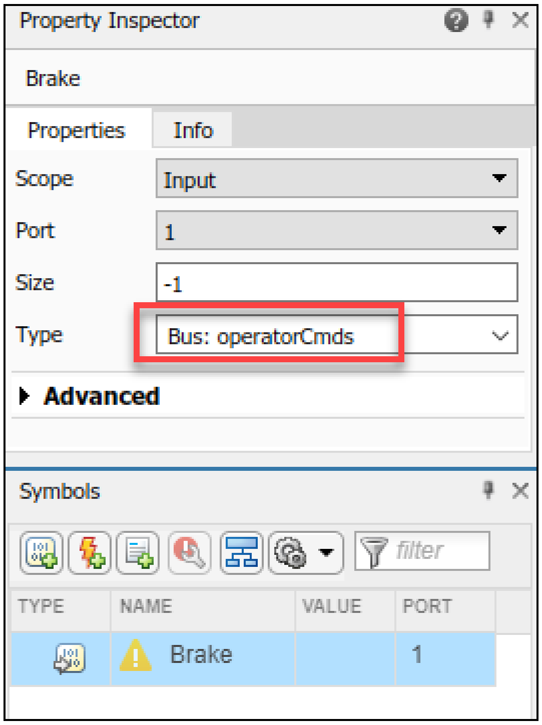


NAME	VALUE
Main	
Name	LandingGear
Stereotype	Add..
OnboardElement	Select
Mass	1.65 kg
Power	0 mW
RFHarnessLength	0 cm

TYPE	NAME	VALUE	PORT
	Brake		1

Since Stateflow ports show up as input and output data objects, they must follow Stateflow naming conventions. Ports are automatically renamed to follow Stateflow naming conventions. For more information, see “Guidelines for Naming Stateflow Objects” (Stateflow).

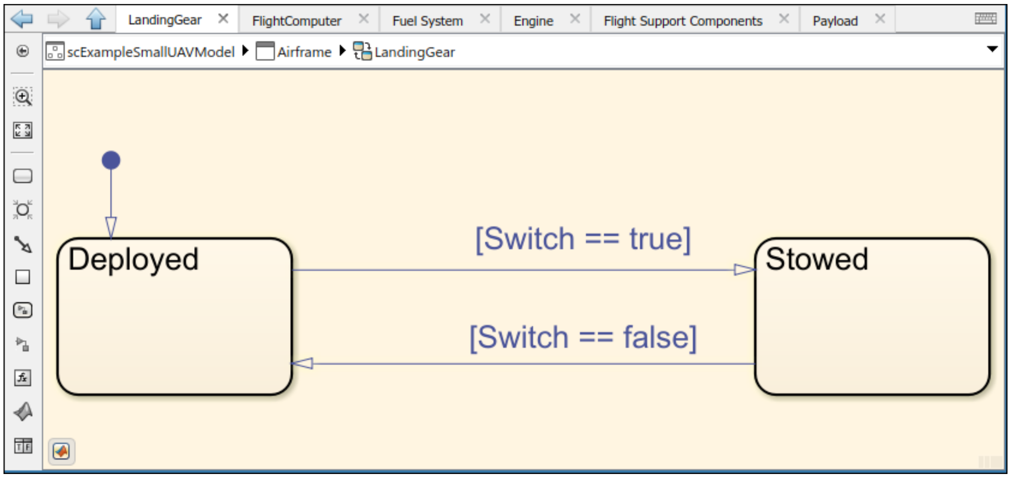
6 Select the `Brake` input and view the interface in the **Property Inspector**. The interface can be accessed like a Simulink bus signal. For information on how to use bus signals in Stateflow, see “Index and Assign Values to Stateflow Structures” (Stateflow).



Scope	Input
Port	1
Size	-1
Type	Bus: operatorCmds

TYPE	NAME	VALUE	PORT
	Brake		1

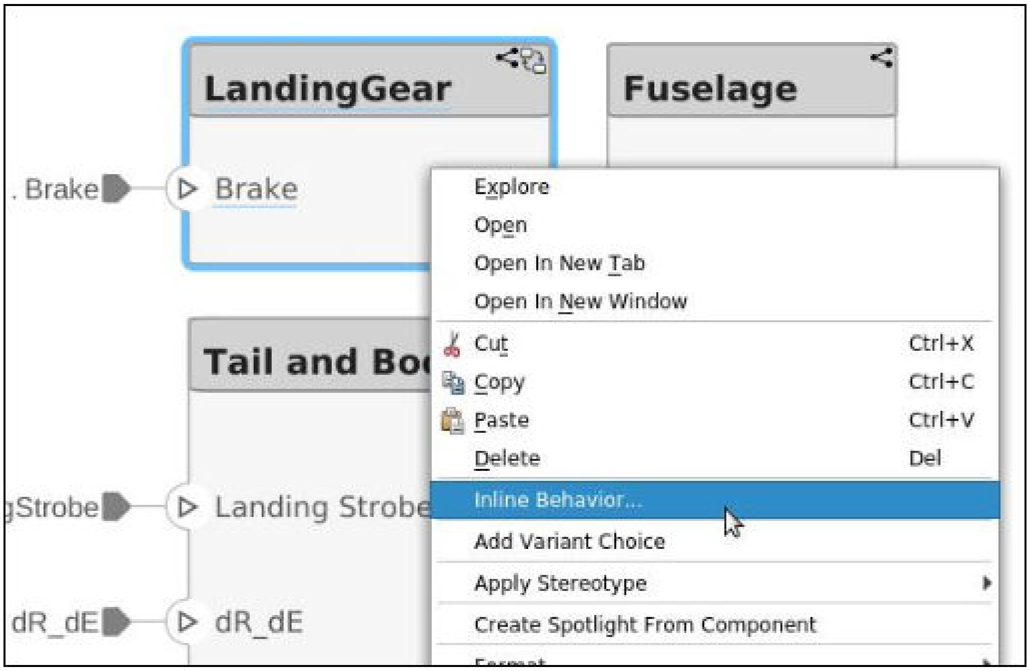
7 You can populate the Stateflow canvas to represent the internal states of the `LandingGear`.



Remove Stateflow Chart Behavior from Component

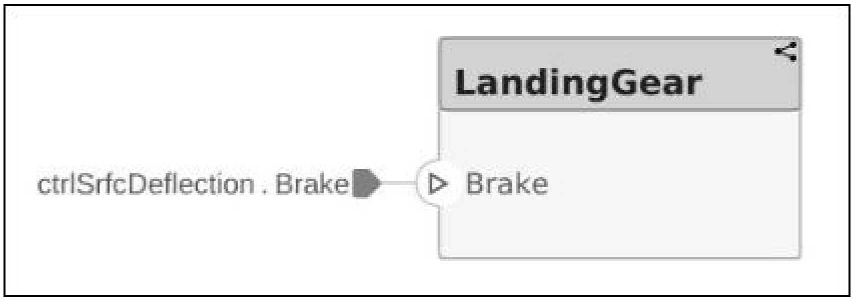
You can remove Stateflow chart behavior from a component to delete the contents inside the Stateflow chart while preserving interfaces on the component.

1 Right-click on the `LandingGear` component and select `Inline Behavior`.



2 To confirm the operation to delete all the content inside the Stateflow chart, click **OK**.

3 The Stateflow chart behavior on the component is removed. Interfaces on the component are preserved.



See Also

`createStateflowChartBehavior` | `inlineComponent`

More About

- "Compose Architectures Visually" on page 1-2
- "Decompose and Reuse Components" on page 1-17
- "Implement Component Behavior Using Simulink" on page 7-2
- "Implement Component Behavior Using Simscape" on page 7-23
- "Extract Architecture from Simulink Model" on page 7-19
- "Describe System Behavior Using Sequence Diagrams" on page 6-2

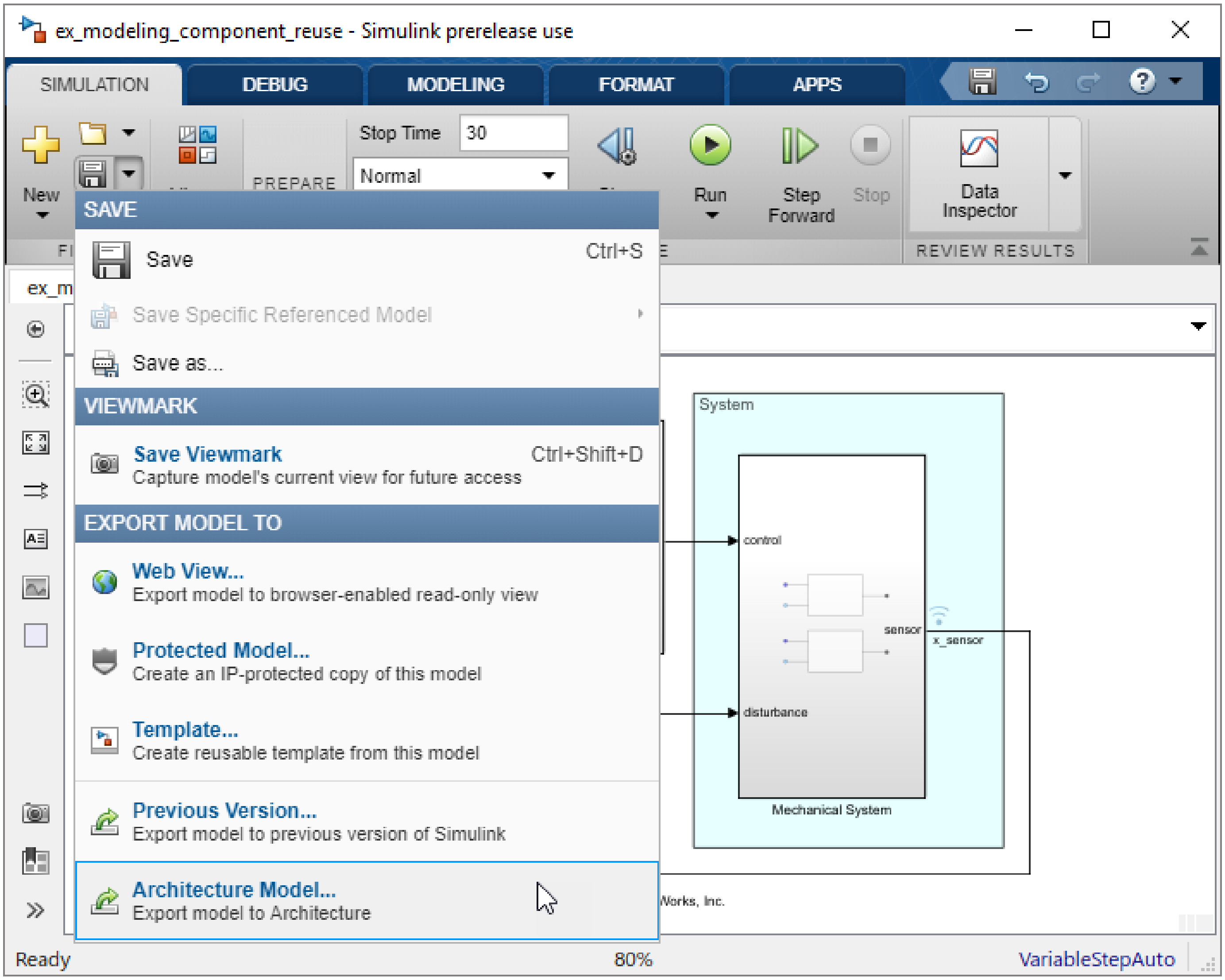
Extract Architecture from Simulink Model

You can use System Composer architecture editing and analysis capabilities on Simulink models. To do so, extract the architecture from a Simulink model. Model and Subsystem blocks, as well as all ports in a Simulink model represent architectural constructs, while all other blocks represent some kind of dynamic or algorithmic behavior. In the architecture model that you obtain from a Simulink model, you can choose to represent architectural constructs or link to behavior models.

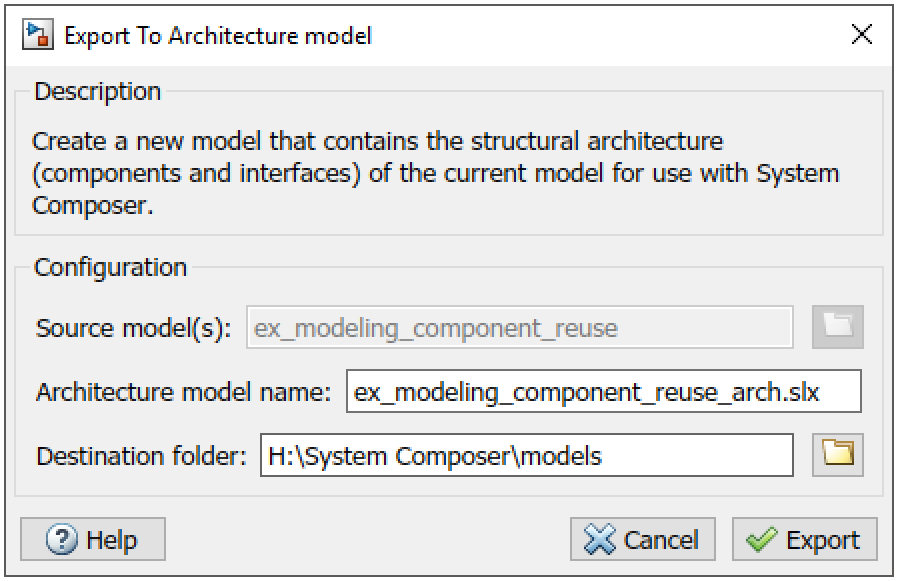
1. Open an example model.

   ```
   openExample('ReferenceFilesForCollaborationExample')
   ```

2. On the **Simulation** tab, click the **Save** arrow. From the **Export Model To** list, select **Architecture Model**.



3. Provide a name and path for the architecture model.



Export To Architecture model

Description

Create a new model that contains the structural architecture (components and interfaces) of the current model for use with System Composer.

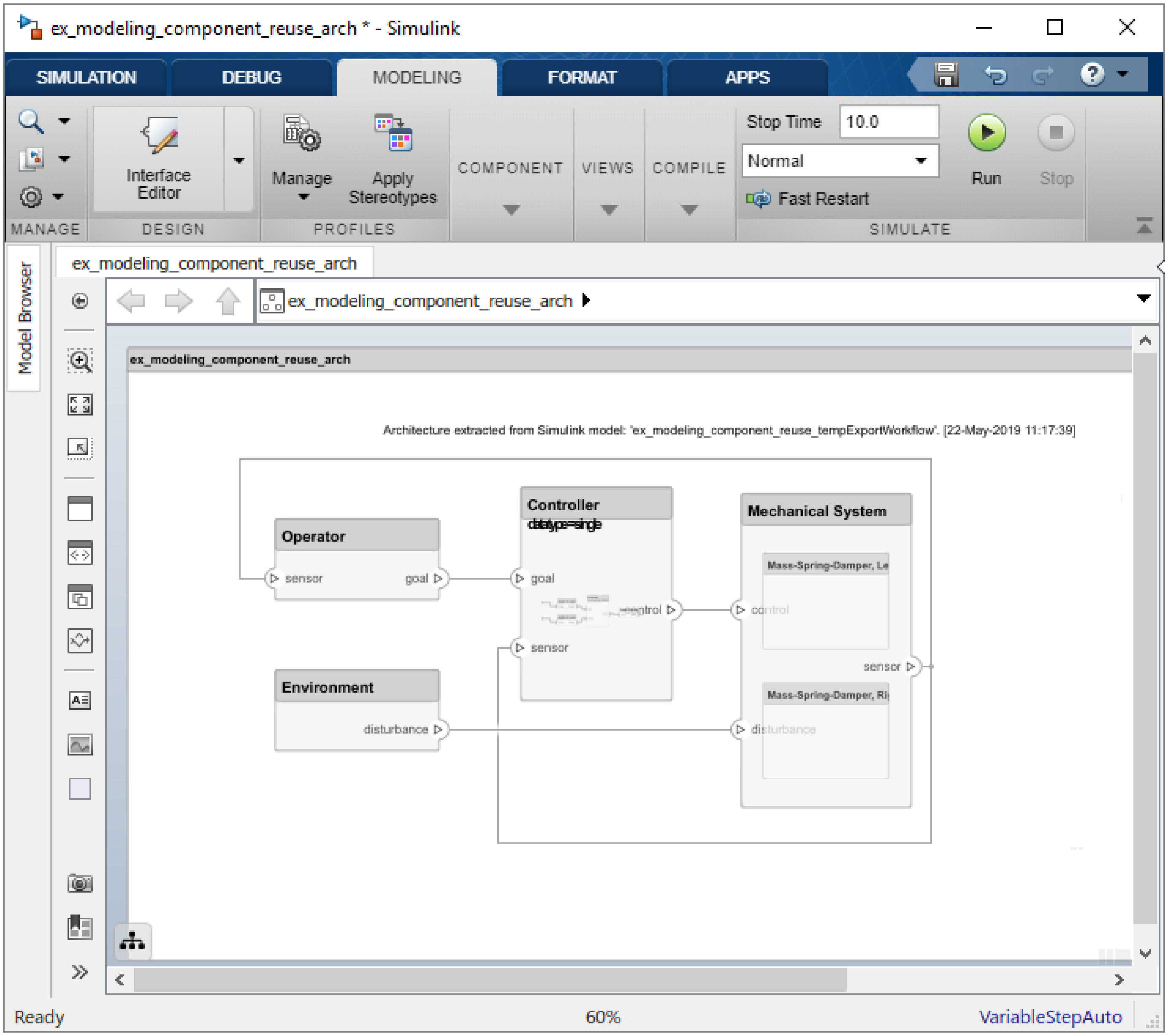
Configuration

Source model(s): ex_modeling_component_reuse

Architecture model name: ex_modeling_component_reuse_arch.slx

Destination folder: H:\System Composer\models

4 Click **Export**. A System Composer Editor window opens with an architecture model corresponding to the Simulink model.

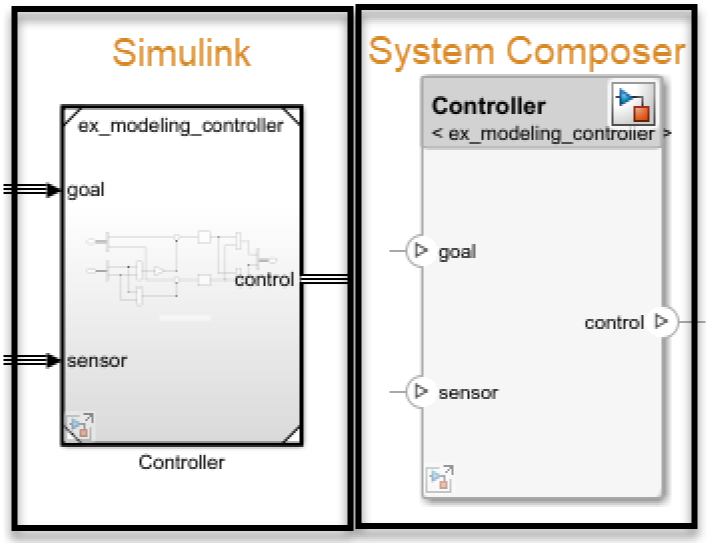


Architecture extracted from Simulink model: 'ex_modeling_component_reuse_tempExportWorkflow'. [22-May-2019 11:17:39]

Each subsystem in the Simulink model corresponds to a component in the architecture model so that the hierarchy in the architecture model reflects the hierarchy of the behavior model.

The requirements for subsystems and Model blocks in the Simulink model are preserved in the architecture model.

Any Model block in the Simulink model that references another model corresponds to a component that links to that same referenced model.



Buses at subsystem and Model block ports, as well as their dictionary links are preserved in the architecture model.

You can use the exported model to add architecture-related information such as interface definitions, nonfunctional properties for model elements and analyze the design.

See Also

`extractArchitectureFromSimulink`

More About

- "Extract Architecture of Simulink Model Using System Composer" on page 7-12
- "Implement Component Behavior Using Simulink" on page 7-2
- "Implement Component Behavior Using Stateflow Charts" on page 7-14
- "Implement Component Behavior Using Simscape" on page 7-23
- "Describe System Behavior Using Sequence Diagrams" on page 6-2
- "Compose Architectures Visually" on page 1-2

Implement Component Behavior Using Simscape

A physical subsystem is a Simulink subsystem with Simscape connections.

A physical subsystem with Simscape connections uses a physical network approach suited for simulating systems with real physical components and represents a mathematical model.

Using Simscape behaviors for components in System Composer improves model simulation and design for systems with physical components. This functionality requires a Simscape license. For more information, see “Basic Principles of Modeling Physical Networks” (Simscape).

You can simulate the Simscape component implementations in System Composer. Use the **Simulation Data Inspector** to view and compare simulation results between model designs.

To describe component behavior in Simscape for a System Composer architecture model, follow these steps:

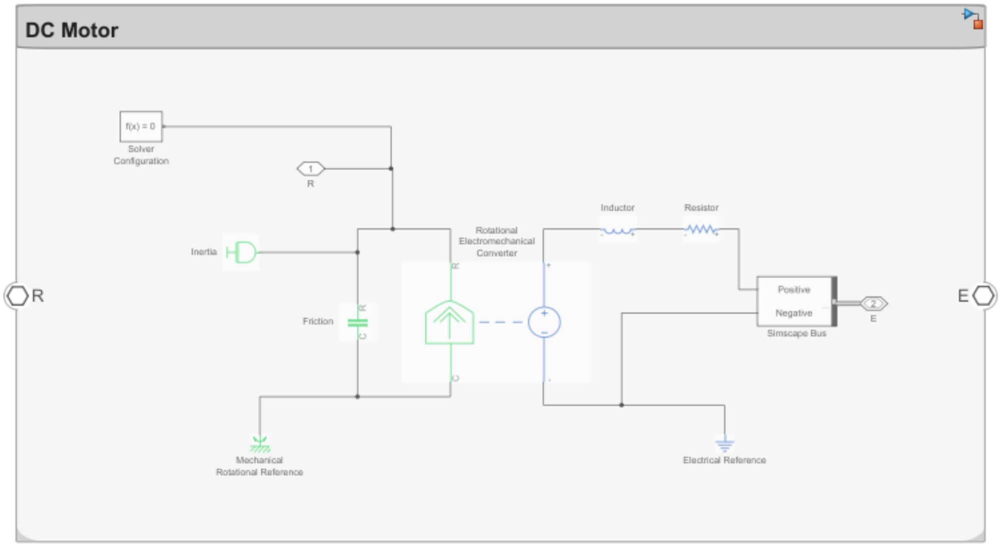
1. “Define Physical Ports on Component” on page 7-24
2. “Specify Physical Interfaces on Ports” on page 7-24
3. “Create Simulink Subsystem Component” on page 7-25
4. “Describe Component Behavior Using Simscape” on page 7-26

Open this model to interact with a System Composer architecture model named `Fan` with Simscape behavior on a component `DC Motor`. The steps in this tutorial will produce this model.

Note This example uses Simscape blocks. If you do not have a Simscape license, you can open and simulate the model but can only make basic changes, such as modifying block parameters.

Architecture Model with Simscape Behavior for a DC Motor

This example shows a DC motor in an architecture model of a fan. The DC motor is modeled using a Simscape behavior within a Simulink subsystem component.

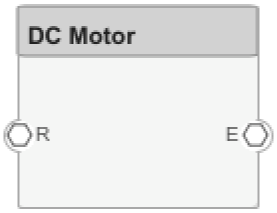


Define Physical Ports on Component

A physical port represents a Simscape physical modeling connector port called a Connection Port.

Use physical ports to connect components in an architecture model or to enable physical systems in a Simulink subsystem.

Create a new System Composer architecture model. Add a component called `DC Motor` to the canvas. To add physical ports to the component, pause on the boundary of the component until a port outline appears. Click the port outline and, from the options, select `Physical`.



Physical ports can also be used to connect to Simscape blocks.

Note Components with physical ports cannot be saved as architecture models, model references, software architectures, or Stateflow chart behaviors. Components with physical ports can only be saved as subsystem references or subsystem component behaviors.

Specify Physical Interfaces on Ports

You can specify physical interfaces on the physical ports.

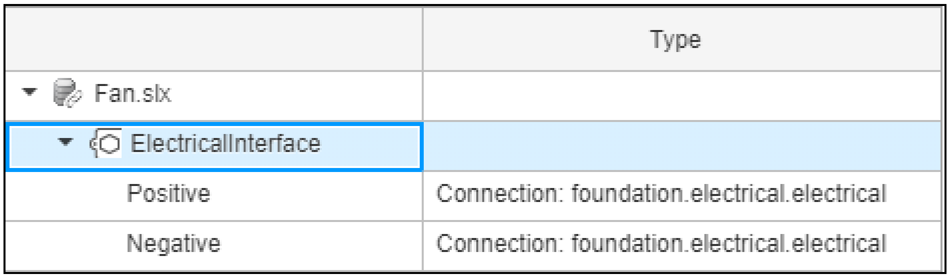
A physical interface defines the kind of information that flows through a physical port. The same interface can be assigned to multiple ports. A physical interface is a composite interface equivalent to a `Simulink.ConnectionBus` object that specifies any number of `Simulink.ConnectionElement` objects.

Use a physical interface to bundle physical elements to describe a physical model using at least one physical domain.

A physical element describes the decomposition of a physical interface. A physical element is equivalent to a `Simulink.ConnectionElement` object.

Define the `Type` of a physical element as a physical domain to enable use of that domain in a physical model.

1. To open the **Interface Editor**, navigate to **Modeling** > **Interface Editor**.
2. To add a new physical interface definition, click the list next to the icon and select **Physical Interface**. Name the physical interface `ElectricalInterface`.
3. To add a physical element to the physical interface, click the icon. Physical interface and physical element names must be valid MATLAB variable names. Create the physical elements `Positive` and `Negative`.
4. In the **Type** column, define the Simscape domain to which these physical elements belong. In this case, both belong to `foundation.electrical.electrical`.



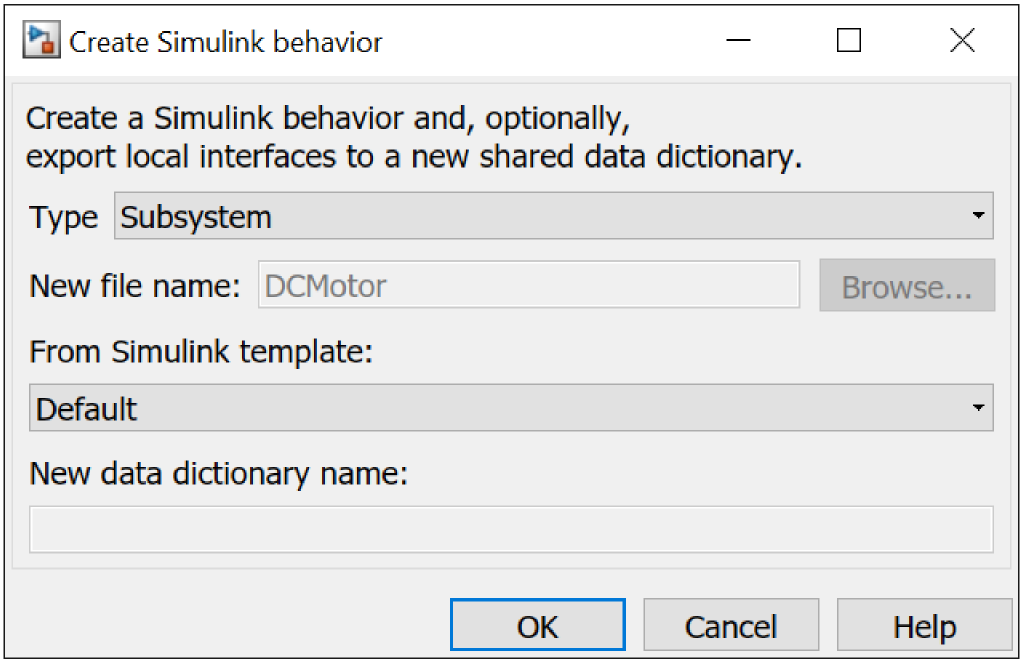
	Type
▾ Fan.slx	
▾ ElectricalInterface	
Positive	Connection: foundation.electrical.electrical
Negative	Connection: foundation.electrical.electrical

5. Select the `E` port on the `DC Motor` component. Right-click the `ElectricalInterface` physical interface on the **Interface Editor** and click **Assign to Selected Port(s)**.

Create Simulink Subsystem Component

You can create a Simulink subsystem in System Composer to enable direct Simscape integration. For more information, see “Create Simulink Subsystem Behavior Using Subsystem Component” on page 7-6.

Select the `DC Motor` component. Navigate to **Modeling** > **Create Simulink Behavior**, or use the right-click menu on the component.



Create Simulink behavior

Create a Simulink behavior and, optionally, export local interfaces to a new shared data dictionary.

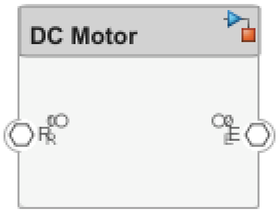
Type: Subsystem

New file name: DCMotor

From Simulink template: Default

New data dictionary name:

Click **OK**.



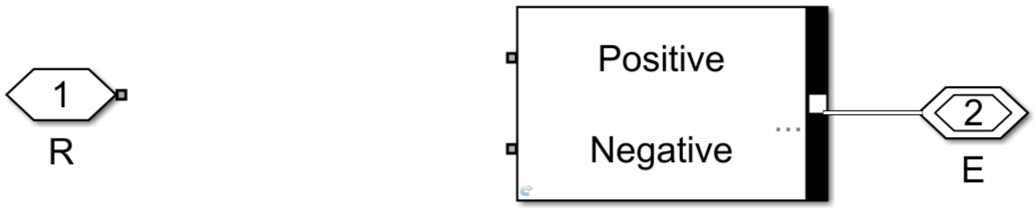
You can convert a subsystem component that is part of the parent System Composer model into a subsystem reference behavior then save and reuse the subsystem as a separate artifact. For more information, see “Convert Simulink Subsystem Component to Subsystem Reference Component” on page 7-8.

Describe Component Behavior Using Simscape

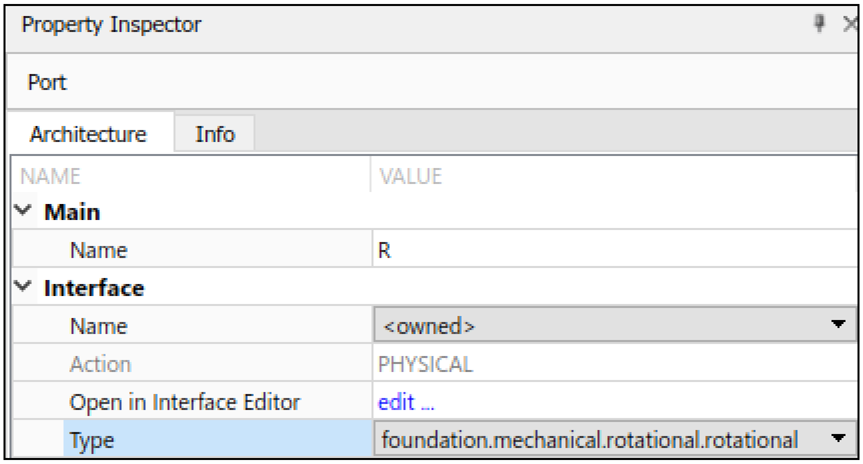
Double-click the subsystem component to describe component behavior using Simscape. For the DC motor this example is based on, see “Evaluating Performance of a DC Motor” (Simscape).

The physical interface can be decomposed into physical elements using a Simscape bus. Each physical element represents a conserving connection associated with a domain in Simscape. Simscape buses bundle conserving connections. For more information, see Simscape Bus (Simscape).

Add a Simscape Bus block next to the `E` physical port. Double-click the Simscape Bus and select the connection type `Bus: ElectricalInterface`. Connect the `E` physical port to the Simscape Bus block. The domain `foundation.electrical.electrical` defined under the **Type** of the `Positive` and `Negative` physical elements are used for any connections from these ports.



You can also use owned interfaces defined locally on ports to enable domain-specific lines on a Simscape behavior model in System Composer. Edit the port interface through the **Property Inspector**. Navigate to **Modeling** > **Property Inspector**. In this case, Simscape Bus blocks are not needed, and the port can connect directly to the physical connection of the specified domain. Add an owned physical interface to the physical port R with **Type** as a `foundation.mechanical.rotational.rotational` domain. Selecting **edit** to **Open in Interface Editor** enters the **Port Interface View** in the **Interface Editor**. For more information, see "Define Owned Interfaces Local to Ports" on page 3-10.



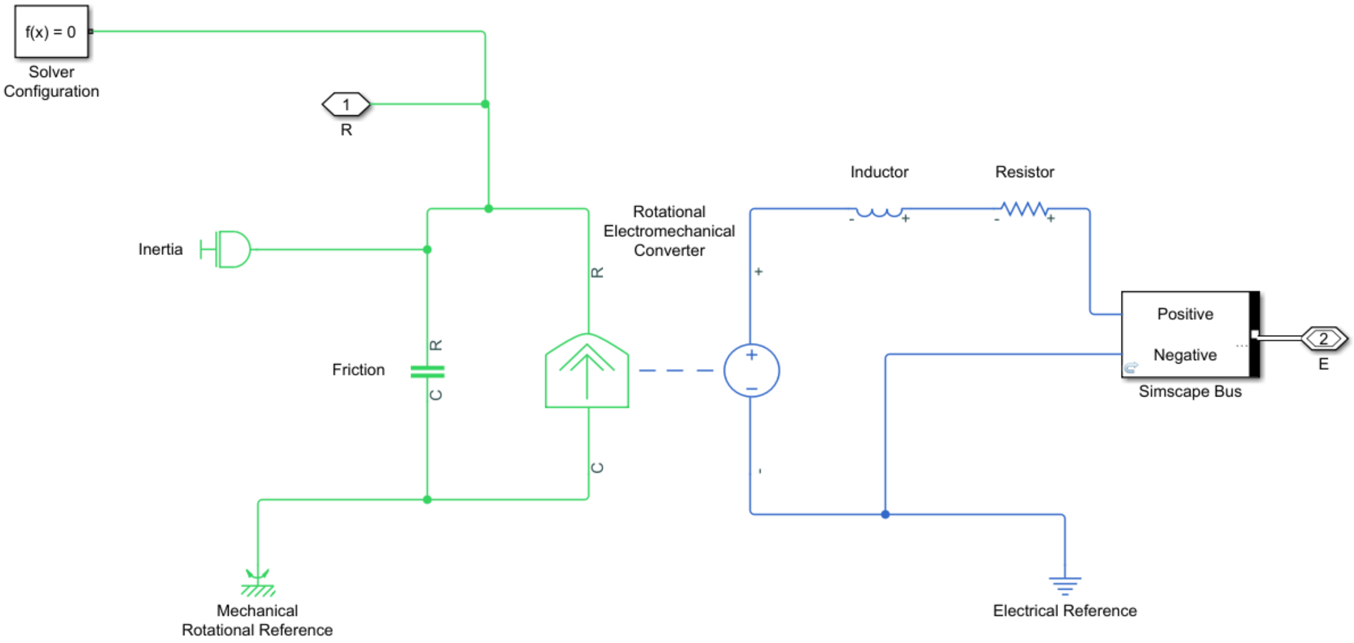
NAME	VALUE
Main	
Name	R
Interface	
Name	<owned>
Action	PHYSICAL
Open in Interface Editor	edit ...
Type	foundation.mechanical.rotational.rotational

Using the Library Browser, retrieve the following Simscape blocks and construct the DC Motor model with electrical and rotational mechanical domain-specific connectors.

A physical connector can represent a nondirectional conserving connection of a specific physical domain. Connectors can also represent physical signals.

Use physical connectors to connect physical components that represent features of a system to simulate mathematically.

For more information, see "Domain-Specific Line Styles" (Simscape).



Physical modeling uses the network approach and is therefore different from regular Simulink modeling. For more information, see “Modeling Best Practices” (Simscape) and “Troubleshooting Simulation Errors” (Simscape).

See Also

`createSimulinkBehavior` | `addPort` | `addPhysicalInterface` | `addElement` | `setInterface` | `createInterface`

More About

- “Describe System Behavior Using Sequence Diagrams” on page 6-2
- “Implement Component Behavior Using Simulink” on page 7-2
- “Implement Component Behavior Using Stateflow Charts” on page 7-14
- “Define Port Interfaces Between Components” on page 3-2

Merge Message Lines for Architectures Using Adapter Block

This example shows how to use an Adapter block to merge multiple message lines in a System Composer™ architecture model.

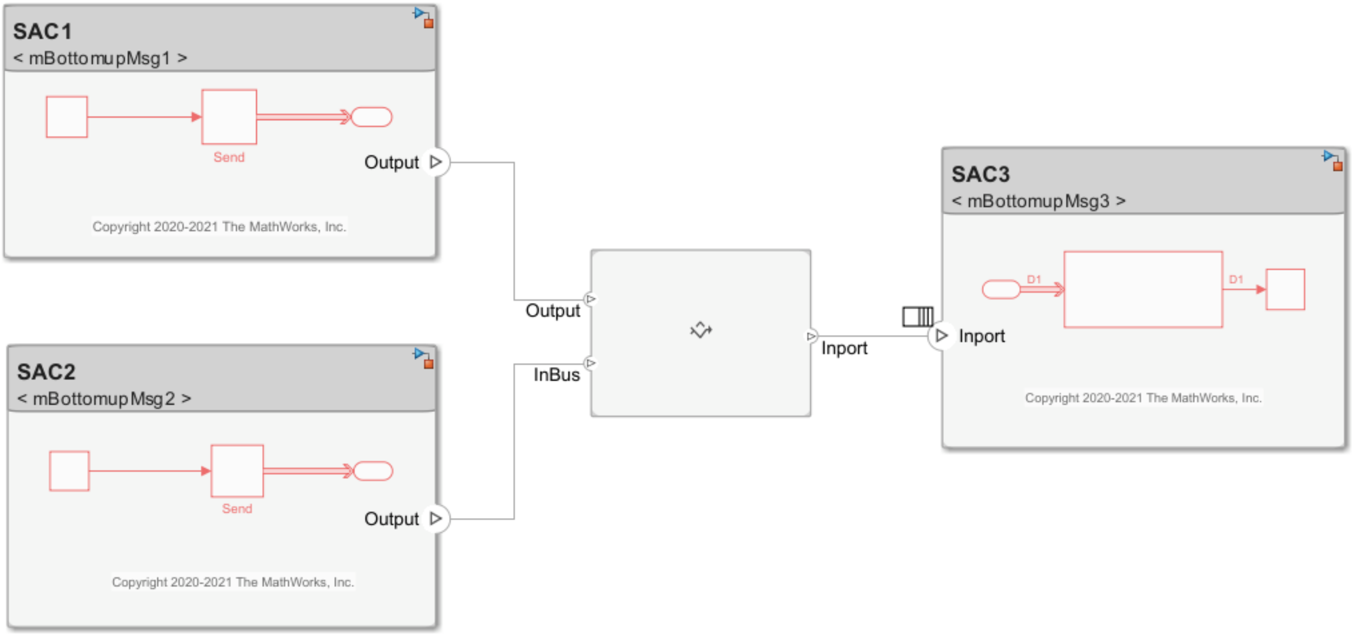
Open the model.

```
systemcomposer.openModel('mSysArchMessageMerge');
```

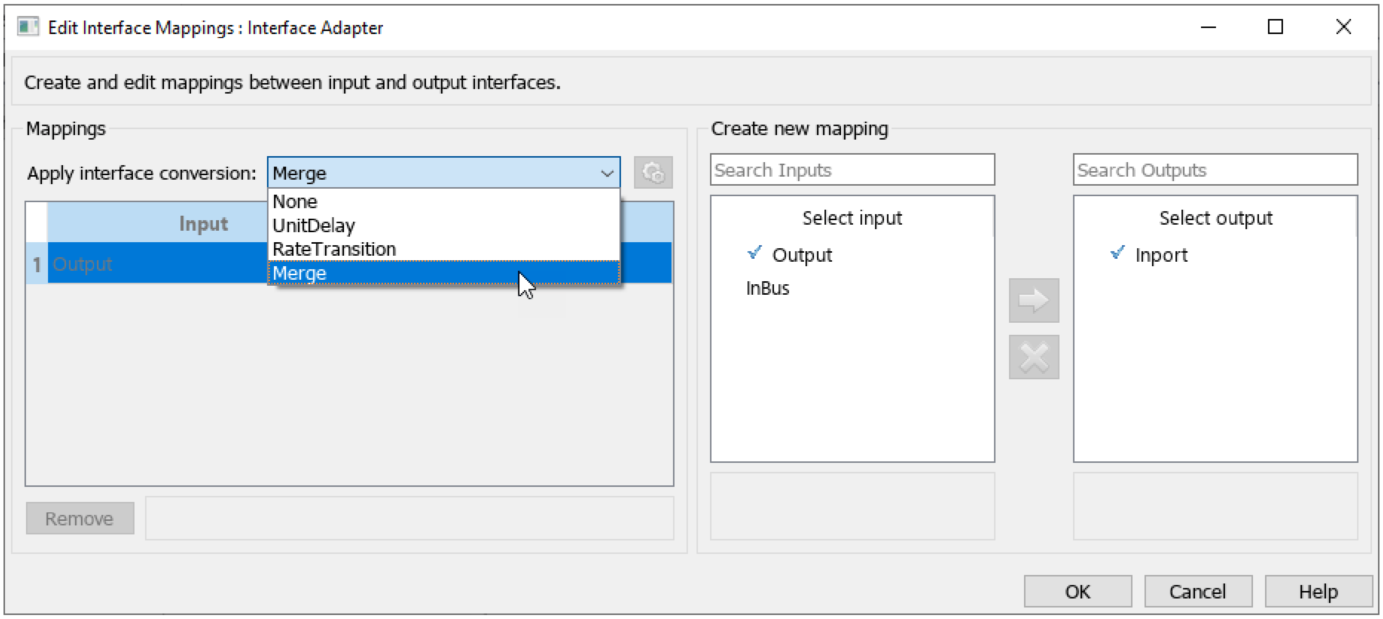
In this model, message-based communication is constructed between three software components: two send components, SAC1 and SAC2, create messages and send them to a receive component, SAC3.

- The SAC1 component linked to the Simulink® behavior model mBottomupMsg1 generates messages with value 1 with a 0.1 sample time.
- The SAC2 component linked to the Simulink behavior model mBottomupMsg2 generates messages with value 8 with a 0.2 sample time.
- The SAC3 component linked to the Simulink behavior model mBottomupMsg3 receives the merged messages using a rate-based Subsystem block with a 0.5 sample time.

A first-in, first-out (FIFO) queue is used as a message buffer between the components.


SAC1
< mBottomupMsg1 >
Send
Output
Copyright 2020-2021 The MathWorks, Inc.
SAC2
< mBottomupMsg2 >
Send
Output
Copyright 2020-2021 The MathWorks, Inc.
Output
InBus
Inport
SAC3
< mBottomupMsg3 >
D1
D1
Inport
Copyright 2020-2021 The MathWorks, Inc.

You can double-click the Adapter block to view the “Interface Adapter” on page 3-16 dialog box. Confirm that the interface conversion Merge is applied. Mappings are now disabled.


Edit Interface Mappings : Interface Adapter

Create and edit mappings between input and output interfaces.

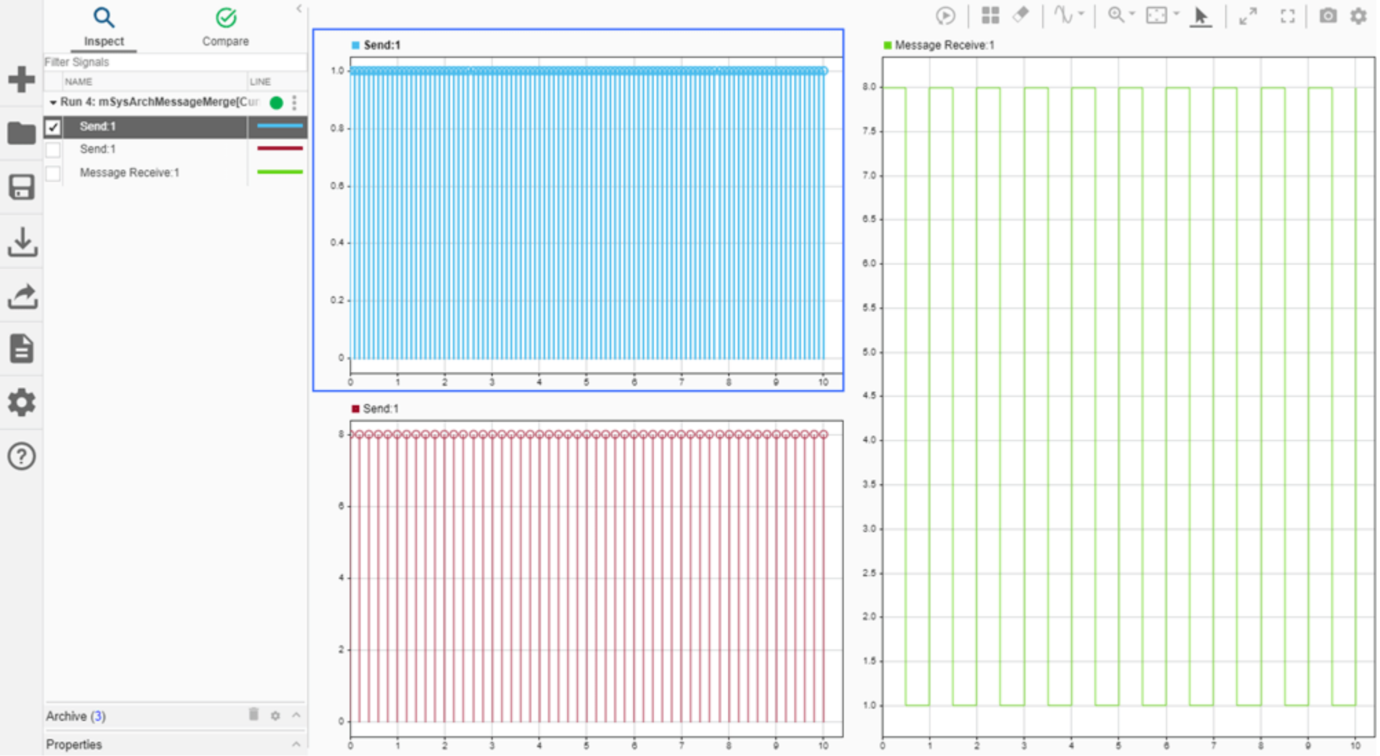
Apply interface conversion: Merge

Simulate the model to merge the messages from the send components SAC1 and SAC2 produced by Simulink behaviors into a single destination, the receive component SAC3.

```
sim('mSysArchMessageMerge');
```

Launch the Simulation Data Inspector to view the three messages together on the same diagram.

```
Simulink.sdi.view
```



See Also

Simulation Data Inspector | Adapter | Send | Receive

Related Examples

- “Merge Message Lines Using Adapter Block” on page 10-32
- “Merge Message Lines Using a Message Merge Block”
- “Create A Rate-Based Model”

Allocate Architecture Models

Create and Manage Allocations Interactively

This example shows how to create and manage System Composer allocations interactively on the model canvas and using the **Allocation Editor**.

In systems engineering, an architectural system is commonly described on different levels. Functional architectures describe the high-level functions of a system. Logical architectures describe the logical components of a system and how data is exchanged between them. You can use allocations to establish relationships from functional components to logical components and to indicate deployment strategies.

- An allocation establishes a directed relationship from architectural elements — components, ports, and connectors — in one model to architectural elements in another model.

  Resource-based allocation allows you to allocate functional architectural elements to logical architectural elements and logical architectural elements to physical architectural elements.
- An allocation scenario contains a set of allocations between a source and a target model.

  Allocate between model elements in an allocation scenario. The default allocation scenario is called `Scenario 1`.
- An allocation set consists of one or more allocation scenarios that describe various allocations between a source and a target model.

  Create an allocation set with allocation scenarios in the **Allocation Editor**. Allocation sets are saved as MLDATX files.

To create allocations programmatically, see “Create and Manage Allocations Programmatically” on page 8-8.

Create and Manage Allocations Interactively Using Tire Pressure Monitoring System

This example uses the Tire Pressure Monitoring System (TPMS) project. To open the project, use this command.

```
scExampleTirePressureMonitorSystem
```

Create Allocations between Two Models

You can create allocations between a functional architecture and a logical architecture of the TPMS to represent directed relationships between components, ports, and connectors.

1. Open the functional architecture model, which is the source model for allocations.

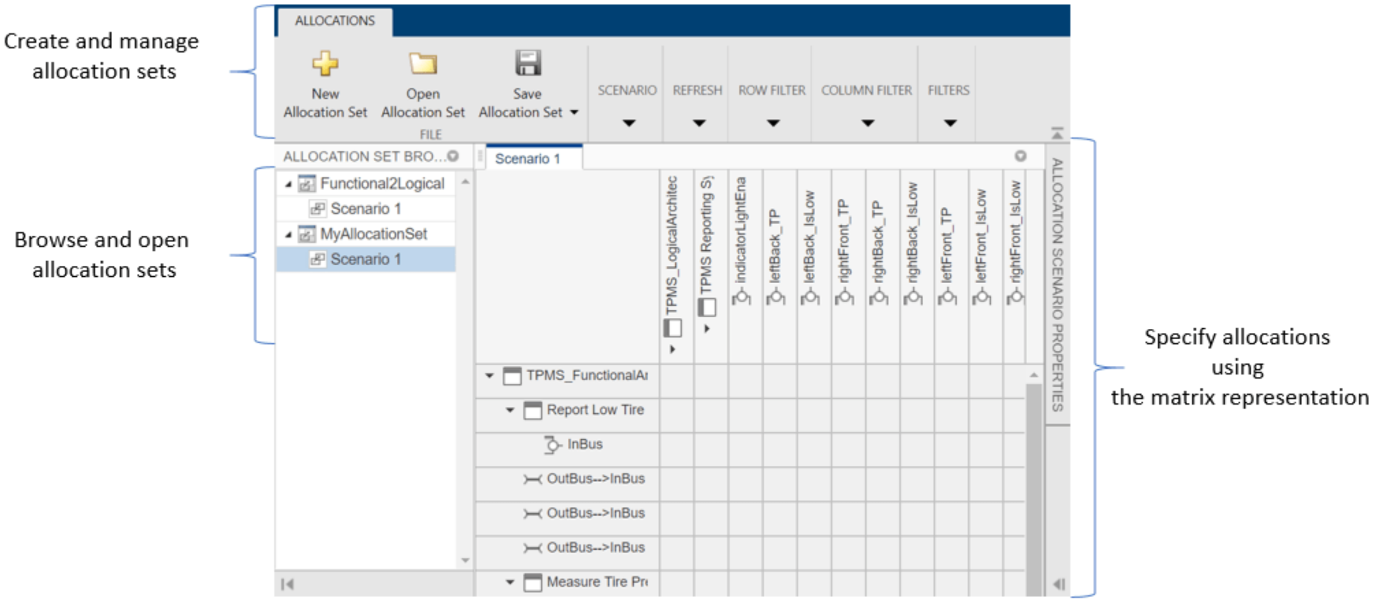
```
systemcomposer.openModel("TPMS_FunctionalArchitecture");
```

2. To create an allocation set for these models, launch the **Allocation Editor** by navigating to **Modeling** > **Allocation Editor** from the toolstrip.

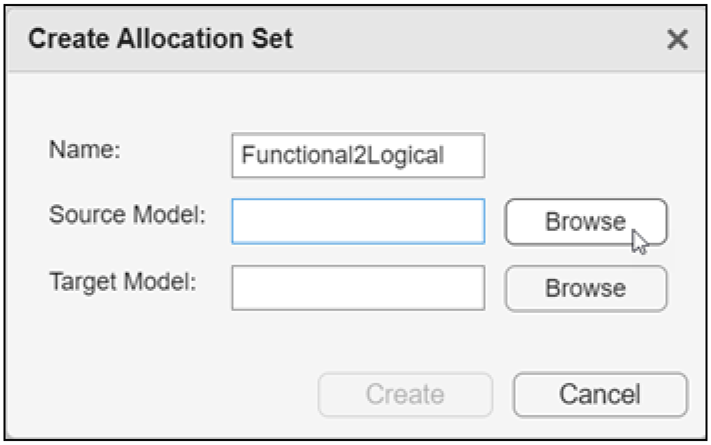
The **Allocation Editor** has three parts: the toolstrip, the browser pane, and the allocation matrix.

- Use the toolstrip to create and manage allocation sets.

- Use the **Allocation Set Browser** pane to browse and open existing allocation sets.
- Use the allocation matrix to specify allocations between the source model elements in the first column and target model elements in the first row. You can create allocations programmatically or by double-clicking a cell in the matrix.



3. Click **New Allocation Set** to create a new allocation set between two models and set the name. In this example, `TPMS_FunctionalArchitecture.slx` is the source model, and `TPMS_LogicalArchitecture.slx` is the target model.



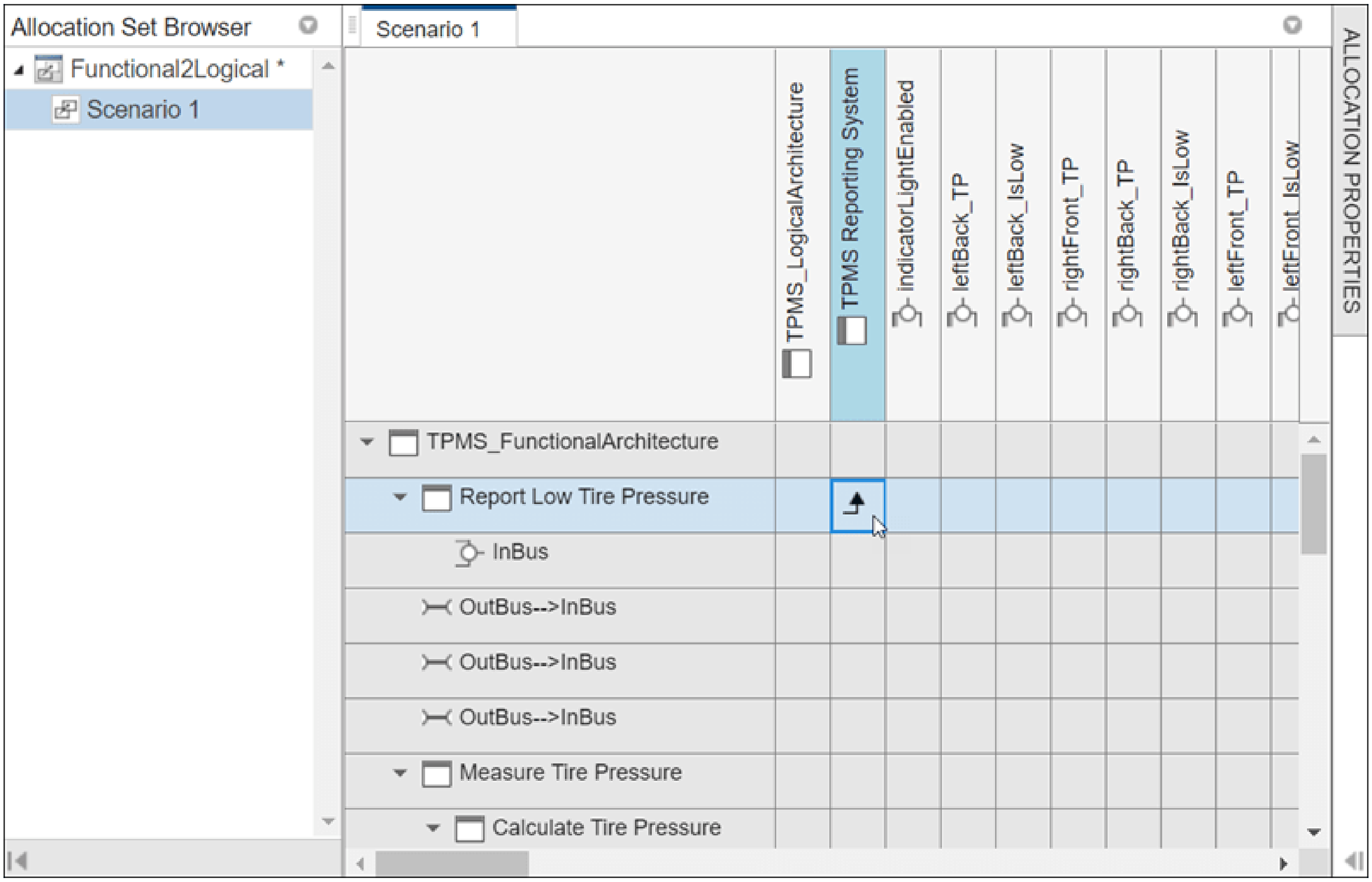
Create Allocation Set

Name: Functional2Logical

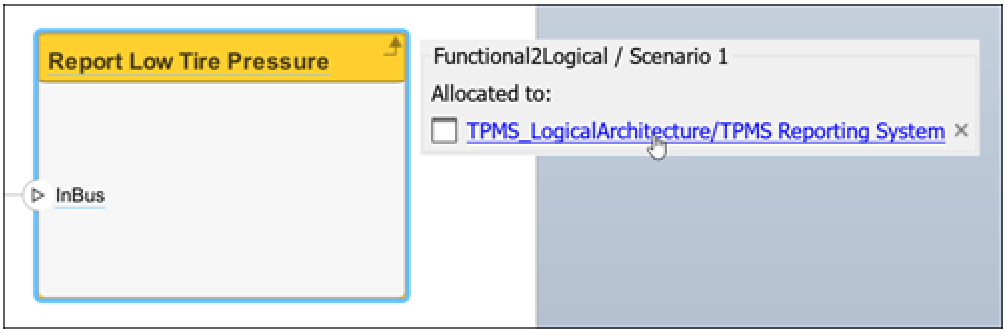
Source Model:

Target Model:

4. To create an allocation between two elements of the same type from the source model to the target model, double-click the corresponding cell in the allocation matrix. Double-click the cell for the `Report Low Tire Pressure` component on the souce model and the `TPMS Reporting System` component on the target model.



5. To show allocations on model elements for the source model `TPMS_FunctionalArchitecture`, on the toolstrip, navigate to **Modeling** > **Allocation Editor** > **Show Allocations**. Select the `Report Low Tire Pressure` source component and click the allocated to symbol. You will see the full path of the target component.

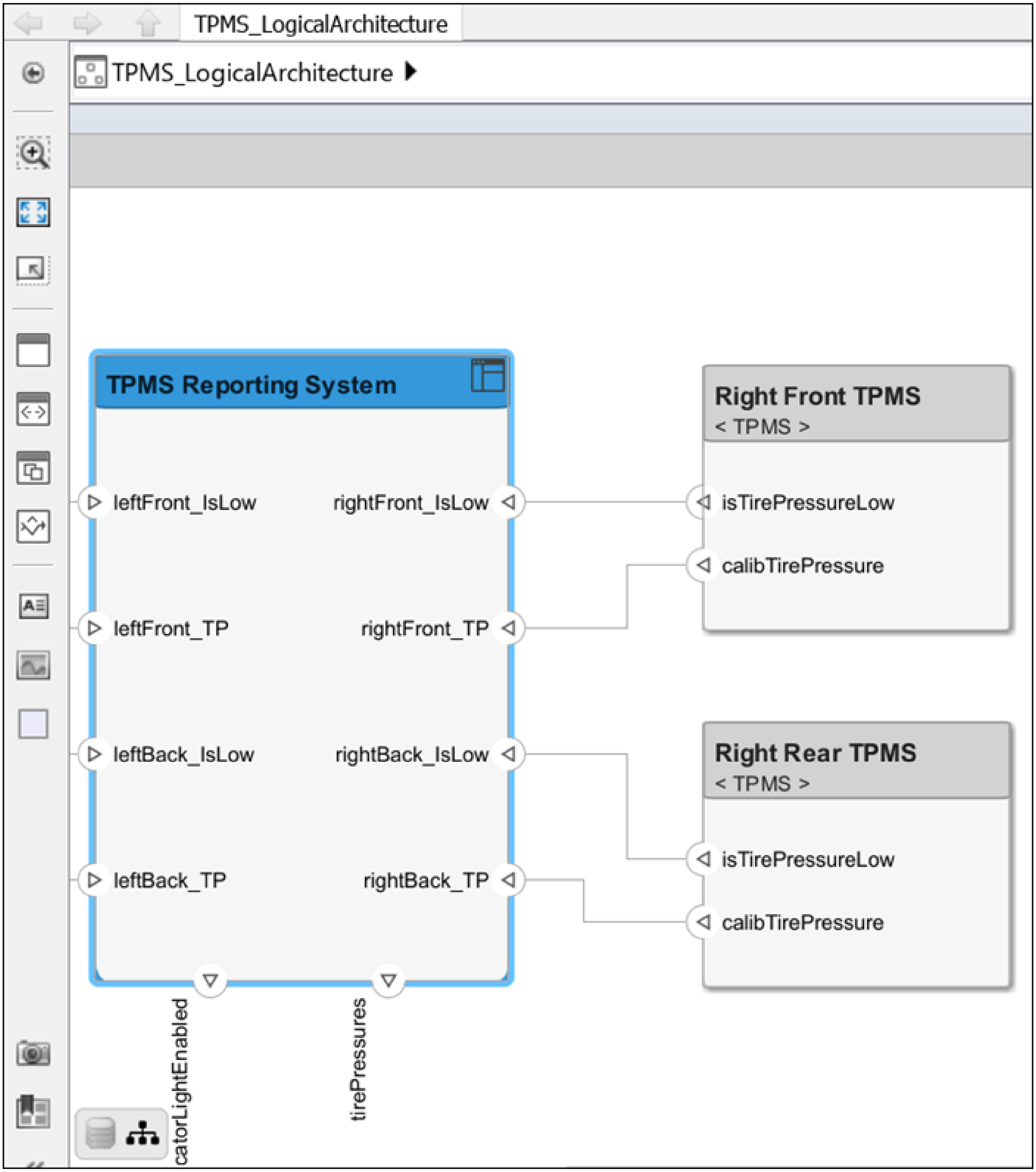


Functional2Logical / Scenario 1

Allocated to:

□ TPMS_LogicalArchitecture/TPMS Reporting System ×

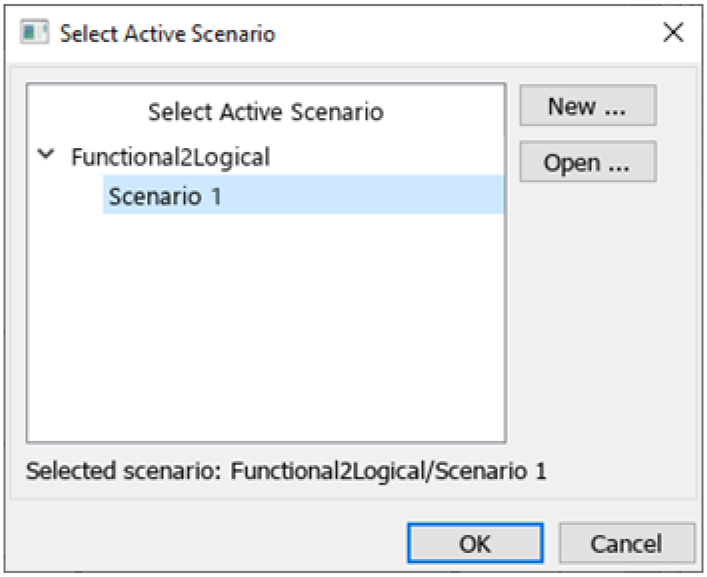
6. Click the target component to navigate to it on the target model.



TPMS_LogicalArchitecture
TPMS_LogicalArchitecture
TPMS Reporting System
leftFront_IsLow
rightFront_IsLow
leftFront_TP
rightFront_TP
leftBack_IsLow
rightBack_IsLow
leftBack_TP
rightBack_TP
catorLightEnabled
tirePressures
Right Front TPMS
< TPMS >
isTirePressureLow
calibTirePressure
Right Rear TPMS
< TPMS >
isTirePressureLow
calibTirePressure

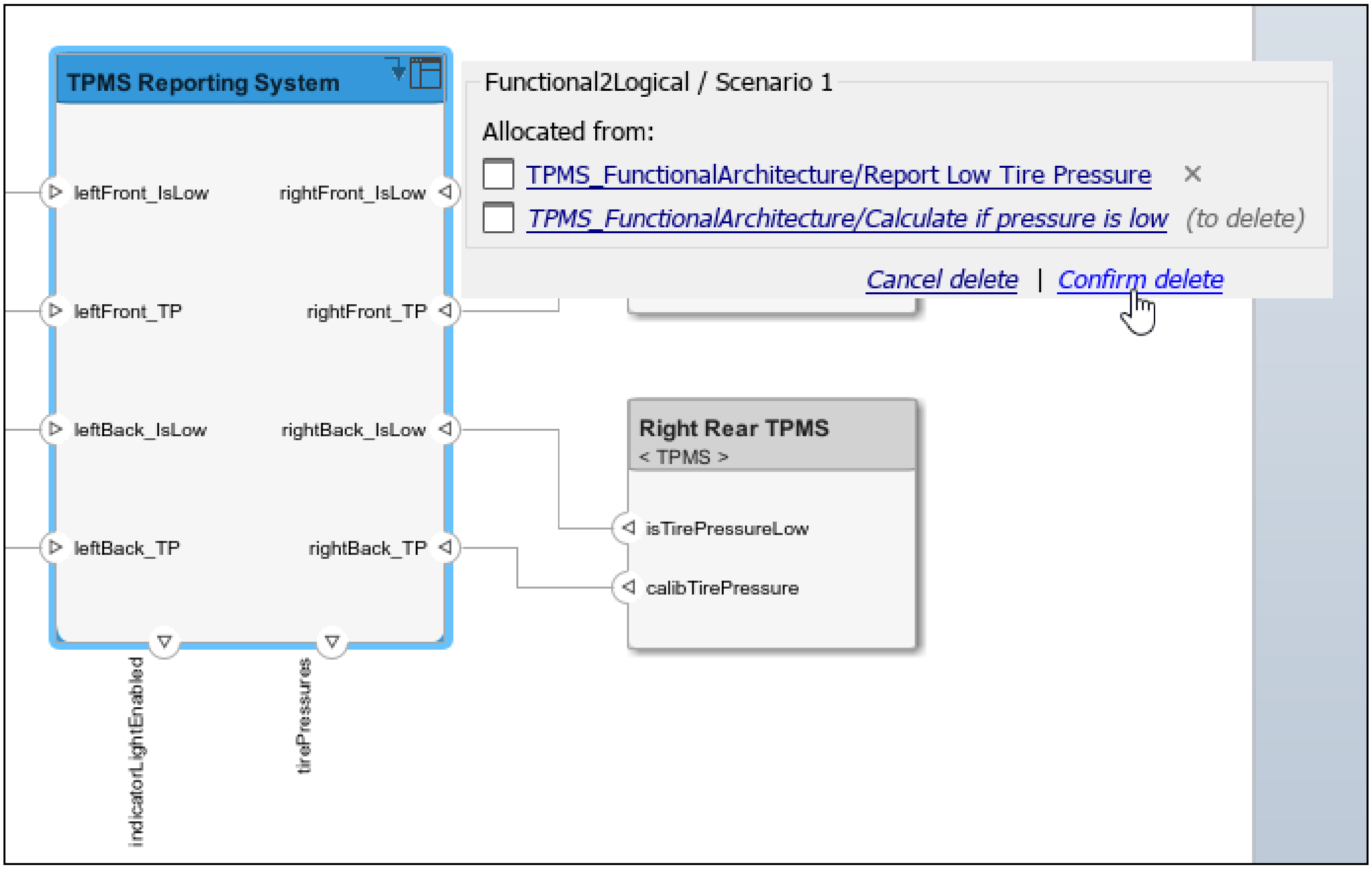
7. Return to the source model `TPMS_FunctionalArchitecture` and create a new allocation from a model element. Right-click the `Calculate if pressure is low` component, and from the tooltip select `Allocations`, then select `Select as allocation source`.

8. On the target model `TPMS_LogicalArchitecture`, right-click the `TPMS Reporting System` component, From the tooltip, select `Allocations`. Then, select `Allocate to selected element`. Choose the active allocation scenario.



Selected scenario: Functional2Logical/Scenario 1

9. To show allocations on model elements for the source model `TPMS_LogicalArchitecture`, on the toolstrip, navigate to **Modeling** > **Allocation Editor** > **Show Allocations**. Click the allocated from symbol on the `TPMS Reporting System` component to view the full path of the two allocated-from components. Click the delete icon on either component to delete the allocation and deallocate the components. Click `Confirm delete` to continue deleting.


Functional2Logical / Scenario 1

Allocated from:

□ TPMS_FunctionalArchitecture/Report Low Tire Pressure ×

□ *TPMS_FunctionalArchitecture/Calculate if pressure is low* *(to delete)*

Cancel delete | *Confirm delete*

See Also

systemcomposer.allocation.AllocationScenario | systemcomposer.allocation.AllocationSet | editor | getScenario | allocate | synchronizeChanges

More About

- “Create and Manage Allocations Programmatically” on page 8-8
- “Manage Requirements” on page 2-8
- “Analyze Architecture” on page 9-2
- “Allocate Architectures in Tire Pressure Monitoring System” on page 8-10
- “Simulate Mobile Robot with System Composer Workflow” on page 5-20

Create and Manage Allocations Programmatically

This example shows how to create and manage System Composer allocations using the **Allocation Editor** and programmatic interfaces.

- An allocation establishes a directed relationship from architectural elements — components, ports, and connectors — in one model to architectural elements in another model.

  Resource-based allocation allows you to allocate functional architectural elements to logical architectural elements and logical architectural elements to physical architectural elements.
- An allocation scenario contains a set of allocations between a source and a target model.

  Allocate between model elements in an allocation scenario. The default allocation scenario is called `Scenario 1`.
- An allocation set consists of one or more allocation scenarios that describe various allocations between a source and a target model.

  Create an allocation set with allocation scenarios in the **Allocation Editor**. Allocation sets are saved as MLDATX files.

To create allocations interactively, see "Create and Manage Allocations Interactively" on page 8-2.

Create and Manage Allocations Using Tire Pressure Monitoring System

This example uses the Tire Pressure Monitoring System (TPMS) project. To open the project, use this command.

```
scExampleTirePressureMonitorSystem
```

Create New Allocation Set

You can create an allocation set using the **Allocation Editor**. In this example, `TPMS_FunctionalArchitecture.slx` is the source model and `TPMS_LogicalArchitecture.slx` is the target model.

To create an allocation set for these models, use this command.

```
allocSet = systemcomposer.allocation.createAllocationSet(...
    'FunctionalToLogical', ...% Name of the allocation set
    'TPMS_FunctionalArchitecture', ... % Source model
    'TPMS_LogicalArchitecture' ... % Target model
     );
```

To see the allocation set, open the **Allocation Editor** by using this command.

```
systemcomposer.allocation.editor
```

Create Allocations between Two Models

This example shows how to programmatically create allocations between two models in the TPMS project.

Get handles to the reporting functions in the functional architecture model.

```
functionalArch = systemcomposer.loadModel('TPMS_FunctionalArchitecture');
reportLevels = functionalArch.lookup('Path','TPMS_FunctionalArchitecture/Report Tire Pressure Lev
reportLow = functionalArch.lookup('Path','TPMS_FunctionalArchitecture/Report Low Tire Pressure')
```

Get the handle to the TPMS reporting system component in the logical architecture model.

```
logicalArch = systemcomposer.loadModel('TPMS_LogicalArchitecture');
reportingSystem = logicalArch.lookup('Path','TPMS_LogicalArchitecture/TPMS Reporting System');
```

Create the allocations in the default scenario that is created.

```
defaultScenario = allocSet.getScenario('Scenario 1');
defaultScenario.allocate(reportLevels,reportingSystem);
defaultScenario.allocate(reportLow,reportingSystem);
```

Optionally, you can delete the allocation between reporting low tire pressure and the reporting system.

```
% defaultScenario.deallocate(reportLow,reportingSystem);
```

See Also

`systemcomposer.allocation.AllocationScenario` | `systemcomposer.allocation.AllocationSet` | `editor` | `getScenario` | `allocate` | `synchronizeChanges`

More About

- “Create and Manage Allocations Interactively” on page 8-2
- “Manage Requirements” on page 2-8
- “Analyze Architecture” on page 9-2
- “Allocate Architectures in Tire Pressure Monitoring System” on page 8-10
- “Simulate Mobile Robot with System Composer Workflow” on page 5-20

Allocate Architectures in Tire Pressure Monitoring System

Use allocations to analyze a tire pressure monitoring system.

Overview

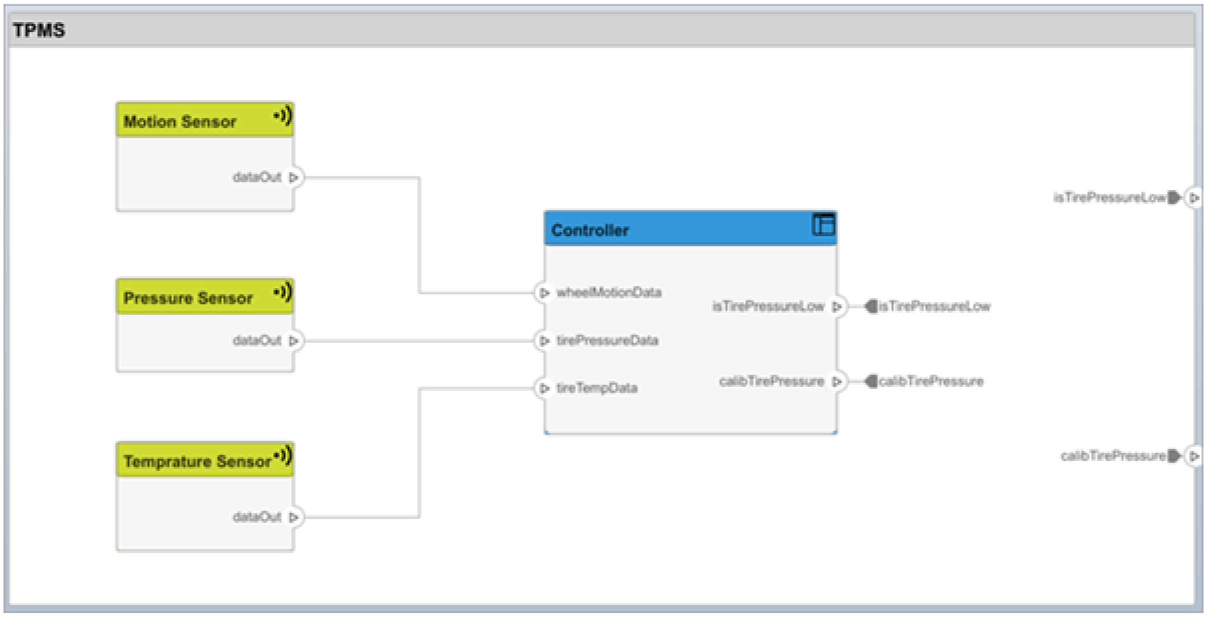
In systems engineering, it is common to describe a system at different levels of abstraction. For example, you can describe a system in terms of its high-level functions. These functions may not have any behavior associated with them but most likely trace back to some operating requirements the system must fulfill. We refer to this layer (or architecture) as the *functional architecture*. In this example, an automobile tire pressure monitoring system is described in three different architectures:

1. Functional Architecture — Describes the system in terms of its high-level functions. The connections show dependencies between functions.
2. Logical Architecture — Describes the system in terms of its logical components and how data is exchanged between them. Additionally, this architecture specifies behaviors for model simulation.
3. Platform Architecture — Describes the physical hardware needed for the system at a high level.

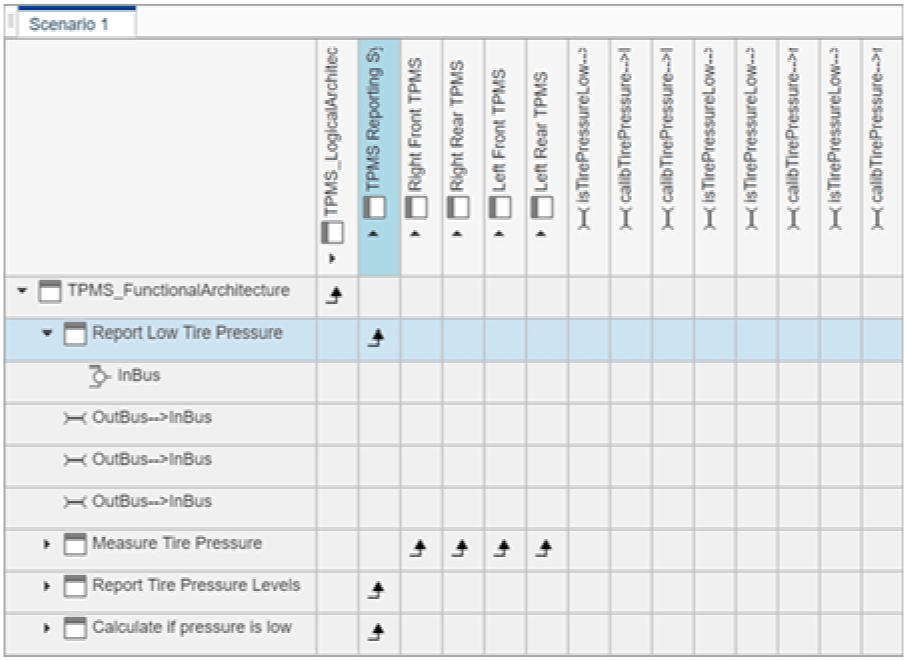
The allocation process is defined as linking these three architectures that fully describe the system. The linking captures the information about each architectural layer and makes it accessible to the others.

Use this command to open the project.

```
scExampleTirePressureMonitorSystem
```



Open the `FunctionalAllocation.mldatx` file, which displays allocations from `TPMS_FunctionalArchitecture` to `TPMS_LogicalArchitecture` in the Allocation Editor. The elements of `TPMS_FunctionalArchitecture` are displayed in the first column. The elements of `TPMS_LogicalArchitecture` are displayed in the first row. The arrows indicate the allocations between model elements.



	TPMS_LogicalArchitec	TPMS Reporting Sy	Right Front TPMS	Right Rear TPMS	Left Front TPMS	Left Rear TPMS	isTirePressureLow-->	calibTirePressure-->I	calibTirePressure-->I	isTirePressureLow-->	isTirePressureLow-->	calibTirePressure-->I	isTirePressureLow-->	calibTirePressure-->I
TPMS_FunctionalArchitecture	↑													
Report Low Tire Pressure		↑												
InBus														
OutBus-->InBus														
OutBus-->InBus														
OutBus-->InBus														
Measure Tire Pressure			↑	↑	↑	↑								
Report Tire Pressure Levels		↑												
Calculate if pressure is low		↑												

The arrows display allocated components in the model. You can observe allocations for each element in the model hierarchy.

The rest of the example shows how to use this allocation information to further analyze the model.

Functional to Logical Allocation and Coverage Analysis

This section shows how to perform coverage analysis to verify that all functions have been allocated. This process requires using the allocation information specified between the functional and logical architectures.

