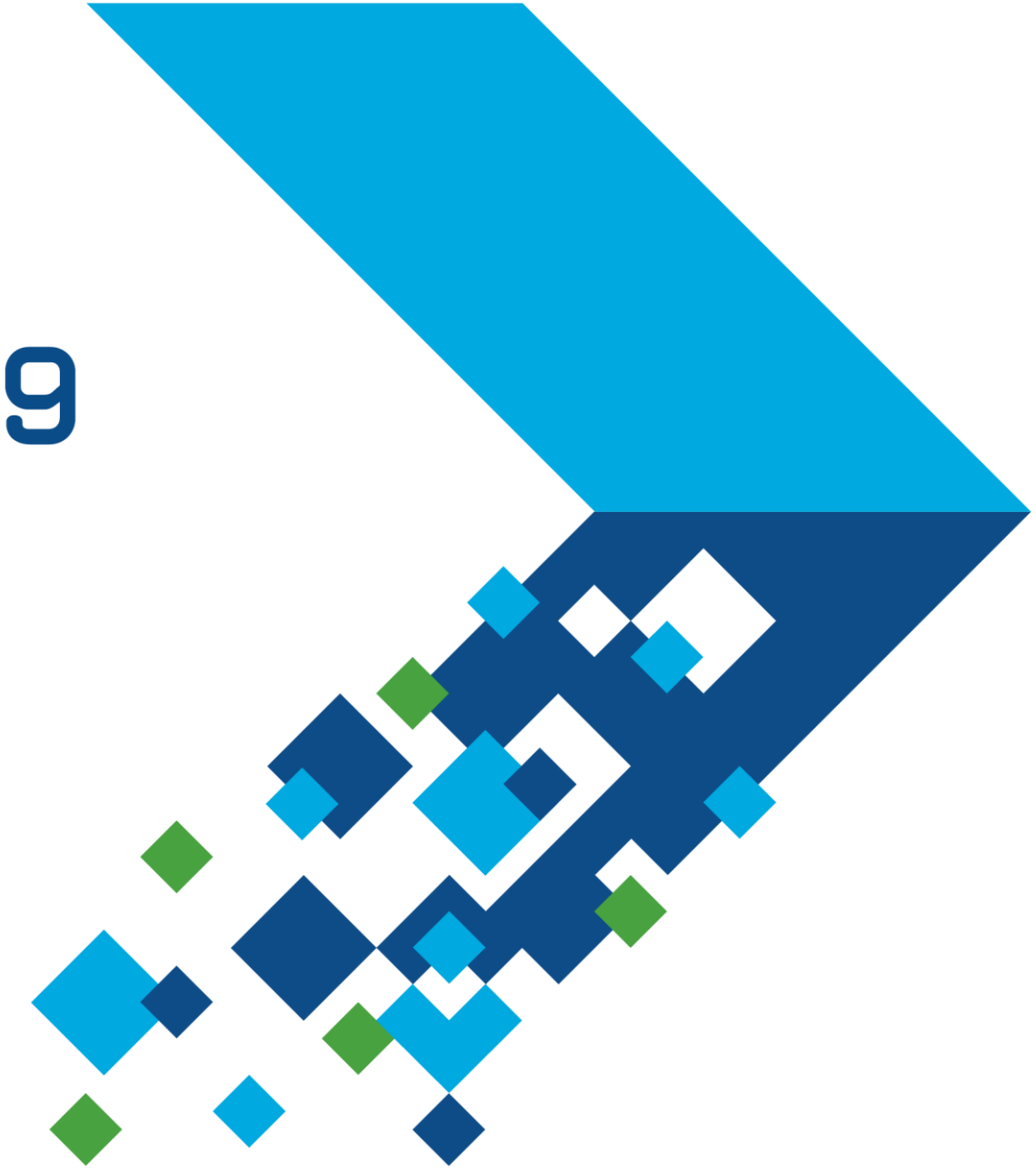
MATLAB EXPO 2019

Systems Engineering

Requirements to Architecture to Simulation

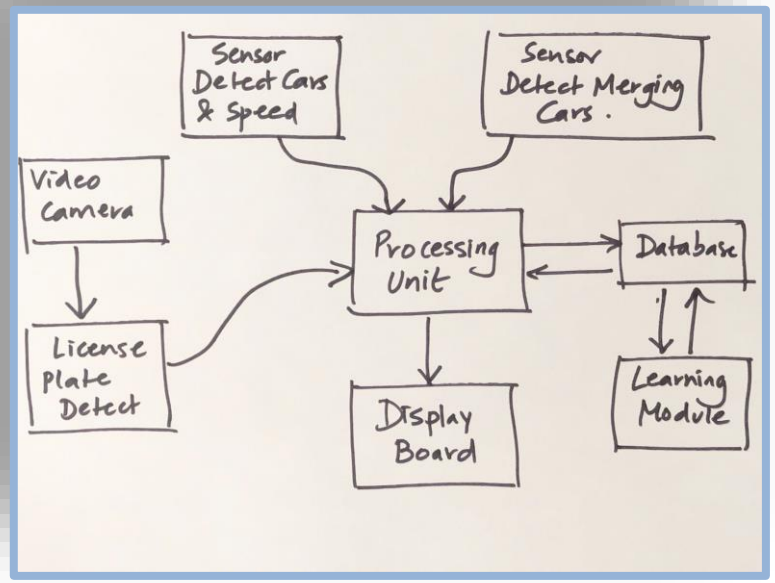
Mark Walker



System Composer

Intuitively design system and software architectures

R2019a



Description

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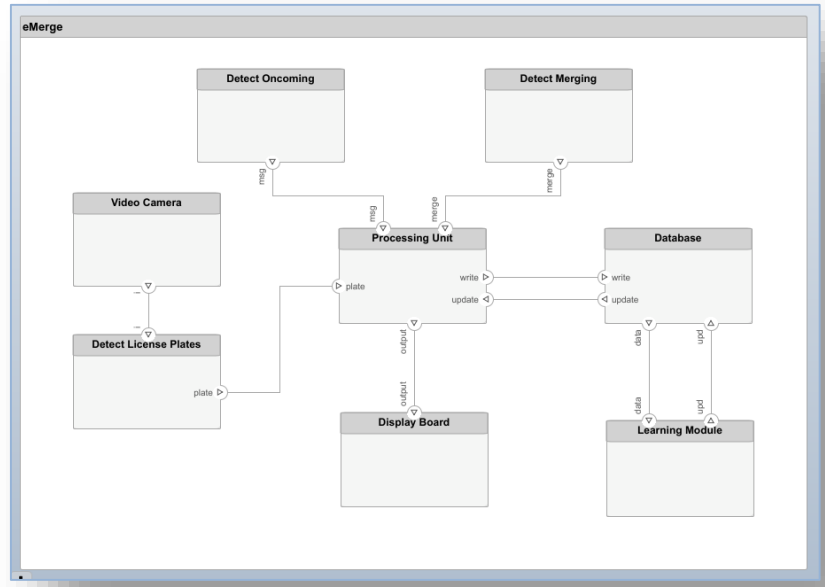
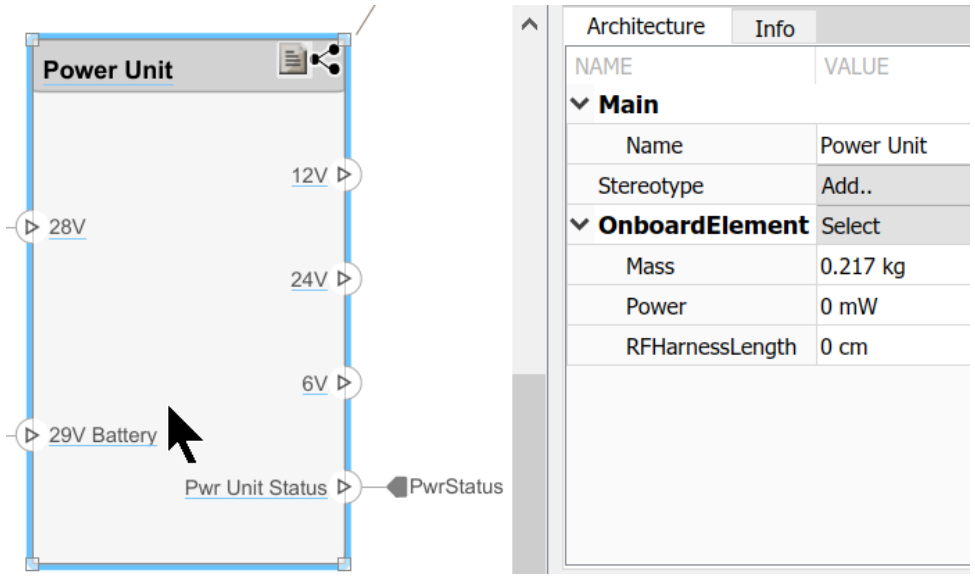
Architecture



