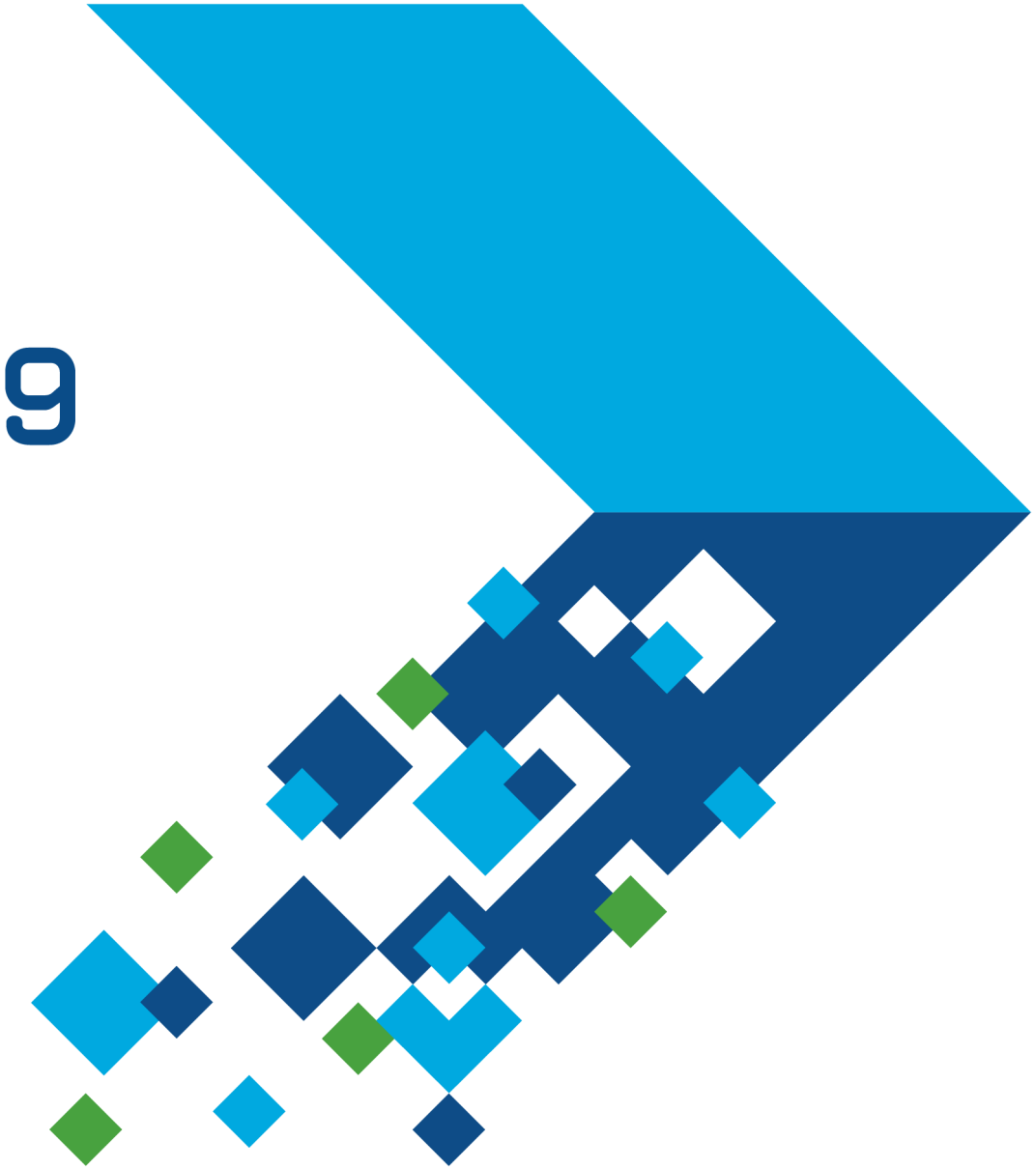
MATLAB EXPO 2019



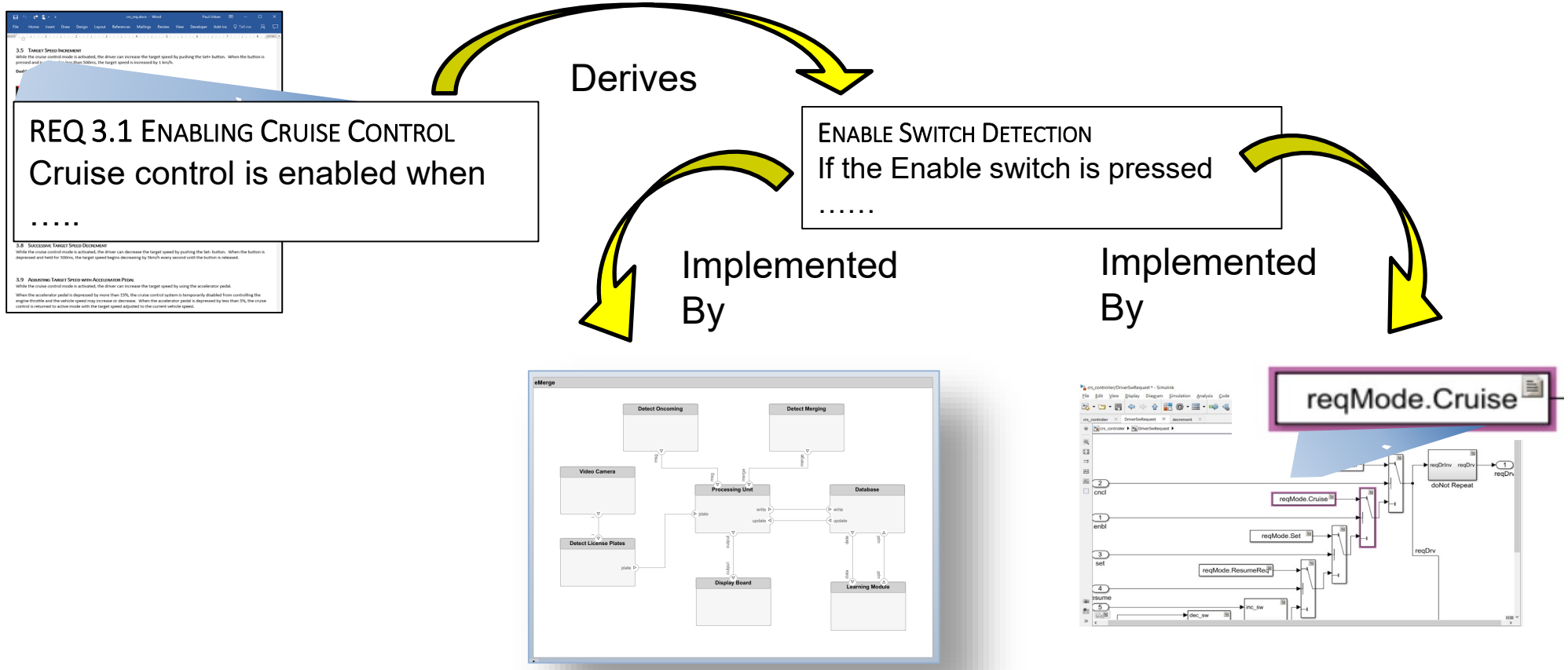
Systems Engineering

Requirements to Architecture to Simulation

Gaurav Dubey, MathWorks

Key Takeaways

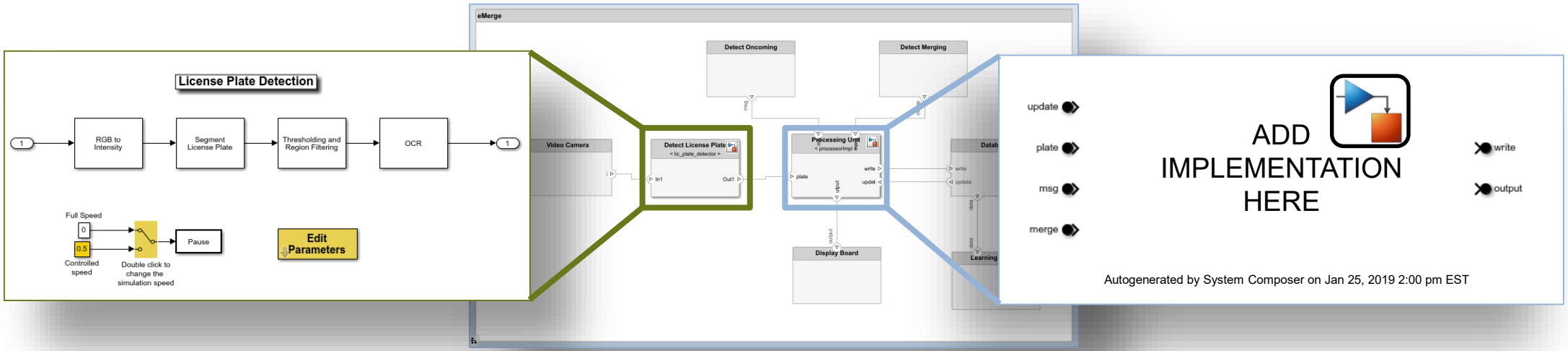
- Digital thread providing traceability between requirements, architecture, and design



Key Takeaways

- Digital thread providing traceability between requirements, architecture, and design

- Connected environment for designing and analyzing architectures and designs

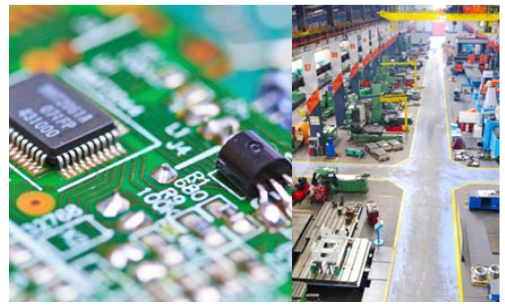


Key Takeaways

- Digital thread providing traceability between requirements, architecture, and design
- Connected environment for designing and analyzing architectures and designs
- Integrated platform for analyzing all parts of your architecture in one multi-domain environment

Dynamic Systems

State Machines

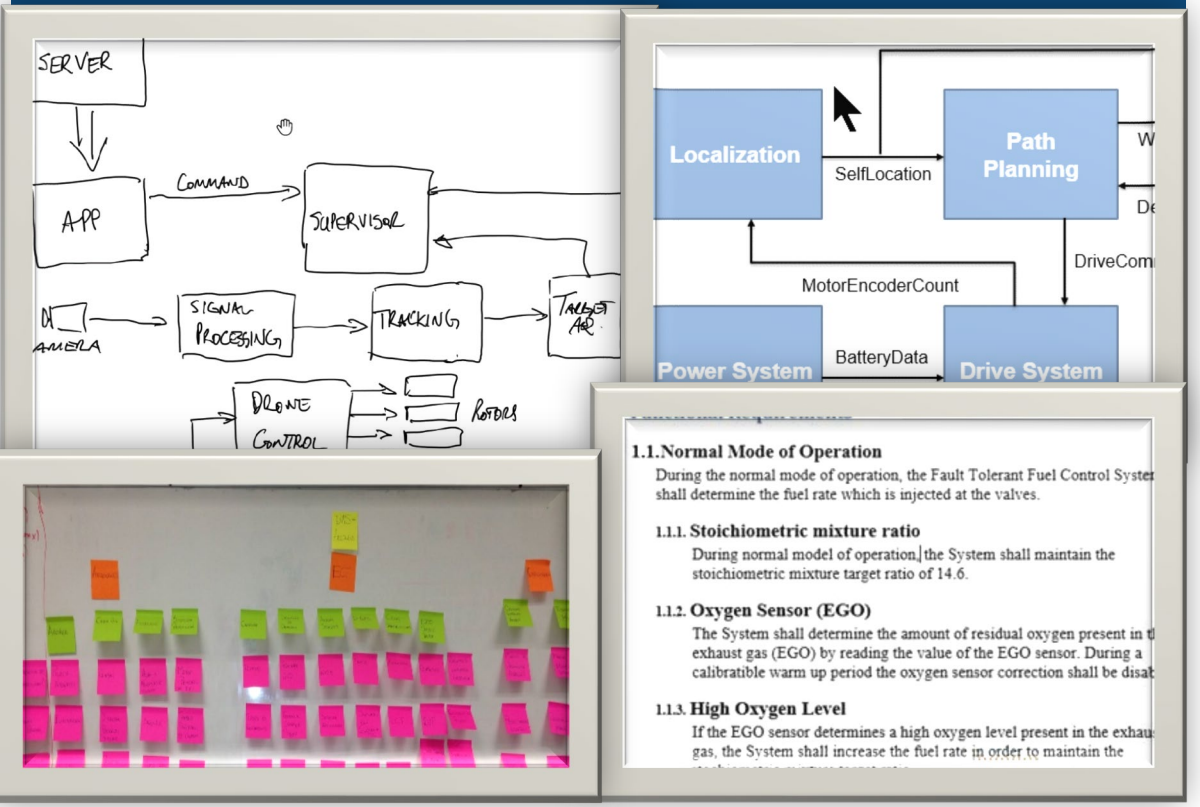


Discrete-Event

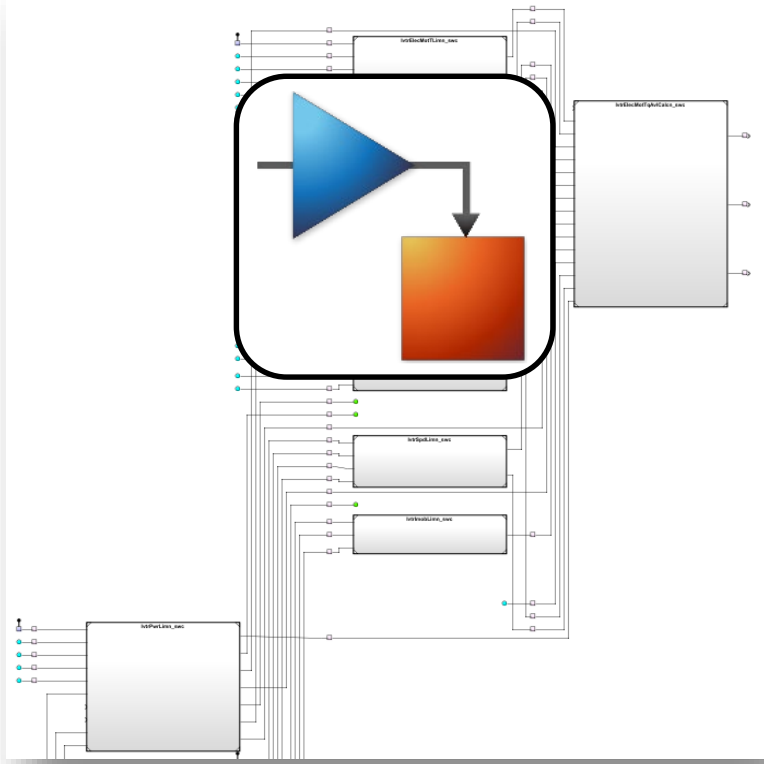
Physical Modeling

What does that mean?