To start the analysis, load the allocation set.

```
allocSet = systemcomposer.allocation.load('FunctionalAllocation');
scenario = allocSet.Scenarios;
```

Verify that each function in the system is allocated.

```
import systemcomposer.query.*;
[~, allFunctions] = allocSet.SourceModel.find(HasStereotype(IsStereotypeDerivedFrom("TPMSProfi
unAllocatedFunctions = [];
for i = 1:numel(allFunctions)
    if isempty(scenario.getAllocatedTo(allFunctions(i)))
        unAllocatedFunctions = [unAllocatedFunctions allFunctions(i)];
    end
end

if isempty(unAllocatedFunctions)
    fprintf('All functions are allocated');
else
    fprintf('%d Functions have not been allocated', numel(unAllocatedFunctions));
end
```

```
All functions are allocated
```

The result displays `All functions are allocated` to verify that all functions in the system are allocated.

Analyze Suppliers Providing Functions

This section shows how to identify which functions will be provided by which suppliers using the specified allocations. Since suppliers will be delivering these components to the system integrator, the supplier information is stored in the logical model.

```
suppliers = {'Supplier A', 'Supplier B', 'Supplier C', 'Supplier D'};
functionNames = arrayfun(@(x) x.Name, allFunctions, 'UniformOutput', false);
numFunNames = length(allFunctions);
numSuppliers = length(suppliers);
allocTable = table('Size', [numFunNames, numSuppliers], 'VariableTypes', repmat("double", 1, nu
allocTable.Properties.VariableNames = suppliers;
allocTable.Properties.RowNames = functionNames;
for i = 1:numFunNames
    elem = scenario.getAllocatedTo(allFunctions(i));
    for j = 1:numel(elem)
        elemSupplier = elem(j).getEvaluatedPropertyValue("TPMSProfile.LogicalComponent.Supplie
        allocTable{i, strcmp(elemSupplier, suppliers)} = 1;
    end

end
```

The table shows which suppliers are responsible for the corresponding functions.

```
allocTable
```

```
allocTable=8×4 table
                                    Supplier A    Supplier B    Supplier C    Supplier D
                                    __________    __________    __________    __________

    Measure temprature of tire          0             0             0             1     
    Measure rotations                   0             1             0             0     
    Calculate Tire Pressure             0             1             0             0     
    Report Tire Pressure Levels         1             0             0             0     
    Measure pressure on tire            0             0             1             0     
    Measure Tire Pressure               0             0             0             0     
    Report Low Tire Pressure            1             0             0             0     
    Calculate if pressure is low        1             0             0             0     
```

Analyze Software Deployment Strategies

You can determine if the Engine Control Unit (ECU) has enough capacity to house all the software components. The software components are allocated to the cores themselves, but the ECU is the component that has the budget property.

Get the platform architecture.

```
platformArch = systemcomposer.loadModel('PlatformArchitecture');
```

Load the allocation.

```
softwareDeployment = systemcomposer.allocation.load('SoftwareDeployment');

frontECU = platformArch.lookup('Path', 'PlatformArchitecture/Front ECU');
```

```
rearECU = platformArch.lookup('Path', 'PlatformArchitecture/Rear ECU');

scenario1 = softwareDeployment.getScenario('Scenario 1');
scenario2 = softwareDeployment.getScenario('Scenario 2');
frontECU_availMemory = frontECU.getEvaluatedPropertyValue("TPMSProfile.ECU.MemoryCapacity");
rearECU_availMemory = rearECU.getEvaluatedPropertyValue("TPMSProfile.ECU.MemoryCapacity");

frontECU_memoryUsed1 = getUtilizedMemoryOnECU(frontECU, scenario1);
frontECU_isOverBudget1 = frontECU_memoryUsed1 > frontECU_availMemory;
rearECU_memoryUsed1 = getUtilizedMemoryOnECU(rearECU, scenario1);
rearECU_isOverBudget1 = rearECU_memoryUsed1 > rearECU_availMemory;

frontECU_memoryUsed2 = getUtilizedMemoryOnECU(frontECU, scenario2);
frontECU_isOverBudget2 = frontECU_memoryUsed2 > frontECU_availMemory;
rearECU_memoryUsed2 = getUtilizedMemoryOnECU(rearECU, scenario2);
rearECU_isOverBudget2 = rearECU_memoryUsed2 > rearECU_availMemory;
```

Build a table to showcase the results.

```
softwareDeploymentTable = table([frontECU_memoryUsed1;frontECU_availMemory; ...
    frontECU_isOverBudget1;rearECU_memoryUsed1;rearECU_availMemory;rearECU_isOverBudget1], ...
    [frontECU_memoryUsed2; frontECU_availMemory; frontECU_isOverBudget2;rearECU_memoryUsed2; .
    rearECU_availMemory; rearECU_isOverBudget2], ...
    'VariableNames',{'Scenario 1','Scenario 2'},...
    'RowNames', {'Front ECUMemory Used (MB)', 'Front ECU Memory (MB)', 'Front ECU Overloaded',
    'Rear ECU Memory Used (MB)', 'Rear ECU Memory (MB)', 'Rear ECU Overloaded'})
```

```
softwareDeploymentTable=6×2 table
                                 Scenario 1    Scenario 2
                                 __________    __________

    Front ECUMemory Used (MB)       110             90
    Front ECU Memory (MB)           100            100
    Front ECU Overloaded              1              0
    Rear ECU Memory Used (MB)         0             20
    Rear ECU Memory (MB)            100            100
    Rear ECU Overloaded               0              0
```

```
function memoryUsed = getUtilizedMemoryOnECU(ecu, scenario)
```

For each component in the ECU, accumulate the binary size required for each allocated software component.

```
coreNames = {'Core1','Core2','Core3','Core4'};
memoryUsed = 0;
for i = 1:numel(coreNames)
    core = ecu.Model.lookup('Path', [ecu.getQualifiedName '/' coreNames{i}]);
    allocatedSWComps = scenario.getAllocatedFrom(core);
    for j = 1:numel(allocatedSWComps)
        binarySize = allocatedSWComps(j).getEvaluatedPropertyValue("TPMSProfile.SWComponent.Bi
        memoryUsed = memoryUsed + binarySize;
    end
end
```

```
end
```

See Also

`getAllocatedTo` | `load` | `getScenario` | `getAllocatedFrom` | `synchronizeChanges` | `getEvaluatedPropertyValue` | `systemcomposer.loadModel` | `find` | `getQualifiedName` | `lookup`

More About

- “Create and Manage Allocations Interactively” on page 8-2
- “Create and Manage Allocations Programmatically” on page 8-8
- “Analyze Architecture” on page 9-2
- “Analysis Function Constructs” on page 9-9
- “Organize System Composer Files in Projects” on page 12-2
- “Simulate Mobile Robot with System Composer Workflow” on page 5-20

Systems Engineering Approach for SoC Applications

This example shows how to design a sample signal detector application on a System on Chip (SoC) platform using a systems engineering approach. The workflow in this example maps the application functions onto the selected hardware architecture.

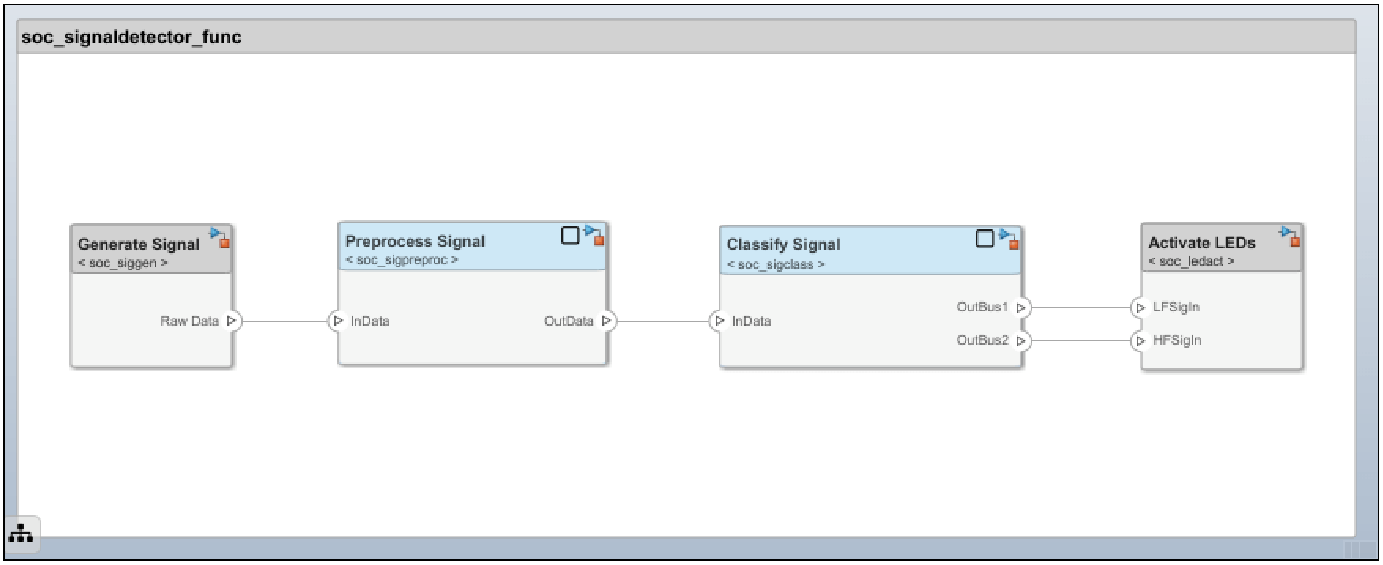
The signal detector application continuously processes the signal data and classifies the signal as either high or low frequency. The signal cannot change between high- and low-frequency classes faster than 1 ms. The signal is sampled at the rate of 10 MHz.

Functional Architecture

Define the functional architecture of the application. At this stage, the implementation of the application components is not known. You can use the System Composer™ software to capture the functional architecture.

This model represents the functional architecture with its main software components and their connections.

```
systemcomposer.openModel('soc_signaldetector_func');
```



The functional architecture of the application consists of these top-level components:

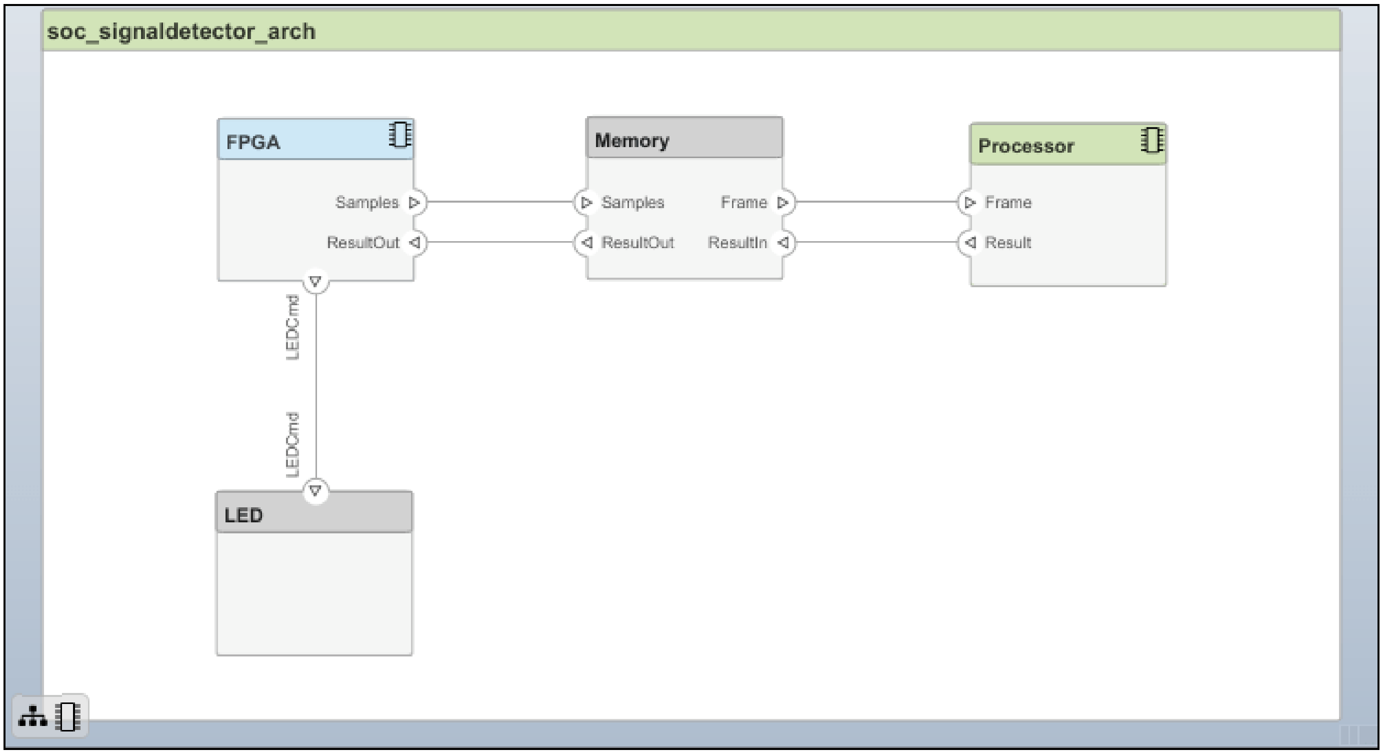
1. Generate Signal
2. Preprocess Signal
3. Classify Signal
4. Activate LEDs

Hardware Architecture

Select the hardware architecture. Due to the anticipated application complexity, choose an SoC device. The chosen SoC device has a hardware programmable logic (FPGA) core and an embedded processor (ARM) core. You can use the System Composer software to capture the details of the hardware architecture.

This model represents the hardware architecture with its main hardware components and their connections.

```
systemcomposer.openModel('soc_signaldetector_arch');
```



Behavioral Modeling

If the implementations for functional components are available, you can add them to the functional architecture as behaviors. In System Composer, for each functional component, you can link the implementation behaviors as Simulink® models. To review the component implementations, double-click each component in the functional architecture model.

After you define the behavior of each component, you can simulate the behavior of the entire application and verify its functional correctness. Select **Run** in the functional architecture model. Then, analyze the signals classification results in the **Simulation Data Inspector**. To change the signal type, select the `Generate Signal` component and then select the Manual Switch block. Confirm that the source signal is classified correctly.

Allocation of Functional and Hardware Elements

After refining the functional and hardware architecture, allocate different functional components to different hardware elements to meet desired system performance benchmarks. In this case, some functional components are constrained as to where in the hardware architecture they can be implemented. You must implement the `Generate Signal` and `Activate LEDs` components on the FPGA core in the chosen hardware architecture due to input output (I/O) connections. Comparatively, you can implement the `Preprocess Signal` and `Classify Signal` components on either the FPGA or on the processor core.

```
          Component   Constraint
       Generate Signal       FPGA
```

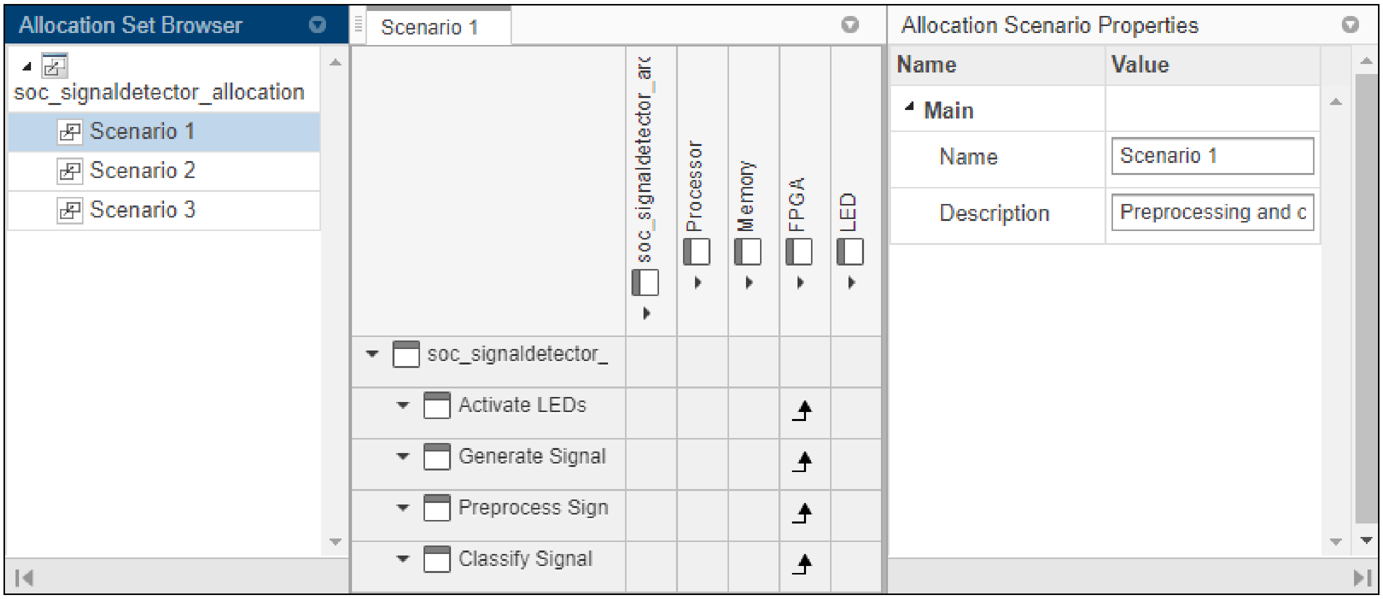
```
          Preprocess Signal           -
            Classify Signal           -
              Activate LEDs        FPGA
```

This example shows how to use three possible scenarios for allocating the application functional architecture to the hardware architecture.

- The FPGA handles preprocessing and classification.
- The FPGA handles preprocessing and the processor handles classification.
- The processor handles preprocessing and classification.

System Composer captures these scenarios as `Scenario 1`, `Scenario 2`, and `Scenario 3` using the Allocation Editor.

```
allocSet = systemcomposer.allocation.load('soc_signaldetector_allocation');
systemcomposer.allocation.editor
```



Name	Value
Main	
Name	Scenario 1
Description	Preprocessing and c

Choosing an allocation scenario requires finding an implementation that optimally meets the application requirements. Often you can find this implementation via static analysis without detailed simulation. In this example, use static analysis to analyze the computational costs of implementing different functional components on the processor and on the FPGA.

Implementation Cost

The implementation cost of a component depends on the required computation operations. To determine the implementation costs, consider these typical approaches.

- Component implementation is not available: Obtain the computational cost from the available reference implementations.
- The implementation and the hardware are available: Measure or profile the implementation cost on the candidate hardware.
- The implementation is available, but the hardware is not: Estimate the implementation cost by using the SoC Blockset™ algorithm analyzer function `socAlgorithmAnalyzerReport`.

The socModelAnalyzer function estimates the number of operations in a Simulink model and generates an algorithm analyzer report. To get the number of operations that a model executes to then analyze the implementation cost on the processor, use the dynamic analysis function option. To get the number of operators an algorithm requires to then analyze the implementation cost on the FPGA, use the static analysis function option. For an example on how to use socModelAnalyzer, see this sample function.

```
soc_signaldetector_costanalysis
```

```
*** Component: 'Preprocess Signal'
                                ADD(+)    MUL(*)
                                ______    ______

    FPGA Implementation            15        16
    Processor Implementation    15300     16320



*** Component: 'Classify Signal'
                                ADD(+)    MUL(*)
                                ______    ______

    FPGA Implementation            32        18
    Processor Implementation    32640     18360
```

The implementation costs for each functional component obtained in this code are entered in the corresponding stereotypes in the functional architecture. To verify the values, select each component in the functional architecture model and use the Property Inspector.

To learn more about socModelAnalyzer, see the “Compare FIR Filter Implementations Using socModelAnalyzer” (SoC Blockset) example. This example shows how to analyze the computational complexity of different implementations of a Simulink algorithm.

Allocation Choice

You can use the number of operators or operations that are required for implementing the application functional components to decide how to allocate the functional components to the hardware components. Analyze the candidate allocations by comparing the implementation cost against the available resources of the FPGA and the processor. This example uses sample values in the FPGA and the processor components in the hardware architecture model for the available computation resources. Verify the values by using the Property Inspector.

Typically, the analysis does not use the number of operators or operations directly. Rather, the number of operators or operations are multiplied by the cost of each operator or operation first. The cost of the operator or operations is hardware dependent. Determining such costs is beyond the scope of this example.

For an example on how to use the cost models, use this function. Observe that we require the capacity of the FPGA and the processor be greater than the estimated implementation cost as well as that the processor headroom be between 60 and 90 %.

```
soc_signaldetector_partitionanalysis
```

```
                  FPGA DSPs Used (out of 900)    FPGA LUT Used (out of 218600)    Processor Instr
                  ___________________________    _____________________________    _______________
```

```
    Scenario 1                 34                                576
    Scenario 2                 16                                192
    Scenario 3                  0                                  0
```

Based on the results Scenario 2 is feasible.

Data Path Design Between FPGA and Processor

The FPGA processes data sample-by-sample, and the processor processes frame-by-frame. Because the duration of a processor task can vary, to prevent data loss, a queue is needed to hold the data between the FPGA and processor. In this case you must set these parameters that are related to the queue: frame size, number of frame buffers, and FIFO size (that is, the number of samples in the FIFO). Also, in embedded applications, the task durations can vary between different task instances (for example, due to different code execution paths or due to variations in OS switching time). As a result, data might be dropped in the memory channel. The “Streaming Data from Hardware to Software” (SoC Blockset) example shows a systematic approach to choosing the previously mentioned parameters that satisfy the application requirements.

See Also

`socAlgorithmAnalyzerReport` | `socModelAnalyzer` | `systemcomposer.allocation.editor`

More About

- “Using the Algorithm Analyzer Report” (SoC Blockset)
- “Create and Manage Allocations Programmatically” on page 8-8
- “Analyze Architecture” on page 9-2
- “Compose Architectures Visually” on page 1-2
- “Implement Component Behavior Using Simulink” on page 7-2

Analyze Architecture Model

Analyze Architecture

Perform static analysis on a System Composer architecture to evaluate characteristics of the system.

Analysis is a method for quantitatively evaluating an architecture for certain characteristics. Static analysis analyzes the structure of the system. Static analysis uses an analysis function and parametric values of properties captured in the system model.

Use analyses to calculate overall reliability, mass roll-up, performance, or thermal characteristics of a system, or to perform a SWaP analysis.

Write static analyses based on element properties to perform data-driven trade studies and verify system requirements. Consider an electromechanical system where there is a trade-off between cost and weight, and lighter components tend to cost more. The decision process involves analyzing the overall cost and weight of the system based on the properties of its elements, and iterating on the properties to arrive at a solution that is acceptable both from the cost and weight perspective.

The analysis workflow consists of these steps:

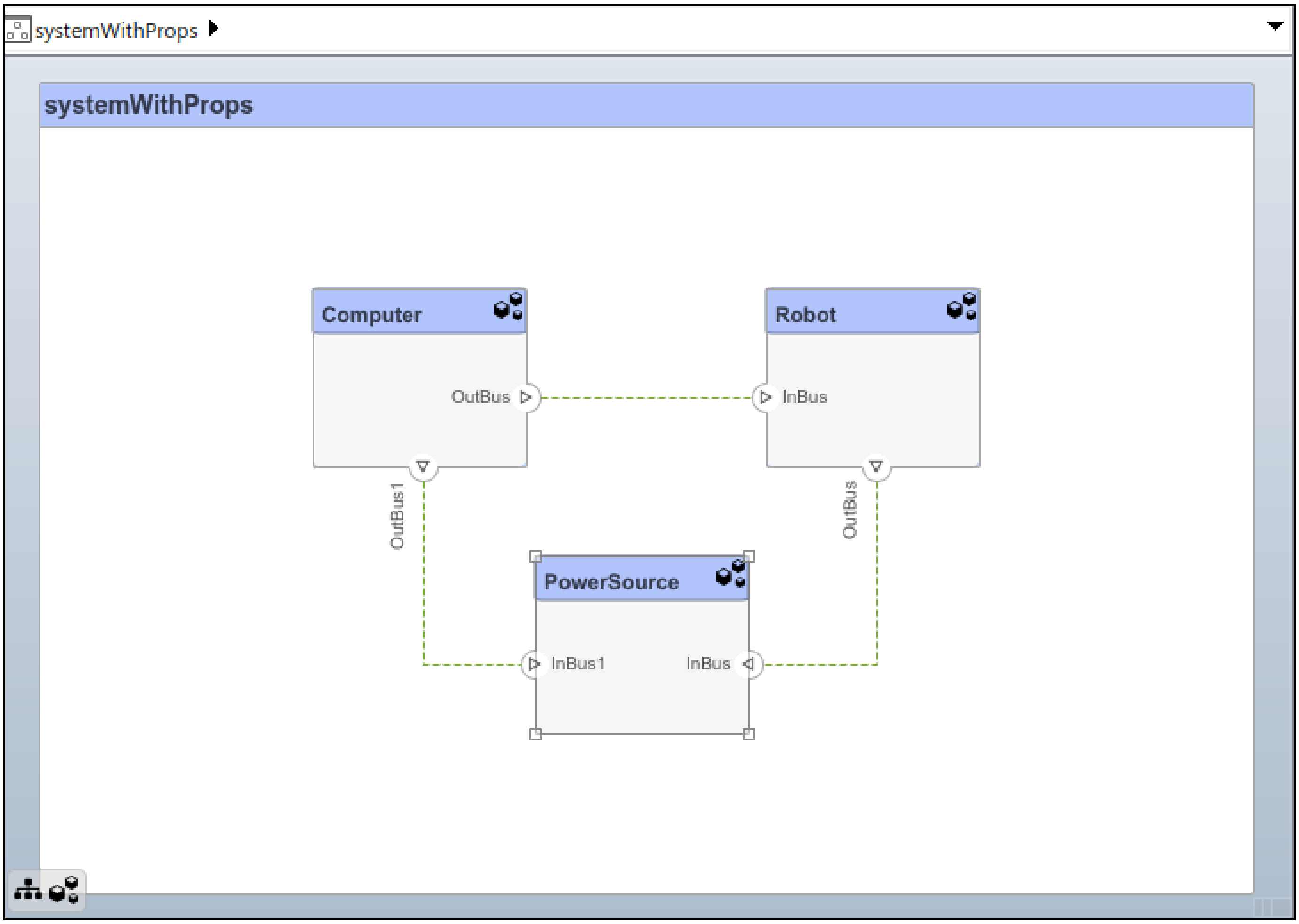
1. Define a profile containing a set of stereotypes that describe some analyzable properties (for example, cost and weight).
2. Apply the profile to an architecture model and add stereotypes from that profile to elements of the model (components, ports, or connectors).
3. Specify values for the properties on those elements.
4. Write an analysis function to compute values necessary for the trade study. This is a static constraint solver for parametrics and values of related properties captured in the system model.
5. Create an instance of the architecture model, which is a tree of elements, corresponding to the model hierarchy with all shared architectures expanded and a variant configuration applied. Use the **Instantiate Architecture Model** tool.
6. Run the analysis function and then see analysis calculations and results in the **Analysis Viewer** tool.

Set Properties for Analysis

This example shows how to enable analysis by adding stereotypes to model elements and setting property values. The model provides the basis to analyze the trade-off between total cost and weight of the components in a simple architecture model of a robot system.

Open the Model

Open the `systemWithProps` architecture model.



Import Profile

Enable analysis of properties by first importing a profile. In the toolstrip, navigate to **Modeling** > **Profiles** > **Import** and browse to the profile to import it.

Apply Stereotypes to Model Elements

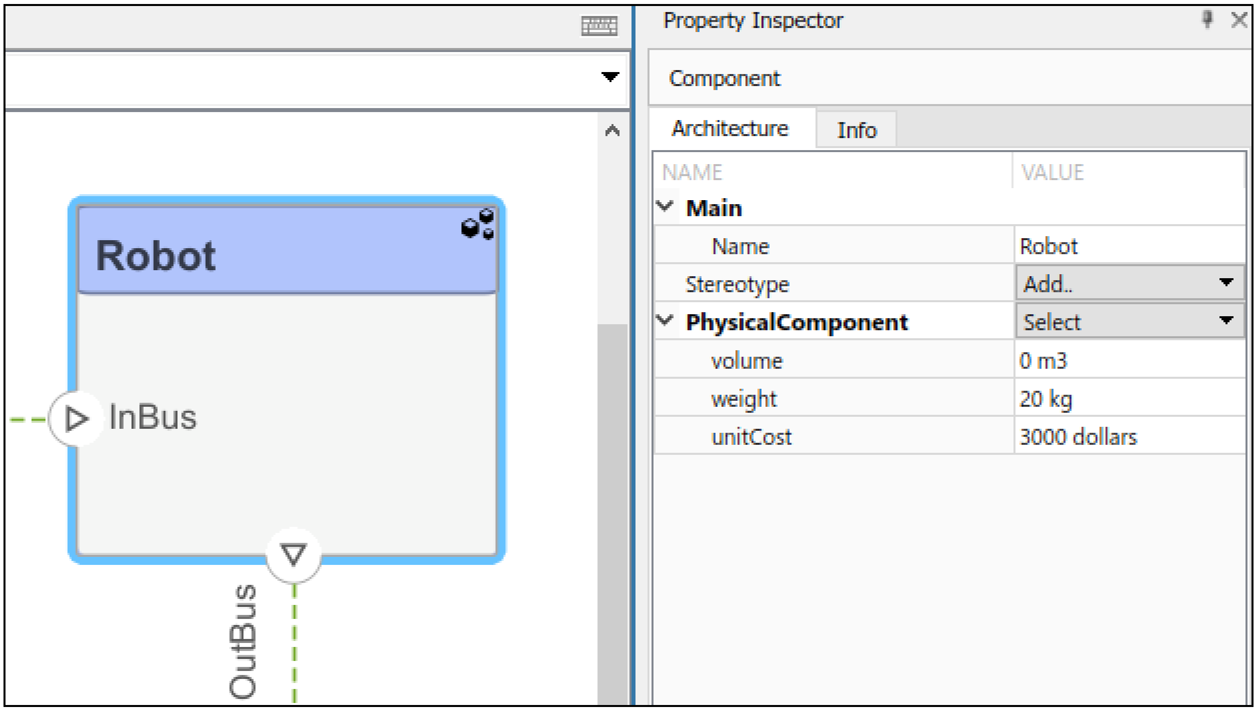
Apply stereotypes to all model elements that are part of the analysis. Use the Apply Stereotypes dialog to apply stereotypes to all elements of a certain type. Navigate to **Modeling** > **Apply Stereotypes**. In Apply Stereotypes, from **Apply stereotype(s) to**, select `Components`. From **Scope**, select `This layer`. For more information, see “Use Apply Stereotypes Dialog to Batch Apply Stereotypes” on page 5-13.

Tip Make sure you apply the stereotype to the top-level component if a cumulative value is to be computed.

Set Property Values

Set property values for each model element in the **Property Inspector**. To open the **Property Inspector**, navigate to **Modeling** > **Property Inspector**.

1. Select the model element.
2. In the **Property Inspector**, expand the stereotype name and type values for properties.



NAME	VALUE
Main	
Name	Robot
Stereotype	Add..
PhysicalComponent	Select
volume	0 m3
weight	20 kg
unitCost	3000 dollars

Create a Model Instance for Analysis

Create an instance of the architecture model that you can use for analysis.

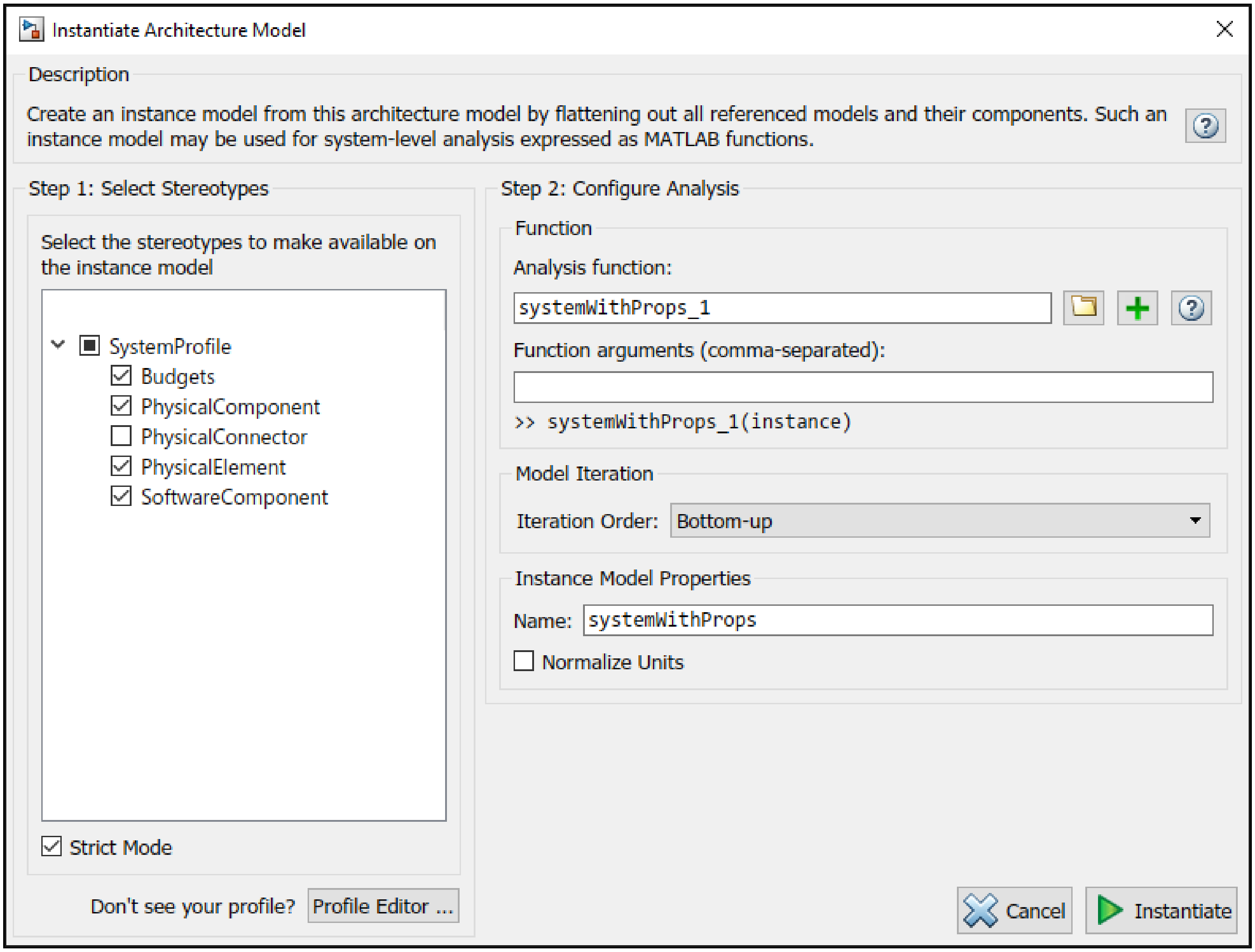
An instance is an occurrence of an architecture model element at a given point in time.

An instance freezes the active variant or model reference of the component in the instance model.

An instance model is a collection of instances.

You can update an instance model with changes to a model, but the instance model will not update with changes in active variants or model references. You can use an instance model, saved in a MAT file, of a System Composer architecture model for analysis.

Navigate to **Modeling** > **Analysis Model** to open the **Instantiate Architecture Model** tool. Specify all the parameters required to create and view an analysis model.



Instantiate Architecture Model

Description

Create an instance model from this architecture model by flattening out all referenced models and their components. Such an instance model may be used for system-level analysis expressed as MATLAB functions.

Step 1: Select Stereotypes

Select the stereotypes to make available on the instance model

- ■ SystemProfile
  - ☑ Budgets
  - ☑ PhysicalComponent
  - ☐ PhysicalConnector
  - ☑ PhysicalElement
  - ☑ SoftwareComponent

☑ Strict Mode

Don't see your profile?

Step 2: Configure Analysis

Function

Analysis function: systemWithProps_1

Function arguments (comma-separated):

```
>> systemWithProps_1(instance)
```

Model Iteration

Iteration Order: Bottom-up

Instance Model Properties

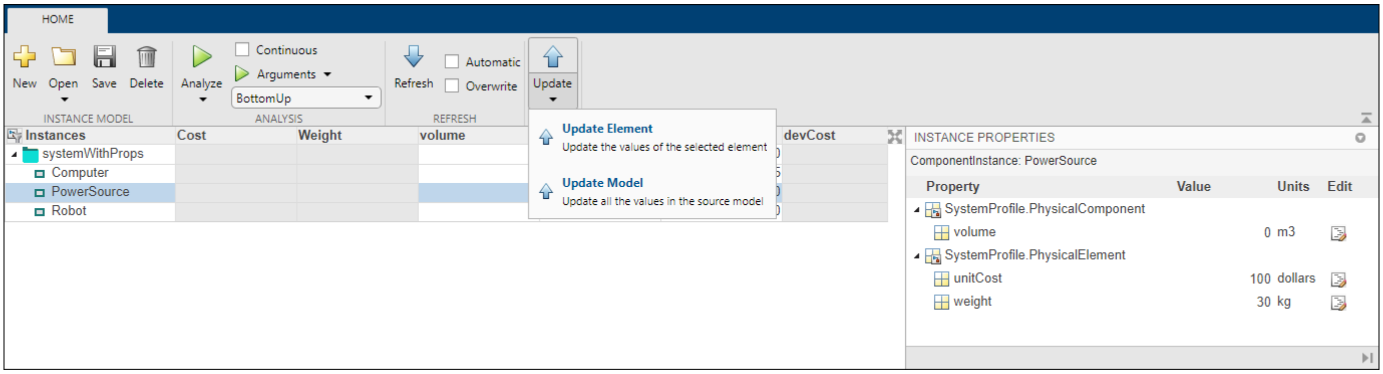
Name: systemWithProps

☐ Normalize Units

The **Select Stereotypes** tree lists the stereotypes of all profiles that have been loaded in the current session and allows you to select those whose properties should be available in the instance model. You can browse for an analysis function, create a new analysis function, or skip analysis at this point. If the analysis function requires inputs other than elements in the model, such as an exchange rate to compute cost, enter it in **Function arguments**. Select a mode for iterating through model elements, for example, `Bottom-up` to move from the leaves of the tree to the root. **Strict Mode** ensures instances get properties only if the corresponding element in the composition model has the stereotype applied.

To view the instance, click **Instantiate** and launch the **Analysis Viewer** tool.

The Analysis Viewer shows all elements in the first column. The other columns show properties for all stereotypes chosen for the current instance. If a property is not part of a stereotype applied to an element, that field is greyed out. You can use the **Filter** button to hide properties for certain stereotypes. When you select an element, Instance Properties shows the stereotypes and property values of the element. You can save an instance in a MAT-file and open it again in the Analysis Viewer.



ComponentInstance: PowerSource

Property	Value	Units	Edit
SystemProfile.PhysicalComponent			
volume	0	m3	
SystemProfile.PhysicalElement			
unitCost	100	dollars	
weight	30	kg	

If you make changes in the model while an instance is open, you can synchronize the instance with the model. **Update** pushes the changes from the instance to the model. **Refresh** pulls changes to the instance from the model. Unsynchronized changes are shown in a different color. Selecting a single element enables the option to **Update Element**.

Write Analysis Function

Write a function to analyze the architecture model using instances. An analysis function quantitatively evaluates an architecture for certain characteristics.

An analysis function is a MATLAB function that computes values necessary to evaluate the architecture using the properties of each element in the model instance.

Use an analysis function to calculate the result of an analysis.

For more information, see “Analysis Function Constructs” on page 9-9.

You can add an analysis function as you set up the analysis instance model. After you select the stereotypes of interest, create a template function by clicking + next to the **Analysis function** field. The generated M-file includes the code to obtain all property values from all stereotypes that are subject to analysis. The analysis function operates on a single element — aggregate values are generated by iterating this function over all elements in the model when you run the analysis using the **Analysis Viewer** tool.

```
function systemWithProps_1(instance,varargin)

if instance.isComponent() && ~isempty(instance.Components)...
 && instance.hasValue('SystemProfile.PhysicalElement.unitCost')
    sysComponent_unitPrice = 0;
    for child = instance.Components
        if child.hasValue('SystemProfile.PhysicalElement.unitCost')
           comp_price = child.getValue('SystemProfile.PhysicalElement.unitCost');
           sysComponent_unitPrice = sysComponent_unitPrice + comp_price;
        end
    end
    instance.setValue('SystemProfile.PhysicalElement.unitCost',sysComponent_unitPrice);
end
```

In the generated file, `instance` is the instance of the element on which the analysis function runs currently. You can perform these operations for analysis:

- Access a property of the instance:
  `instance.getValue("<profile>.<stereotype>.<property>")`

- Set a property of an instance: `instance.setValue("<profile>.<stereotype>.<property>",value)`
- Access the subcomponents of a component: `instance.Components`
- Access the connectors in component: `instance.Connectors`

The `getValue` function generates an error if the property does not exist. You can use `hasValue` to query whether elements in the model have the properties before getting the value.

As an example, this code computes the weight of a component as a sum of the weights of its subcomponents.

```
if instance.isComponent() && ~isempty(instance.Components)...
 && instance.hasValue('SystemProfile.PhysicalElement.weight')
    weight = 0;
    for child = instance.Components
        if child.hasValue('SystemProfile.PhysicalElement.weight')
           subcomp_weight = child.getValue('SystemProfile.PhysicalElement.weight');
           weight = weight + subcomp_weight;
        end
    end
    instance.setValue('SystemProfile.PhysicalElement.weight',weight);
end
```

Once the analysis function is complete, add it to the analysis under the **Analysis function** box. An analysis function can take additional input arguments, for example, a conversion constant if the weights are in different units in different stereotypes. When this code runs for all components recursively, starting from the deepest components in the hierarchy to the top level, the overall weight of the system is assigned to the `weight` property of the top-level component.

Run Analysis Function

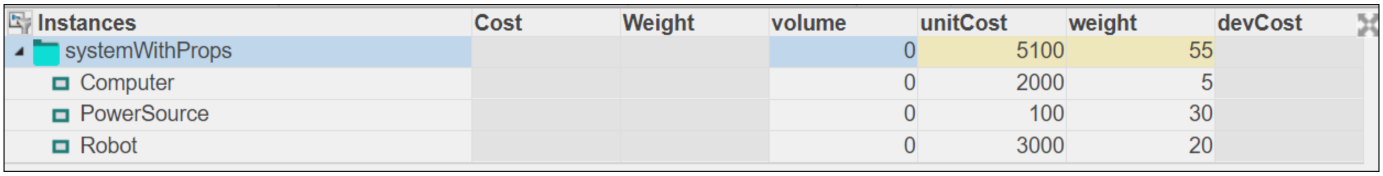
Run an analysis function using the **Analysis Viewer**.

1. Select or change the analysis function using the **Analyze** menu.
2. Select the iteration method.

   - `Pre-order` — Start from the top level, move to a child component, and process the subcomponents of that component recursively before moving to a sibling component.
   - `Top-Down` — Like pre-order, but process all sibling components before moving to their subcomponents.
   - `Post-order` — Start from components with no subcomponents, process each sibling, and then move to parent.
   - `Bottom-up` — Like post-order, but process all subcomponents at the same depth before moving to their parents.

   The iteration method depends on what kind of analysis is to be run. For example, for an analysis where the component weight is the sum of the weights of its components, you must make sure the subcomponent weights are computed first, so the iteration method must be bottom-up.
3. Click the **Analyze** button.

System Composer runs the analysis function over each model element and computes results. The computed properties are highlighted yellow in the **Analysis Viewer**.



Instances	Cost	Weight	volume	unitCost	weight	devCost
systemWithProps			0	5100	55	
Computer			0	2000	5	
PowerSource			0	100	30	
Robot			0	3000	20	

Here, the total cost of the system is `5100 dollars` and the total weight is `55 kg`.

See Also

`systemcomposer.analysis.Instance` | `iterate` | `instantiate` | `deleteInstance` | `update` | `refresh` | `save` | `loadInstance` | `lookup` | `getValue` | `setValue` | `hasValue`

More About

- “Define Profiles and Stereotypes” on page 5-2
- “Organize System Composer Files in Projects” on page 12-2
- “Analysis Function Constructs” on page 9-9
- “Calculate Endurance Using Quadcopter Architectural Design” on page 9-16
- “Battery Sizing and Automotive Electrical System Analysis” on page 9-14

Analysis Function Constructs

Analyze architectures to choose between design alternatives or improve existing designs. You can use analysis functions with System Composer architecture models to perform systems analysis and trade studies.

An analysis function is a MATLAB function that computes values necessary to evaluate the architecture using the properties of each element in the model instance.

Use an analysis function to calculate the result of an analysis and determine the optimal parameters to use for behavior models to simulate the architectural system.

Type	Section
Roll-up analysis	“Roll-Up Analysis for Quadcopter Design” on page 9-9
Class-based analysis	“Class-Based Analysis for Battery Sizing” on page 9-10
Allocation-based analysis	“Allocation-Based Analysis for Tire Pressure Monitoring” on page 9-11
Remaining useful life (RUL) analysis	“Remaining Useful Life Analysis for Mobile Robot Design” on page 9-11
Variant analysis	“Variant Analysis for Insulin Infusion Pump Design” on page 9-12

For more information on analysis functions and architecture instances, see “Analyze Architecture” on page 9-2.

Roll-Up Analysis for Quadcopter Design

Use a roll-up analysis function to calculate a total or average of model element property values. Assign properties to model elements using stereotypes. For more information, see “Define Profiles and Stereotypes” on page 5-2.

In this example, the analysis function `systemWithProps_1`calculates the total cost of all components in the model and is compatible with the **Analysis Viewer** tool.

```
function systemWithProps_1(instance,varargin)

if instance.isComponent() && ~isempty(instance.Components)...
 && instance.hasValue('SystemProfile.PhysicalElement.unitCost')
    sysComponent_unitPrice = 0;
    for child = instance.Components
        if child.hasValue('SystemProfile.PhysicalElement.unitCost')
           comp_price = child.getValue('SystemProfile.PhysicalElement.unitCost');
           sysComponent_unitPrice = sysComponent_unitPrice + comp_price;
        end
    end
    instance.setValue('SystemProfile.PhysicalElement.unitCost',sysComponent_unitPrice);
end
```

This analysis function iterates through an architecture instance. First, the `sysComponent_unitPrice` variable is set to zero so that every time the analysis is run, sums do not accumulate indefinitely. Each component instance is checked for a `unitCost` property value. All `unitCost` property values are summed up and saved in the `sysComponent_unitPrice` variable. Finally, the `unitCost` property of the current component instance is updated with the value of `sysComponent_unitPrice`. For more information, see “Write Analysis Function” on page 9-6.

In this example, a section of the analysis function `calculateEndurance` calculates endurance for a quadcopter using component instance properties. The calculated endurance value is then set for the architecture instance of the quadcopter with the `setValue` function.

```
if payloadBatteryCapacity == 0
      totalPower = powerConsumption + hoverPower/efficiency;
      endurance = (batteryCapacity/1000)/(totalPower/voltage)*60;
else
      payloadEndurance = (payloadBatteryCapacity/1000)/(powerConsumption/voltage)*60;
      flightEndurance = (batteryCapacity/1000)/((hoverPower/efficiency)/voltage)*60;
      if flightEndurance < payloadEndurance
            endurance = flightEndurance;
      else
            endurance = payloadEndurance;
            warning('Endurance is limited by payload electronics.')
      end
end
instance.setValue('AirVehicle.Endurance',endurance)
```

For more information and for the supporting files, see “Calculate Endurance Using Quadcopter Architectural Design” on page 9-16.

Class-Based Analysis for Battery Sizing

Use MATLAB classes for an analysis function to iterate over an object, or instantiation of the class.

In this example, the class called `computeBatterySizing` involves properties and methods useful for the analysis function `computeLoad`.

```
classdef computeBatterySizing < handle

    properties
        totalCrankingInrushCurrent;
        totalCrankingCurrent;
        totalAccesoriesCurrent;
        totalKeyOffLoad;
        batteryCCA;
        batteryCapacity;
        puekertcoefficient;
    end

    methods
        function obj = computeBatterySizing(obj)
            obj.totalCrankingInrushCurrent = 0;
            obj.totalCrankingCurrent = 0;
            obj.totalAccesoriesCurrent = 0;
            obj.totalKeyOffLoad = 0;
            obj.batteryCCA = 0;
            obj.batteryCapacity = 0;
            obj.puekertcoefficient = 1.2;
        end

        function obj = displayResults(obj)
            tempNumdaysToDischarge = (((obj.batteryCapacity/obj.puekertcoefficient)*0.3)/(obj.totalKeyOffLoad*1e-3))/24;
            disp("Total KeyOffLoad: " + num2str(obj.totalKeyOffLoad) + " mA");
            disp("Number of days required for KeyOffLoad to discharge 30% of battery: " + ...
                 num2str(tempNumdaysToDischarge) + ".");
            disp("Total CrankingInRush current: " + num2str(obj.totalCrankingInrushCurrent) + " A");
            disp("Total Cranking current: " + num2str(obj.totalCrankingCurrent) + " A");

            if(obj.totalCrankingCurrent > obj.batteryCCA)
                disp("The Cold Cranking Amps of the specified battery is not sufficient to start the car 0 F.")
            else
                disp("CCA of the specified battery is sufficient to start the car at 0 F.")
            end
        end
    end
end
```

For more information and for the supporting files, see “Battery Sizing and Automotive Electrical System Analysis” on page 9-14.

Allocation-Based Analysis for Tire Pressure Monitoring

A functional-to-logical allocation matrix allocates components in a functional architecture to components in a logical architecture. Coverage analysis is the most basic form of analysis to determine whether all elements have been allocated.

First, open the project for this example. Then, load the allocation set and collect the scenarios.

```
scExampleTirePressureMonitorSystem
allocSet = systemcomposer.allocation.load('FunctionalAllocation');
  scenario = allocSet.Scenarios;
```

Verify that each function in the system is allocated.

```
import systemcomposer.query.*;
  [~, allFunctions] = allocSet.SourceModel.find(HasStereotype(IsStereotypeDerivedFrom("TPMSProfile.Function")));
  unAllocatedFunctions = [];
  for i = 1:numel(allFunctions)
      if isempty(scenario.getAllocatedTo(allFunctions(i)))
          unAllocatedFunctions = [unAllocatedFunctions allFunctions(i)];
      end
  end

  if isempty(unAllocatedFunctions)
      fprintf('All functions are allocated');
  else
      fprintf('%d Functions have not been allocated', numel(unAllocatedFunctions));
  end
```

```
All functions are allocated
```

The output verifies that all functions are allocated.

For more information and for the supporting files, see “Allocate Architectures in Tire Pressure Monitoring System” on page 8-10.

Remaining Useful Life Analysis for Mobile Robot Design

Remaining useful life (RUL) analysis estimates the time remaining before different subsystems fail. The goal is to anticipate maintenance and thus minimize system disruptions.

In this example, the analysis function `scMobileRobotAnalysis` is compatible with the **Analysis Viewer** tool.

```
function scMobileRobotAnalysis(instance,varargin)

    ExpectedYearsBeforeFirstMaintenance = 2;

    if ~instance.isArchitecture()
        if instance.hasValue("HardwareBaseStereotype.Life")
            Life = instance.getValue("HardwareBaseStereotype.Life");
            UsagePerDay = instance.getValue("HardwareBaseStereotype.UsagePerDay");
            UsagePerYear = instance.getValue("HardwareBaseStereotype.UsagePerYear");
            WillSurvive = Life > UsagePerDay * UsagePerYear * ExpectedYearsBeforeFirstMaintenance;
            instance.setValue("HardwareBaseStereotype.ExceedExpectedMaintenance", WillSurvive);
        end
    end
end
```

After running this analysis function, you can optimize the desired first expected maintenance time in years. Each component that exceeds the expected maintenance time, in this case set to two years, is flagged with a check box. Unchecked components should be optimized or replaced with longer-lasting parts.

For more information and for the supporting files, see “Define Stereotypes and Perform Analysis” on page 5-32.

Variant Analysis for Insulin Infusion Pump Design

Use variant analysis to choose one optimal combination of variants by comparing them with a calculated metric.

In this example, the analysis function `OutcomeAnalysis` is used to determine the best configuration for an insulin infusion pump. This standalone analysis function does not involve the **Analysis Viewer** tool. Instead, the analysis function uses the `iterate` function and can be executed directly from the MATLAB Command Window.

The `OutcomeAnalysis` function first gathers all variant choice components named `Pump` and `BGSensor`.

```
function outcomes = OutcomeAnalysis()

modelname = 'InsulinInfusionPumpSystem';

therapyModel = systemcomposer.openModel(modelname);
components = therapyModel.Architecture.Components;
for idx = 1:numel(components)
    if strcmp(components(idx).Name,'Pump')
        pumps = components(idx).getChoices;
        pumpNames = {};
        for jdx = 1:numel(pumps)
            pumpNames{end+1} = pumps(jdx).Name;
        end
    elseif strcmp(components(idx).Name,'BGSensor')
        sensors = components(idx).getChoices;
        sensorNames = {};
        for jdx = 1:numel(sensors)
            sensorNames{end+1} = sensors(jdx).Name;
        end
    end
end
```

The analysis function then collects all variant combinations to iterate over.

```
config.Sensor = sensorNames{1};
config.Pump = pumpNames{1};
configs = {};

for idx = 1:numel(sensorNames)
    for jdx = 1:numel(pumpNames)
        config.Sensor = sensorNames{idx};
        config.Pump = pumpNames{jdx};
        configs{end+1} = config;
    end
end
```

The analysis function activates the variants one by one, iterates over the model properties, and collects outcomes. To set variant combinations, `OutcomeAnalysis` uses the `setVariants` function. To compute the outcomes, `OutcomeAnalysis` uses the `computeOutcome` function.

```
outcomes = {};

for idx = 1:numel(configs)
    hOutcome = OutcomeContainer(configs{idx});
    therapyModel.iterate('Topdown',@setVariants,configs{idx});
    therapyModel.iterate('BottomUp',@computeOutcome,hOutcome);
    hOutcome.setWeights([1e-6 1 10 1 1000]');
    outcomes{end+1} = hOutcome;
end
```

Finally, the analysis function plots the net outcome to reveal the optimal design choice.

```
properties = {'Lower NRE','Higher Accuracy','Better Compliance',...
'Sooner To Market','Lower Operating Cost'};
plotMatrix = zeros(numel(outcomes), numel(properties));
plotStrings = {};
for idx = 1:numel(outcomes)
    plotStrings{idx} = [outcomes{idx}.Sensor '+' outcomes{idx}.Pump];
    plotMatrix(idx,1) = 1/(outcomes{idx}.NRE);
    plotMatrix(idx,2) = outcomes{idx}.Accuracy;
    plotMatrix(idx,3) = outcomes{idx}.Compliance;
    plotMatrix(idx,4) = 1/(outcomes{idx}.TimeToMarket);
    plotMatrix(idx,5) = 1/(outcomes{idx}.AnnualCost);
end

colmin = zeros(1,5);
colmax = max(plotMatrix);
normalizedMatrix = rescale(plotMatrix,'InputMin',colmin,'InputMax',colmax);

if exist('spider_plot') == 2
    fig = figure;
    spider_plot(normalizedMatrix,'AxesLabels',properties,'FillOption','on',...
        'FillTransparency',0.1,'AxesDisplay','one');

    title(sprintf('Trade Study Outcome'),...
        'FontSize', 14);
    legend(plotStrings, 'Location', 'eastoutside');
    pos = fig.Position;
    pos(2) = pos(2) - pos(4);
    pos(3) = 2*pos(3);
    pos(4) = 2*pos(4);
    fig.Position = pos;
else
    vals = sum(normalizedMatrix,2)/5;
    x_labels = categorical(plotStrings);
    h = bar(x_labels,vals);
    title('Net outcome');
    ax = h.Parent;
    ax.YLabel.String = 'Normalized units';
end
```

For more information and for the supporting files, see “Design Insulin Infusion Pump Using Model-Based Systems Engineering” on page 9-23.

See Also

systemcomposer.analysis.Instance | iterate | instantiate | deleteInstance | update | refresh | save | loadInstance | lookup | getValue | setValue | hasValue

More About

- “Define Profiles and Stereotypes” on page 5-2
- “Analyze Architecture” on page 9-2
- “Organize System Composer Files in Projects” on page 12-2

Battery Sizing and Automotive Electrical System Analysis

Overview

Model a typical automotive electrical system as an architectural model and run a primitive analysis. The elements in the model can be broadly grouped as either a source or a load. Various properties of the sources and loads are set as part of the stereotype. This example uses the `iterate` method of the specification API to iterate through each element of the model and run analysis using the stereotype properties.

Structure of Model

The generator charges the battery while the engine is running. The battery and the generator support the electrical loads in the vehicle, like ECU, radio, and body control. The inductive loads like motors and other coils have the `InRushCurrent` stereotype property defined. Based on the properties set on each component, the following analyses are performed:

- Total `KeyOffLoad`.
- Number of days required for `KeyOffLoad` to discharge 30% of the battery.
- Total `CrankingInRush` current.
- Total `Cranking` current.
- Ability of the battery to start the vehicle at 0°F based on the battery cold cranking amps (CCA). The discharge time is computed based on Puekert coefficient (k), which describes the relationship between the rate of discharge and the available capacity of the battery.

Load Model and Run Analysis

```
scExampleAutomotiveElectricalSystemAnalysis
archModel = systemcomposer.loadModel('scExampleAutomotiveElectricalSystemAnalysis');
```

Instantiate battery sizing class used by the analysis function to store analysis results.

```
objcomputeBatterySizing = computeBatterySizing;
```

Run the analysis using the iterator.

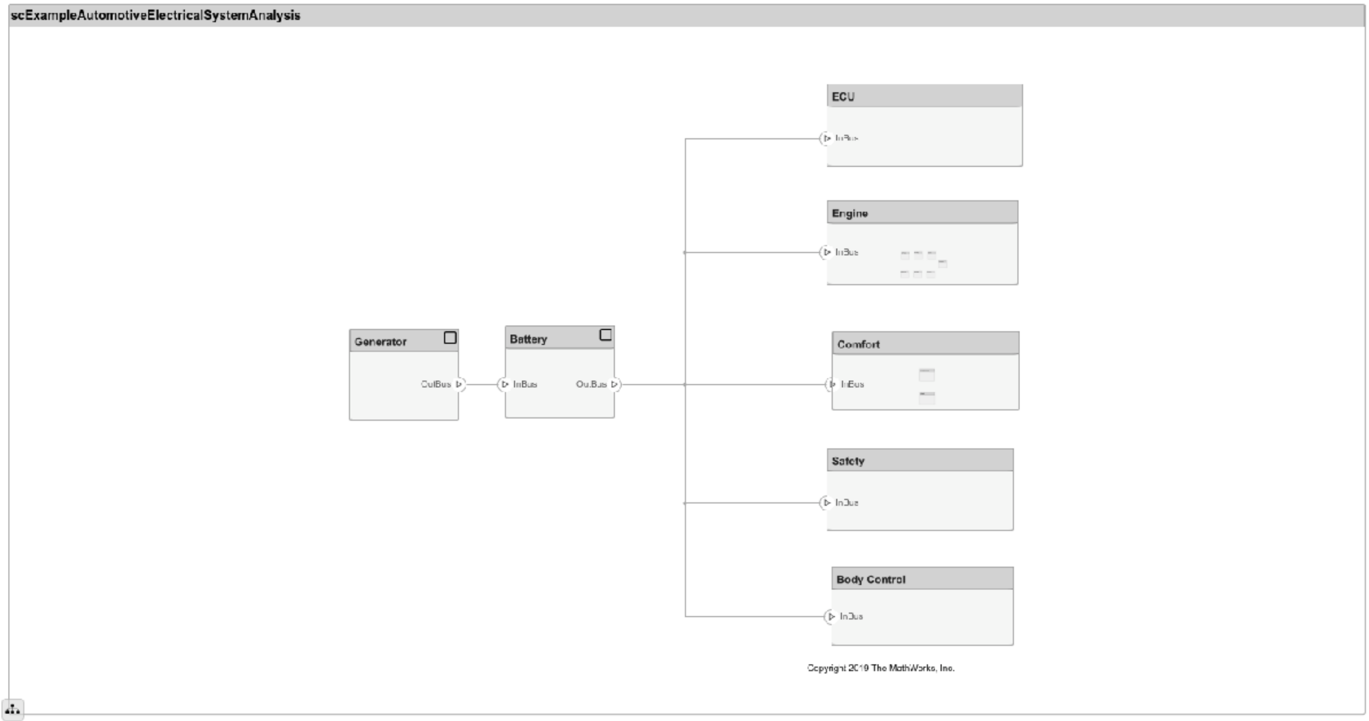
```
archModel.iterate('Topdown',@computeLoad,objcomputeBatterySizing)
```

Display analysis results.

```
objcomputeBatterySizing.displayResults
```

```
Total KeyOffLoad: 158.708 mA
Number of days required for KeyOffLoad to discharge 30% of battery: 55.789.
Total CrankingInRush current: 70 A
Total Cranking current: 104 A
CCA of the specified battery is sufficient to start the car at 0 F.

ans = 
  computeBatterySizing with properties:

    totalCrankingInrushCurrent: 70
          totalCrankingCurrent: 104
        totalAccesoriesCurrent: 71.6667
```

```
       totalKeyOffLoad: 158.7080
            batteryCCA: 500
       batteryCapacity: 850
    puekertcoefficient: 1.2000
```



Close Model

```
bdclose('scExampleAutomotiveElectricalSystemAnalysis');
```

See Also

systemcomposer.analysis.Instance | iterate | instantiate | deleteInstance | update | save | loadInstance | getValue | setValue | hasValue | lookup

More About

- “Analyze Architecture” on page 9-2
- “Analysis Function Constructs” on page 9-9
- “Simulate Mobile Robot with System Composer Workflow” on page 5-20
- “Allocate Architectures in Tire Pressure Monitoring System” on page 8-10
- “Calculate Endurance Using Quadcopter Architectural Design” on page 9-16

Calculate Endurance Using Quadcopter Architectural Design

This example shows you how to create the physical architecture of a quadcopter following a target green ball using System Composer™ and Requirements Toolbox™ and following a model-based systems engineering (MBSE) workflow. Start by defining requirements, then extend architectural data using stereotypes and custom property values for model elements, and finally use analysis to iteratively improve on the design.

Define Functional Requirements for Quadcopter Design

The first step in the MBSE methodology is to define requirements. The concept of operations, or *conops*, define the overall idea of the system. You then derive functional requirements from conops requirements and further define the logical and physical subsystems by linking requirements.

1. Load Simulink® customizations.

```
sl_refresh_customizations
```

2. Load the physical architecture model in memory to view its requirement links.

```
systemcomposer.loadModel("QuadArchPhysical");
```

3. Open the requirement sets.

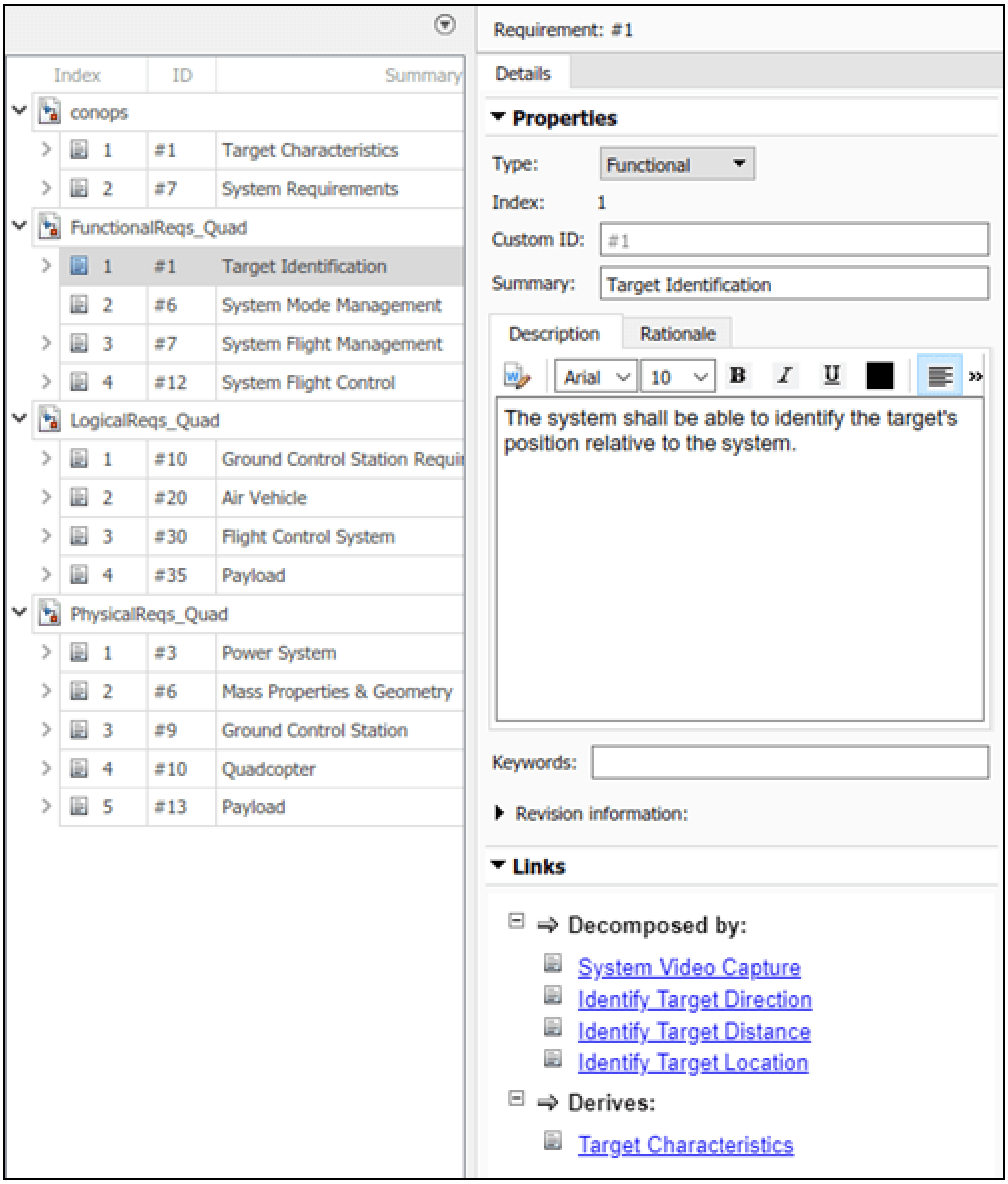
- Concept of operations
- Functional requirements
- Logical requirements
- Physical requirements

```
slreq.open("conops");
slreq.open("FunctionalReqs_Quad");
slreq.open("LogicalReqs_Quad");
slreq.open("PhysicalReqs_Quad");
```

4. Open the Requirements Editor (Requirements Toolbox).

```
slreq.editor
```

Inspect the conops requirement `Target Characteristics`. The requirements under the **Decomposed by** list represent the requirements contained in the top-level requirement. The requirement `Target Identification` under the **Derived from** list represents requirements derived from the conops requirement.



Index	ID	Summary
conops		
1	#1	Target Characteristics
2	#7	System Requirements
FunctionalReqs_Quad		
1	#1	Target Identification
2	#6	System Mode Management
3	#7	System Flight Management
4	#12	System Flight Control
LogicalReqs_Quad		
1	#10	Ground Control Station Requi
2	#20	Air Vehicle
3	#30	Flight Control System
4	#35	Payload
PhysicalReqs_Quad		
1	#3	Power System
2	#6	Mass Properties & Geometry
3	#9	Ground Control Station
4	#10	Quadcopter
5	#13	Payload

Requirement: #1

Details

Properties

Type: Functional

Index: 1

Custom ID: #1

Summary: Target Identification

The system shall be able to identify the target's position relative to the system.

Keywords:

Revision information:

Links

Decomposed by:

- System Video Capture
- Identify Target Direction
- Identify Target Distance
- Identify Target Location

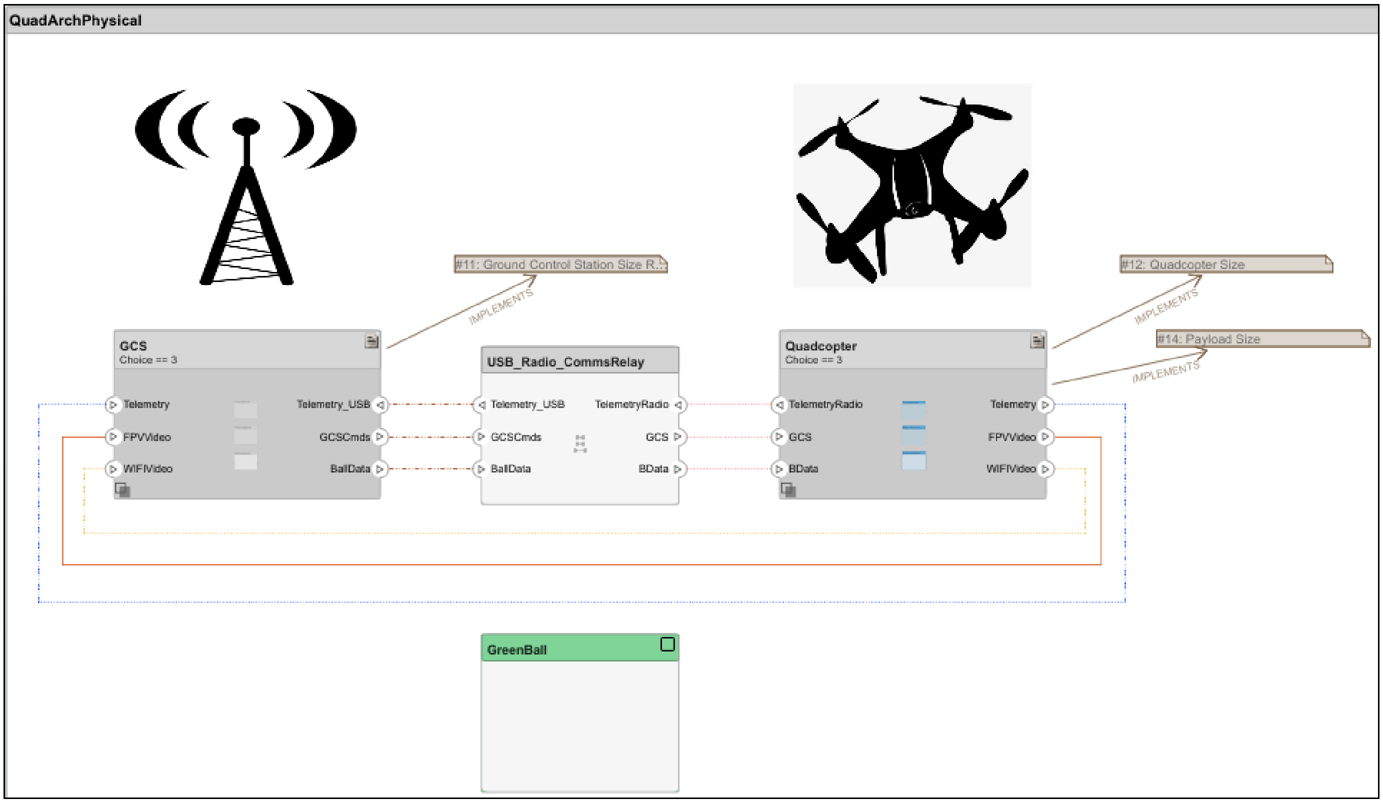
Derives:

- Target Characteristics

To open the quadcopter physical architecture model, run this code.

```
systemcomposer.openModel("QuadArchPhysical");
```

Manage requirements and architecture together in the **Requirements Manager** from Requirements Toolbox. Navigate to **Apps** > **Requirements Manager**. You are now in the Requirements perspective in System Composer. In this perspective, you can see which requirements are associated with specific components in the physical architecture.

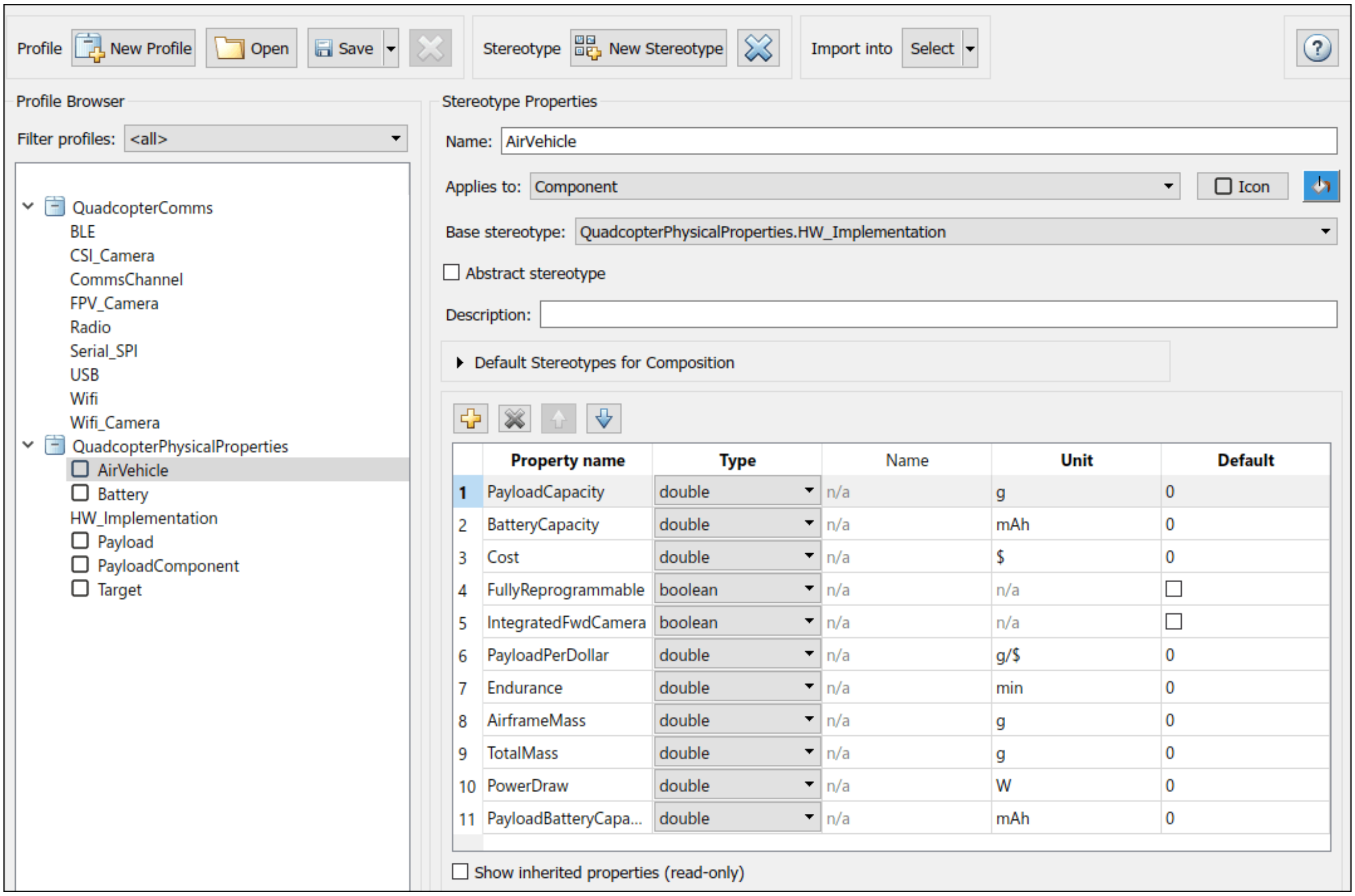


Specify Functional Design Using Stereotypes and Properties

Stereotypes, defined on a profile, include properties to specify metadata on model elements to which stereotypes are applied.

To open the Profile Editor tool, on the System Composer toolstrip, navigate to **Modeling** > **Profile Editor**. Alternatively, run this command.

```
systemcomposer.profile.editor
```



Filter profiles: <all>

- QuadcopterComms
  - BLE
  - CSI_Camera
  - CommsChannel
  - FPV_Camera
  - Radio
  - Serial_SPI
  - USB
  - Wifi
  - Wifi_Camera
- QuadcopterPhysicalProperties
  - AirVehicle
  - Battery
  - HW_Implementation
  - Payload
  - PayloadComponent
  - Target

Name: AirVehicle

Applies to: Component

Base stereotype: QuadcopterPhysicalProperties.HW_Implementation

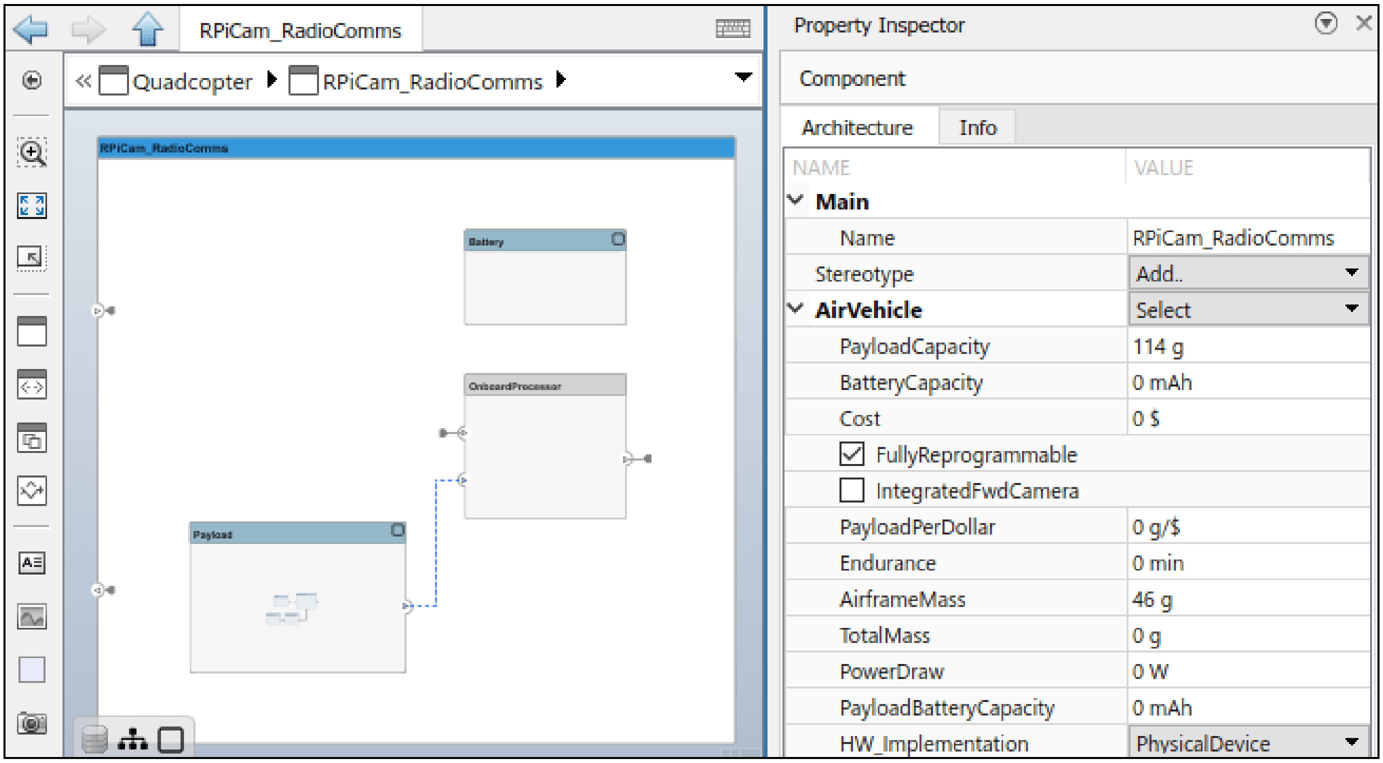
☐ Abstract stereotype

Description:

	Property name	Type	Name	Unit	Default
1	PayloadCapacity	double	n/a	g	0
2	BatteryCapacity	double	n/a	mAh	0
3	Cost	double	n/a	$	0
4	FullyReprogrammable	boolean	n/a	n/a	☐
5	IntegratedFwdCamera	boolean	n/a	n/a	☐
6	PayloadPerDollar	double	n/a	g/$	0
7	Endurance	double	n/a	min	0
8	AirframeMass	double	n/a	g	0
9	TotalMass	double	n/a	g	0
10	PowerDraw	double	n/a	W	0
11	PayloadBatteryCapa...	double	n/a	mAh	0

☐ Show inherited properties (read-only)

The AirVehicle stereotype applies to components and inherits from the base stereotype HW_Implementation. Each property under the AirVehicle stereotype is specified by a data type defined by Type, and some properties include an engineering unit defined by Unit. You can apply the AirVehicle stereotype to components in the quadcopter physical architecture to elaborate on these components with specific property values. Define these property values for the RPiCam_RadioComms component in the Property Inspector.