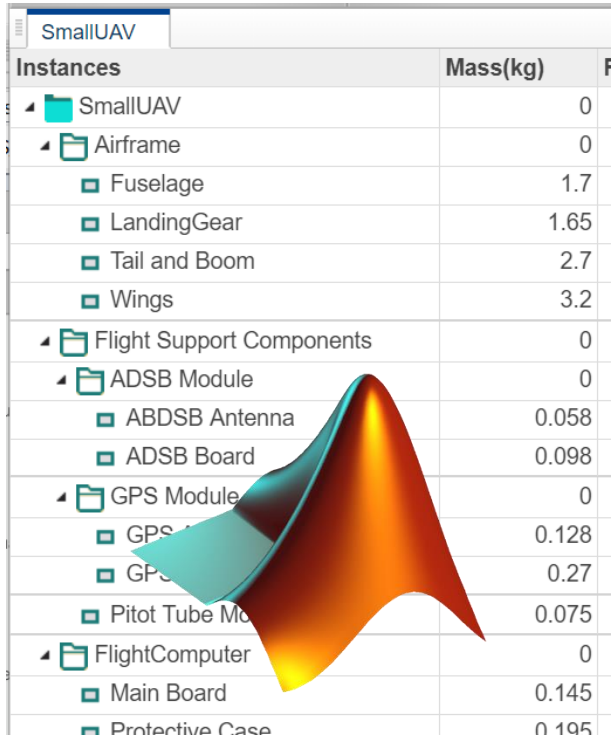
System Composer

Perform trade studies based on data driven analysis to optimize architectures

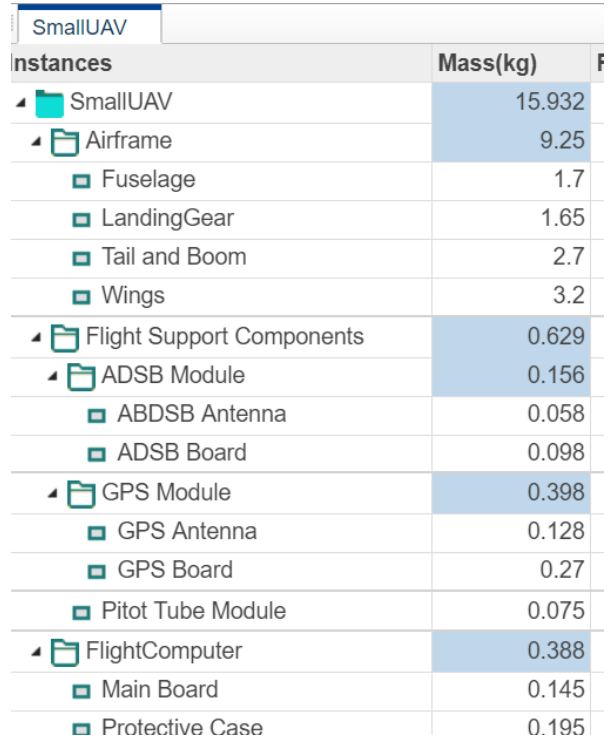
Add custom data



Create analysis model



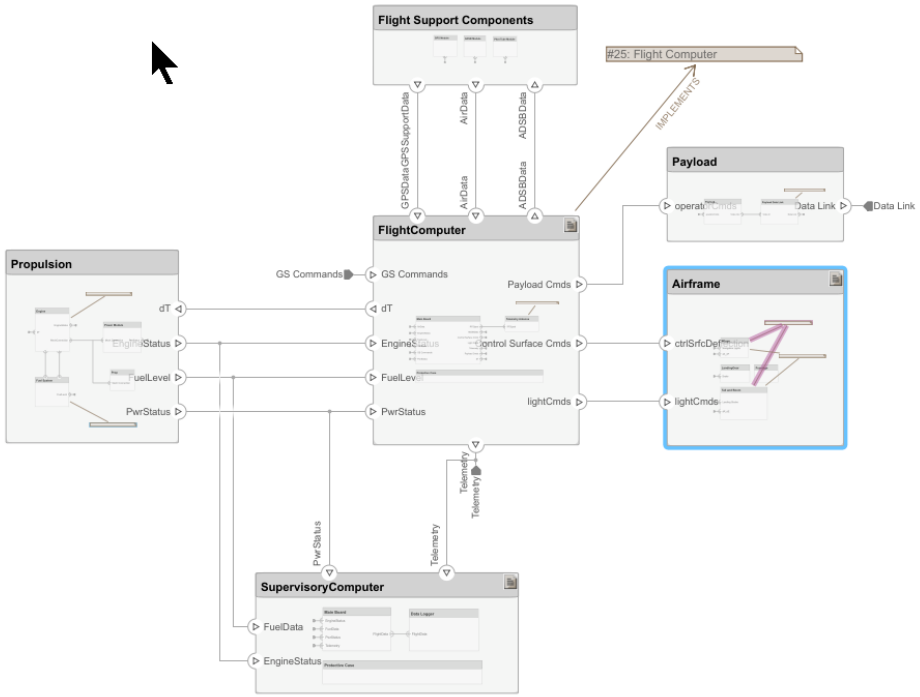
Calculate mass roll-up data



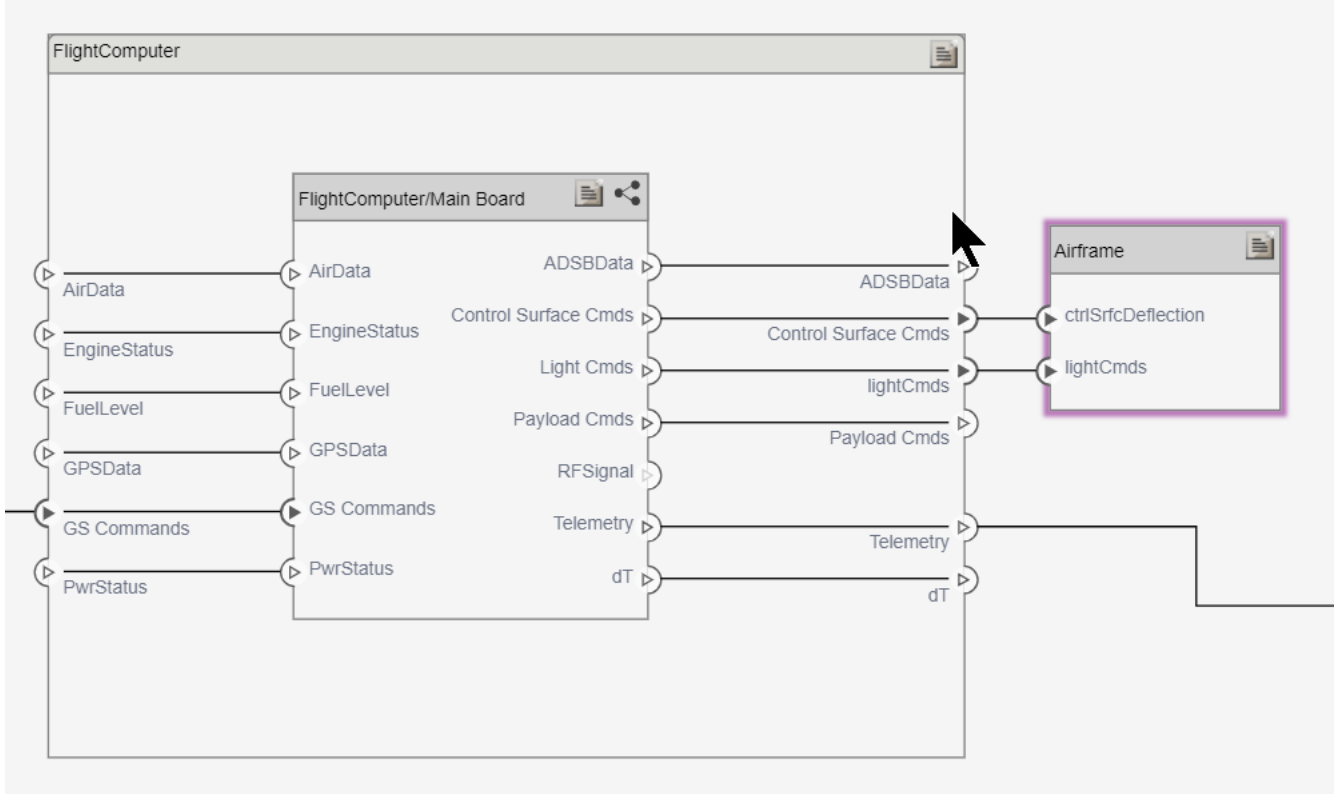
System Composer

Tackle Architecture complexity with spotlight views

Composition



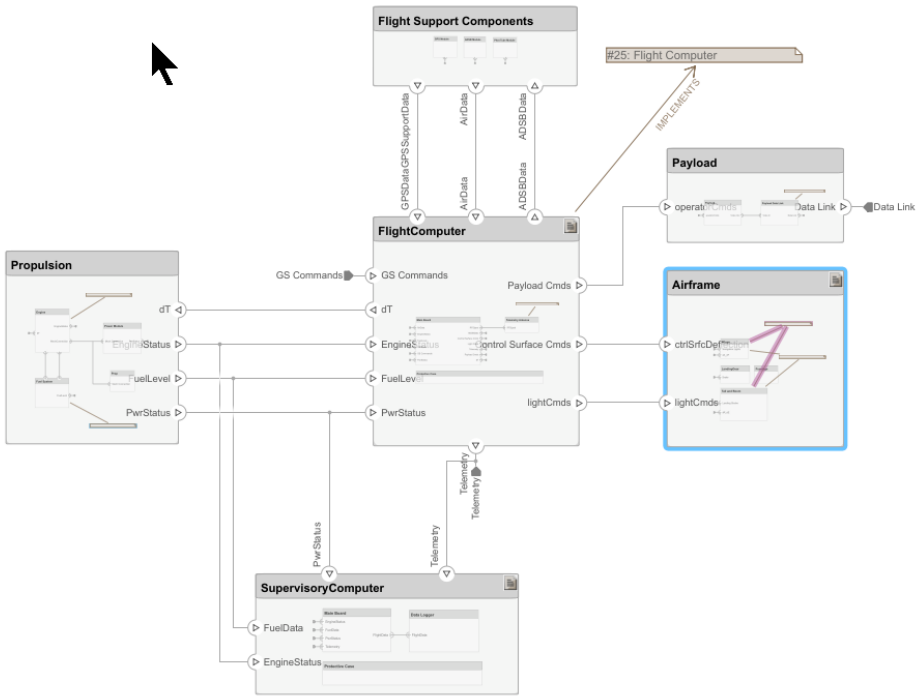
Spotlight



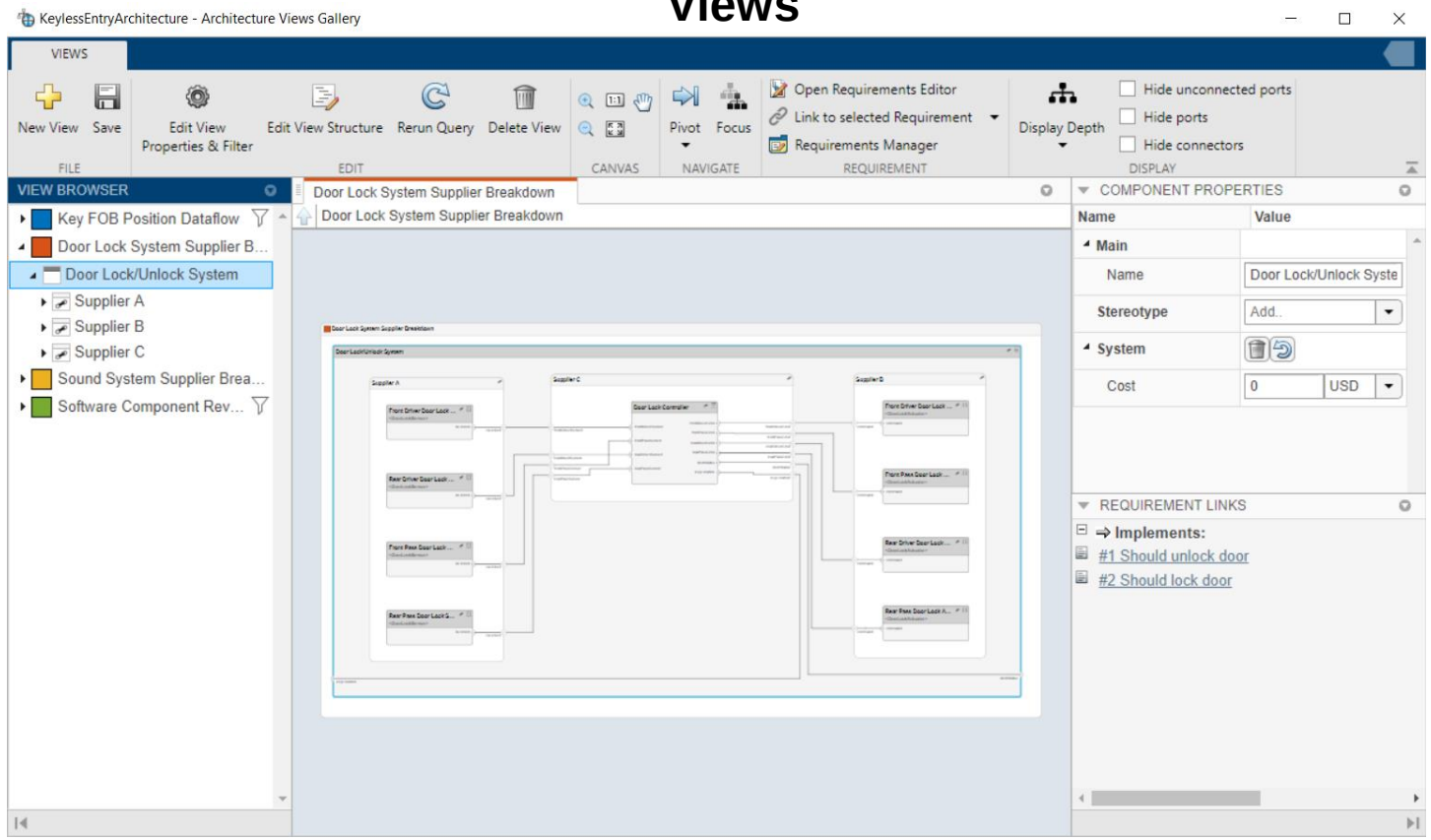
System Composer

Tackle Architecture complexity with views

Composition



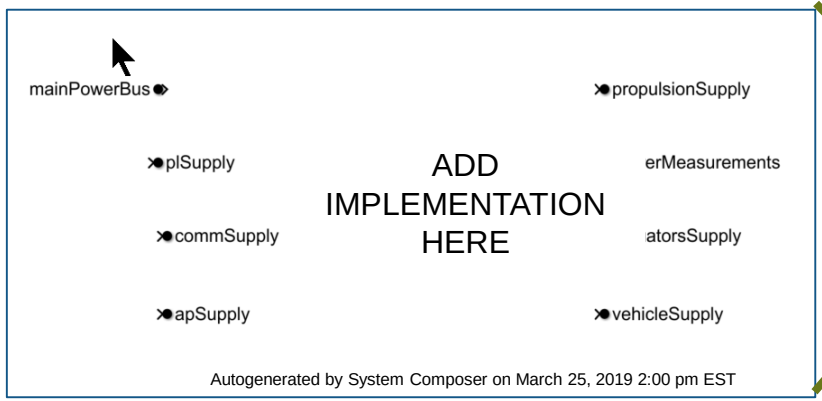
Views



System Composer

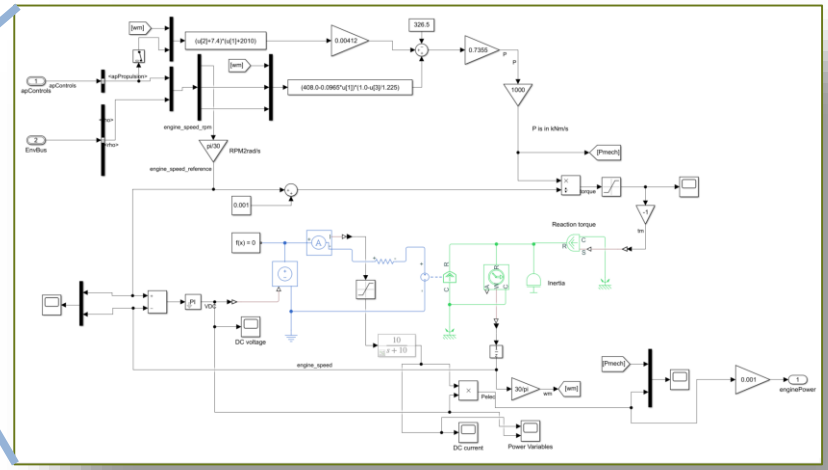
System and software architectures connected to implementations in Simulink