Early in the Process
Concepts/Descriptions

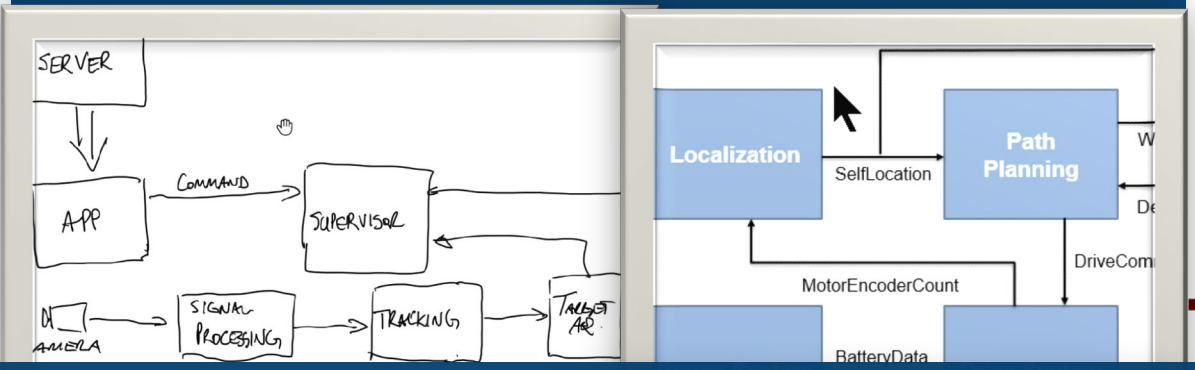


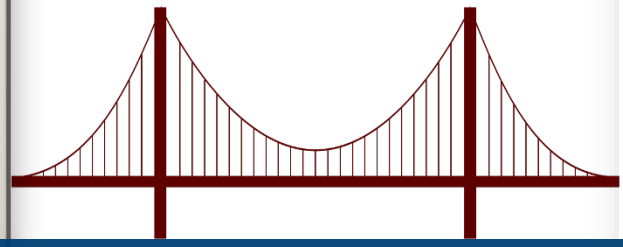
Later in the Process
Models



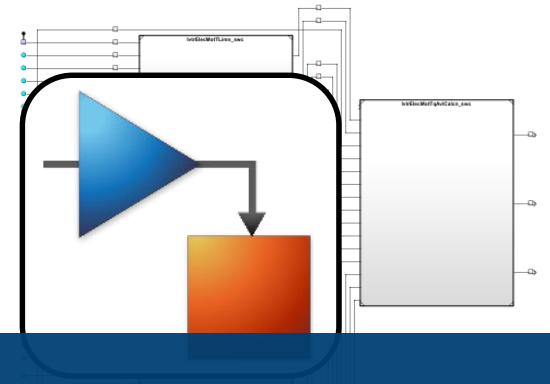
What is the Gap?

Early in the Process
Concepts/Descriptions





Later in the Process
Models



Digital Thread
Connected Environment
Analysis & Simulation Platform

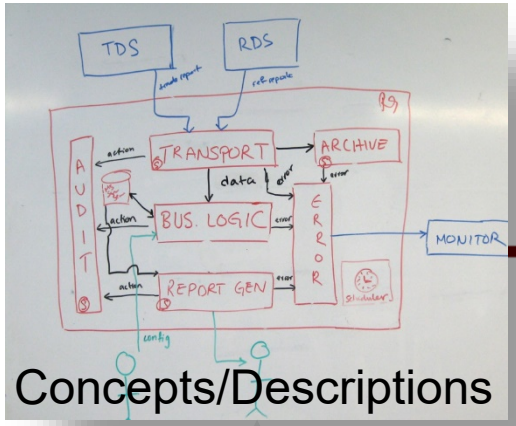
What goes into the bridge?

Be Intuitive

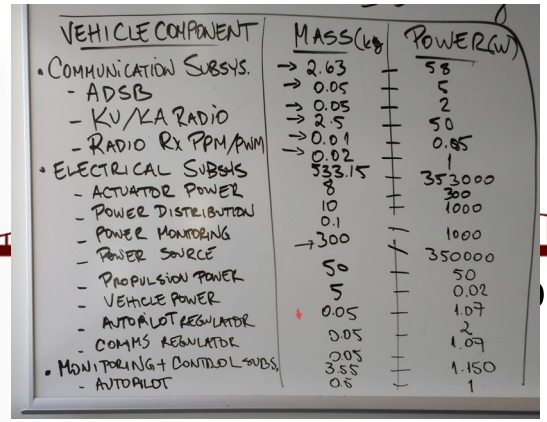
Facilitate Analysis

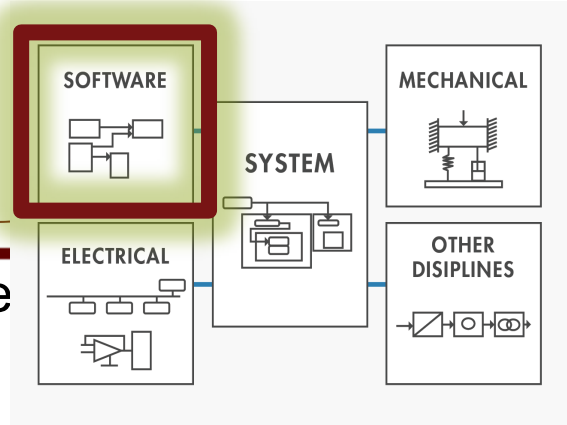
Tackle Complexity

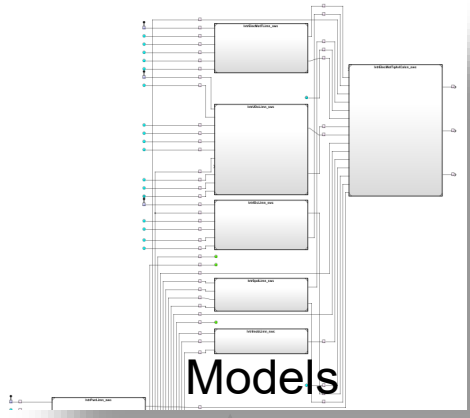
Enable Implementation



Concepts/Descriptions

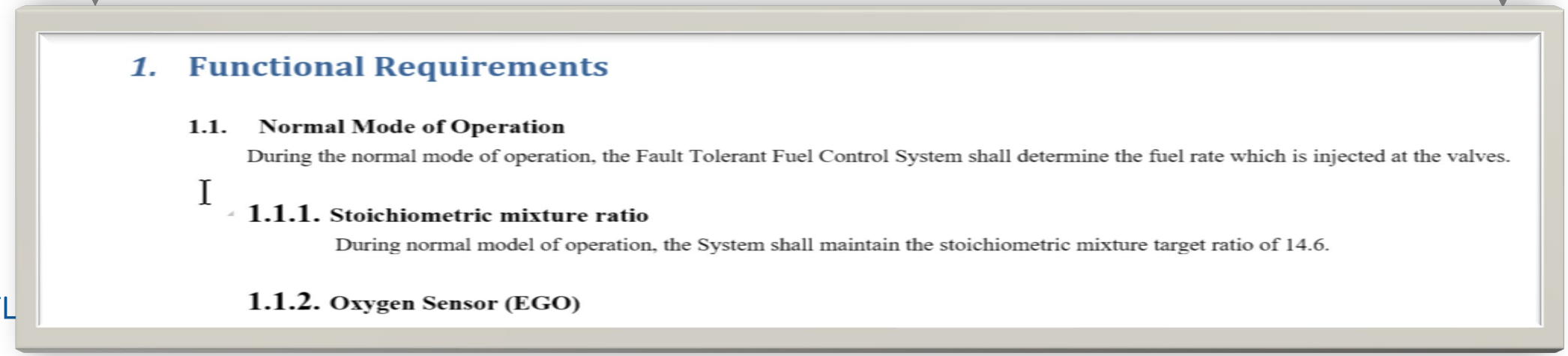






Models

Digital Thread for Traceability



1. Functional Requirements

1.1. Normal Mode of Operation

During the normal mode of operation, the Fault Tolerant Fuel Control System shall determine the fuel rate which is injected at the valves.

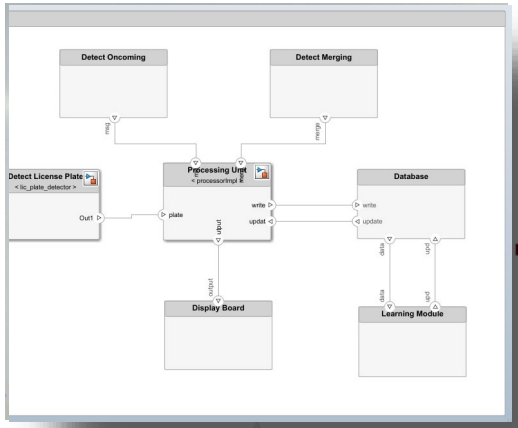
1.1.1. Stoichiometric mixture ratio

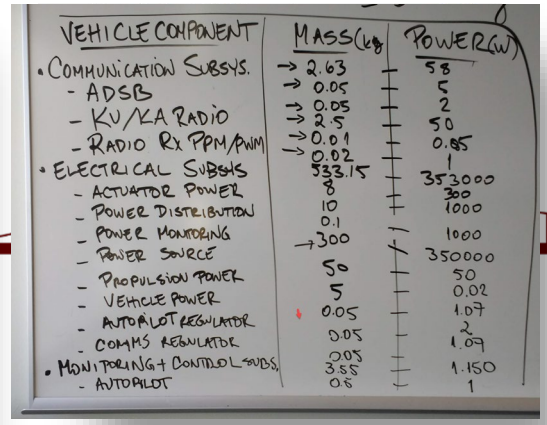
During normal model of operation, the System shall maintain the stoichiometric mixture target ratio of 14.6.

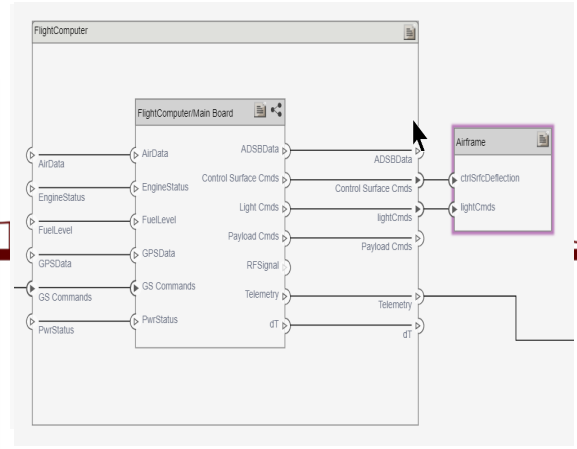
1.1.2. Oxygen Sensor (EGO)