Property Inspector

Component

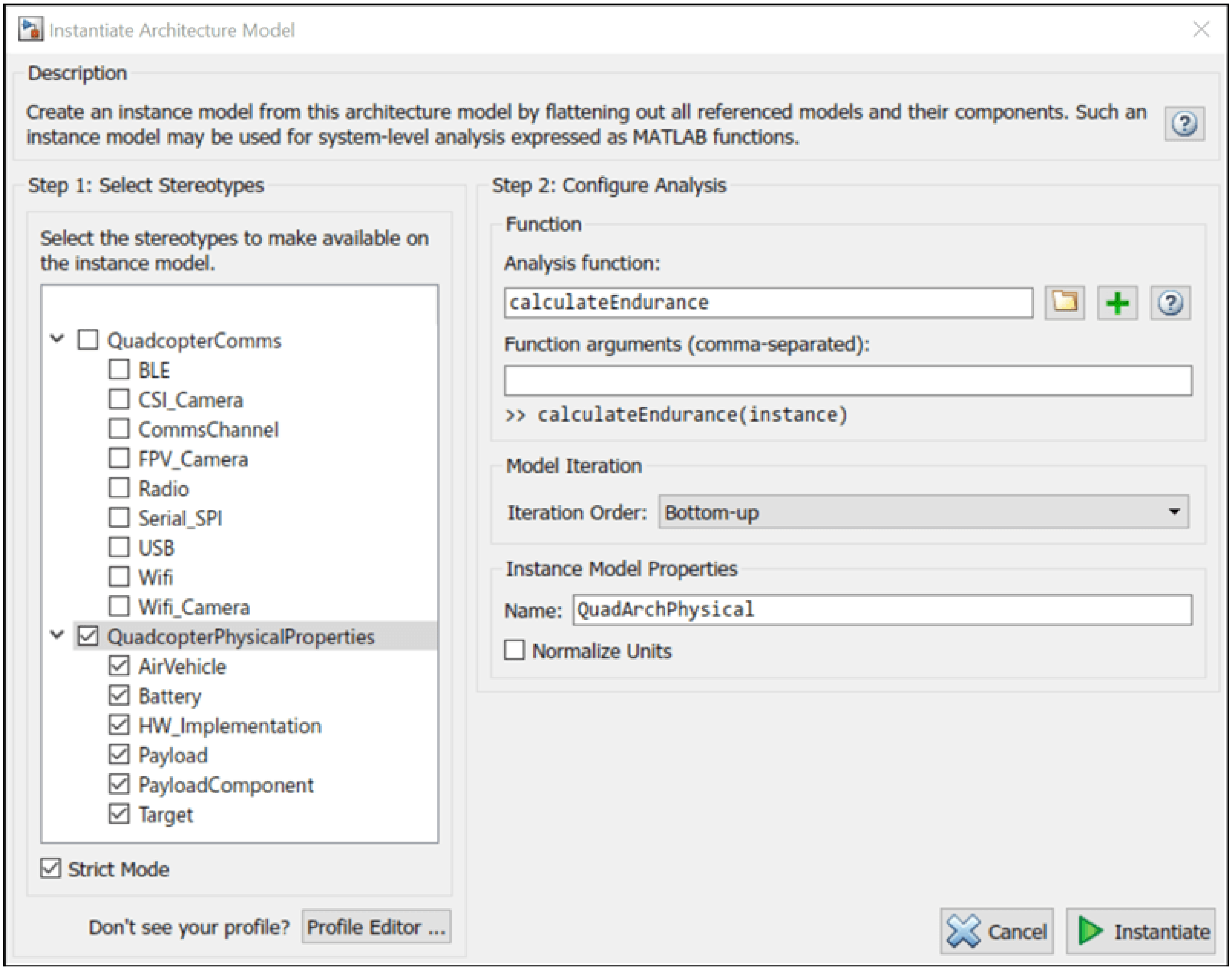
Architecture | Info

NAME	VALUE
Main	
Name	RPiCam_RadioComms
Stereotype	Add..
AirVehicle	Select
PayloadCapacity	114 g
BatteryCapacity	0 mAh
Cost	0 $
☑ FullyReprogrammable	
□ IntegratedFwdCamera	
PayloadPerDollar	0 g/$
Endurance	0 min
AirframeMass	46 g
TotalMass	0 g
PowerDraw	0 W
PayloadBatteryCapacity	0 mAh
HW_Implementation	PhysicalDevice

Perform Roll-Up Analysis to Calculate Endurance for Quadcopter Design

To open the Instantiate Architecture Model tool, on the System Composer toolstrip, navigate to **Modeling** > **Analysis Model**. Select all the stereotypes under the

`QuadcopterPhysicalProperties` profile. Click the open 📂 button, then open the analysis function file `calculateEndurance.m`. Select `Bottom-up` for **Iteration Order**. Click **Instantiate**.


Instantiate Architecture Model
Description
Step 1: Select Stereotypes
Step 2: Configure Analysis
Function
Model Iteration
Instance Model Properties
Don't see your profile?
Profile Editor ...
Cancel
Instantiate

Create an instance model from this architecture model by flattening out all referenced models and their components. Such an instance model may be used for system-level analysis expressed as MATLAB functions.

Select the stereotypes to make available on the instance model.

- □ QuadcopterComms
  - □ BLE
  - □ CSI_Camera
  - □ CommsChannel
  - □ FPV_Camera
  - □ Radio
  - □ Serial_SPI
  - □ USB
  - □ Wifi
  - □ Wifi_Camera
- ☑ QuadcopterPhysicalProperties
  - ☑ AirVehicle
  - ☑ Battery
  - ☑ HW_Implementation
  - ☑ Payload
  - ☑ PayloadComponent
  - ☑ Target

☑ Strict Mode

Analysis function: calculateEndurance

Function arguments (comma-separated):

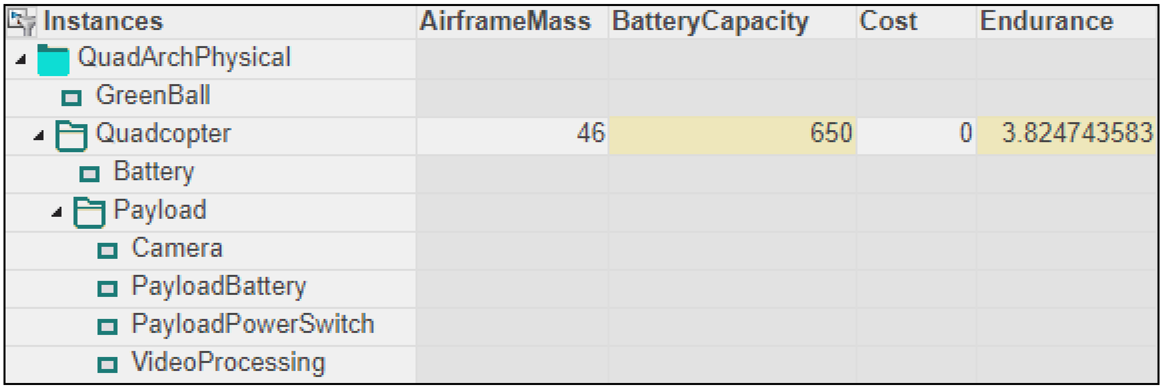
```
>> calculateEndurance(instance)
```

Iteration Order: Bottom-up

Name: QuadArchPhysical

□ Normalize Units

In the Analysis Viewer tool, you can use an analysis function to calculate roll-up property values such as `BatteryCapacity`, `PayloadBatteryCapacity`, `PowerDraw`, and `TotalMass`. The analysis function also calculates the performance characteristics `PowerDraw` and `Endurance`. For more information, see “Analysis Function Constructs” on page 9-9. Click **Analyze** to view the analysis results highlighted in yellow.



Instances	AirframeMass	BatteryCapacity	Cost	Endurance
QuadArchPhysical				
GreenBall				
Quadcopter	46	650	0	3.824743583
Battery				
Payload				
Camera				
PayloadBattery				
PayloadPowerSwitch				
VideoProcessing				

The `Endurance` property for this particular configuration is calculated as approximately `3.825` using this equation.

$$endurance = \frac{\left(\frac{batteryCapacity}{1000}\right)}{\left(\frac{totalPower}{voltage}\right)} * 60$$

You can change the variant configuration and run the analysis function again to calculate `Endurance` and compare different proposed designs.

See Also

`systemcomposer.profile.editor` | `slreq.editor` | `sl_refresh_customizations`

More About

- “Analyze Architecture” on page 9-2
- “Compose Architectures Visually” on page 1-2
- “Analysis Function Constructs” on page 9-9
- “Simulate Mobile Robot with System Composer Workflow” on page 5-20
- “Modeling System Architecture of Keyless Entry System” on page 11-25
- “Model-Based Systems Engineering for Space-Based Applications” on page 1-38

Design Insulin Infusion Pump Using Model-Based Systems Engineering

This example show you how to use a model-based systems engineering workflow to investigate optimal insulin infusion pump design. Insulin pumps are medical devices used by people with diabetes that mimic the human pancreas by delivering insulin continuously and delivering variable amounts of insulin with food intake.

The purpose of an insulin pump wearable device is to keep the blood glucose level of the wearer near a healthy set point by infusing insulin as needed and in response to food intake. This example shows a proposed insulin infusion pump system with two sensor and three pump variants that represent alternate design choices.

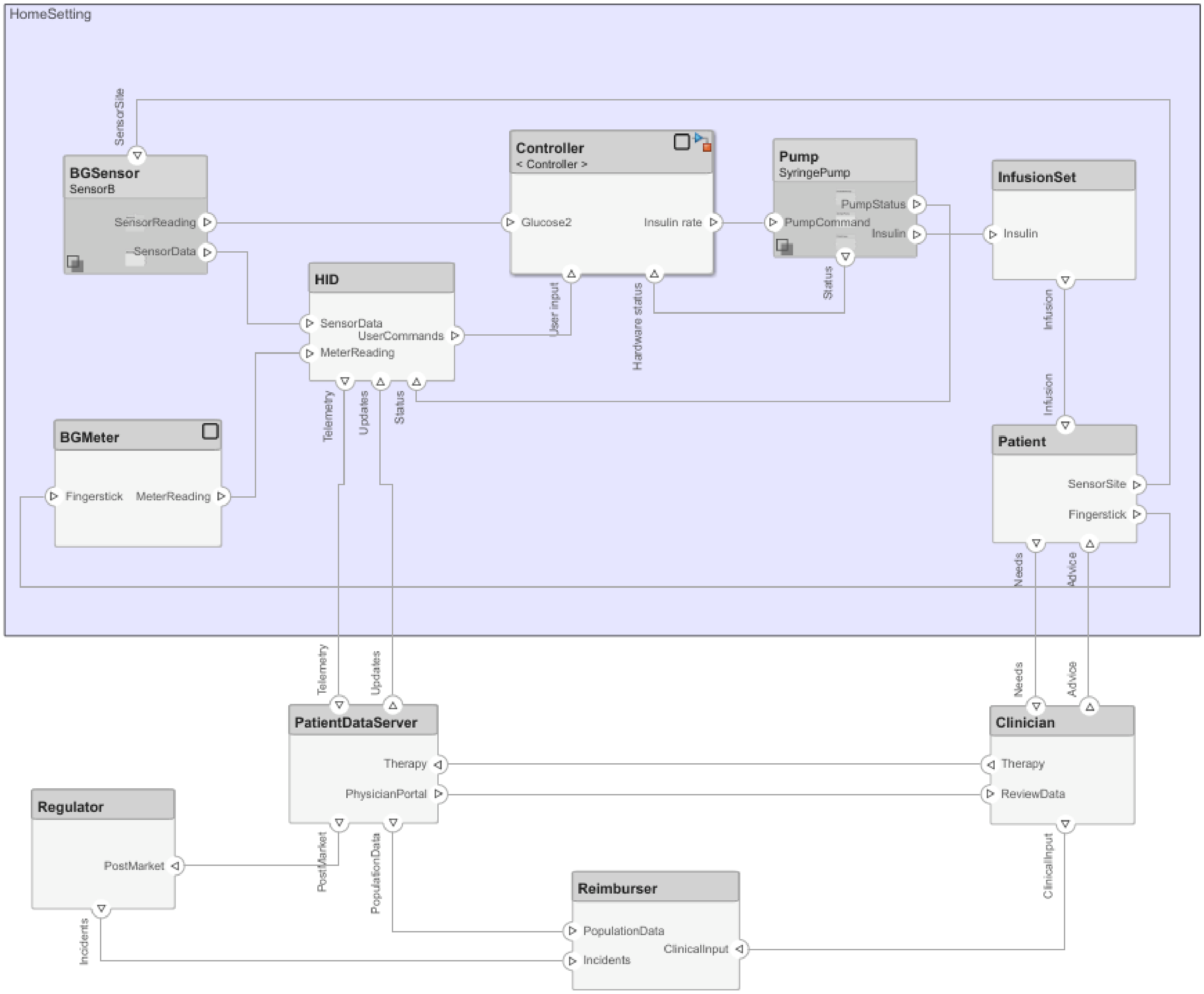
Begin by determining system requirements, then create detailed design models with code generation and verification tests. Finally, simulate the system architecture model that meets the evolving requirements.

Insulin Pump System Architecture Model

This figure shows the System Composer™ architecture model for the insulin pump system. This example uses Stateflow® blocks. If you do not have a Stateflow license, you can open and simulate the model but can only make basic changes, such as modifying block parameters.

```
systemcomposer.openModel("InsulinInfusionPumpSystem");
```

The `BGSensor` component measures the blood glucose level. The `Controller` component makes a decision about insulin rate. The `Pump` component provides insulin to the body using the `InfusionSet`. The `Patient` recieves the treatment. The `BGMeter` calibrates the `BGSensor`. Finally, the `HID` (human interface device) component may be a mobile app on the phone for the patient to communicate with the system. The `HID` provides information the the `PatientDataServer` component, which sends analyses to the `Clinician`, `Regulator`, and `Reimburser` components.

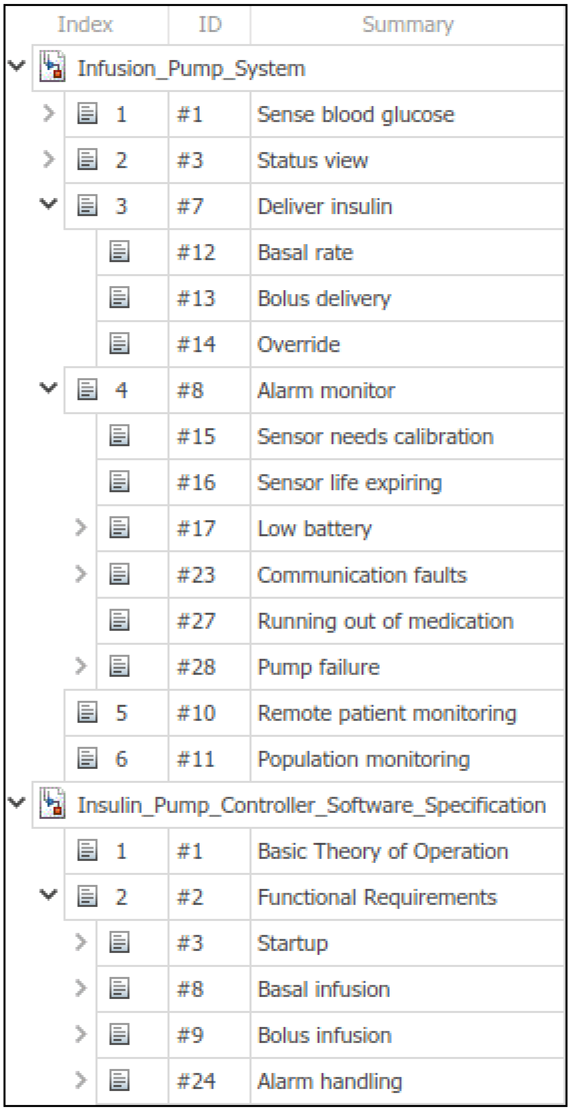


System Requirements and Links

Use Requirements Toolbox™ to analyze the system requirements, further break them down into subsystem requirements, and link derived requirements to architectural components that satisfy them. A Requirements Toolbox license is required to link, trace, and manage requirements in System Composer.

Manage requirements and architecture together in the Requirements Perspective from Requirements Toolbox. Select **Apps** > **Requirements Manager**. To edit requirements, select **Requirements** > **Requirements Editor** or enter these commands to open the Requirements Editor (Requirements Toolbox).

```
slreq.open("Infusion_Pump_System");
slreq.open("Insulin_Pump_Controller_Software_Specification");
slreq.editor
```

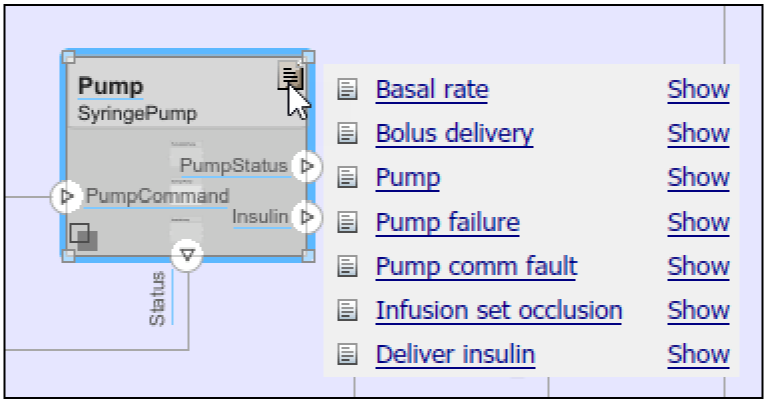


Index	ID	Summary
Infusion_Pump_System		
1	#1	Sense blood glucose
2	#3	Status view
3	#7	Deliver insulin
	#12	Basal rate
	#13	Bolus delivery
	#14	Override
4	#8	Alarm monitor
	#15	Sensor needs calibration
	#16	Sensor life expiring
	#17	Low battery
	#23	Communication faults
	#27	Running out of medication
	#28	Pump failure
5	#10	Remote patient monitoring
6	#11	Population monitoring
Insulin_Pump_Controller_Software_Specification		
1	#1	Basic Theory of Operation
2	#2	Functional Requirements
	#3	Startup
	#8	Basal infusion
	#9	Bolus infusion
	#24	Alarm handling

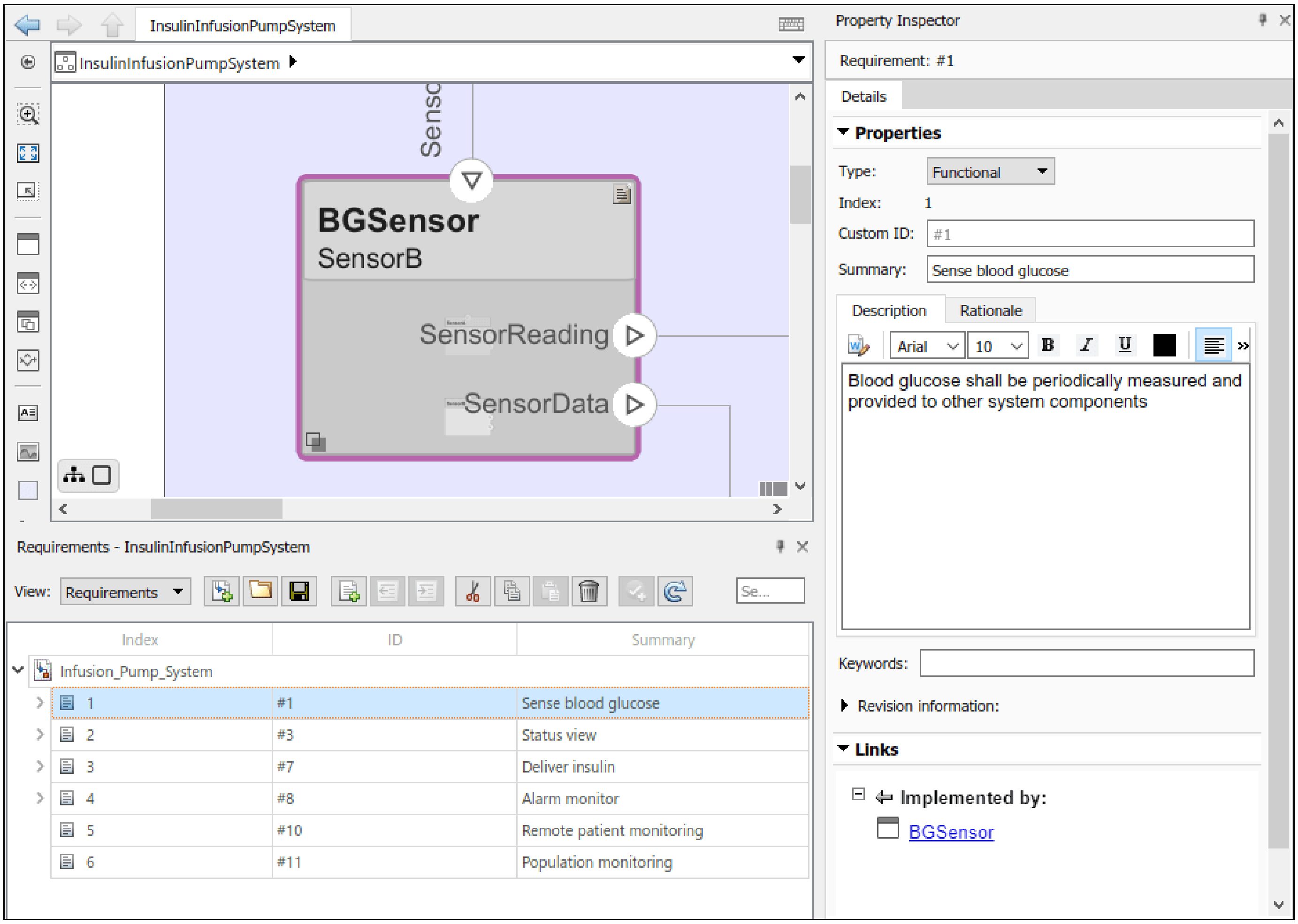
The requirements decomposition and analysis at this point represent these concerns:

- Accuracy of delivery
- Mitigations against over-infusion, which leads to dangerously low blood glucose levels
- Fault analysis to prevent negative outcomes, for example, when the battery is depleted or the device runs out of medication

On the architecture model, select the requirements icon to see the requirements that are associated with the component. For example, below are the requirements linked to the Pump component.



Conversely, select a requirement to see the highlighted component by which the requirement is implemented. For example, the `BGSensor` component implements the `Sense blood glucose` requirement.



Index	ID	Summary
Infusion_Pump_System		
1	#1	Sense blood glucose
2	#3	Status view
3	#7	Deliver insulin
4	#8	Alarm monitor
5	#10	Remote patient monitoring
6	#11	Population monitoring

Requirement: #1

Properties

Type: Functional

Index: 1

Custom ID: #1

Summary: Sense blood glucose

Blood glucose shall be periodically measured and provided to other system components

Keywords:

Links

Implemented by:

BGSensor

Outcome Analysis for Optimal Design Choice

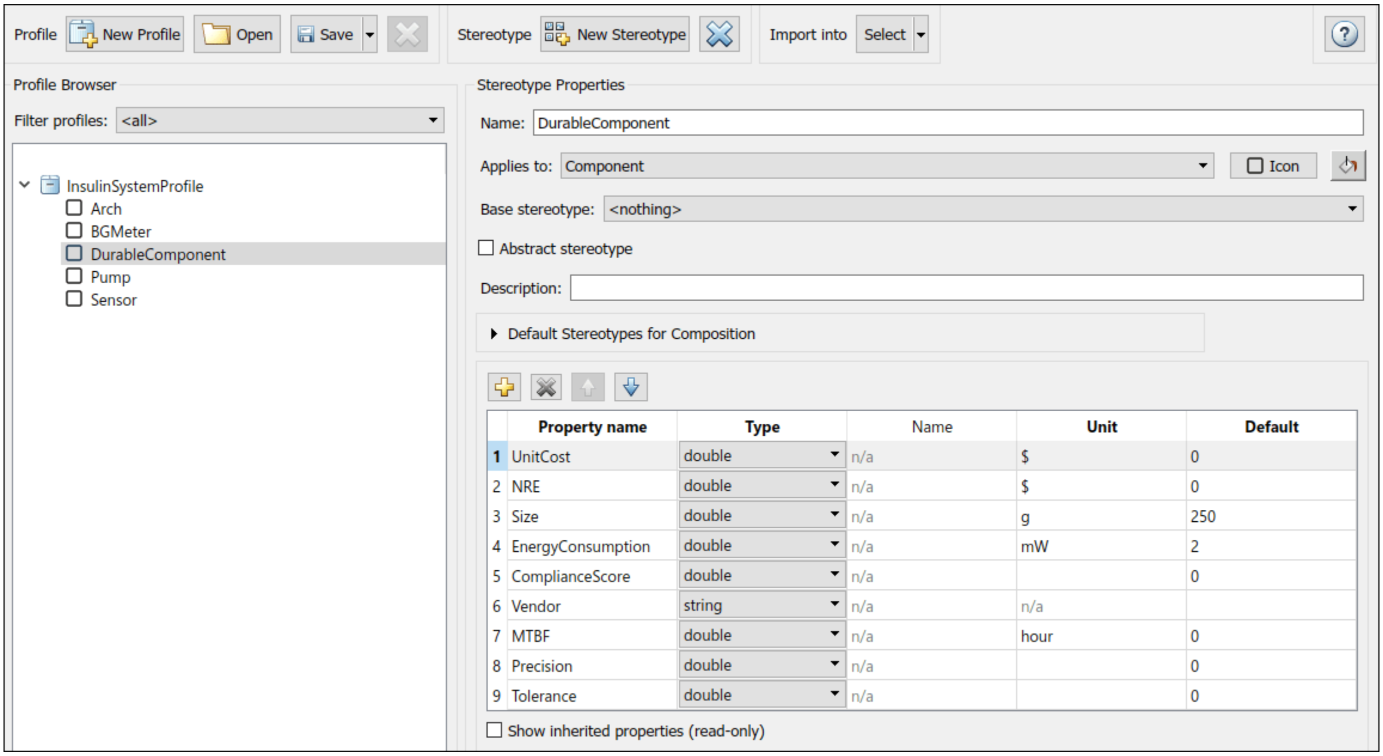
Outcome analysis consists of a trade study where the goal is to maximize the business value of the design options based on calculations that sum up different component properties with weighting factors. Many are directly entered properties, such as non-recurring engineering (NRE) costs to develop the component. Compliance score, however, is a derived property that is based on different data for each type of component. These properties model the burden to an end user of the system. The compliance score includes these considerations:

- Energy consumption
- Size and weight
- Accuracy
- Mean time between failures (MTBF)
- Sound level produced during operation
- Ease of use

Navigate to **Modeling** > **Profiles** > **Profile Editor**, or enter this command.

```
systemcomposer.profile.editor
```

A System Composer profile, defined in the Profile Editor, is composed of stereotypes with properties defined. You can apply stereotypes to components in the model to assign specific property values to each component.



Filter profiles: <all>

InsulinSystemProfile
- □ Arch
- □ BGMeter
- □ DurableComponent
- □ Pump
- □ Sensor

Name: DurableComponent

Applies to: Component

Base stereotype: <nothing>

□ Abstract stereotype

Description:

	Property name	Type	Name	Unit	Default
1	UnitCost	double	n/a	$	0
2	NRE	double	n/a	$	0
3	Size	double	n/a	g	250
4	EnergyConsumption	double	n/a	mW	2
5	ComplianceScore	double	n/a		0
6	Vendor	string	n/a	n/a	
7	MTBF	double	n/a	hour	0
8	Precision	double	n/a		0
9	Tolerance	double	n/a		0

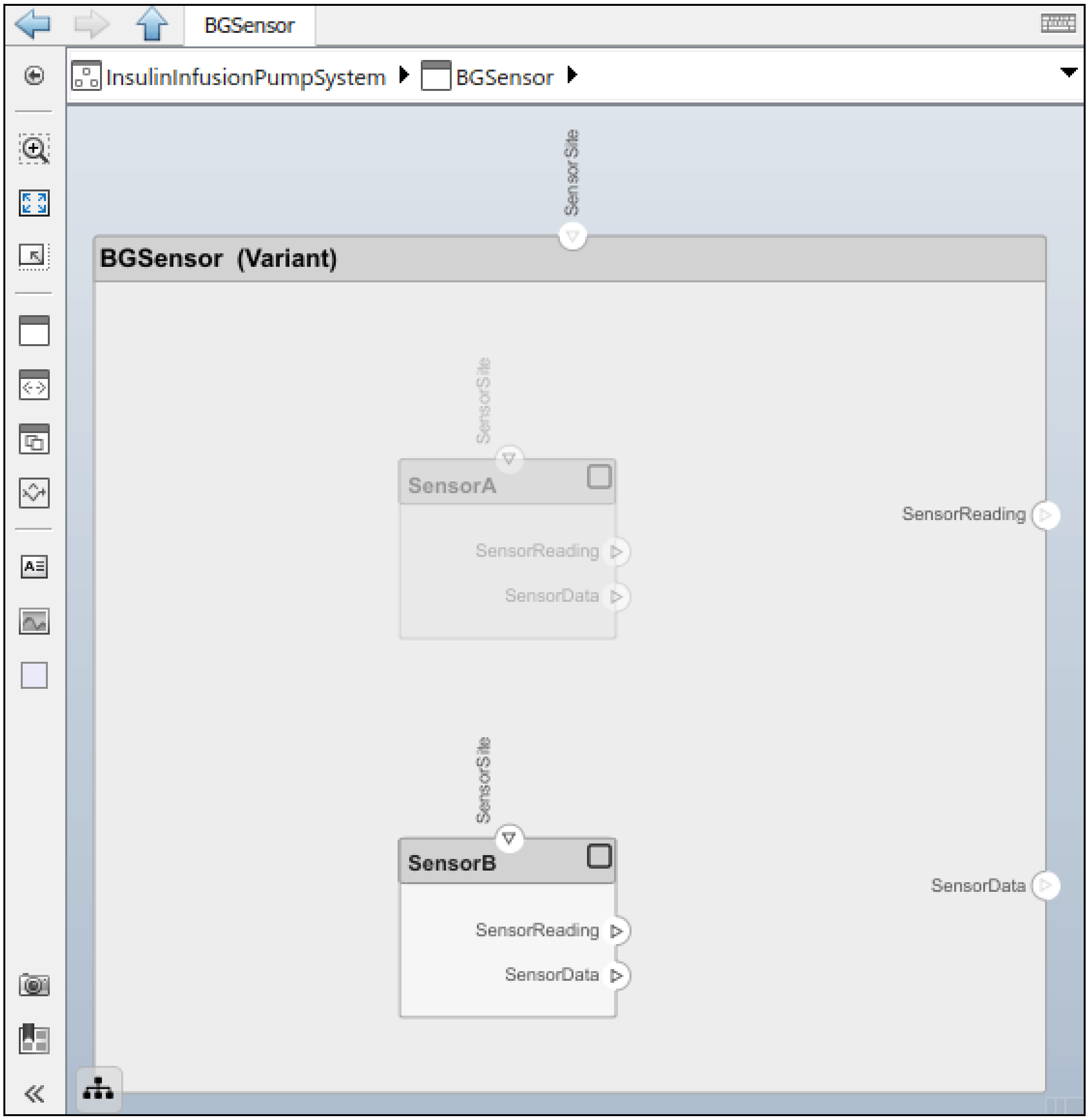
□ Show inherited properties (read-only)

The pump and sensor trade study includes these steps:

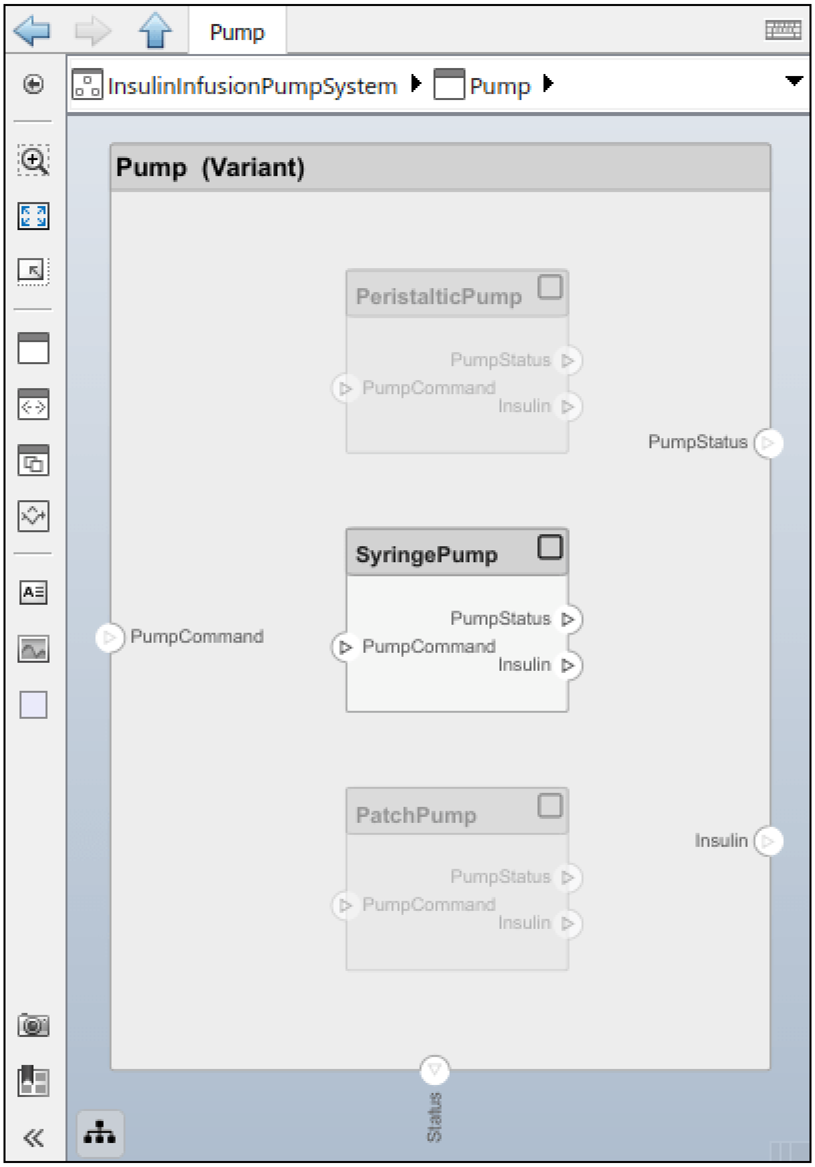
1 Collect all variant combinations.

2 Activate variants one by one to represent all the combinations.
3 Iterate over the model to calculate compliance and compute the outcome using the stored and calculated parameters.
4 Collect outcomes and weight them using the same units.
5 Provide the optimized option.

A Variant Component block named `BGSensor` contains two different sensor variants representing example sensors from different manufacturers.

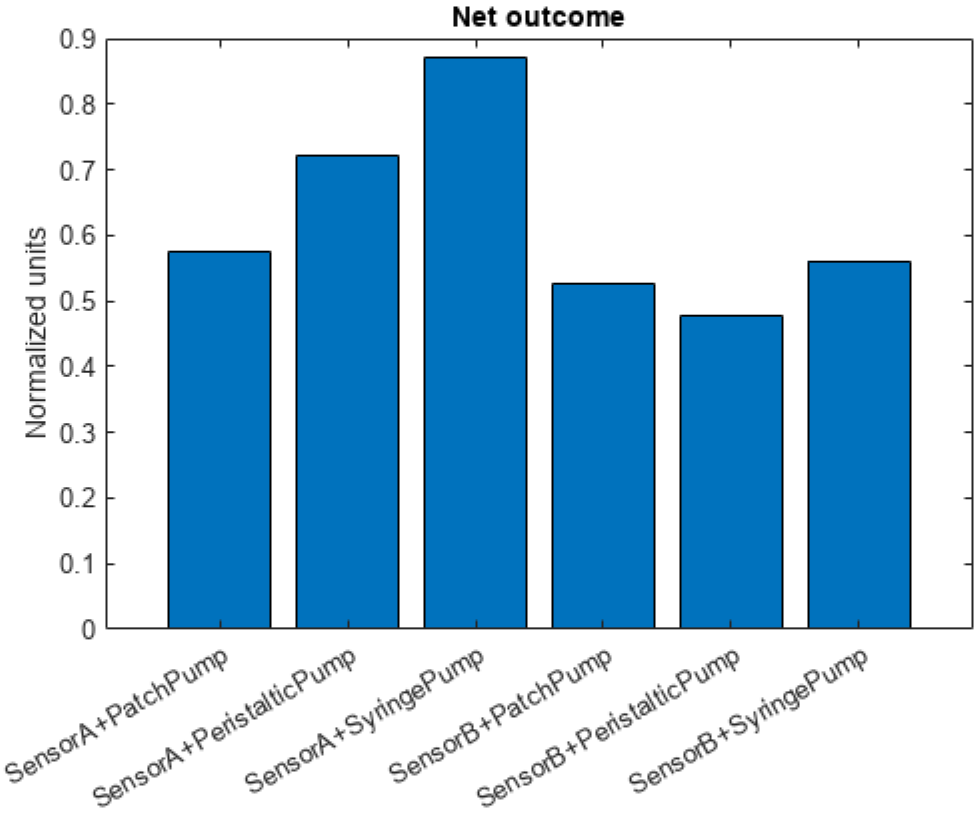


The Variant Component block named `Pump` contains three different pumps in this example called `PeristalticPump`, `SyringePump`, and `PatchPump`.



To programmatically cycle between the different variant choice combinations, calculate compliance, and monitor the outcome to determine the optimal design choice, run `OutcomeAnalysis.m`. For more information on variant analysis, see “Analysis Function Constructs” on page 9-9.

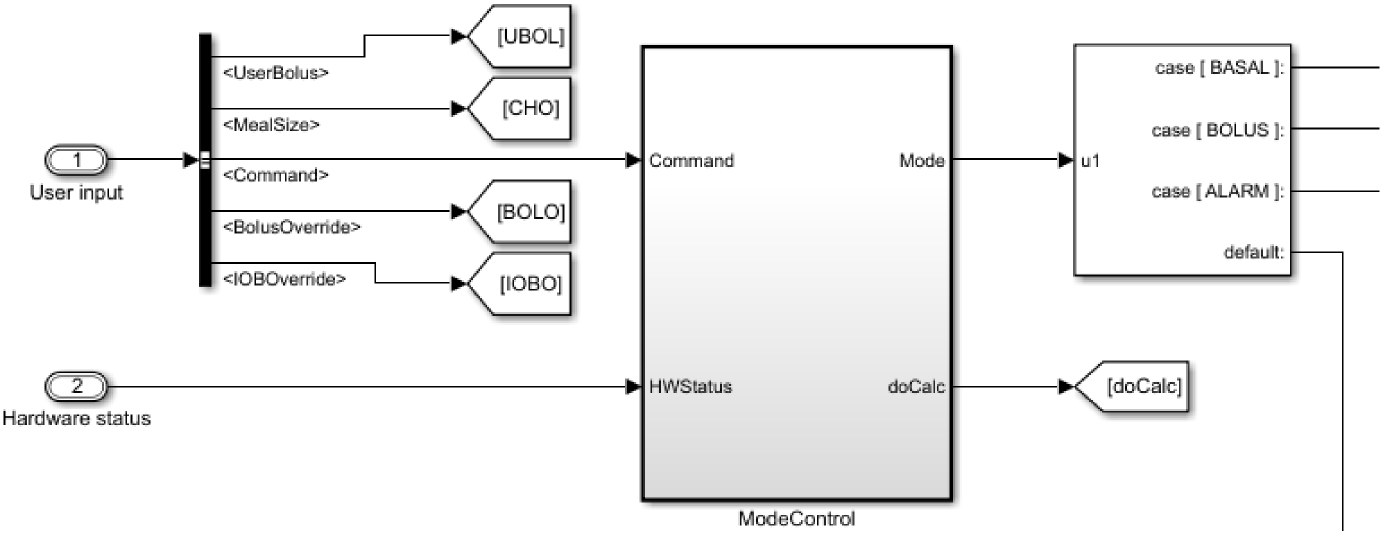
```
run("OutcomeAnalysis.m")
```



The normalized outcome score is at a maximum for the `SensorA + SyringePump` combination. This design choice is optimal for the insulin pump.

Controller Implementation Model

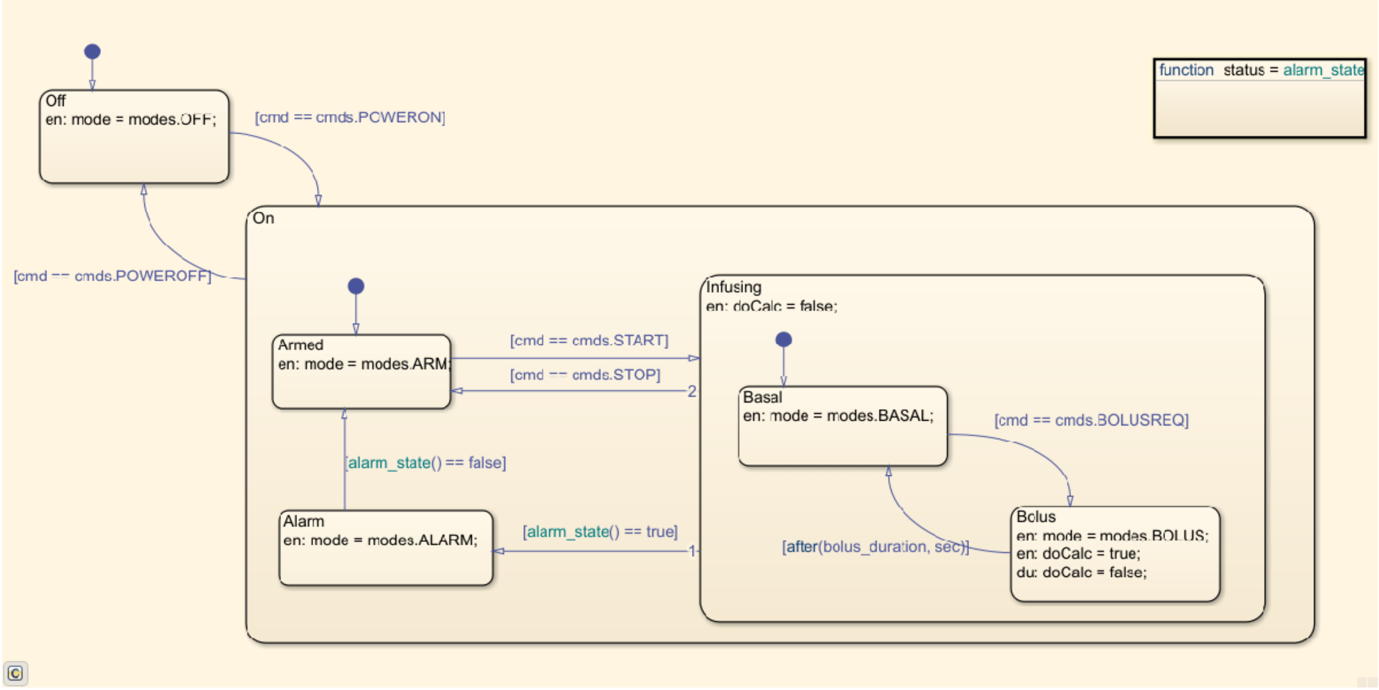
Implement the insulin infusion pump controller in Simulink®. The input ports in this implementation include `User input`, with user metrics that the insulin pump reads, and `Hardware status`, with information about the insulin pump. The block named `ModeControl` deteremines in which mode the insulin pump must operate.



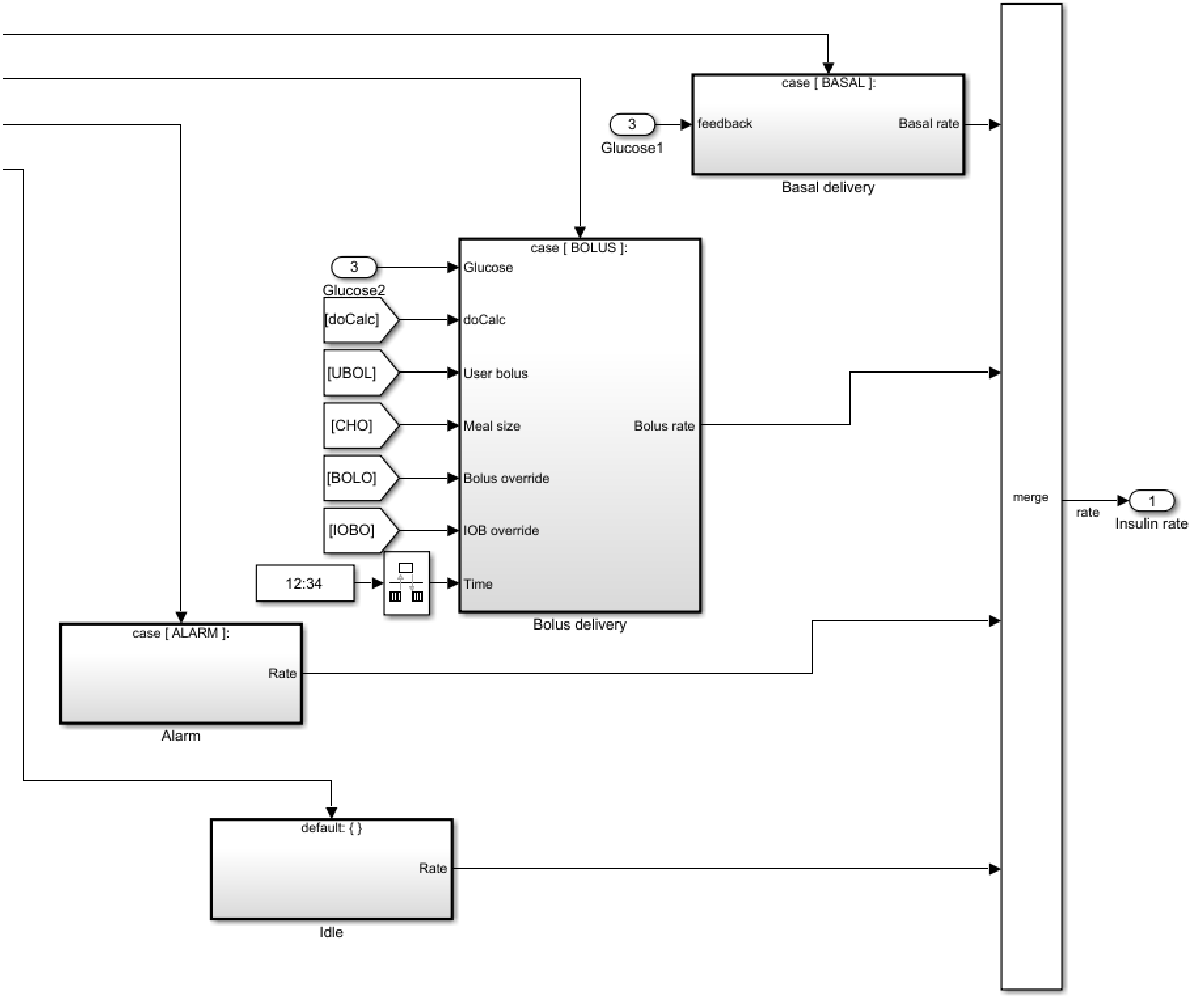
The block named `ModeControl` contains a Stateflow chart with details on how to select the mode.

The three modes include:

- `Alarm` mode, where the system is be suspended, repaired, and restarted once clear
- `Bolus` delivery mode to deliver insulin quickly with food intake
- `Basal` delivery mode to deliver insulin over a longer period of time to keep glucose levels steady throughout the day



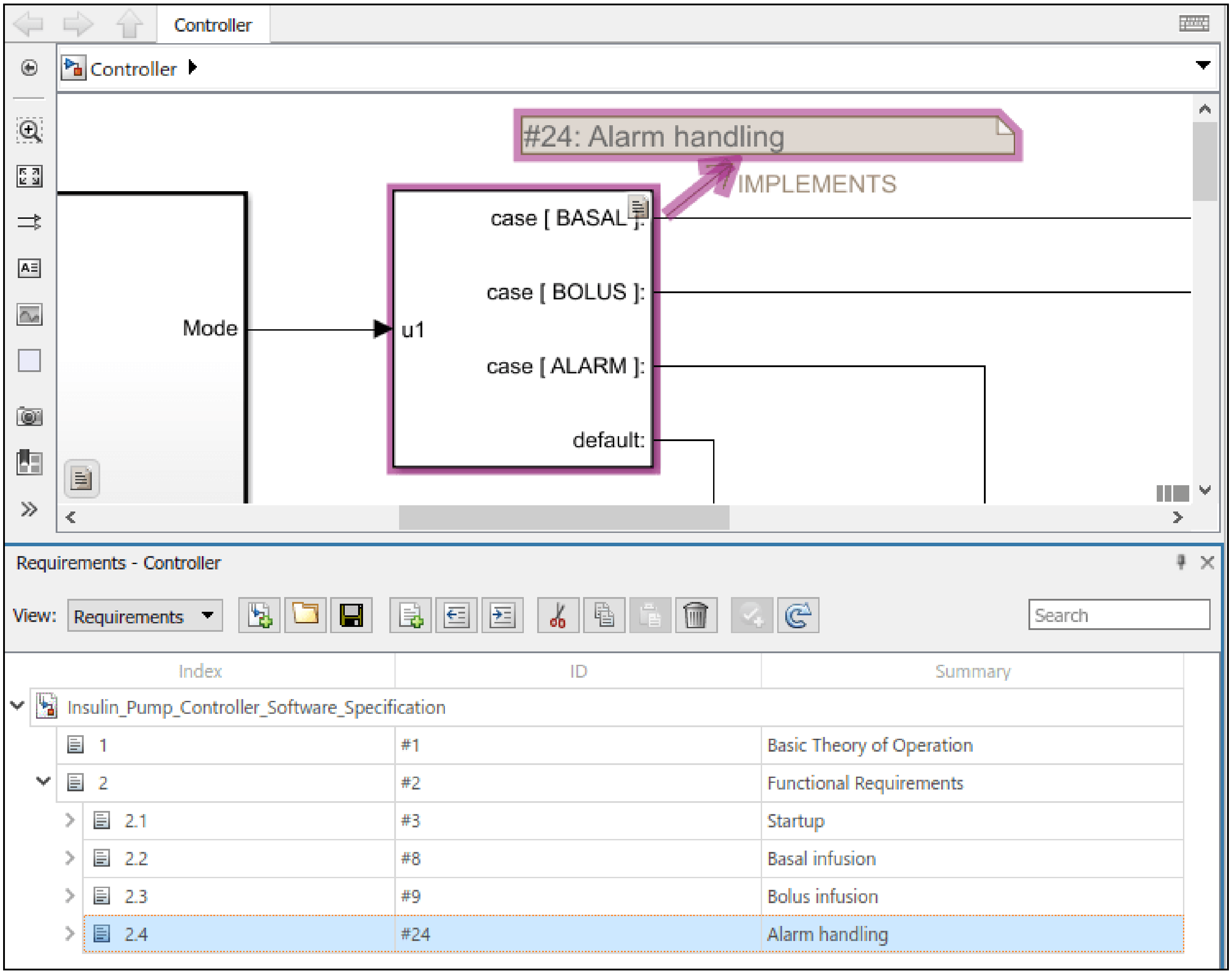
After the mode is selected, this component behavior determines the insulin rate for the outport.



Verification and Validation Using Test Manager

You can use model-based design to verify architectural designs and system requirements. The abstract architecture model and the detailed Simulink design model are connected with traceable requirement links. This section requires a Simulink® Test™ license.

The `Controller` implementation model in Simulink demonstrates requirements traceability for the `Alarm handling` requirement.

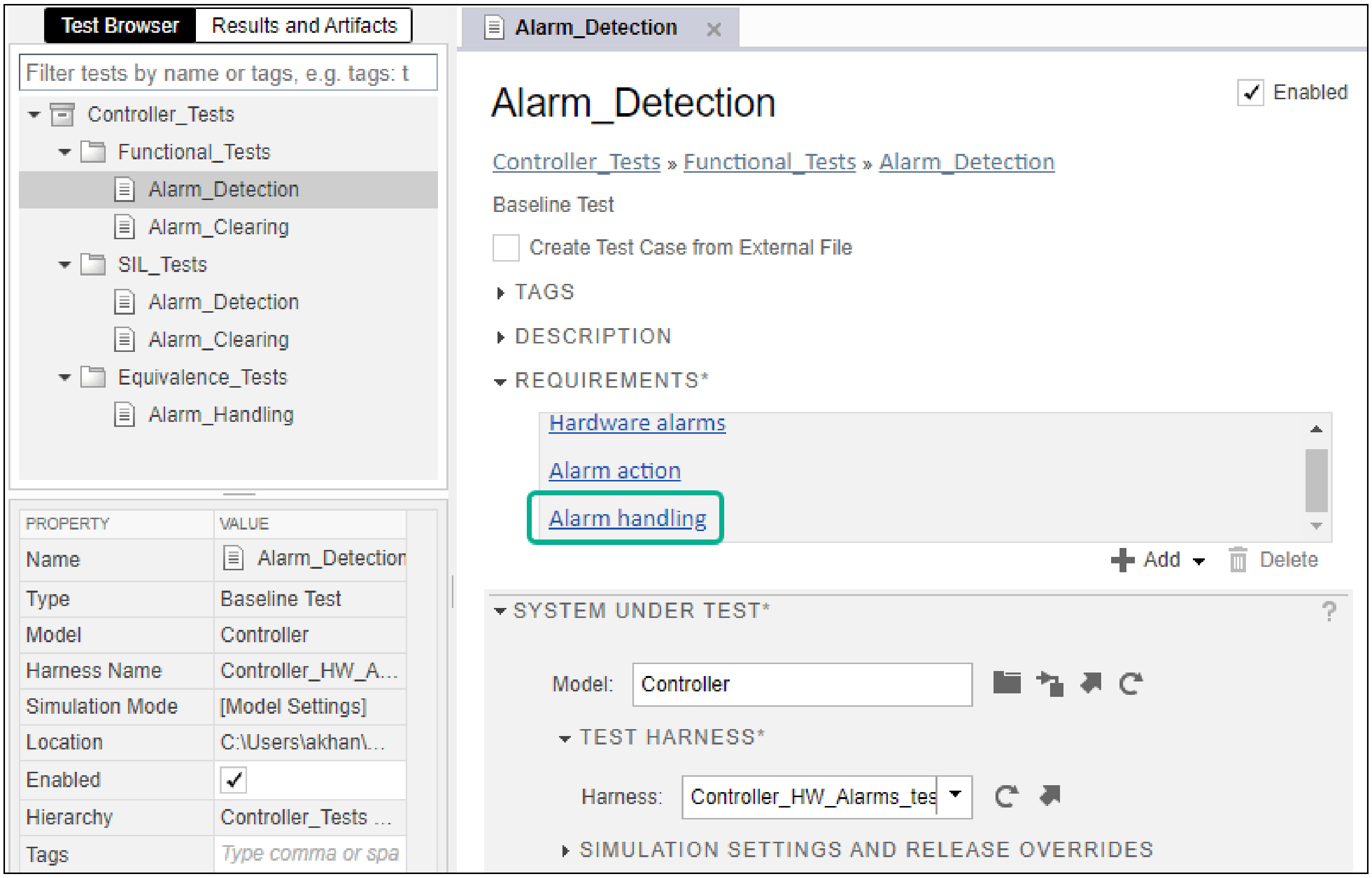


Index	ID	Summary
Insulin_Pump_Controller_Software_Specification		
1	#1	Basic Theory of Operation
2	#2	Functional Requirements
2.1	#3	Startup
2.2	#8	Basal infusion
2.3	#9	Bolus infusion
2.4	#24	Alarm handling

Load and view the Test Manager (Simulink Test) using these commands.

```
sltest.testmanager.load("Controller_Tests.mldatx");
sltest.testmanager.view
```

The `Alarm_Detection` functional test verifies the `Alarm handling` requirement.



- Controller_Tests
  - Functional_Tests
    - Alarm_Detection
    - Alarm_Clearing
  - SIL_Tests
    - Alarm_Detection
    - Alarm_Clearing
  - Equivalence_Tests
    - Alarm_Handling

PROPERTY	VALUE
Name	Alarm_Detection
Type	Baseline Test
Model	Controller
Harness Name	Controller_HW_A...
Simulation Mode	[Model Settings]
Location	C:\Users\akhan\...
Enabled	✓
Hierarchy	Controller_Tests ...
Tags	Type comma or spa

Alarm_Detection

☑ Enabled

Controller_Tests » Functional_Tests » Alarm_Detection

Baseline Test

□ Create Test Case from External File

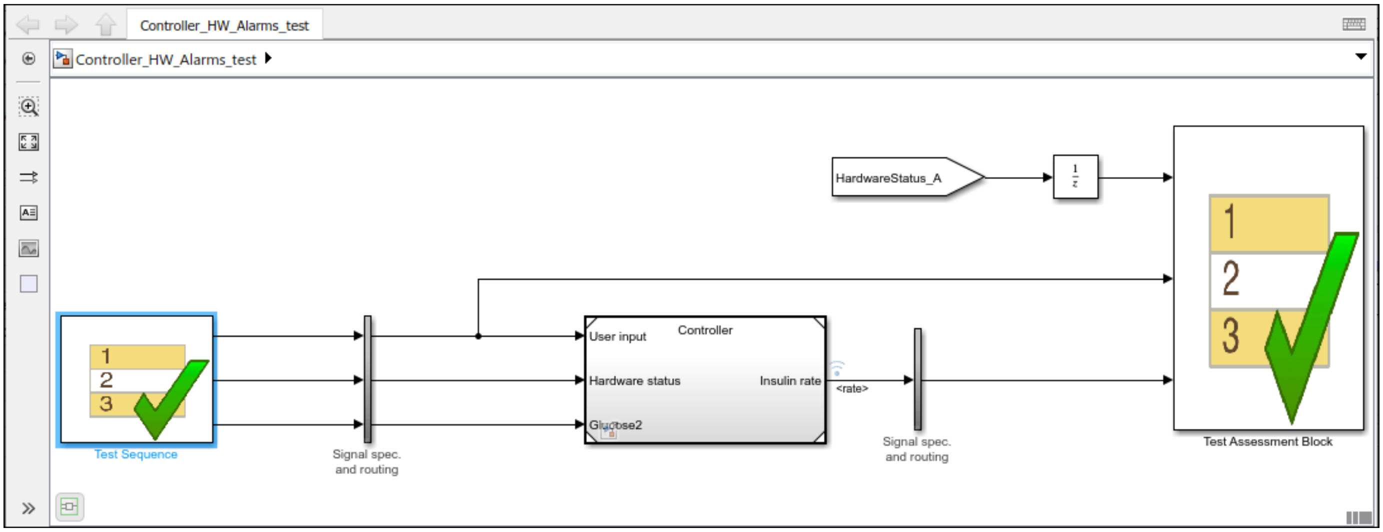
REQUIREMENTS*

- Hardware alarms
- Alarm action
- Alarm handling

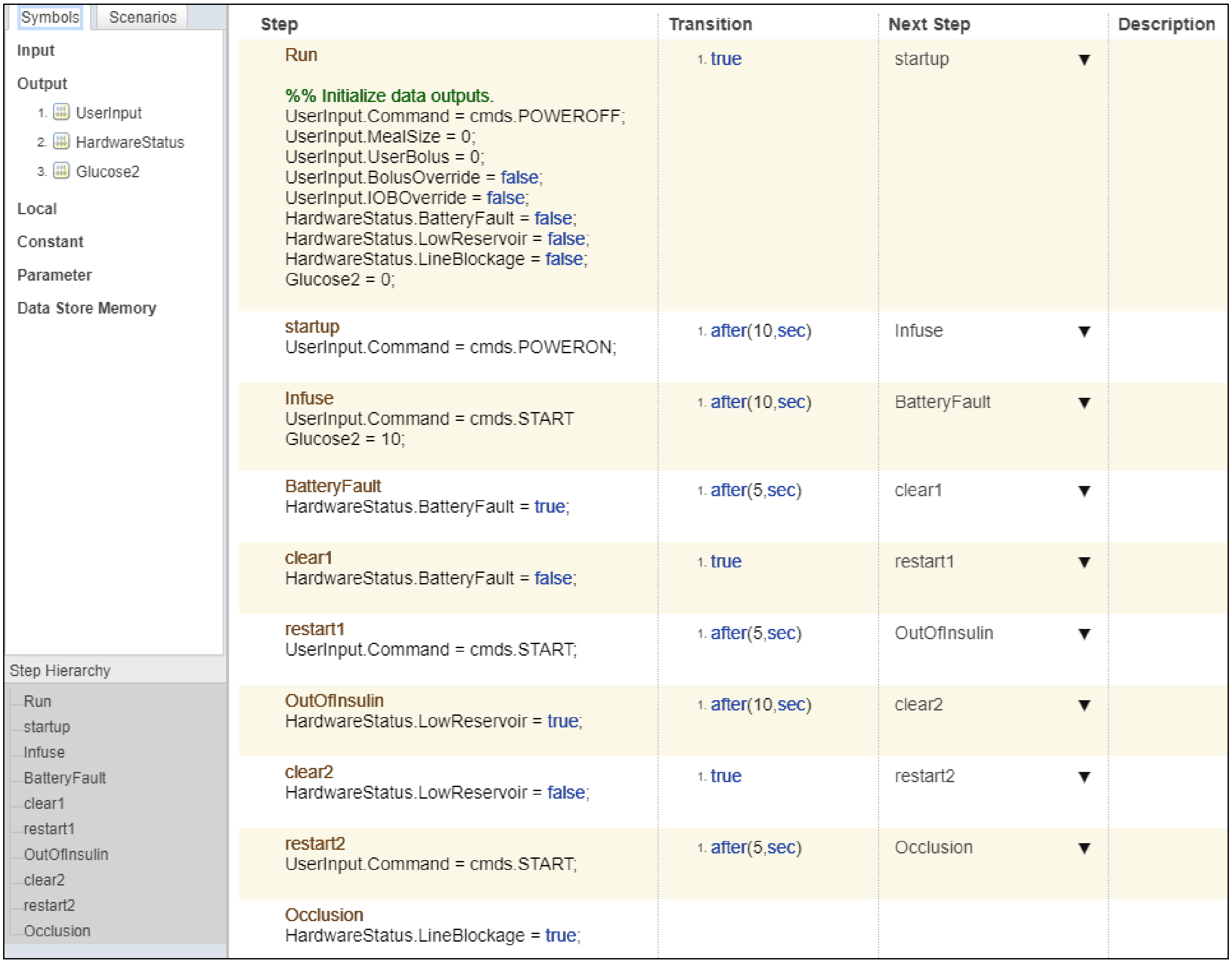
Model: Controller

Harness: Controller_HW_Alarms_tes

Click the icon to the right of the **Harness** box to open the test harness. In this example, the block named `Controller` is isolated for unit testing using a test harness. For more information on creating a test harness, see “Create Test Harnesses and Select Properties” (Simulink Test).



Double-click the Test Sequence block to view the steps in the test sequence. The steps define a scenario to verify the functioning of the alarm system.



Input

Output

1. UserInput
2. HardwareStatus
3. Glucose2

Local

Constant

Parameter

Data Store Memory

Step Hierarchy

- Run
- startup
- Infuse
- BatteryFault
- clear1
- restart1
- OutOfInsulin
- clear2
- restart2
- Occlusion

Step	Transition	Next Step	Description

Run
 	
%% Initialize data outputs.
UserInput.Command = cmds.POWEROFF;
UserInput.MealSize = 0;
UserInput.UserBolus = 0;
UserInput.BolusOverride = false;
UserInput.IOBOverride = false;
HardwareStatus.BatteryFault = false;
HardwareStatus.LowReservoir = false;
HardwareStatus.LineBlockage = false;
Glucose2 = 0;
	1. true	startup ▼	

startup UserInput.Command = cmds.POWERON;	1. after(10,sec)	Infuse ▼	

Infuse
UserInput.Command = cmds.START
Glucose2 = 10;
	1. after(10,sec)	BatteryFault ▼	

BatteryFault HardwareStatus.BatteryFault = true;	1. after(5,sec)	clear1 ▼	
clear1 HardwareStatus.BatteryFault = false;	1. true	restart1 ▼	
restart1 UserInput.Command = cmds.START;	1. after(5,sec)	OutOfInsulin ▼	
OutOfInsulin HardwareStatus.LowReservoir = true;	1. after(10,sec)	clear2 ▼	
clear2 HardwareStatus.LowReservoir = false;	1. true	restart2 ▼	
restart2 UserInput.Command = cmds.START;	1. after(5,sec)	Occlusion ▼	
Occlusion HardwareStatus.LineBlockage = true;			

To run this test, go back into the Test Manager (Simulink Test).

```
sltest.testmanager.view
```

Right-click the test `Alarm_Detection` in the Test Browser and select **Run**. In the Results and Artifacts section, view your test results. A passing test indicates that the system requirement `Alarm handling` is verified by the conditions defined in the Test Assessment Block:

- Whether the alarm disables insulin delivery when there is low battery, occlusion (line blockage), or low medication (insulin)
- Whether the system restarts after the issue has passed

See Also

`systemcomposer.profile.editor` | `slreq.editor` | `sltest.testmanager.view`

More About

- “Manage Requirements” on page 2-8
- “Compose Architectures Visually” on page 1-2
- “Analysis Function Constructs” on page 9-9
- “Simulate Mobile Robot with System Composer Workflow” on page 5-20
- “Calculate Endurance Using Quadcopter Architectural Design” on page 9-16
- “Model-Based Systems Engineering for Space-Based Applications” on page 1-38

Software Architectures

Author Software Architectures

Software architectures in System Composer provide capabilities to author software architecture models composed of software components, ports, and interfaces. Use System Composer to design your software architecture model, simulate your design in the architecture level, and generate code.

Use software architectures to link your Simulink export-function, rate-based, or JMAAB models to components in your architecture model to simulate and generate code.

Create New Software Architecture Model

The workflow for authoring software architecture models is similar to authoring system architectures. Start with a blank software architecture template to model.

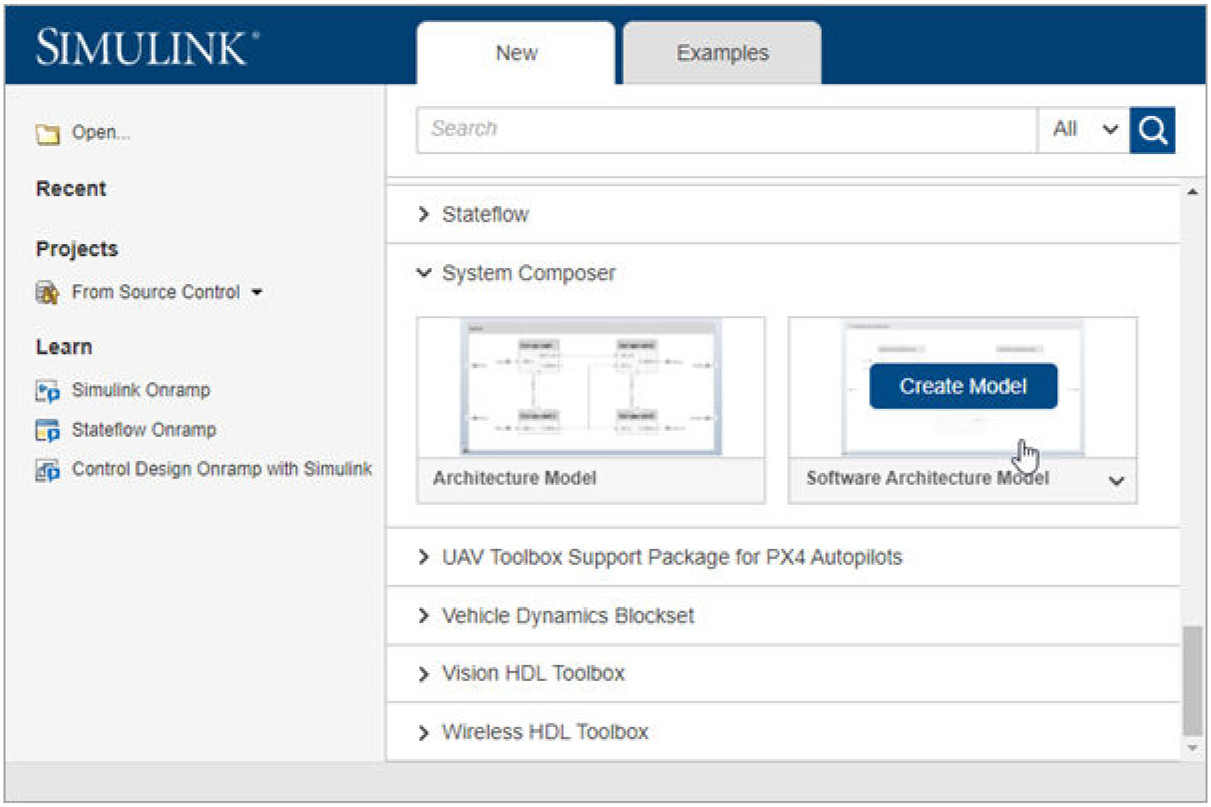
You can create a software architecture programmatically by using the function.

```
systemcomposer.createModel("mySoftwareArchitectureDesign","SoftwareArchitecture")
```

where `mySoftwareArchitectureDesign` is the name of the new model.

You can also use the provided template in the Simulink start page.

Select **Software Architecture Model**.

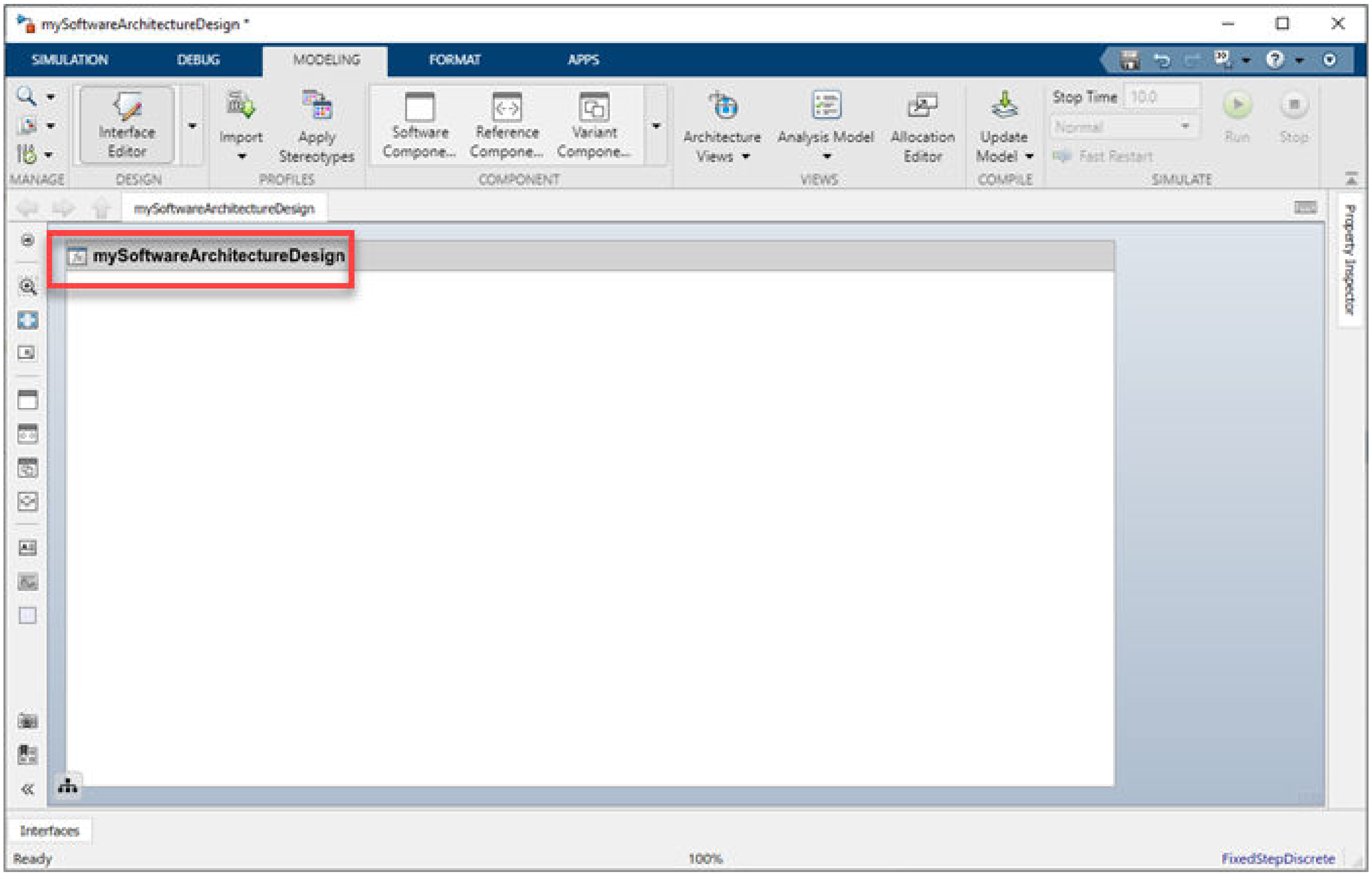


Use a System Composer **Architecture Model** to describe systems as a combination of structural elements with underlying behavioral descriptions. Use a **Software Architecture Model** to easily define the execution order of your functions from your components, simulate your design in the architecture level, and generate code by linking your Simulink export-function, rate-based, or JMAAB models to components.

For more information about architecture models, see “Compose Architectures Visually” on page 1-2.

From a Simulink model or a System Composer architecture model, on the **Simulation** tab, select **New**, and then select **Architecture**. Then, select **Software Architecture Model**.

System Composer opens a new empty software architecture model. Observe the icon on the upper left corner that distinguishes the empty model from a system architecture.



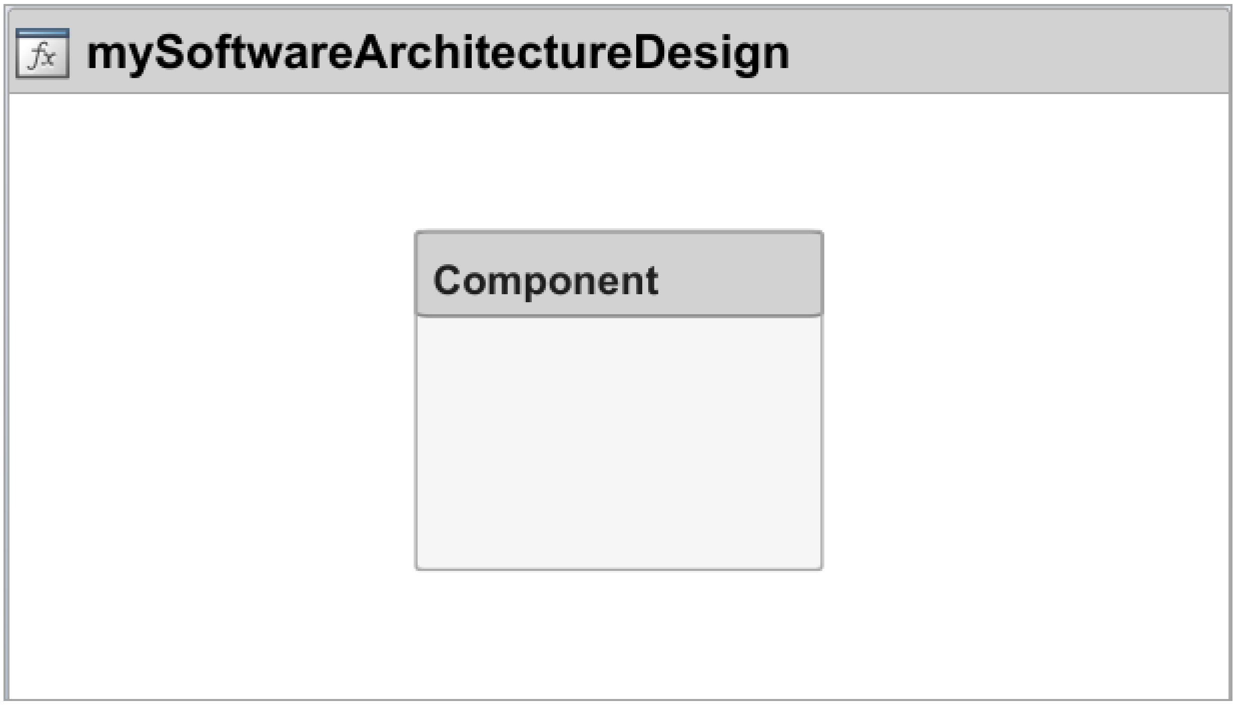
When you model software architectures, you can:

- Use model-building and visualization tools provided by System Composer such as components, connections, and ports. For more information, see “Compose Architectures Visually” on page 1-2.
- Define interfaces. For more information, see **Interface Editor**.
- Define profiles and stereotypes. For more information, see **Profile Editor**.
- Create custom views and sequence diagrams. For more information, see **Architecture Views Gallery**.
- Use tools to write analysis. For more information, see **Instantiate Architecture Model** and **Analysis Viewer**.
- Create allocations. For more information, see **Allocation Editor**.

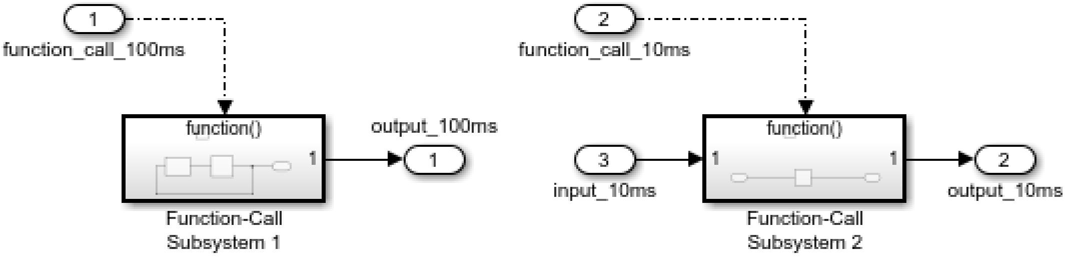
- Define parameters. For more information, see **Parameter Editor**.
- Compare differences between two models. For more information, see **Comparison Tool**.