Generate Simulink models from architecture components



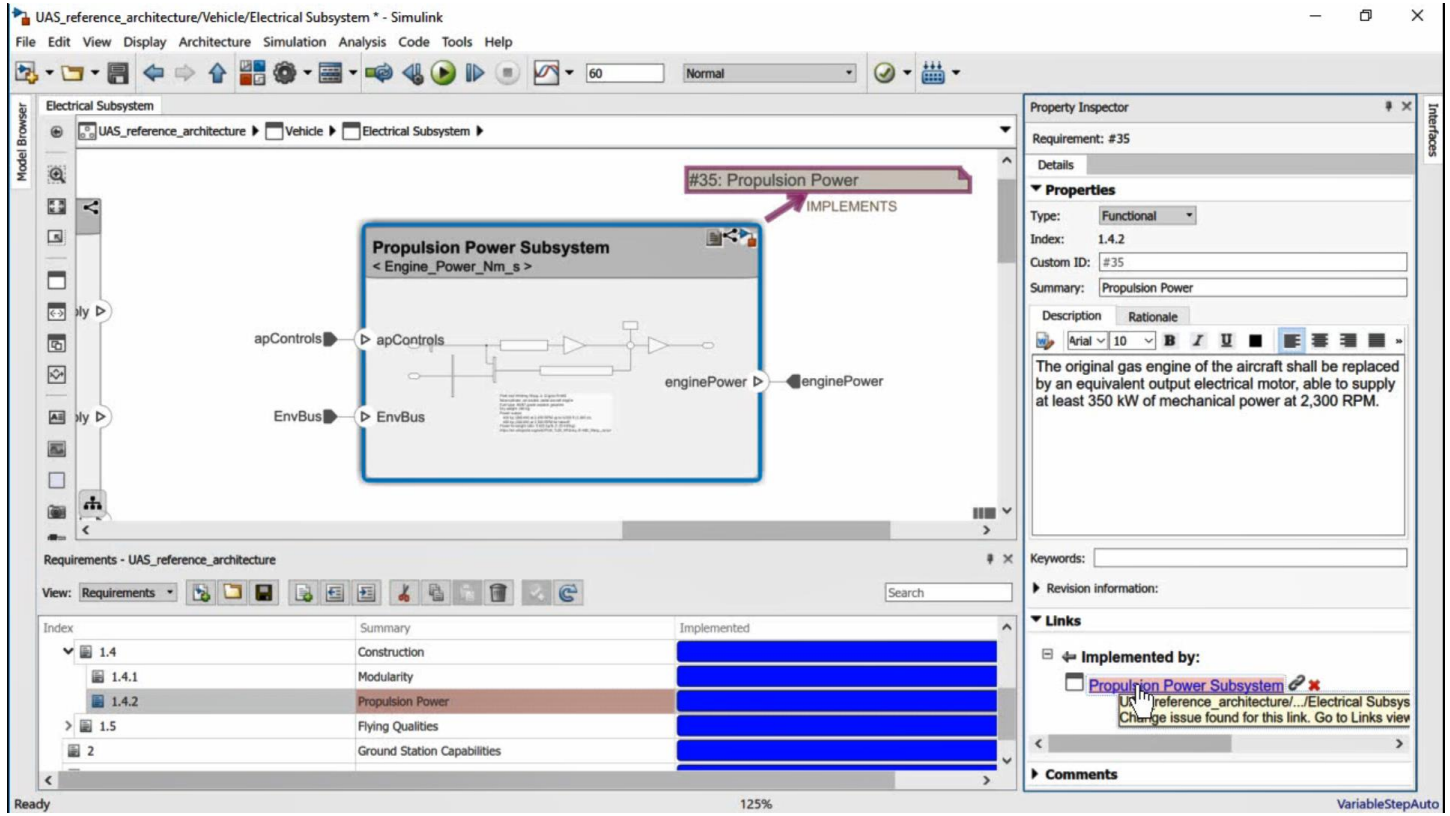
System Composer

Link Simulink models to architecture components



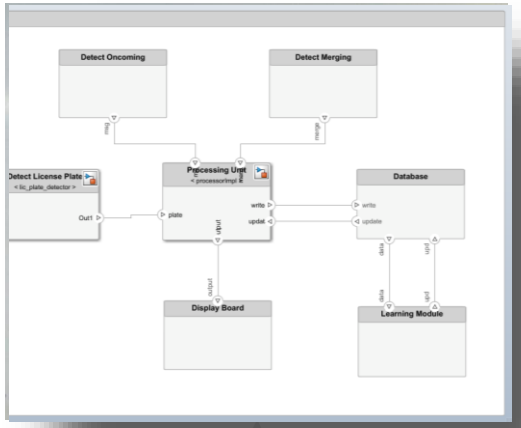
System Composer

Link system models to Simulink Requirements

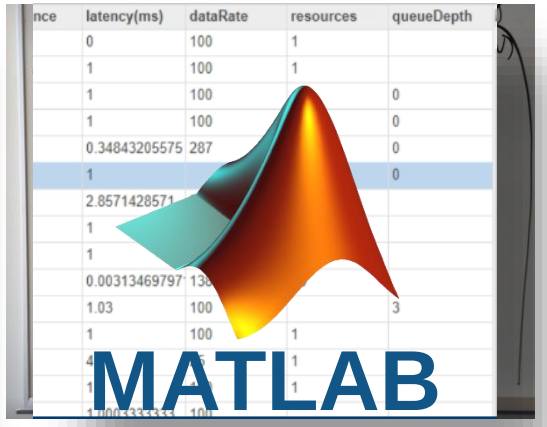


System Composer

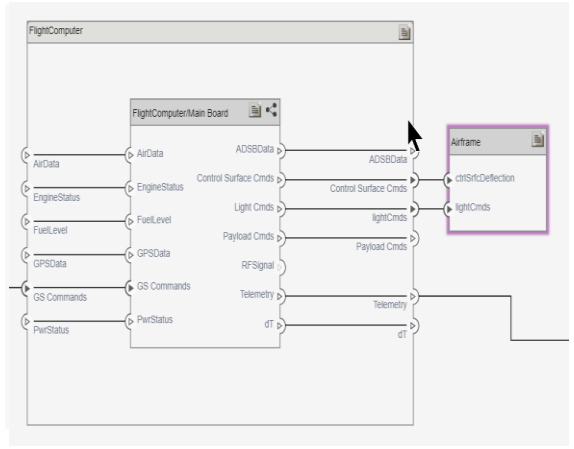
Be Intuitive



Facilitate Analysis



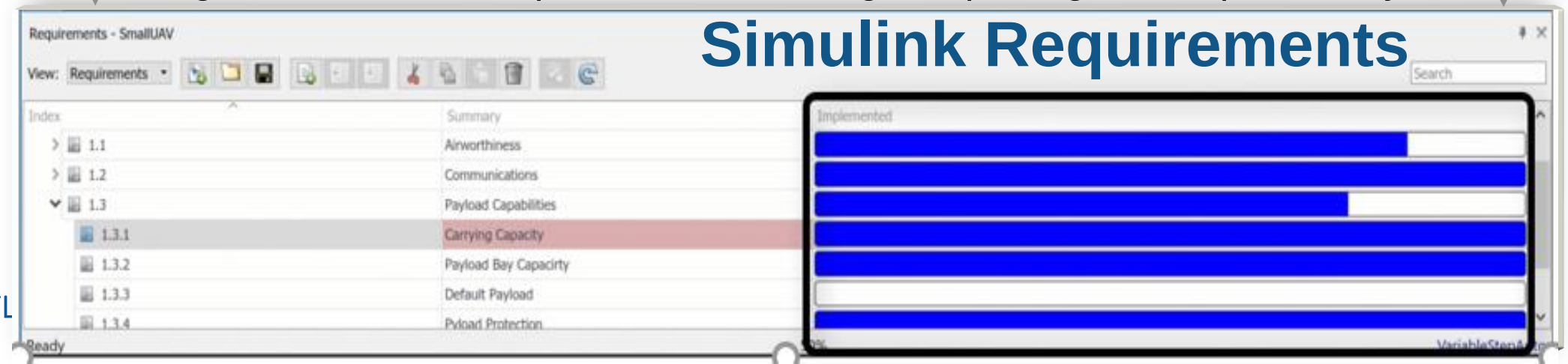
Tackle Complexity



Enable Implementation

Digital Thread for Requirements Coverage Reporting and Impact Analysis

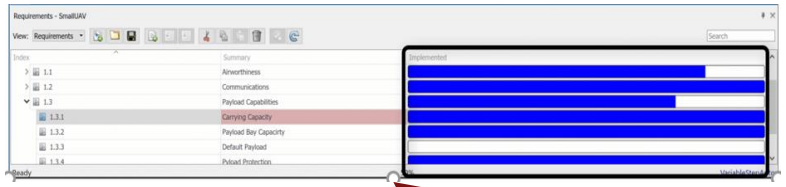
Simulink Requirements



System Composer and Model-Based Design

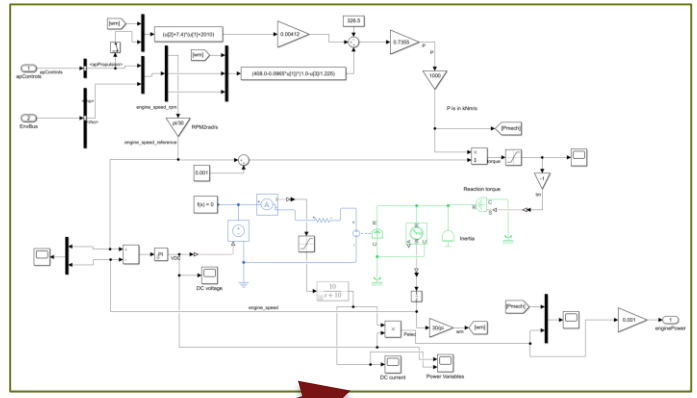
A Systems Engineer

Simulink Requirements



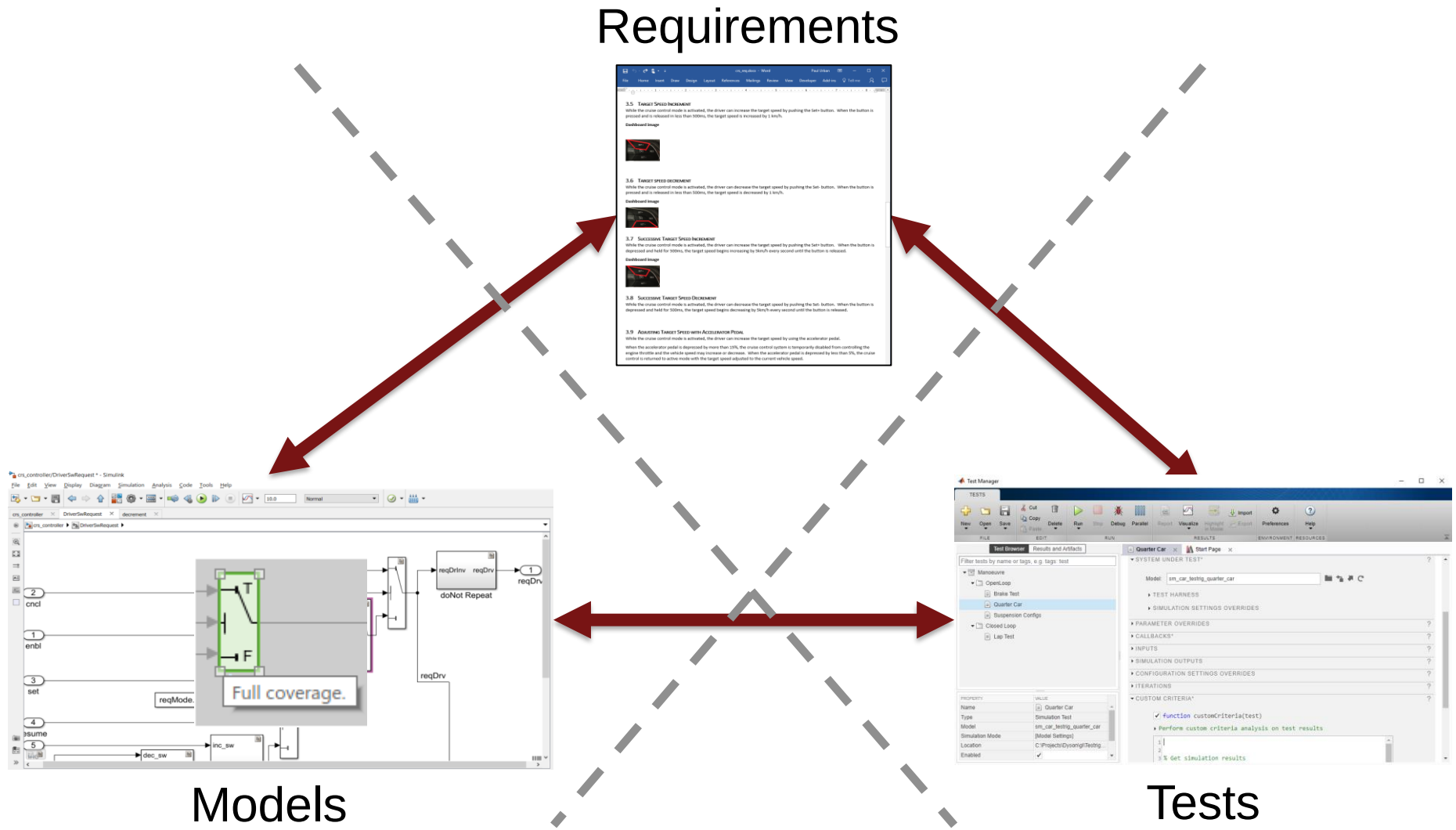
Systems engineering techniques are used in complex projects: spacecraft design, computer chip design, robotics, software integration, and bridge building. Systems engineering uses a host of tools that include modeling and simulation, requirements analysis and scheduling to manage complexity.