MathWorks Solution: System Composer R2019a and

✓Be Intuitive ✓Facilitate Analysis ✓Tackle Complexity ✓Enable Implementation

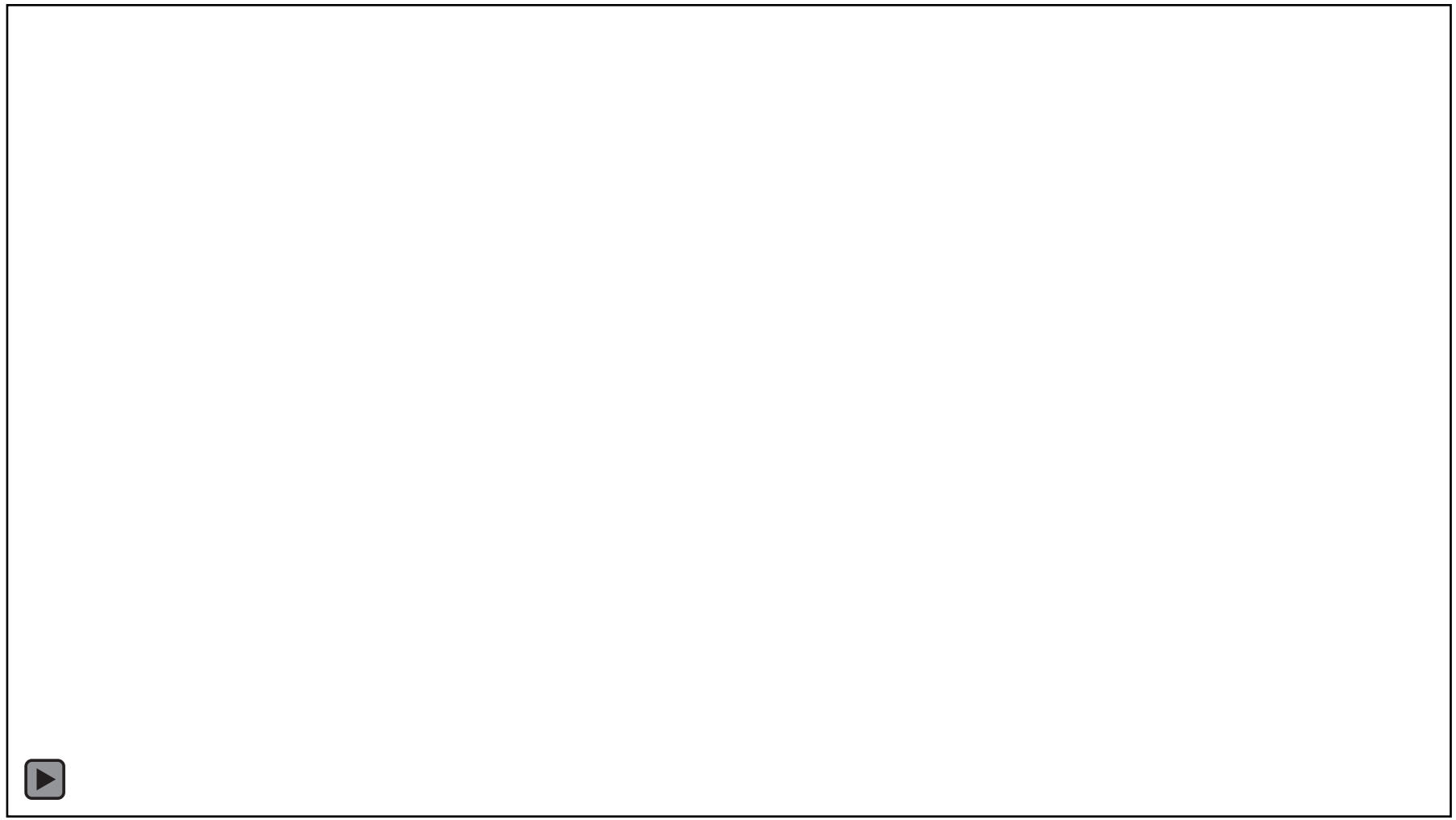


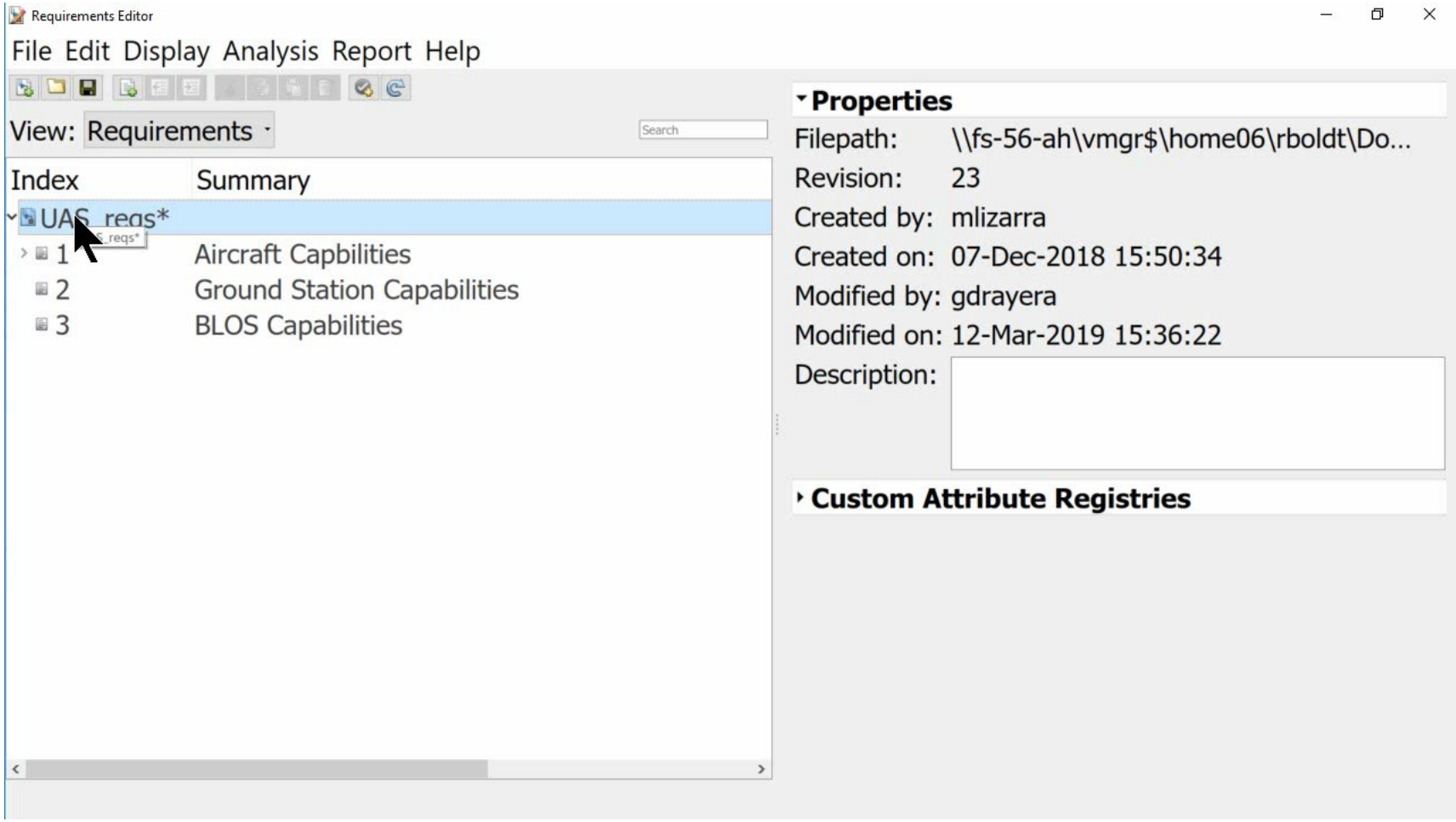




Requirements Coverage Reporting and Impact Analysis

Now let’s see it in action




Requirements Editor
File Edit Display Analysis Report Help
View: Requirements
Search
Index
Summary
UAS_reqs*
1
Aircraft Capbilities
2
Ground Station Capabilities
3
BLOS Capabilities
Properties
Filepath: \\fs-56-ah\vmgr$\home06\rboldt\Do...
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Created on: 07-Dec-2018 15:50:34
Modified by: gdrayera
Modified on: 12-Mar-2019 15:36:22
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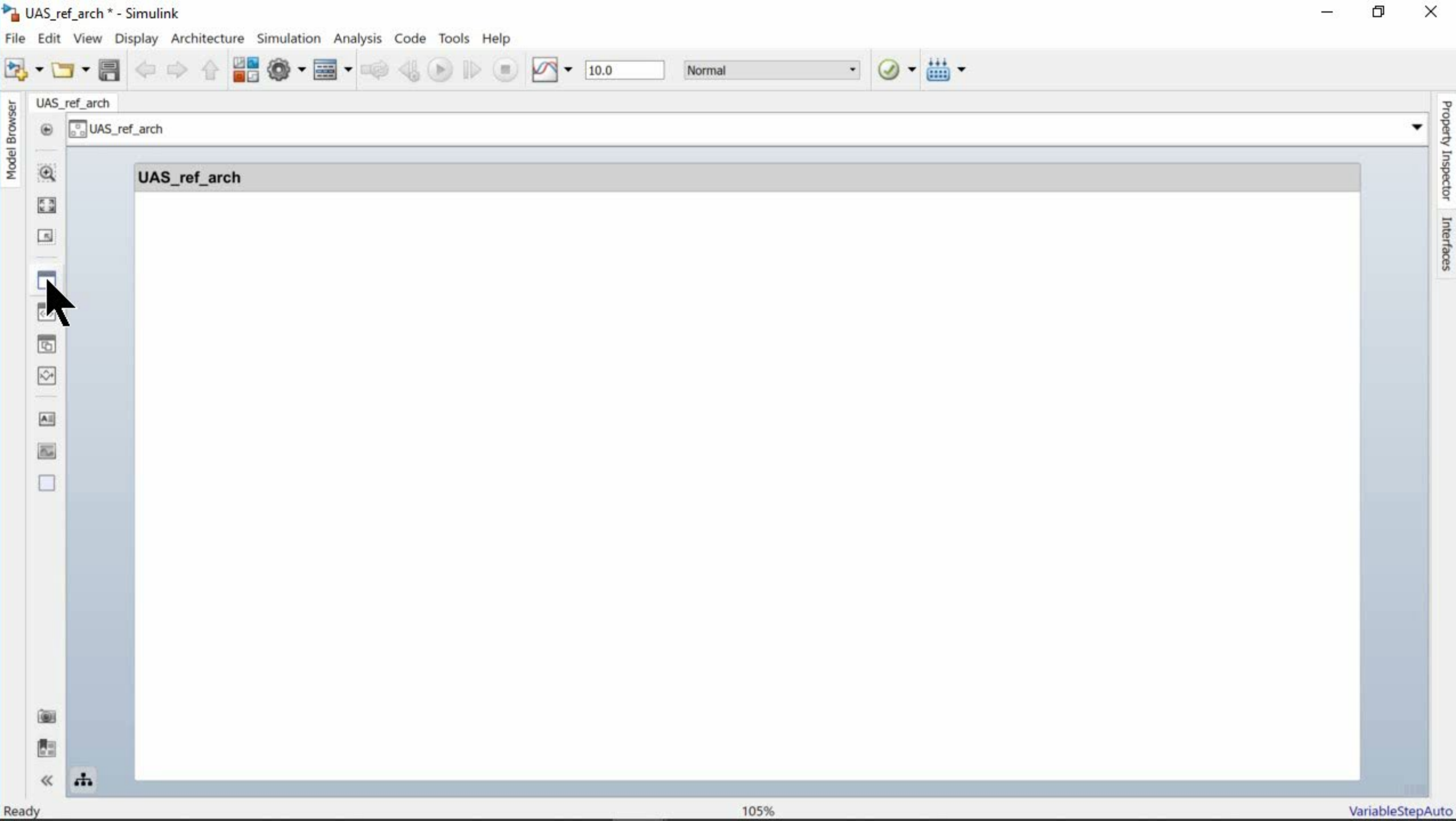
Custom Attribute Registries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Model Browser
Property Inspector
Interfaces
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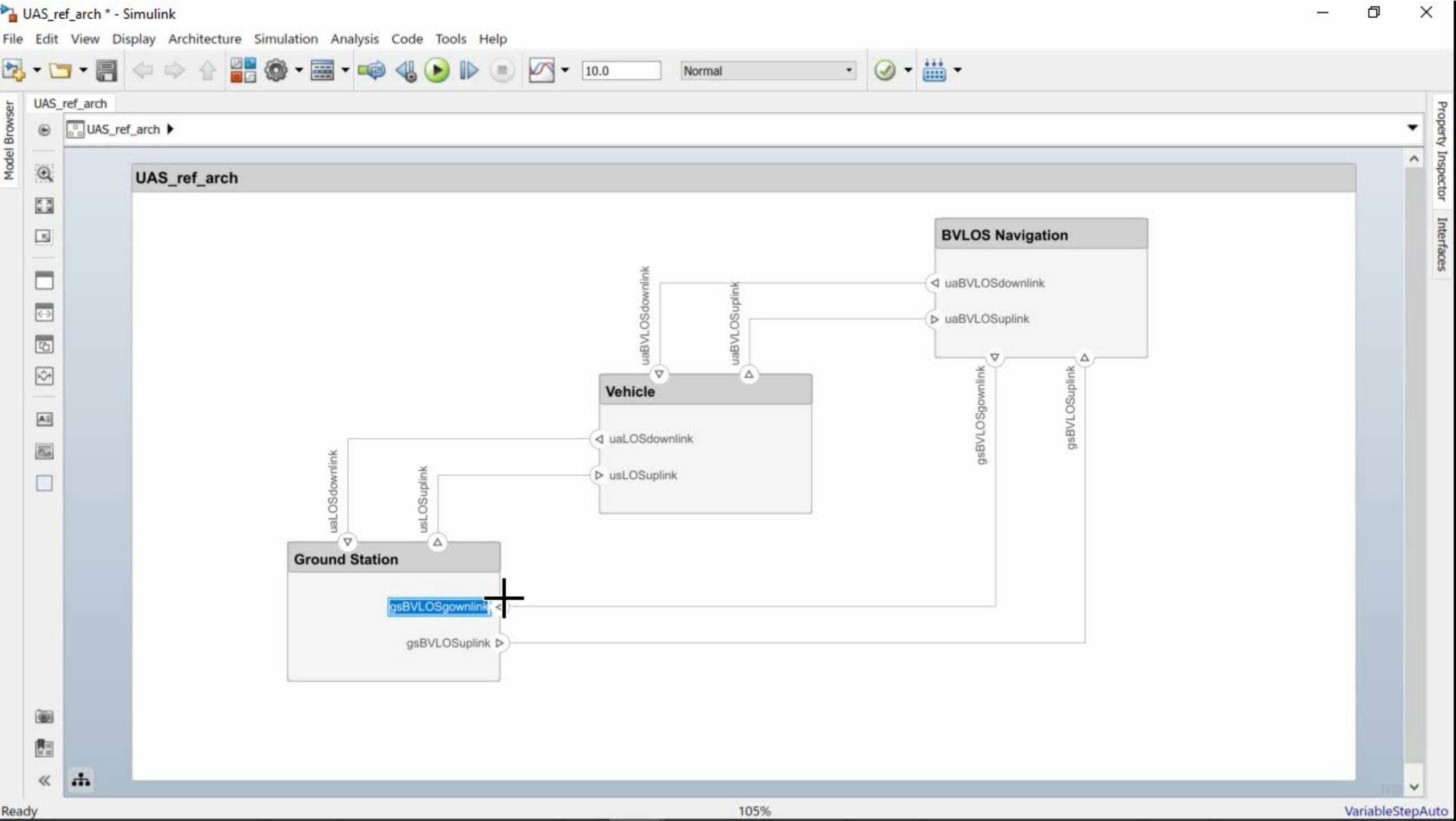
Ready
105%
VariableStepAuto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uaBVLOSuplink
uaBVLOSdownlink
uaBVLOSuplink
Vehicle
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usLOSuplink
gsBVLOSgownlink
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usLOSuplink
Ground Station
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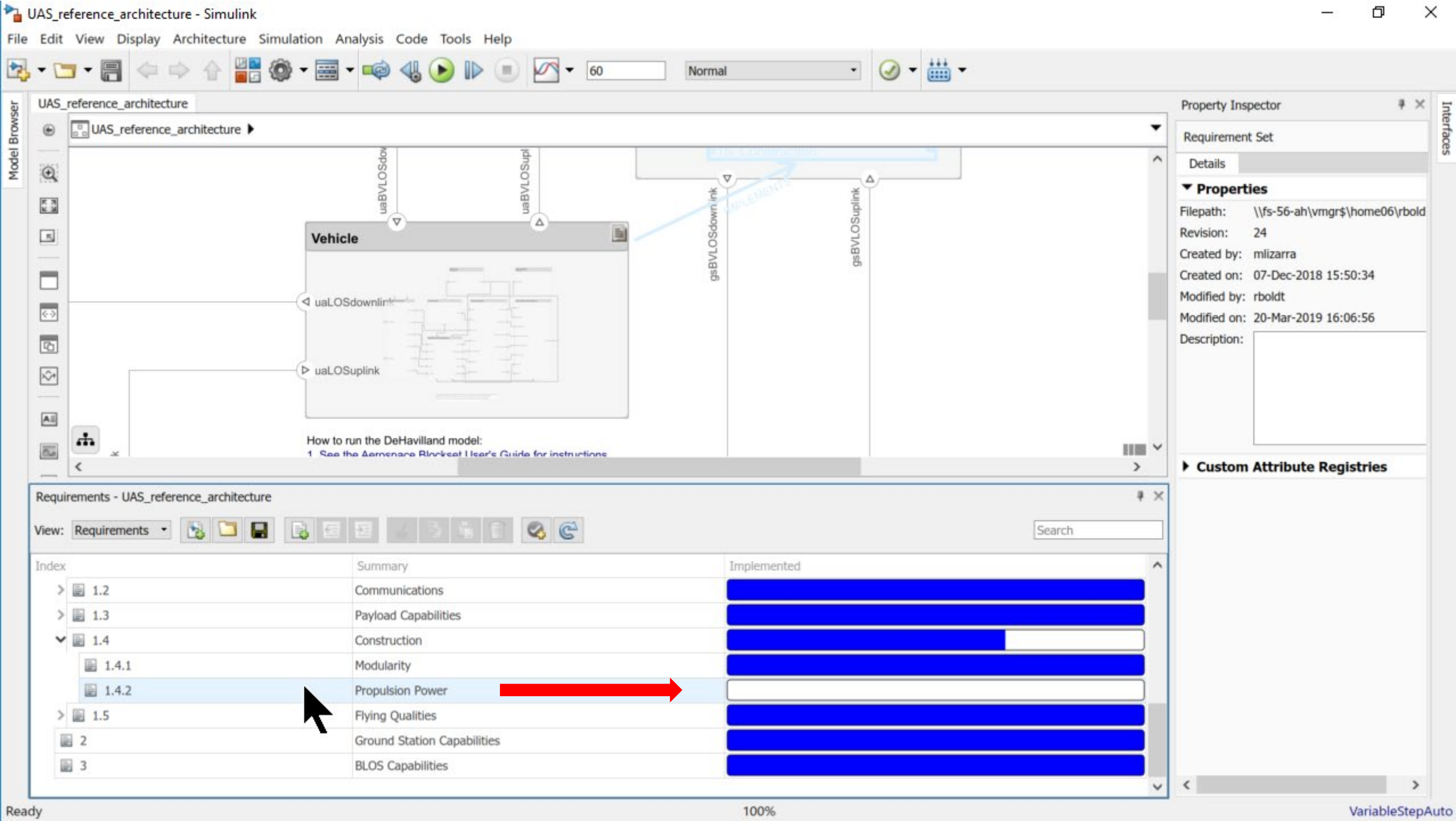
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Normal
Model Browser
UAS_reference_architecture
UAS_reference_architecture
Vehicle
uaLOSdownlink
uaLOSuplink
gsBVLOSdownlink
gsBVLOSuplink
How to run the DeHavilland model:
1. See the Aerospace Blockset User's Guide for instructions
Property Inspector
Requirement Set
Details
Properties
Filepath: \\fs-56-ah\vmgr$\home06\rbold
Revision: 24
Created by: mlizarra
Created on: 07-Dec-2018 15:50:34
Modified by: rboldt
Modified on: 20-Mar-2019 16:06:56
Description:
Custom Attribute Registries
Interfaces
Requirements - UAS_reference_architecture
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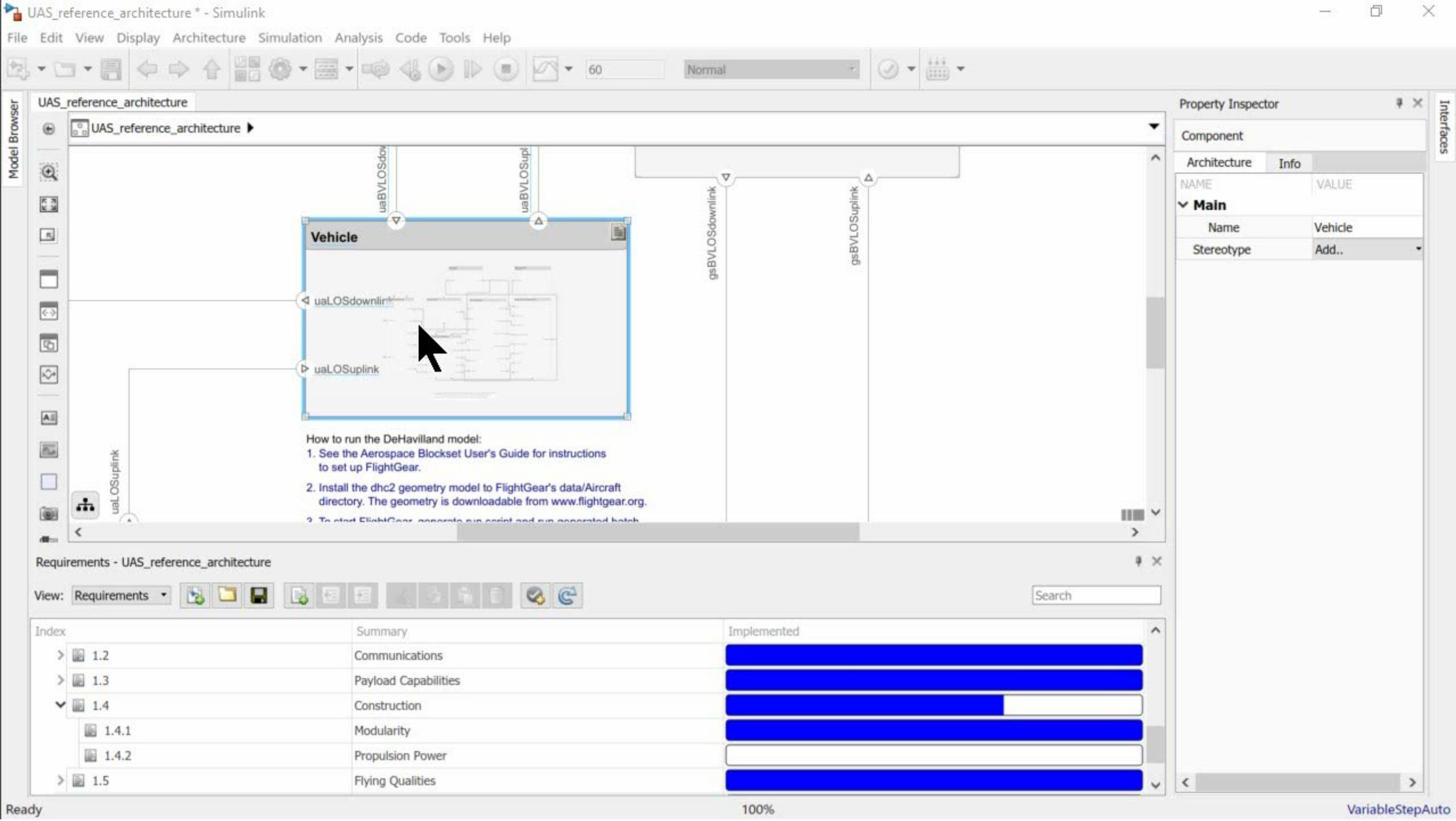