Build a Simple Software Architecture Model

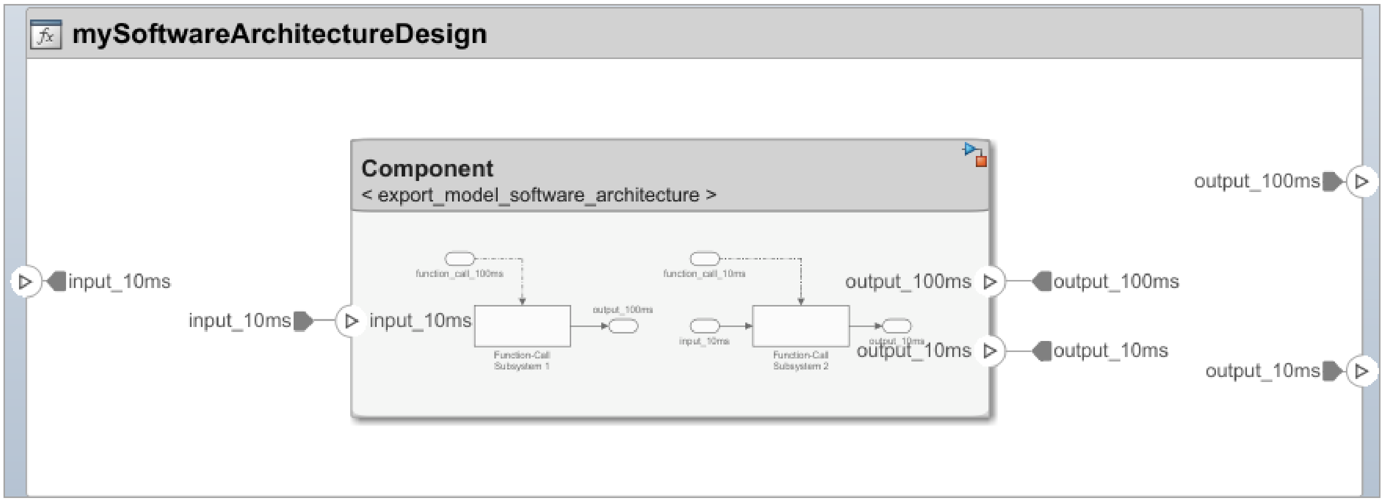
1 Drag an empty component to the `mySoftwareArchitectureDesign` model.



2 Link this simple Simulink Export-Function model, `export_model_software_architecture` to your component by right-clicking the component and selecting **Link to Model**. For more information about building this Simulink model, see “Create an Export-Function Model”.



3 Connect component input port and output ports to architecture input ports and output ports.



In this example, you start from a blank template and create a simple software architecture model. To learn how to simulate a software architecture model and generate code, see “Simulate and Deploy Software Architectures” on page 10-8.

Import and Export Software Architectures

You can import a software architecture model using the `systemcomposer.importModel` function.

```
archModel = systemcomposer.importModel(modelName,importStruct)
```

If the `domain` field of `importStruct` is `"Software"`, the `importModel` function creates a new software architecture based on the structure of the MATLAB tables.

To export a System Composer software architecture model, use the `systemcomposer.exportModel` function.

```
exportedSet = systemcomposer.exportModel(modelName)
```

The `exportModel` function returns a structure containing MATLAB tables that contains `components`, `ports`, `connections`, `portInterfaces`, `requirementLinks`, and a `domain` field with value `'Software'` to indicate that the exported architecture is a software architecture.

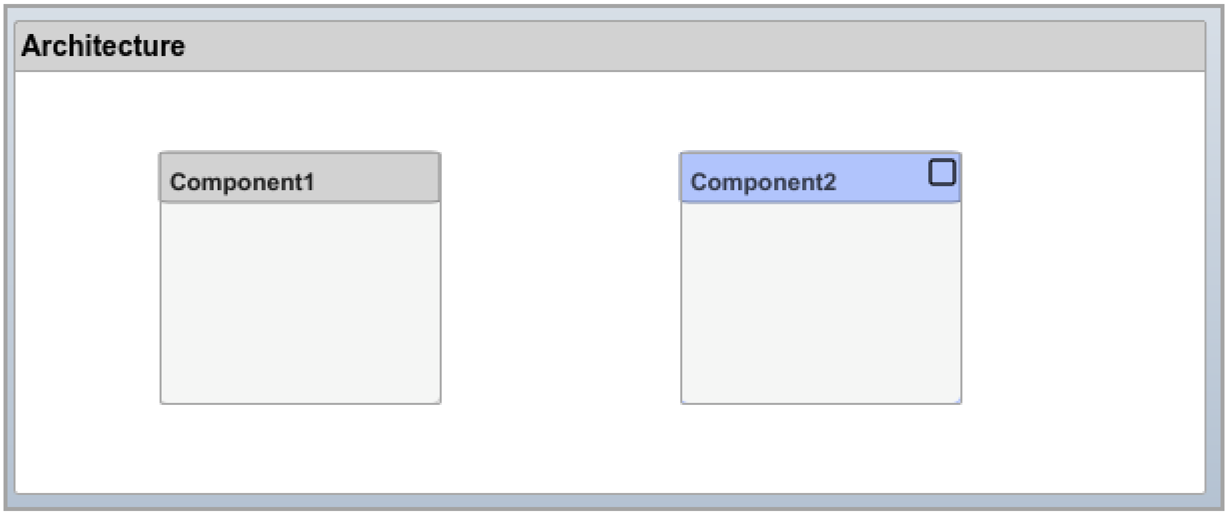
For more information on importing and exporting software architectures with functions, see “Import and Export Functions of Software Architectures” on page 10-30.

Create Software Architecture from Architecture Model Component

You can also create a software architecture model from an existing component in a System Composer architecture model.

To create a software architecture model from a component:

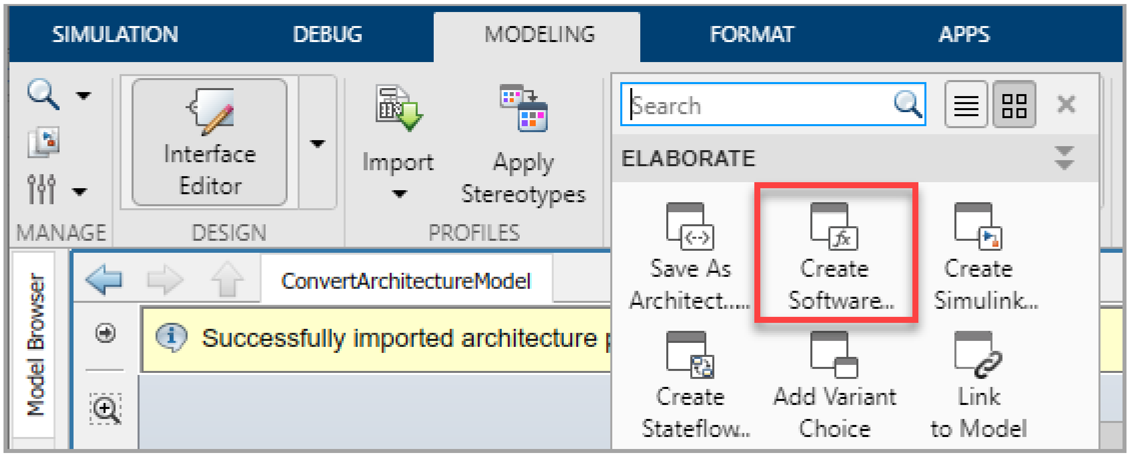
1. Select an existing component from your architecture model. In this example, we select `Component2`.



2 To create a software architecture model from `Component2`, you can use any of these three methods:

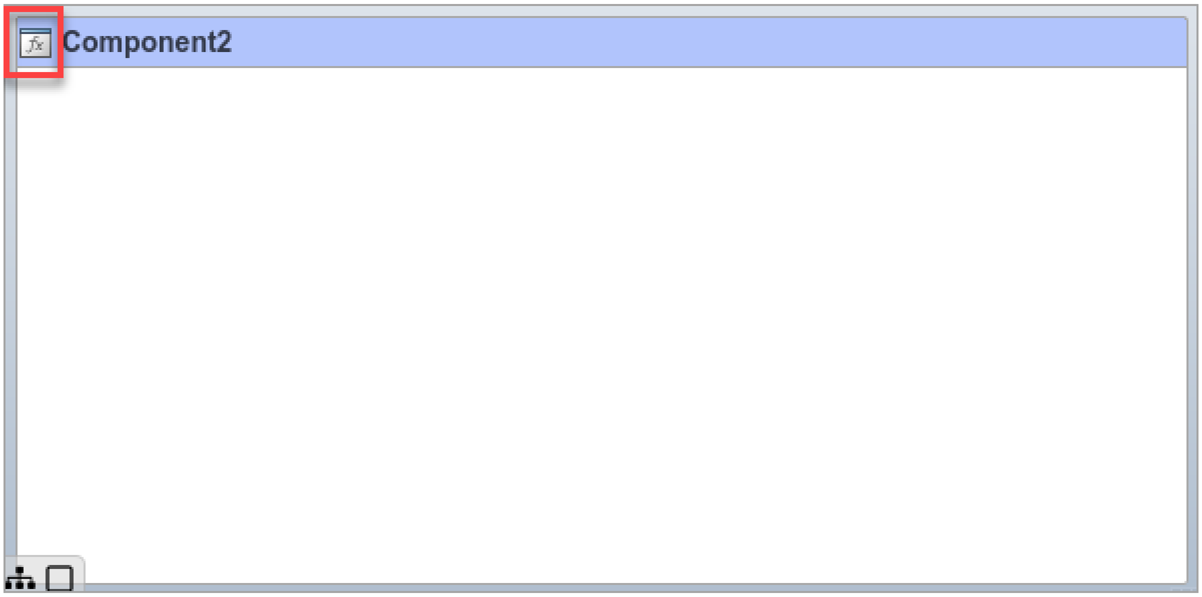
   a Right-click the component and select `Create Software Architecture Model`.

   b Select the component and, on the toolstrip, click **Create Software Architecture Model**.



   c To create a software architecture programmatically, use the `createArchitectureModel` function.

3 Observe the software architecture model icon in the upper left corner. The new software architecture contains all elements from the component, including previously applied stereotypes.



The following elements are not supported if you create a software architecture from an existing component:

- A reference component that references a system architecture.
- A component with Stateflow chart behavior.
- Adapter blocks with applied interface conversions. “Interface Adapter” on page 3-16 conversions are removed when you create a software architecture from an existing component.

See Also

`systemcomposer.createModel` | `createArchitectureModel` | `createSimulinkBehavior`

More About

- “Compose Architectures Visually” on page 1-2
- “Create an Export-Function Model”
- “Class Diagram View of Software Architectures” on page 10-20
- “Modeling Software Architecture of Throttle Position Control System” on page 10-14
- “Simulate and Deploy Software Architectures” on page 10-8

Simulate and Deploy Software Architectures

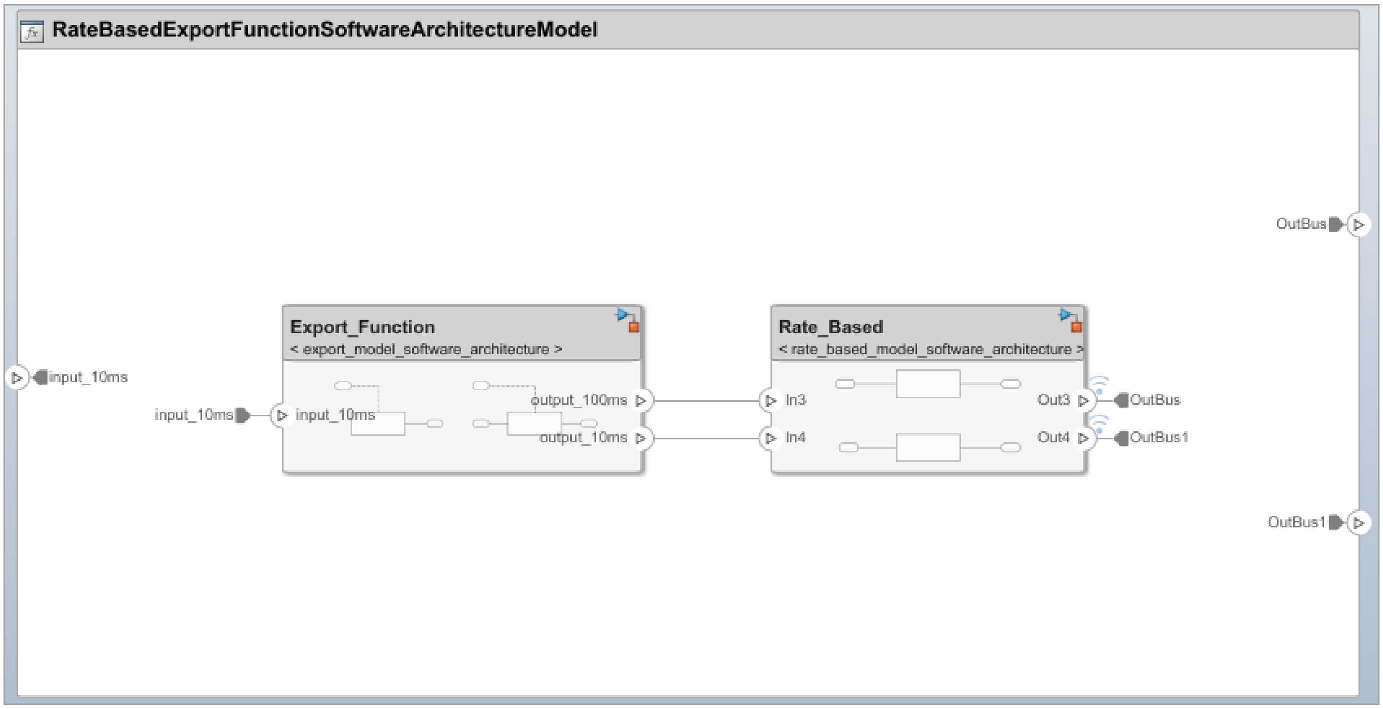
This example shows how to build a multi-component software architecture model with a rate-based and export-function components, how to simulate your design at the architecture level, and how to generate code.

Open the Software Architecture Model

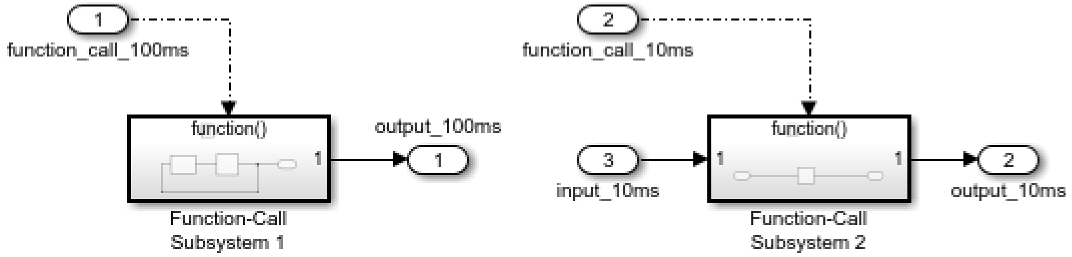
After opening the example, open the model below. This software architecture model has two software components: `Export_Function` and `Rate_Based`.

```
open_system('RateBasedExportFunctionSoftwareArchitectureModel')
```

In the software architecture model, the `Export_Function` component is linked to a Simulink® export-function behavior model, `export_model_software_architecture`.

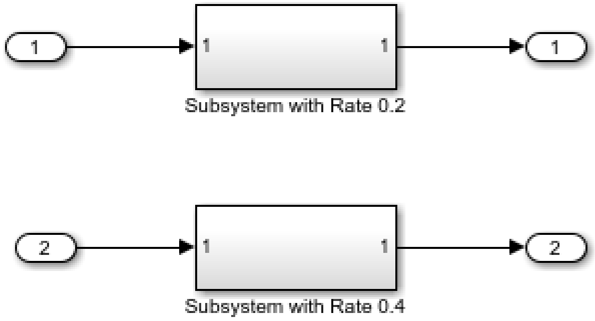

RateBasedExportFunctionSoftwareArchitectureModel
input_10ms
input_10ms
Export_Function
< export_model_software_architecture >
input_10ms
output_100ms
output_10ms
Rate_Based
< rate_based_model_software_architecture >
In3
In4
Out3
Out4
OutBus
OutBus1
OutBus
OutBus1

In this Simulink behavior, two functions are modeled using Function-Call Subsystem blocks. The inport blocks are connected to the function-call input ports and generate periodic function-call events with sample times `10ms` and `100ms`. To learn how to model this behavior, see “Create an Export-Function Model”.



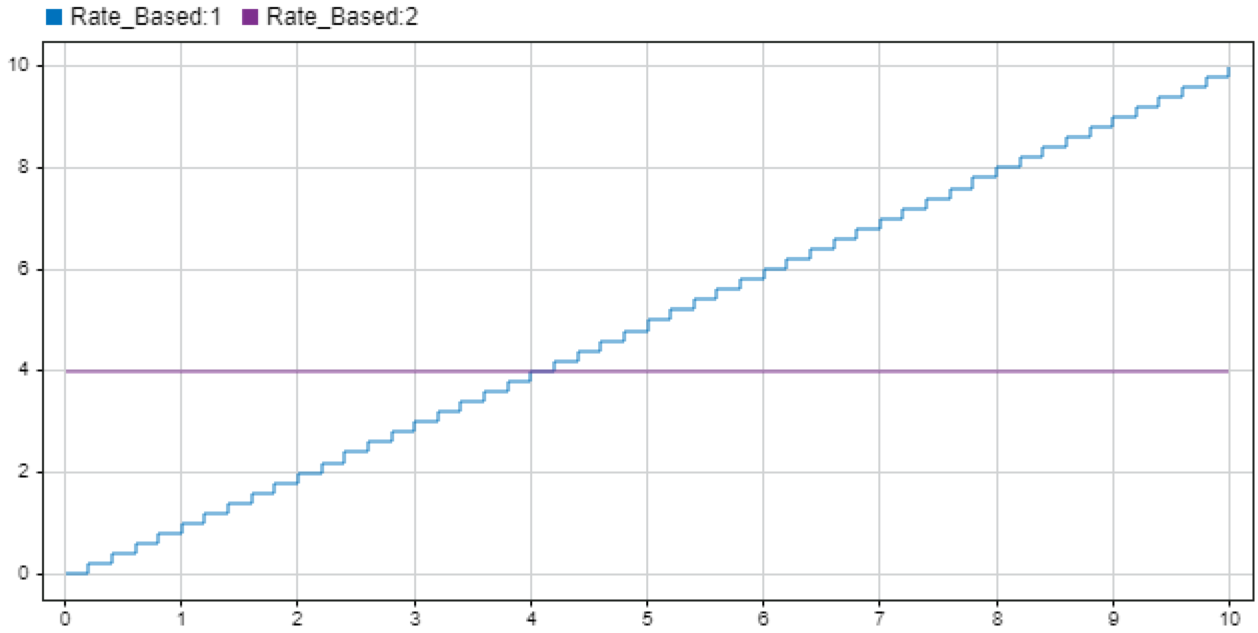
If the inport blocks that are connected to the function-call input ports with sample time specified as -1, meaning the functions are aperiodic, use a Simulink test model with explicit scheduling blocks such as a Stateflow chart to simulate. For more information see Test Software Architecture on page 10-11.

The Rate_Based component is linked to `rate_based_model_software_architecture` as the Simulink behavior model. To learn how to create this rate-based model, see “Create A Rate-Based Model”.



Simulate the Model with Default Execution Order

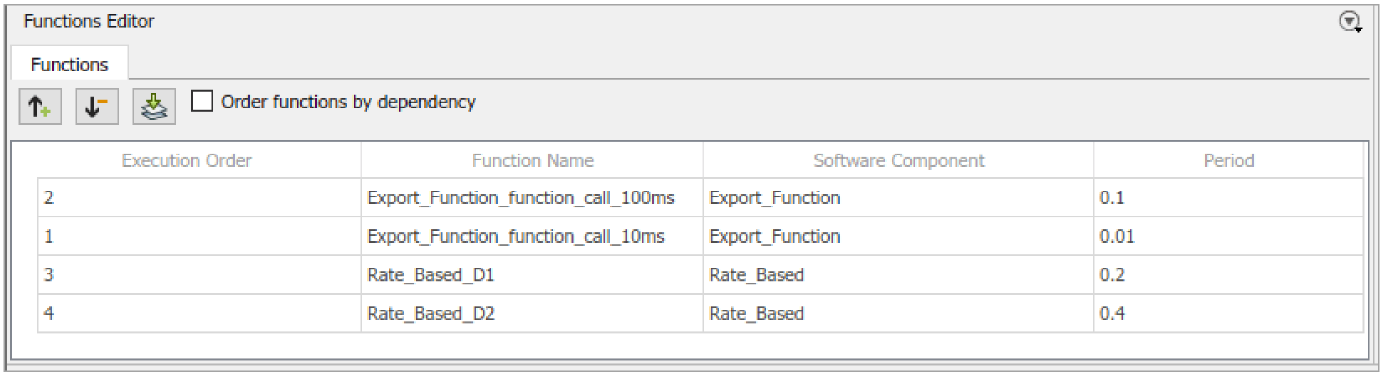
Simulate the model. Observe that the Simulation Data Inspector displays the output from the Rate-Based component.



Visualize and Edit Component Functions Using Functions Editor

Use the Functions Editor to edit simulation execution order of the functions in your software architecture. You can also edit the sample time of the functions with inherited sample time (-1).

The Functions Editor is visible only when you model software architectures. To open the Functions Editor, in the toolstrip on the Modeling tab, select **Functions Editor**.



Execution Order	Function Name	Software Component	Period
2	Export_Function_function_call_100ms	Export_Function	0.1
1	Export_Function_function_call_10ms	Export_Function	0.01
3	Rate_Based_D1	Rate_Based	0.2
4	Rate_Based_D2	Rate_Based	0.4

To edit the functions in your software architecture:

1. Open the Functions Editor. When you open the Functions Editor, the model will automatically update, and the table will display the functions populated from your model.
2. If there are changes in the software architecture model, the **Update Model** button becomes yellow to signal that an update is required to refresh your functions table.
3. To arrange the execution order of the functions, use the up and down arrows or drag and drop functions to sort them.
4. To edit sample times of the functions, specify their period in the table.

To order functions based on their data dependencies, select the **Order functions by dependency** check box. To enable sorting of functions based on dependencies, you can set this parameter.

```
set_param('RateBasedExportFunctionSoftwareArchitectureModel','OrderFunctionsByDependency','on')
```

The default value for the parameter is `off`.

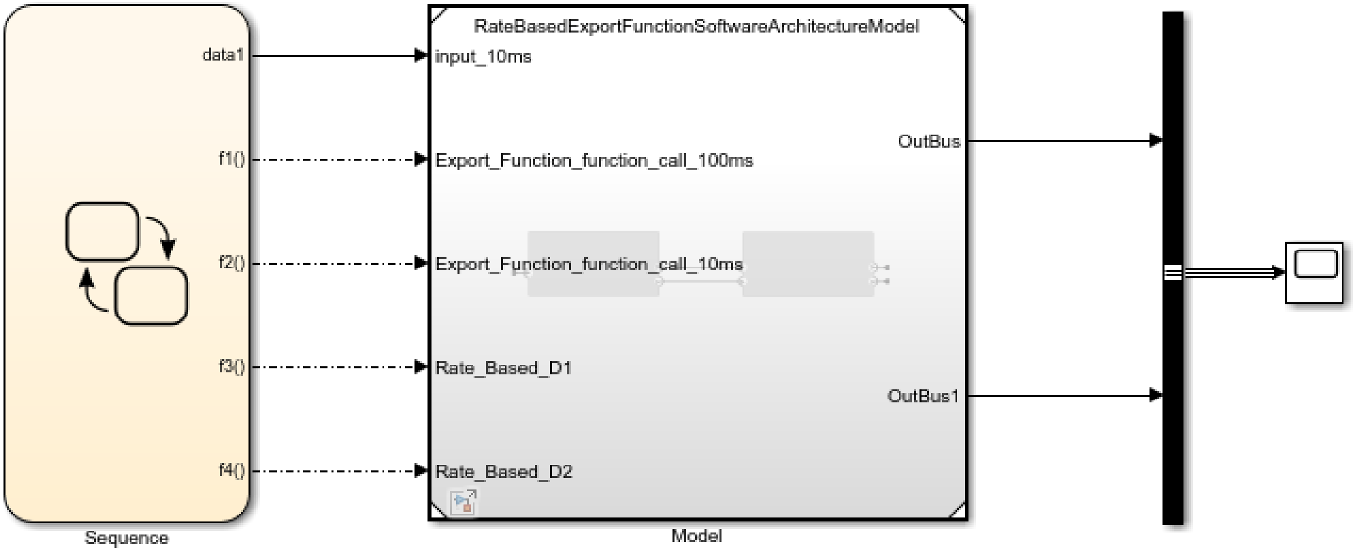
Alternatively, you can use the `systemcomposer.arch.Function` object to get the functions programmatically.

Test Software Architecture

You can test a software architecture model and simulate different execution orders of functions by referencing it from a Model block in a Simulink test model with explicit scheduling blocks such as Stateflow® Chart (Stateflow).

In this example, a Model block that references a software architecture model has a function-call input port for each function in the architecture model.

To simulate the architecture model with a Stateflow chart periodic scheduler, connect the Stateflow chart function-call outputs to the Model block function-call inputs.

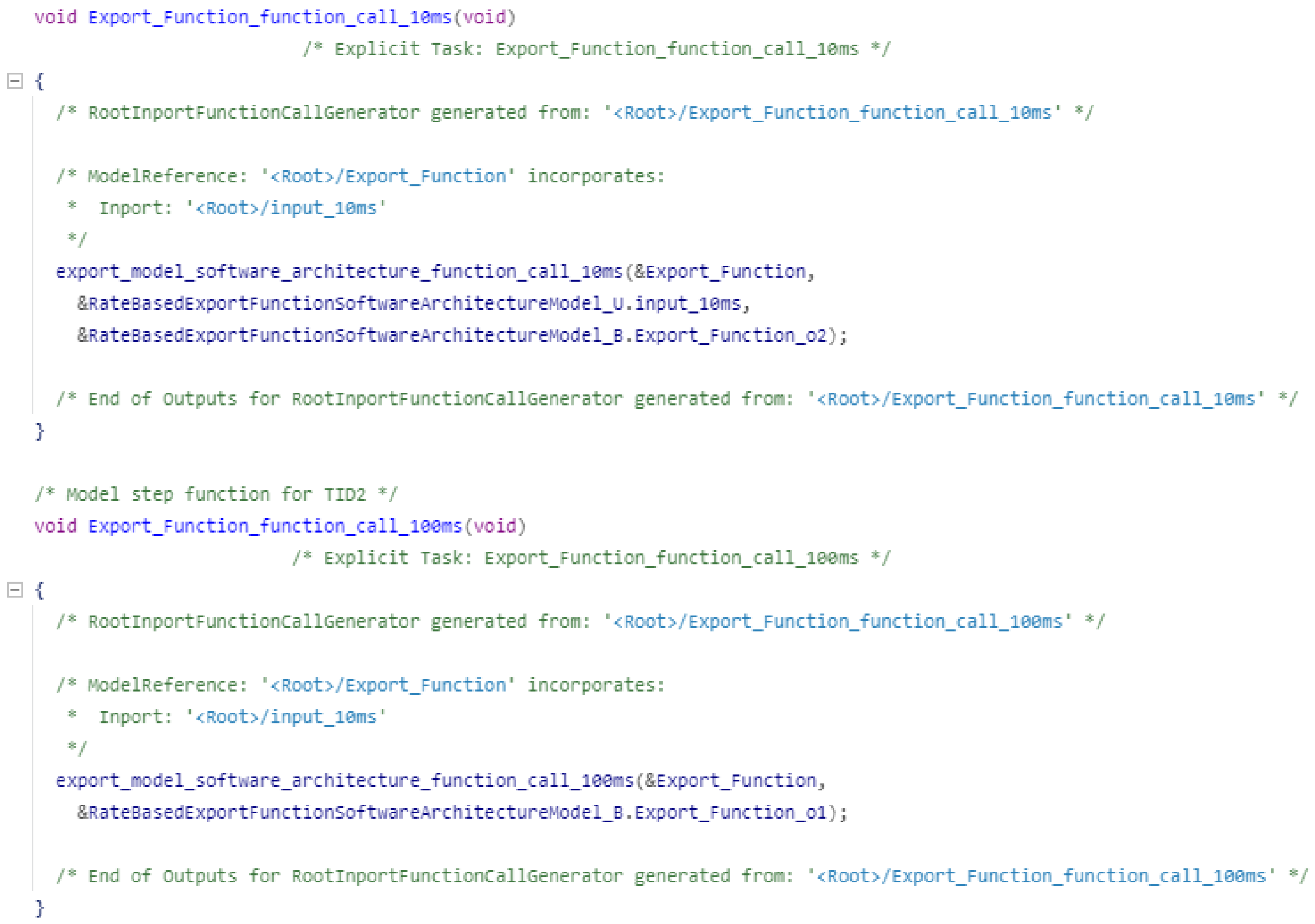

data1
f1()
f2()
f3()
f4()
Sequence
RateBasedExportFunctionSoftwareArchitectureModel
input_10ms
Export_Function_function_call_100ms
Export_Function_function_call_10ms
Rate_Based_D1
Rate_Based_D2
OutBus
OutBus1
Model

Deploy Software Architecture

You can generate code from the software architecture model for the functions of the export-function and rate-based components.

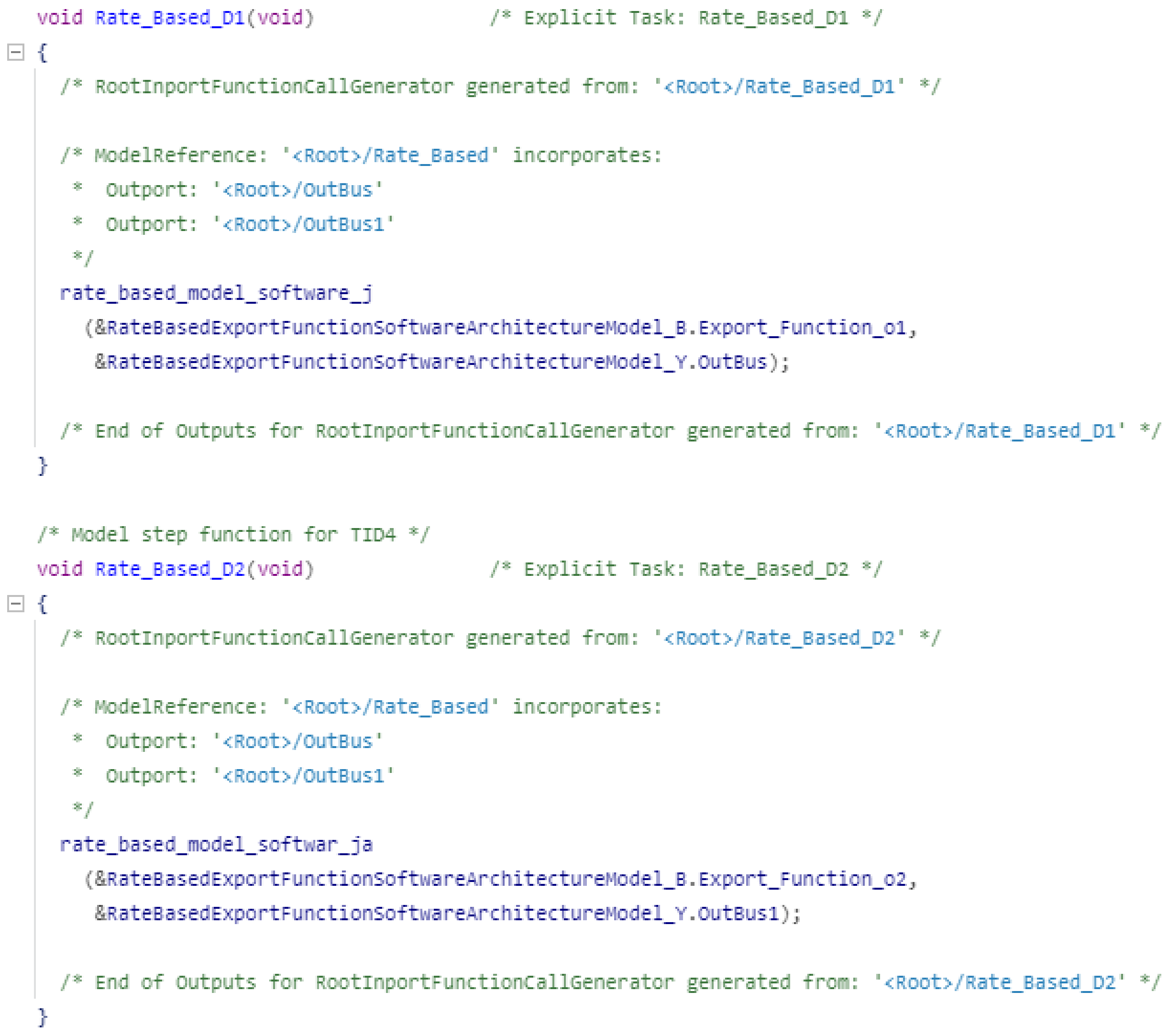
To generate code, from the **Apps** tab, select **Embedded Coder**. On the **C Code** tab, select **Generate Code**. The generated code contains an entry-point for each function of the component. For more information, see “Generate Code for Export-Function Model”.

For the export-function component, it generated the two functions that correspond to the function-call inport blocks inside the referenced export-function model.



```
void Export_Function_function_call_10ms(void)
                         /* Explicit Task: Export_Function_function_call_10ms */
{
  /* RootInportFunctionCallGenerator generated from: '<Root>/Export_Function_function_call_10ms' */

  /* ModelReference: '<Root>/Export_Function' incorporates:
   *  Inport: '<Root>/input_10ms'
   */
  export_model_software_architecture_function_call_10ms(&Export_Function,
    &RateBasedExportFunctionSoftwareArchitectureModel_U.input_10ms,
    &RateBasedExportFunctionSoftwareArchitectureModel_B.Export_Function_o2);

  /* End of Outputs for RootInportFunctionCallGenerator generated from: '<Root>/Export_Function_function_call_10ms' */
}

/* Model step function for TID2 */
void Export_Function_function_call_100ms(void)
                        /* Explicit Task: Export_Function_function_call_100ms */
{
  /* RootInportFunctionCallGenerator generated from: '<Root>/Export_Function_function_call_100ms' */

  /* ModelReference: '<Root>/Export_Function' incorporates:
   *  Inport: '<Root>/input_10ms'
   */
  export_model_software_architecture_function_call_100ms(&Export_Function,
    &RateBasedExportFunctionSoftwareArchitectureModel_B.Export_Function_o1);

  /* End of Outputs for RootInportFunctionCallGenerator generated from: '<Root>/Export_Function_function_call_100ms' */
}
```

Observe that, each rate-based component has separate entry point functions that correspond to each sample time in the referenced rate based model.



```
void Rate_Based_D1(void)               /* Explicit Task: Rate_Based_D1 */
{
  /* RootInportFunctionCallGenerator generated from: '<Root>/Rate_Based_D1' */

  /* ModelReference: '<Root>/Rate_Based' incorporates:
   *  Outport: '<Root>/OutBus'
   *  Outport: '<Root>/OutBus1'
   */
  rate_based_model_software_j
    (&RateBasedExportFunctionSoftwareArchitectureModel_B.Export_Function_o1,
     &RateBasedExportFunctionSoftwareArchitectureModel_Y.OutBus);

  /* End of Outputs for RootInportFunctionCallGenerator generated from: '<Root>/Rate_Based_D1' */
}

/* Model step function for TID4 */
void Rate_Based_D2(void)               /* Explicit Task: Rate_Based_D2 */
{
  /* RootInportFunctionCallGenerator generated from: '<Root>/Rate_Based_D2' */

  /* ModelReference: '<Root>/Rate_Based' incorporates:
   *  Outport: '<Root>/OutBus'
   *  Outport: '<Root>/OutBus1'
   */
  rate_based_model_softwar_ja
    (&RateBasedExportFunctionSoftwareArchitectureModel_B.Export_Function_o2,
     &RateBasedExportFunctionSoftwareArchitectureModel_Y.OutBus1);

  /* End of Outputs for RootInportFunctionCallGenerator generated from: '<Root>/Rate_Based_D2' */
}
```

See Also

`systemcomposer.createModel` | `createArchitectureModel` | `createSimulinkBehavior` | `increaseExecutionOrder` | `decreaseExecutionOrder`

More About

- “Author Software Architectures” on page 10-2
- “Compose Architectures Visually” on page 1-2
- “Create an Export-Function Model”
- “Create A Rate-Based Model”
- “Class Diagram View of Software Architectures” on page 10-20
- “Modeling Software Architecture of Throttle Position Control System” on page 10-14
- “Software Component Modeling”

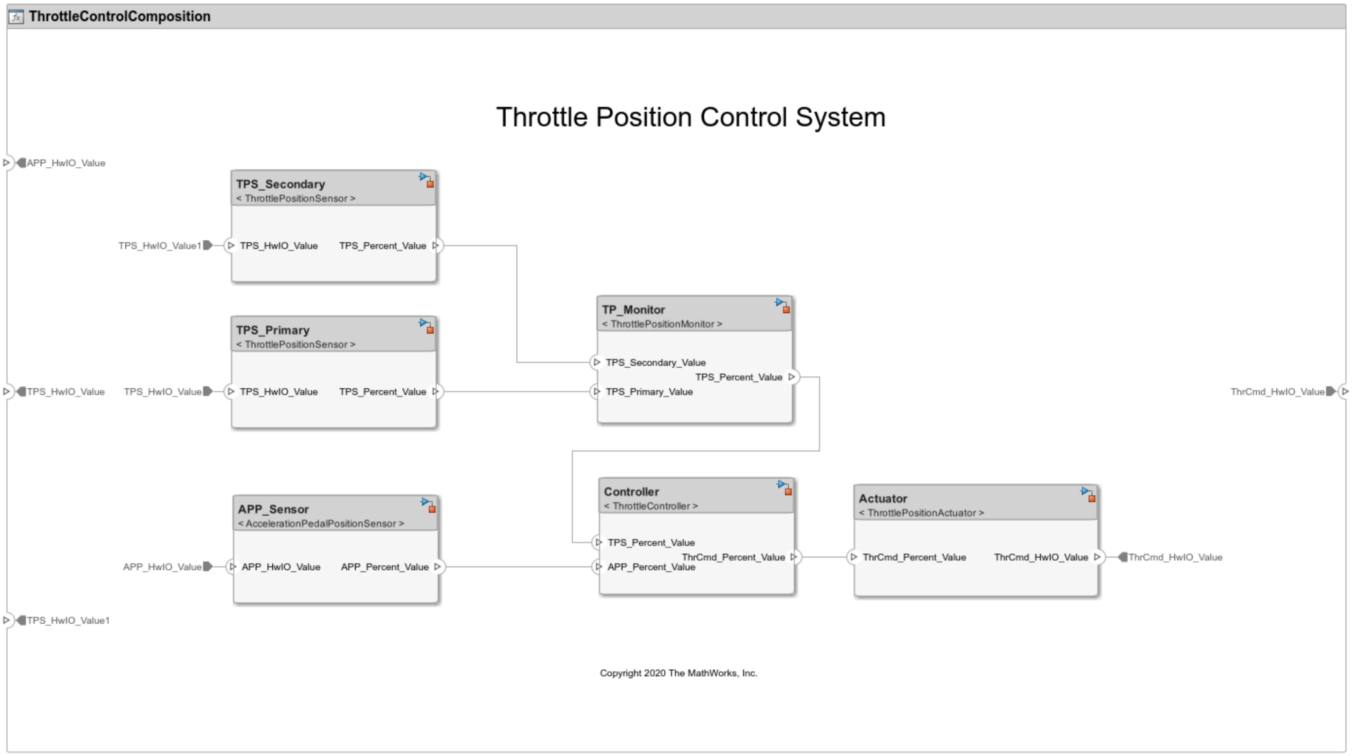
Modeling Software Architecture of Throttle Position Control System

This example shows how to author the software architecture of a throttle position control system in System Composer™, schedule and simulate the execution order of the functions from its components, and generate code.

Throttle Control Composition

In this example, the software architecture of a throttle position control system is modeled in System Composer using six components. The throttle position control component reads the throttle and pedal positions and outputs the new throttle position. Two throttle position sensor components provide the current position of the throttle, and a pedal position sensor component provides the applied pedal position. A controller component uses these signals to determine the new throttle position as a percent value. An actuator component then converts the percent value to the appropriate value for the hardware.

```
model = systemcomposer.openModel('ThrottleControlComposition');
```

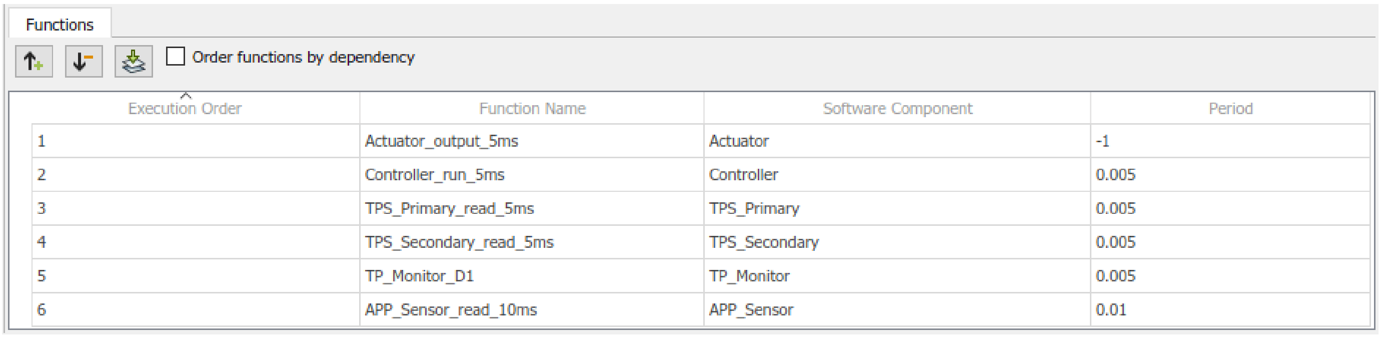


Simulate the Model at the Architecture Level

Simulate the software architecture model.

```
sim('ThrottleControlComposition');
```

To view the list of functions from the components and edit their properties, such as execution order, use the Functions Editor. To open the Functions Editor, on the **Modeling** tab, in the **Design** section, click **Functions Editor**. For more information about the Functions Editor, see “Simulate and Deploy Software Architectures” on page 10-8.



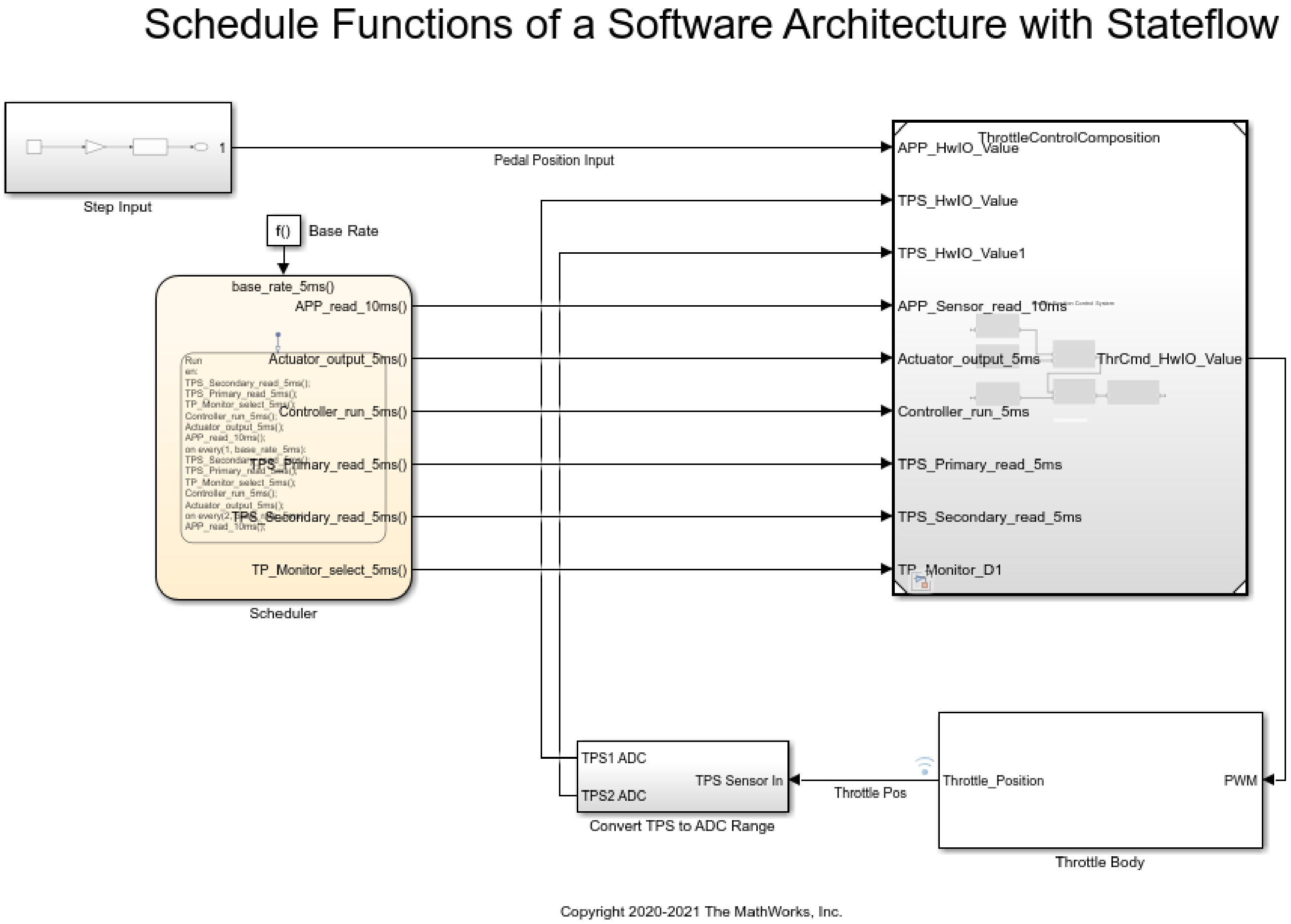
Execution Order	Function Name	Software Component	Period
1	Actuator_output_5ms	Actuator	-1
2	Controller_run_5ms	Controller	0.005
3	TPS_Primary_read_5ms	TPS_Primary	0.005
4	TPS_Secondary_read_5ms	TPS_Secondary	0.005
5	TP_Monitor_D1	TP_Monitor	0.005
6	APP_Sensor_read_10ms	APP_Sensor	0.01

Simulate the Model at the System Level

To simulate the throttle control system with the throttle body, use a Model block to reference the software architecture model in the system model. The `ThrottleControlSystem` model also contains a Stateflow® Chart block to model a more complex scheduling of the functions of the software architecture.

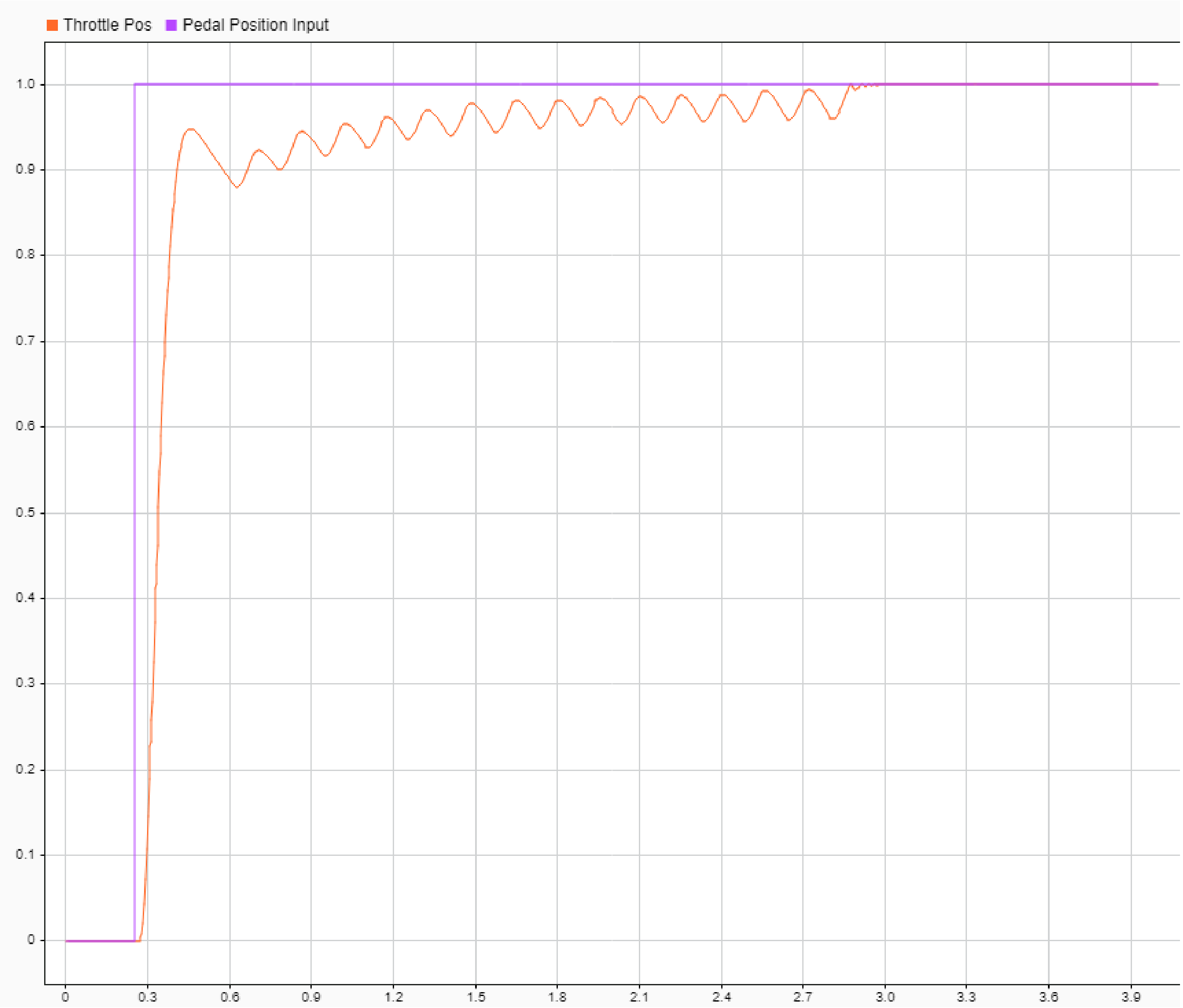
A Stateflow license is required for this functionality.

```
open_system('ThrottleControlSystem');
```



To simulate the system model containing the plant and Stateflow scheduler, use this command.

```
sim('ThrottleControlSystem');
```

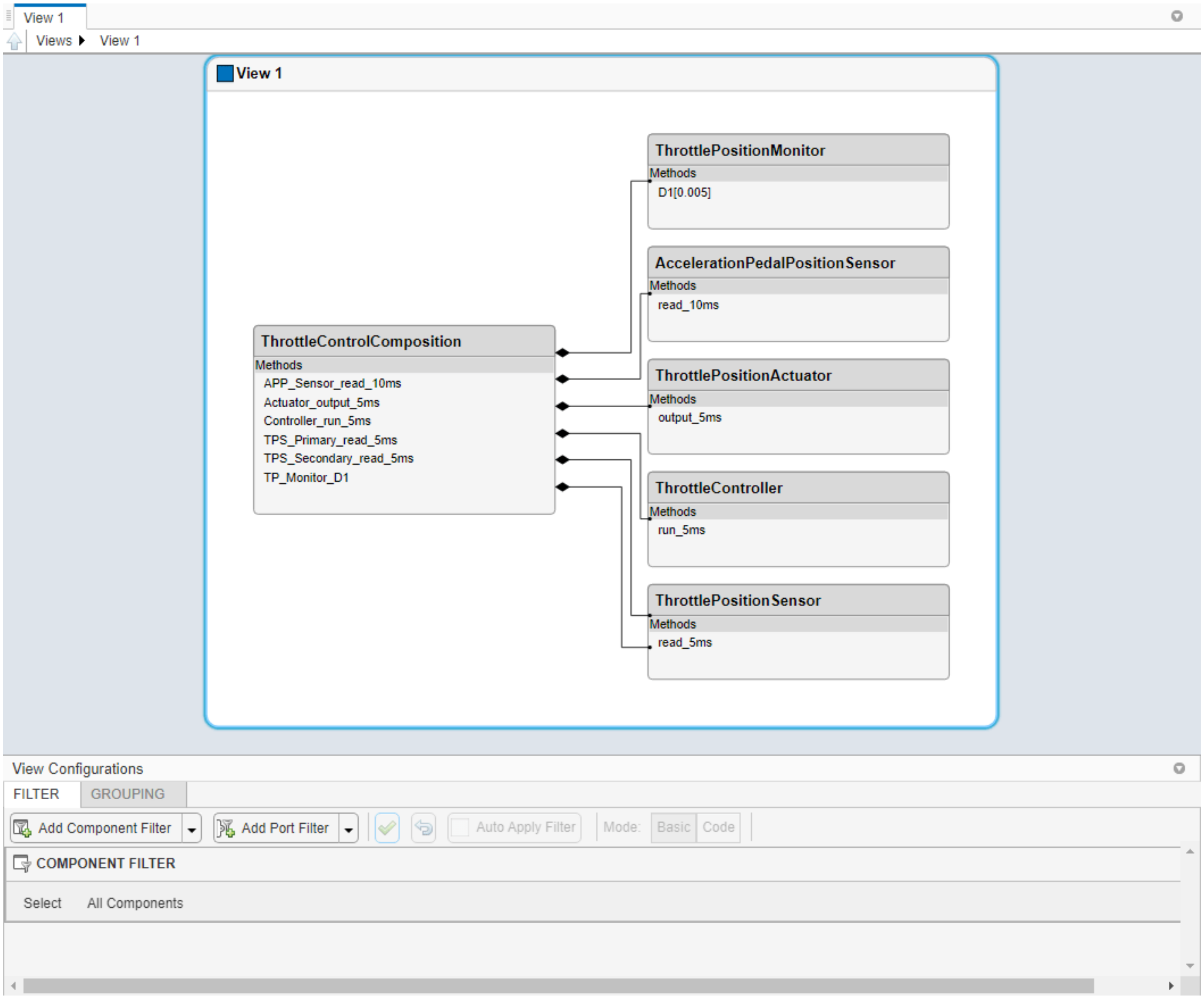


View the Types in the Software Architecture

To view the unique component types in the software architecture, create a class diagram view and add all components. To create a class diagram view, on the **Modeling** tab, in the **Views** section, click **Architecture Views**, then click **New** to create a new class diagram. Select **Class Diagram** from the **Diagram** section in the Views Gallery. From the list, select **Add Component Filter > Select All Components** to add all components in the software architecture to the view.

To populate methods in the class diagram, you must compile the software architecture model. To compile the model, navigate to **Modeling > Update Model**.

For more information, see “Class Diagram View of Software Architectures” on page 10-20.

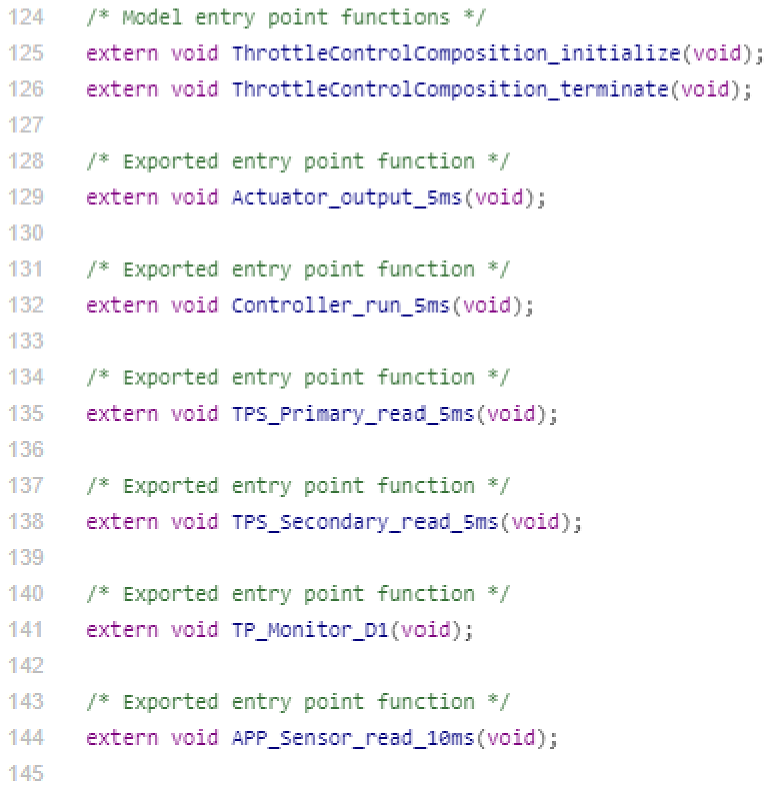


Code Generation

You can generate code to deploy the control system to the target hardware. Code generation requires an Embedded Coder® license. Open the `ThrottleControlComposition` model and execute the `slbuild` command, or press **Ctrl+B** to build the model and generate code.

```
slbuild('ThrottleControlComposition');
```

The generated code contains an entry-point function for each function of the components in the software architecture. For more information on code generation for export-function models, see “Generate Code for Export-Function Model”



```
/* Model entry point functions */
extern void ThrottleControlComposition_initialize(void);
extern void ThrottleControlComposition_terminate(void);

/* Exported entry point function */
extern void Actuator_output_5ms(void);

/* Exported entry point function */
extern void Controller_run_5ms(void);

/* Exported entry point function */
extern void TPS_Primary_read_5ms(void);

/* Exported entry point function */
extern void TPS_Secondary_read_5ms(void);

/* Exported entry point function */
extern void TP_Monitor_D1(void);

/* Exported entry point function */
extern void APP_Sensor_read_10ms(void);

```

See Also

`systemcomposer.createModel` | `createArchitectureModel` | `createSimulinkBehavior` | `increaseExecutionOrder` | `decreaseExecutionOrder`

More About

- “Author Software Architectures” on page 10-2
- “Simulate and Deploy Software Architectures” on page 10-8
- “Class Diagram View of Software Architectures” on page 10-20

Class Diagram View of Software Architectures

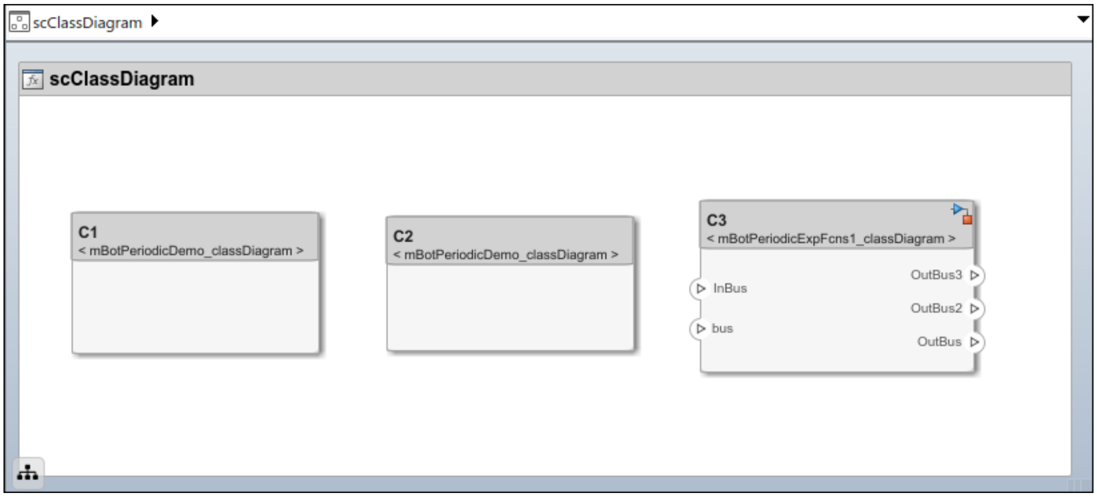
Use class diagrams to display a graphical representation of the structure of a software architecture model. You can also use spotlight views to analyze component dependencies and hierarchy, and you can use component hierarchy views to visualize the component hierarchy as a tree diagram. For more information, see “Create Spotlight Views” on page 11-2 and “Display Component Hierarchy and Architecture Hierarchy Using Views” on page 11-21.

A class diagram is a graphical representation of a static structural model that displays unique architecture types of the software components optionally with software methods and properties.

Class diagrams capture one instance of each referenced model and show relationships between them. Any component diagram view can be optionally represented as a class diagram for a software architecture model.

Software Architecture with Class Diagram View

This example uses a software architecture model with functions, stereotypes, and properties to explore class diagrams in the Architecture Views Gallery. Open the model to follow the steps in this tutorial.


scClassDiagram
scClassDiagram
C1
< mBotPeriodicDemo_classDiagram >
C2
< mBotPeriodicDemo_classDiagram >
C3
< mBotPeriodicExpFcns1_classDiagram >
InBus
bus
OutBus3
OutBus2
OutBus

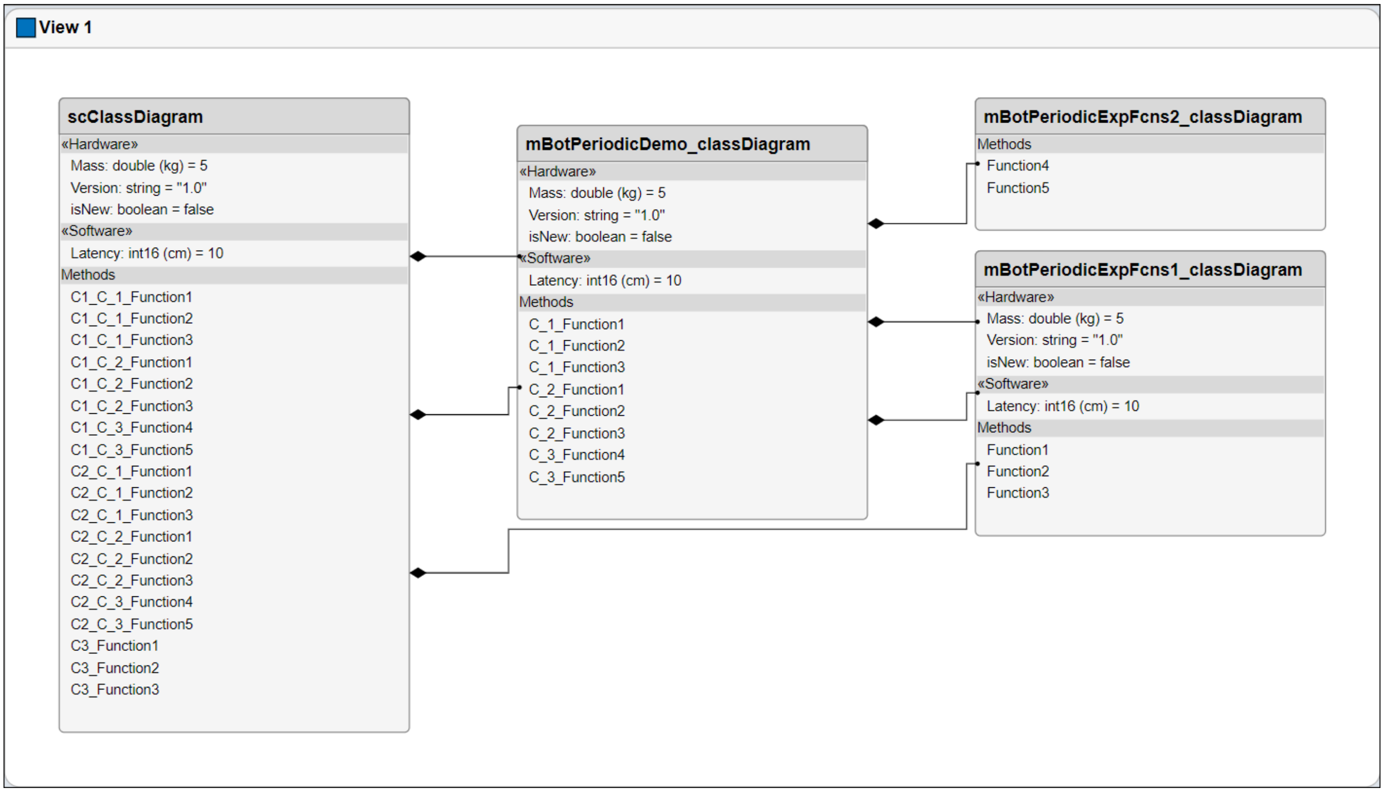
Interact with Class Diagram View

1 Simulate the model to compile it and populate functions. On the toolstrip, click **Run**. Alternatively, update the model to compile it by navigating to **Modeling** > **Update Model**.

2 To open the **Architecture Views Gallery**, navigate to **Modeling** > **Architecture Views**.

3 From the View Browser, select the **View 1** view.

4 To open the class diagram view, click **Diagram** > **Class Diagram**.

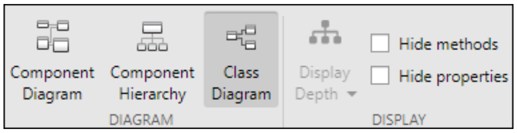


The class diagram consists of:

- A class box for each unique component type, including reference components.
- A class box as the root that corresponds to the root architecture of the top model.
- Composition connections between the types.

If there are multiple instances of the same type of component, for example, multiple components that reference the same model across the model hierarchy, then the type of the component is still represented as one unique box. The component will also relate to its parents and children via multiple composition connections.

5 You can select **Hide methods** to simplify the output by removing software functions from the diagram. Select **Hide properties** to hide information about stereotypes and property values applied to the components.

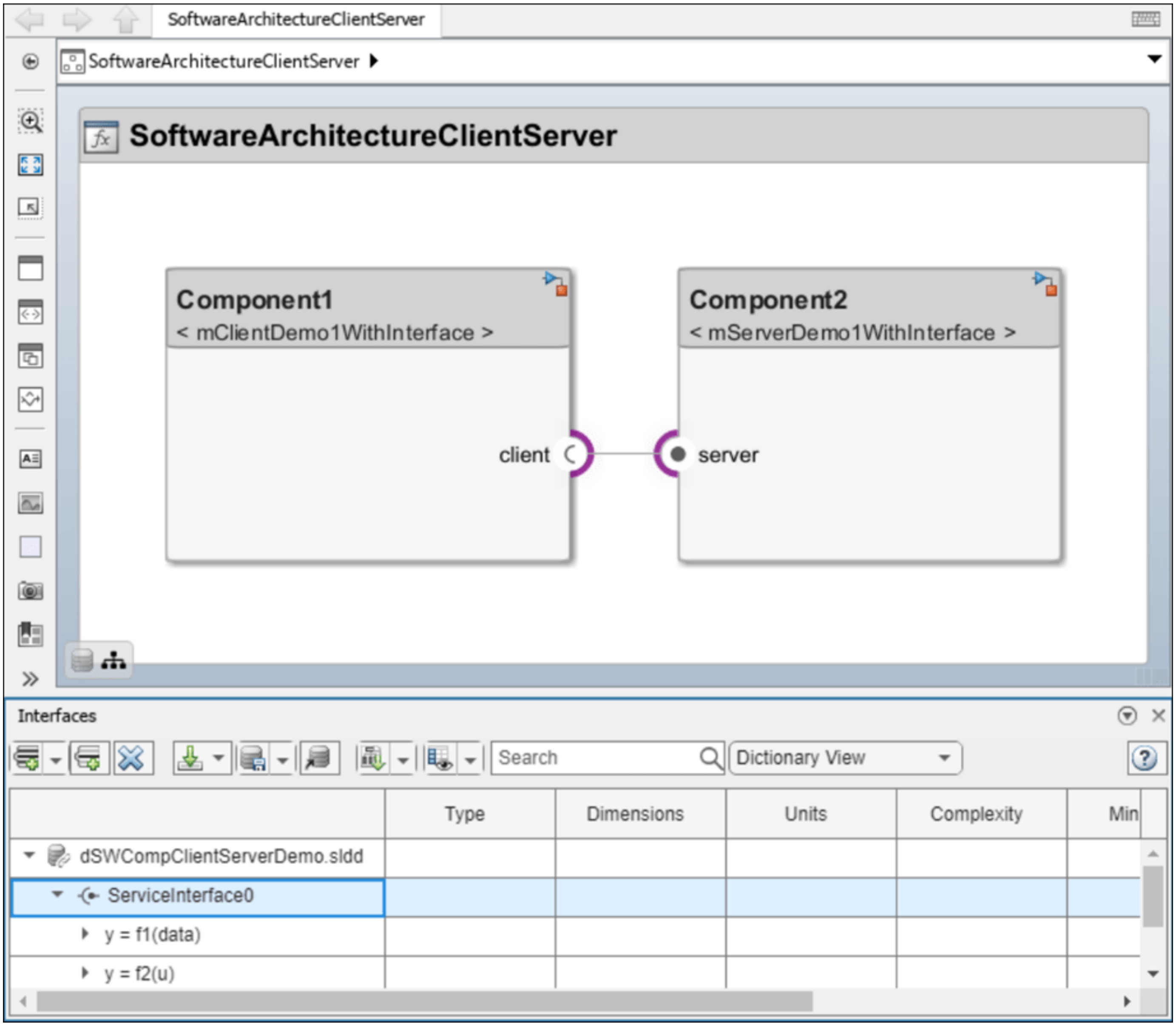


Client-Server Interfaces in Class Diagram View

Class diagrams display service (client-server) interfaces. The diagram shows the service interface classes and available services.

In this example, a software architecture has two components that are connected with client and server ports. The Interface Editor shows the interface assigned to the client and server ports.

```
model = systemcomposer.openModel("SoftwareArchitectureClientServer");
```

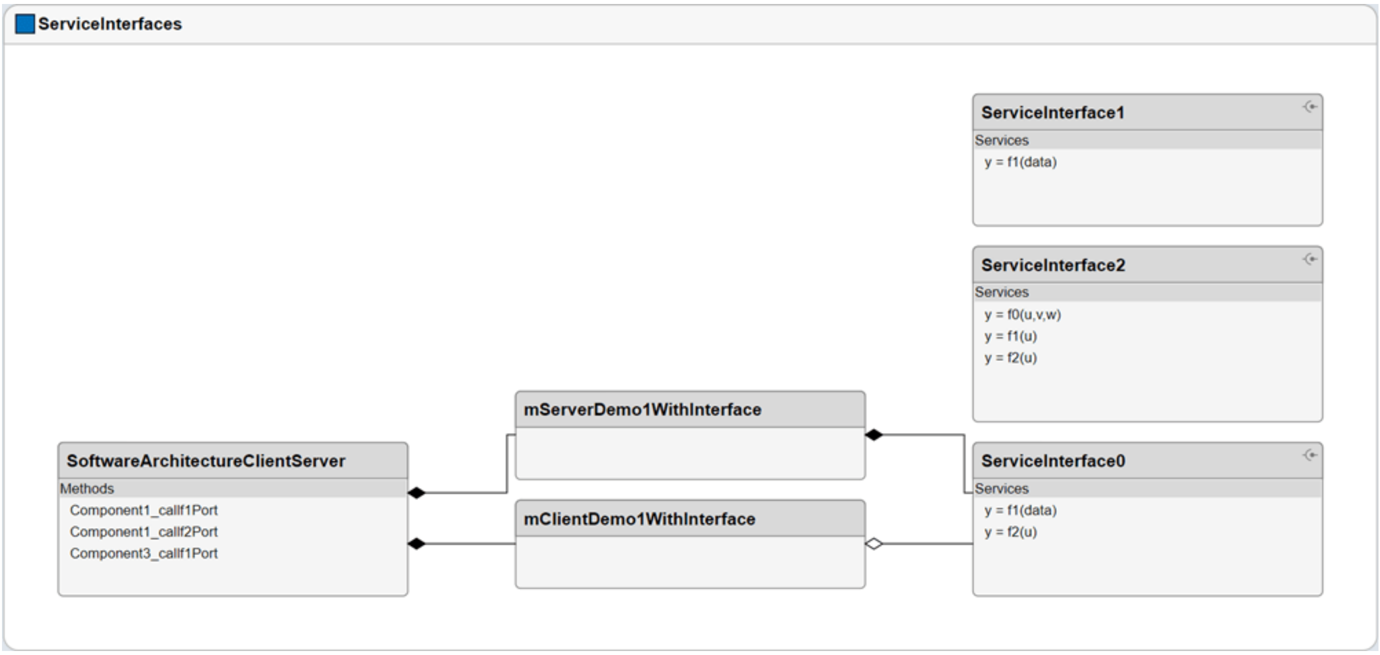

SoftwareArchitectureClientServer
SoftwareArchitectureClientServer
SoftwareArchitectureClientServer
Component1
< mClientDemo1WithInterface >
client
Component2
< mServerDemo1WithInterface >
server
Interfaces
Search
Dictionary View

	Type	Dimensions	Units	Complexity	Min
dSWCompClientServerDemo.sldd					
ServiceInterface0					
y = f1(data)					
y = f2(u)					

```
openViews(model)
```

This is the class diagram view of the software architecture.

- The icon on the upper right of the component distinguishes the service interface class.
- The service interface class contains function prototypes as services.
- The diagram displays an aggregation connection for the client port.
- The diagram displays a composition connection for the server port.



See Also

More About

- “Author Software Architectures” on page 10-2
- “Simulate and Deploy Software Architectures” on page 10-8
- “Modeling Software Architecture of Throttle Position Control System” on page 10-14
- “Display Component Hierarchy and Architecture Hierarchy Using Views” on page 11-21
- “Author Service Interfaces for Client-Server Communication” on page 10-41

Author and Extend Functions for Software Architectures

For inline components, you can author functions in the architecture level using the **Functions Editor** or by using the `addFunction` function. You can then implement Simulink behaviors for your authored functions.

For reference components, the functions are automatically created from the referenced behavior Simulink models. For information, see “Simulate and Deploy Software Architectures” on page 10-8.

In this topic, we explain the workflow to create functions in the architecture level and describe how to:

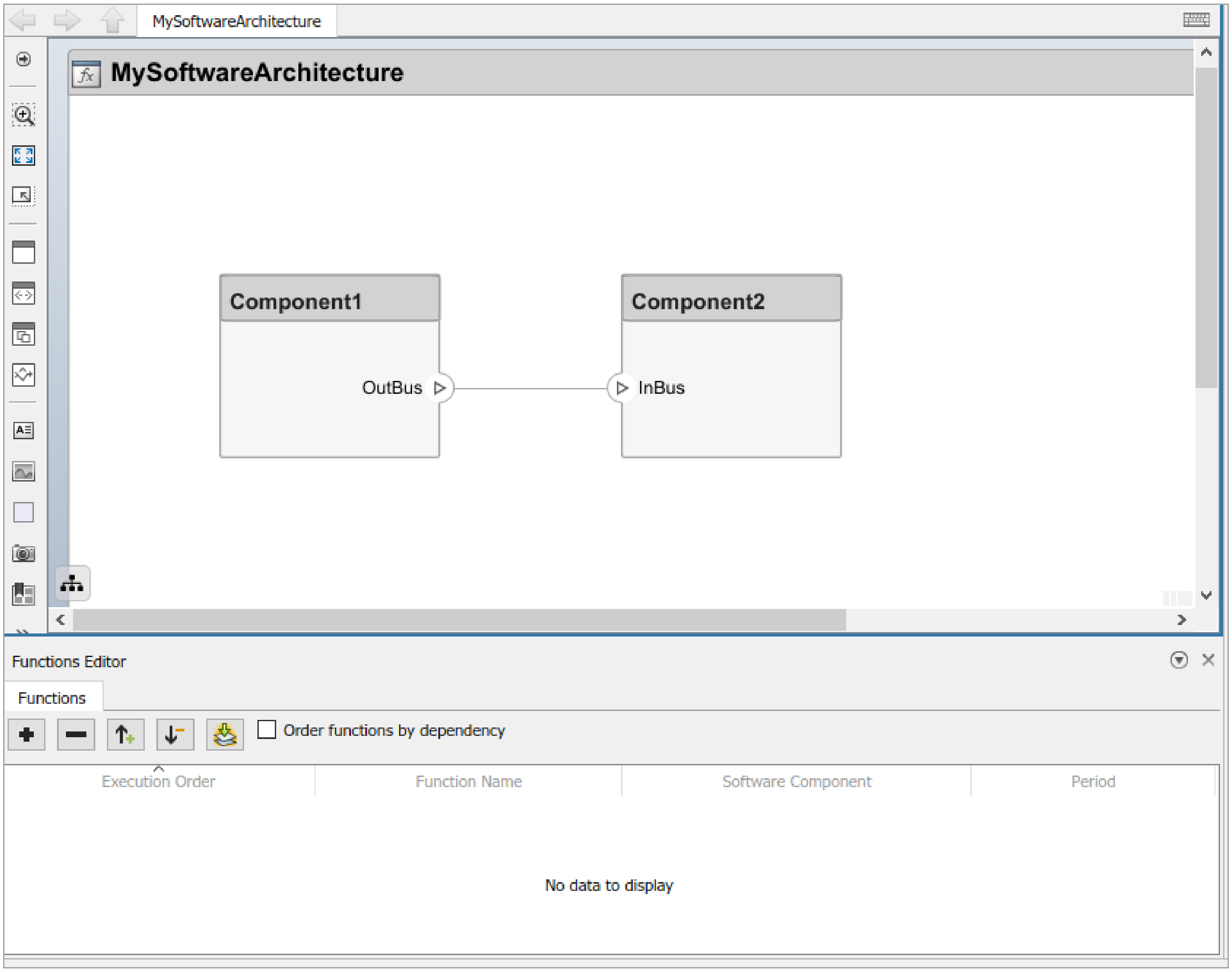
- Author and visualize functions.
- Implement behaviors for the functions.
- Import and export functions.
- Add custom properties to functions using stereotypes.

Author and Visualize Functions Using Functions Editor

You can author and visualize functions for your software architectures using the **Functions Editor**. The **Functions Editor** is visible only when you model software architectures.

To open the **Functions Editor**, in the toolstrip, navigate to **Modeling > Functions Editor**. The model automatically updates, and the table displays the functions of components in your model.

This example shows a software architecture with two components and the **Functions Editor** with an empty table.