Simulink Models

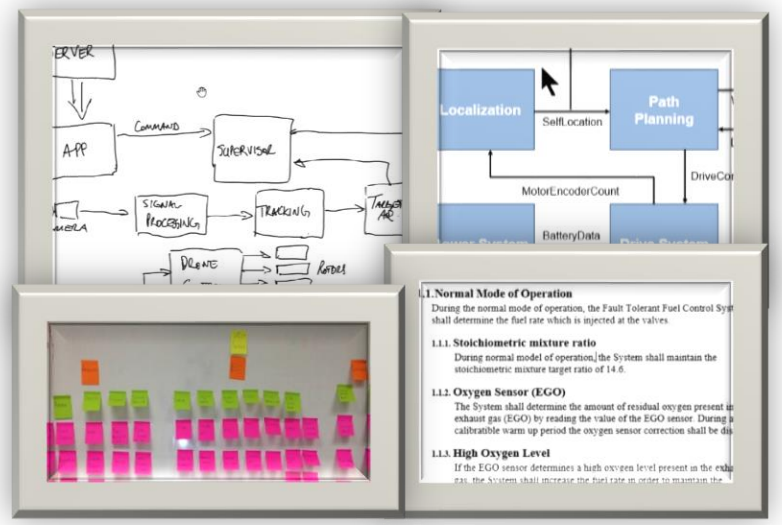


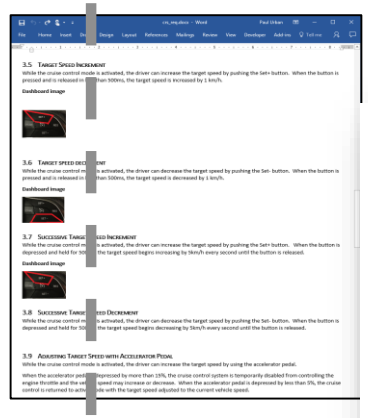
Source: Wikipedia

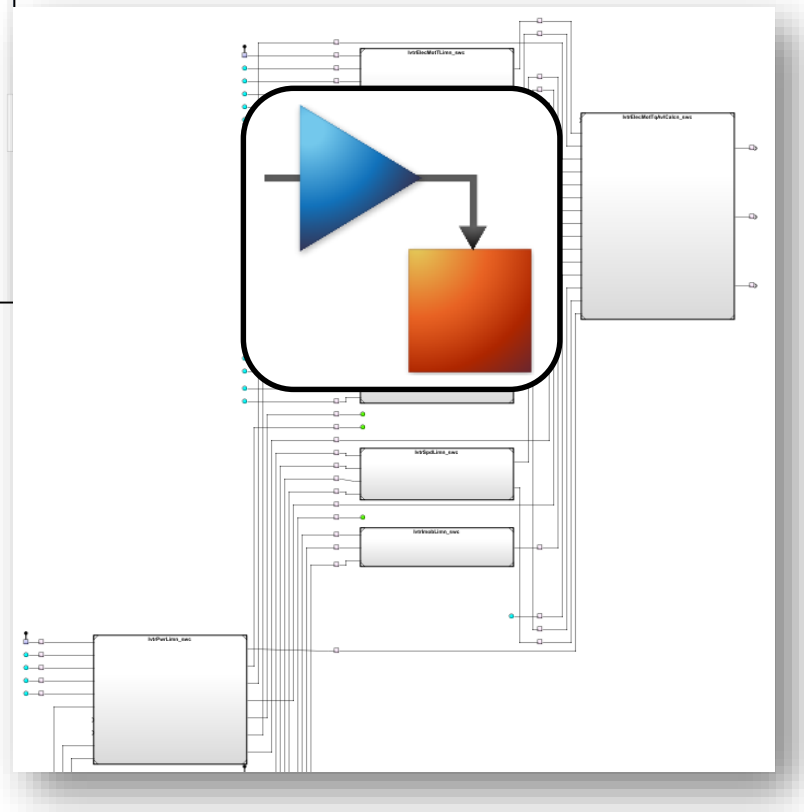
Requirements, Models and Tests – Bottom-up