1.3 Payload Capabilities
1.4 Construction
1.4.1 Modularity
1.4.2 Propulsion Power
1.5 Flying Qualities
2 Ground Station Capabilities
3 BLOS Capabilities
Ready
100%
VariableStepAuto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Model Browser
UAS_reference_architecture
UAS_reference_architecture
Vehicle
uaLOSdownlink
uaLOSuplink
uaBVLOSdow
uaBVLOSupl
gsBVLOSdownlink
gsBVLOSuplink
uaLOSuplink
How to run the DeHavilland model:
1. See the Aerospace Blockset User's Guide for instructions to set up FlightGear.
2. Install the dhc2 geometry model to FlightGear's data/Aircraft directory. The geometry is downloadable from www.flightgear.org.
Property Inspector
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NAME
VALUE
Main
Name
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1.3 Payload Capabilities
1.4 Construction
1.4.1 Modularity
1.4.2 Propulsion Power
1.5 Flying Qualities
Ready
100%
VariableStepAuto

UAS_reference_architecture/Vehicle/Electrical Subsystem * - Simulink

File Edit View Display Architecture Simulation Analysis Code Tools Help

Model Browser

Electrical Subsystem

UAS_reference_architecture ▸ Vehicle ▸ Electrical Subsystem ▸

propulsionSupply

actuatorsSupply

vehicleSupply

Propulsion Power Subsystem
< Engine_Power_Nm_s >

apControls apControls

EnvBus EnvBus

enginePower enginePower

Property Inspector

Requirement: #35

Details

Properties

Type: Functional

Index: 1.4.2

Custom ID: #35

Summary: Propulsion Power

Description Rationale

Arial 14

Gas Engine: Nine-cylinder, air-cooled, radial aircraft engine
Fuel type: 80/87 grade aviation gasoline
Dry weight: 290 kg
Power output:
400 hp (298 kW) at

Keywords:

Revision information:

Links

No links

Comments

Interfaces

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View: Requirements

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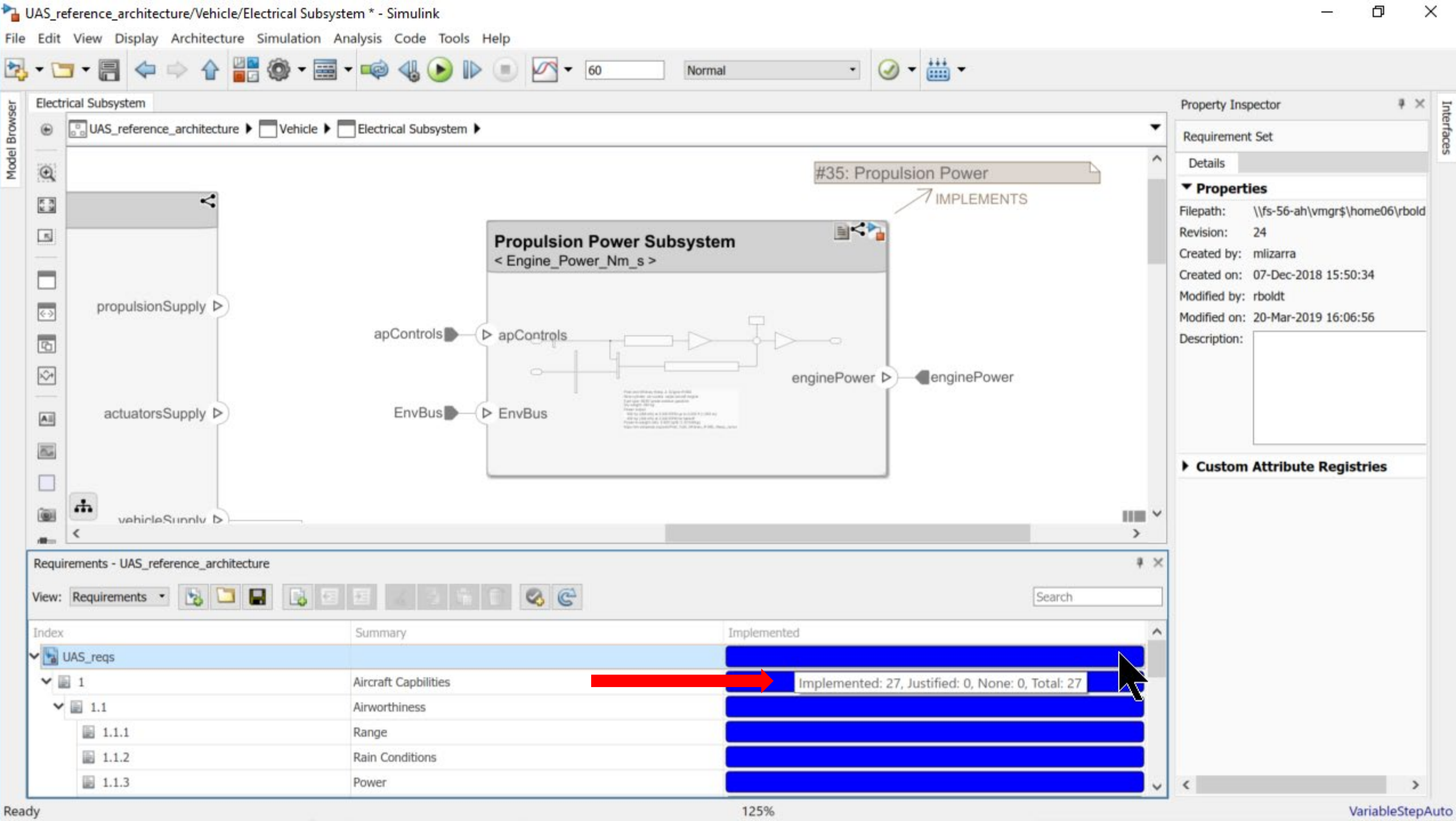
Index	Summary	Implemented
1.2	Communications	
1.3	Payload Capabilities	
1.4	Construction	
1.4.1	Modularity	
1.4.2	Propulsion Power	
1.5	Flyin alities	