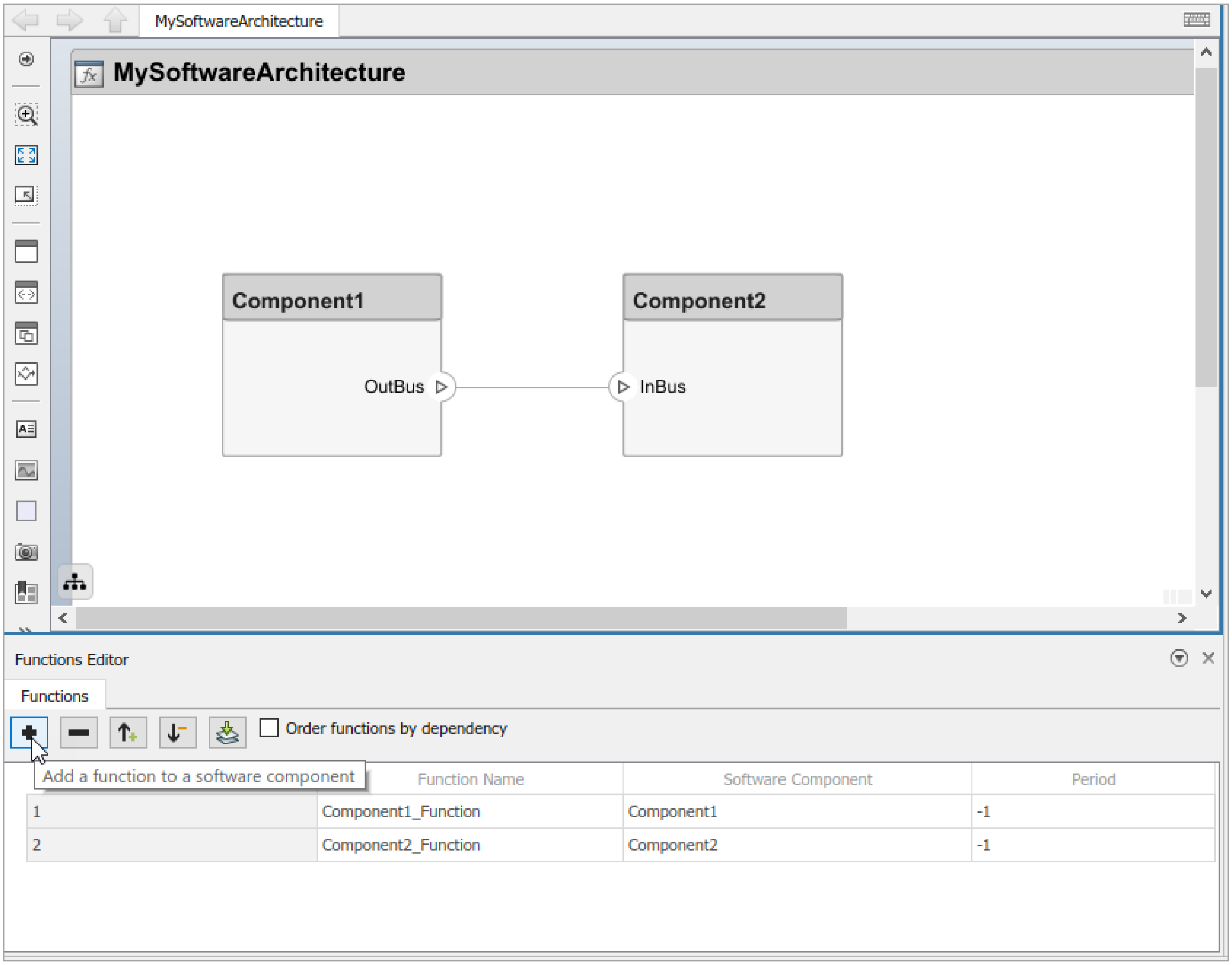
□ Order functions by dependency

Execution Order	Function Name	Software Component	Period

No data to display

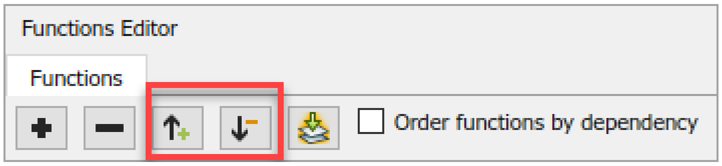
To author functions and sort them based on the order of execution:

1 Add a function. Select `Component1` as the parent. Use the same steps to add a function for `Component2`.

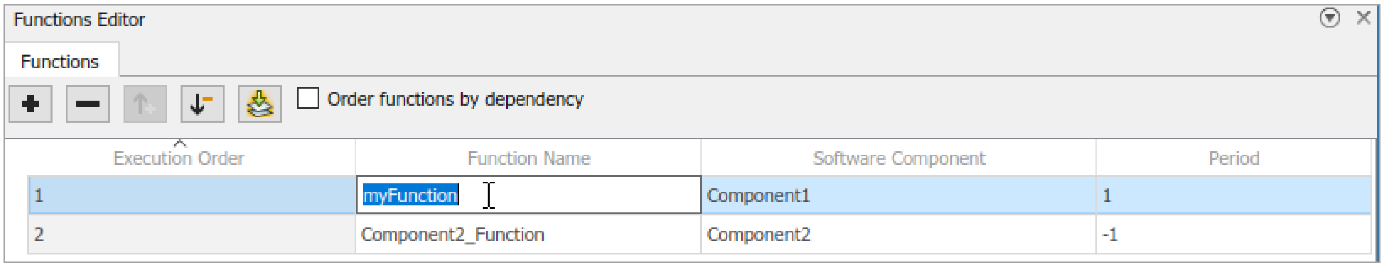


	Function Name	Software Component	Period
1	Component1_Function	Component1	-1
2	Component2_Function	Component2	-1

2 Arrange the execution order of the functions by using the up and down arrows or clicking and dragging functions to sort them.



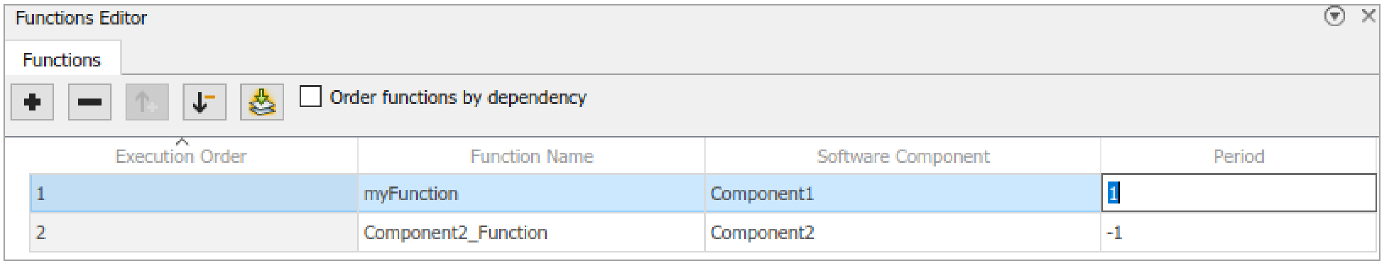
3 You can change the name of these functions by modifying the name in the table. Change the name of the first function to `myFunction`.



☐ Order functions by dependency

Execution Order	Function Name	Software Component	Period
1	myFunction	Component1	1
2	Component2_Function	Component2	-1

4 You can edit sample times of these functions by specifying their period in the table. Change the period of the first function to `1`.



☐ Order functions by dependency

Execution Order	Function Name	Software Component	Period
1	myFunction	Component1	1
2	Component2_Function	Component2	-1

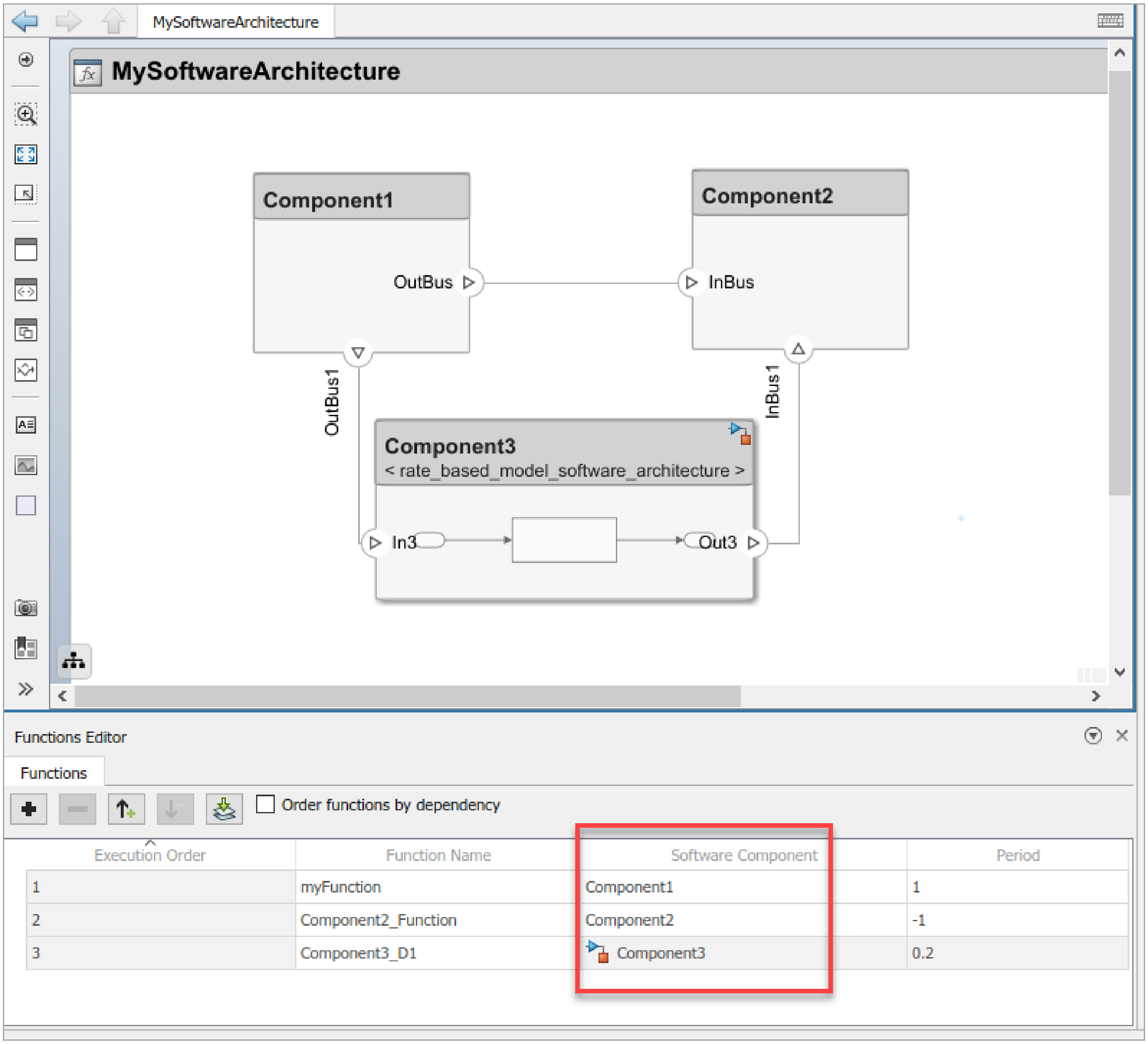
5 You can order functions automatically based on their data dependencies. This functionality is available for functions from behavior models. To enable automatic sorting, select the **Order functions by dependency** check box or enable `OrderFunctionsByDependency` on the architecture model.

```
set_param('RateBasedExportFunctionSoftwareArchitectureModel','OrderFunctionsByDependency','on')
```

The default value for the parameter is `off`.

The **Functions Editor** visualizes the functions created at the architecture level and the functions implemented in a Simulink model that is referenced by a component.

In this example, a third function is created in a Simulink behavior model, and the model is referenced by a third component, `Component3`. The **Software Component** column of the table shows the difference between functions created at the architecture level and functions created in a Simulink behavior and referenced by a component.



☐ Order functions by dependency

Execution Order	Function Name	Software Component	Period
1	myFunction	Component1	1
2	Component2_Function	Component2	-1
3	Component3_D1	Component3	0.2

Author Functions Programmatically

You can also author functions for your components using the addFunction function.

Use the addFunction function to add a set of functions to the software architecture component, architecture with specified names functionNames.

```
addFunction(architecture,functionNames)
```

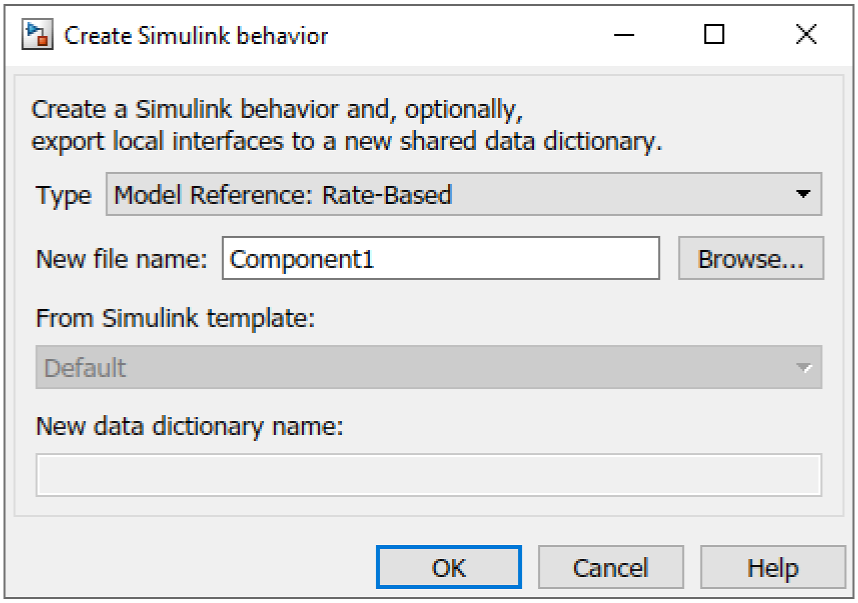
For more information, see addFunction.

Implement Behaviors for Functions in the Architecture Level

You can create functions in the architecture level, and then implement behaviors for your functions.

- To implement functions using the toolstrip:

  1. Under the **Modeling** tab, select **Component**, and select **Create Simulink Behavior**.
  2. Select the **Type** of the Simulink behavior as `rate-based` or `export-function`.



Create a Simulink behavior and, optionally,
export local interfaces to a new shared data dictionary.

Type: Model Reference: Rate-Based

New file name: Component1

From Simulink template: Default

New data dictionary name:

Alternatively, you can right-click a component and select **Create Simulink Behavior**.

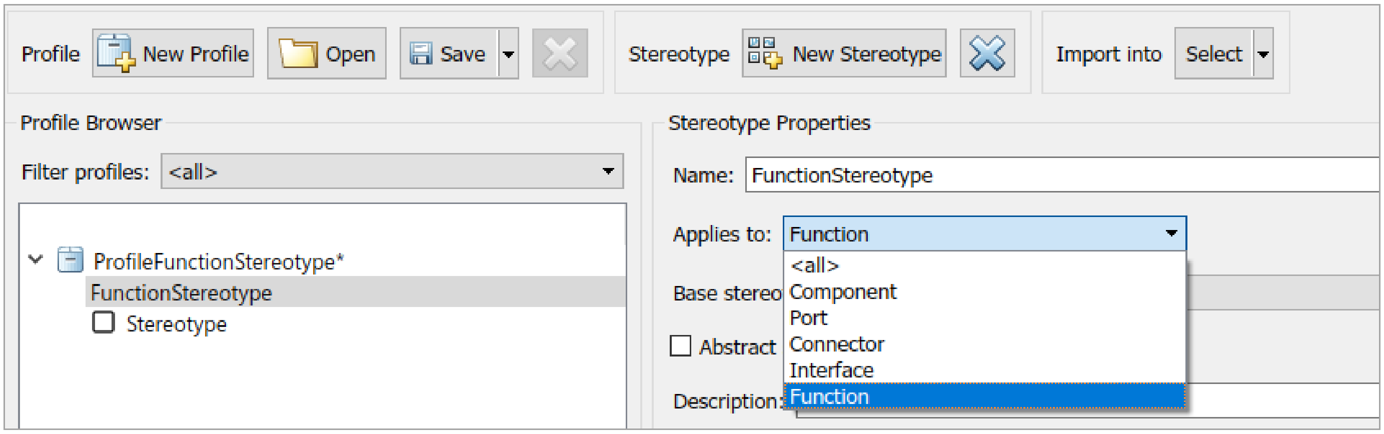
- You can also use the `createSimulinkBehavior` function to implement functions programmatically. The function creates a new rate-based or export-function behavior and links the software component to the new model. You can create rate-based or export-function behaviors only for software architectures.

```
createSimulinkBehavior(component,"mySoftwareModel",BehaviorType="RateBased")
```

Apply Stereotypes to Functions of Software Architectures

You can extend software architecture functions by adding stereotypes containing custom properties. These steps describe how to add stereotypes to your functions and are very similar to the steps to add stereotypes to other architectural elements. For more information, see “Extend Architectural Elements”.

1. Define your function stereotypes using the **Profile Editor**.



Profile Browser

Filter profiles: <all>

ProfileFunctionStereotype*
FunctionStereotype
☐ Stereotype

Stereotype Properties

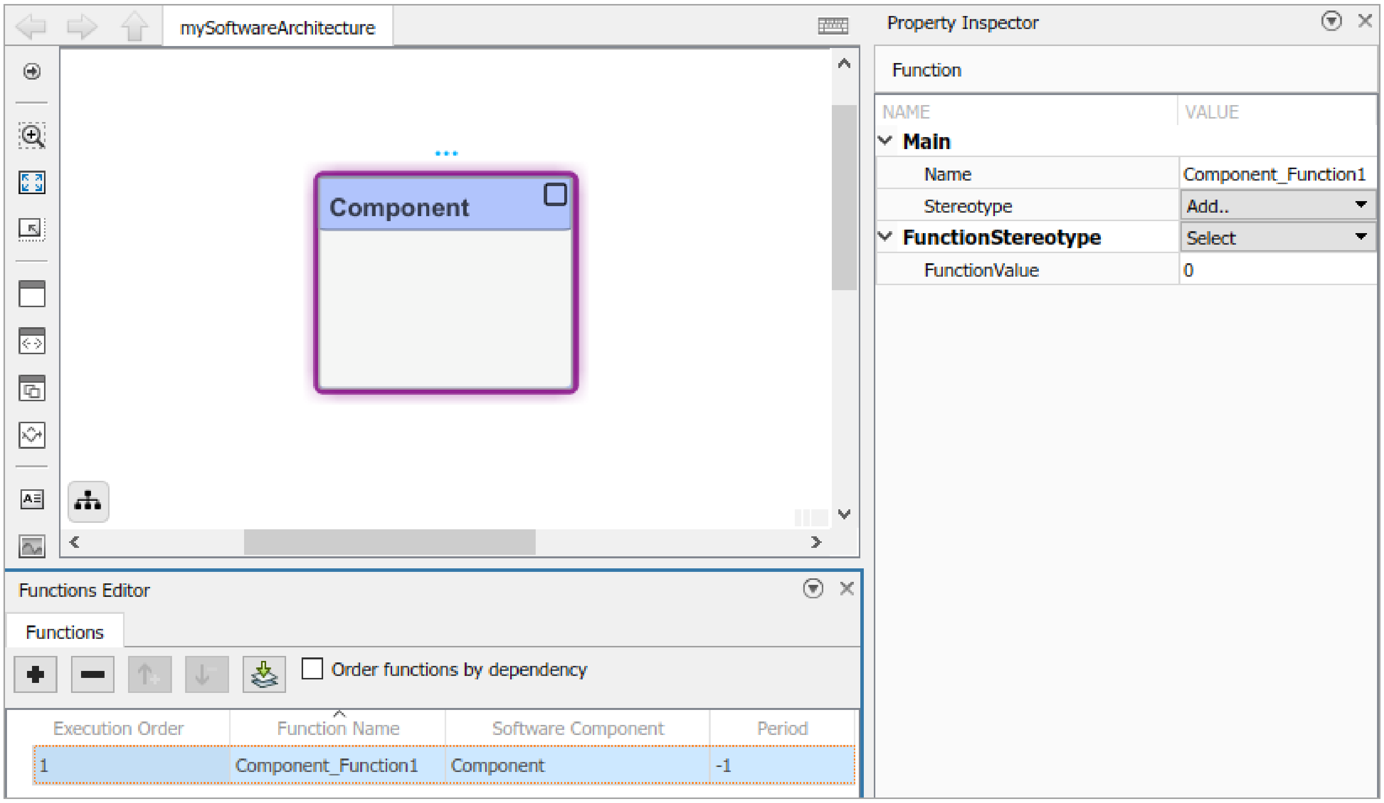
Name: FunctionStereotype

Applies to: Function

☐ Abstract

2 Use the **Functions Editor** to select functions in your software component, apply stereotypes, view the stereotypes applied to your functions, and edit the stereotype property values.

In this example, you can specify the value for the `FunctionValue` property of the stereotype called `FunctionStereotype` using the **Property Inspector**.



Property Inspector

Function

NAME	VALUE
Main	
Name	Component_Function1
Stereotype	Add..
FunctionStereotype	Select
FunctionValue	0

Functions Editor

Functions

☐ Order functions by dependency

Execution Order	Function Name	Software Component	Period
1	Component_Function1	Component	-1

Import and Export Functions of Software Architectures

You can import and export functions of your software architectures.

- Use the `systemcomposer.exportModel` function to output a `functions` field that contains a table with information such as the name, execution order, parent component ID, period, and stereotypes of a function.

This example shows how to export a software architecture model mySoftwareArchitecture. The exportedSet output has the functions field that contains the table with function information.

```
exportedSet = systemcomposer.exportModel('MySoftwareArchitecture')

exportedSet = 

  struct with fields:

          components: [4×5 table]
               ports: [6×4 table]
         connections: [3×5 table]
      portInterfaces: [0×9 table]
    requirementLinks: [0×15 table]
              domain: 'Software'
           functions: [3×4 table]

>> exportedSet.functions

ans =

  3×4 table

            Name             ExecutionOrder    CompID    Period
    _____________________    ______________    ______    ______

    "myFunction"                  "1"           "1"      "1"   
    "Component2_Function"         "2"           "2"      "-1"  
    "Component3_D1"               "3"           "3"      "0.2" 
```

- Use the systemcomposer.importModel function to import a model with functions where the importStruct argument can have a functions field that contains function information.

See Also

More About

- “Author Software Architectures” on page 10-2
- “Simulate and Deploy Software Architectures” on page 10-8
- “Modeling Software Architecture of Throttle Position Control System” on page 10-14
- “Display Component Hierarchy and Architecture Hierarchy Using Views” on page 11-21

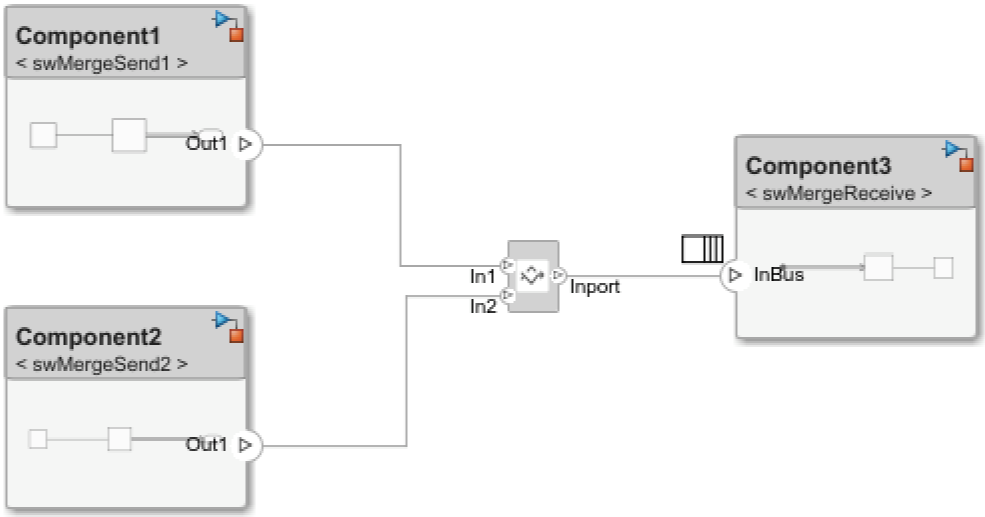
Merge Message Lines Using Adapter Block

This example shows how to use a Merge block to route messages between software components in a software architecture. A Merge block is an Adapter block preconfigured to merge message and signal lines.

Open the model.

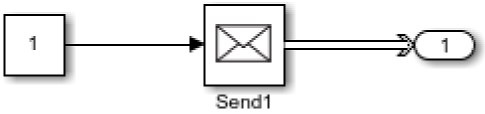
```
systemcomposer.openModel('MergeMessagesfromSoftwareComponents');
```

In this model, message-based communication is constructed between three software components: two send components, `Component1` and `Component2` create messages and send them to a receive component, `Component3`.

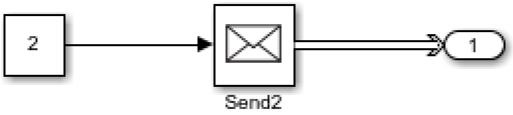


A FIFO queue is used as a message buffer between the components.

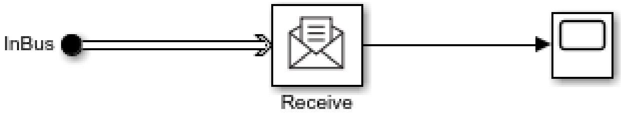
`Component1` is linked to the Simulink® behavior model `swMergeSend1` that generates messages with value `1` in every `0.1` sample time.



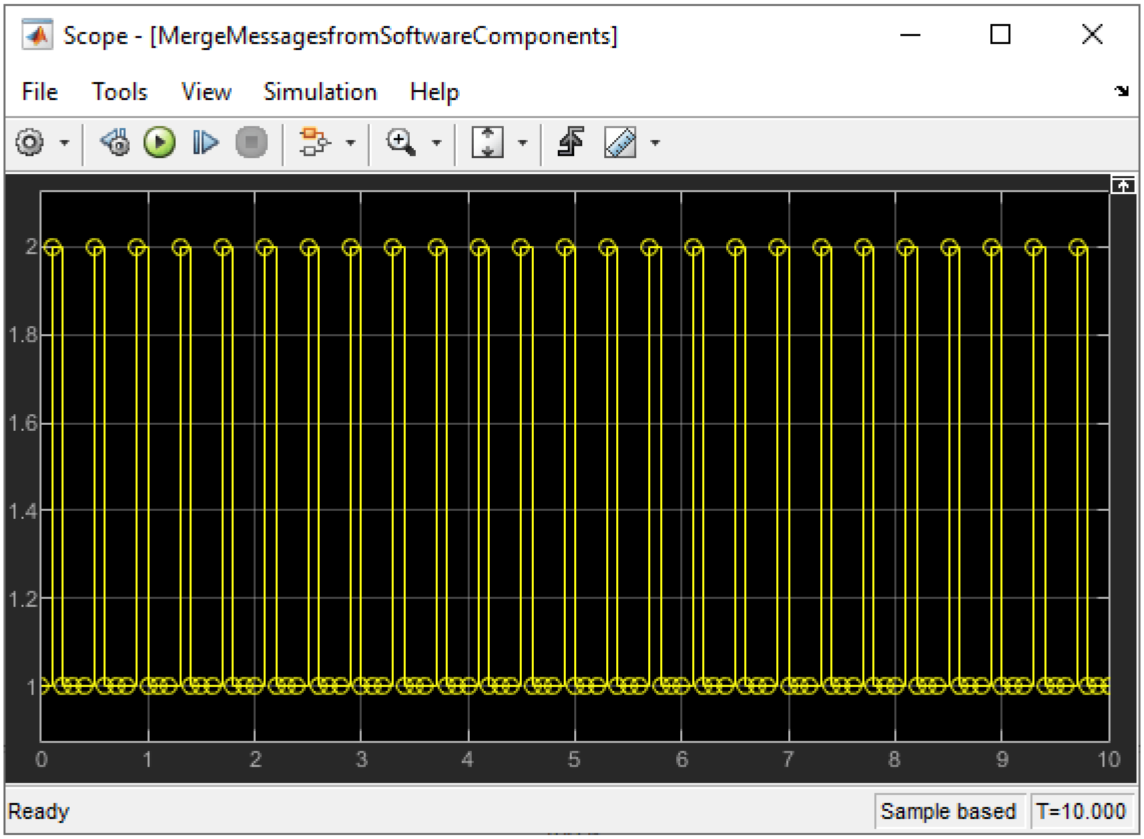
`Component2` is linked to the Simulink behavior `swMergeSend2` that generates messages with value `2` in every `0.3` sample time.



Component3 is linked to the Simulink behavior swMergeReceive that receives messages and converts them to signals. The In Bus Element port block is used to configure the queue outside the component as a FIFO queue of capacity 100.



Simulate the model. Observe that the Scope block in swMergeReceive displays the values received from both components.



See Also

Adapter | Send | Receive

More About

- “Author Software Architectures” on page 10-2
- “Simulate and Deploy Software Architectures” on page 10-8
- “Merge Message Lines for Architectures Using Adapter Block” on page 7-29
- “Merge Message Lines Using a Message Merge Block”

Authoring Functions for Software Components of an Adaptive Cruise Control

This example shows how to design an adaptive cruise control system in System Composer™:

- Capture the system architecture in terms of constituent software components and functions.
- Indicate which functions are critical for maintaining the desired speed of the vehicle using custom properties.
- Implement the behavior of the functions using Simulink.

Adaptive Cruise Control Architecture

An adaptive cruise control (ACC) system is a control system that modifies the speed of a vehicle in response to conditions on the road. As in regular cruise control, the driver sets a desired speed for the vehicle. Additionally, the adaptive cruise control system can slow the vehicle down if there is another vehicle moving more slowly in the lane in front of it.

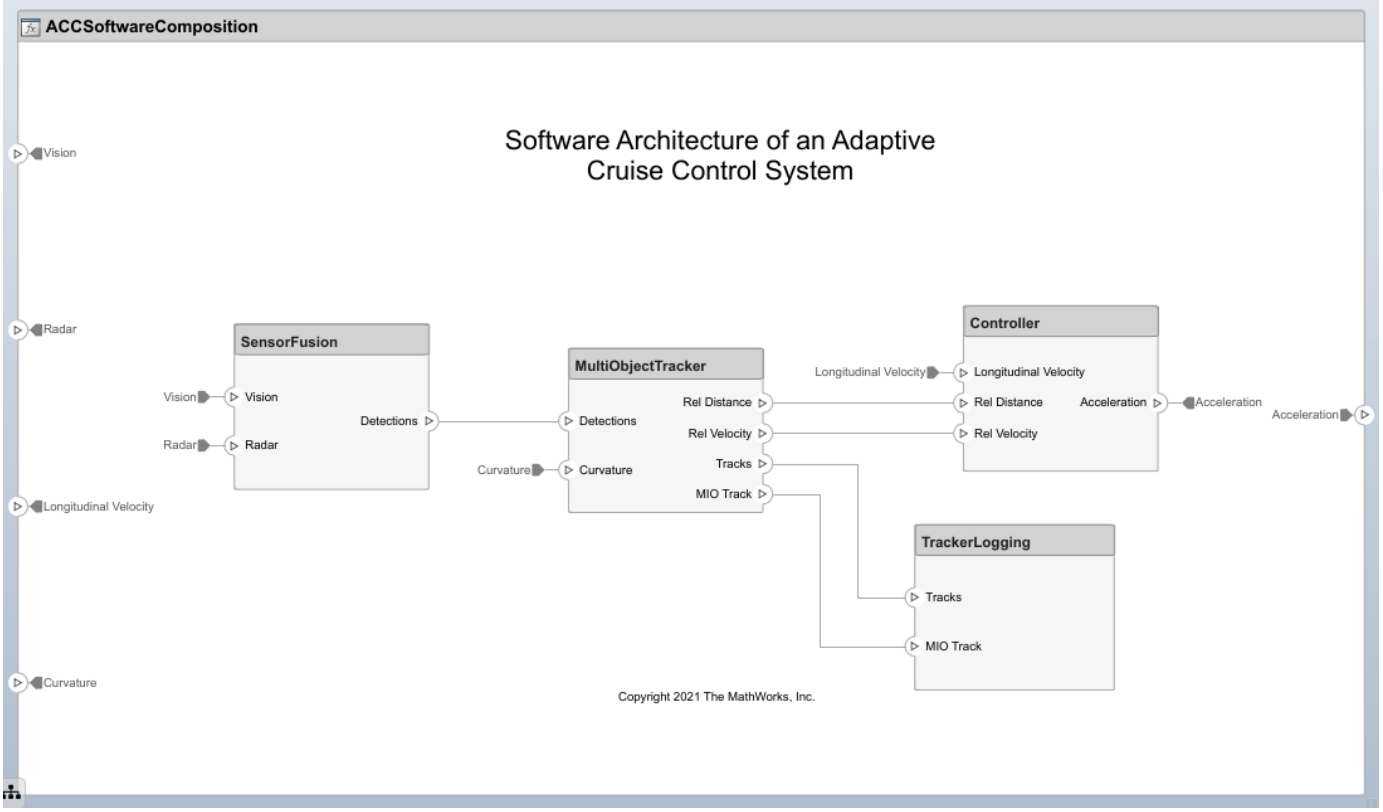
The ACC algorithm requires that the vehicle knows the curvature of the road, the relative distance, and velocity of the lead vehicle immediately in front of it. For more information about the ACC algorithm and the entire system, see “Adaptive Cruise Control with Sensor Fusion” (Automated Driving Toolbox). The system software retrieves detections from a radar sensor and video from a camera, which are fused by a sensor fusion component for more accurate detections. The detections are provided to multi-object tracker to determine the relative distance and velocity of the lead vehicle. These states and the longitudinal velocity of the vehicle are then provided to a controller component to compute the acceleration to apply to the vehicle to maintain a safe distance.

Author Components and Interfaces

First, create the architecture of the adaptive cruise control software. To open a new software architecture model, use this command.

```
systemcomposer.createModel('ACCSoftwareCompositionScratch', 'SoftwareArchitecture', true);
```

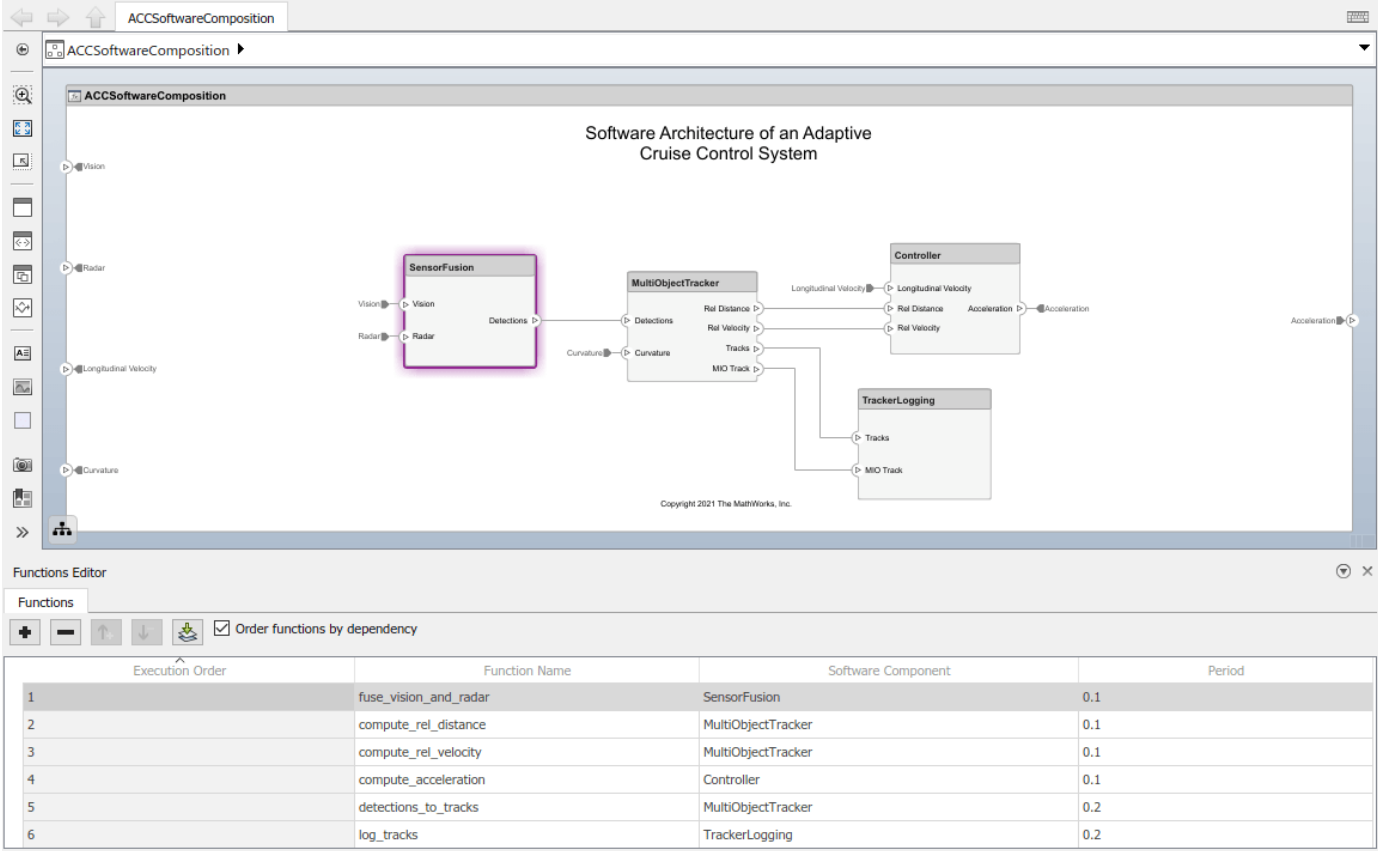
The system is composed of a `SensorFusion` component, a `MultiObjectTracking` component, a `Controller` component, and a `TrackerLogging` component for monitoring.



Author Component Functions

To specify the functions that define the behavior of each component, open the Functions Editor. To open the Functions Editor, on the **Modeling** tab, in the **Design** section, click **Functions Editor**. To create the functions to implement the behavior of each component, select a component and use the add button. For more information about authoring functions using the Functions Editor, see “Author and Extend Functions for Software Architectures” on page 10-24.

You can modify the built-in function properties such as the name, period, or execution order. The name and period properties can be modified by editing the corresponding cells in the table. You can specify the execution order of functions in the Functions Editor by dragging functions into the desired order or by selecting a function and clicking the up and down buttons.



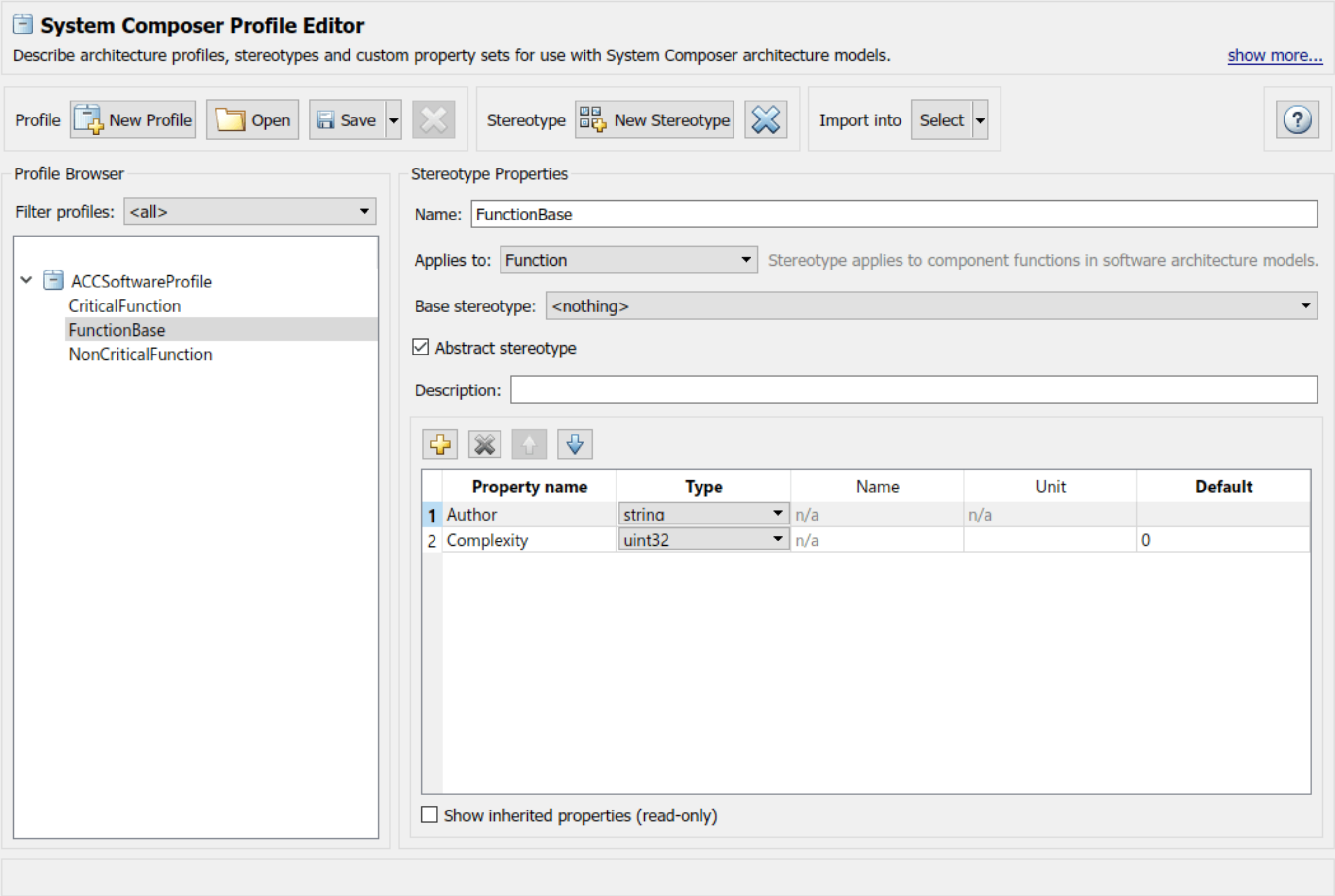
☑ Order functions by dependency

Execution Order	Function Name	Software Component	Period
1	fuse_vision_and_radar	SensorFusion	0.1
2	compute_rel_distance	MultiObjectTracker	0.1
3	compute_rel_velocity	MultiObjectTracker	0.1
4	compute_acceleration	Controller	0.1
5	detections_to_tracks	MultiObjectTracker	0.2
6	log_tracks	TrackerLogging	0.2

Add Custom Properties to Functions

You can apply custom properties using System Composer profiles and stereotypes. Load the profile `ACCSoftwareProfile` and import it into the composition. The profile constains three stereotypes.

- `FunctionBase` is a stereotype used as the base for all function stereotypes.
- `CriticalFunction` stereotype applies to functions that are critical in determining the output acceleration.
- `NonCriticalFunction` stereotype applies to functions that are not critical in determining the output acceleration.



System Composer Profile Editor

Describe architecture profiles, stereotypes and custom property sets for use with System Composer architecture models.

Filter profiles: <all>

- ACCSoftwareProfile
  - CriticalFunction
  - FunctionBase
  - NonCriticalFunction

Name: FunctionBase

Applies to: Function

Stereotype applies to component functions in software architecture models.

Base stereotype: <nothing>

☑ Abstract stereotype

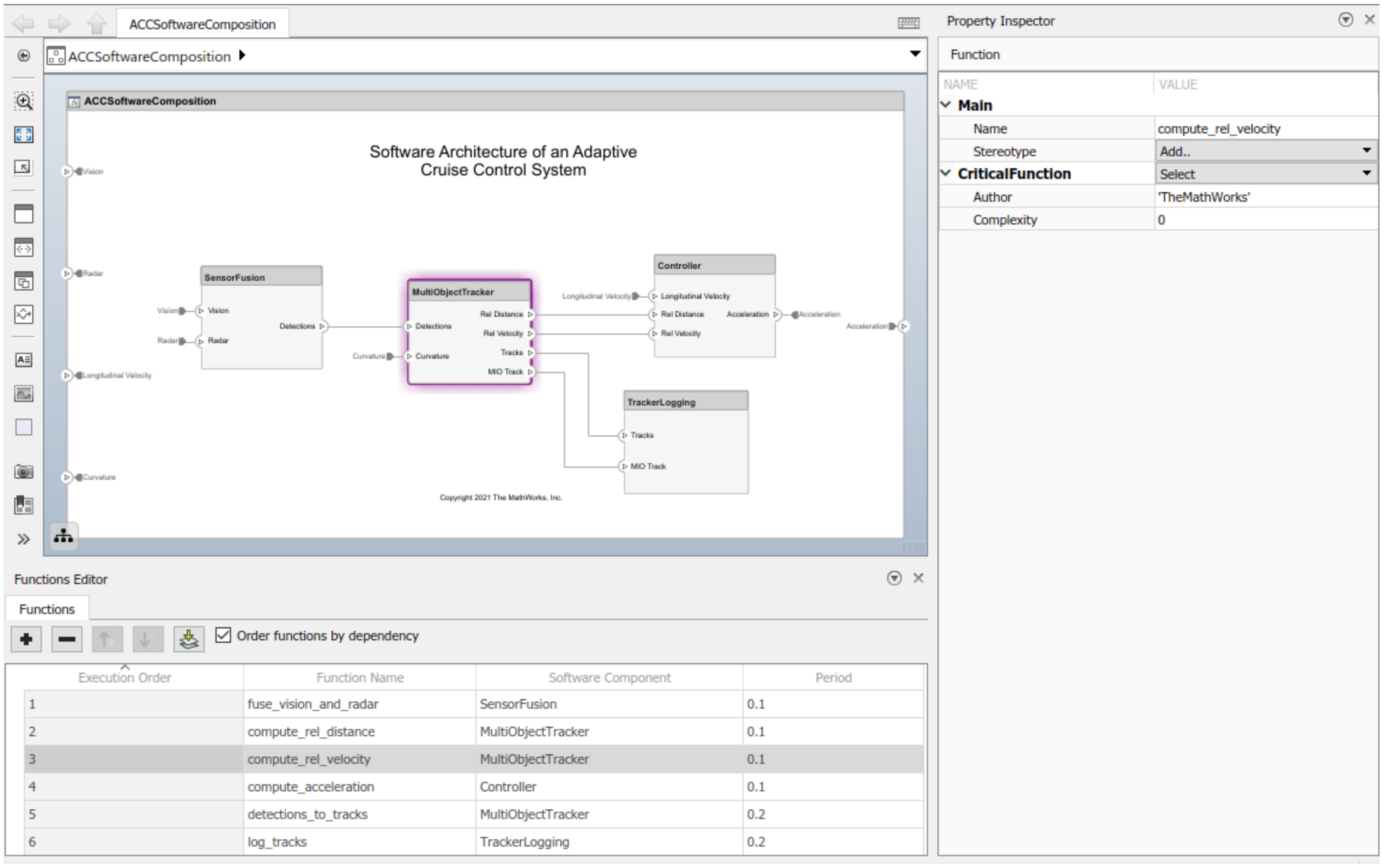
Description:

	Property name	Type	Name	Unit	Default
1	Author	string	n/a	n/a	
2	Complexity	uint32	n/a		0

☐ Show inherited properties (read-only)

Add custom properties to a function by applying stereotypes from the loaded profile.

1. To open the Property Inspector, select **Modeling** > **Design** > **Property Inspector**.
2. In the Functions Editor, select `fuse_vision_and_radar`.
3. In the Property Inspector, select **Stereotype** > **Add** `ACCSoftwareProfile.CriticalFunction` to apply the stereotype.



☑ Order functions by dependency

Execution Order	Function Name	Software Component	Period
1	fuse_vision_and_radar	SensorFusion	0.1
2	compute_rel_distance	MultiObjectTracker	0.1
3	compute_rel_velocity	MultiObjectTracker	0.1
4	compute_acceleration	Controller	0.1
5	detections_to_tracks	MultiObjectTracker	0.2
6	log_tracks	TrackerLogging	0.2

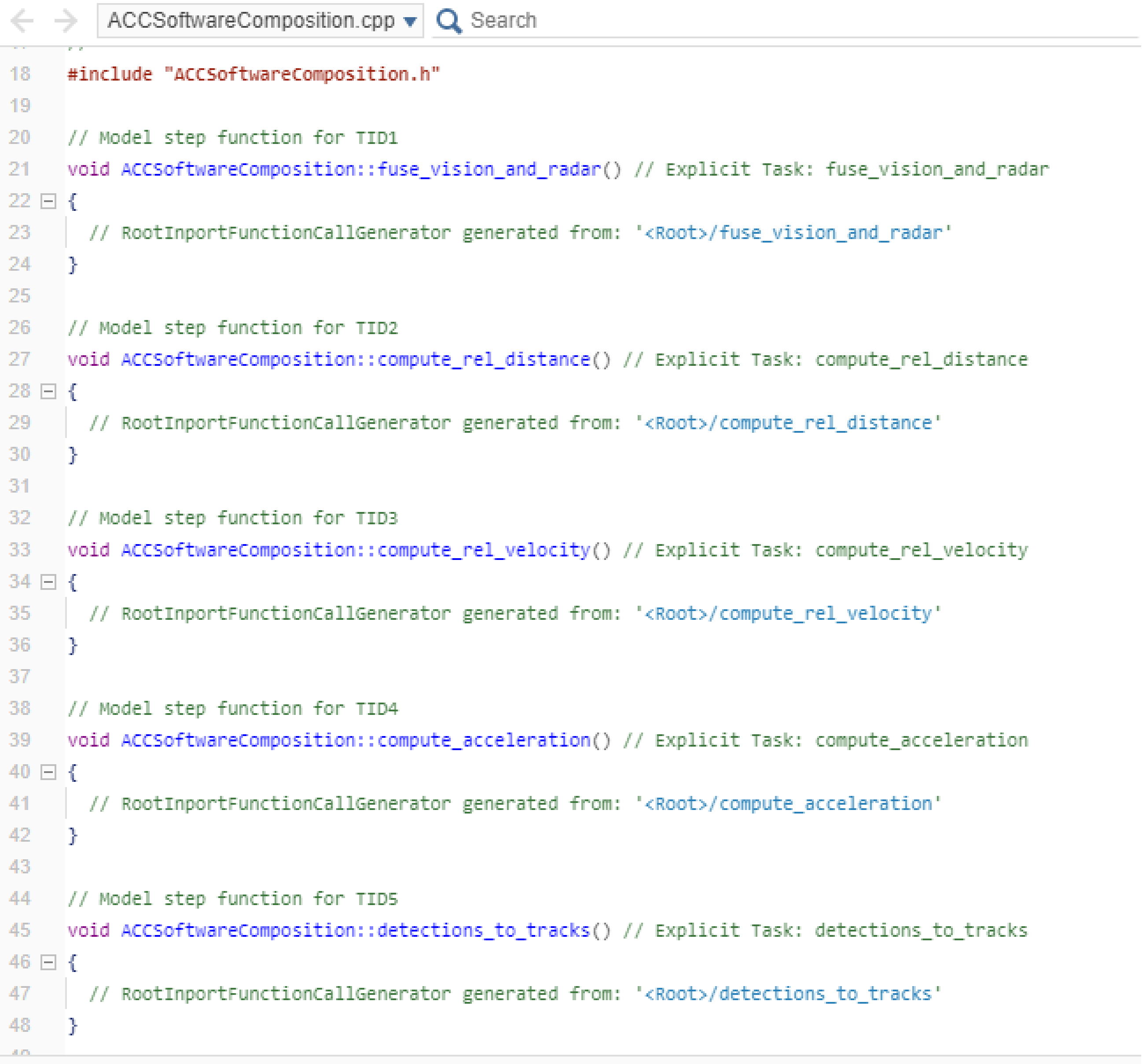
NAME	VALUE
Main	
Name	compute_rel_velocity
Stereotype	Add..
CriticalFunction	Select
Author	'TheMathWorks'
Complexity	0

This stereotype designates functions that are executed to determine the output acceleration. In the ACC software architecture, all functions are critical to determining the acceleration except for the functions defined in the `TrackerLogging` component.

Generate Code for Functions

Code for the adaptive cruise control system can be generated and deployed to the target hardware using Embedded Coder®. To generate code, execute the `slbuild` command, or press **Ctrl+B** to build the model.

```
slbuild('ACCSoftwareCompositionScratch');
```



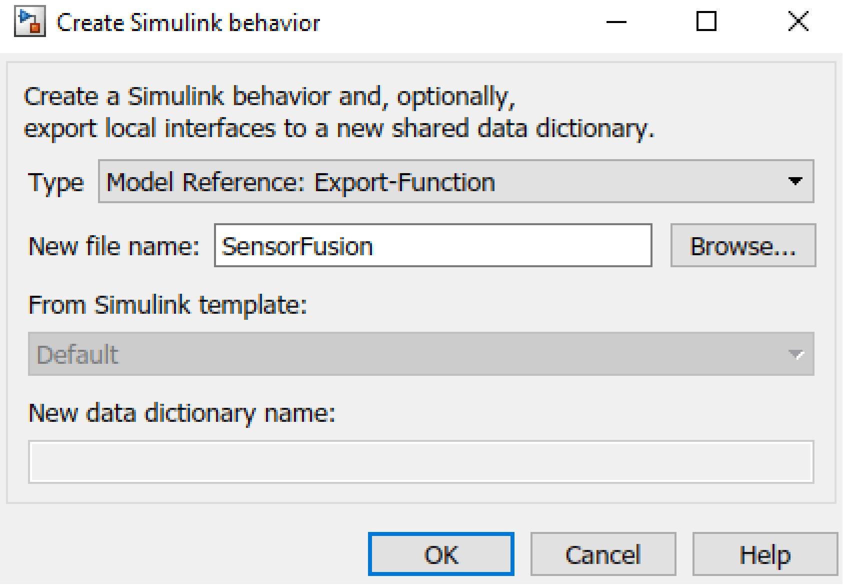
```
#include "ACCSoftwareComposition.h"

// Model step function for TID1
void ACCSoftwareComposition::fuse_vision_and_radar() // Explicit Task: fuse_vision_and_radar
{
  // RootInportFunctionCallGenerator generated from: '<Root>/fuse_vision_and_radar'
}

// Model step function for TID2
void ACCSoftwareComposition::compute_rel_distance() // Explicit Task: compute_rel_distance
{
  // RootInportFunctionCallGenerator generated from: '<Root>/compute_rel_distance'
}

// Model step function for TID3
void ACCSoftwareComposition::compute_rel_velocity() // Explicit Task: compute_rel_velocity
{
  // RootInportFunctionCallGenerator generated from: '<Root>/compute_rel_velocity'
}

// Model step function for TID4
void ACCSoftwareComposition::compute_acceleration() // Explicit Task: compute_acceleration
{
  // RootInportFunctionCallGenerator generated from: '<Root>/compute_acceleration'
}

// Model step function for TID5
void ACCSoftwareComposition::detections_to_tracks() // Explicit Task: detections_to_tracks
{
  // RootInportFunctionCallGenerator generated from: '<Root>/detections_to_tracks'
}
```

Since no component has a linked behavior, the generated code contains empty definitions for each function in the software architecture.

Implement Behaviors for Functions

You can implement the behaviors for functions of a component in Simulink by creating a Simulink behavior. Right-click the SensorFusion component and select Create Simulink Behavior, or navigate to **Modeling** > **Component** > **Create Simulink Behavior**. To choose the type of the Simulink behavior, for **Type**, select Model Reference: Export-Function or Model Reference: Rate-Based. Click **OK** to create a SensorFusion export-function model linked to the SensorFusion component.

For more information on using the export-function modeling style, see “Export-Function Models Overview”.



Create Simulink behavior

Create a Simulink behavior and, optionally,
export local interfaces to a new shared data dictionary.

Type: Model Reference: Export-Function

New file name: SensorFusion

From Simulink template: Default

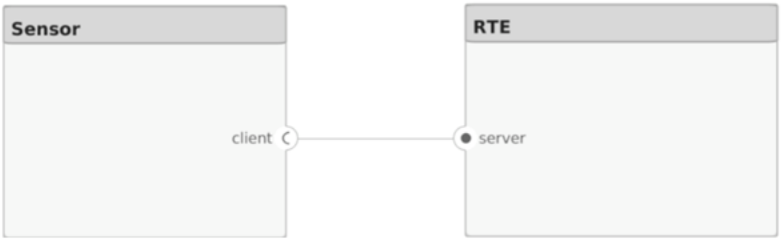
New data dictionary name:

The new model contains one inport block with a function-call output port, `fuse_vision_and_radar`, with a sample time of 0.1 seconds, as specified in the Functions Editor. You can connect the output port to a function-call subsystem that models the behavior of that function.

Author Service Interfaces for Client-Server Communication

You can model client-server connections between software components in software architectures in System Composer using client ports and server ports and associating service interfaces with these ports.

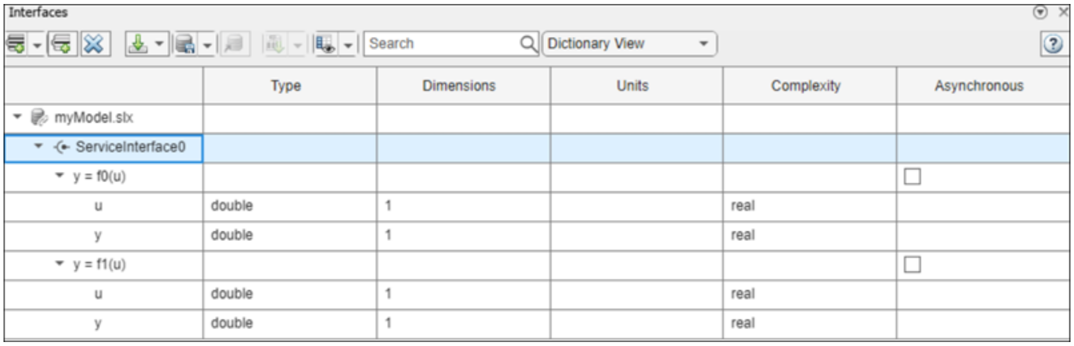
To expose services performed by a software component, create a server port on that component. To access those services from within another software component, create a client port on the second component and connect the two ports. The ball and socket icons represent server and client ports, respectively. You can also author client and server ports at the composition level, with client-server lines crossing multiple hierarchies.



A service interface defines the functional interface between client and server components. Each service interface consists of one or more function elements.

A function element describes the attributes of a function in a client-server interface.

Use the **Interface Editor** to author and edit service interfaces.

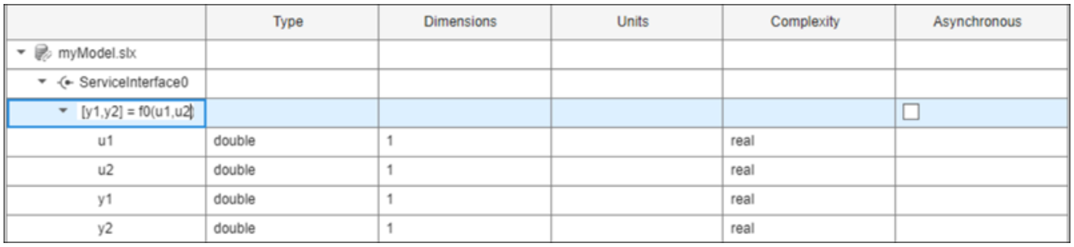


	Type	Dimensions	Units	Complexity	Asynchronous
myModel.slx					
ServiceInterface0					
y = f0(u)					☐
u	double	1		real	
y	double	1		real	
y = f1(u)					☐
u	double	1		real	
y	double	1		real	

Edit the function prototype on a function element to change the number and names of inputs and outputs of the function. Edit function element properties as you would edit other interface element properties. Function argument types can include built-in types as well as bus objects. You can specify function elements to support:

- Synchronous execution — When the client calls the server, the function runs immediately and returns the output arguments to the client.
- Asynchronous execution — When the client makes a request to call the server, the function is executed asynchronously based on the priority order defined in the **Functions Editor** and **Schedule Editor** and returns the output arguments to the client.

For asynchronous simulation, for the function element on the **Interface Editor**, select the **Asynchronous** check box.



	Type	Dimensions	Units	Complexity	Asynchronous
myModel.slx					
ServiceInterface0					
[y1,y2] = f0(u1,u2)					☐
u1	double	1		real	
u2	double	1		real	
y1	double	1		real	
y2	double	1		real	

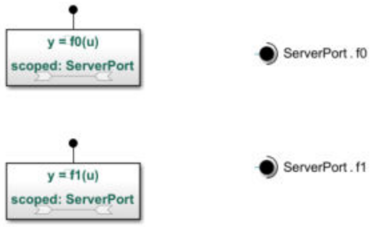
A function argument describes the attributes of an input or output argument in a function element.

You can set the properties of a function argument in the **Interface Editor** just as you would any value type: `Type`, `Dimensions`, `Units`, `Complexity`, `Minimum`, `Maximum`, and `Description`.

Once you have defined a service interface in the **Interface Editor**, you can assign it to client and server ports using the **Property Inspector**. You can also use the **Property Inspector** to assign stereotypes to service interfaces.

To implement function behavior for components with client or server ports using referenced Simulink models, right-click a component and select `Create Simulink behavior`, or use the `createSimulinkBehavior` function. System Composer creates a new export-function model and links the component to the new model.

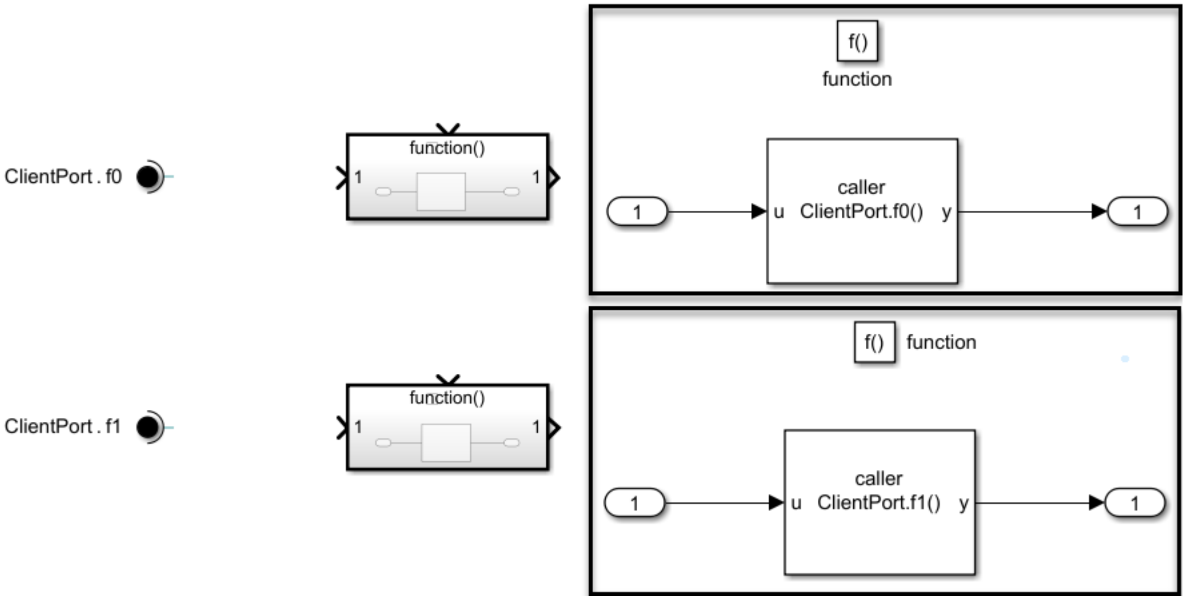
For a component with a server port, the model contains a Function Element block and a port-scoped Simulink Function block for each function element of the service interface associated with the server port. The Simulink Function blocks are preconfigured with a function interface specification to match each function element of the service interface. The Function Element block creates an exporting function port in the Simulink model. The attributes of the port are based on the service interface definition.



To implement the desired algorithm for each server function, open the Simulink Function blocks and add and connect the needed blocks and other modeling elements.

Synchronous Client-Server Simulink Behavior

For a component with a client port, the model contains a Function Element Call block and a Function-Call Subsystem block containing a Function Caller block for each function element of the service interface associated with the client port. The Function Caller blocks are preconfigured with a **Function prototype** and argument specifications to match each function element of the service interface. The Function Element Call block creates an invoking function port in the Simulink model. The attributes of the port are based on the service interface definition.



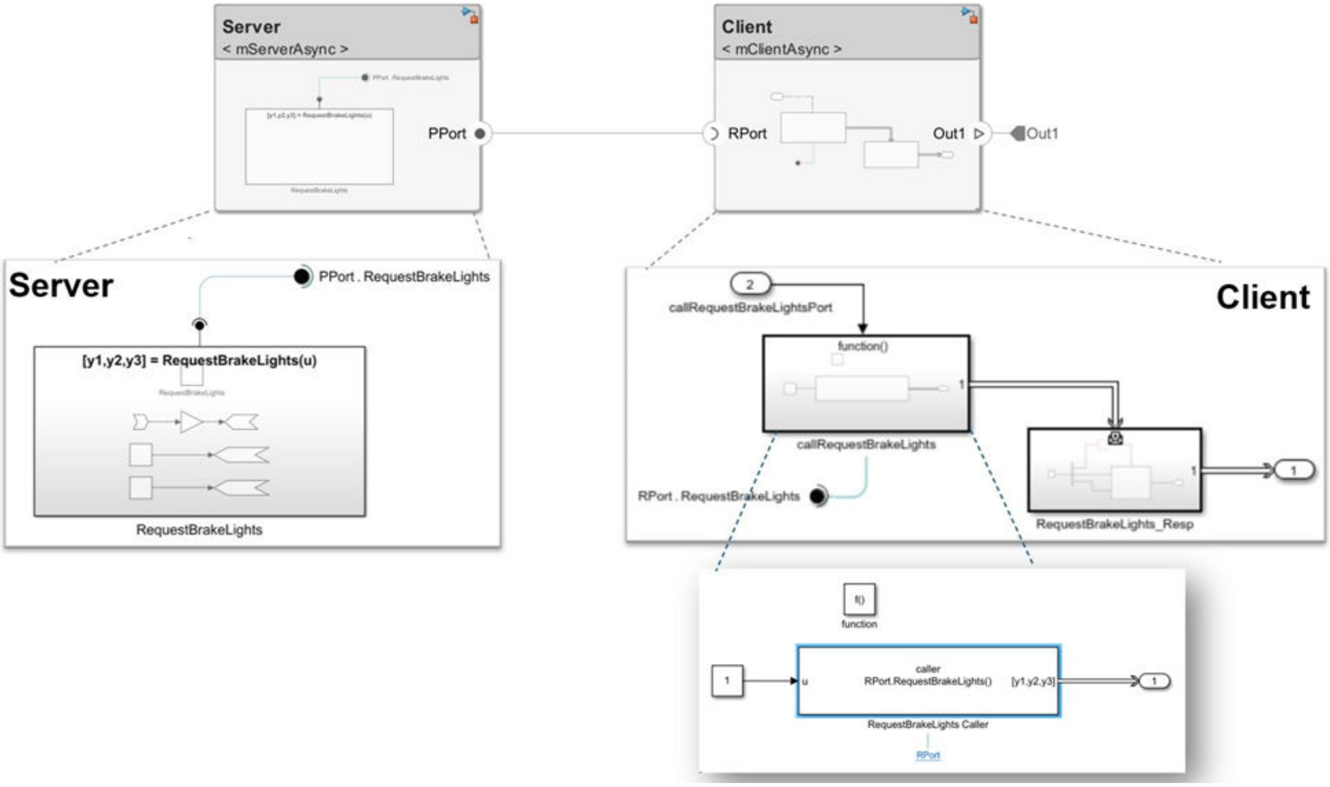
Asynchronous Client-Server Simulink Behavior

You can model asynchronous execution if you select the **Asynchronous** check box on the **Interface Editor** for your function element.

The export-function model for the Simulink behavior for the client model now has a Function Caller block with a message output port consistent with the number of output arguments for the Simulink Function.

- If there is one function output argument, the output argument becomes the message payload.
- If there is more than one function output argument, the Function Caller block bundles the output arguments as a structure that becomes the message payload.

The Function Caller message output port is connected to a Message Triggered Subsystem that processes messages.



See Also

Function Element | Function Element Call | Simulink Function | Function Caller | Function-Call Subsystem | Message Triggered Subsystem | `addServiceInterface` | `setFunctionPrototype` | `getFunctionArgument` | `setAsynchronous`

Related Examples

- “Simulate Asynchronous Services for Vehicle Headlight Management” on page 10-53
- “Define Port Interfaces Between Components” on page 3-2
- “Call Simulink Functions in Other Models Using Function Ports”
- “Service-Oriented Sensor Modeling” on page 10-45
- “Software Component Modeling”
- “Author and Extend Functions for Software Architectures” on page 10-24

Service-Oriented Sensor Modeling

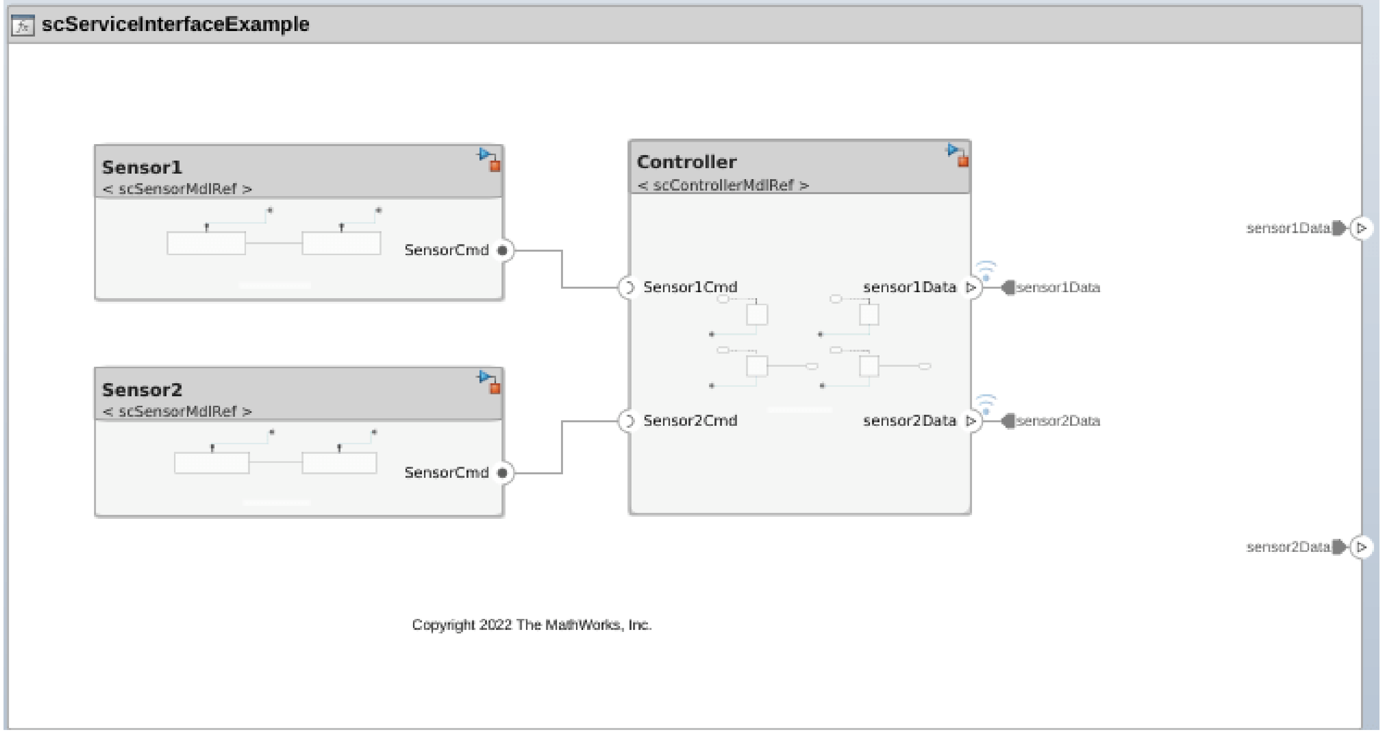
This example shows how to use a service interface in a software architecture model to allow a component to call services provided by specific instances of a referenced component.

Overview

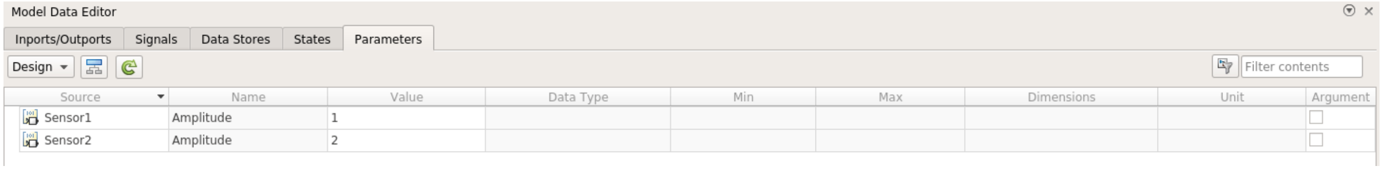
In this example, the model `slexServiceInterfaceExample` consists of a controller component, `Controller`, and two sensor components, `Sensor1` and `Sensor2`. The sensor components are modeled as two different instances of the same referenced model, `scSensorModelRef`. The referenced model defines two services: `reset`, which resets the sensor from drifting over time, and `fetchData`, which reads the latest sensor values. A single service interface is specified between the controller and the two sensor instances, which allows the controller to call `reset` or `fetchData` for a specific instance of the referenced sensor component.

Open the model.

```
model = systemcomposer.openModel('scServiceInterfaceExample');
```

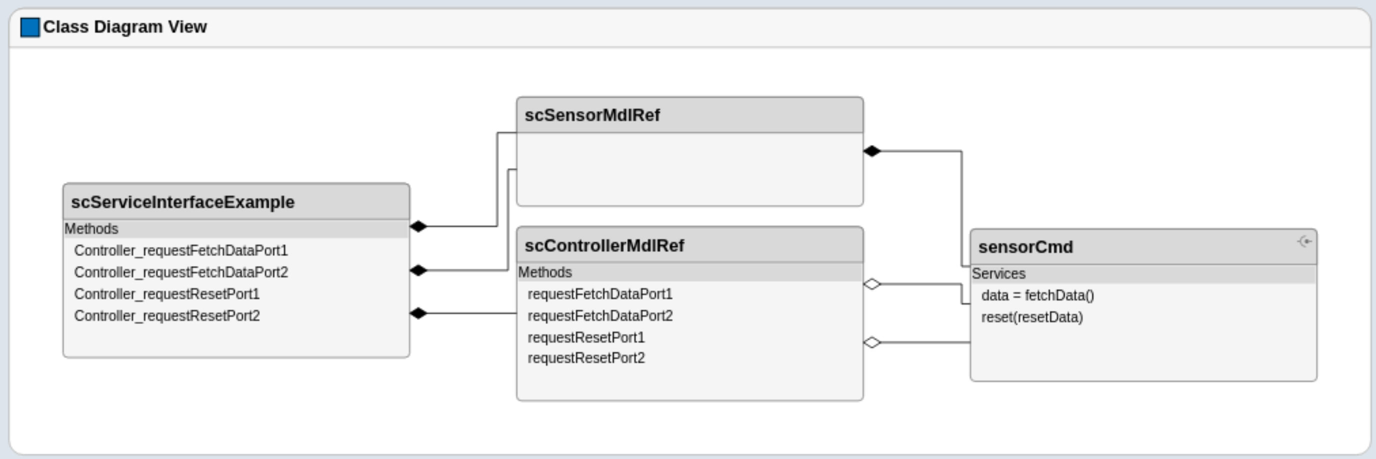


Both instances of the referenced sensor model output a sine wave with different amplitudes. You can view and specify the amplitudes in the Model Data Editor of the top model. To access the Model Data Editor, go to the **Modeling** tab, and in the **Design** section, select **Model Data Editor**.



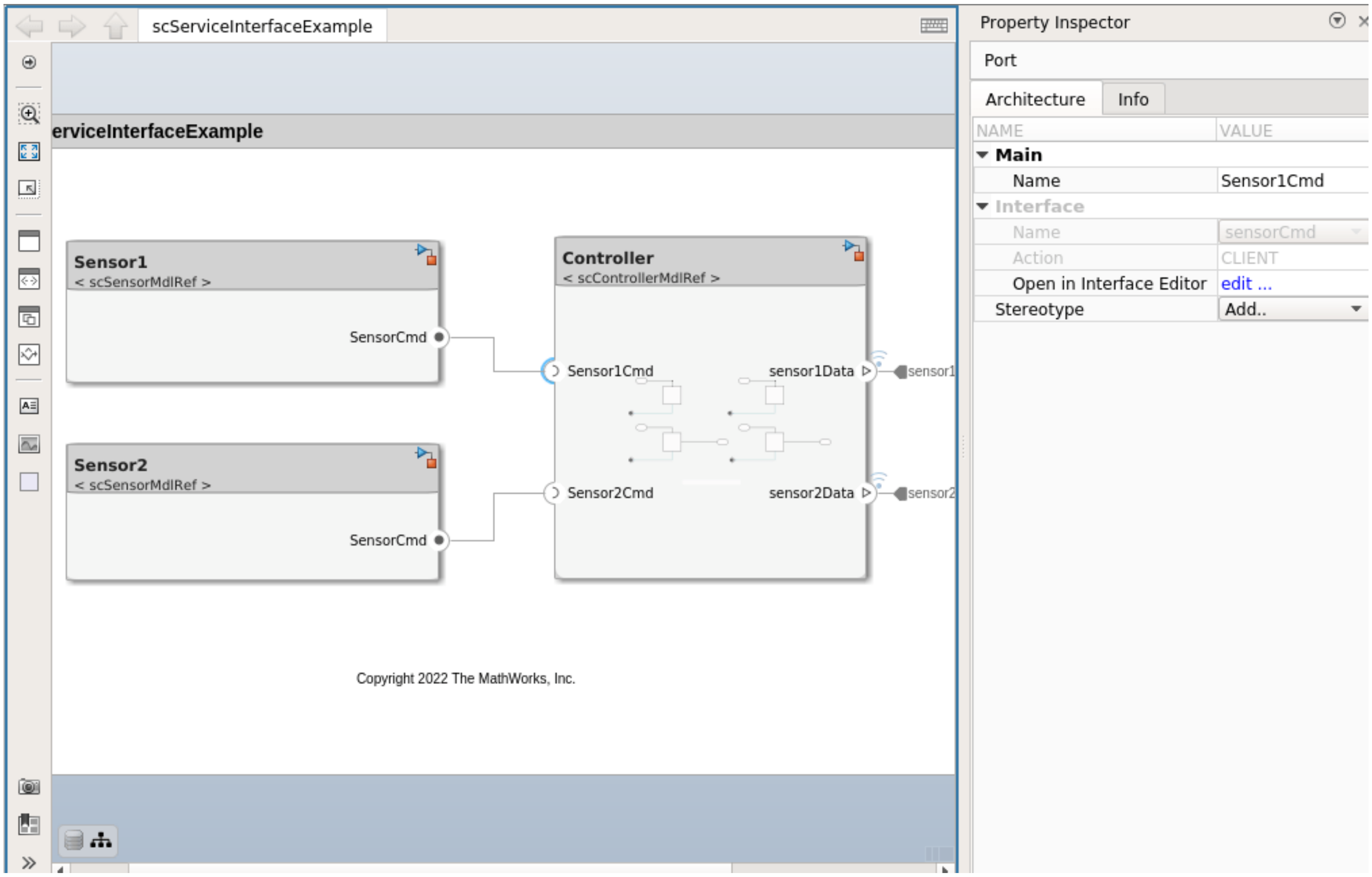
Source	Name	Value	Data Type	Min	Max	Dimensions	Unit	Argument
Sensor1	Amplitude	1						☐
Sensor2	Amplitude	2						☐

A Class Diagram View can be used to visualize the relationship between the controller and the referenced sensor component. To open the Class Diagram View, go to the **Modeling** tab, and in the **Views** section, select **Architecture Views**.



Client-Server Ports

The controller component interacts with the sensor components using client-server ports. Function calls to the services provided by the sensors and their responses are handled through these ports. Each client-server port is mapped to the service interface `sensorCmd`, which defines the services.