Systems Engineering and Requirements – Top Down

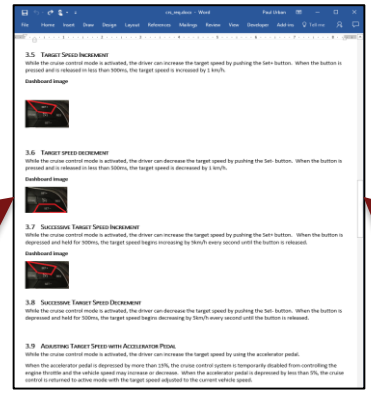


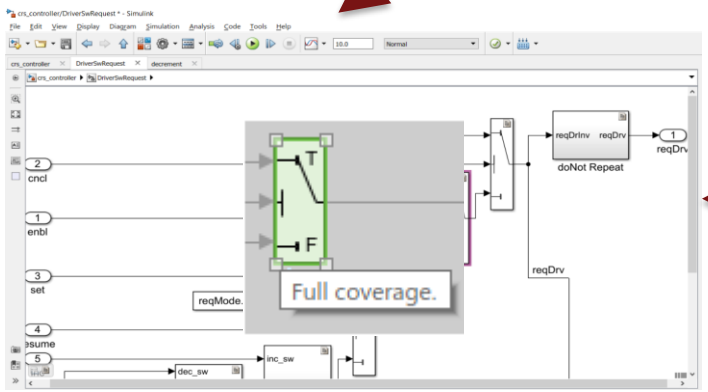




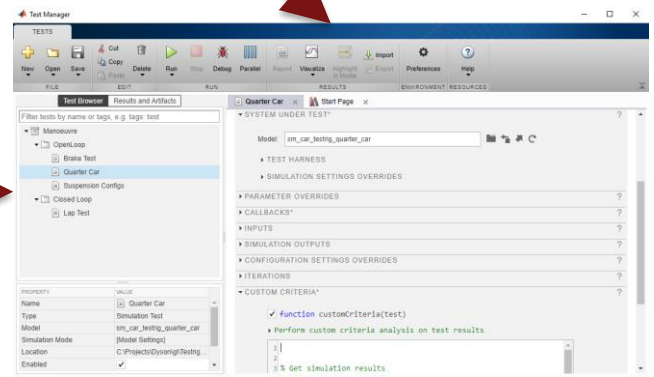
Independence Forced by Tooling

Requirements





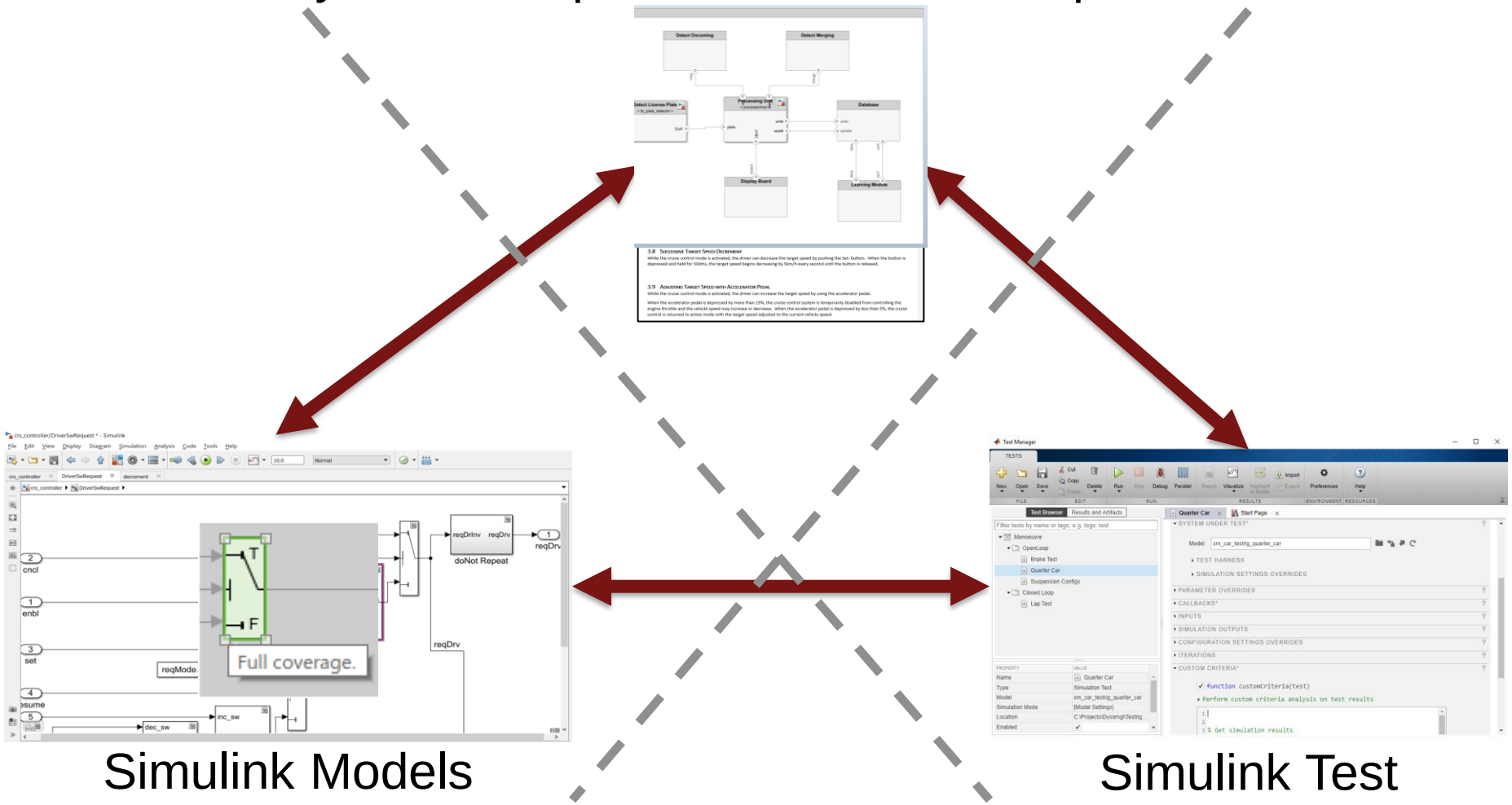
Models



Tests

Flexibility between Systems and Software

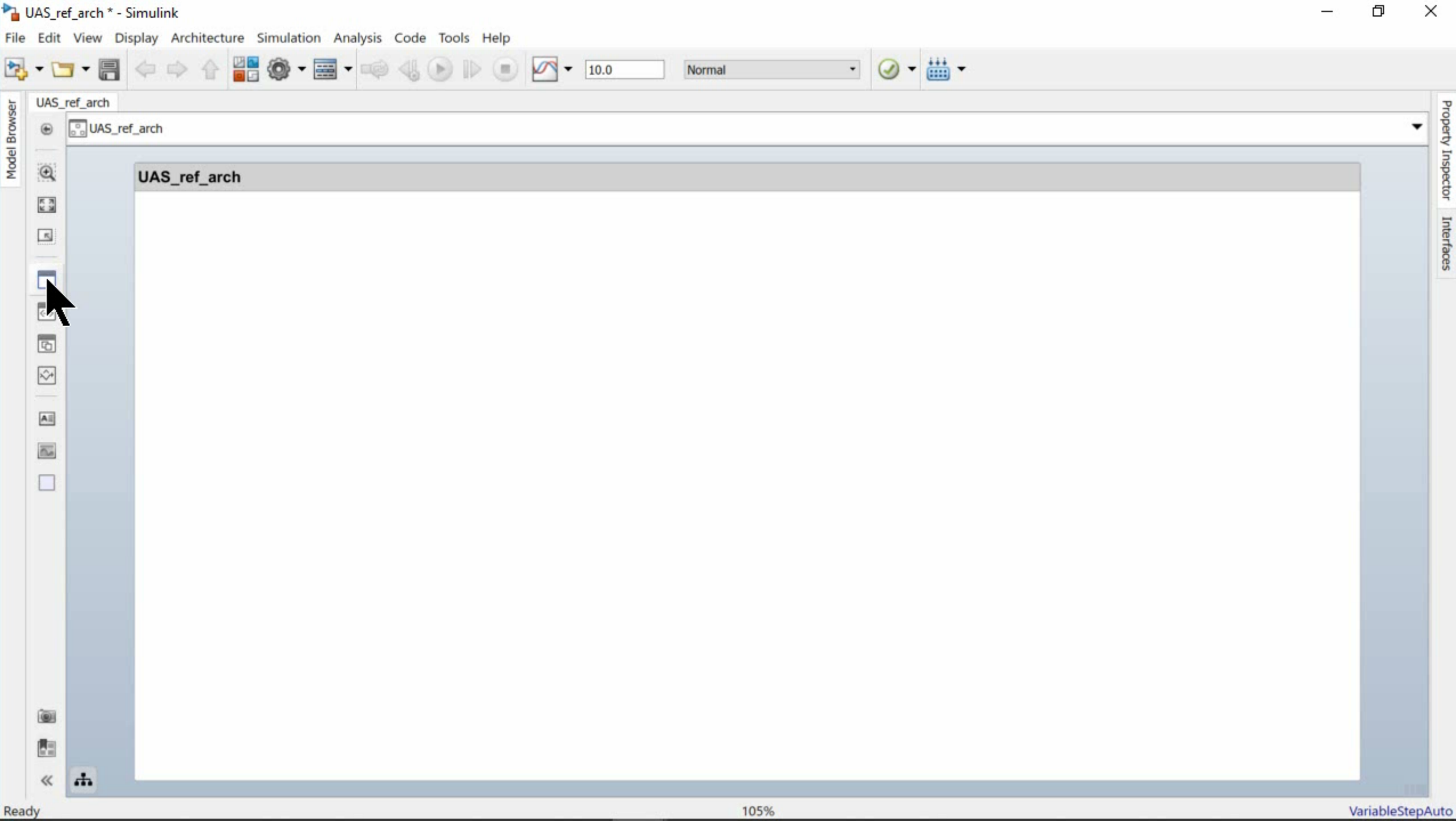
System Composer Models and Requirements



Simulink Models

Simulink Test

Now let’s see it in action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File Edit View Display Architecture Simulation Analysis Code Tools Help
10.0
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UAS_ref_arch
Model Browser
Property Inspector
Interfaces
UAS_ref_arch
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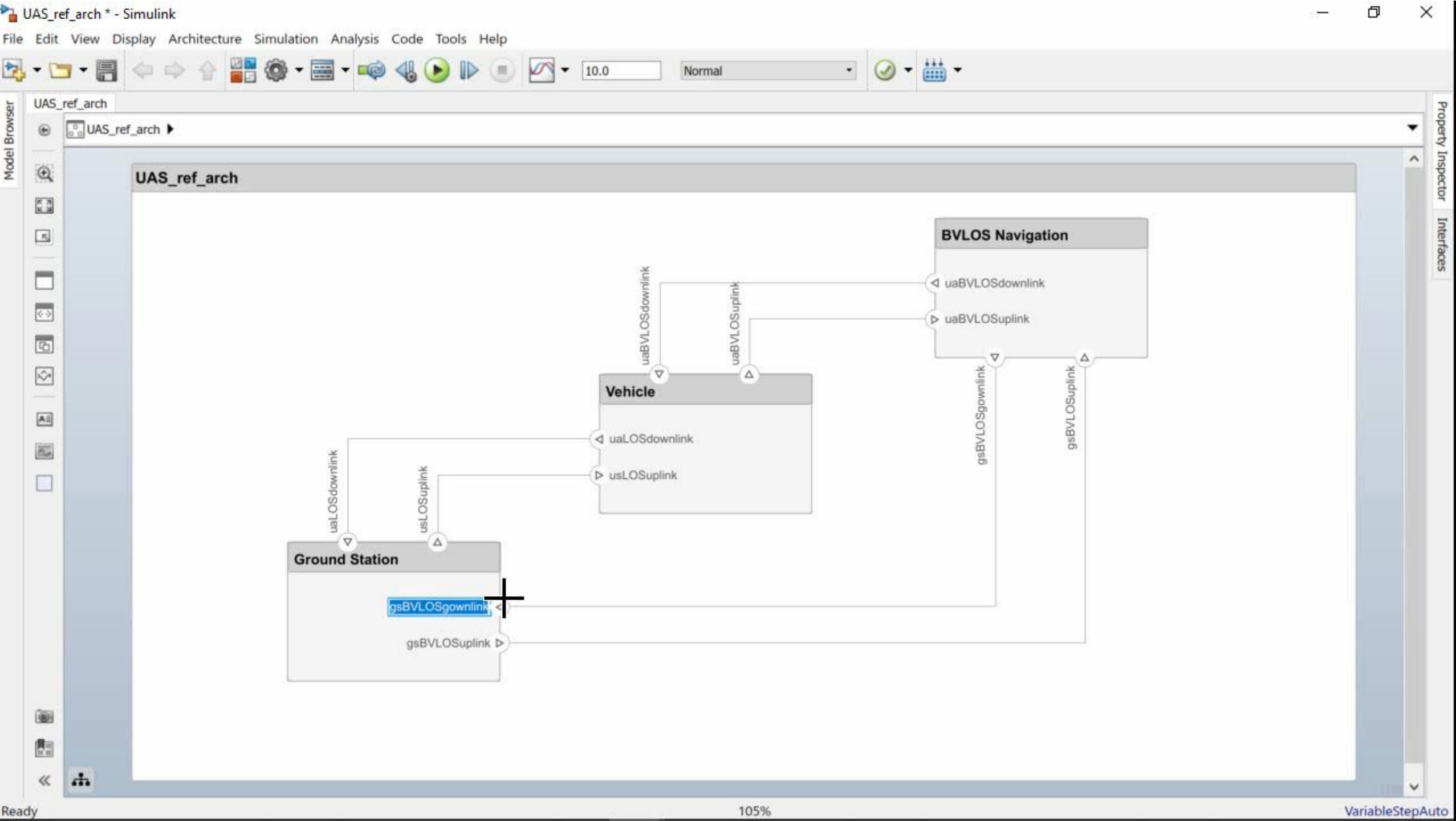
Ready
105%
VariableStepAuto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Model Browser
Property Inspector
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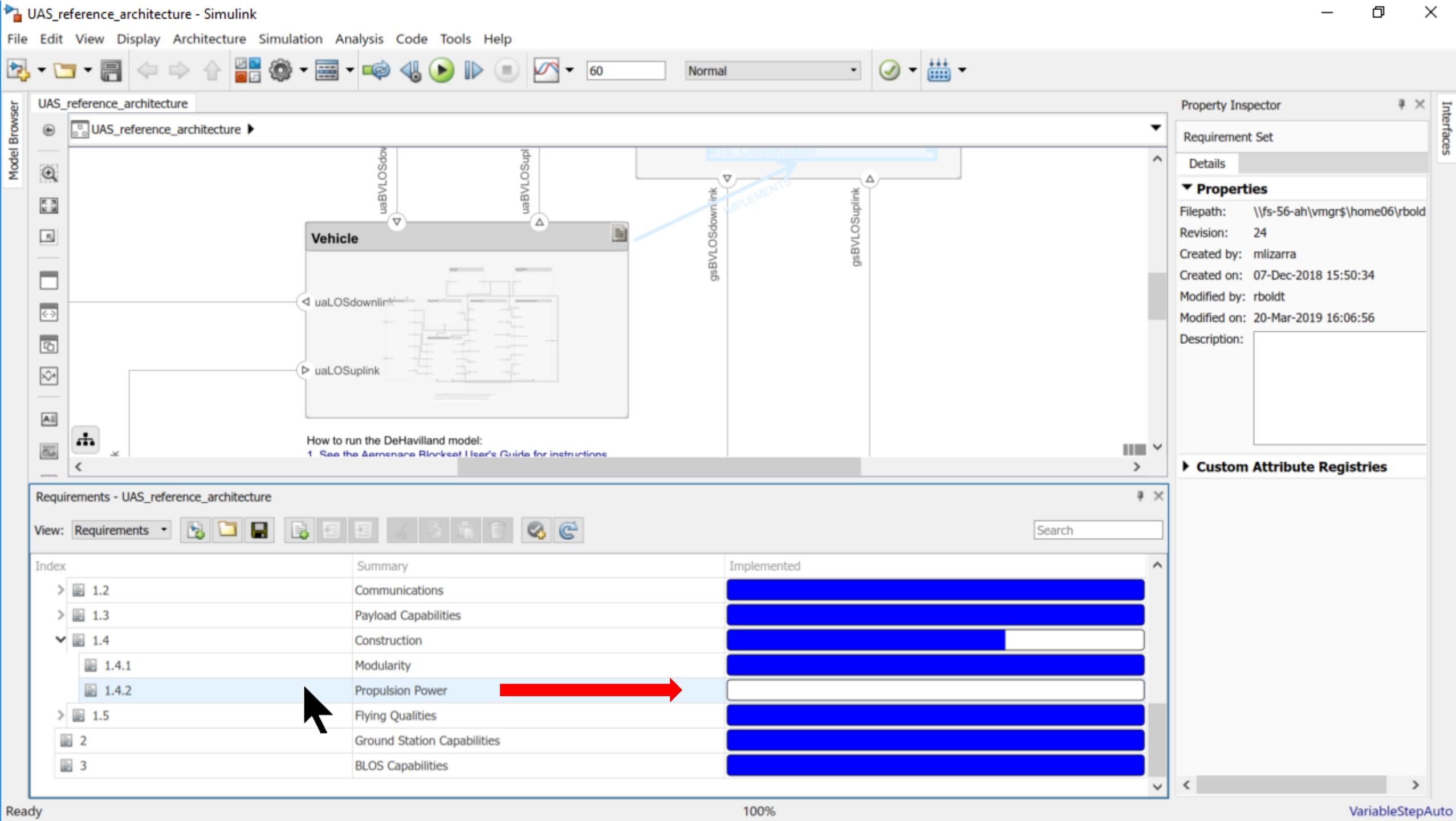
uaBVLOSuplink
uaBVLOSdownlink
uaBVLOSuplink
Vehicle
uaLOSdownlink
usLOSuplink
gsBVLOSgownlink
gsBVLOSuplink
uaLOSdownlink
usLOSuplink
Ground Station
gsBVLOSgownlink
gsBVLOSuplink
Ready
105%
VariableStepAuto


UAS_reference_architecture - Simulink
File Edit View Display Architecture Simulation Analysis Code Tools Help
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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
View: Requirements
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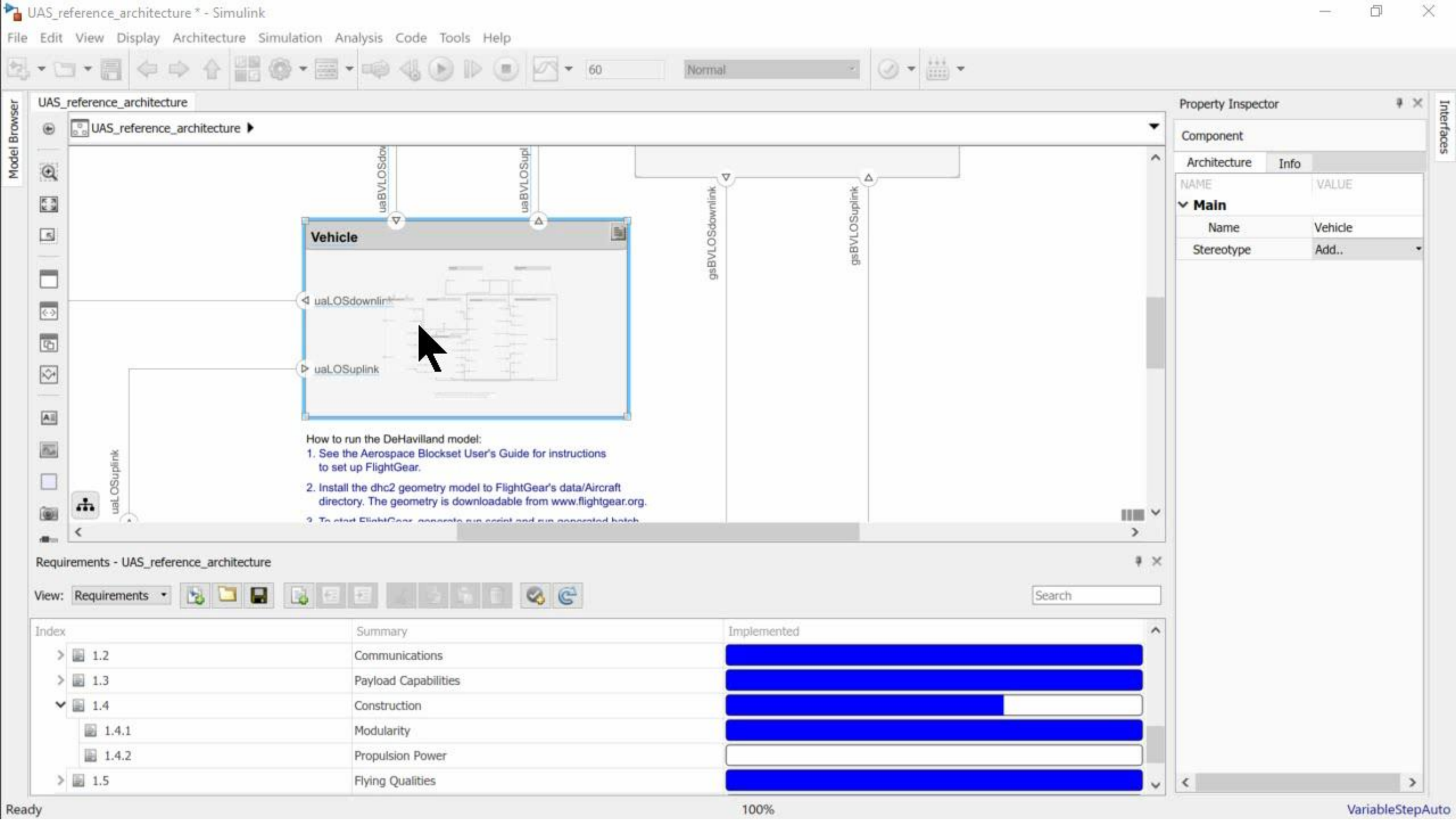
1.2 Communications
1.3 Payload Capabilities
1.4 Construction
1.4.1 Modularity
1.4.2 Propulsion Power
1.5 Flying Qualities
2 Ground Station Capabilities
3 BLOS Capabilities
Ready
100%
VariableStepAuto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File Edit View Display Architecture Simulation Analysis Code Tools Help
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 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
Component
Architecture
Info
NAME
VALUE
Main
Name
Vehicle
Stereotype
Add..
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Implemented
1.2 Communications
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 ▸