Ready

125%

VariableStepAuto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File Edit View Display Architecture Simulation Analysis Code Tools Help
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Normal
Model Browser
Electrical Subsystem
UAS_reference_architecture
Vehicle
Electrical Subsystem
#35: Propulsion Power
IMPLEMENTS
Propulsion Power Subsystem
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actuatorsSupply
vehicleSupply
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apControls
EnvBus
EnvBus
enginePower
enginePower
Property Inspector
Requirement Set
Details
Properties
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Created by: mlizarra
Created on: 07-Dec-2018 15:50:34
Modified by: rboldt
Modified on: 20-Mar-2019 16:06:56
Description:
Custom Attribute Registries
Interfaces
Requirements - UAS_reference_architecture
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Implemented
UAS_reqs
1
Aircraft Capbilities
Implemented: 27, Justified: 0, None: 0, Total: 27
1.1
Airworthiness
1.1.1
Range
1.1.2
Rain Conditions
1.1.3
Power
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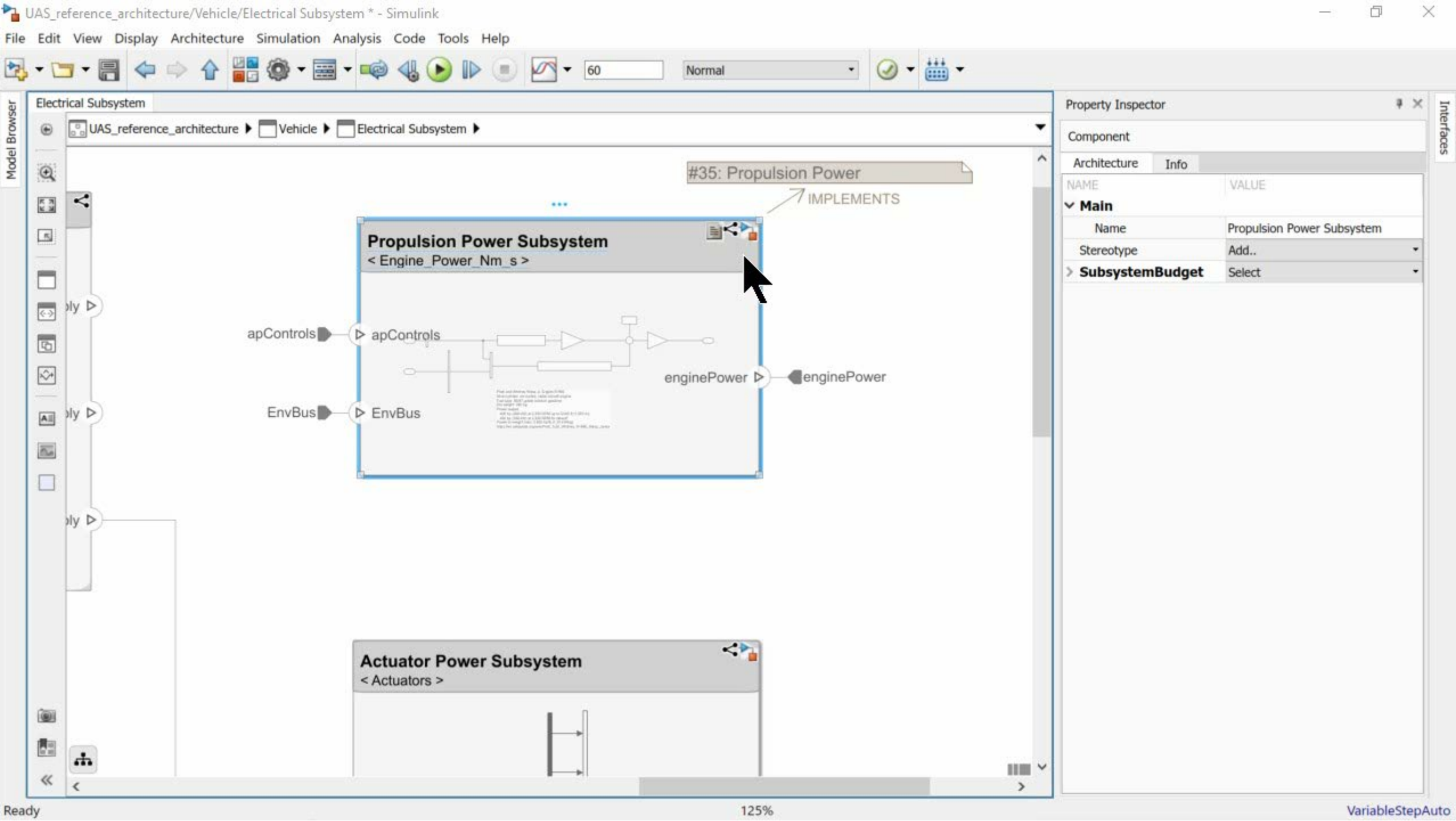
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Model Browser
Electrical Subsystem
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Vehicle
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#35: Propulsion Power
IMPLEMENTS
Propulsion Power Subsystem
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apControls
enginePower
enginePower
EnvBus
EnvBus
Actuator Power Subsystem
< Actuators >
Property Inspector
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Info
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VALUE
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Name
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SubsystemBudget
Select
Interfaces
Ready
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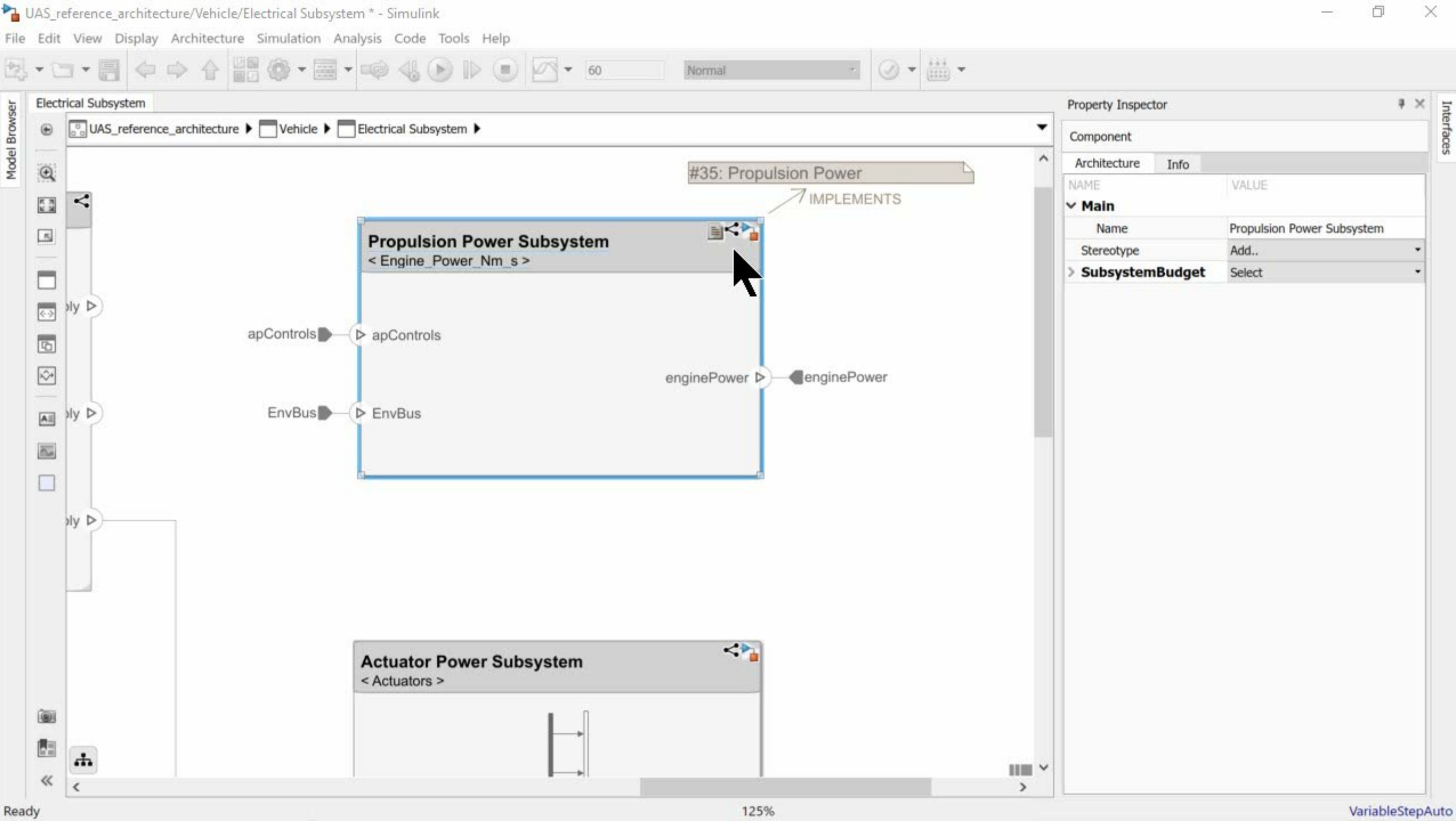
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UAS_reference_architecture
Vehicle
Electrical Subsystem
#35: Propulsion Power
IMPLEMENTS
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Actuator Power Subsystem
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Add..
SubsystemBudget
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Interfaces
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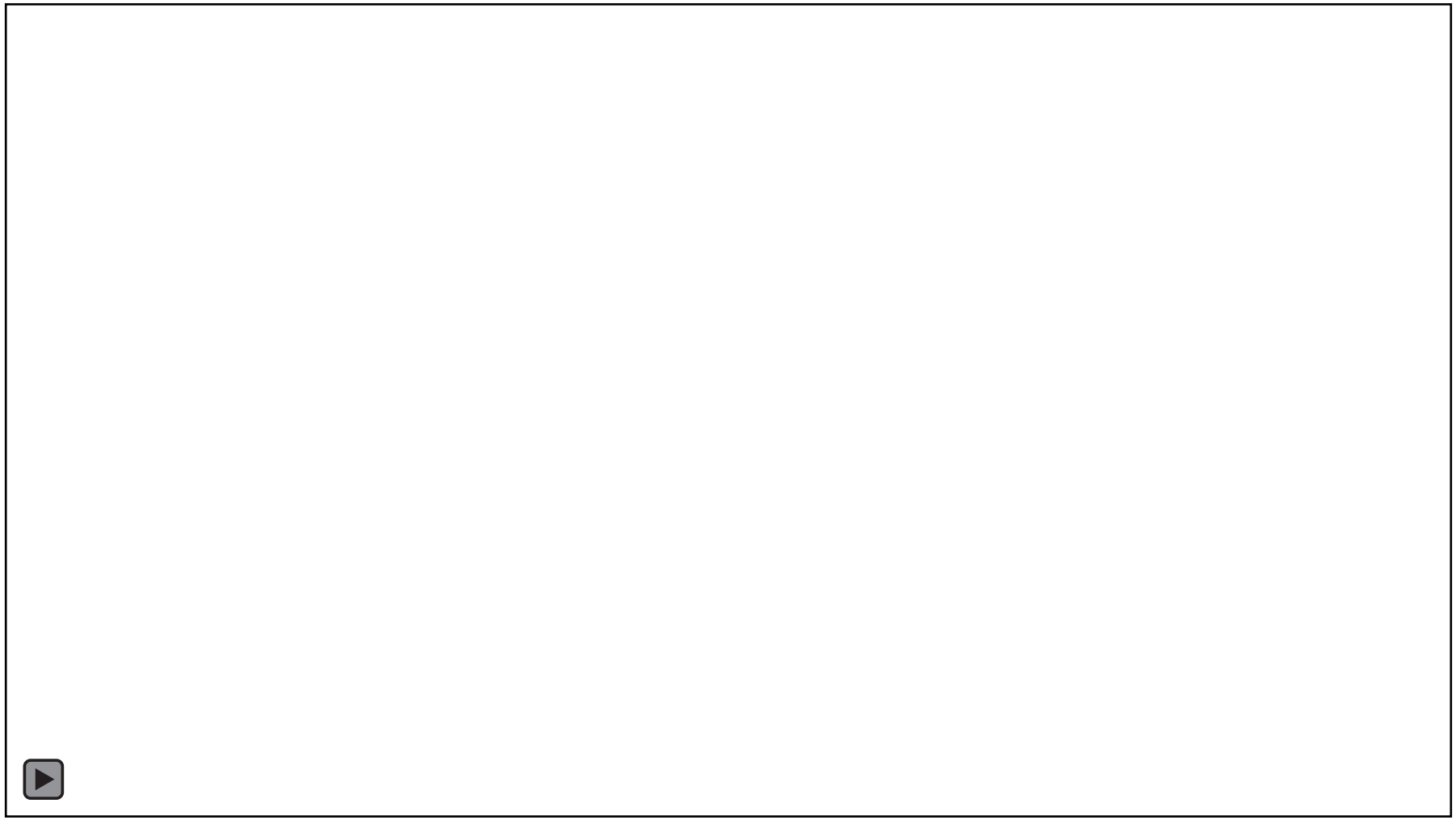
VariableStepAuto



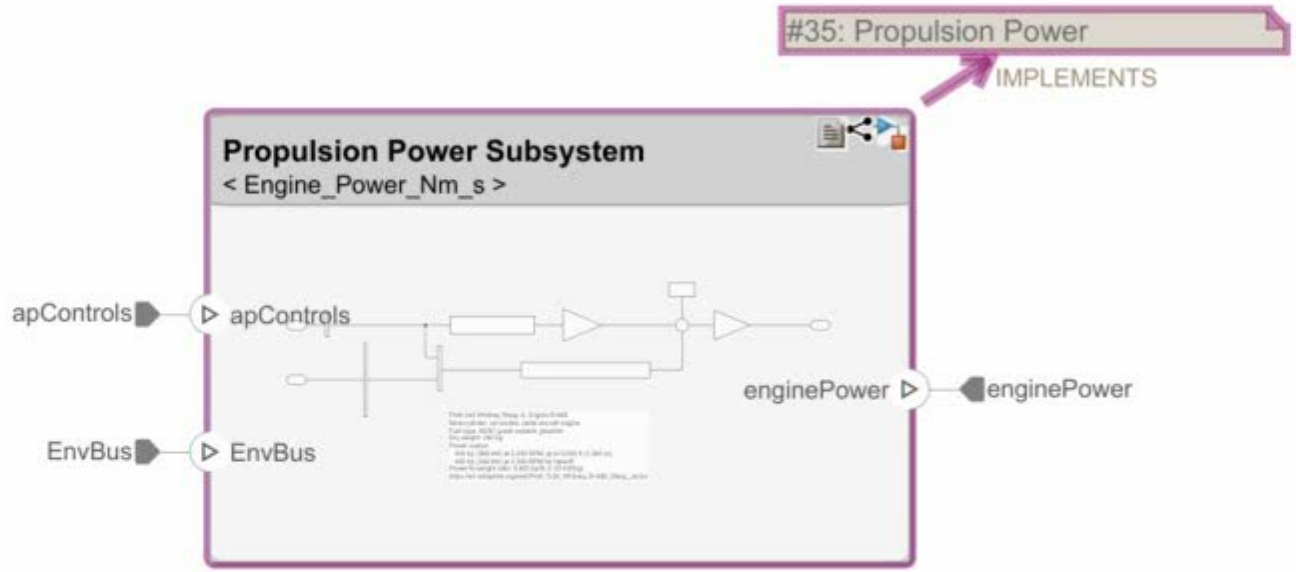
UAS_reference_architecture/Vehicle/Electrical Subsystem * - Simulink