Property Inspector

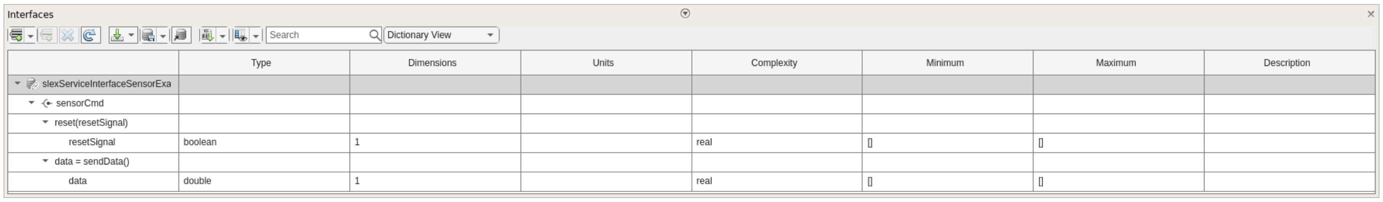
Port

Architecture | Info

NAME	VALUE
Main	
Name	Sensor1Cmd
Interface	
Name	sensorCmd
Action	CLIENT
Open in Interface Editor	edit ...
Stereotype	Add..

Service Interface Specification

The service interface `sensorCmd` is defined through the Interface Editor. To access the Interface Editor, go to the **Modeling** tab, and in the **Design** section, select **Interface Editor**. The service interface `sensorCmd` is used across referenced models and stored in the data dictionary `slexServiceInterfaceExample.sldd`. Note that `sensorCmd` contains two functions, `reset` and `fetchData`.

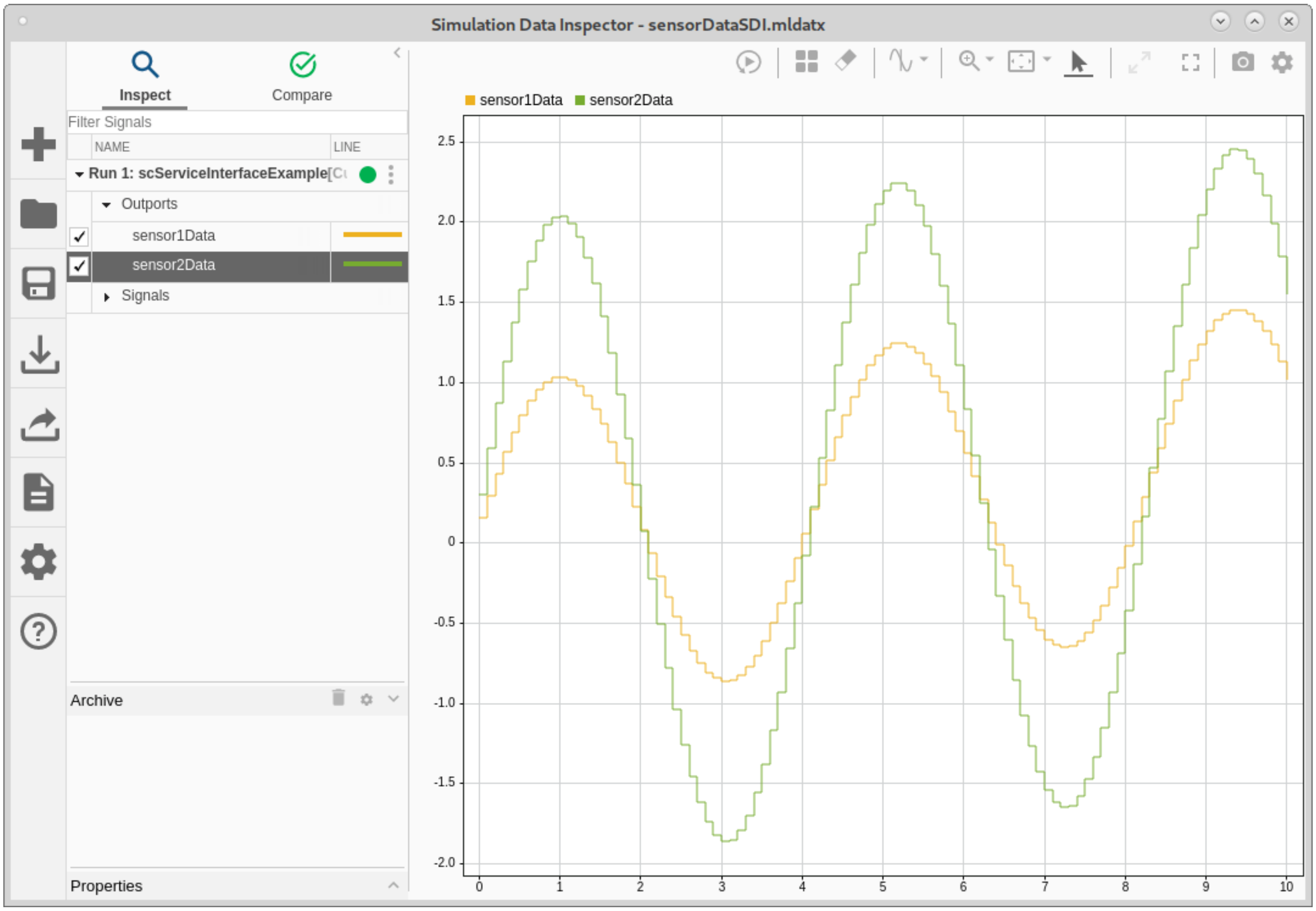


Interfaces

Search | Dictionary View

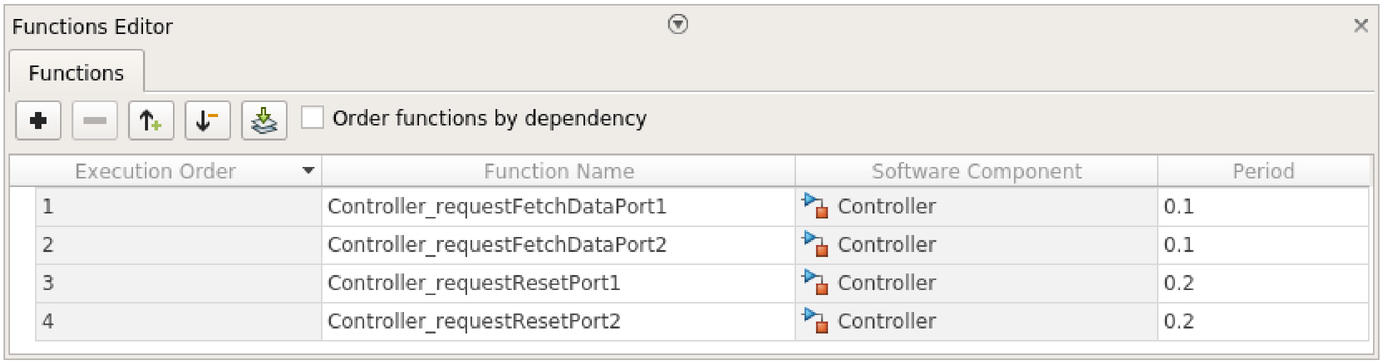
	Type	Dimensions	Units	Complexity	Minimum	Maximum	Description
slexServiceInterfaceSensorExa							
sensorCmd							
reset(resetSignal)							
resetSignal	boolean	1		real	[]	[]	
data = sendData()							
data	double	1		real	[]	[]	

In this example, the sensors exhibit a drift that increases over time. The controller calls the `fetchData` service to receive the sensor output and calls the `reset` service periodically to reset the drift back to 0. To visualize the sensor outputs, go to the **Simulation** tab, and in the **Review Results** section, select **Data Inspector**.



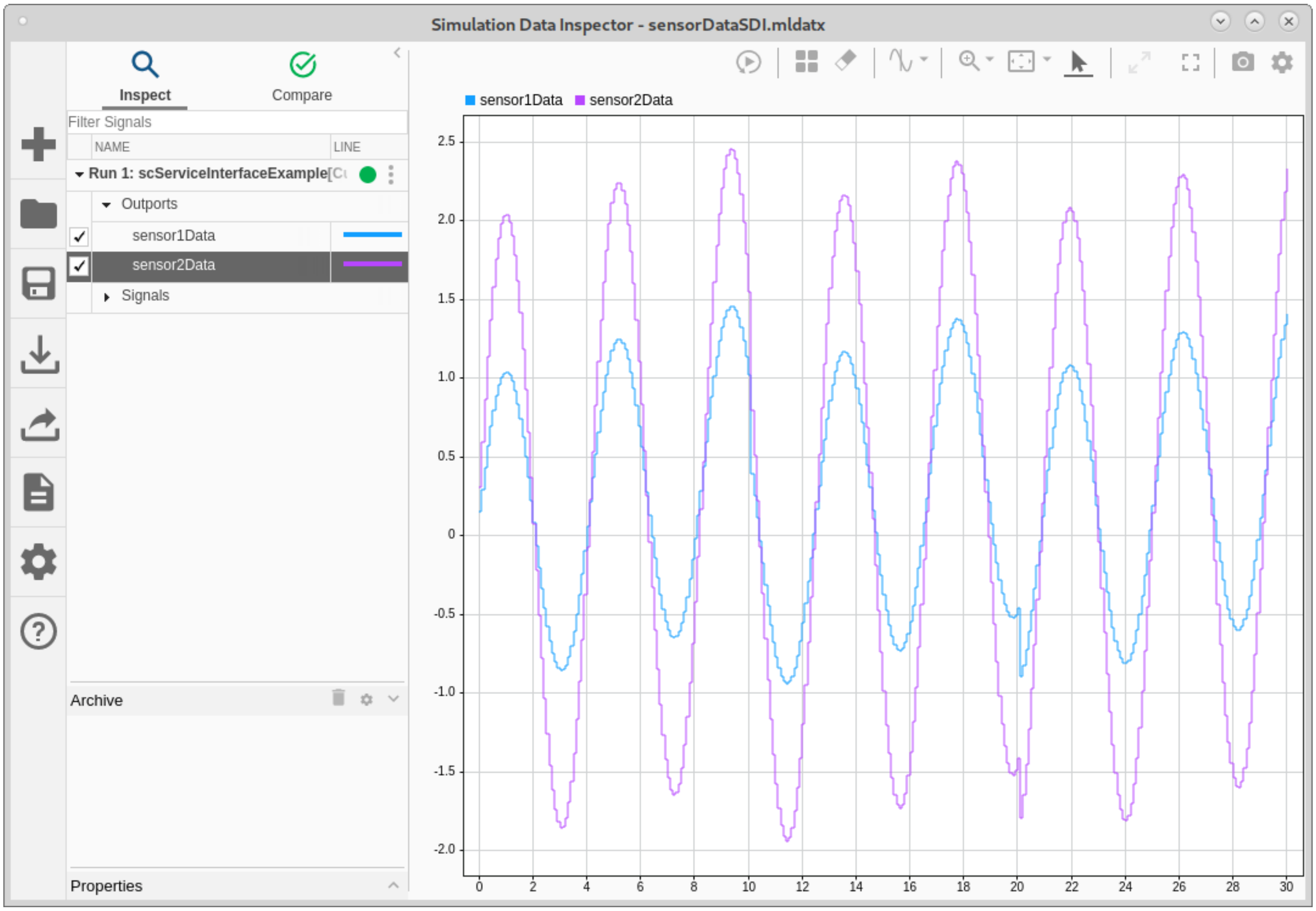
Function Scheduling

You can schedule the functions of the controller through the Functions Editor. To access the Functions Editor, go to the **Modeling** tab, and in the **Design** section, select **Functions Editor**. In this example, the `reset` function is called by the controller every 0.2 seconds, while the `fetchData` function is called every 0.1 seconds. Note that there is a Boolean input argument for the `reset` function, `resetData`. By default, `resetData` is `false`, and thus the `reset` function does not reset the sensors until the controller sets `resetData` to `true`. In this example, the controller component is configured to set `resetData` to `true` every 50 samples of the `reset` function, or every 10 seconds.

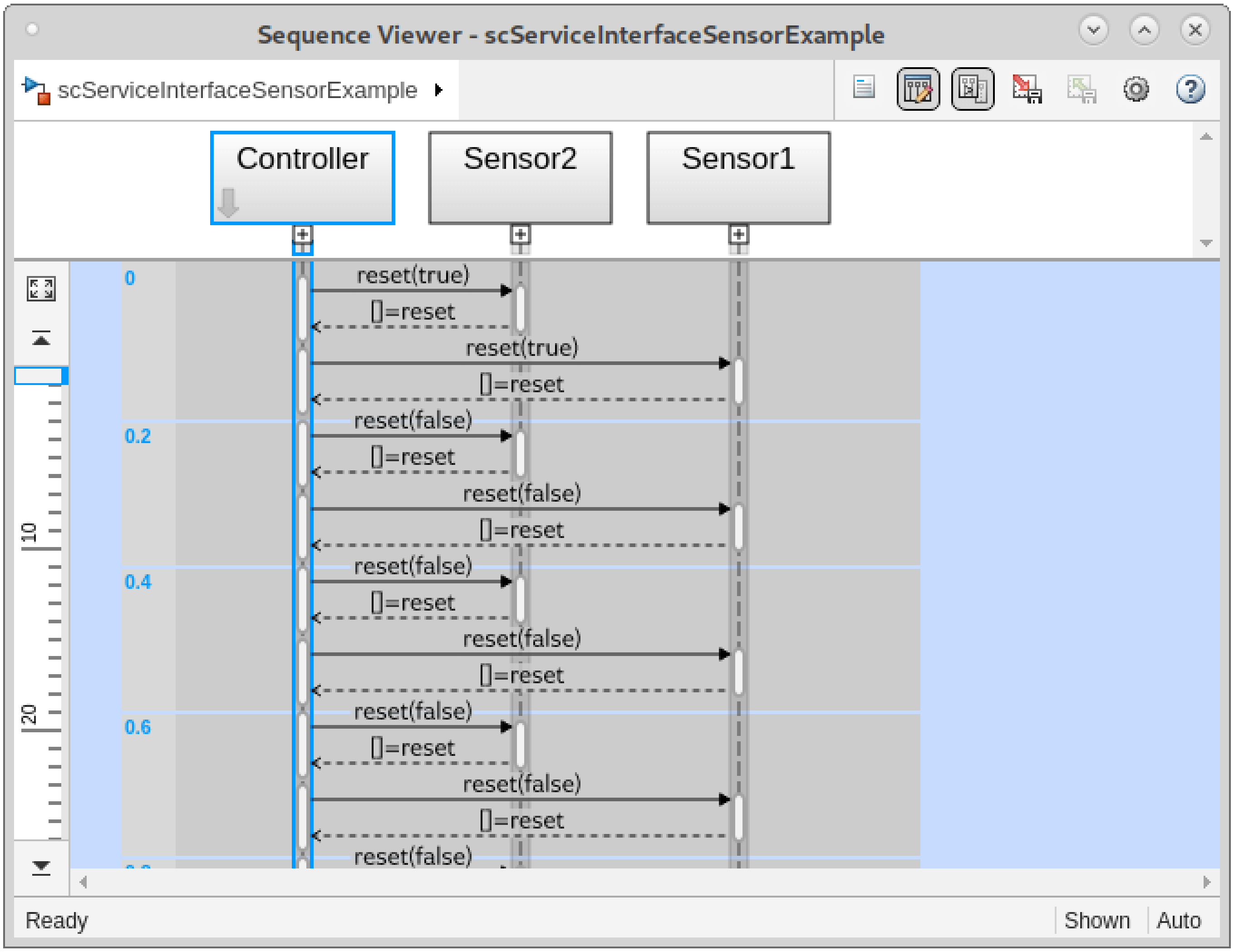


☐ Order functions by dependency

Execution Order	Function Name	Software Component	Period
1	Controller_requestFetchDataPort1	Controller	0.1
2	Controller_requestFetchDataPort2	Controller	0.1
3	Controller_requestResetPort1	Controller	0.2
4	Controller_requestResetPort2	Controller	0.2



You can view the sequence of function calls throughout the simulation of the model in the Sequence Viewer. To access the Sequence Viewer, go to the **Simulation** tab, and in the **Review Results** section, select **Sequence Viewer**.



Code Generation

To generate code for the model, which includes the service interface `sensorCmd`, use this command.

```
rtwbuild('scServiceInterfaceSensorExample');
```

Note that the service interface `SensorCmd` is generated as an abstract class. This action enables implementation to be separate from the interface.

```
#ifndef RTW_HEADER_sensorCmdT_h_
#define RTW_HEADER_sensorCmdT_h_
#include "rtwtypes.h"

class sensorCmdT
{
 public:
  virtual void reset(boolean_T)
  {
  }

  virtual ~sensorCmdT()
  {
  }

  virtual void fetchData(real_T *)
  {
  }
};

#endif                                 // RTW_HEADER_sensorCmdT_h_
```

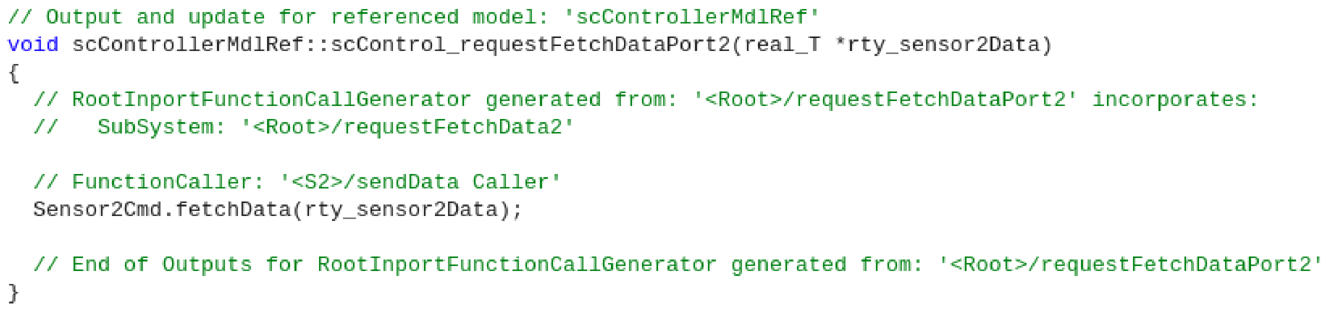
This abstract class is implemented by the generated code for the referenced sensor model.

```
// Output and update for referenced model: 'scSensorMdlRef'
void scSensorMdlRef::fetchData(real_T *rty_data)
{
  // Outputs for Function Call SubSystem: '<Root>/fetchData'
  // MATLAB Function: '<S1>/MATLAB Function' incorporates:
  //   SignalConversion generated from: '<S1>/reset'

  if (scSensorMdlRef_B.TmpSignalConversionAtresetData0) {
    scSensorMdlRef_DW.offset = 0.0;
  } else {
    scSensorMdlRef_DW.offset += 0.005;
  }

  scSensorMdlRef_DW.time += 0.1;

  // SignalConversion generated from: '<S1>/data' incorporates:
  //   Constant: '<S1>/Constant'
  //   MATLAB Function: '<S1>/MATLAB Function'

  *rty_data = std::sin(1.5 * scSensorMdlRef_DW.time) *
    scSensorMdlRef_InstP_ref->Amplitude + scSensorMdlRef_DW.offset;

  // End of Outputs for SubSystem: '<Root>/fetchData'
}

// Output and update for referenced model: 'scSensorMdlRef'
void scSensorMdlRef::reset(boolean_T rtu_resetData)
{
  // Outputs for Function Call SubSystem: '<Root>/reset'
  // SignalConversion generated from: '<S2>/resetData'
  scSensorMdlRef_B.TmpSignalConversionAtresetData0 = rtu_resetData;

  // End of Outputs for SubSystem: '<Root>/reset'
}
```

The generated abstract class is also used to construct the class of the controller.

```
// Constructor
scControllerMdlRef::scControllerMdlRef(sensorCmdT& Sensor1Cmd_arg,sensorCmdT&
  Sensor2Cmd_arg) :
  scControllerMdlRef_DW(),
  Sensor1Cmd(Sensor1Cmd_arg),
  Sensor2Cmd(Sensor2Cmd_arg),
  scControllerMdlRef_M()
{
  // Currently there is no constructor body generated.
}
```

The service is subsequently called by the controller from the SensorCmd abstract class.



```
// Output and update for referenced model: 'scControllerMdlRef'
void scControllerMdlRef::scControl_requestFetchDataPort2(real_T *rty_sensor2Data)
{
  // RootInportFunctionCallGenerator generated from: '<Root>/requestFetchDataPort2' incorporates:
  //   SubSystem: '<Root>/requestFetchData2'

  // FunctionCaller: '<S2>/sendData Caller'
  Sensor2Cmd.fetchData(rty_sensor2Data);

  // End of Outputs for RootInportFunctionCallGenerator generated from: '<Root>/requestFetchDataPort2'
}
```

See Also

Function Element | Function Element Call | Simulink Function | Function Caller | Function-Call Subsystem | addServiceInterface | setFunctionPrototype | getFunctionArgument

Related Examples

- “Define Port Interfaces Between Components” on page 3-2
- “Author and Extend Functions for Software Architectures” on page 10-24
- “Software Component Modeling”
- “Author Service Interfaces for Client-Server Communication” on page 10-41
- “Call Simulink Functions in Other Models Using Function Ports”
- “Simulate Asynchronous Services for Vehicle Headlight Management” on page 10-53

Simulate Asynchronous Services for Vehicle Headlight Management

This example shows how to use asynchronous services to simulate vehicle headlights in a System Composer™ software architecture model.

Overview

In this example, the model `HeadlightArch` consists of a lighting manager component, `LightingManager`, two headlight components, `LeftHeadlight` and `RightHeadlight`, and a component for logging, `Logging`. The headlight components are modeled as two different instances of the same referenced model, `HeadLight`.

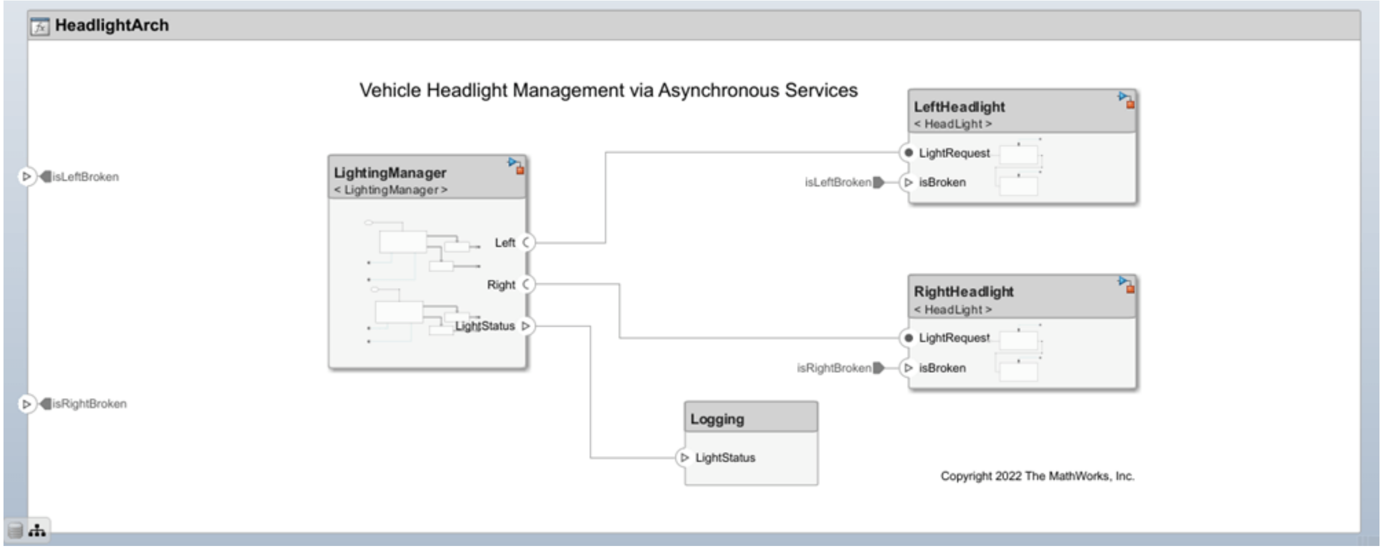
The referenced model defines two Simulink® Functions:

- `setMode`, which takes in the `lightMode` variable and returns an output that indicates whether the headlight is broken
- `getMode`, which returns the `lightMode` variable

A single service interface is specified between the lighting manager and the two headlight instances, which allows the manager to call `setMode` or `getMode` for a specific instance of the referenced headlight component.

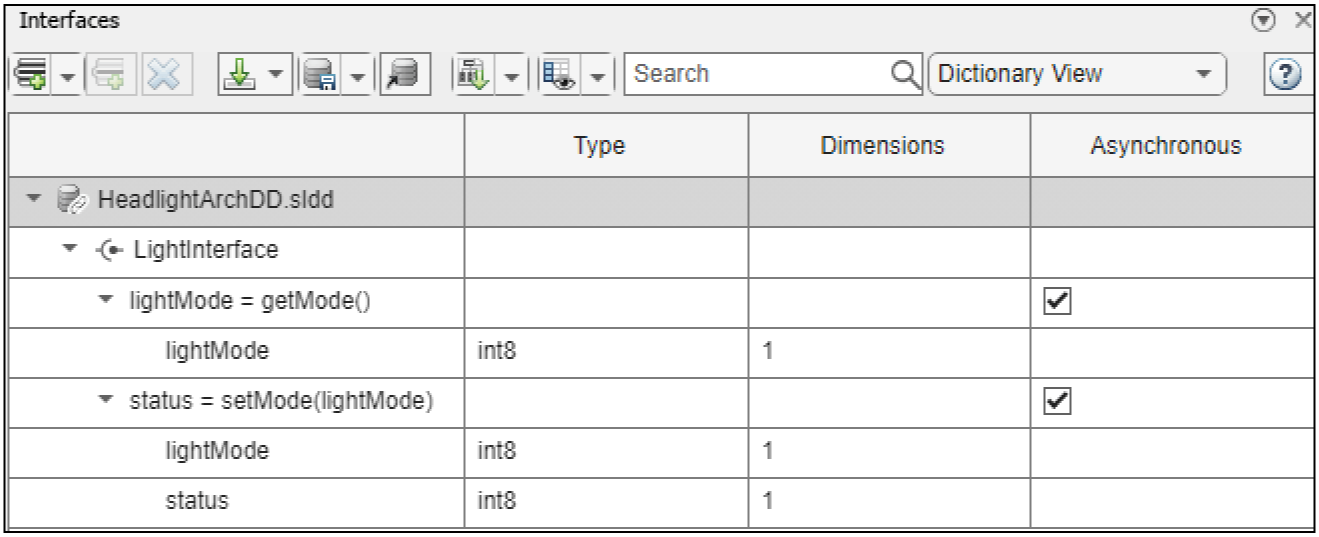
Open the model.

```
model = systemcomposer.openModel("HeadlightArch");
```



Define Asynchronous Services Using Interface Editor

To view the Interface Editor, on the toolstrip, navigate to **Modeling** > **Interface Editor**. Notice that the **Asynchronous** check box is selected for the function elements representing the functions `getMode` and `setMode`.



	Type	Dimensions	Asynchronous
HeadlightArchDD.sldd			
LightInterface			
lightMode = getMode()			☑
lightMode	int8	1	
status = setMode(lightMode)			☑
lightMode	int8	1	
status	int8	1	

The block parameters for the Simulink behavior models are preconfigured to support asynchronous simulation.

On the server model, the Trigger block parameter `Execute function call asynchronously` within the Simulink Function blocks for `setMode` and `getMode` is selected. On the client model, the Function Caller block parameter `Execute function call asynchronously` is selected.

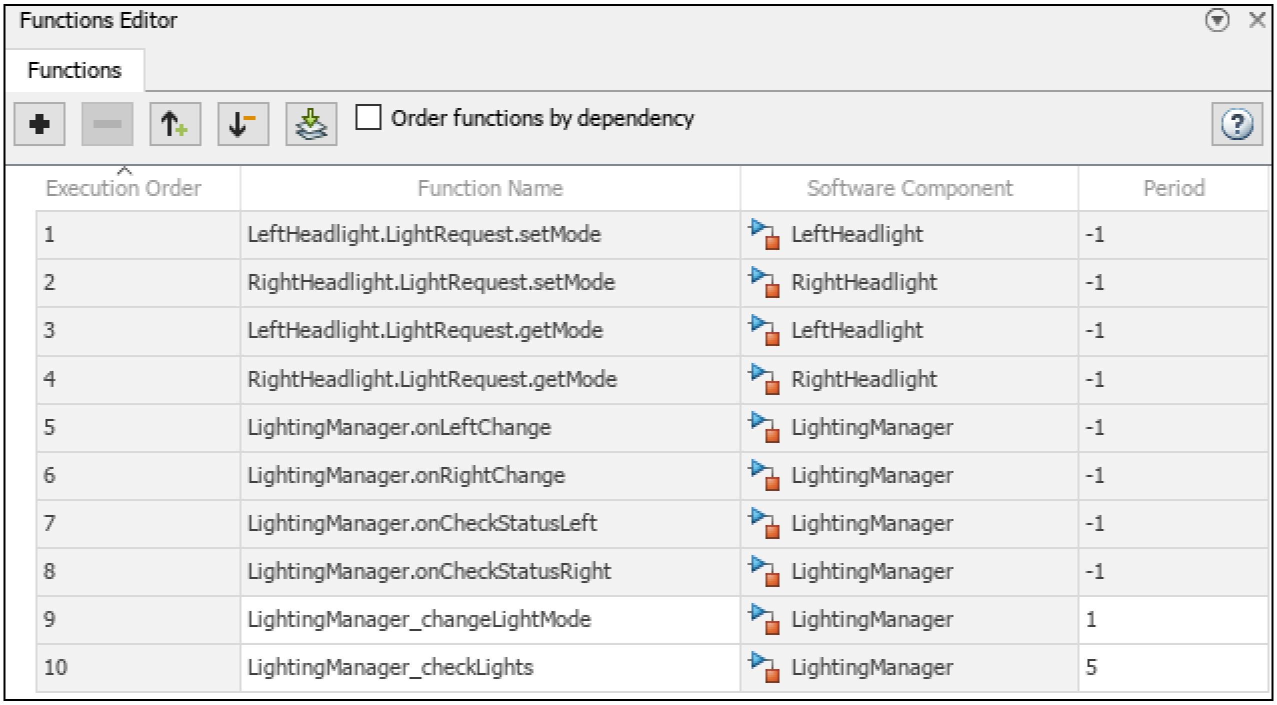
Asynchronous Function Calls for Simulation of Vehicle Headlights

For asynchronous execution, when the client makes a request to the server, the server responds according to the priority order defined in the Functions Editor instead of the order in which the requests were received. To launch the **Functions Editor** tool, on the toolstrip, go to **Modeling** > **Functions Editor**.

Use the **Functions Editor** tool to change the order of execution of the functions so that when these functions are called at the same time, the higher priority function is executed first.

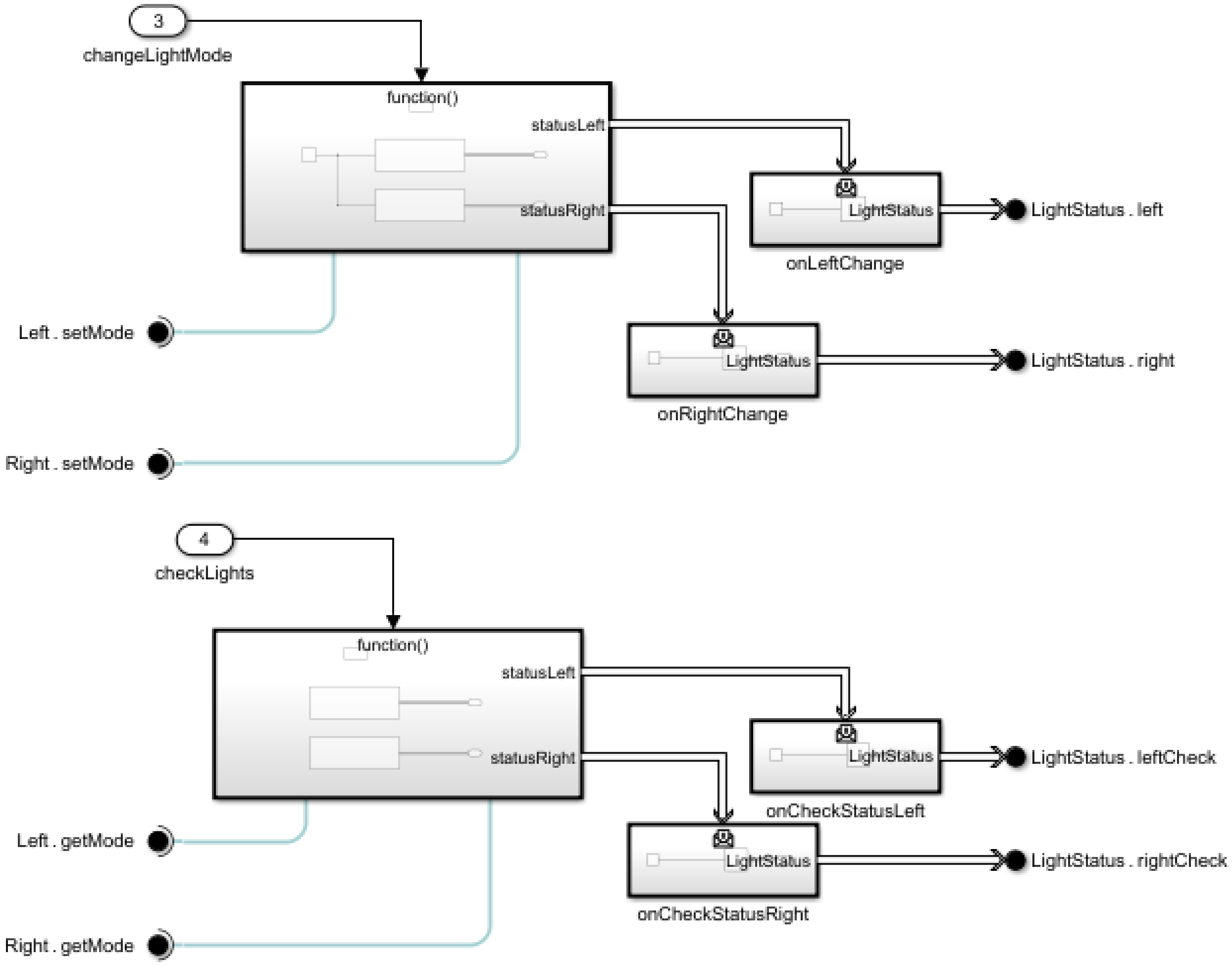
If a function from the list calls another function:

- If a lower priority function is already running, the higher priority function runs. After its completion, the lower priority function continues to run.
- If a higher priority function is already running, the lower priority function runs after the higher priority one.



Execution Order	Function Name	Software Component	Period
1	LeftHeadlight.LightRequest.setMode	LeftHeadlight	-1
2	RightHeadlight.LightRequest.setMode	RightHeadlight	-1
3	LeftHeadlight.LightRequest.getMode	LeftHeadlight	-1
4	RightHeadlight.LightRequest.getMode	RightHeadlight	-1
5	LightingManager.onLeftChange	LightingManager	-1
6	LightingManager.onRightChange	LightingManager	-1
7	LightingManager.onCheckStatusLeft	LightingManager	-1
8	LightingManager.onCheckStatusRight	LightingManager	-1
9	LightingManager_changeLightMode	LightingManager	1
10	LightingManager_checkLights	LightingManager	5

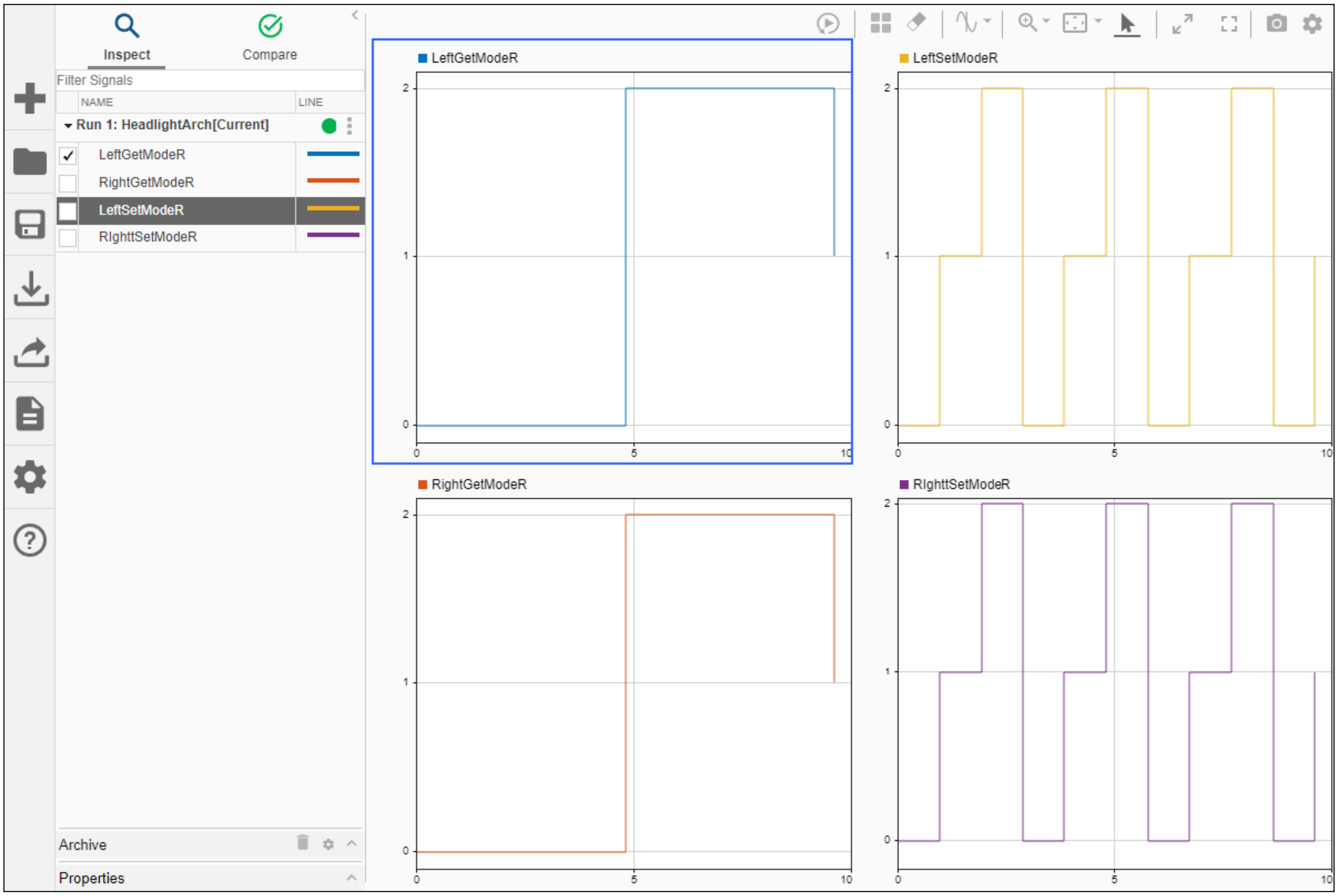
For asynchronous function calls, the Function Caller block has a message output port consistent with the number of output arguments. This message output port connects to a Message Triggered Subsystem block to process the messages. The `LightingManager` component references the `LightingManager` Simulink model that consists of two asynchronous function calls. The `changelLightMode` Function-Call Subsystem uses the `setMode` function and determines how each headlight should change its lighting mode. The `checkLight` Function-Call Subsystem uses the `getMode` function and checks whether each headlight is broken and returns its status.



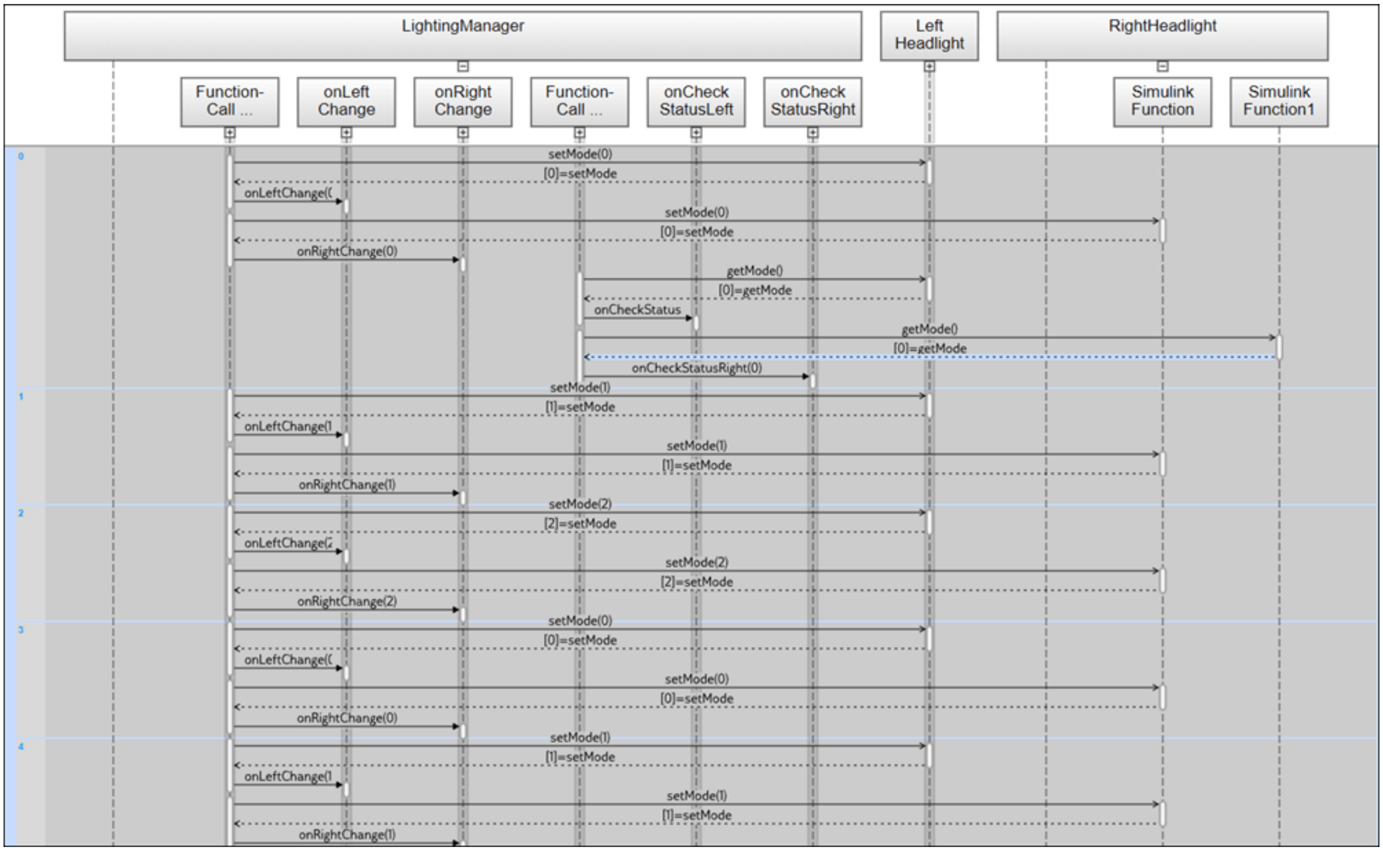
Simulate the model.

```
sim("HeadlightArch");
```

You can visualize the logged signals after simulation using the Simulation Data Inspector. On the toolstrip, go to **Simulation** > **Data Inspector**.



To view the execution order of the function calls, on the toolstrip, launch the Sequence Viewer by navigating to **Simulation** > **Sequence Viewer**. Simulate the model again to view the logged messages on the **Sequence Viewer** and the order in which messages are executed. Since the `setMode` function is at a higher priority order on the **Functions Editor**, those server calls are received first.



You can change the priority order of the functions in the **Functions Editor** and view the result in the **Sequence Viewer**.

See Also

Function Element | Function Element Call | Simulink Function | Function Caller | Function-Call Subsystem | Message Triggered Subsystem | `addServiceInterface` | `setFunctionPrototype` | `getFunctionArgument` | `setAsynchronous`

Related Examples

- “Define Port Interfaces Between Components” on page 3-2
- “Author and Extend Functions for Software Architectures” on page 10-24
- “Software Component Modeling”
- “Author Service Interfaces for Client-Server Communication” on page 10-41
- “Call Simulink Functions in Other Models Using Function Ports”
- “Service-Oriented Sensor Modeling” on page 10-45

11

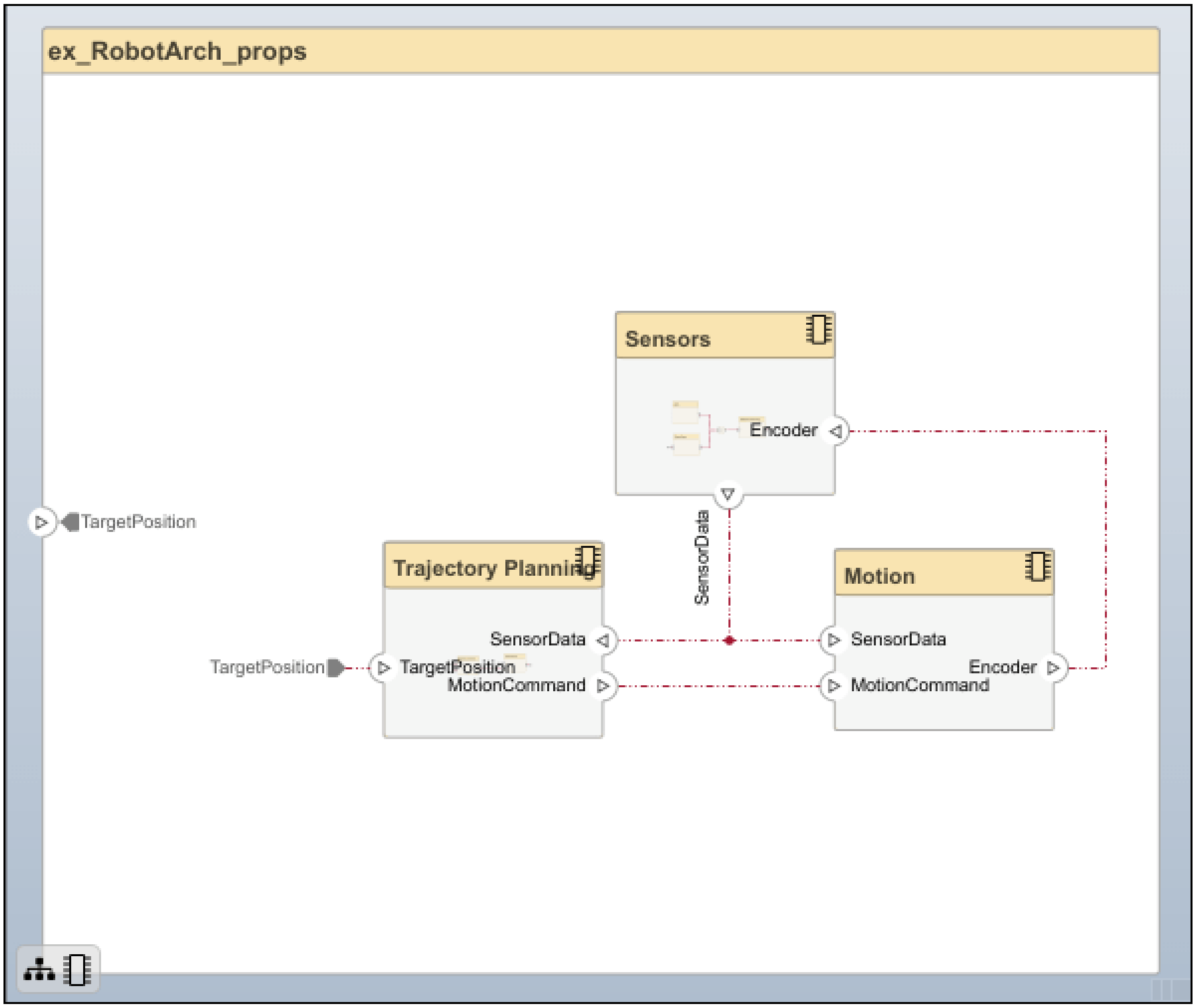
Create Custom Views

Create Spotlight Views

A system being designed in System Composer for a real application is usually large and complex. It typically consists of many complex functions working together to fulfill the system requirements. In the process of designing and analyzing such architectures, you must understand existing components and what needs to be added. A spotlight view is a simplified view of a model that captures the upstream and downstream dependencies of a specific component. Use the model below to begin creating spotlight views.

Mobile Robot Architecture Model with Properties

This example shows a mobile robot architecture model with stereotypes applied to components and properties defined.



Create Spotlight Views from Components

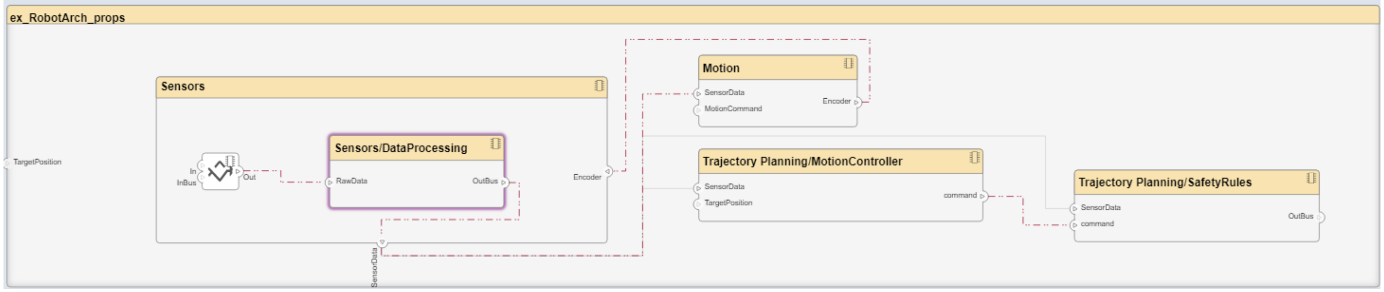
Create views dynamically using spotlight views.

1 Double-click the `Sensors` component, then select the `DataProcessing` component.

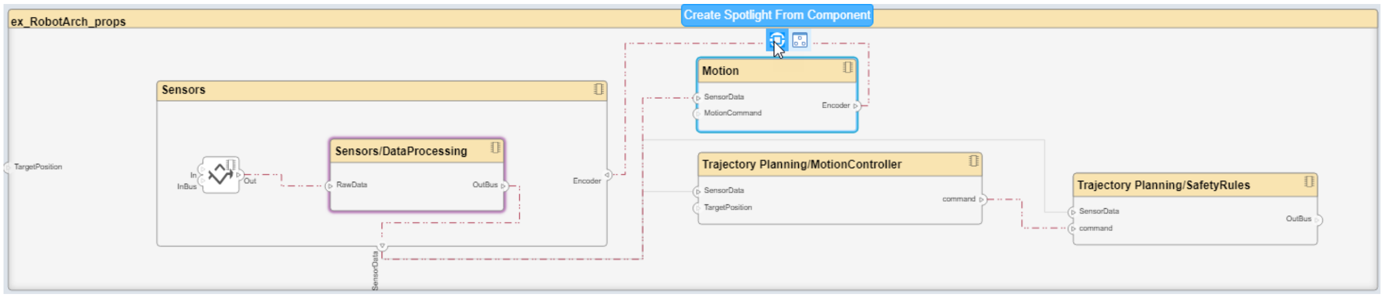
2 Select the `DataProcessing` component and navigate to **Modeling** > **Architecture Views** > **Spotlight**. Alternatively, right-click the `DataProcessing` component and select `Create Spotlight from Component`.

The spotlight view launches and shows all model elements to which the `DataProcessing` component connects. The spotlight diagram is laid out automatically and cannot be edited. However, it allows you to inspect just a single component and study its connectivity to other components.

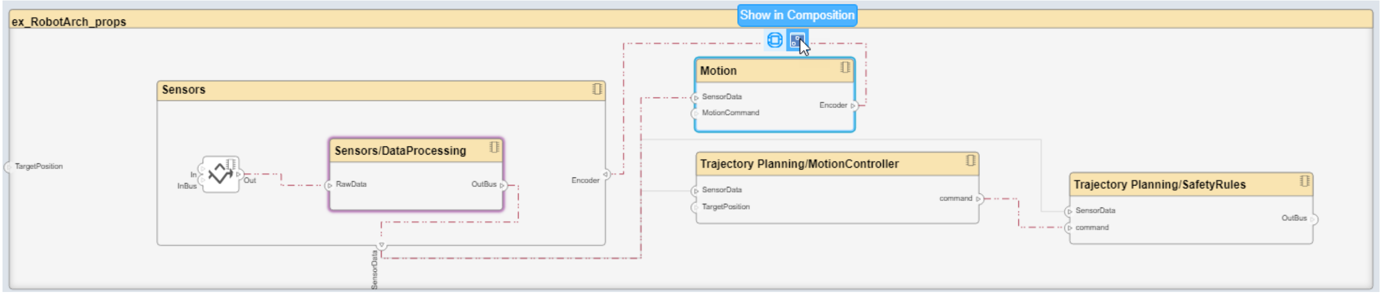
Note Spotlight views are transient. They are not saved with the model.



3 Shift the spotlight to another component. Select the `Motion` component. Click the ellipsis above the component to open the action menu. To create a spotlight from the component, click .



To view the architecture model at the level of a particular component, select the component and click .



4 To return to the architecture model view, click .

You can make the hierarchy and connectivity of a component visible at all times during model development by opening the spotlight view in a separate window. To show the spotlight view in a dedicated window, in the component context menu, select **Open in New Window**, then create the spotlight view. Spotlight views are dynamic and transient: any change in the composition refreshes any open spotlight views, and spotlight views are not saved with the model.

See Also

More About

- “Create Architecture Views Interactively” on page 11-5
- “Display Component Hierarchy and Architecture Hierarchy Using Views” on page 11-21
- “Create Architectural Views Programmatically” on page 11-15
- “Modeling System Architecture of Keyless Entry System” on page 11-25

Create Architecture Views Interactively

The structural hierarchy of a system typically differs from the hierarchy of the functional requirements of a system. With architecture views in System Composer, you can view a system based on different hierarchies.

A view shows a customizable subset of elements in a model. Views can be filtered based on stereotypes or names of components, ports, and interfaces, along with the name, type, or units of an interface element. Create views by adding elements manually. Views create a simplified way to work with complex architectures by focusing on certain parts of the architectural design.

You can use different types of views to represent the system:

- *Operational views* demonstrate how a system will be used and should be integrated with requirements analysis.
- *Functional views* focus on what the system must do to operate.
- *Physical views* show how the system is constructed and configured.

A viewpoint represents a stakeholder perspective that specifies the contents of the view.

For example, you can author a system using requirements. A view allows you to better understand what components you need to satisfy your requirements while not necessarily focusing on the structure.

This example uses the architecture model for a keyless entry system to create component diagram views.

A component diagram represents a view with components, ports, and connectors based on how the model is structured.

Component diagrams allow you to programmatically or manually add and remove components from the view.

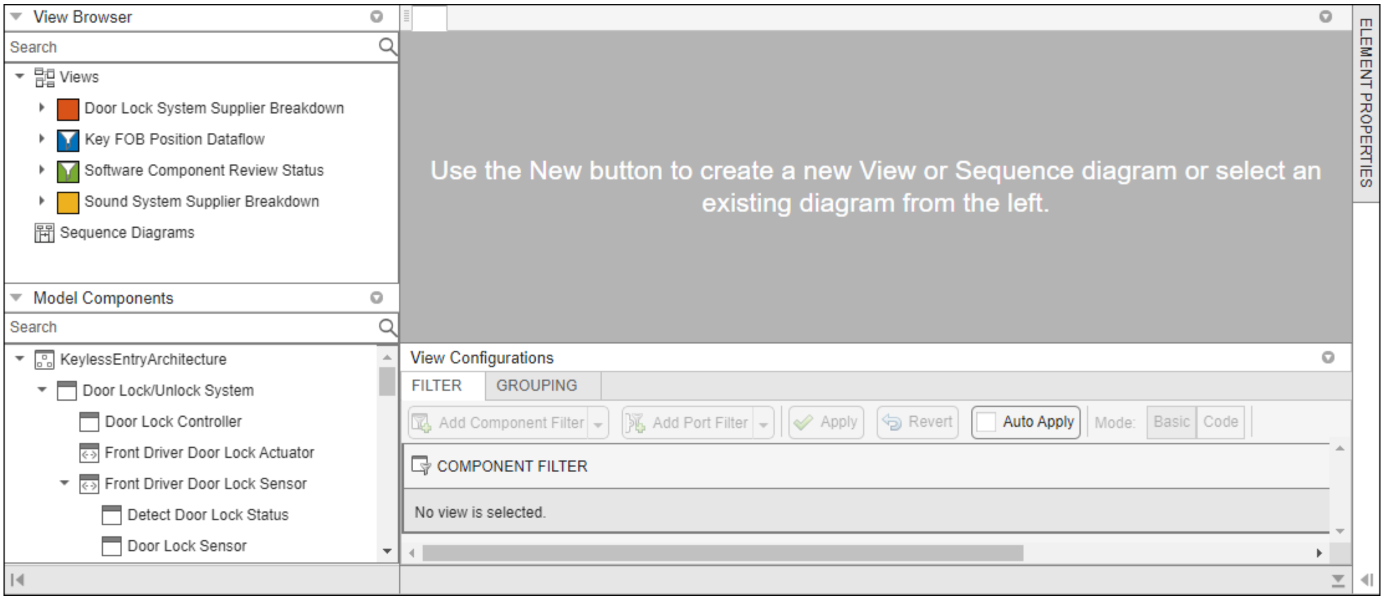
For more information on the keyless entry architecture, see “Modeling System Architecture of Keyless Entry System” on page 11-25.

Create Filtered Views with Component Filters and Port Filters

1. In the MATLAB Command Window, enter this command.

   ```
   scKeylessEntrySystem
   ```

   The architecture model opens in System Composer.
2. Navigate to **Modeling** > **Architecture Views** to open the **Architecture Views Gallery**.

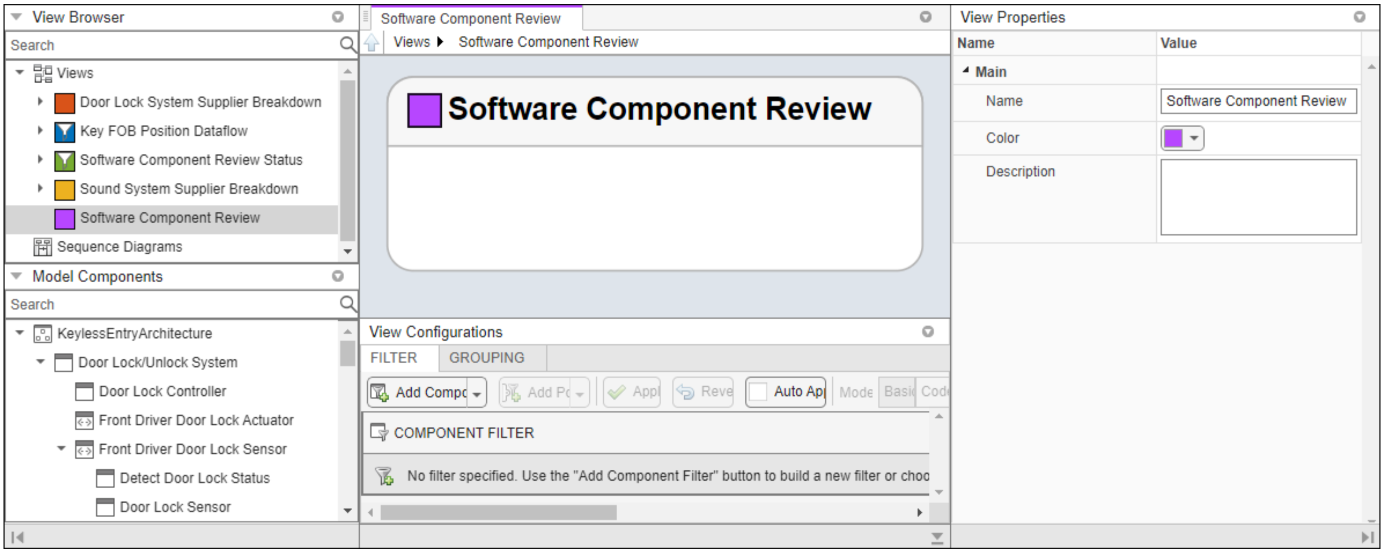


Use the New button to create a new View or Sequence diagram or select an existing diagram from the left.

No view is selected.

3 Select **New** > **View** to create a new view.

4 In **View Properties** on the right pane, in the **Name** box, enter a name for this view, for example, `Software Component Review`. Choose a **Color** and enter a **Description**, if necessary.

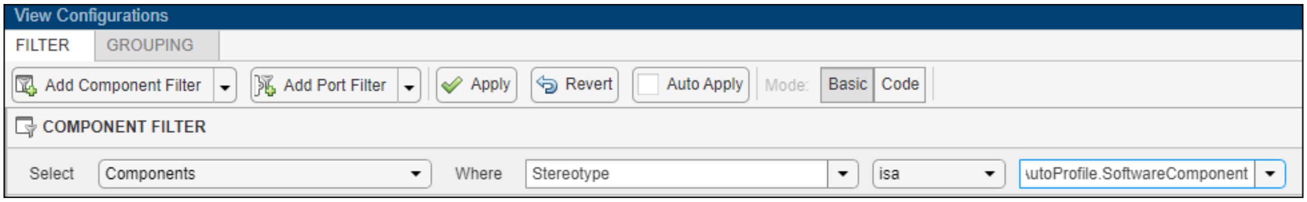


Name: Software Component Review

No filter specified. Use the "Add Component Filter" button to build a new filter or choo

5 In the bottom pane on **View Configurations**, from the **Filter** tab, click **Add Component Filter** to add new form-based criterion to a component filter.

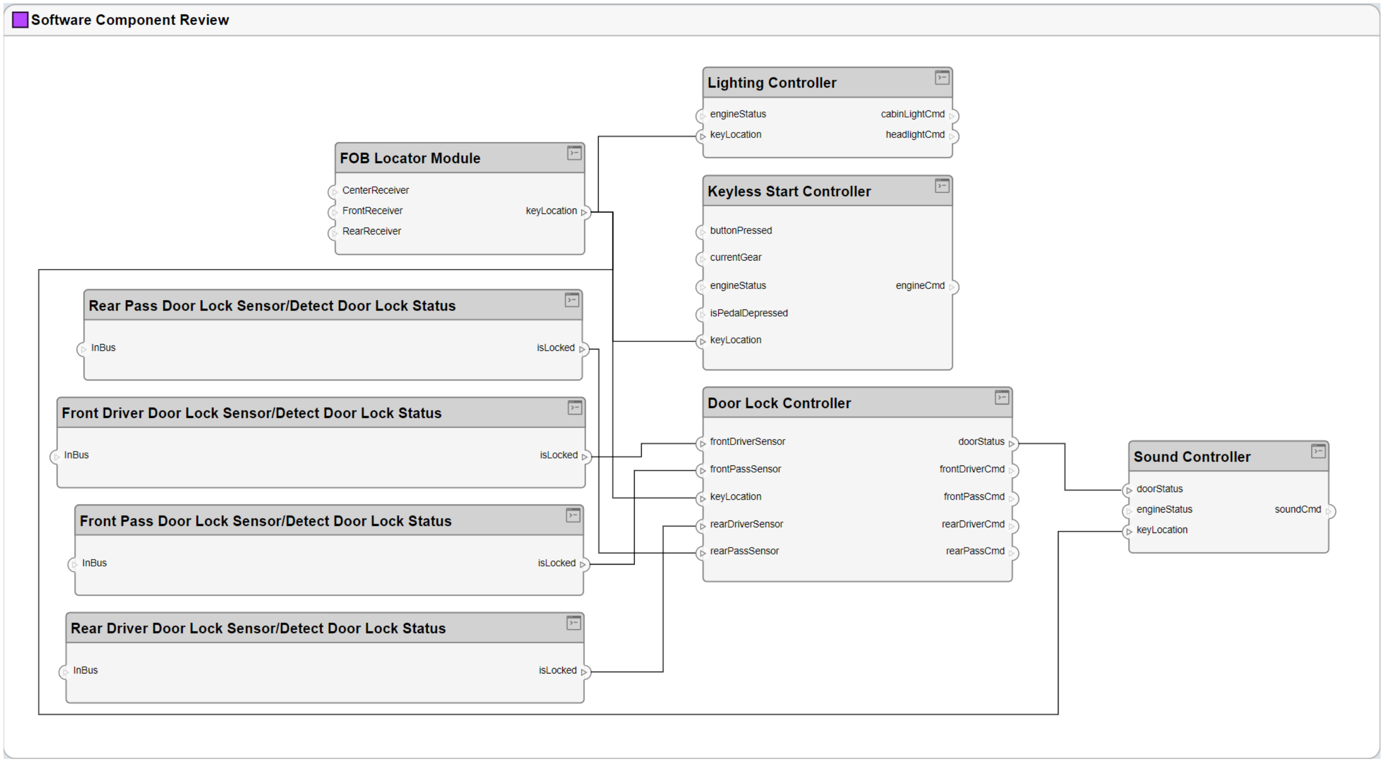
6 From the **Select** list, select `Components`. From the **Where** list, select `Stereotype`. Select **isa**. In the text box, from the list select `AutoProfile.SoftwareComponent`.



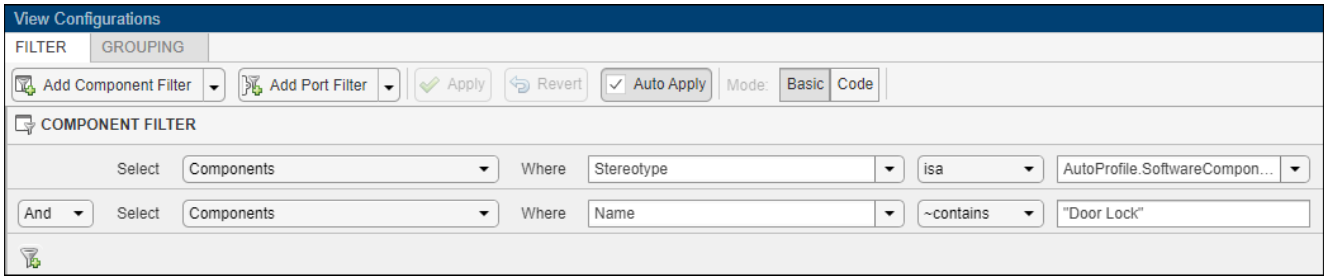
Select: Components ▾ Where: Stereotype ▾ isa ▾ utoProfile.SoftwareComponent ▾

7 Select **Apply** .

An architecture view is created using the query in the **Component Filter** box. The view is filtered to select all components with the `AutoProfile.SoftwareComponent` stereotype applied to them.



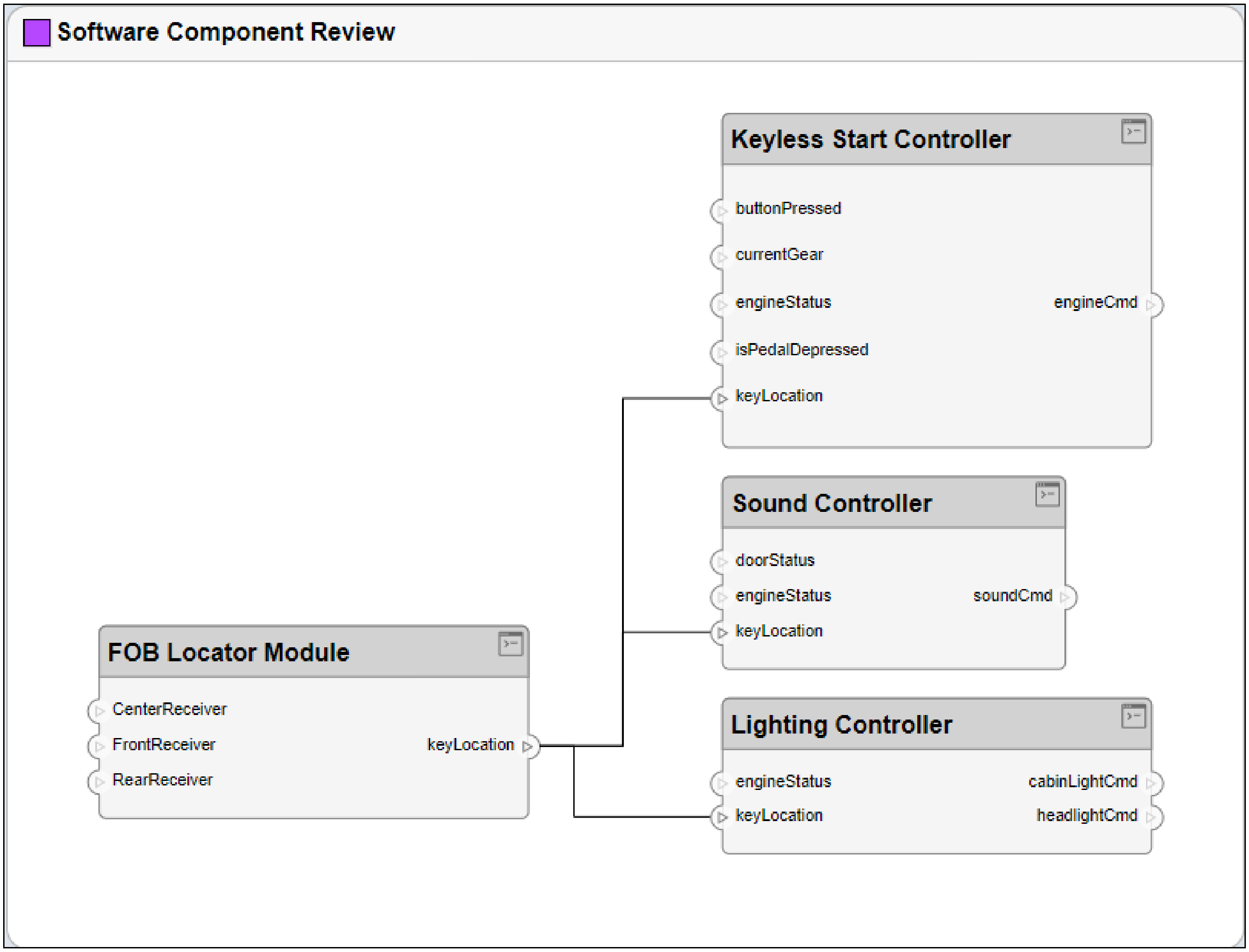
8 Select **Add Component Filter**. From the **Select** list, select `Components`. From the **Where** list, select `Name`. Select **~contains**. In the text box, enter `"Door Lock"`. Select the **Auto Apply** check box so that future changes are applied without selecting **Apply**.



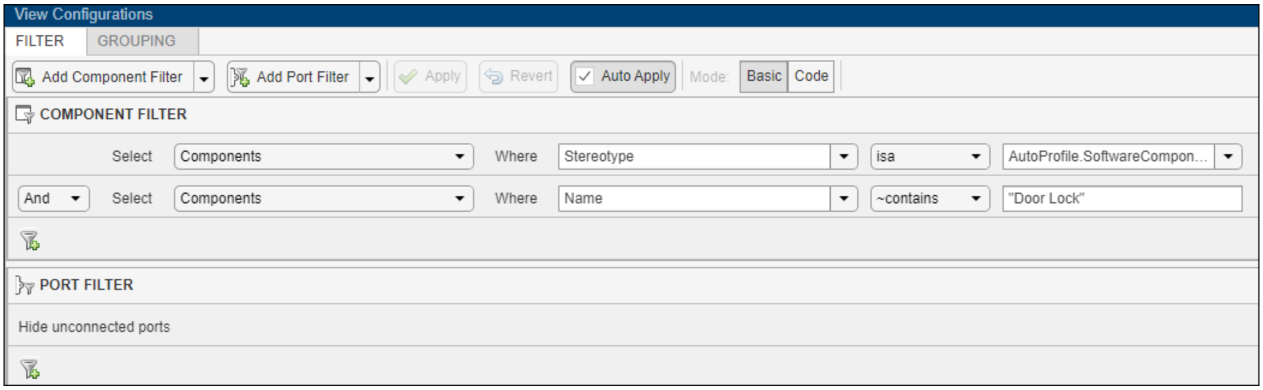
COMPONENT FILTER

	Select	Components	Where	Stereotype	isa	AutoProfile.SoftwareCompon...
And	Select	Components	Where	Name	~contains	"Door Lock"

9 An architecture view is created using the additional query in the **Component Filter** box. The view is filtered to select all components not named `"Door Lock"`.



10 From the **Add Port Filter** list, select the option `Hide Unconnected Ports`.



COMPONENT FILTER

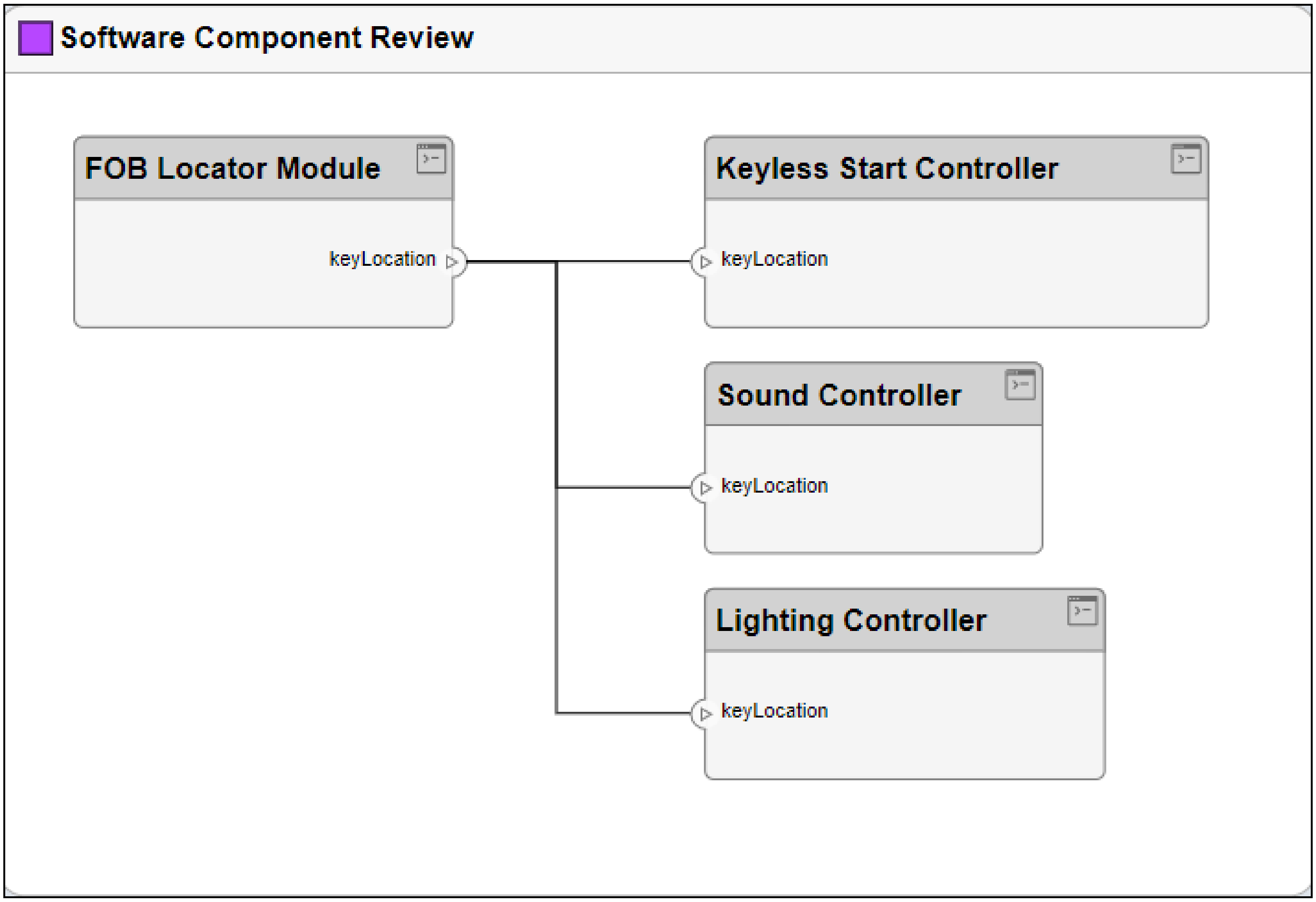
Select Components Where Stereotype isa AutoProfile.SoftwareCompon...

And Select Components Where Name ~contains "Door Lock"

PORT FILTER

Hide unconnected ports

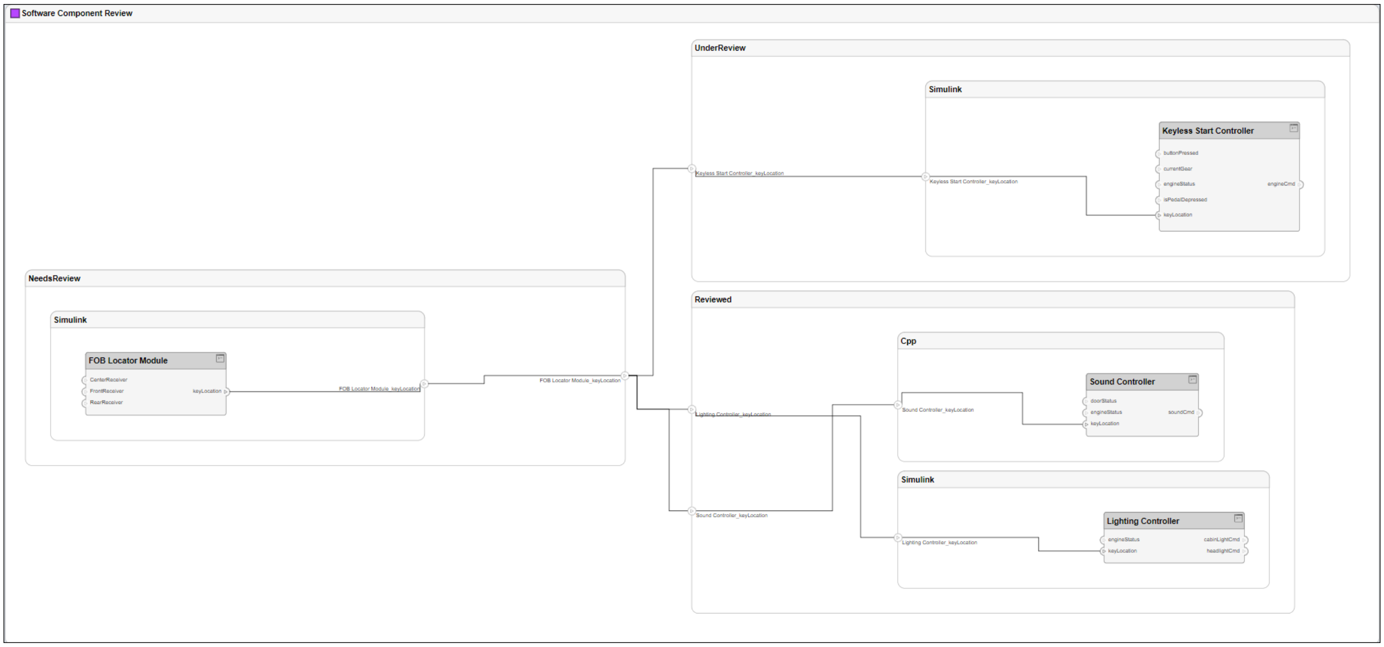
11 An architecture view is created using the additional query in the **Port Filter** box. The view is filtered to hide unconnected ports.



12 Delete the port filter. Pause on the constraint and select the 🗑 button.

Add Group By Criteria to Filtered Views

1. In the View Configurations pane, select **Grouping**.
2. To choose a property enumeration for grouping, click **Add Group By**.
3. From the list, select `AutoProfile.BaseComponent.ReviewStatus`.
4. Click **Add Group By** again.
5. From the list, select `AutoProfile.SoftwareComponent.ImplementationLanguage`.
6. Click **Apply**.