#35: Propulsion Power

IMPLEMENTS

Propulsion Power Subsystem

< Engine_Power_Nm_s >

propulsionSupply

actuatorsSupply

vehicleSupply

apControls

apControls

EnvBus

EnvBus

enginePower

enginePower

Property Inspector

Requirement Set

Details

Properties

Filepath: \\fs-56-ah\vmgr$\home06\rboldt

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

View: Requirements

Search

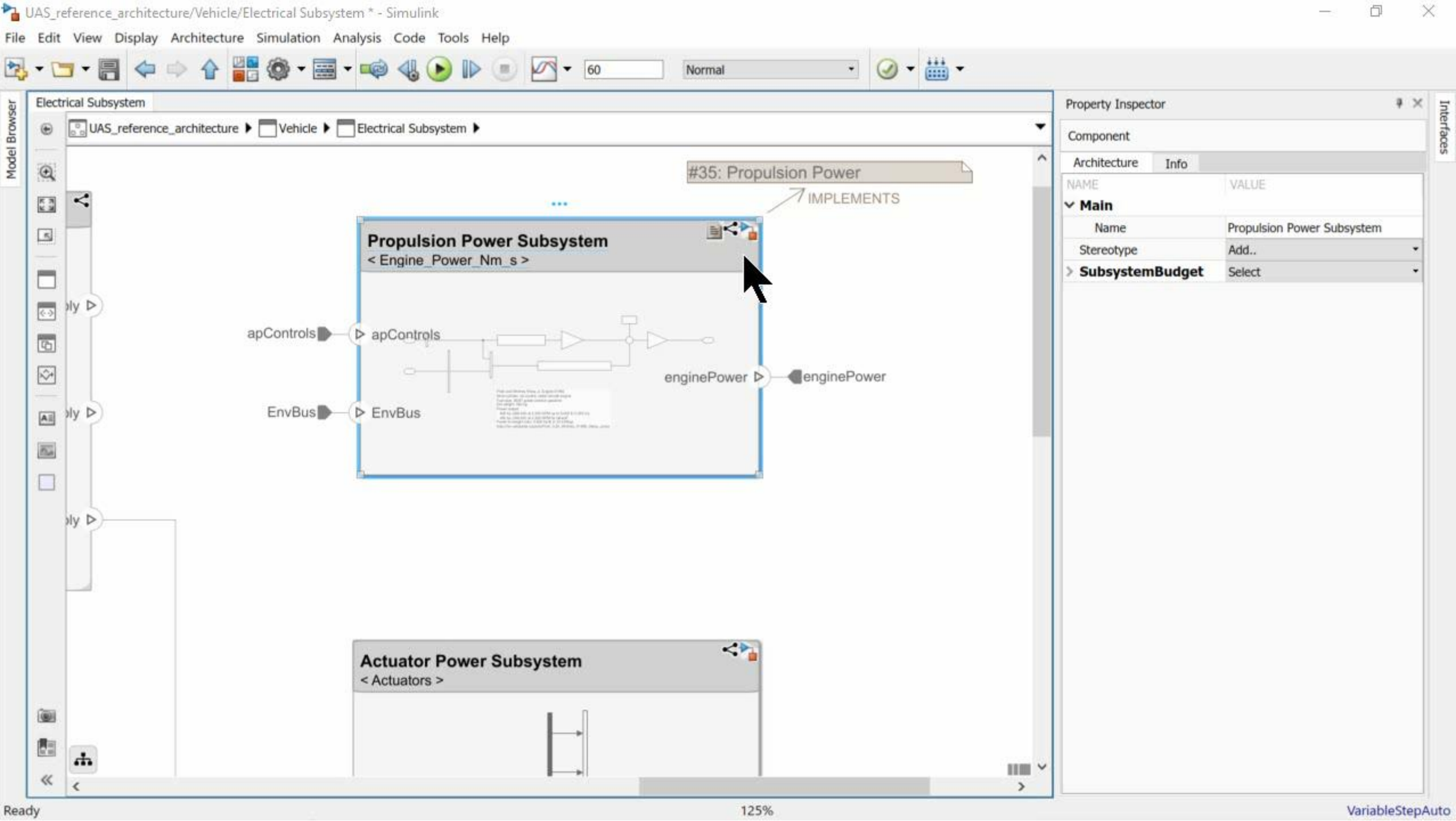
Index	Summary	Implemented
UAS_reqs		
1	Aircraft Capbilities	
1.1	Airworthiness	
1.1.1	Range	
1.1.2	Rain Conditions	
1.1.3	Power	

Implemented: 27, Justified: 0, None: 0, Total: 27

Ready

125%

VariableStepAuto


UAS_reference_architecture/Vehicle/Electrical Subsystem * - Simulink
File Edit View Display Architecture Simulation Analysis Code Tools Help
60
Normal
Model Browser
Electrical Subsystem
UAS_reference_architecture
Vehicle
Electrical Subsystem
#35: Propulsion Power
IMPLEMENTS
Propulsion Power Subsystem
< Engine_Power_Nm_s >
apControls
apControls
enginePower
enginePower
EnvBus
EnvBus
Actuator Power Subsystem
< Actuators >
Property Inspector
Component
Architecture
Info
NAME
VALUE
Main
Name
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Stereotype
Add..
SubsystemBudget
Select
Interfaces
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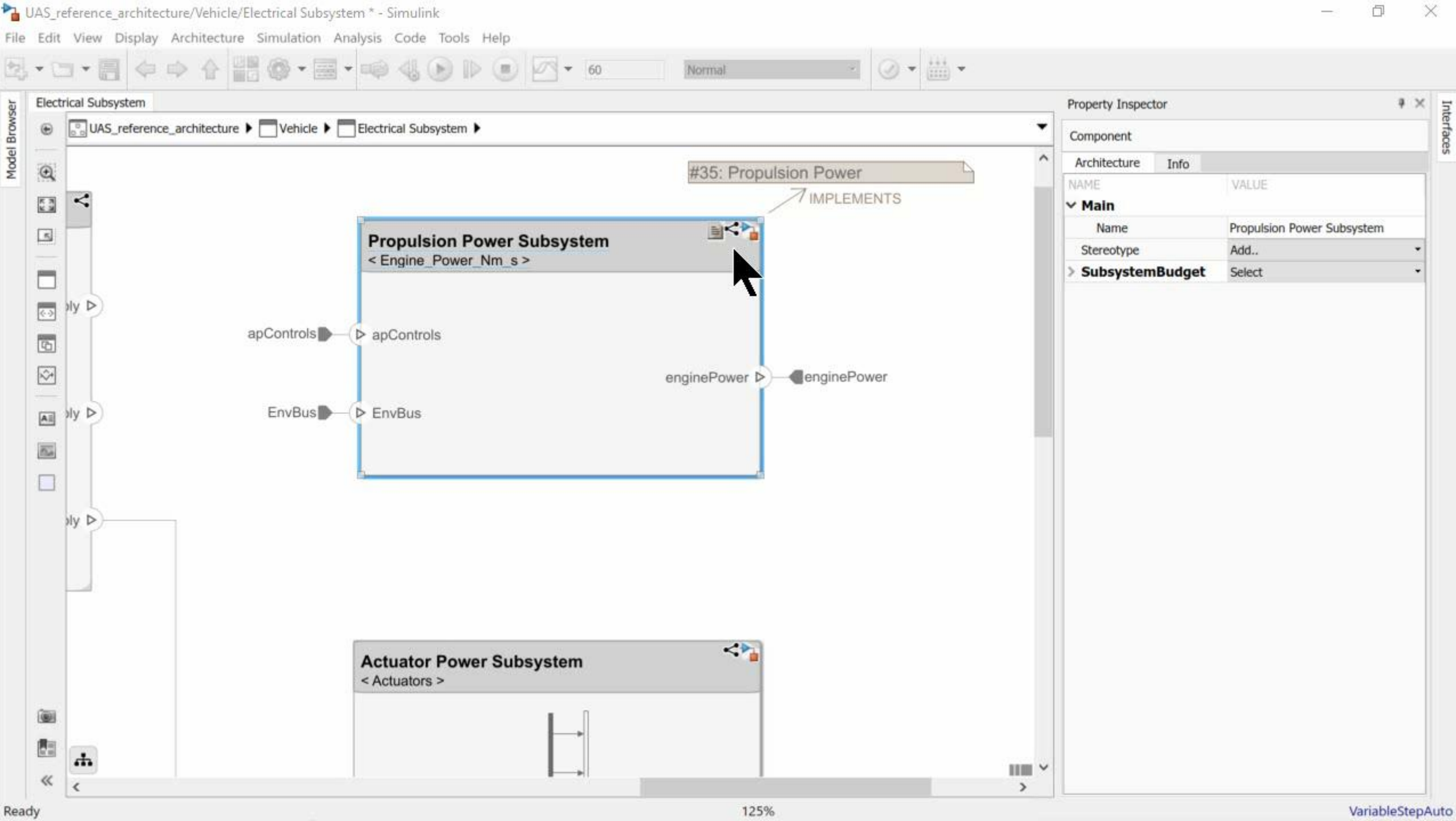
125%
VariableStepAuto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Model Browser
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Vehicle
Electrical Subsystem
#35: Propulsion Power
IMPLEMENTS
Propulsion Power Subsystem
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enginePower
enginePower
EnvBus
EnvBus
Actuator Power Subsystem
< Actuators >
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VALUE
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SubsystemBudget
Select
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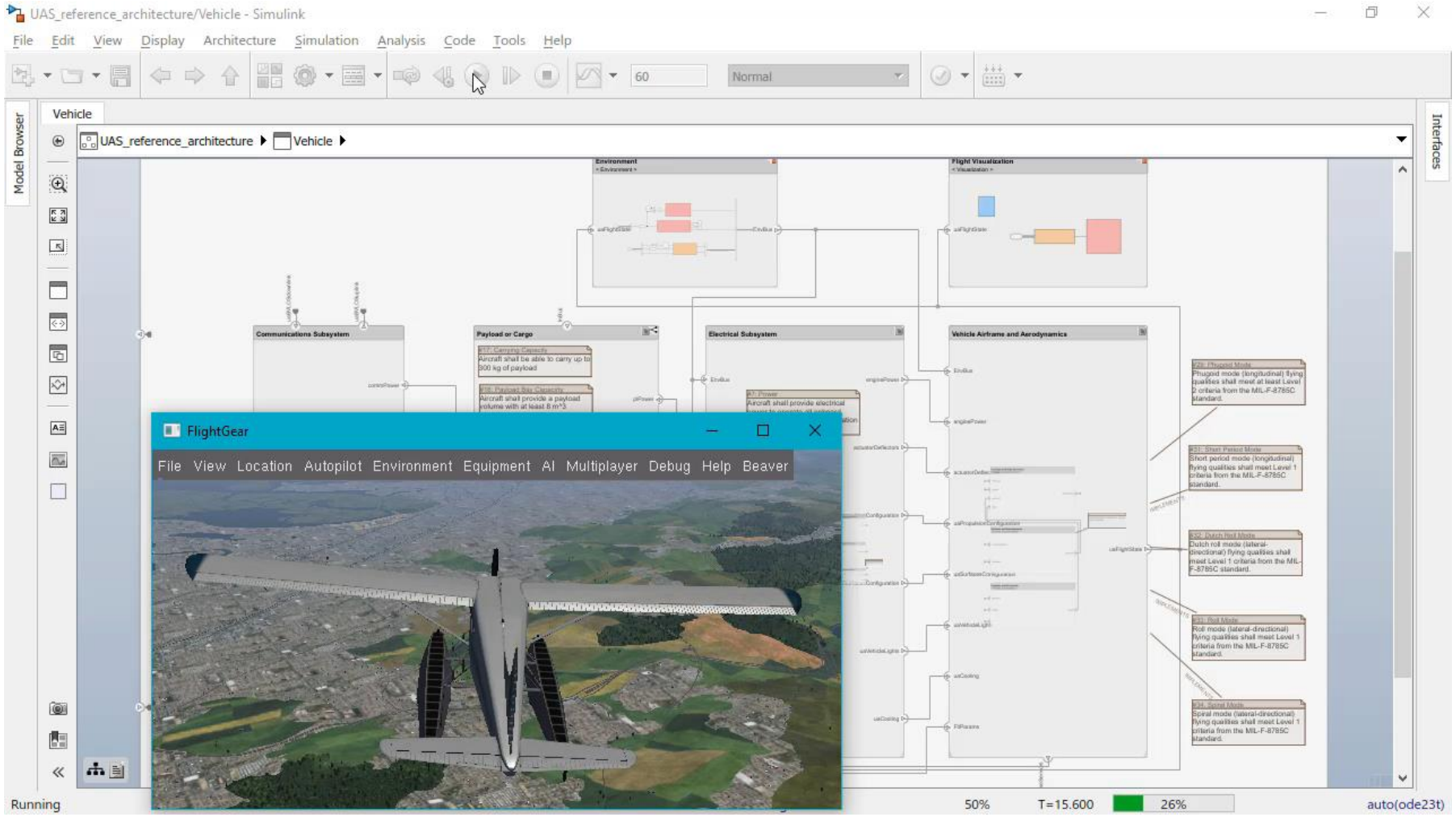
VariableStepAuto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File Edit View Display Architecture Simulation Analysis Code Tools Help
Vehicle
UAS_reference_architecture
Vehicle
Model Browser
Interfaces
FlightGear
File View Location Autopilot Environment Equipment AI Multiplayer Debug Help Beaver
Running
50%
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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 ▸