File Edit View Display Architecture Simulation Analysis Code Tools Help

Model Browser

Electrical Subsystem

UAS_reference_architecture ▸ Vehicle ▸ Electrical Subsystem ▸



Requirements - UAS_reference_architecture

View: Requirements

Search

Index	Summary	Implemented
1.4	Construction	
1.4.1	Modularity	
1.4.2	Propulsion Power	
1.5	Flying Qualities	
2	Ground Station Capabilities	

Property Inspector

Requirement: #35

Details

Properties

Type: Functional

Index: 1.4.2

Custom ID: #35

Summary: Propulsion Power

Description Rationale

Arial 14

Engine: Nine-cylinder, air-cooled, radial aircraft engine
Fuel type: 80/87 grade aviation gasoline
Dry weightp/lb (1.03 kW/kg): 290 kg
Power output:
400 hp (298 kW) at 2,200 RPM up

Keywords:

Revision information:

Links

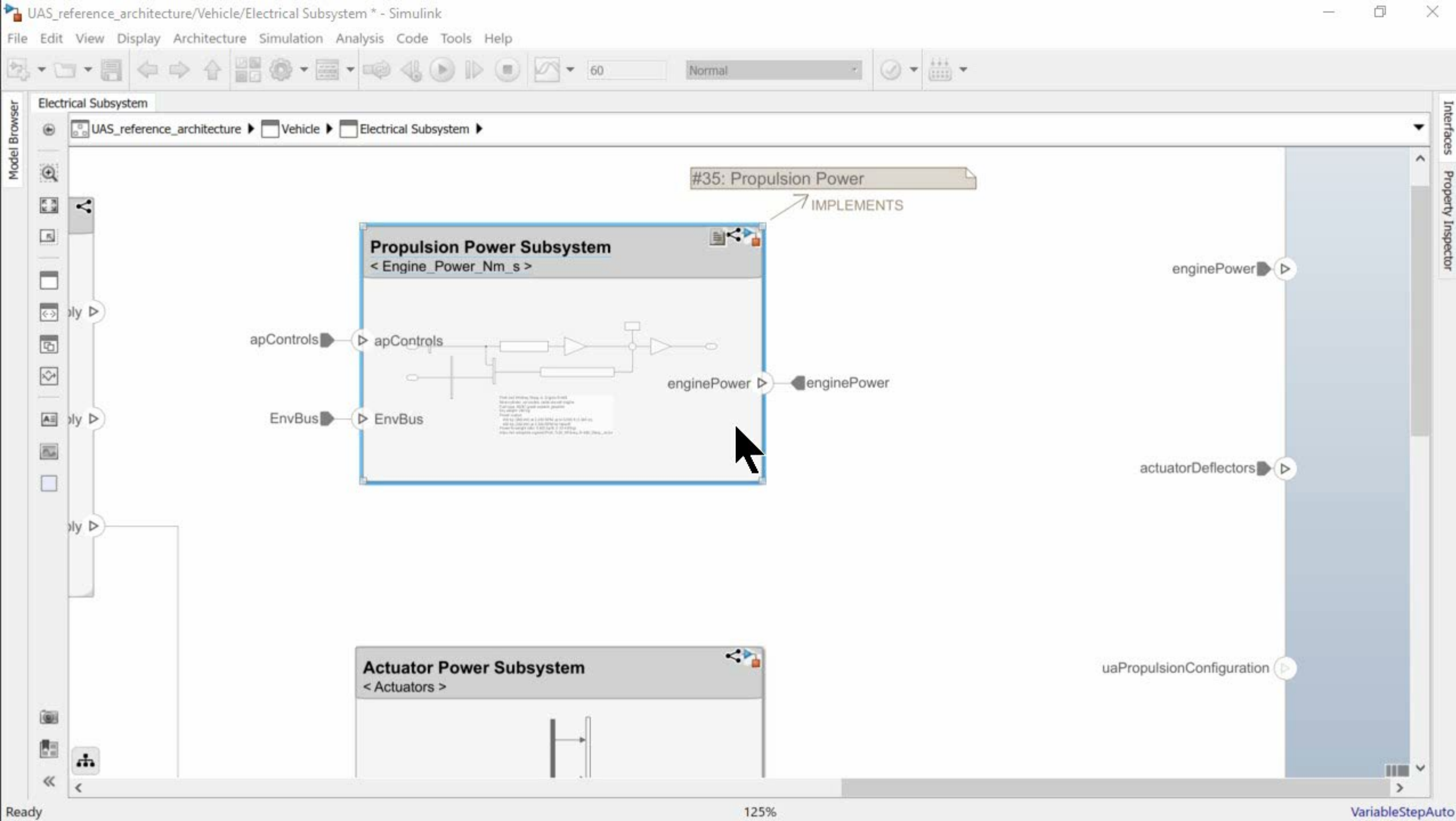
Implemented by:

Propulsion Power Subsystem

Comments

Interfaces

Ready 125% VariableStepAuto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Vehicle
Electrical Subsystem
#35: Propulsion Power
IMPLEMENTS
Propulsion Power Subsystem
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EnvBus
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Property Inspector
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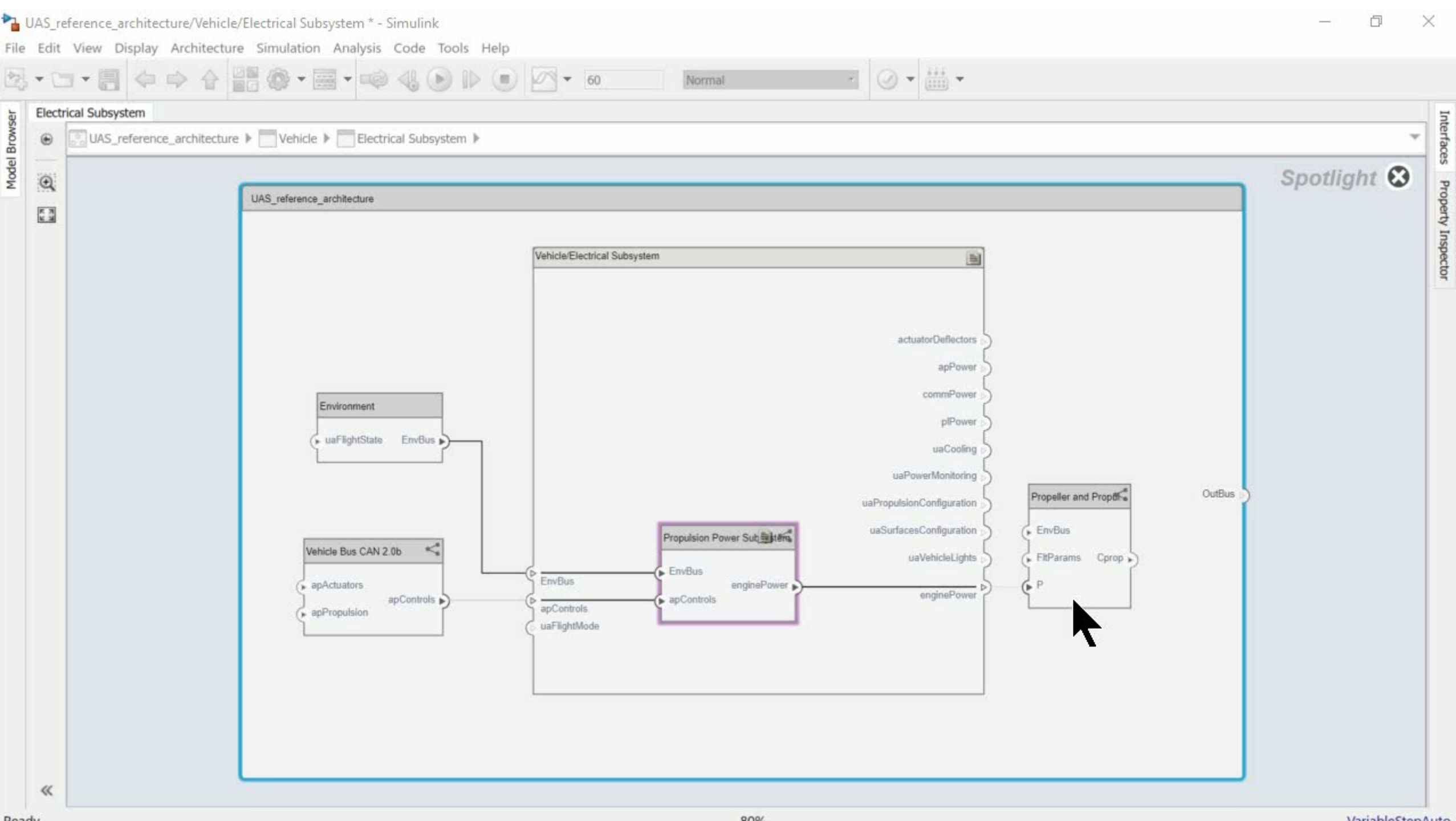
125%
VariableStepAuto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UAS_reference_architecture ▸ Vehicle ▸ Electrical Subsystem ▸
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UAS_reference_architecture
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Environment
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EnvBus
Vehicle Bus CAN 2.0b
apActuators
apPropulsion
apControls
EnvBus
apControls
uaFlightMode
Propulsion Power Subsystem
EnvBus
apControls
enginePower
actuatorDeflectors
apPower
commPower
plPower
uaCooling
uaPowerMonitoring
uaPropulsionConfiguration
uaSurfacesConfiguration
uaVehicleLights
enginePower
Propeller and Propeller
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FltParams
Cprop
P
OutBus
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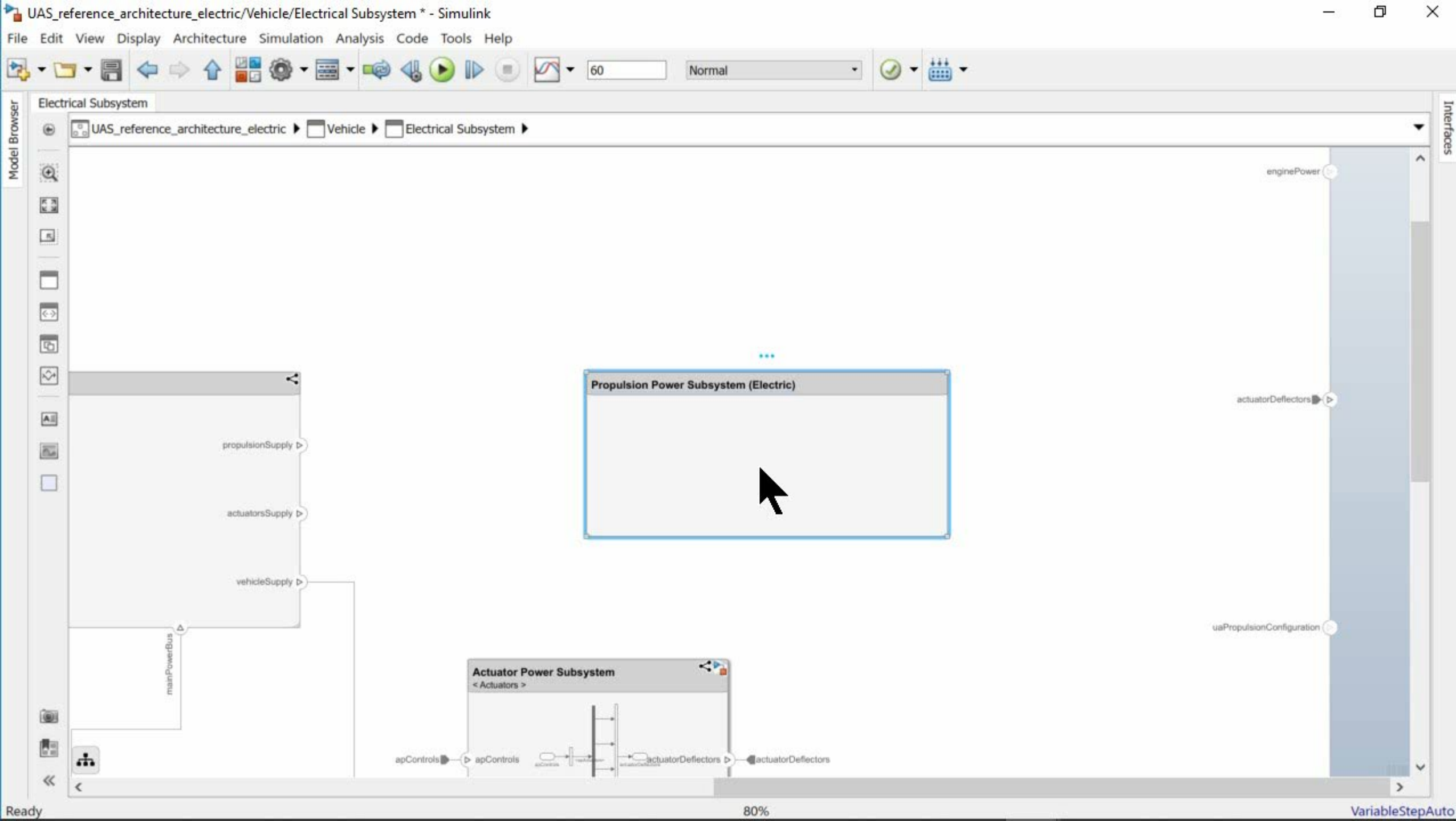
80%
VariableStepAuto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60
Normal
Electrical Subsystem
Model Browser
Interfaces
UAS_reference_architecture_electric
Vehicle
Electrical Subsystem
enginePower
Propulsion Power Subsystem (Electric)
actuatorDeflectors
propulsionSupply
actuatorsSupply
vehicleSupply
uaPropulsionConfiguration
mainPowerBus
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actuatorDeflectors
actuatorDeflectors
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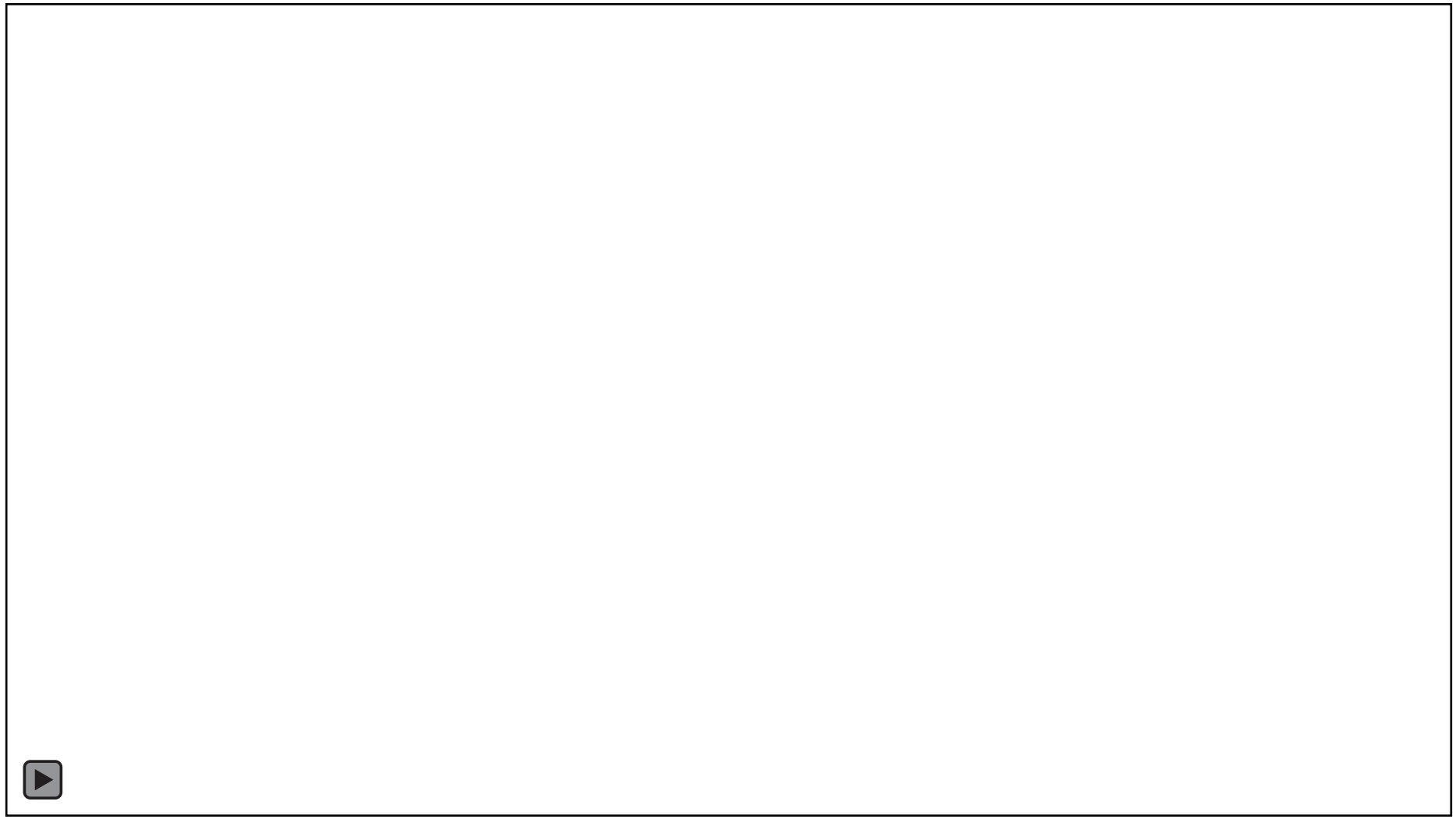
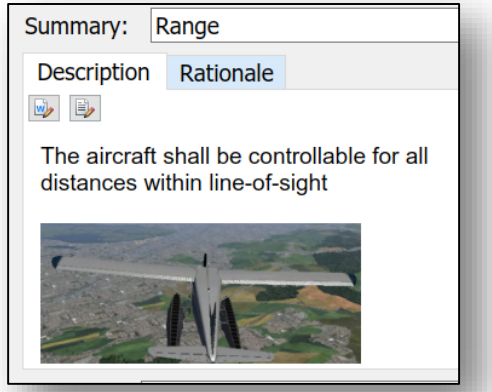
80%
VariableStepAuto