Edit Views Interactively

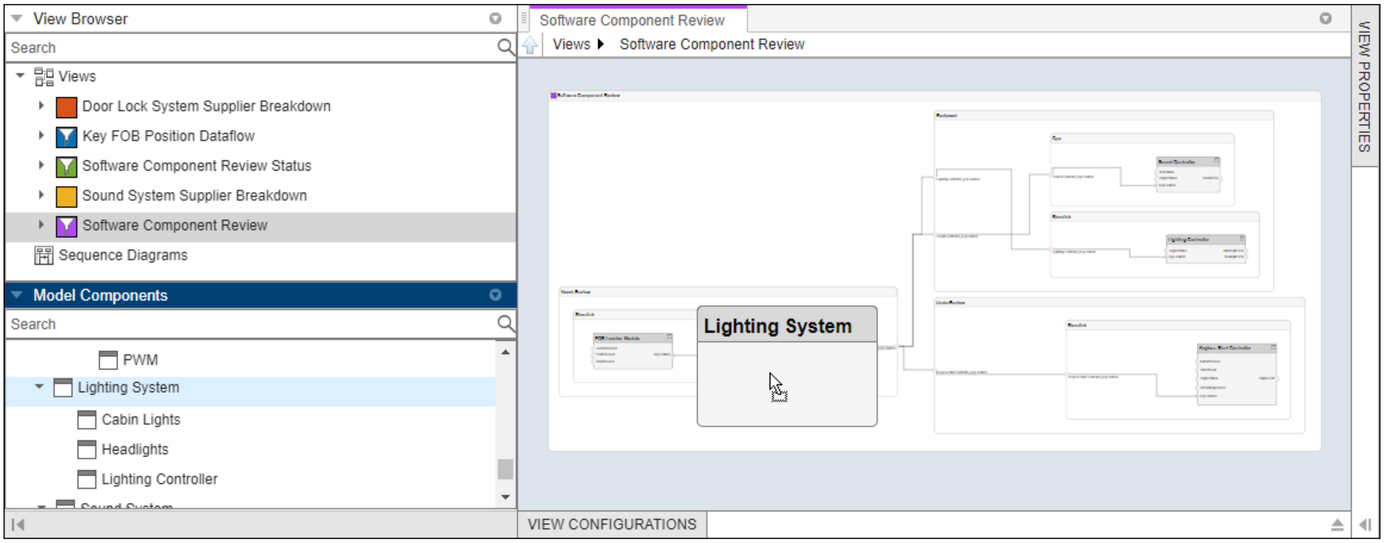
With the **Architecture Views Gallery** tool, you can edit and rearrange your view layout interactively.

- Click and drag components anywhere inside or outside the views canvas. Resize components inside and outside the views canvas. The views canvas expands to accommodate the moves.
- Move and resize a parent component with its children. Rearrange child components inside a parent component. After moving a child component, the parent component expands to accommodate the change.
- When a moved or resized component partially overlaps another component, the system is highlighted to indicate an incorrect final state.
- Click and drag around a region to select multiple components and manipulate them together.
- Double-click a component on the **Model Components** browser to add the component to the diagram. Right-click a component on the **Model Components** browser for additional options.
- Undo or redo interactive edits on the views canvas.

Follow these steps to add or delete elements from a view using the **Model Components** browser.

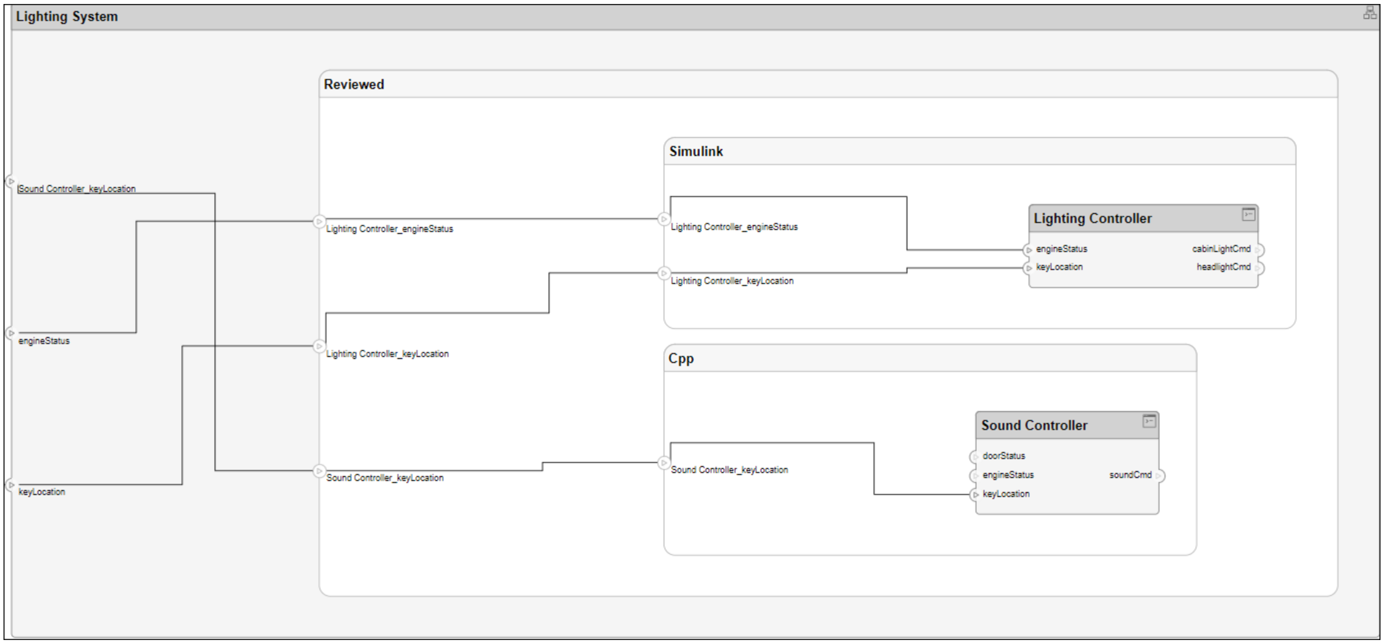
1 To add more components to the view, drag and drop components from **Model Components**. Drag and drop the `Lighting System` component to the `Software Component Review` view. Alternatively, click **Add** on the toolstrip. You can also press **Ctrl+I** to add component instantiations to your view when you select them.

   Note Interactively adding and removing elements from your view with an associated query is not supported. You will receive a warning message: `Remove associated query?` Click **OK** to proceed.


View Browser
Search
Views
Door Lock System Supplier Breakdown
Key FOB Position Dataflow
Software Component Review Status
Sound System Supplier Breakdown
Software Component Review
Sequence Diagrams
Model Components
Search
PWM
Lighting System
Cabin Lights
Headlights
Lighting Controller
Software Component Review
Views
Software Component Review
Lighting System
VIEW PROPERTIES
VIEW CONFIGURATIONS

You can press **Delete** to delete components from the view.

2 Observe that the `Lighting System` component has been added to the view.

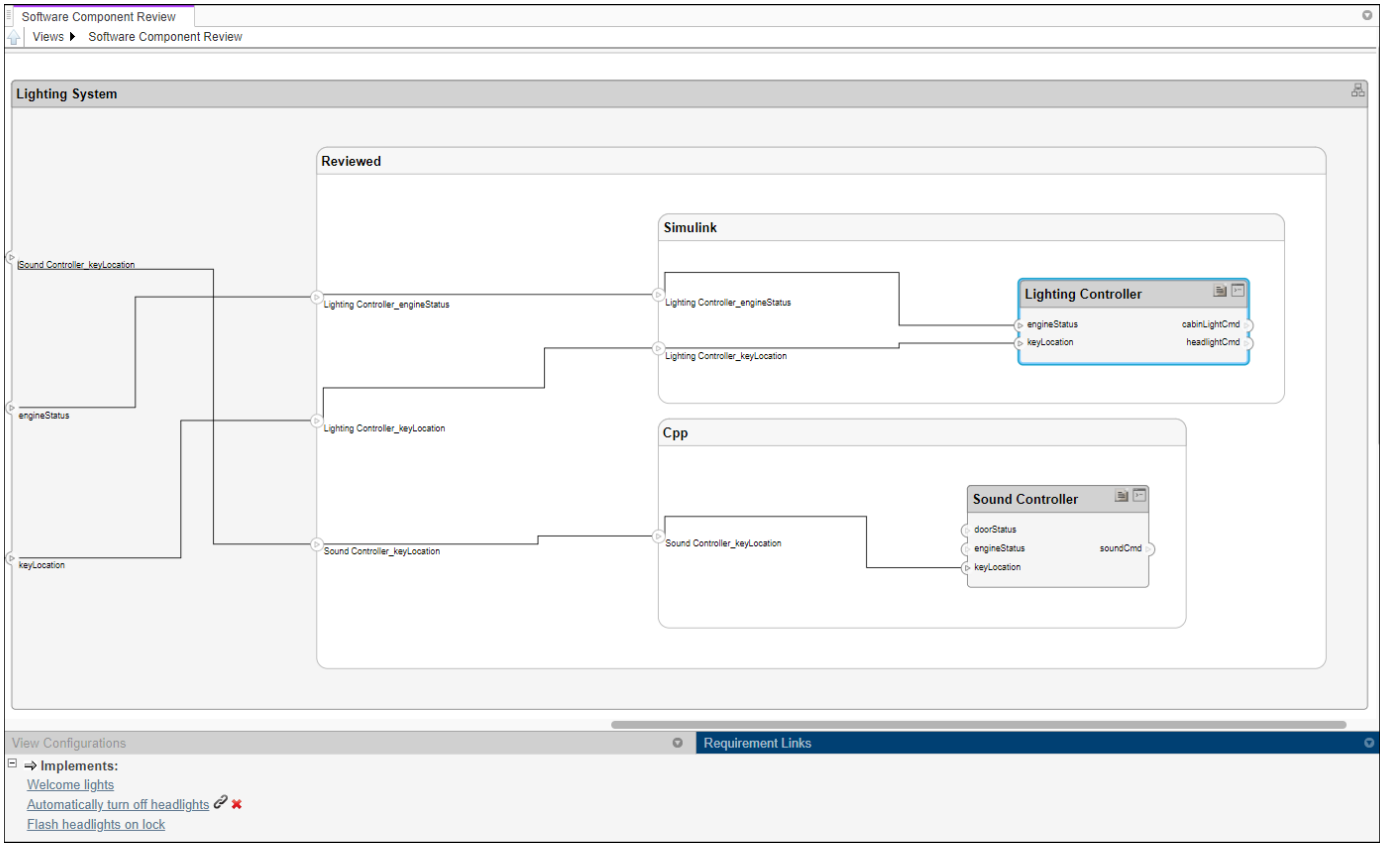


This view is now considered a freeform view.

Add or Remove Requirements Links from Views

1 Navigate to **Requirement** > **Requirements Manager**. A Requirements Toolbox license is required. The **Requirement Links** tab appears at the bottom of the `Software Component Review` view.

2 Select the `Lighting Controller` component and observe the linked requirement `Automatically turn off headlights`.


Software Component Review
Views
Software Component Review
Lighting System
Reviewed
Simulink
Cpp
Lighting Controller
engineStatus
keyLocation
cabinLightCmd
headlightCmd
Sound Controller
doorStatus
engineStatus
keyLocation
soundCmd
Sound Controller_keyLocation
engineStatus
keyLocation
Lighting Controller_engineStatus
Lighting Controller_keyLocation
Sound Controller_keyLocation
Lighting Controller_engineStatus
Lighting Controller_keyLocation
Sound Controller_keyLocation
View Configurations
Requirement Links

⇒ Implements:

Welcome lights

Automatically turn off headlights

Flash headlights on lock

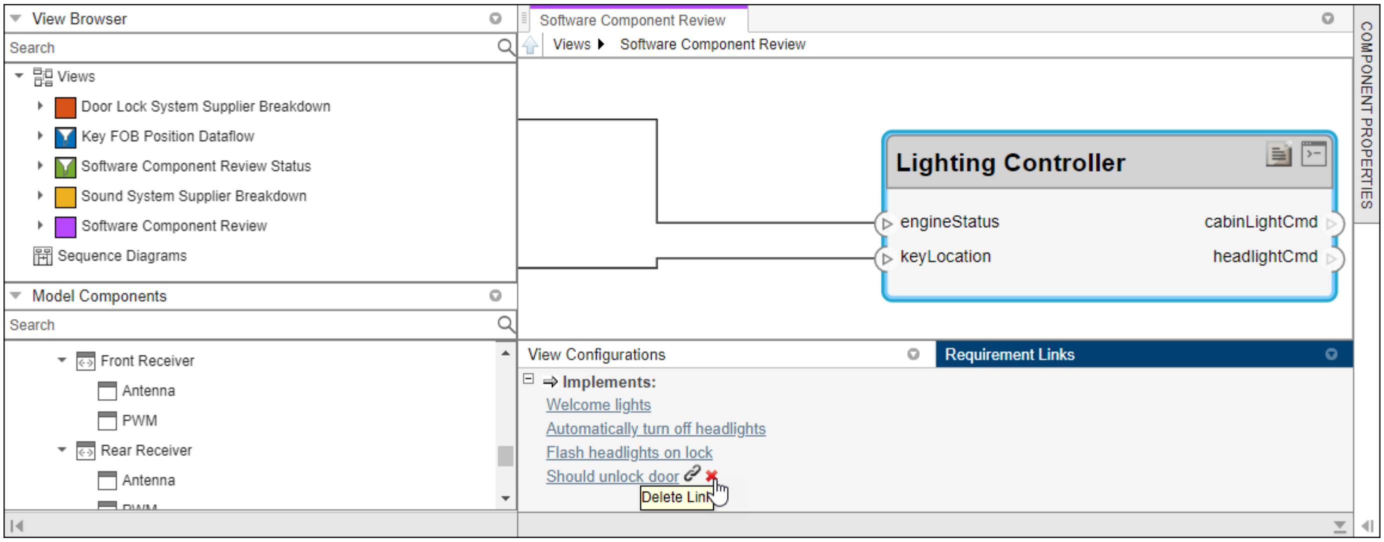
3 Select the requirement `Automatically turn off headlights` to open the Requirements Editor to view or modify requirement links.

4 In the **Architecture Views Gallery**, navigate to **Requirement** > **Open Requirements Editor** if the Requirements Editor is not open already.

5 Select the `Should unlock door` requirement.

6 Return to the **Architecture Views Gallery**. In the `Software Component Review` view, select the `Lighting Controller` component.

7 Navigate to **Requirement** > **Link to selected requirement**. The new requirement `Should unlock door` is added.



8 To remove a requirement link, select ✖ and confirm deletion.

Add Custom Clauses to Component Filters and Port Filters

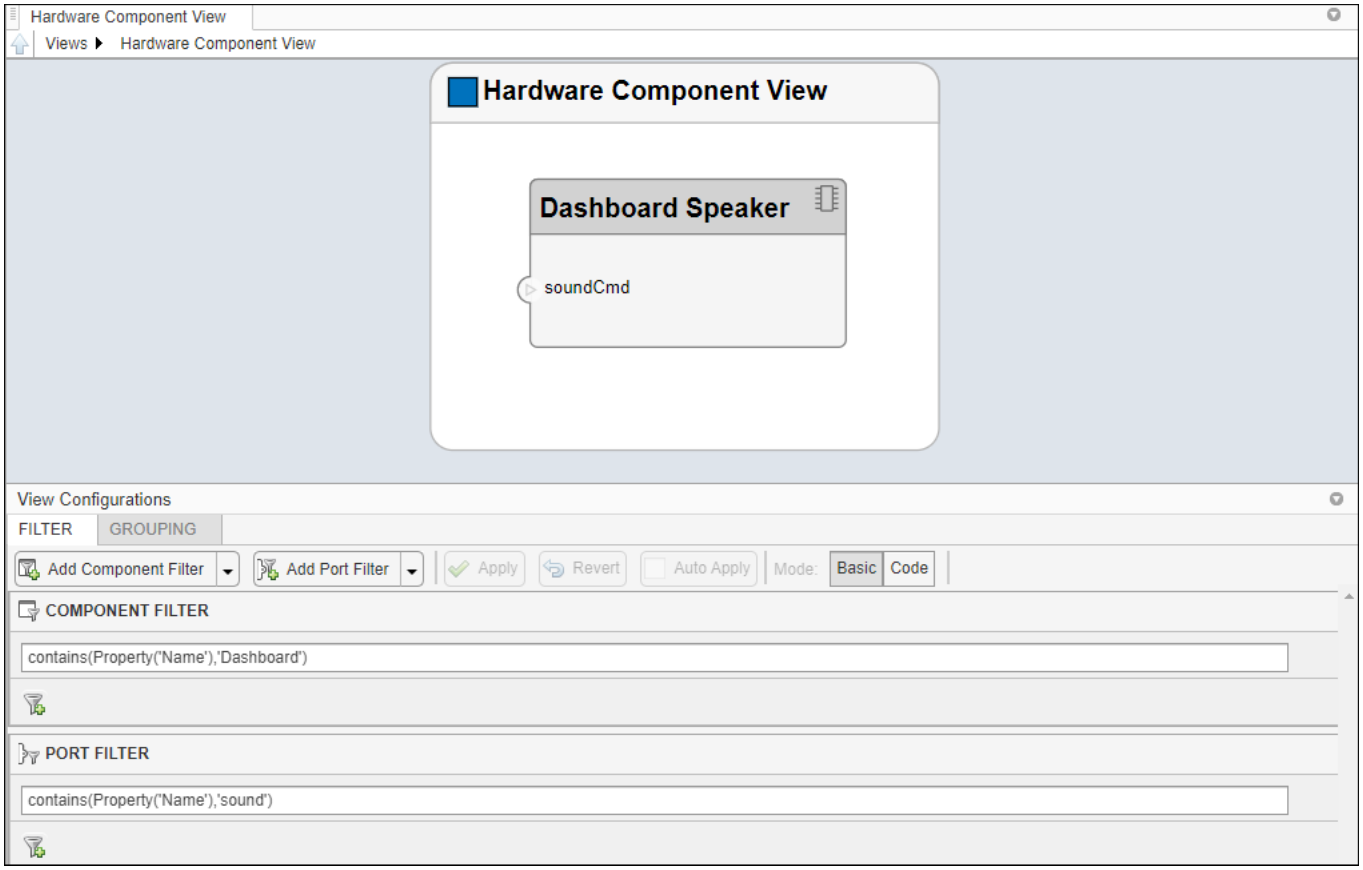
1 Select **New** > **View** to create a new view.

2 In **View Properties** on the right pane, in the **Name** box, enter a name for this view, for example, `Hardware Component View`. Choose a **Color** and enter a **Description**, if necessary.

3 In the bottom pane on **View Configurations**, from the **Filter** tab, select from the list **Add Component Filter** > **Add Custom Component Filter** to enter a constraint by which to filter. In the box, enter `contains(Property('Name'),'Dashboard')`.

4 In the bottom pane on **View Configurations**, from the **Filter** tab, select from the list **Add Port Filter** > **Add Custom Port Filter** to enter a constraint by which to filter. In the box, enter `contains(Property('Name'),'sound')`.

5 Select **Apply** ✓.



```
contains(Property('Name'),'Dashboard')
```

```
contains(Property('Name'),'sound')
```

The view is filtered using the constraints in the custom filters. For more information on structuring constraints, see `systemcomposer.query.Constraint`.

See Also

More About

- “Create Architectural Views Programmatically” on page 11-15
- “Display Component Hierarchy and Architecture Hierarchy Using Views” on page 11-21
- “Create Spotlight Views” on page 11-2
- “Modeling System Architecture of Keyless Entry System” on page 11-25

Create Architectural Views Programmatically

You can create an architecture view programmatically. This topic presents two examples of creating architecture views programmatically using a keyless entry system architecture using element groups.

An element group is a grouping of components in a view.

Use element groups to programmatically populate a view.

For more information on the keyless entry architecture, see “Modeling System Architecture of Keyless Entry System” on page 11-25.

The third example is about how to use queries to find elements in a System Composer model.

A query is a specification that describes certain constraints or criteria to be satisfied by model elements.

Use queries to search elements with constraint criteria and to filter views.

Create Architecture Views in System Composer with Keyless Entry System

Use a keyless entry system to programmatically create architecture views.

1. Import the package with queries.

```
import systemcomposer.query.*
```

2. Open the Simulink® project file for the Keyless Entry System.

```
scKeylessEntrySystem
```

3. Load the example model into System Composer™.

```
model = systemcomposer.loadModel("KeylessEntryArchitecture");
```

Example 1: Hardware Component Review Status View

Create a filtered view that selects all hardware components in the architecture model and groups them using the `ReviewStatus` property.

1. Construct a query to select all hardware components.

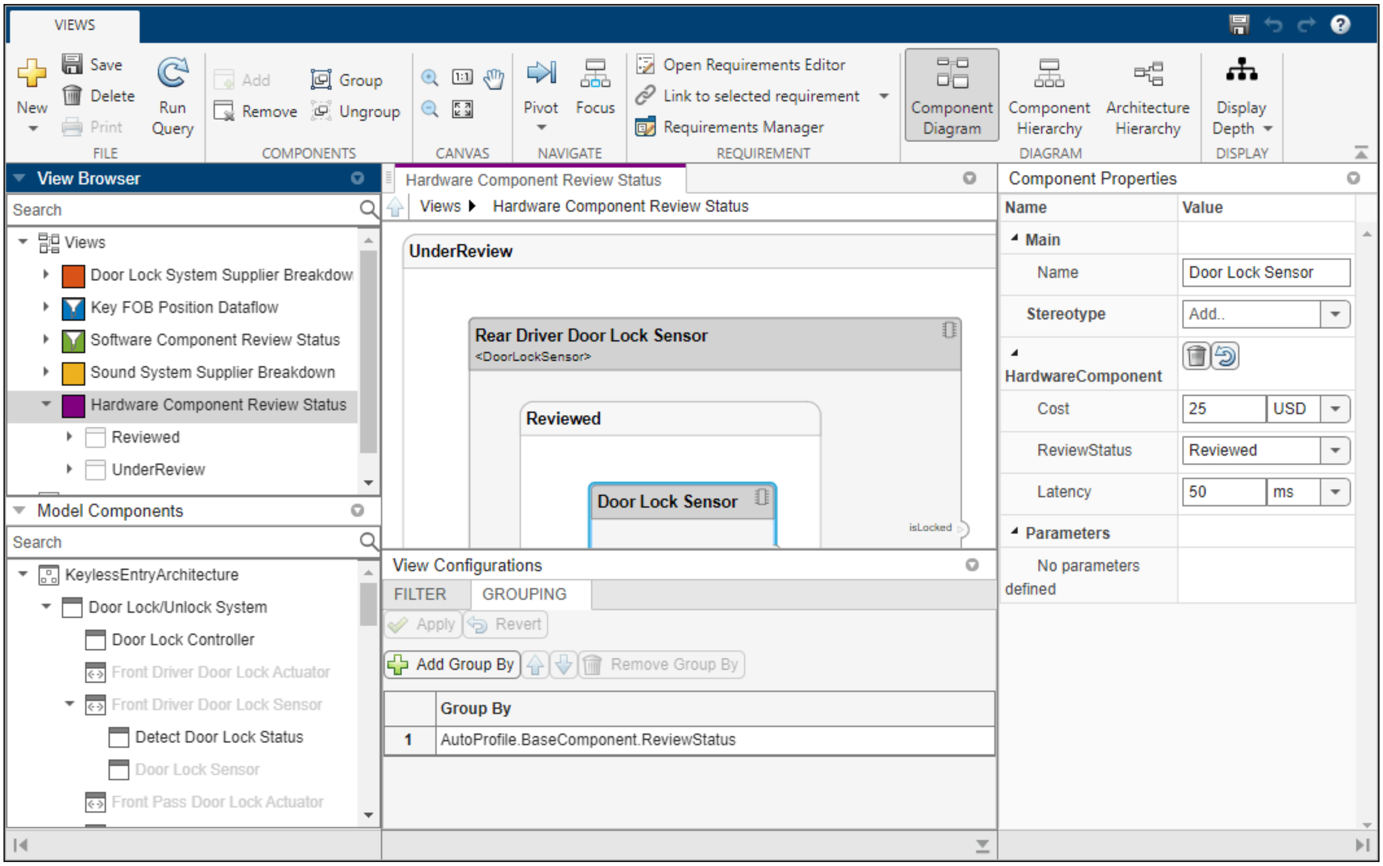
```
hwCompQuery = HasStereotype(IsStereotypeDerivedFrom("AutoProfile.HardwareComponent"));
```

2. Use the query to create a view.

```
model.createView("Hardware Component Review Status",...
 Select=hwCompQuery,...
 GroupBy={'AutoProfile.BaseComponent.ReviewStatus'},...
 IncludeReferenceModels=true,...
 Color="purple");
```

3. To open the Architecture Views Gallery the **Views** section, click **Architecture Views**.

```
model.openViews
```



Name	Value
Main	
Name	Door Lock Sensor
Stereotype	Add..
HardwareComponent	
Cost	25 USD
ReviewStatus	Reviewed
Latency	50 ms
Parameters	
No parameters defined	

	Group By
1	AutoProfile.BaseComponent.ReviewStatus

Example 2: FOB Locator System Supplier View

Create a freeform view that manually pulls the components from the FOB Locator System and groups them using existing and new view components for the suppliers. In this example, you will use *element groups*, groupings of components in a view, to programmatically populate a view.

1. Create a view architecture.

```
fobSupplierView = model.createView("FOB Locator System Supplier Breakdown",...
    Color="lightblue");
```

2. Add a subgroup called `Supplier D`. Add the `FOB Locator Module` to the view element subgroup.

```
supplierD = fobSupplierView.Root.createSubGroup("Supplier D");
supplierD.addElement("KeylessEntryArchitecture/FOB Locator System/FOB Locator Module");
```

3. Create a new subgroup for `Supplier A`.

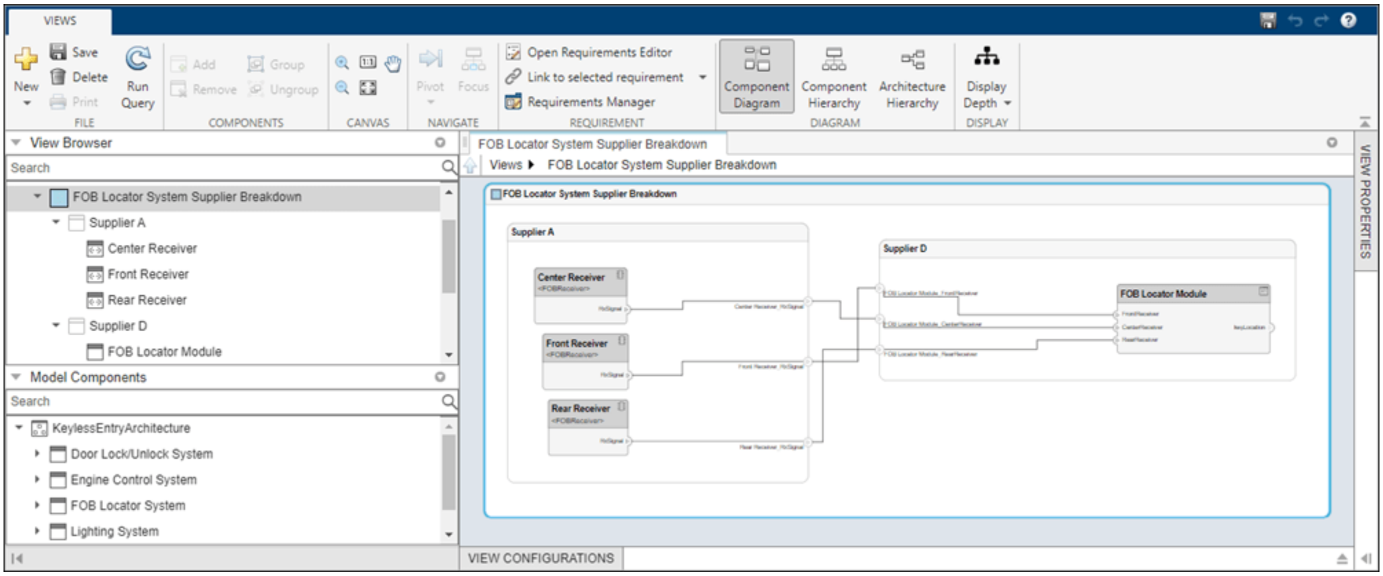
```
supplierA = fobSupplierView.Root.createSubGroup("Supplier A");
```

4. Add each of the FOB Receivers to view element subgroup.

```
FOBLocatorSystem = model.lookup("Path","KeylessEntryArchitecture/FOB Locator System");
```

Find all the components which contain the name `"Receiver"`.

```
receiverCompPaths = model.find(...
    contains(Property("Name"),"Receiver"),...
    FOBLocatorSystem.Architecture);

supplierA.addElement(receiverCompPaths)
```



5. Save the model.

```
model.save
```

Find Elements in Model Using Queries

Find components in a System Composer model using queries.

Import the package that contains all of the System Composer queries.

```
import systemcomposer.query.*
```

Open the model.

```
scKeylessEntrySystem
model = systemcomposer.loadModel("KeylessEntryArchitecture");
```

Find all the software components in the system.

```
con1 = HasStereotype(Property("Name") == "SoftwareComponent");
[compPaths,compObjs] = model.find(con1)
```

```
compPaths = 5x1 cell
    {'KeylessEntryArchitecture/Door Lock//Unlock System/Door Lock Controller' }
    {'KeylessEntryArchitecture/Engine Control System/Keyless Start Controller'}
    {'KeylessEntryArchitecture/FOB Locator System/FOB Locator Module'         }
    {'KeylessEntryArchitecture/Lighting System/Lighting Controller'           }
    {'KeylessEntryArchitecture/Sound System/Sound Controller'                 }
```

```
compObjs=1×5 object
  1x5 Component array with properties:

    IsAdapterComponent
    Architecture
    ReferenceName
    Name
    Parent
    Ports
    OwnedPorts
    OwnedArchitecture
    Parameters
    Position
    Model
    SimulinkHandle
    SimulinkModelHandle
    UUID
    ExternalUID
```

Include reference models in the search.

```
softwareComps = model.find(con1,IncludeReferenceModels=true)
```

```
softwareComps = 9x1 cell
    {'KeylessEntryArchitecture/Door Lock//Unlock System/Door Lock Controller'
    {'KeylessEntryArchitecture/Door Lock//Unlock System/Front Driver Door Lock Sensor/Detect Door
    {'KeylessEntryArchitecture/Door Lock//Unlock System/Front Pass Door Lock Sensor/Detect Door L
    {'KeylessEntryArchitecture/Door Lock//Unlock System/Rear Driver Door Lock Sensor/Detect Door
    {'KeylessEntryArchitecture/Door Lock//Unlock System/Rear Pass Door Lock Sensor/Detect Door Lo
    {'KeylessEntryArchitecture/Engine Control System/Keyless Start Controller'
    {'KeylessEntryArchitecture/FOB Locator System/FOB Locator Module'
    {'KeylessEntryArchitecture/Lighting System/Lighting Controller'
    {'KeylessEntryArchitecture/Sound System/Sound Controller'
```

Find all the base components in the system.

```
con2 = HasStereotype(IsStereotypeDerivedFrom("AutoProfile.BaseComponent"));
baseComps = model.find(con2)
```

```
baseComps = 18x1 cell
    {'KeylessEntryArchitecture/Engine Control System/Start//Stop Button'                }
    {'KeylessEntryArchitecture/Engine Control System/Keyless Start Controller'          }
    {'KeylessEntryArchitecture/FOB Locator System/FOB Locator Module'                   }
    {'KeylessEntryArchitecture/Sound System/Dashboard Speaker'                          }
    {'KeylessEntryArchitecture/Lighting System/Lighting Controller'                     }
    {'KeylessEntryArchitecture/Sound System/Sound Controller'                           }
    {'KeylessEntryArchitecture/Door Lock//Unlock System/Door Lock Controller'           }
    {'KeylessEntryArchitecture/Door Lock//Unlock System/Front Driver Door Lock Sensor'  }
    {'KeylessEntryArchitecture/Door Lock//Unlock System/Front Pass Door Lock Sensor'    }
    {'KeylessEntryArchitecture/Door Lock//Unlock System/Rear Driver Door Lock Sensor'   }
    {'KeylessEntryArchitecture/Door Lock//Unlock System/Rear Pass Door Lock Sensor'     }
    {'KeylessEntryArchitecture/Door Lock//Unlock System/Front Driver Door Lock Actuator'}
    {'KeylessEntryArchitecture/Door Lock//Unlock System/Front Pass Door Lock Actuator'  }
    {'KeylessEntryArchitecture/Door Lock//Unlock System/Rear Driver Door Lock Actuator' }
    {'KeylessEntryArchitecture/Door Lock//Unlock System/Rear Pass Door Lock Actuator'   }
    {'KeylessEntryArchitecture/FOB Locator System/Center Receiver'                      }
    {'KeylessEntryArchitecture/FOB Locator System/Front Receiver'                       }
    {'KeylessEntryArchitecture/FOB Locator System/Rear Receiver'                        }
```

Find all components using the interface `KeyFOBPosition`.

```
con3 = HasPort(HasInterface(Property("Name") == "KeyFOBPosition"));
con3_a = HasPort(Property("InterfaceName") == "KeyFOBPosition");
keyFOBPosComps = model.find(con3)
```

```
keyFOBPosComps = 10x1 cell
    {'KeylessEntryArchitecture/Door Lock//Unlock System'                      }
    {'KeylessEntryArchitecture/Door Lock//Unlock System/Door Lock Controller' }
    {'KeylessEntryArchitecture/Engine Control System'                         }
    {'KeylessEntryArchitecture/Engine Control System/Keyless Start Controller'}
    {'KeylessEntryArchitecture/FOB Locator System'                            }
    {'KeylessEntryArchitecture/FOB Locator System/FOB Locator Module'         }
    {'KeylessEntryArchitecture/Lighting System'                               }
    {'KeylessEntryArchitecture/Lighting System/Lighting Controller'           }
    {'KeylessEntryArchitecture/Sound System'                                  }
    {'KeylessEntryArchitecture/Sound System/Sound Controller'                 }
```

Find all components whose `WCET` is less than or equal to `5 ms`.

```
con4 = PropertyValue("AutoProfile.SoftwareComponent.WCET") <= 5;
model.find(con4)
```

```
ans = 1x1 cell array
    {'KeylessEntryArchitecture/Sound System/Sound Controller'}
```

You can specify units for automatic unit conversion.

```
con5 = PropertyValue("AutoProfile.SoftwareComponent.WCET") <= Value(5,'ms');
query1Comps = model.find(con5)
```

```
query1Comps = 3x1 cell
    {'KeylessEntryArchitecture/Lighting System/Lighting Controller'  }
    {'KeylessEntryArchitecture/FOB Locator System/FOB Locator Module'}
    {'KeylessEntryArchitecture/Sound System/Sound Controller'        }
```

Find all components whose `WCET` is greater than `1 ms` or that have a cost greater than `10 USD`.

```
con6 = PropertyValue("AutoProfile.SoftwareComponent.WCET") > Value(1,'ms') | PropertyValue("Auto
query2Comps = model.find(con6)
```

```
query2Comps = 2x1 cell
    {'KeylessEntryArchitecture/Engine Control System/Keyless Start Controller'}
    {'KeylessEntryArchitecture/Door Lock//Unlock System/Door Lock Controller' }
```

Close the model.

```
model.close
```

See Also

`find` | `lookup` | `systemcomposer.query.Constraint` | `createView` | `getView` | `openViews` | `deleteView` | `systemcomposer.view.View` | `systemcomposer.view.ElementGroup`

More About

- “Create Architecture Views Interactively” on page 11-5
- “Display Component Hierarchy and Architecture Hierarchy Using Views” on page 11-21
- “Create Spotlight Views” on page 11-2
- “Modeling System Architecture of Keyless Entry System” on page 11-25

Display Component Hierarchy and Architecture Hierarchy Using Views

This example shows how to use hierarchy views in the **Architecture Views Gallery** to use hierarchy views to visualize hierarchical relationships.

You can visualize a hierarchy diagram as a view with components, ports, reference types, component stereotypes, and stereotype properties.

There are two types of hierarchy diagrams:

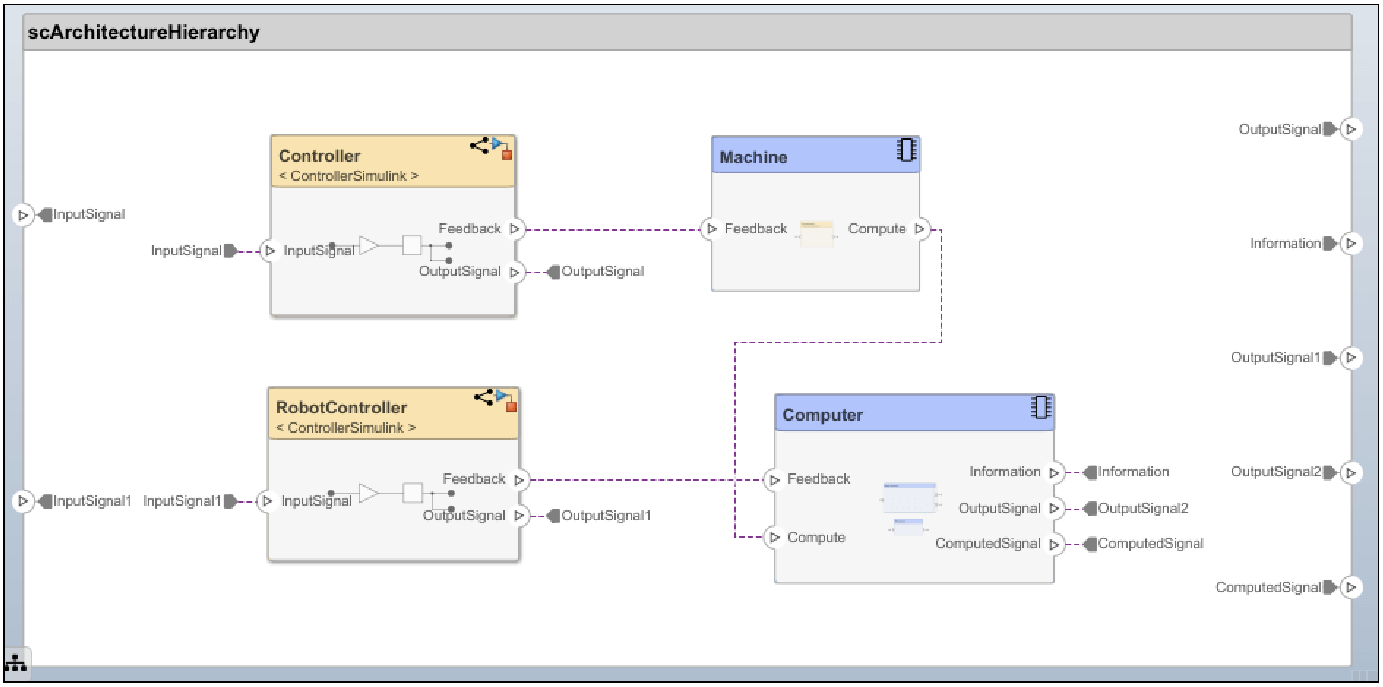
- *Component hierarchy diagrams* display components in tree form with parents above children. In a component hierarchy view, each referenced model is represented as many times as it is used.
- *Architecture hierarchy diagrams* display unique component architecture types and their relationships using composition connections. In an architecture hierarchy view, each referenced model is represented only once.

Any component diagram view can be optionally represented as a hierarchy diagram. The hierarchy view shows the same set of components visible in the component diagram view, and the components are selected and filtered in the same way as in a component diagram view.

This example uses an architecture model representing data flow within a robotic system. Open this model to follow the steps in the tutorial.

Robot Computer Systems Architecture

Use a robot computer system with controllers that simulate transmission of data to explore hierarchy diagrams in the Architecture Views Gallery.

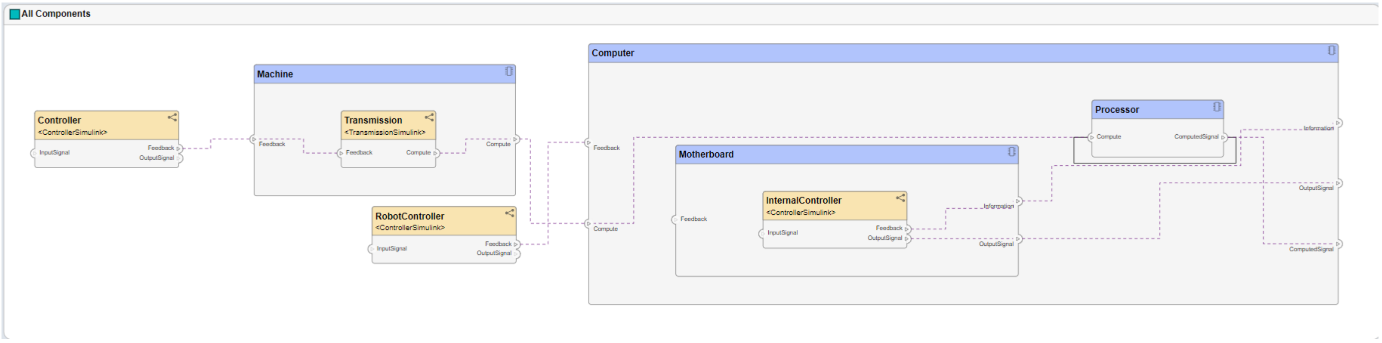


Switch Between Component Diagram View and Hierarchy Views

1 To open the **Architecture Views Gallery**, navigate to **Modeling** > **Architecture Views**.

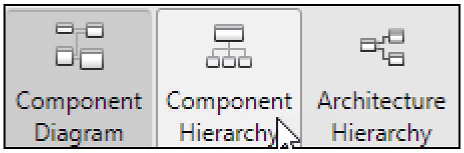
2 From the **View Browser**, select the `All Components` view.

3 Observe the component diagram view that corresponds to the all the components in the architecture model.

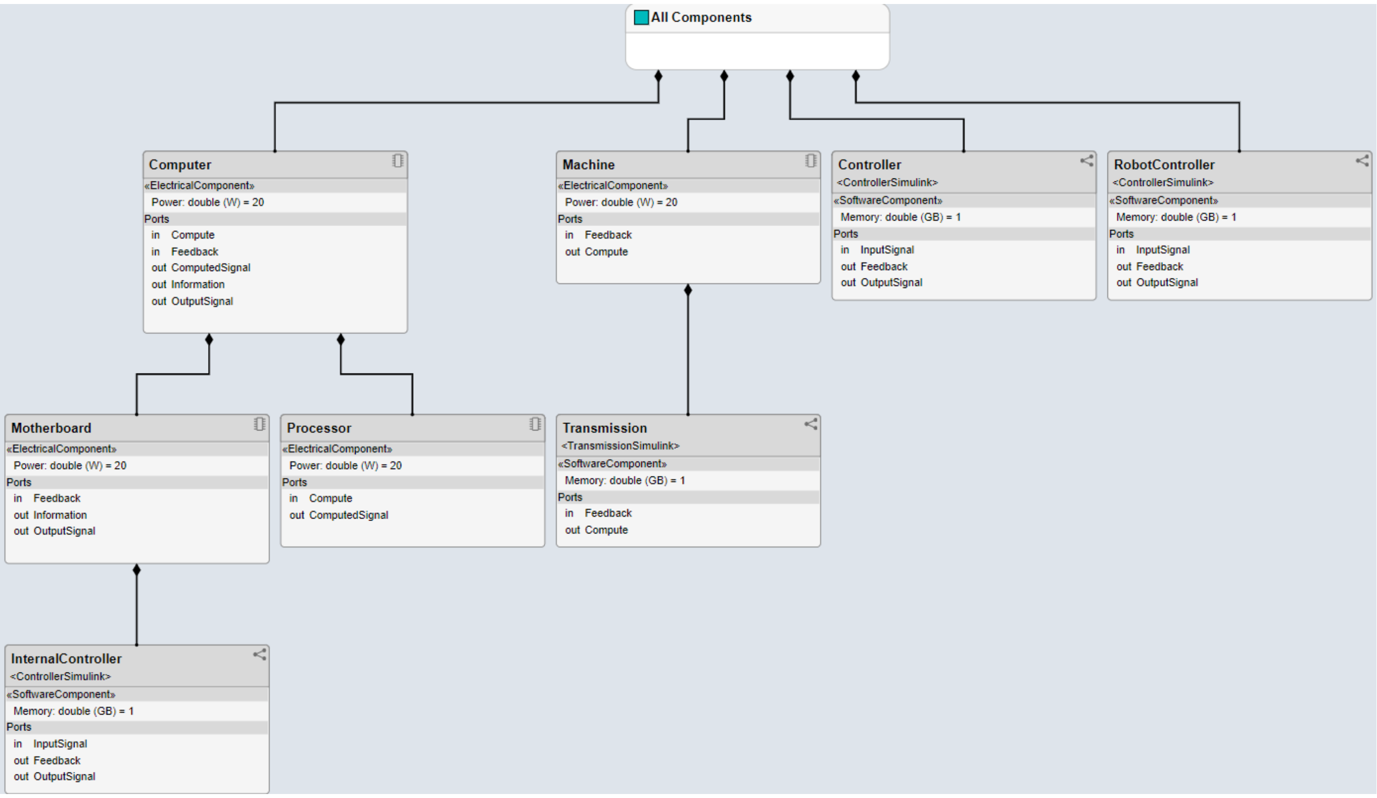


The component diagram represents a view with components, ports, and connectors based on how the model is structured.

4 In the **Diagram** section of the toolstrip, click **Component Hierarchy**.

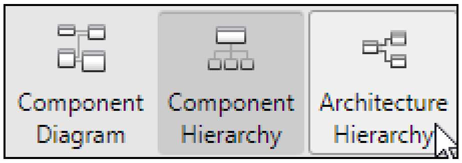


5 Observe the component hierarchy view that corresponds to the same set of components.

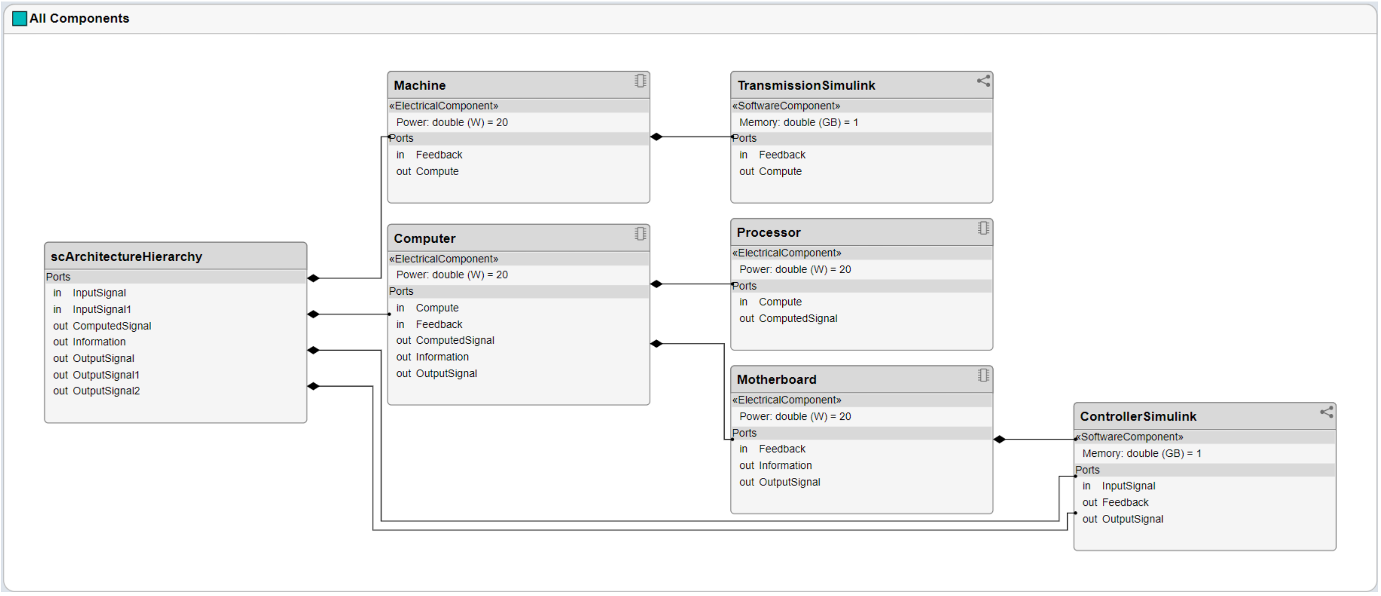


The component hierarchy diagram shows a single root, which is the view specification itself. The root corresponds to the name of the view shown in the component diagram. The connections in the component hierarchy diagram originate from the child components and end with a diamond symbol at each parent component.

6 In the **Diagram** section of the toolstrip, click **Architecture Hierarchy**.



7 Observe the architecture hierarchy view that corresponds to the same set of components.



The architecture hierarchy diagram starts with the root architecture. The root corresponds to the boundary of the system. A box in an architecture hierarchy diagram represents a referenced model and appears only once even if it is referenced multiple times in the same model. For example, `ControllerSimulink`, a referenced model that appears on three components, has three connections to its parent architectures. The connectivity of the boxes represents the relationship between `ContollerSimulink` and its parents.

See Also

More About

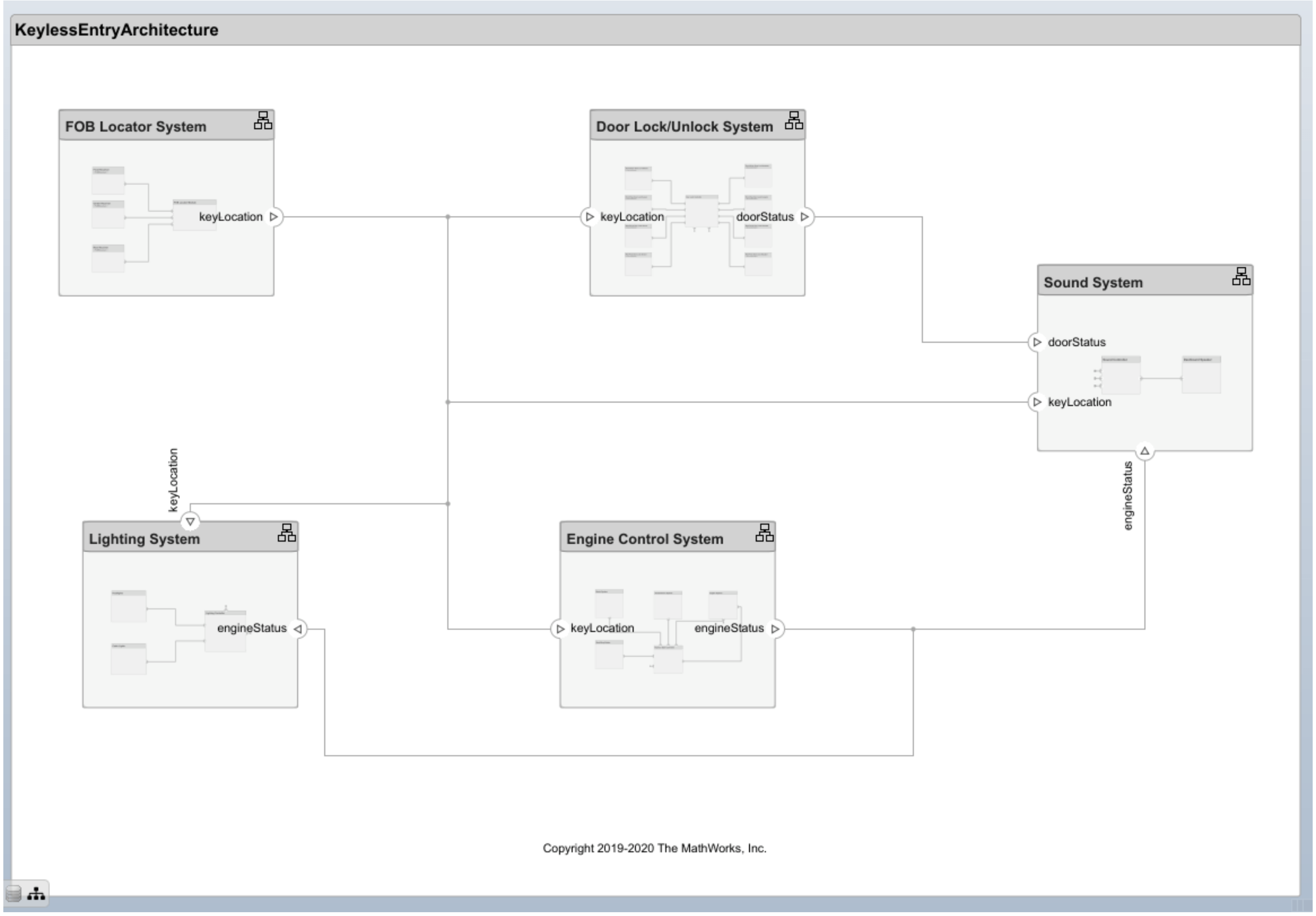
- “Create Architectural Views Programmatically” on page 11-15
- “Create Architecture Views Interactively” on page 11-5
- “Create Spotlight Views” on page 11-2
- “Modeling System Architecture of Keyless Entry System” on page 11-25
- “Class Diagram View of Software Architectures” on page 10-20

Modeling System Architecture of Keyless Entry System

This example shows how to set up the architecture for a keyless entry system for a vehicle in System Composer™. You also learn how to create different architecture views for different stakeholder concerns. This example follows a model-based systems engineering (MBSE) workflow:

1. Define Stakeholder Requirements
2. Define Logical Architecture Model
3. Define Stereotypes to Classify Components
4. Define Port Interfaces to Describe Data Flow
5. Create Views to Present to Stakeholders

```
scKeylessEntrySystem
```

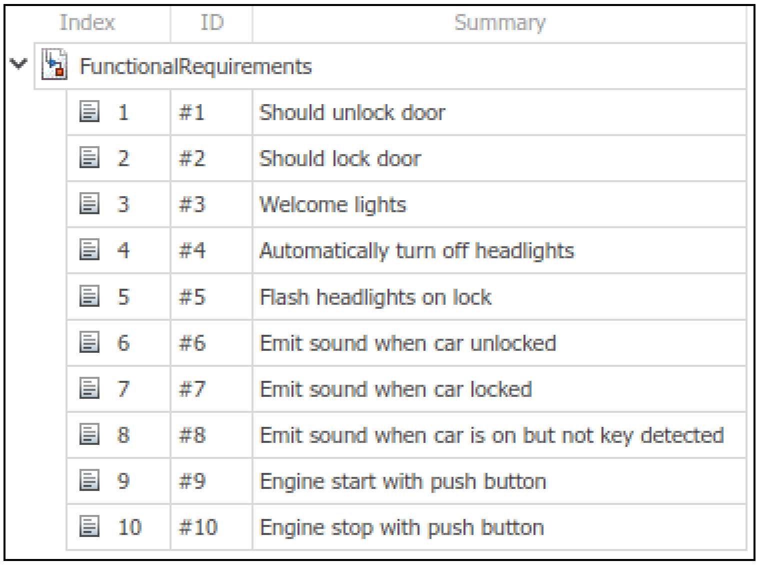


Define Stakeholder Requirements

In MBSE design, functional requirements represent high-level stakeholder requirements based on needs and concerns for the design to address. Run this command to open the Requirements Editor (Requirements Toolbox) with the functional requirements. A Requirements Toolbox™ license is required to inspect requirements in a System Composer architecture model.

```
slreq.load('FunctionalRequirements');
```

```
slreq.editor
```



Index	ID	Summary
FunctionalRequirements		
1	#1	Should unlock door
2	#2	Should lock door
3	#3	Welcome lights
4	#4	Automatically turn off headlights
5	#5	Flash headlights on lock
6	#6	Emit sound when car unlocked
7	#7	Emit sound when car locked
8	#8	Emit sound when car is on but not key detected
9	#9	Engine start with push button
10	#10	Engine stop with push button

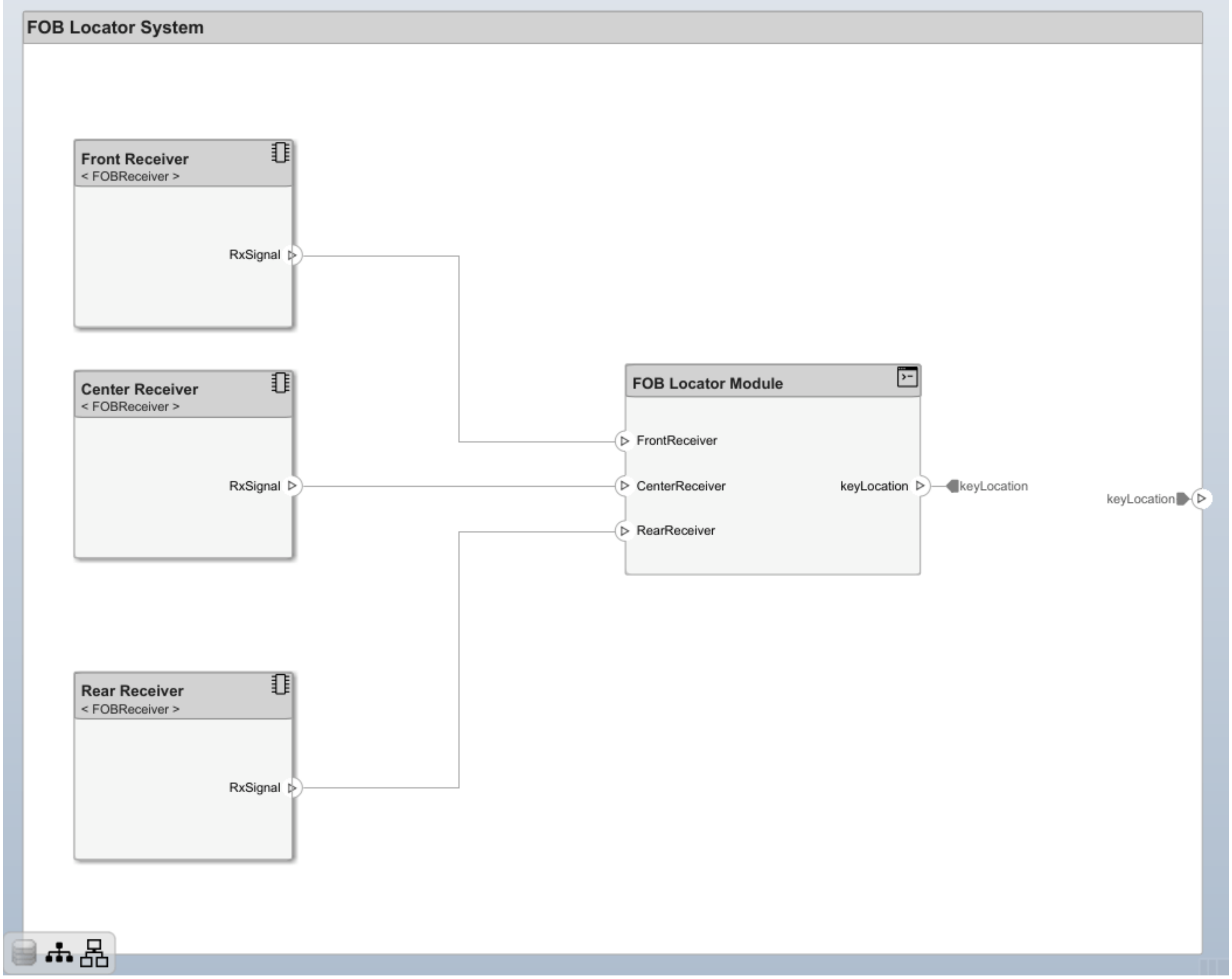
These stakeholder requirements specify that the architecture model must include a door lock and unlock system, a lighting control system, a sound system, and an engine control system. These components should meet requirements after passing quality checks. For more information, see “Manage Requirements” on page 2-8.

Define Logical Architecture Model

The logical architecture of a keyless entry system includes sensors, a mechanical door lock system, a lighting system, a sound system, and an engine control system. These components interact based on the information passed through their ports by connections. Each top-level component can be decomposed into its subcomponents to represent an architectural hierarchy.

Decompose the FOB Locator System

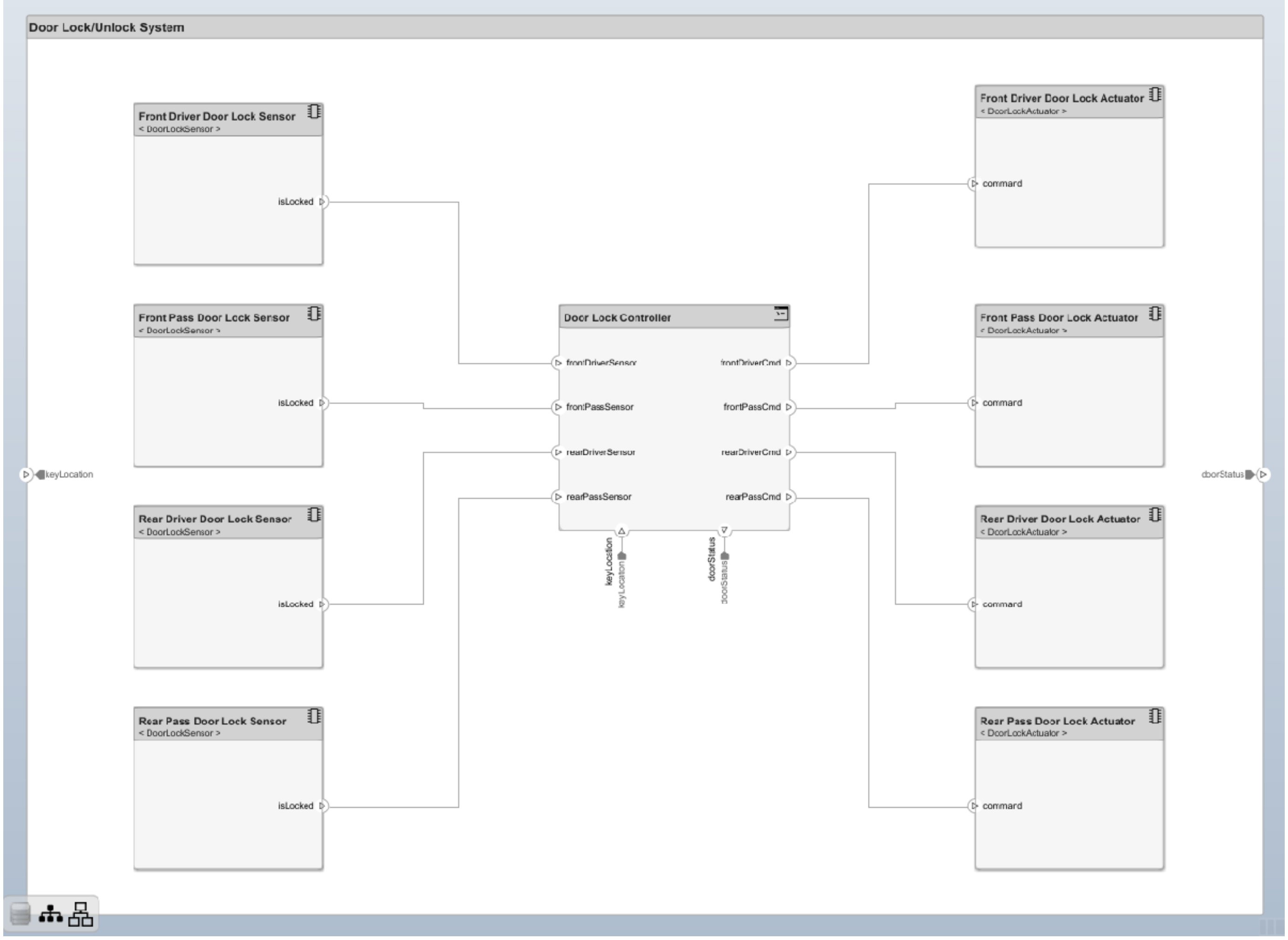
The `FOB Locator System` component includes the system the vehicle uses to receive a wireless signal and isolate the location of the key to lock or unlock doors. This action is the first step in implementing a keyless entry system.



The referenced architecture `FOB Receiver` is reused to type the three receivers on the vehicle on the front, center, and rear. Each receiver sends a signal, `RxSignal`, to the `FOB Locator Module` component that determines the key location, `keyLocation`, and transmits the key location to all the other systems represented by components.

Decompose the Door Lock and Unlock System

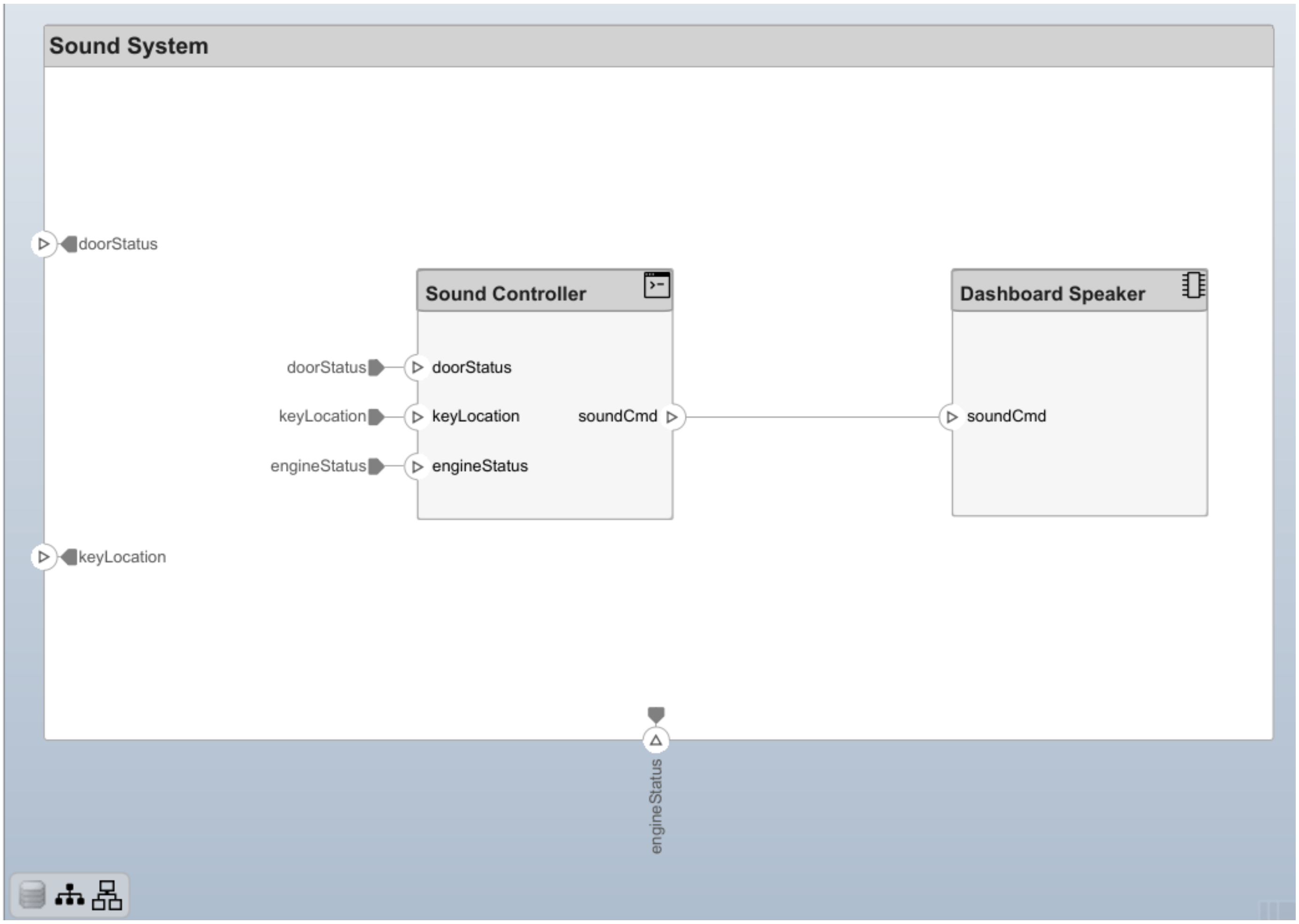
After the key location is identified, the automated door lock and unlock system activates. The door lock and unlock system has both hardware and software components.



All four doors for the vehicle have sensors that detect whether the door is locked. The DoorLockSensor referenced architecture types these components. According to the information passed through the FOB, the Door Lock Controller component activates the actuators for the four doors to optionally implement the door locks. The DoorLockActuator referenced architecture types the actuators. The door lock status doorStatus is transmitted through the boundary from the Door Lock Controller component.

Decompose the Sound System

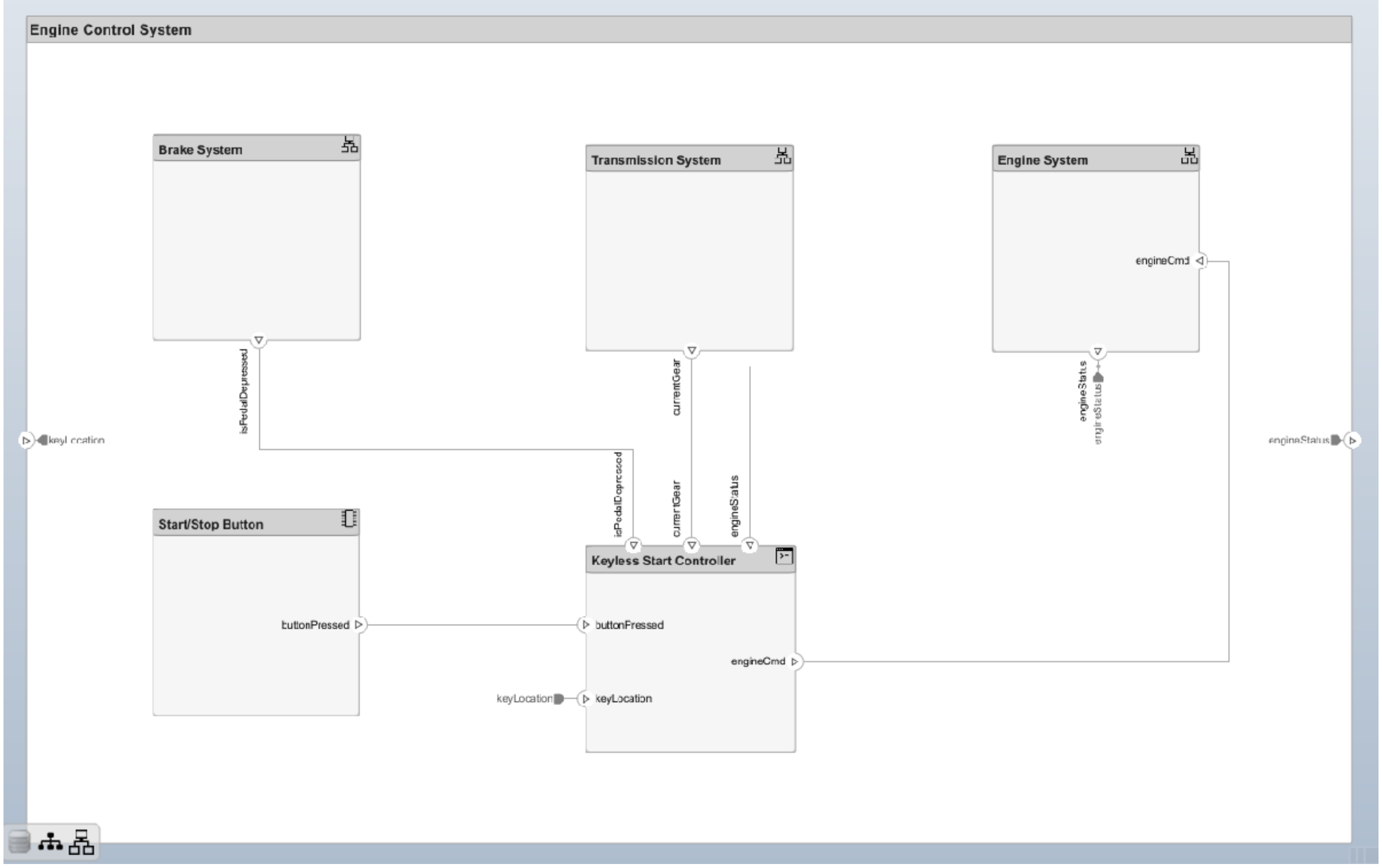
The Sound System component controls emitting sounds to indicate key location, door status, and engine status.



The software for the `Sound Controller` component sends a command to the `Dashboard Speaker` component to process and make the sounds.

Decompose the Engine Control System

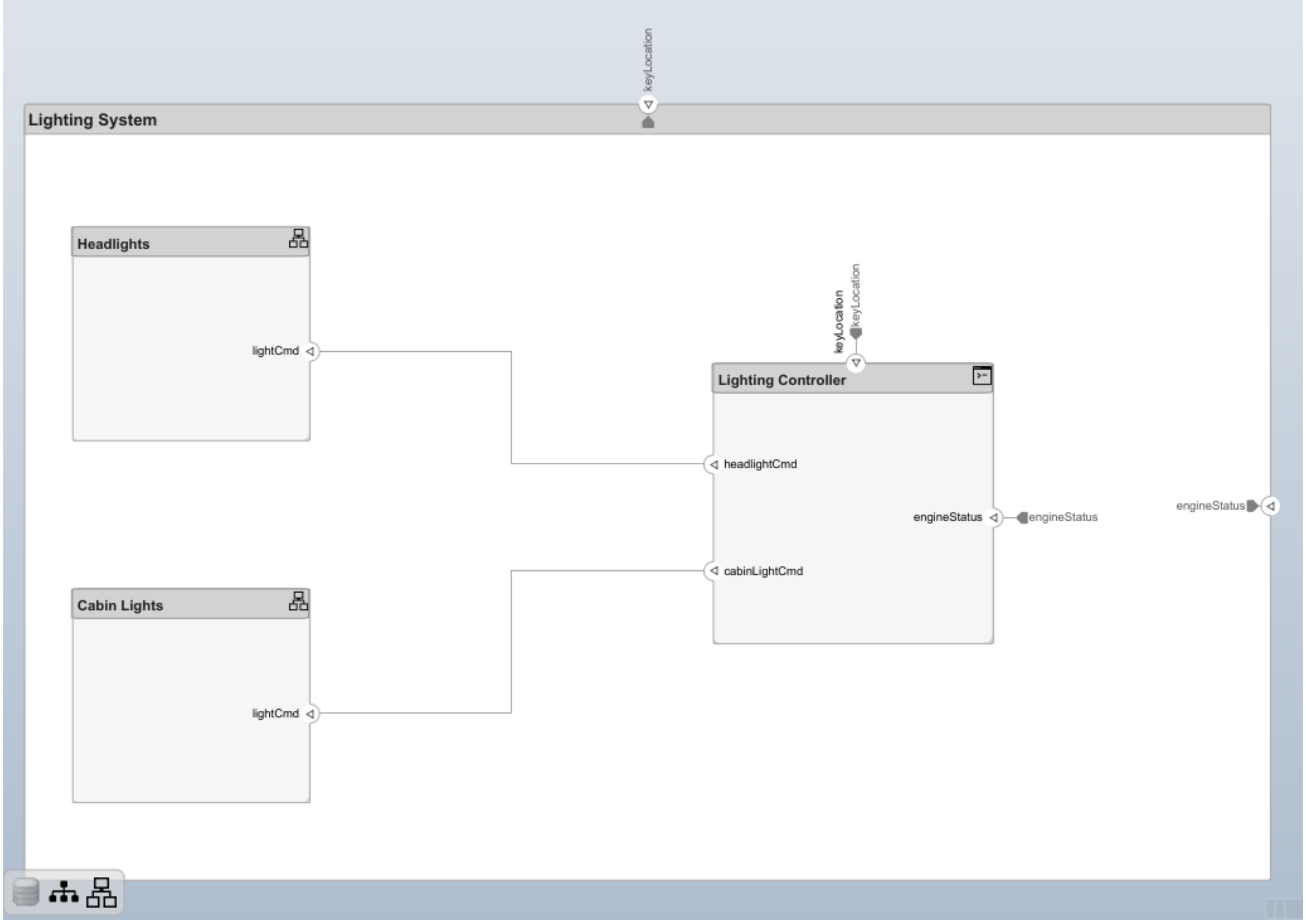
The engine control system contains a system to control the brakes, transmission, and engine. The keyless entry system activates a keyless start controller that starts or stops the vehicle.



The keyLocation signal from the FOB Locator System enters the Keyless Start Controller component, which receives feedback from the Brake System, Transmission System, and Engine System components. Next, a signal is sent to the Engine System to start or stop the vehicle according to the buttonPressed signal from the Start/Stop Button component.

Decompose the Lighting System

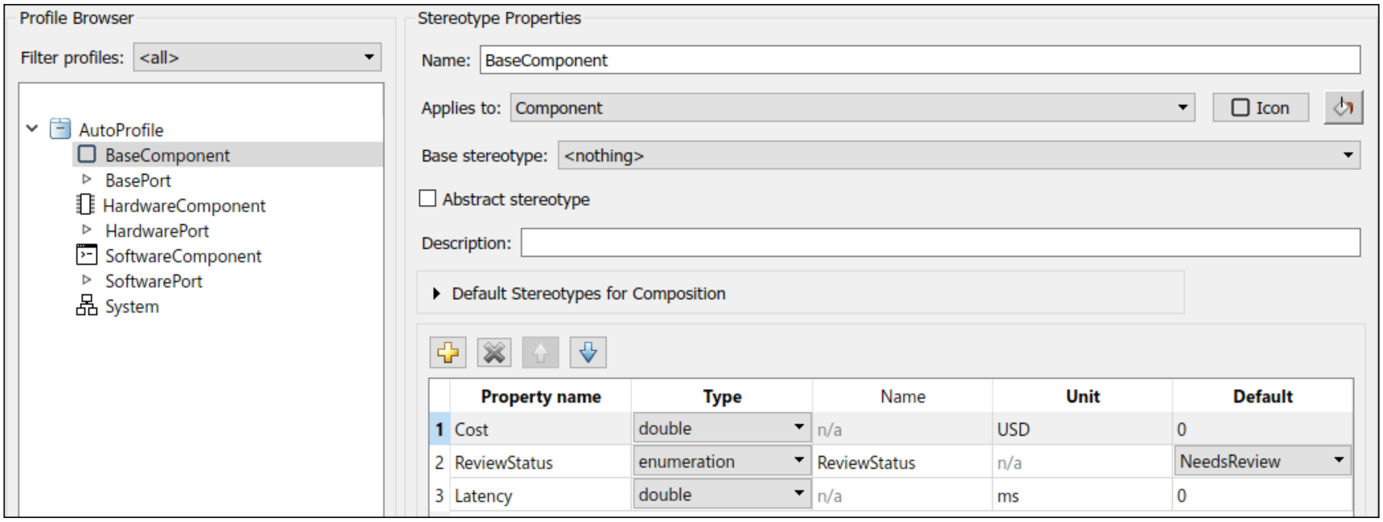
The keyless entry system sends commands from a lighting controller to activate the headlights and cabin lights.



Engine status and key location information sent to the `Lighting Controller` component might activate the different lights represented by the `Headlights` and `Cabin Lights` components.

Define Stereotypes to Classify Components

All components in the architecture have the appropriate stereotype applied. Use the Profile Editor tool to define profiles, stereotypes, and properties to apply to components, ports, connectors, and interfaces. Each of the component stereotypes inherits properties from the parent stereotype `BaseComponent`. For each stereotyped component, you can define the `Cost`, `ReviewStatus`, or `Latency` property values.