#35: Propulsion Power

IMPLEMENTS

Propulsion Power Subsystem

< Engine_Power_Nm_s >

apControls apControls

enginePower enginePower

EnvBus EnvBus

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

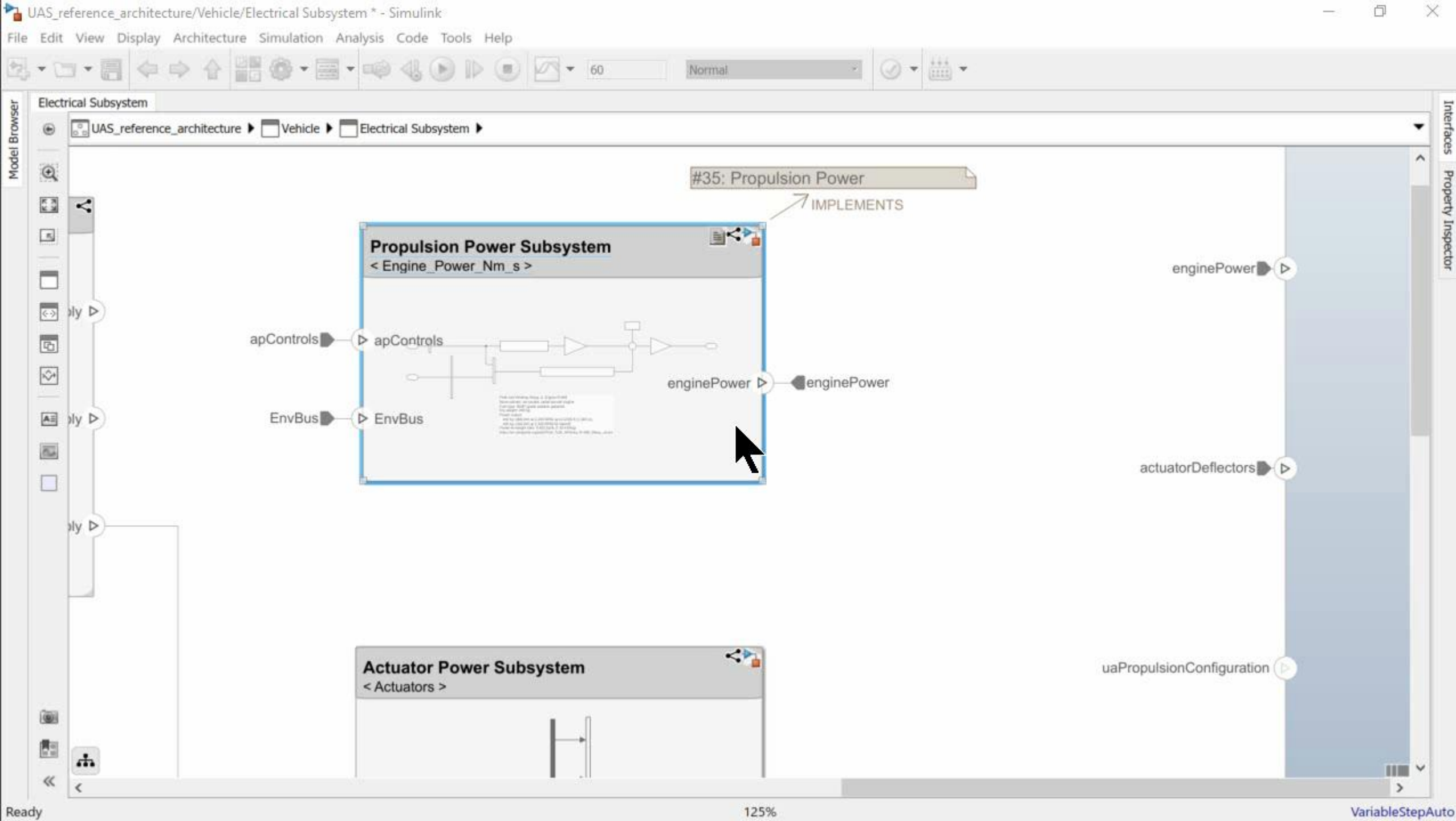
Implemented by:

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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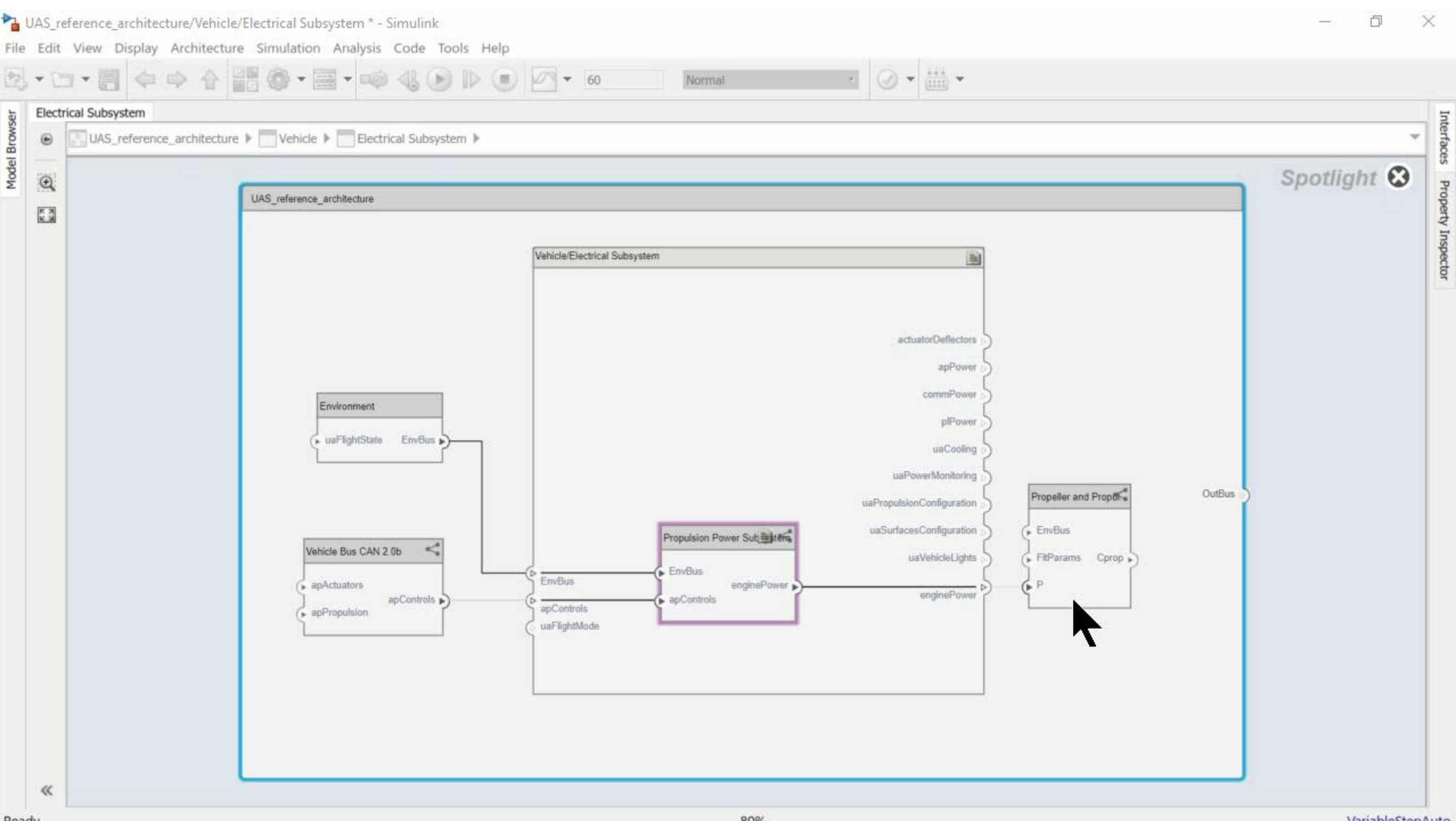
Interfaces
Property Inspector
Ready
125%
VariableStepAuto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Electrical Subsystem
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Vehicle
Electrical Subsystem
Spotlight
UAS_reference_architecture
Vehicle/Electrical Subsystem
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EnvBus
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 Propel
EnvBus
FltParams
Cprop
P
OutBus
Model Browser
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Property Inspector
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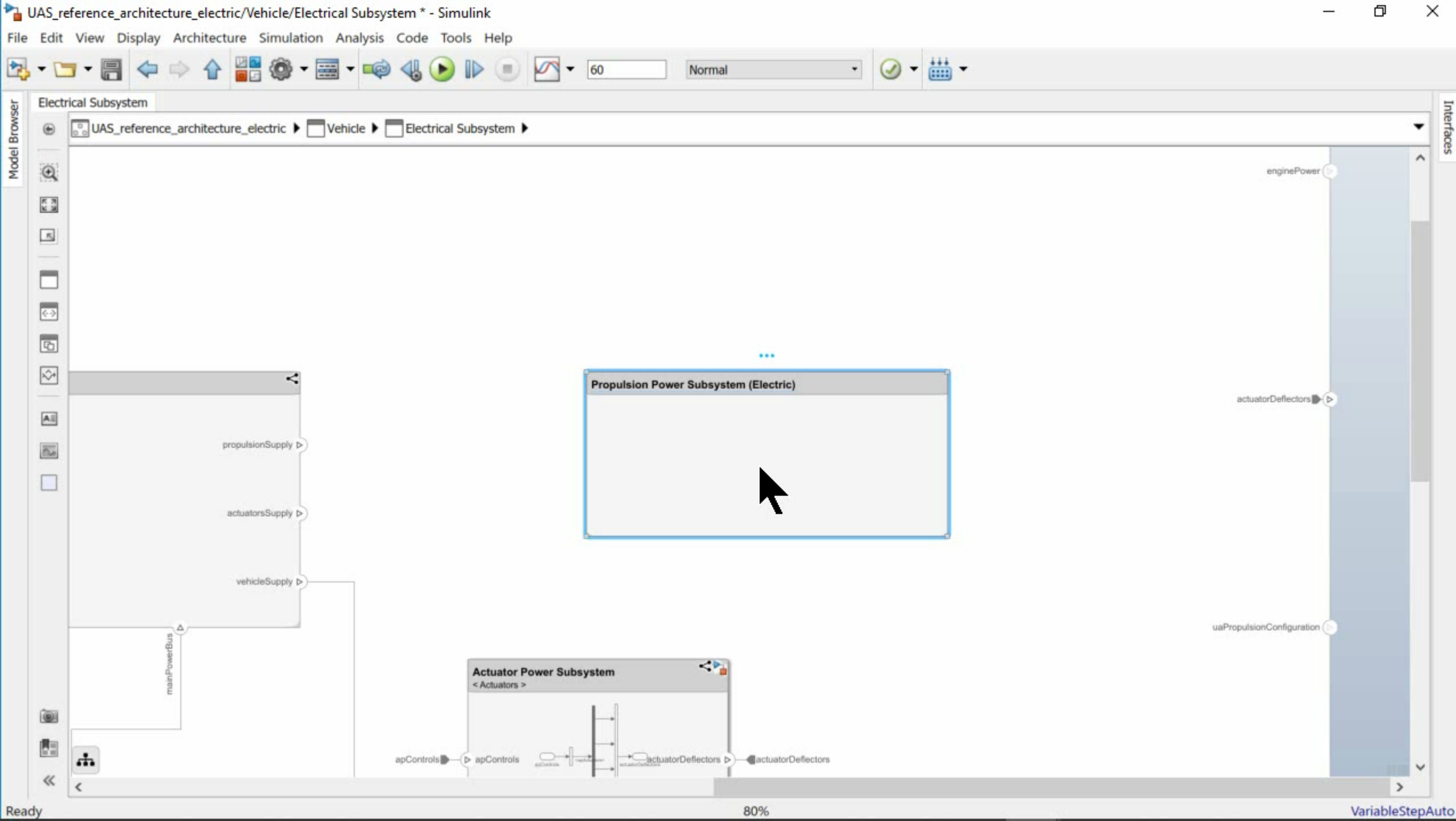
VariableStepAuto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Electrical Subsystem
Model Browser
Interfaces
UAS_reference_architecture_electric
Vehicle
Electrical Subsystem
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Propulsion Power Subsystem (Electric)
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propulsionSupply
actuatorsSupply
vehicleSupply
uaPropulsionConfiguration
mainPowerBus
Actuator Power Subsystem
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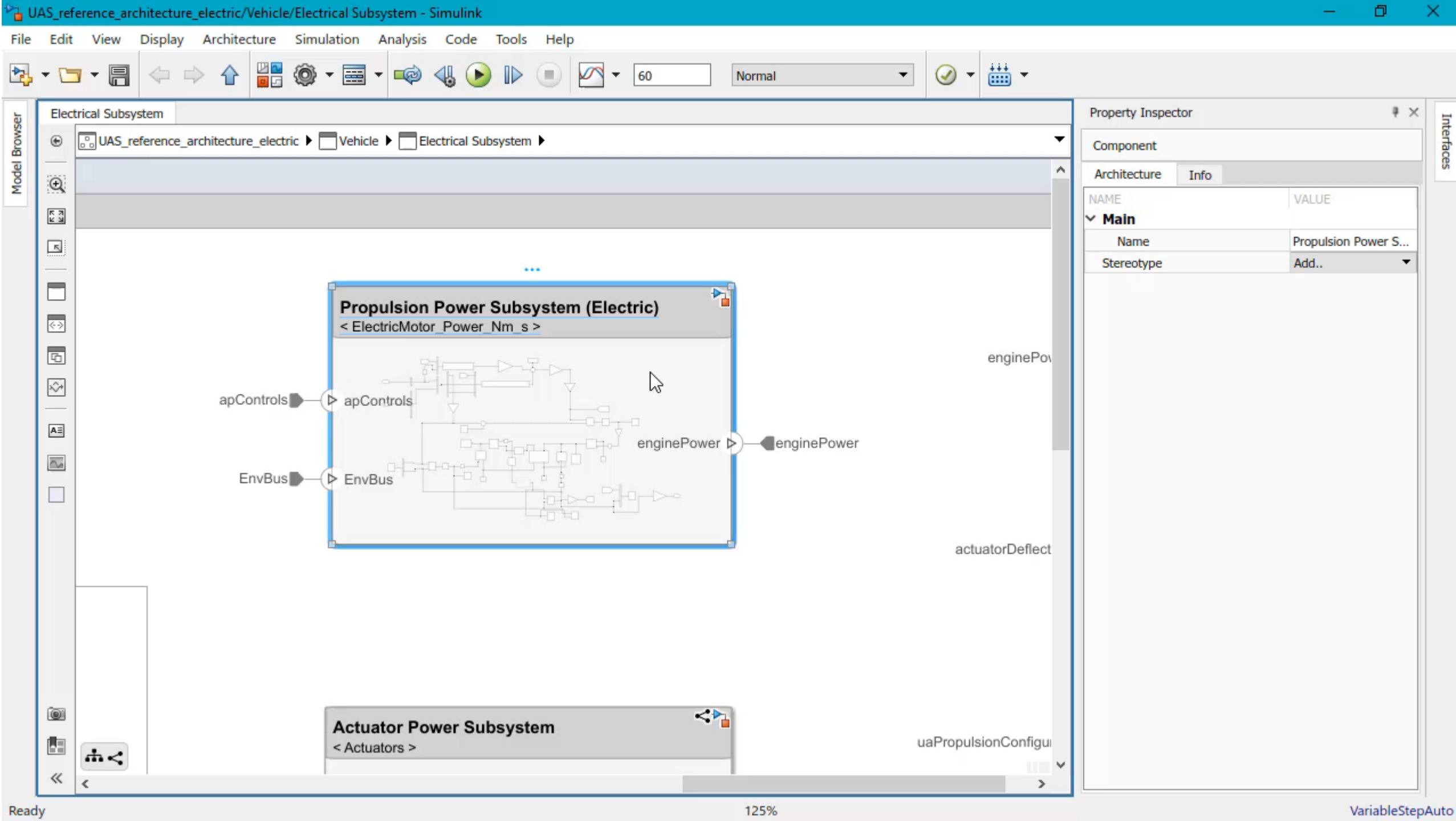
apControls
actuatorDeflectors
actuatorDeflectors
Ready
80%
VariableStepAuto