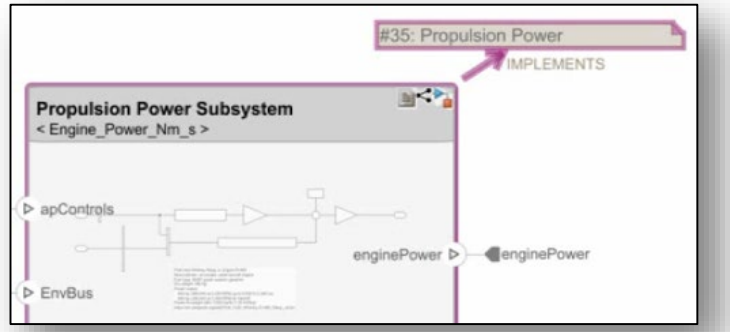
Simulink Requirements

Digital Thread from Requirements to Architecture and Design

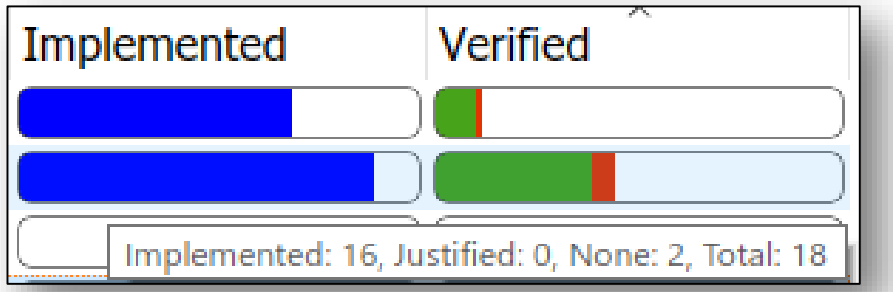
Author requirements or view from external source



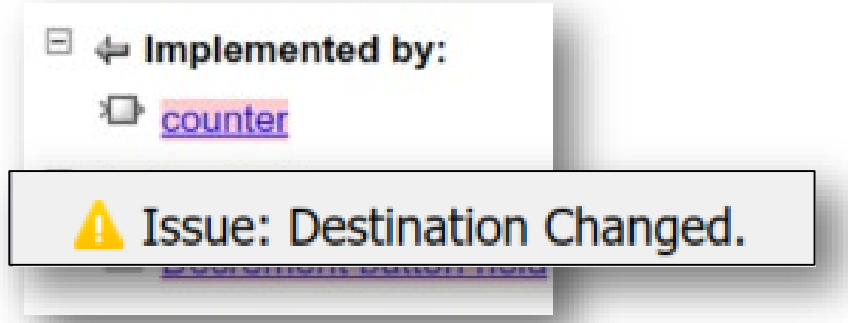
Link requirements, architectures, design, code and test



Identify gaps in architecture or design



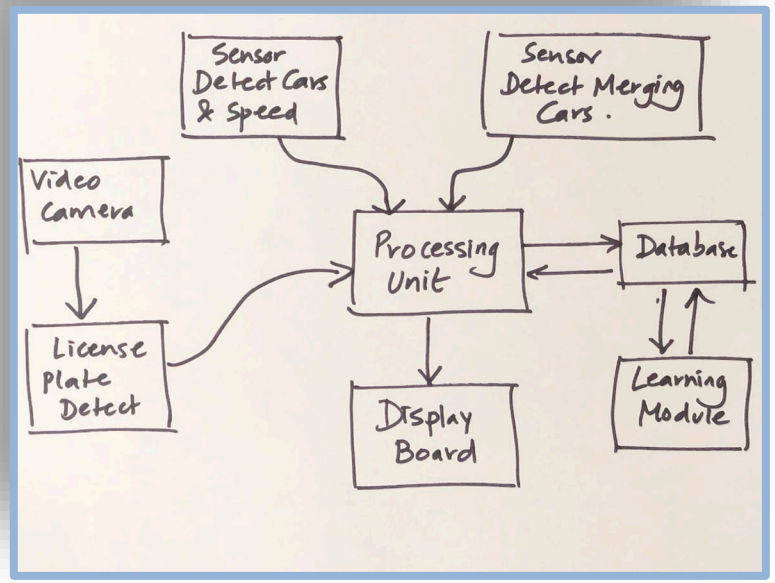
Identify impact of requirement changes



System Composer

Intuitively design system and software architectures

R2019a



Description

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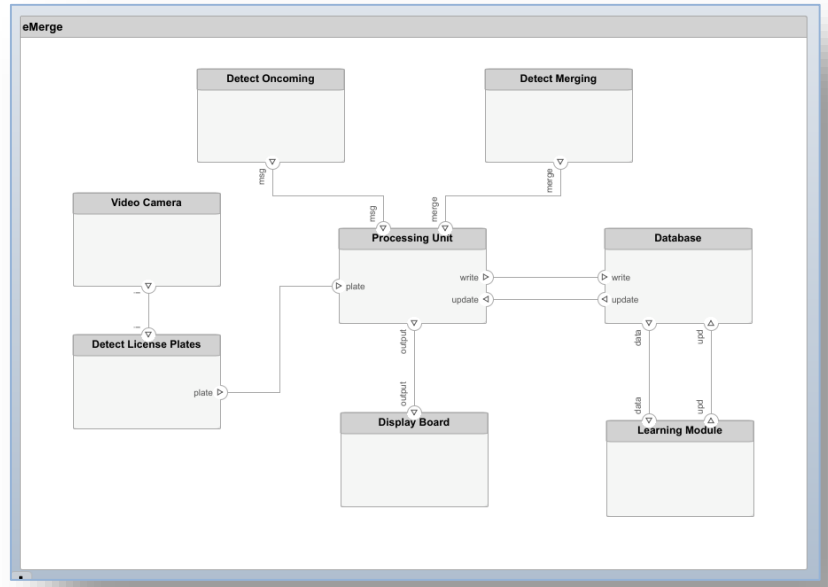
Architecture