Filter profiles: <all>

- AutoProfile
  - BaseComponent
  - BasePort
  - HardwareComponent
  - HardwarePort
  - SoftwareComponent
  - SoftwarePort
  - System

Name: BaseComponent

Applies to: Component

Base stereotype: <nothing>

□ Abstract stereotype

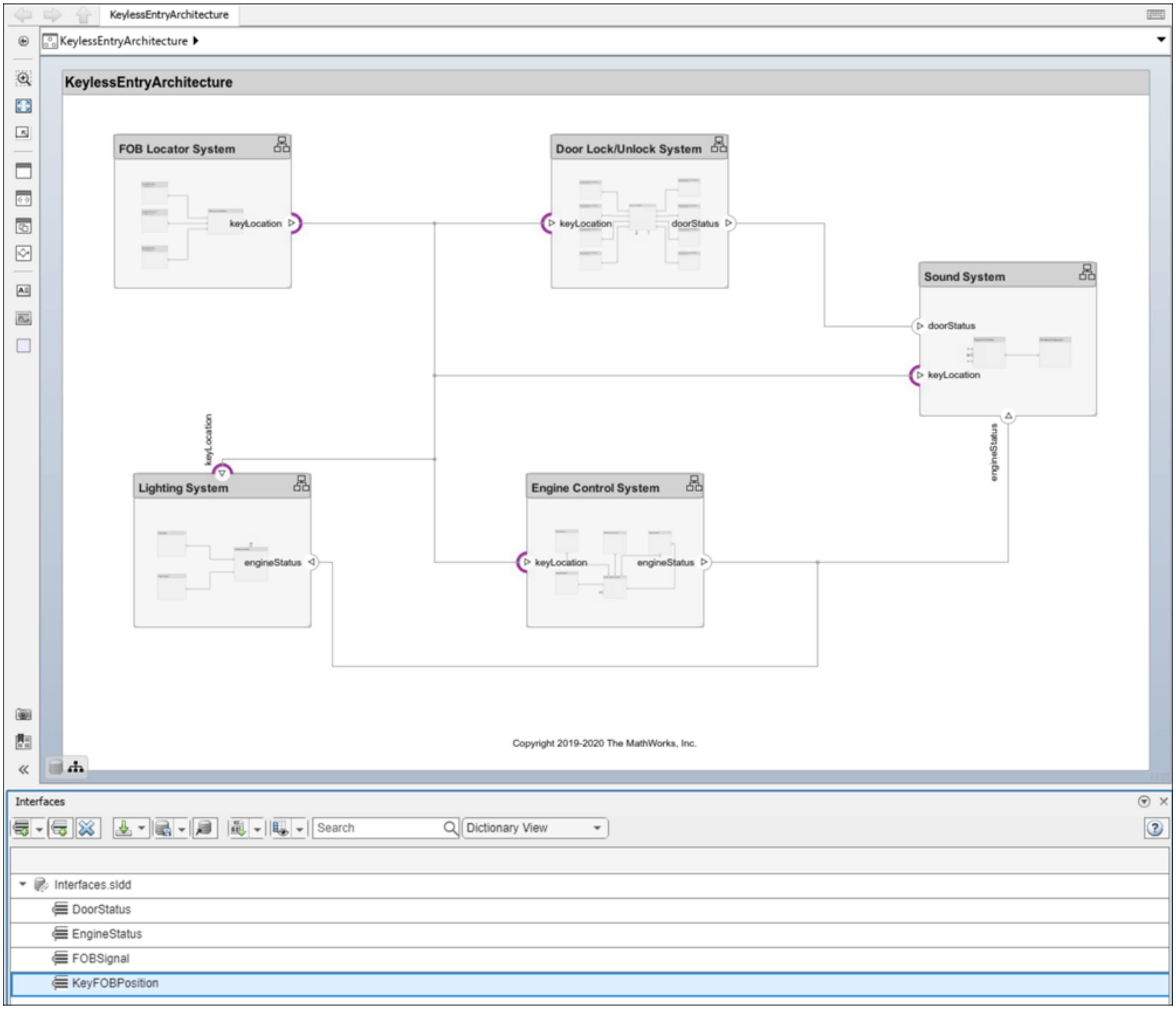
Description:

	Property name	Type	Name	Unit	Default
1	Cost	double	n/a	USD	0
2	ReviewStatus	enumeration	ReviewStatus	n/a	NeedsReview
3	Latency	double	n/a	ms	0

To stereotype components and ports, first apply the profile `AutoProfile` to the top model. Each of the component stereotypes includes an icon that represents the usage of the stereotype and indicates the component type. To apply stereotypes to all model elements in a batch process, use the Apply Stereotypes dialog. To apply stereotypes one by one, use the Property Inspector. For more information, see “Use Stereotypes and Profiles” on page 5-9.

Define Port Interfaces to Describe Data Flow

Composite data interfaces assigned to ports allow you to decompose the data transfer through those ports along the connections between them. For example, the `keyFOBPosition` interface might describe the elements of information passing through the `keyLocation` ports to different components of the architecture.



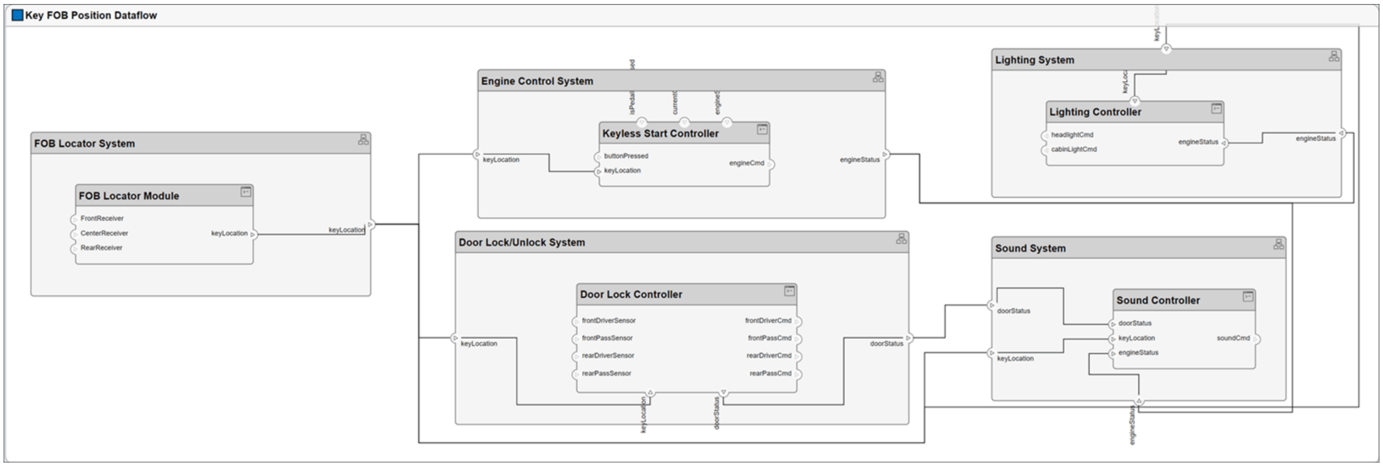
Interfaces.sldd
- DoorStatus
- EngineStatus
- FOBSignal
- KeyFOBPosition

The composite data interfaces that have not been decomposed demonstrate an early version of interfaces design using the Interface Editor. To decompose data intefaces, you can add data elements, or data elements typed by other data interfaces or typed by other value types. For more information, see “Assign Interfaces to Ports” on page 3-9.

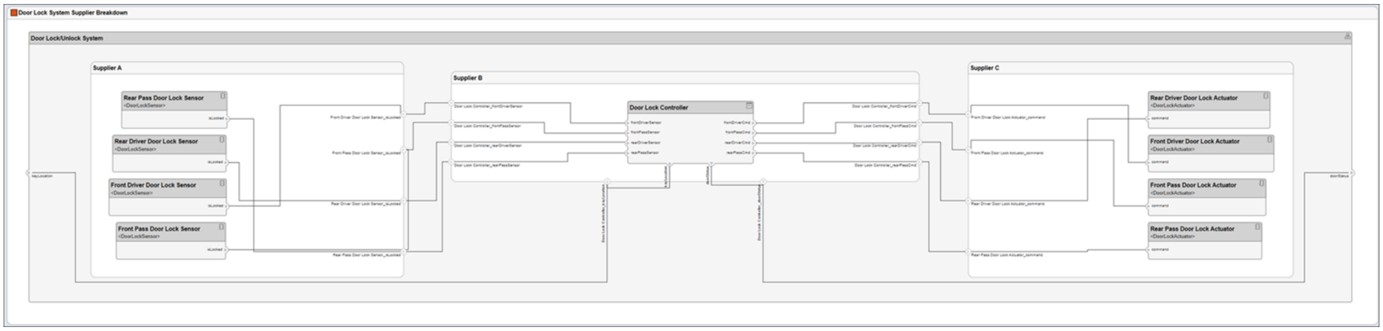
Create Views to Present to Stakeholders

You can create, view, and edit architecture views in the Architecture Views Gallery. To launch the editor, on the **Modeling** tab in the toolstrip, click **Architecture Views**. Filtered views update dynamically with changes to the model. Alternatively, you can use Spotlight Views, which are transient views centered on specific components. For more information, see “Create Spotlight Views” on page 11-2. The `KeylessEntryArchitecture` model has these views:

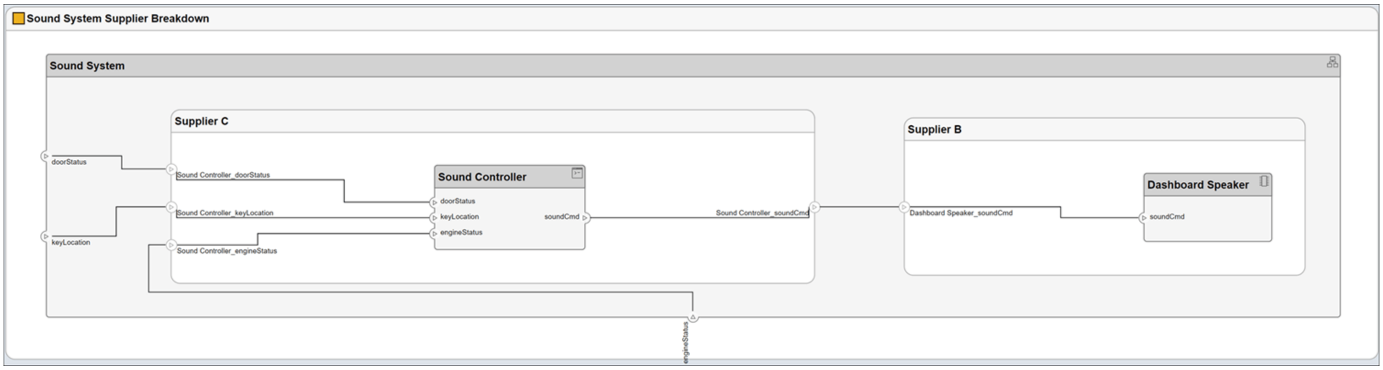
- Key FOB Position Dataflow — An operational view of the components in the model that make use of the `KeyFOBPosition` interface.



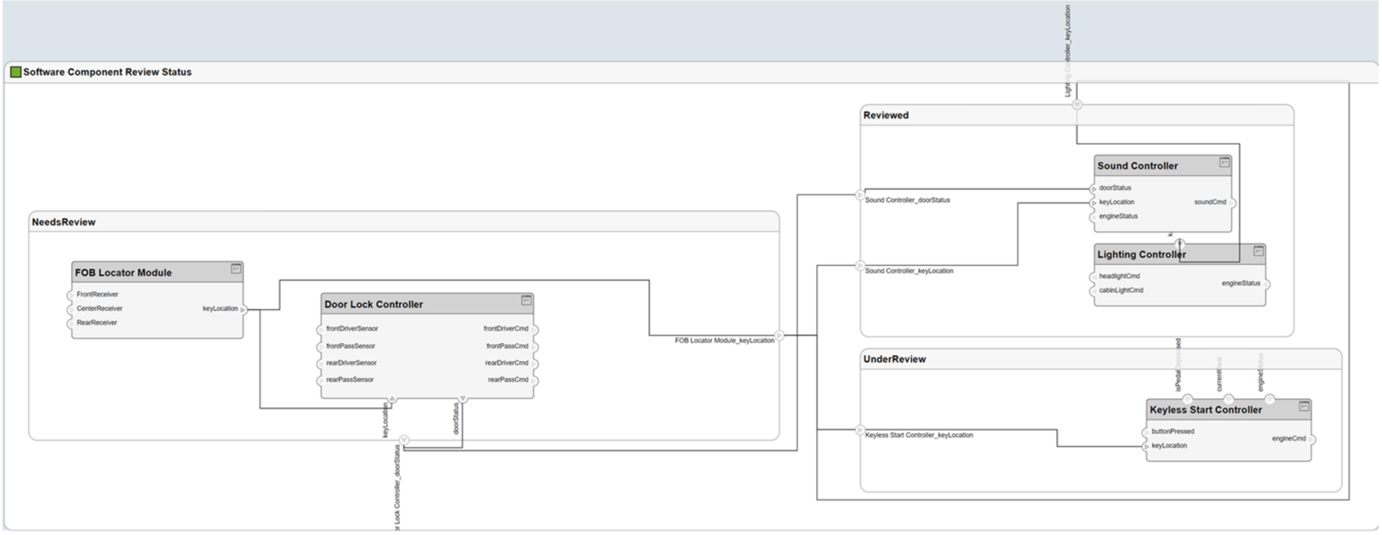
- Door Lock System Supplier Breakdown — A functional view of the components in the door lock system grouped by which supplier provides the given components.


Door Lock System Supplier Breakdown
Door Lock/Unlock System
Supplier A
Rear Pass Door Lock Sensor
<DoorLockSensor>
isLocked
Rear Driver Door Lock Sensor
<DoorLockSensor>
isLocked
Front Driver Door Lock Sensor
<DoorLockSensor>
isLocked
Front Pass Door Lock Sensor
<DoorLockSensor>
isLocked
Front Driver Door Lock Sensor_isLocked
Front Pass Door Lock Sensor_isLocked
Rear Driver Door Lock Sensor_isLocked
Rear Pass Door Lock Sensor_isLocked
keyLocation
Supplier B
Door Lock Controller_frontDriverSensor
Door Lock Controller_frontPassSensor
Door Lock Controller_rearDriverSensor
Door Lock Controller_rearPassSensor
Door Lock Controller
frontDriverSensor
frontPassSensor
rearDriverSensor
rearPassSensor
frontDriverCmd
frontPassCmd
rearDriverCmd
rearPassCmd
keyLocation
doorStatus
Door Lock Controller_frontDriverCmd
Door Lock Controller_frontPassCmd
Door Lock Controller_rearDriverCmd
Door Lock Controller_rearPassCmd
Door Lock Controller_keyLocation
Door Lock Controller_doorStatus
Supplier C
Front Driver Door Lock Actuator_command
Front Pass Door Lock Actuator_command
Rear Driver Door Lock Actuator_command
Rear Pass Door Lock Actuator_command
Rear Driver Door Lock Actuator
<DoorLockActuator>
command
Front Driver Door Lock Actuator
<DoorLockActuator>
command
Front Pass Door Lock Actuator
<DoorLockActuator>
command
Rear Pass Door Lock Actuator
<DoorLockActuator>
command
doorStatus

- Sound System Supplier Breakdown — A functional view of the components in the sound system grouped by which supplier provides the given components.


Sound System Supplier Breakdown
Sound System
Supplier C
doorStatus
keyLocation
Sound Controller_doorStatus
Sound Controller_keyLocation
Sound Controller_engineStatus
Sound Controller
doorStatus
keyLocation
engineStatus
soundCmd
Sound Controller_soundCmd
Supplier B
Dashboard Speaker_soundCmd
Dashboard Speaker
soundCmd
engineStatus

- Software Component Review Status — A physical view of the components in the model with the `SoftwareComponent` stereotype applied grouped by the value of the `ReviewStatus` property.



See Also

`createView` | `getView` | `openViews` | `deleteView` | `systemcomposer.view.View` | `systemcomposer.view.ElementGroup`

More About

- “Create Architecture Views Interactively” on page 11-5
- “Create Architectural Views Programmatically” on page 11-15
- “Display Component Hierarchy and Architecture Hierarchy Using Views” on page 11-21
- “Organize System Composer Files in Projects” on page 12-2
- “Modeling System Architecture of Small UAV” on page 1-32
- “Model-Based Systems Engineering for Space-Based Applications” on page 1-38

12

Manage Architecture Models

Organize System Composer Files in Projects

Use projects to organize your work, manage files and settings, and interact with source control. Using System Composer generates multiple files, including but not limited to:

- Architecture models (`.slx`)
- Requirements Toolbox links (`.slmx`) and requirement sets (`.slreqx`)
- Allocation sets (`.mldatx`)
- Profiles (`.xml`)
- Interface data dictionaries (`.sldd`)
- Simulink Test files (`.mldatx`)
- MATLAB functions (`.m`) and live scripts (`.mlx`)
- Simulink behavior models (`.slx`)

To help organize these files, use projects.

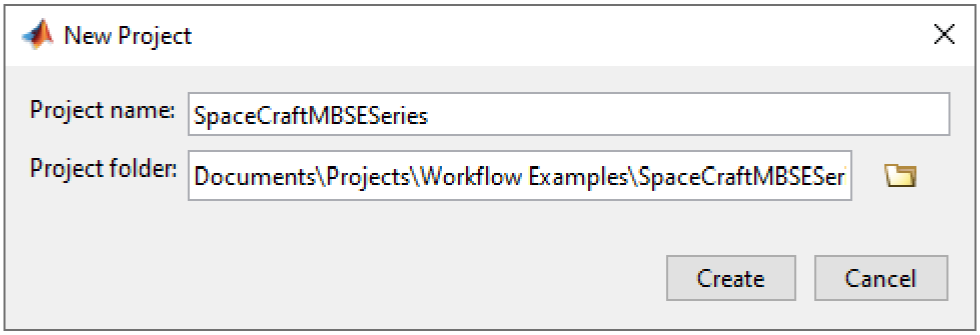
Use Projects to Organize Files and Folders

Create a project from a folder with supporting files and folders.

For example, this folder structure represents typical steps in the process of model-based systems engineering: `models`, `profiles`, `interfaces`, `requirements`, `tools`, `tests`, `livescripts`

The `models` folder can include architecture models, Simulink behavior models, and requirement links. If architecture models and behavior models are constructed separately, you can split the `models` folder into two folders, `architectures` and `simulation`, and decompose the folders further to represent the different stages of architectural model-based design. The `tools` folder can include functions and scripts for trade studies and analyses.

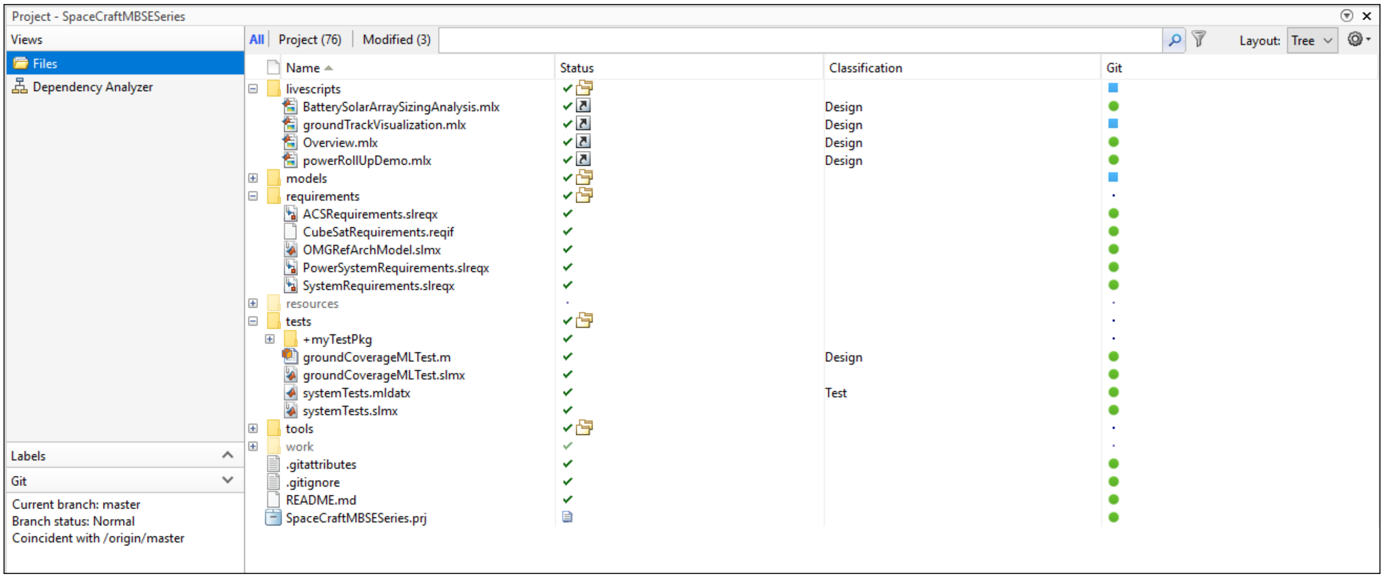
1. In MATLAB, navigate to the directory where your model files and artifacts are located.
2. Select **New** > **Project** > **From Folder**. Enter a name for your project.



Project name: SpaceCraftMBSESeries

Project folder: Documents\Projects\Workflow Examples\SpaceCraftMBSESer

3. The files in the folder you specify are added to the project, and the **Project** menu appears. To generate your own project shortcuts, on the **Project Shortcuts** tab, click **New Shortcut** or **Organize Groups**.
4. You can open the project again using the generated `.prj` file in your directory.



Name	Status	Classification	Git
livescripts	✓		■
BatterySolarArraySizingAnalysis.mlx	✓	Design	●
groundTrackVisualization.mlx	✓	Design	■
Overview.mlx	✓	Design	●
powerRollUpDemo.mlx	✓	Design	●
models	✓		■
requirements	✓		·
ACSRequirements.slreqx	✓		●
CubeSatRequirements.reqif	✓		●
OMGRefArchModel.slmx	✓		●
PowerSystemRequirements.slreqx	✓		●
SystemRequirements.slreqx	✓		●
resources	·		·
tests	✓		·
+myTestPkg	✓		·
groundCoverageMLTest.m	✓	Design	●
groundCoverageMLTest.slmx	✓		●
systemTests.mldatx	✓	Test	●
systemTests.slmx	✓		●
tools	✓		·
work	✓		·
.gitattributes	✓		●
.gitignore	✓		●
README.md	✓		●
SpaceCraftMBSESeries.prj	🗎		●

Current branch: master
Branch status: Normal
Coincident with /origin/master

Any changes you make will be organized in the project. You can manage changes to files with multiple contributors using source control. For more information on source control with projects, see “About Source Control with Projects”.

To illustrate file dependencies across the project, use the **Dependency Analyzer**. For more information, see “Dependency Analysis for Projects”. To check and upgrade the project, use the **Run Checks** option.

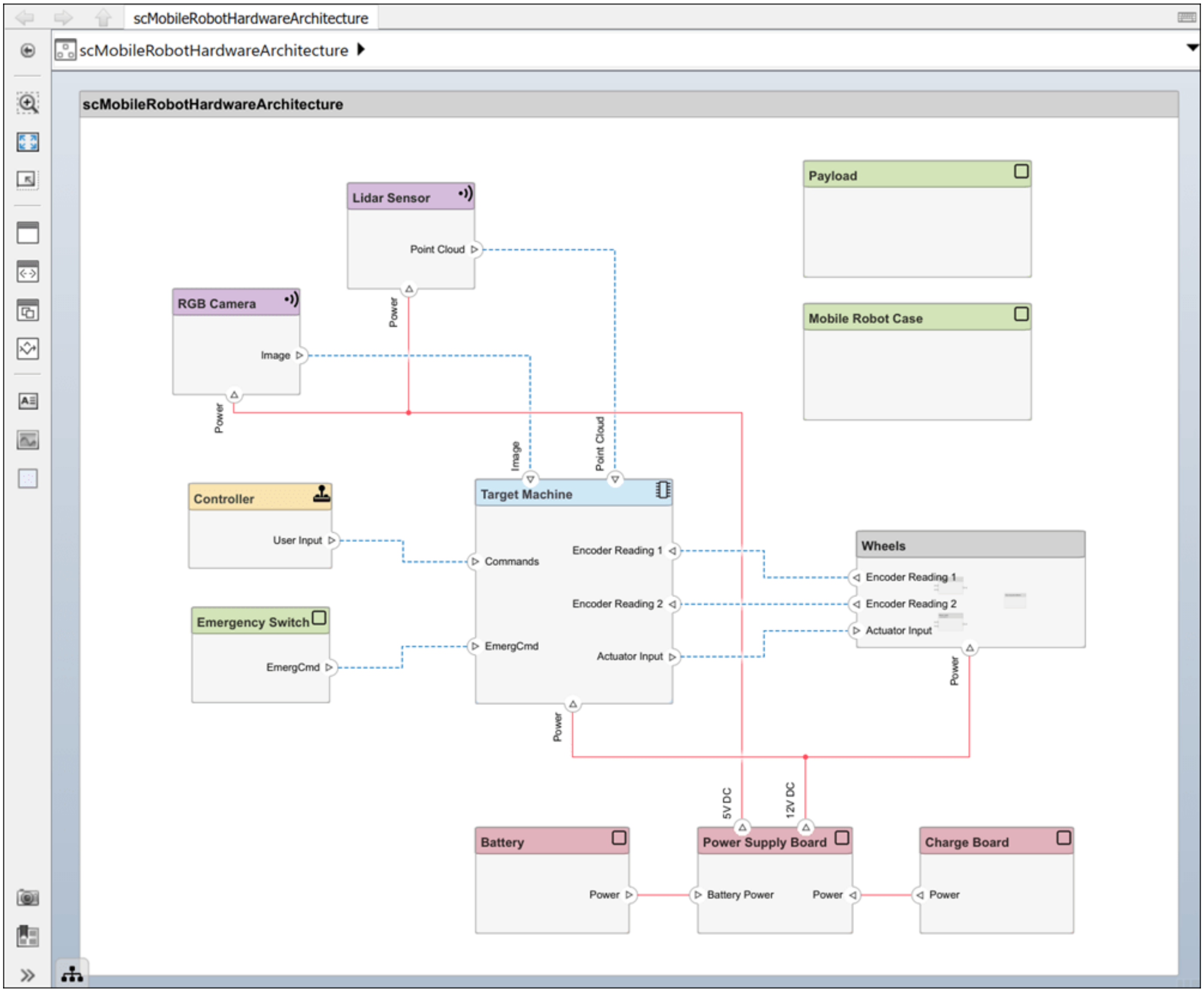
See Also

More About

- “Modeling System Architecture of Small UAV” on page 1-32
- “Modeling System Architecture of Keyless Entry System” on page 11-25
- “Allocate Architectures in Tire Pressure Monitoring System” on page 8-10
- “Calculate Endurance Using Quadcopter Architectural Design” on page 9-16
- “Design Insulin Infusion Pump Using Model-Based Systems Engineering” on page 9-23
- “Model-Based Systems Engineering for Space-Based Applications” on page 1-38

Compare Model Differences Using System Composer Comparison Tool

This example shows how to use the Comparison Tool to compare two System Composer™ architecture models with differences in architectural data. The models represent a mobile robot hardware architecture and an edited version of the same model.



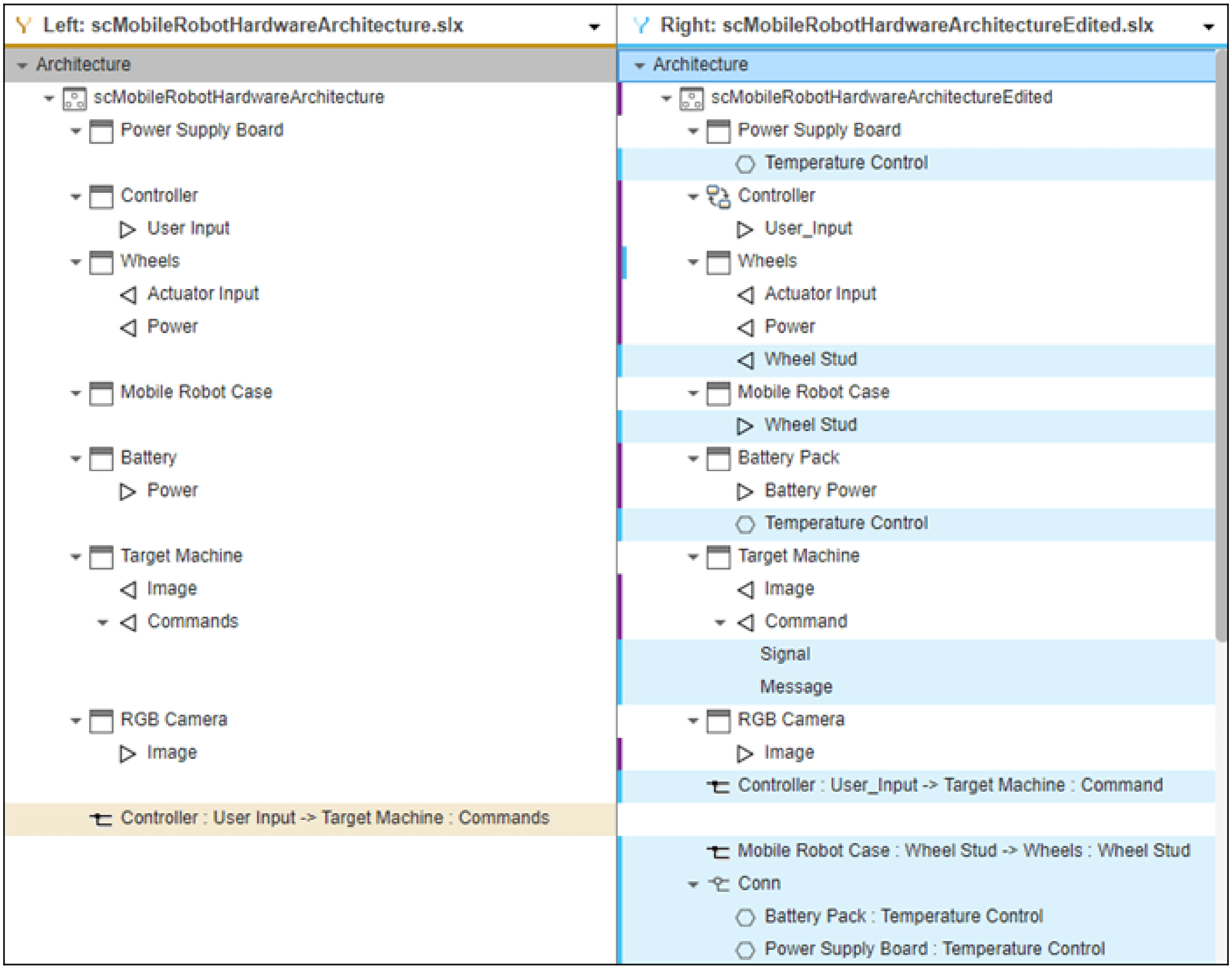
To open the Comparison Tool, enter this command.

```
visdiff("scMobileRobotHardwareArchitecture.slx","scMobileRobotHardwareArchitectureEdited.slx")
```

Compare Structural Differences

The first section of the System Composer comparison report is called `Architecture`. The differences in this section include changes to components, ports, and connectors. This section also includes changes to component types, port types, and any owned interfaces added to ports. The comparison report displays:

- A new physical port named `Temperature Control` added to the `Power Supply Board` component and connected to the `Battery Pack` component.
- A new port named `Wheel Stud` connected from the `Wheels` component to the `Mobile Robot Case` component.
- A new owned interface with elements `Signal` and `Message` owned by the `Command` ouput port.
- A port on the `Target Machine` component renamed from `Commands` to `Command`.
- The `Controller` component that is converted to a Stateflow® chart component.



Left: scMobileRobotHardwareArchitecture.slx

Architecture
scMobileRobotHardwareArchitecture
Power Supply Board
Controller
User Input
Wheels
Actuator Input
Power
Mobile Robot Case
Battery
Power
Target Machine
Image
Commands
RGB Camera
Image
Controller : User Input -> Target Machine : Commands

Right: scMobileRobotHardwareArchitectureEdited.slx

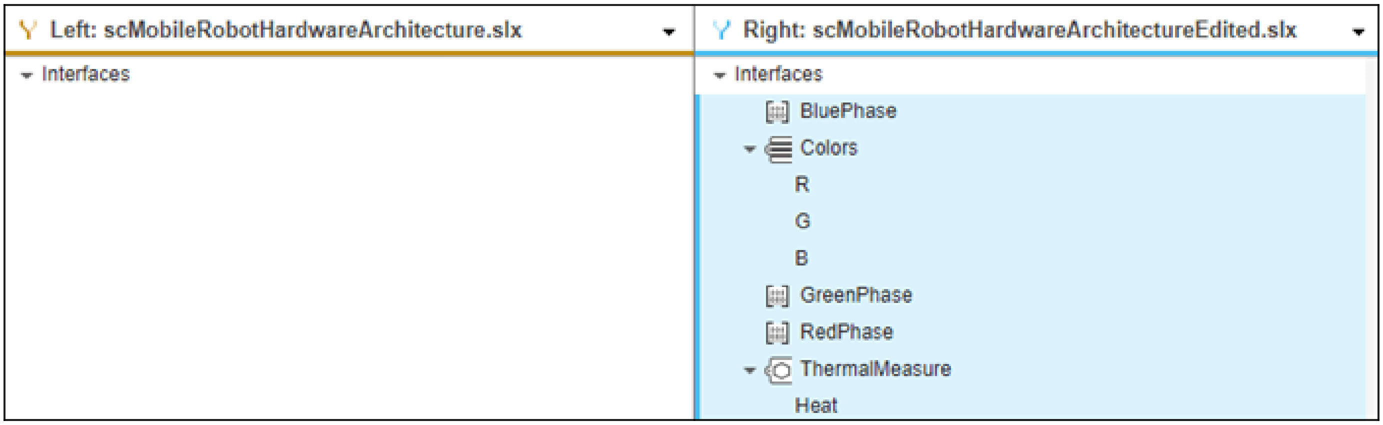
Architecture
scMobileRobotHardwareArchitectureEdited
Power Supply Board
Temperature Control
Controller
User_Input
Wheels
Actuator Input
Power
Wheel Stud
Mobile Robot Case
Wheel Stud
Battery Pack
Battery Power
Temperature Control
Target Machine
Image
Command
Signal
Message
RGB Camera
Image
Controller : User_Input -> Target Machine : Command
Mobile Robot Case : Wheel Stud -> Wheels : Wheel Stud
Conn
Battery Pack : Temperature Control
Power Supply Board : Temperature Control

To learn more about specific changes, you can select the row in the comparison report and view additional information in the bottom pane. As you click on each row of the comparison report, the corresponding open models on the right side are highlighted.

Compare Interface Dictionary Differences

The second section of the System Composer comparison report is called Interfaces. The differences in this section include changes to interfaces on the model data dictionary. The comparison report displays:

- Three new value type interfaces called RedPhase, GreenPhase, and BluePhase.
- A new Colors data interface with three data elements: R, G, and B.
- A new physical interface named ThermalMeasure with the physical element Heat.

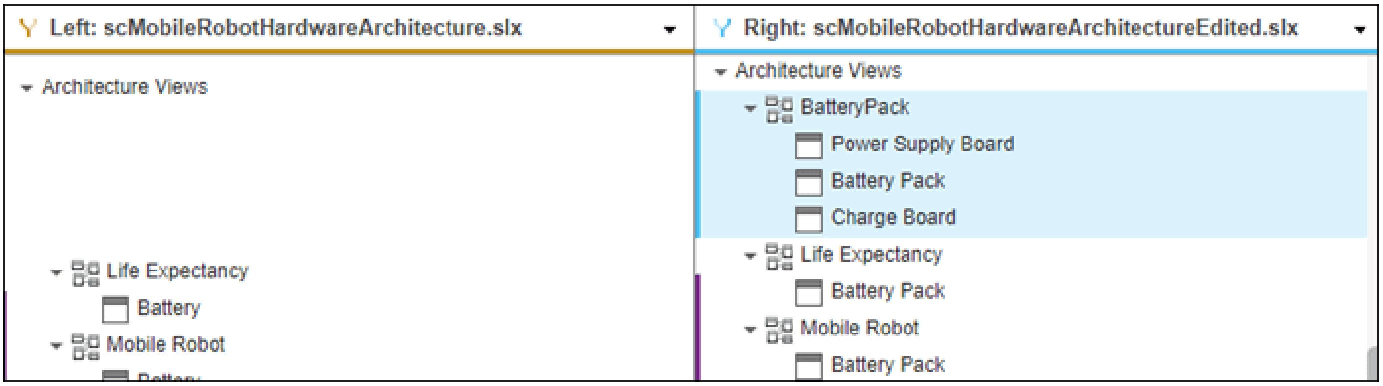

Left: scMobileRobotHardwareArchitecture.slx
Right: scMobileRobotHardwareArchitectureEdited.slx
Interfaces
Interfaces
BluePhase
Colors
R
G
B
GreenPhase
RedPhase
ThermalMeasure
Heat

When you click on the data element: R, G, or B, you can see that the element is typed by its value type. You can also inspect the physical domain that types the physical element Heat.

Compare Views Differences

The third section of the System Composer comparison report is called Architecture Views. The differences in this section added or deleted architecture views and shows whether the view mode has changed between Component Diagram, Component Hierarchy, or Architecture Hierarchy. The comparison report displays:

- The new BatteryPack view and the components that are displayed within it: Power Supply Board, Battery Pack, and Charge Board.
- Changes to the existing views Life Expectancy and Mobile Robot due to renaming the Battery component to Battery Pack.



When you click on each of the view names, the bottom pane will indicate if there are further modifications to the views.

See Also

`visdiff`

More About

- “Compose Architectures Visually” on page 1-2
- “Define Port Interfaces Between Components” on page 3-2
- “Define Profiles and Stereotypes” on page 5-2
- “Create Architecture Views Interactively” on page 11-5
- “Implement Component Behavior Using Simulink” on page 7-2
- “Organize System Composer Files in Projects” on page 12-2

Import and Export Architecture Models

Import and Export Architectures

In System Composer™, an architecture is fully defined by three sets of information:

- Component information
- Port information
- Connection information

You can import an architecture into System Composer when this information is defined in or converted into MATLAB® tables.

In this example, the architecture information of a simple unmanned aerial vehicle (UAV) system is defined in a Microsoft® Excel® spreadsheet and is used to create a System Composer architecture model. It also links elements to the specified system level requirement. You can modify the files in this example to import architectures defined in external tools, when the data includes the required information. The example also shows how to export this architecture information from System Composer architecture model to an Excel spreadsheet.

Architecture Definition Data

You can characterize the architecture as a network of components and import by defining components, ports, connections, interfaces and requirement links in MATLAB tables. The `components` table must include name, unique ID, and parent component ID for each component. The spreadsheet can also include other relevant information required to construct the architecture hierarchy for referenced model, and stereotype qualifier names. The `ports` table must include port name, direction, component, and port ID information. Port interface information may also be required to assign ports to components. The `connections` table includes information to connect ports. At a minimum, this table must include the connection ID, source port ID, and destination port ID.

The `systemcomposer.importModel(importModelName)` function:

- Reads stereotype names from the `components` table and loads the profiles
- Creates components and attaches ports
- Creates connections using the connection map
- Sets interfaces on ports
- Links elements to specified requirements (requires a Requirements Toolbox™ license)
- Saves referenced models
- Saves the architecture model

Instantiate adapter class to read from Excel.

```
modelName = "simpleUAVArchitecture";
```

`ImportModelFromExcel` function reads the Excel file and creates the MATLAB tables.

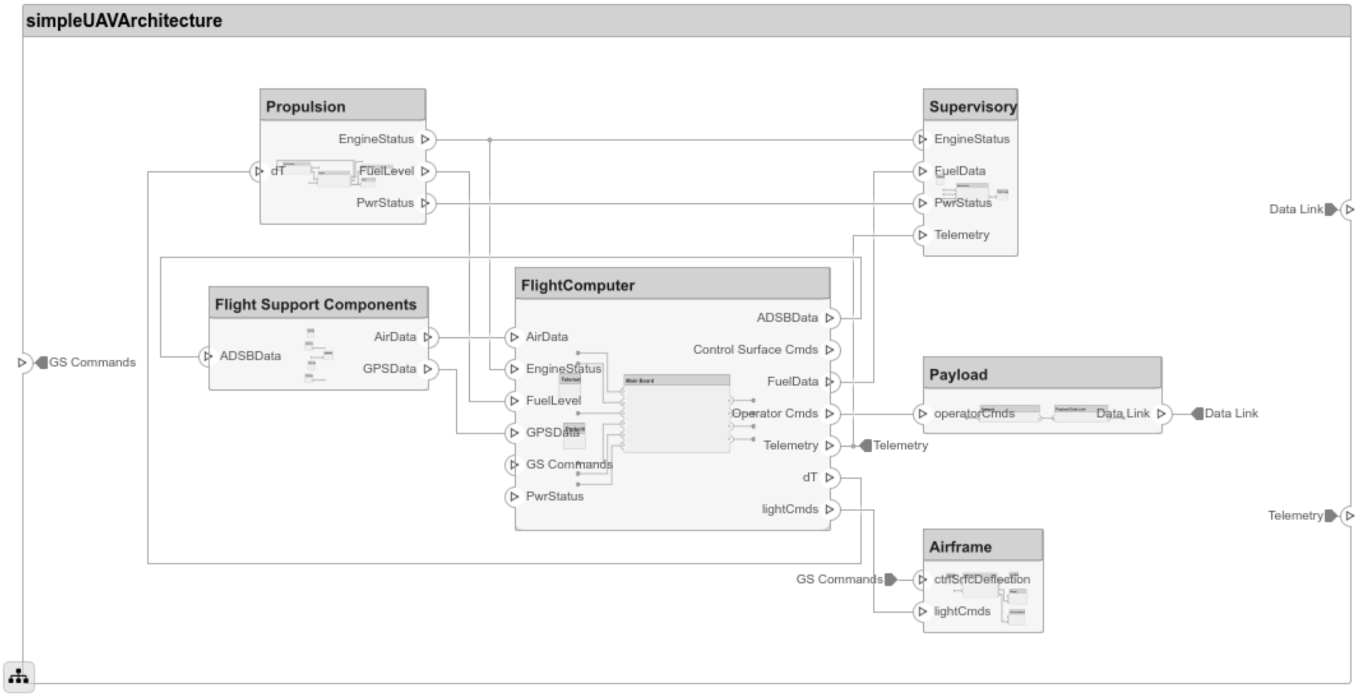
```
importAdapter = ImportModelFromExcel("SmallUAVModel.xls","Components", ...
    "Ports","Connections","PortInterfaces","RequirementLinks");
importAdapter.readTableFromExcel();
```

Import an Architecture

```
model = systemcomposer.importModel(modelName,importAdapter.Components, ...
    importAdapter.Ports,importAdapter.Connections,importAdapter.Interfaces, ...
    importAdapter.RequirementLinks);
```

Auto-arrange blocks in the generated model.

```
Simulink.BlockDiagram.arrangeSystem(modelName)
```



Export an Architecture

You can export an architecture to MATLAB tables and then convert the tables to an external file.

```
exportedSet = systemcomposer.exportModel(modelName);
```

The output of the function is a structure that contains the component table, port table, connection table, the interface table, and the requirement links table. Save this structure to an Excel file.

```
SaveToExcel("ExportedUAVModel",exportedSet);
```

See Also

importModel | exportModel | updateLinksToReferenceRequirements

More About

- “Import and Export Architecture Models” on page 13-5
- “Compose Architectures Visually” on page 1-2
- “Decompose and Reuse Components” on page 1-17

- “Manage Requirements” on page 2-8
- “Import System Composer Architecture Using ModelBuilder” on page 13-13
- “Simulate Mobile Robot with System Composer Workflow” on page 5-20

Import and Export Architecture Models

To build a System Composer model, you can import information about components, ports, and connections in a predefined format using MATLAB table objects. You can extend these tables and add information like applied stereotypes, property values, linked model references, variant components, interfaces, and requirement links.

Similarly, you can export information about components, hierarchy of components, ports on components, connections between components, linked model references, variants, stereotypes on elements, interfaces, and requirement links.

Define Basic Architecture

The minimum required structure for a System Composer model consists of these sets of information:

- Components table
- Ports table
- Connections table

To import additional elements, you need to add columns to the tables and add specific values for these elements.

Components Table

The information about components is passed as values in a MATLAB table against predefined column names, where:

- `Name` is the component name.
- `ID` is a user-defined ID used to map child components and add ports to components.
- `ParentID` is the parent component ID.

For example, `Component_1_1` and `Component_1_2` are children of `Component_1`.

Name	ID	ParentID
root	0	
Component_1	1	0
Component_1_1	2	1
Component_1_2	3	1
Component_2	4	0

Ports Table

The information about ports is passed as values in a MATLAB table against predefined column names, where:

- `Name` is the port name.
- `Direction` can be one of `Input`, `Output`, or `Physical`.
- `ID` is a user-defined port ID used to map ports to port connections.

- CompID is the ID of the component to which the port is added. It is the component passed in the components table.

Name	Direction	ID	CompID
Port1	Output	1	1
Port2	Physical	2	4
Port1_1	Output	3	2
Port1_2	Input	4	3

Connections Table

The information about connections is passed as values in a MATLAB table against predefined column names, where:

- Name is the connection name.
- ID is connection ID used to check that the connections are properly created during the import process.
- Kind is the kind of connection specified by Data by default or Physical. The Kind column is optional and will default to Data if undefined.
- SourcePortID is the ID of the source port.
- DestPortID is the ID of the destination port.
- PortIDs are a comma-separated list of port IDs for physical ports that support nondirectional connections.

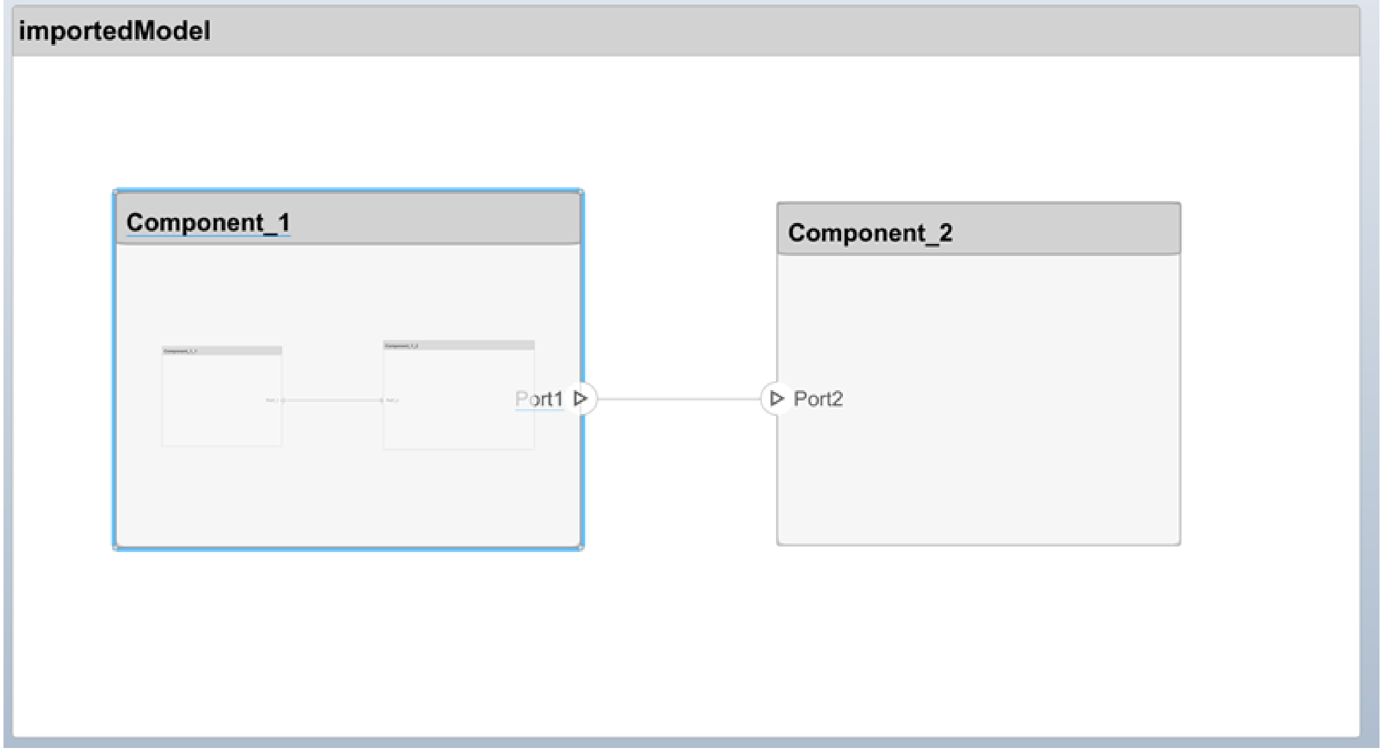
Name	Kind	ID	SourcePortID	DestPortID	PortIDs
Conn1	Data	1	1	2	
Conn2	Physical	2			3,4

Import Basic Architecture

Import the basic architecture from the tables created above into System Composer from the MATLAB Command Window using the importModel function.

```
systemcomposer.importModel("importedModel",components,ports,connections)
```

The basic architecture model opens.



Tip The tables do not include information about the model's visual layout. You can arrange the components manually or use **Architecture** > **Arrange** > **Arrange Automatically**.

Extend Basic Architecture Import

You can import other model elements into the basic structure tables.

Import Data Interfaces and Map Ports to Interfaces

To define the data interfaces, add interface names in the `ports` table to associate ports to corresponding `portInterfaces` table. Create a table similar to `components`, `ports`, and `connections`. Information like interface name, associated element name along with data type, dimensions, units, complexity, minimum, and maximum values are passed to the `importModel` function in a table format shown below.

Name	ID	ParentID	DataType	Dimensions	Units	Complexity	Minimum	Maximum
`interface1`	`1`		`DataInterface`					
`elem1`	`2`	`1`	`interface2`					
`interface2`	`3`		`DataInterface`					
`elem2`	`4`	`1`	`double`	`1`	`""`	`real`	`"[]"`	`"[]"`

Name	ID	ParentID	DataType	Dimensions	Units	Complexity	Minimum	Maximum
elem3	5	1	valueType	3	cm	real	0	100
valueType	6		int32	3	cm	real	0	100
interface3	7		PhysicalInterface					
elec	8	7	Connection: foundation.electrical.electrical					
mech	9	7	Connection: foundation.mechanical.mechanical.rotational					

Data interfaces `interface1` and `interface2` are defined with data elements `elem1` and `elem2` under `interface1`. Data element `elem2` is typed by `interface2`, inheriting its structure. For more information, see “Nest Interfaces to Reuse Data” on page 3-7.

Note Owned interfaces cannot be nested. You cannot define an owned interface as the data type of data elements. For more information, see “Define Owned Interfaces Local to Ports” on page 3-10.

This data interface `interface1` includes a data element `elem3`, which is typed by a value type `valueType` and inherits its properties. For more information, see “Create Value Types as Interfaces” on page 3-6.

This physical interface `interface3` includes physical elements `elec` and `mech`, which are typed under their respective physical domains. For more information, see “Specify Physical Interfaces on Ports” on page 7-24.

To map the added data interface to ports, add the column `InterfaceID` in the `ports` table and specify the data interface to be linked. For example, `interface1` is mapped to `Port1` as shown below.

Name	Direction	ID	CompID	InterfaceID
Port1	Output	1	1	interface1
Port2	Input	2	4	interface2

Name	Direction	ID	CompID	InterfaceID
Port1_1	Output	3	2	""
Port1_2	Input	4	3	interface1

Import Variant Components, Stateflow Behaviors, or Reference Components

You can add variant components just like any other component in the `components` table, except you specify the name of the active variant. Add choices as child components to the variant components. Specify the variant choices as string values in the `VariantControl` column. You can enter expressions in the `VariantCondition` column. For more information, see “Create Variants” on page 1-21.

Add a variant component `VarComp` using component type `Variant` with choices `Choice1` and `Choice2`. Set `Choice2` as the active choice.

To add a referenced Simulink model, change the component type to `Behavior` and specify the reference model name `simulink_model`.

To add a Stateflow chart behavior on a component, change the component type to `StateflowBehavior`. If System Composer does not detect a license or installation of Stateflow, a `Composition` component is imported instead.

Name	ID	ParentID	ReferenceModelName	ComponentType	ActiveChoice	VariantControl	VariantCondition
root	0						
Component1	C1	0	simulink_model	Behavior			
VarComp	V2	0		Variant	Choice2		
Choice1	C6	V2				petrol	
Choice2	C7	V2				diesel	
Component3	C3	0		StateflowBehavior			
Component1_1	C4	C1					
Component1_2	C5	C1					

Pass the modified `components` table along with the `ports` and `connections` tables to the `importModel` function.

Apply Stereotypes and Set Property Values on Imported Model

To apply stereotypes on components, ports, and connections, add a `StereotypeNames` column to the `components` table. To set the properties for the stereotypes, add a column with a name defined using the profile name, stereotype name, and property name. For example, name the column `UAVComponent_OnboardElement_Mass` for a `UAVComponent` profile, a `OnBoardElement` stereotype, and a `Mass` property.

You set the property values in the format `value{units}`. Units and values are populated from the default values defined in the loaded profile file. For more information, see “Define Profiles and Stereotypes” on page 5-2.

Name	ID	ParentID	StereotypeNames	UAVComponent_OnboardElement_Mass	UAVComponent_OnboardElement_Power
root	0				
Component_1	1	0	UAVComponent.OnboardElement	0.93{kg}	0.65{mW}
Component_1_1	2	1			
Component_1_2	3	1	UAVComponent.OnboardElement	0.93{kg}	""
Component_2	4	0			

Assign Requirement Links on Imported Model

To assign requirement links to the model, add a `requirementLinks` table with these required columns:

- `Label` is the name of the requirement.
- `ID` is the ID of the requirement.
- `SourceID` is the architectural element to which the requirement is attached.
- `DestinationType` is how requirements are saved.
- `DestinationID` is where the requirement is located.
- `Type` is the requirement type.

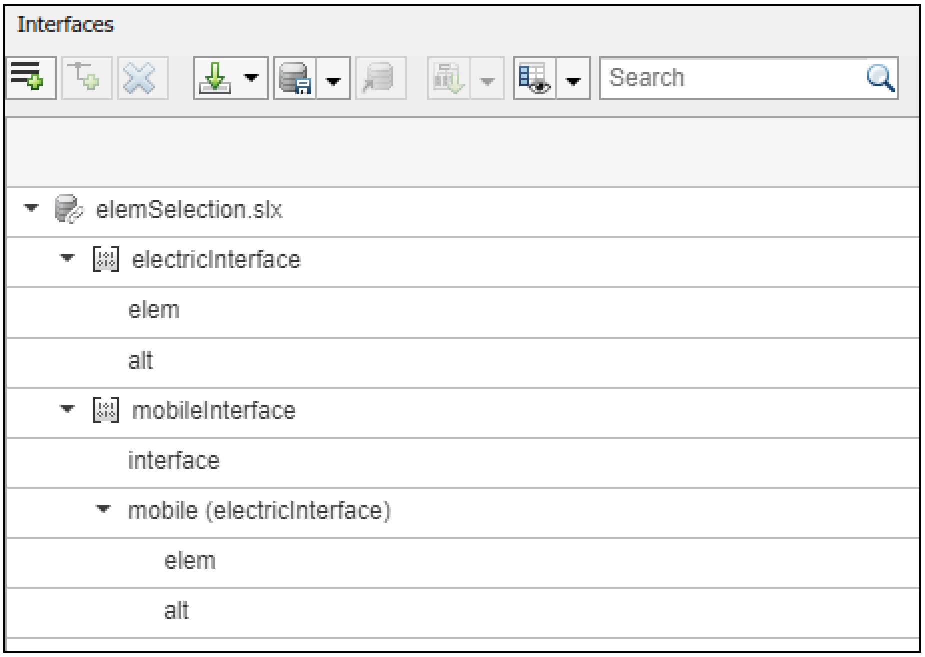
For more information, see “Manage Requirements” on page 2-8.

Label	ID	SourceID	DestinationType	DestinationID	Type
rset#1	1	components:1	linktype_rmi_slreq	C:\Temp\rset.slreqx#1	Implement
rset#2	2	components:0	linktype_rmi_slreq	C:\Temp\rset.slreqx#2	Implement
rset#3	3	ports:1	linktype_rmi_slreq	C:\Temp\rset.slreqx#3	Implement
rset#4	4	ports:3	linktype_rmi_slreq	C:\Temp\rset.slreqx#4	Implement

A Requirements Toolbox license is required to import requirement links into a System Composer architecture model.

Specify Elements on Architecture Port

In the `connections` table, you can specify different kinds of signal interface elements as source elements or destination elements. Connections can be formed from a root architecture port to a component port, from a component port to a root architecture port, or between two root architecture ports of the same architecture.



- elemSelection.slx
  - electricInterface
    - elem
    - alt
  - mobileInterface
    - interface
    - mobile (electricInterface)
      - elem
      - alt

The nested interface element `mobile.elem` is the source element for the connection between an architecture port and a component port. The nested element `mobile.alt` is the destination element for the connection between an architecture port and a component port. The interface element `mobile` and the nested element `mobile.alt` are source elements for the connection between two architecture ports of the same architecture.

For more information, see “Specify Source Element or Destination Element for Ports” on page 3-13.

Name	ID	SourcePortID	DestPortID	SourceElement	DestinationElement
`RootToComp1`	`1`	`5`	`4`	`mobile.elem`	
`RootToComp2`	`2`	`5`	`1`	`mobile.alt`	
`Comp1ToRoot`	`3`	`2`	`6`		`interface`
`Comp2ToRoot`	`4`	`3`	`6`		`mobile.alt`
`RootToRoot`	`5`	`5`	`6`	`mobile,mobile.alt`	

Define Architecture Domain for Software Architectures

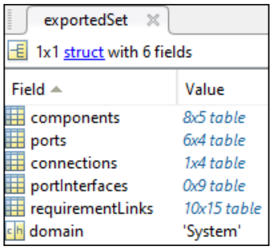
To specify that the architecture to be imported is a software architecture, specify the domain field of the import structure as `"Software"`. For more information, see “Import and Export Software Architectures” on page 10-5.

Export Architecture

To export a model, pass the model name as an argument to the `exportModel` function. The function returns a structure containing five tables: `components`, `ports`, `connections`, `portInterfaces`, and `requirementLinks`, and the field `domain` that is a character vector that represents the type of architecture being exported. The value of `domain` is `'System'` for architecture models or `'Software'` for software architecture models.

```
exportedSet = systemcomposer.exportModel(modelName)
```

You can export the set to MATLAB tables and then convert those tables to external file formats, including Microsoft® Excel® or databases.



exportedSet

1x1 struct with 6 fields

Field	Value
components	8x5 table
ports	6x4 table
connections	1x4 table
portInterfaces	0x9 table
requirementLinks	10x15 table
domain	'System'

If requirements were imported to the model using an external file, in order to export and reimport those requirements, update reference requirement links within the model. You can use the `systemcomposer.updateLinksToReferenceRequirements` function for the requirement links to point to the imported referenced requirements instead of the external documents.

See Also

`importModel` | `exportModel` | `systemcomposer.io.ModelBuilder` | `systemcomposer.updateLinksToReferenceRequirements`

More About

- “Compose Architectures Visually” on page 1-2
- “Decompose and Reuse Components” on page 1-17
- “Implement Component Behavior Using Simulink” on page 7-2
- “Manage Requirements” on page 2-8
- “Import and Export Architectures” on page 13-2
- “Import System Composer Architecture Using ModelBuilder” on page 13-13

Import System Composer Architecture Using ModelBuilder

Import architecture specifications into System Composer™ using the `systemcomposer.io.ModelBuilder` utility class. These architecture specifications can be defined in an external source, such as an Excel® file.

In System Composer, an architecture is fully defined by four sets of information:

- Components and their position in the architecture hierarchy.
- Ports and their mapping to components.
- Connections among components through ports. In this example, we also import interface data definitions from an external source.
- Interfaces in architecture models and their mapping to ports.

This example uses the `systemcomposer.io.ModelBuilder` class to pass all of the above architecture information and import a System Composer model.

In this example, architecture information of a small UAV system is defined in an Excel spreadsheet and is used to create a System Composer architecture model.

External Source Files

- `Architecture.xlsx` — This Excel file contains hierarchical information of the architecture model. This example maps the external source data to System Composer model elements. This information maps in column names to System Composer model elements.

```
# Element    : Name of the element. Either can be component or port name.
# Parent     : Name of the parent element.
# Class      : Can be either component or port(Input/Output direction of the port).
# Domain     : Mapped as component property. Property "Manufacturer" defined in the
               profile UAVComponent under Stereotype PartDescriptor maps to Domain values in
# Kind       : Mapped as component property. Property "ModelName" defined in the
               profile UAVComponent under Stereotype PartDescriptor maps to Kind values in e
# InterfaceName : If class is of port type. InterfaceName maps to name of the interface link
# ConnectedTo : In case of port type, it specifies the connection to
                other port defined in format "ComponentName::PortName".
```

- `DataDefinitions.xlsx` — This Excel file contains interface data definitions of the model. This example assumes this mapping between the data definitions in the Excel source file and interfaces hierarchy in System Composer.

```
# Name        : Name of the interface or element.
# Parent      : Name of the parent interface Name(Applicable only for elements) .
# Datatype    : Datatype of element. Can be another interface in format
                Bus: InterfaceName
# Dimensions  : Dimensions of the element.
# Units       : Unit property of the element.
# Minimum     : Minimum value of the element.
# Maximum     : Maximum value of the element.
```

Step 1. Instantiate the `ModelBuilder` Class

You can instantiate the `ModelBuilder` class with a profile name.

```
[stat,fa] = fileattrib(pwd);
if ~fa.UserWrite
    disp('This script must be run in a writable directory');
    return;
end
```

Specify the name of the model to build.

```
modelName = 'scExampleModelBuilder';
```

Specify the name of the profile.

```
profile = 'UAVComponent';
```

Specify the name of the source file to read architecture information.

```
architectureFileName = 'Architecture.xlsx';
```

Instantiate the `ModelBuilder`.

```
builder = systemcomposer.io.ModelBuilder(profile);
```

Step 2. Build Interface Data Definitions

Reading the information in the external source file `DataDefinitions.xlsx` to build the interface data model.

Create MATLAB® tables from the Excel source file.

```
opts = detectImportOptions('DataDefinitions.xlsx');
opts.DataRange = 'A2';
```

Force `readtable` to start reading from the second row.

```
definitionContents = readtable('DataDefinitions.xlsx',opts);
```

The `systemcomposer.io.IdService` class generates unique `ID` for a given key.

```
idService = systemcomposer.io.IdService();

for rowItr =1:numel(definitionContents(:,1))
    parentInterface = definitionContents.Parent{rowItr};
    if isempty(parentInterface)
```

In the case of interfaces, add the interface name to the model builder.

```
        interfaceName = definitionContents.Name{rowItr};
```

Get the unique interface `ID`.

`getID(container,key)` generates or returns (if key is already present) same value for input key within the container.

```
        interfaceID = idService.getID('interfaces',interfaceName);
```

Use `builder.addInterface` to add the interface to the data dictionary.

```
        builder.addInterface(interfaceName,interfaceID);
    else
```

In the case of an element, read the element properties and add the element to the parent interface.

```
        elementName  = definitionContents.Name{rowItr};
        interfaceID = idService.getID('interfaces',parentInterface);
```

The `ElementID` is unique within a interface. Append `E` at the start of an `ID` for uniformity. The generated `ID` for an input element is unique within parent interface name as a container.

```
        elemID = idService.getID(parentInterface,elementName,'E');
```

Set the data type, dimensions, units, minimum, and maximum properties of the element.

```
        datatype = definitionContents.DataType{rowItr};
        dimensions = string(definitionContents.Dimensions(rowItr));
        units = definitionContents.Units(rowItr);
```

Make sure that input to builder utility function is always a string.

```
        if ~ischar(units)
            units = '';
        end
        minimum = definitionContents.Minimum{rowItr};
        maximum = definitionContents.Maximum{rowItr};
```

Use `builder.addElementInInterface` to add an element with properties in the interface.

```
        builder.addElementInInterface(elementName,elemID,interfaceID,datatype,dimensions,units,'
    end
end
```

Step 3. Build Architecture Specifications

Architecture specifications are created by MATLAB tables from the Excel source file.

```
excelContents = readtable(architectureFileName);
```

Iterate over each row in the table.

```
for rowItr =1:numel(excelContents(:,1))
```

Read each row of the Excel file and columns.

```
    class = excelContents.Class(rowItr);
    Parent = excelContents.Parent(rowItr);
    Name = excelContents.Element{rowItr};
```

Populate the contents of the table.

```
    if strcmp(class,'component')
        ID = idService.getID('comp',Name);
```

The `Root ID` is by default set as zero.

```
        if strcmp(Parent,'scExampleSmallUAV')
            parentID = "0";
        else
            parentID = idService.getID('comp',Parent);
        end
```

Use `builder.addComponent` to add a component.

```
        builder.addComponent(Name,ID,parentID);
```

Read the property values.

```
        kind = excelContents.Kind{rowItr};
        domain = excelContents.Domain{rowItr};
```

Use `builder.setComponentProperty` to set stereotype and property values.

```
        builder.setComponentProperty(ID,'StereotypeName','UAVComponent.PartDescriptor','ModelName
    else
```

In this example, concatenation of the port name and parent component name is used as key to generate unique IDs for ports.

```
        portID = idService.getID('port',strcat(Name,Parent));
```

For ports on root architecture, the `compID` is assumed as `0`.

```
        if strcmp(Parent,'scExampleSmallUAV')
            compID = "0";
        else
            compID = idService.getID('comp',Parent);
        end
```

Use `builder.addPort` to add a port.

```
        builder.addPort(Name,class,portID,compID );
```

The `InterfaceName` specifies the name of the interface linked to the port.

```
        interfaceName = excelContents.InterfaceName{rowItr};
```

Get the interface ID.

`getID` will return the same IDs already generated while adding interface in Step 2.

```
        interfaceID = idService.getID('interfaces',interfaceName);
```

Use `builder.addInterfaceToPort` to map interface to port.

```
        builder.addInterfaceToPort(interfaceID,portID);
```

Read the `ConnectedTo` information to build connections between components.

```
        connectedTo = excelContents.ConnectedTo{rowItr};
```

`ConnectedTo` is in the format:

`(DestinationComponentName::DestinationPortName)`

For this example, consider the current port as source of the connection.

```
        if ~isempty(connectedTo)
            connID = idService.getID('connection',connectedTo);
            splits = split(connectedTo,'::');
```

Get the port ID of the connected port.

In this example, port ID is generated by concatenating the port name and the parent component name. If the port ID is already generated, the `getID` function returns the same ID for the input key.

```
            connectedPortID = idService.getID('port',strcat(splits(2),splits(1)));
```

Populate the connection table.

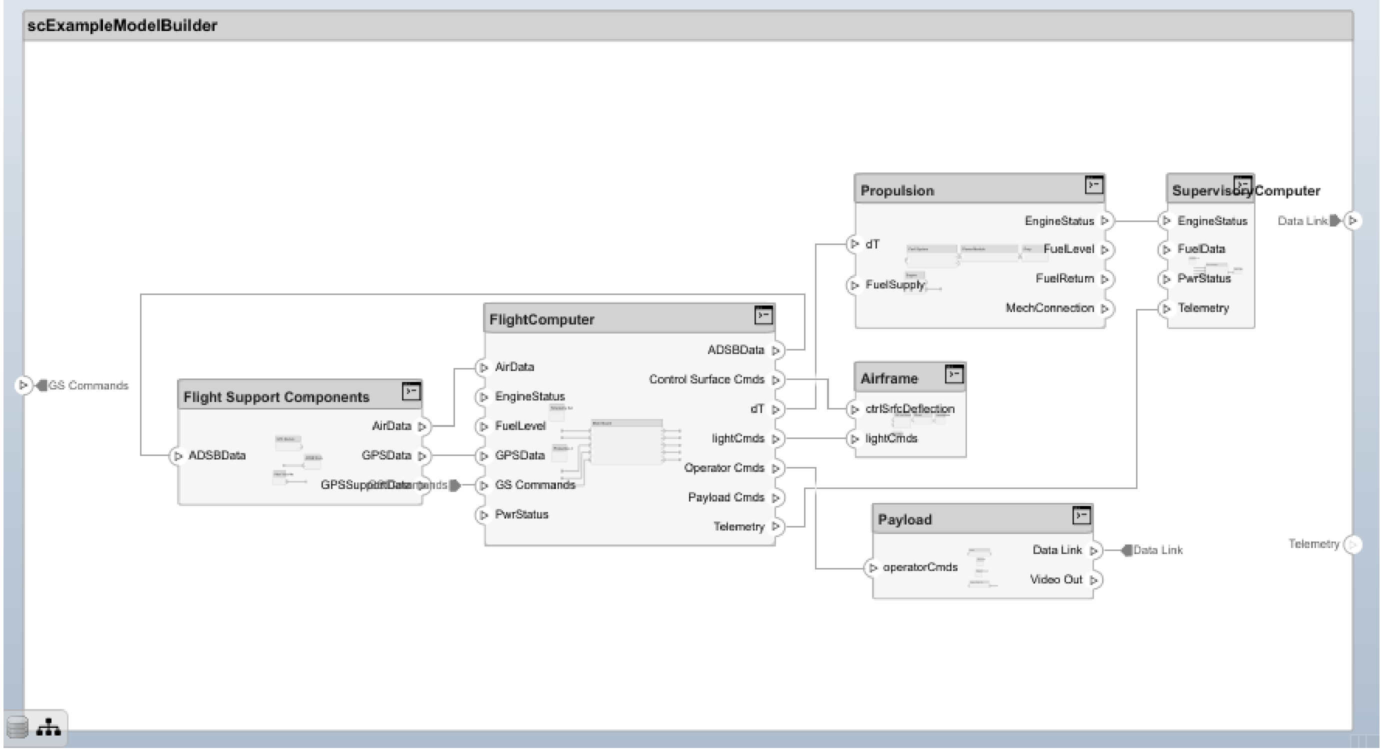
```
            sourcePortID = portID;
            destPortID = connectedPortID;
```

Use `builder.addConnection` to add connections.

```
            builder.addConnection(connectedTo,connID,sourcePortID,destPortID);
        end
    end
end
```

Step 3. Import Model from Populated Tables with `builder.build` Function

```
[model,importReport] = builder.build(modelName);
```



Clean up artifacts.

```
cleanUp
```

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See Also

`systemcomposer.io.ModelBuilder` | `importModel` | `exportModel`

More About

- “Import and Export Architecture Models” on page 13-5
- “Compose Architectures Visually” on page 1-2
- “Import and Export Architectures” on page 13-2
- “Simulate Mobile Robot with System Composer Workflow” on page 5-20

System Composer Report Generation for System Architectures

This example shows the different parts of a report generation script for a System Composer™ architecture model and its artifacts.

Import the relevant packages and then add the folder with the example files to the MATLAB® path.

```
import mlreportgen.report.*
import slreportgen.report.*
import slreportgen.finder.*
import mlreportgen.dom.*
import mlreportgen.utils.*
import systemcomposer.query.*
import systemcomposer.rptgen.finder.*

addpath(fullfile(matlabroot,'toolbox','systemcomposer','examples','rpt'))
```

Initialize the report.

```
rpt = slreportgen.report.Report(CompileModelBeforeReporting=false,output="SystemArchitectureRepor
```

Load the model and reference model.

```
systemcomposer.loadModel(fullfile(matlabroot,'toolbox','systemcomposer','examples','rpt','mTest'
model = systemcomposer.loadModel("mTestModel");
```

Append the title page and the table of contents.

```
add(rpt,TitlePage("Title",sprintf('%s',model.Name)));
add(rpt,TableOfContents);
```

Introduction

Add sections and paragraphs to add textual information to the report.

```
Introduction = Chapter("Title", "Introduction");
sec1_1 = Section('Title', "Purpose");
p1 = Paragraph(['This document provides a comprehensive architectural ...' ...
    'overview of the system using a number of different architecture views...' ...
    ' to depict different aspects of the system. It is intended to capture...' ...
    ' and convey the significant architectural decisions which have been...' ...
    ' made for the system.']);
append(sec1_1, p1);

sec1_2 = Section("Scope");
p2 = Paragraph(['This System Architecture Description provides an architectural...' ...
    ' overview of the Mobile Robot System being designed and developed by the...' ...
    ' Acme Corporation. The document was generated directly from the Mobile...' ...
    ' Robot models implemented in MATLAB, Simulink and System Composer.']);
append(sec1_2, p2);
append(Introduction, sec1_1);
append(Introduction, sec1_2);
```

Architectural Elements

Create a new chapter to represent architectural elements.

```
ArchitecturalElements = Chapter("Architecture Description");
```

Use the Simulink® `slreportgen.finder.SystemDiagramFinder` (Simulink Report Generator) finder to add a snapshot of the model to the report.

```
systemContext = Section(model.Name);
finder = SystemDiagramFinder(model.Name);
finder.SearchDepth = 0;
results = find(finder);
append(systemContext, results);

append(ArchitecturalElements, systemContext);
```

Use the `systemcomposer.rptgen.finder.ComponentFinder` finder to report on components in the model.

```
cf = ComponentFinder(model.Name);
cf.Query = AnyComponent();
comp_finder = find(cf);

for comp = comp_finder
    componentSection = Section("Title", comp.Name);
```

Create a list of components allocated from or to a particular component using the `systemcomposer.rptgen.finder.AllocationListFinder` finder.

```
    d = AllocationListFinder(fullfile(matlabroot, 'toolbox', 'systemcomposer', 'examples', 'rpt'
    compObject = lookup(model,'UUID',comp.Object);
    d.ComponentName = getfullname(compObject.SimulinkHandle);
    result = find(d);
    append(componentSection, comp);
```

Append the component information to the report.

```
    append(systemContext,componentSection);
```

Append the allocation information to the report.

```
    append(systemContext, result);
end
```

Allocation Sets

Create a chapter to report on the allocation sets associated with the model.

Find all allocation sets using the `systemcomposer.rptgen.finder.AllocationSetFinder` finder.

```
allocation_finder = AllocationSetFinder(fullfile(matlabroot, 'toolbox', 'systemcomposer', 'examp
AllocationChapter = Chapter("Allocations");
while hasNext(allocation_finder)
    alloc = next(allocation_finder);
    allocationName = Section(alloc.Name);
    append(allocationName, alloc);
    append(AllocationChapter, allocationName);
end
```

Architecture Views

Create a chapter to display information about the architecture views in the model.

Find all the views using the `systemcomposer.rptgen.finder.ViewFinder` finder.

```
ViewChapter = Chapter("Architecture Views");
view_finder = ViewFinder(model.Name);
while(hasNext(view_finder))
    v = next(view_finder);
    viewName = Section('Title', v.Name);
    append(viewName, v);
    append(ViewChapter, viewName);
end
```

Dependency Graph

Create a chapter to display the dependency graph image using the `systemcomposer.rptgen.report.DependencyGraph` reporter.

```
Packaging = Chapter("Packaging");
packaging = Section('Title', 'Packaging');
graph = systemcomposer.rptgen.report.DependencyGraph("Source", [model.Name '.slx']);
append(packaging, graph);
append(Packaging, packaging);
```

Requirements Analysis

Report on all the requirement sets and requirement link sets associated with the model.

```
ReqChapter = Chapter("Requirements Analysis");
```

Requirement Sets

Collect the requirement sets using the `systemcomposer.rptgen.finder.RequirementSetFinder` finder.

```
RequirementSetSection = Section("Requirement Sets");
reqFinder1 = RequirementSetFinder(fullfile(matlabroot, 'toolbox', 'systemcomposer', 'examples',
result = find(reqFinder1);
pp = Paragraph("This requirement set describes the system requirements for the mobile robot that
append(RequirementSetSection, pp);
append(RequirementSetSection, result.getReporter);
```

Requirement Link Sets

Collect the requirement link sets using the `systemcomposer.rptgen.finder.RequirementLinkFinder` finder.

```
RequirementLinkSection = Section("Requirement Link Sets");
reqLinkFinder = RequirementLinkFinder(fullfile(matlabroot, 'toolbox', 'systemcomposer', 'example
resultL = find(reqLinkFinder);
rptr = systemcomposer.rptgen.report.RequirementLink("Source", resultL);
append(RequirementLinkSection, rptr);

append(ReqChapter, RequirementSetSection);
append(ReqChapter, RequirementLinkSection);
```

Interfaces

Create a chapter to report on all the interfaces in the model.

Check if any dictionaries are linked within the model using the `systemcomposer.rptgen.finder.DictionaryFinder` finder.

```
df = DictionaryFinder(model.Name);
dictionary = find(df);
```

```
No Dictionaries present in the Model
```

```
boolHasNoDictionary = isempty(dictionary)
```

```
boolHasNoDictionary = logical
   1
```

Since `boolHasNoDictionary` is `true`, create a separate chapter for interfaces to report on all the interfaces associated with the model using the `systemcomposer.rptgen.finder.InterfaceFinder` finder.

```
if boolHasNoDictionary
    InterfaceChapter = Chapter("Interfaces Appendix");
    interfaceFinder = InterfaceFinder(model.Name);
    interfaceFinder.SearchIn = "Model";
    while hasNext(interfaceFinder)
        intf = next(interfaceFinder);
        interfaceName = Section(intf.InterfaceName);
        append(interfaceName, intf);
        append(InterfaceChapter, interfaceName);
    end
end
```

Profiles

Create a chapter to report on all the profiles in the model.

Find all the profiles using the `systemcomposer.rptgen.finder.ProfileFinder` finder.

```
ProfileChapter = Chapter("Profiles Appendix");
pf = ProfileFinder("TestProfile.xml");
while hasNext(pf)
    intf = next(pf);
    profileName = Section(intf.Name);
    append(profileName, intf);
    append(ProfileChapter, profileName);
end
```

Stereotypes

Create a section to report on all the stereotypes in the profiles in the model.

Find all the stereotypes using the `systemcomposer.rptgen.finder.StereotypeFinder` finder.

```
StereotypeSection = Section("Stereotypes");
sf = StereotypeFinder("TestProfile.xml");
while hasNext(sf)
    stf = next(sf);
    stereotypeName = Section(stf.Name);
    append(stereotypeName, stf);
    append(StereotypeSection, stereotypeName);
end

append(ProfileChapter, StereotypeSection);
```

Final Report

Add all the chapters to the report in the desired order.

```
append(rpt, Introduction);
append(rpt, ArchitecturalElements);
append(rpt, ViewChapter);
append(rpt, Packaging);
append(rpt, AllocationChapter);
append(rpt, ReqChapter);
append(rpt, InterfaceChapter);
append(rpt, ProfileChapter);

rptview(rpt)
```

See Also

`importModel` | `exportModel`

More About

- “Compose Architectures Visually” on page 1-2
- “Create Architecture Views Interactively” on page 11-5
- “Create and Manage Allocations Programmatically” on page 8-8
- “Manage Requirements” on page 2-8
- “Define Port Interfaces Between Components” on page 3-2
- “Define Profiles and Stereotypes” on page 5-2
- “Import and Export Architecture Models” on page 13-5