UAS_reference_architecture_electric/Vehicle/Electrical Subsystem - Simulink
File Edit View Display Architecture Simulation Analysis Code Tools Help
60
Normal
Model Browser
Electrical Subsystem
UAS_reference_architecture_electric
Vehicle
Electrical Subsystem
Propulsion Power Subsystem (Electric)
< ElectricMotor_Power_Nm_s >
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apControls
EnvBus
EnvBus
enginePower
enginePower
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Actuator Power Subsystem
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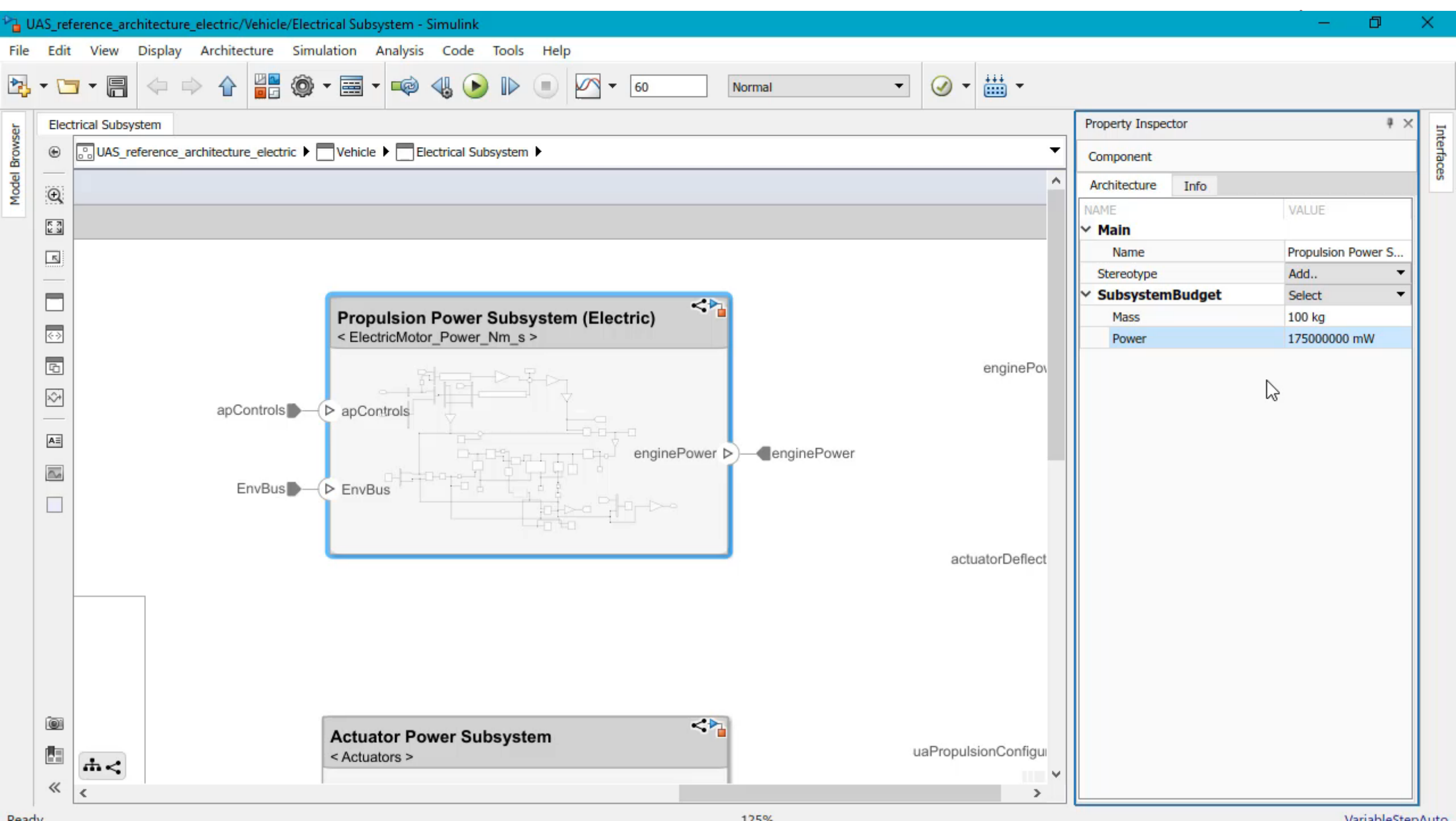
UAS_reference_architecture_electric/Vehicle/Electrical Subsystem - Simulink
File
Edit
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Display
Architecture
Simulation
Analysis
Code
Tools
Help
60
Normal
Model Browser
Electrical Subsystem
UAS_reference_architecture_electric
Vehicle
Electrical Subsystem
Propulsion Power Subsystem (Electric)
< ElectricMotor_Power_Nm_s >
apControls
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Stereotype
Add..
SubsystemBudget
Select
Mass
100 kg
Power
175000000 mW
Interfaces
Ready
125%
VariableStepAuto

Analysis Viewer (Technical Preview)

HOME

New Open Save Delete — INSTANCE MODEL

Analyze — Continuous — Arguments — BottomUp — ANALYSIS

Update — Automatic — Overwrite — UPDATE

Instances	Mass	Power
UAS_reference_architecture_electric_budgetRollup	392.33	175614300
BVLOS Navigation	0	0
Ground Station	0	0
Communication Box	0	0
Ground Station GPS interface	0	0
USB Serial Converter	0	0
Wireless Communication Subsystem	0	0
GPS receiver	0	0
Guidance and Navigation Computer	0	0
Flight Commands	0	0
Payload Computer	0	0
Vehicle	392.33	175614300
Communications Subsystem	2.63	58050
Automatic Dependent Surveillance-Broadcast	0.05	5000
C-Band Radio Modem	0.05	2000
KU-Band Radio TX/RX	2.5	50000
On-Board GPS	0.01	50
Radio RX PPM/PWM	0.02	1000
Electrical Subsystem	143.15	175355090
Actuator Power Subsystem	8	300000
Power Distribution	10	1000
Power Monitor	0	0
Power Source	20	1000
Propulsion Power Subsystem (Electric)	100	175000000
Vehicle Power Subsystem	5	50000
apRegulator	0.05	20
commRegulator	0.05	1070
plRegulator	0.05	2000
Environment	0	0

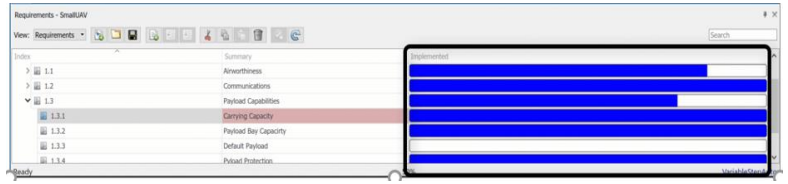
INSTANCE PROPERTIES

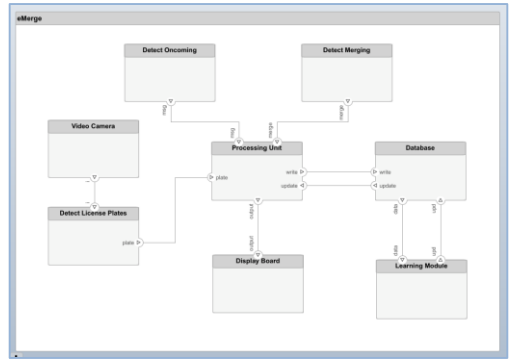
NodeInstance: Propulsion Power Subsystem (Electric)

Property	Units	Value	Edit
SubsystemBudget			
Mass	kg	100	
Power	mW	175,000,000	

Key Takeaways

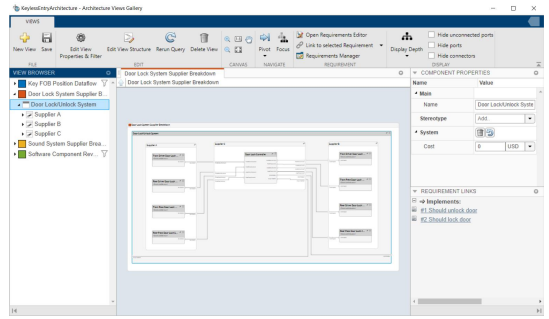
- System Composer connects architectures with requirements and simulation
- A flexible canvas
- Enables analysis and simulation
- Helps manage complexity





SmallUAV

Instances	Mass(kg)
SmallUAV	15.932
Airframe	9.25
Fuselage	1.7
LandingGear	1.65
Tail and Boom	2.7
Wings	3.2
Flight Support Components	0.629
ADSB Module	0.156
ABDSB Antenna	0.058
ADSB Board	0.098
GPS Module	0.398
GPS Antenna	0.128
GPS Board	0.27
Pitot Tube Module	0.075
FlightComputer	0.388
Main Board	0.145
Protective Case	0.195



Learn More

- System Composer Webpage
- Simulink Requirement Webpage
- System Modeling and Simulation Webpage
- See more at the System Modelling demo station
  - Including AUTOSAR composition authoring

- Trial