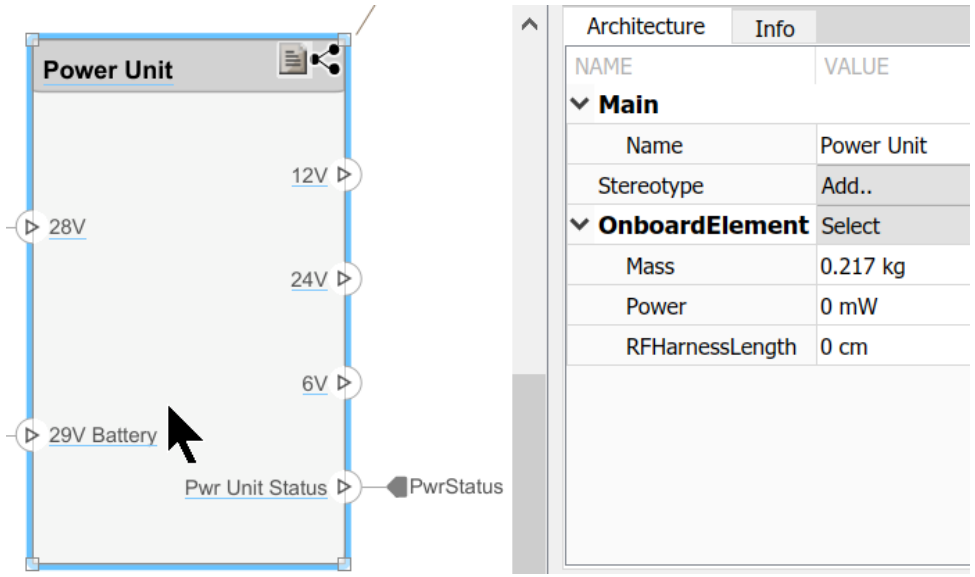


System Composer

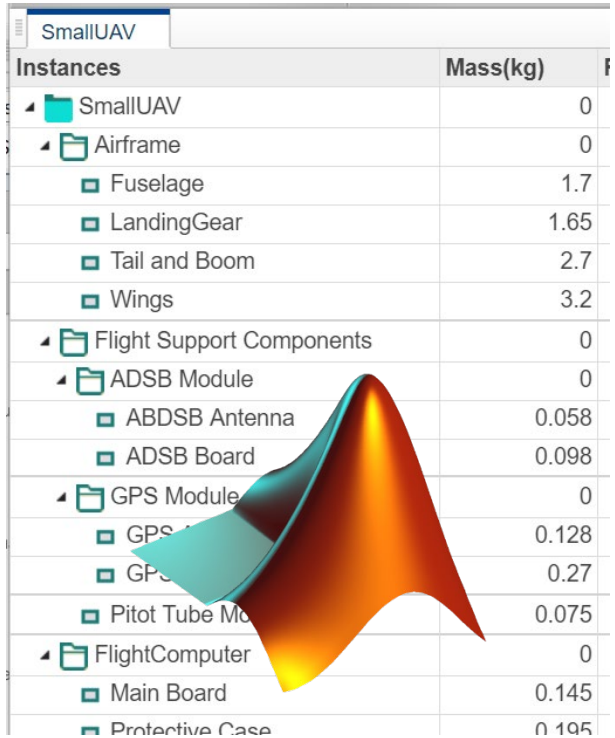
R2019a

Perform trade studies based on data driven analysis to optimize architectures

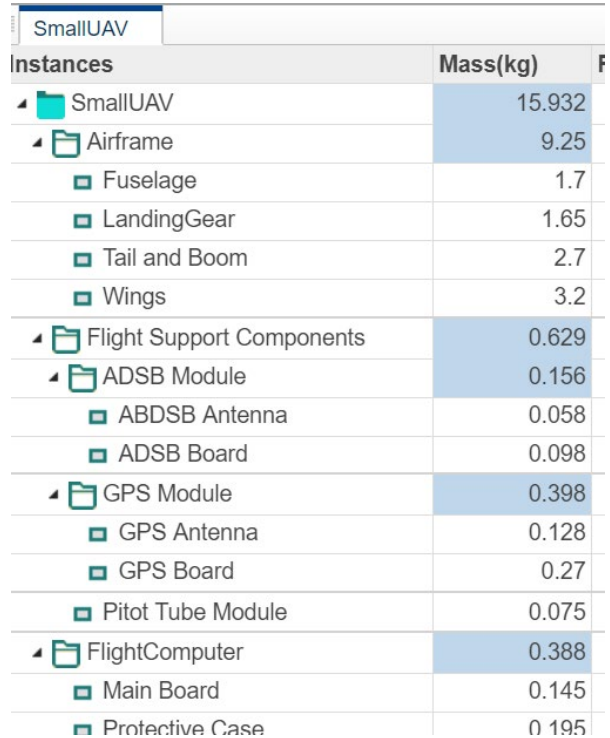
Add custom data



Create analysis model



Calculate mass roll-up data

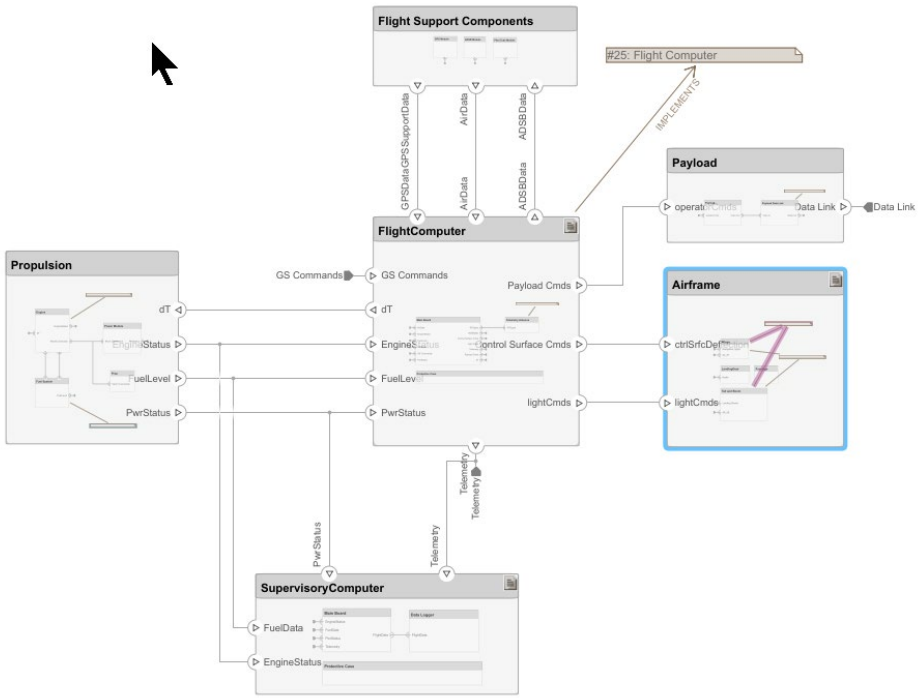


System Composer

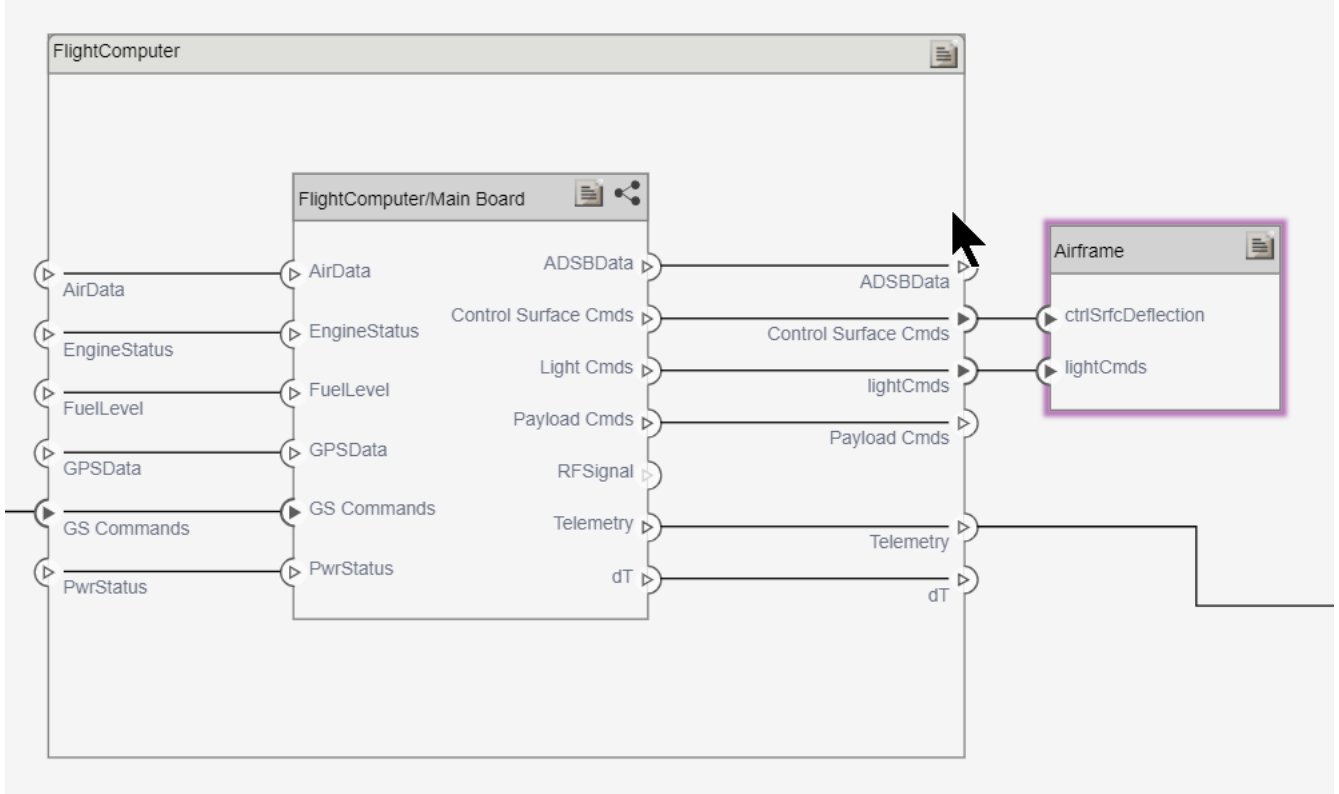
Tackle Architecture complexity with spotlight views

R2019a

Composition



Spotlight

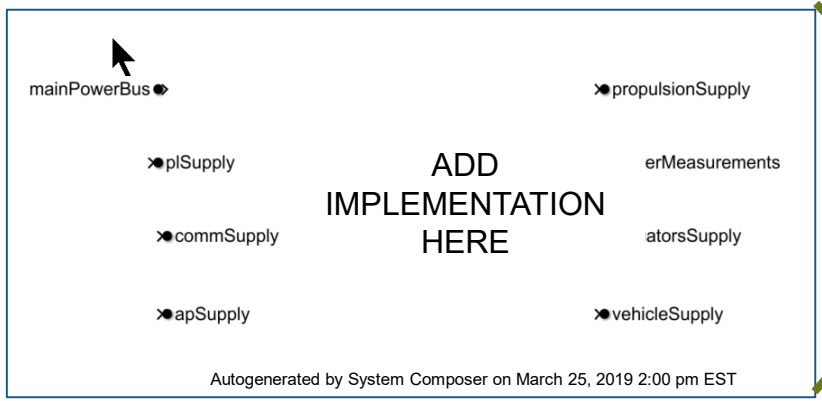


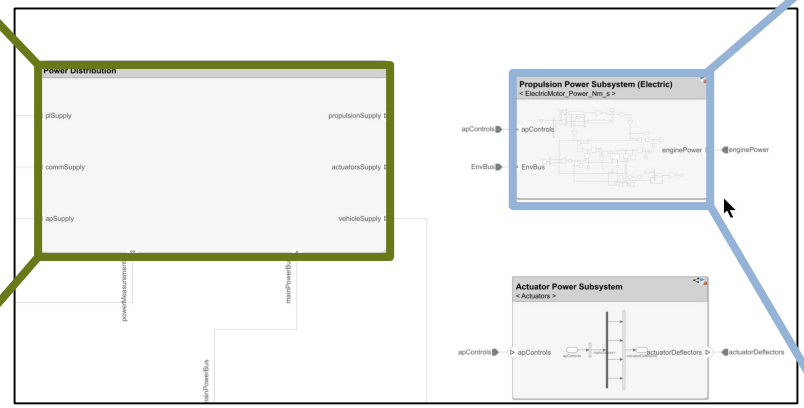
System Composer

R2019a

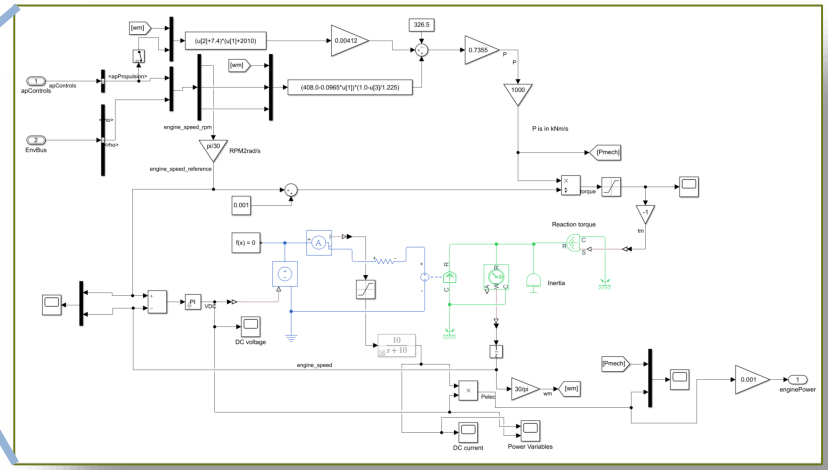
System and software architectures connected to implementations in Simulink

Generate Simulink models from architecture components





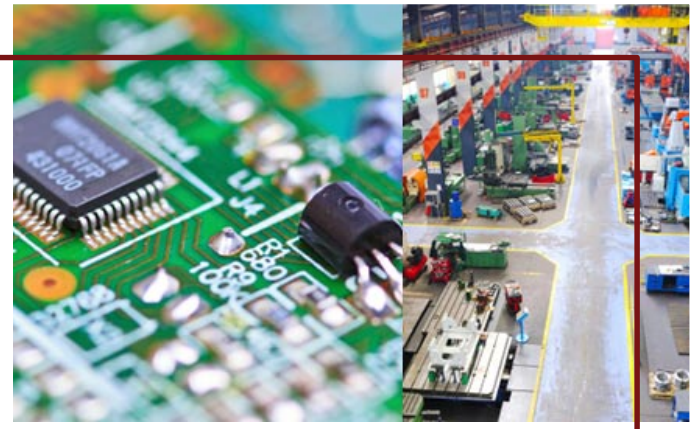
Link Simulink models to architecture components



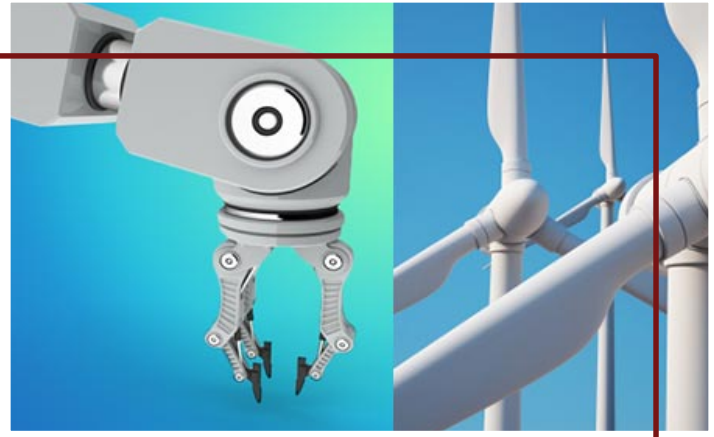
Simulink: A Multi-Language Simulation Environment

Dynamic Systems

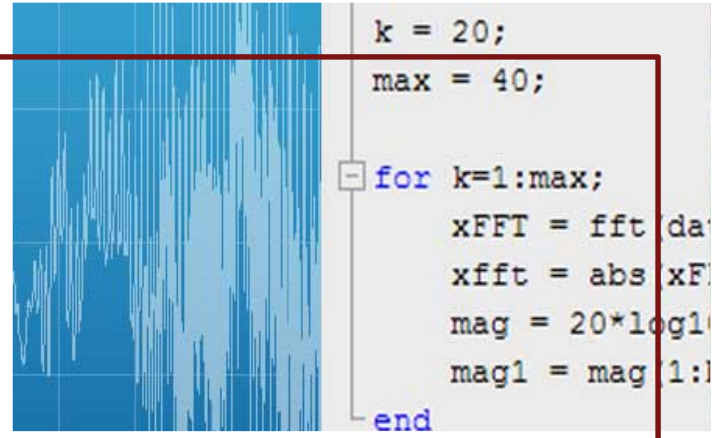
State Machines



Discrete-Event Systems



Physical Modeling



Object-Oriented

Learn More

- Simulink Requirement Webpage
- System Composer Webpage
- System Modeling and Simulation Webpage

- Trial