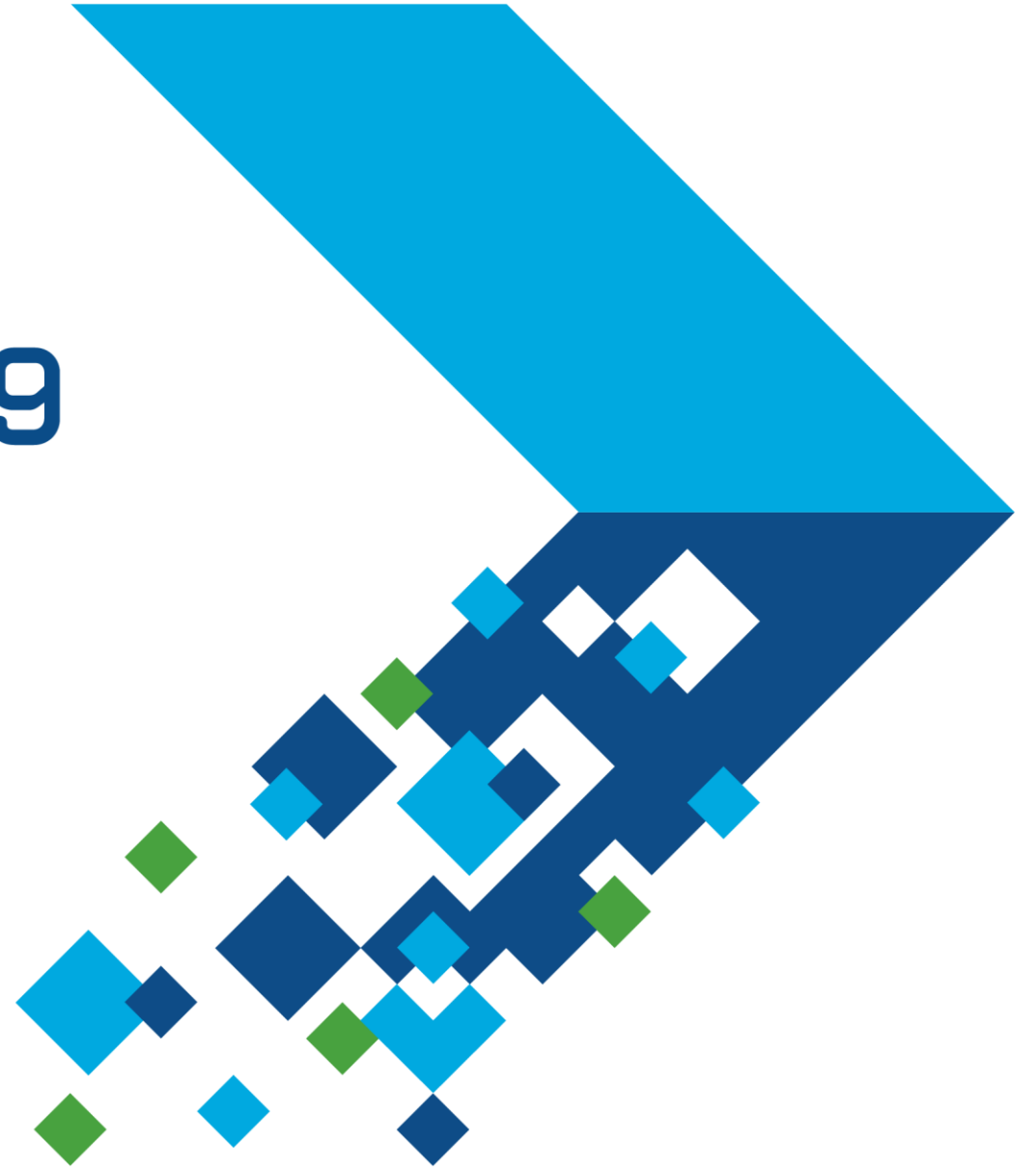


MATLAB EXPO 2019

Systems Engineering
Requirements to Architecture to
Simulation

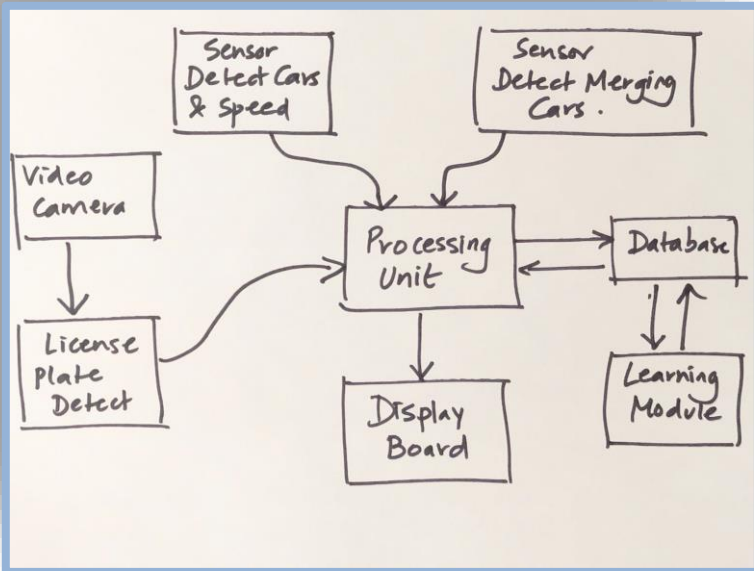
Mark Walker



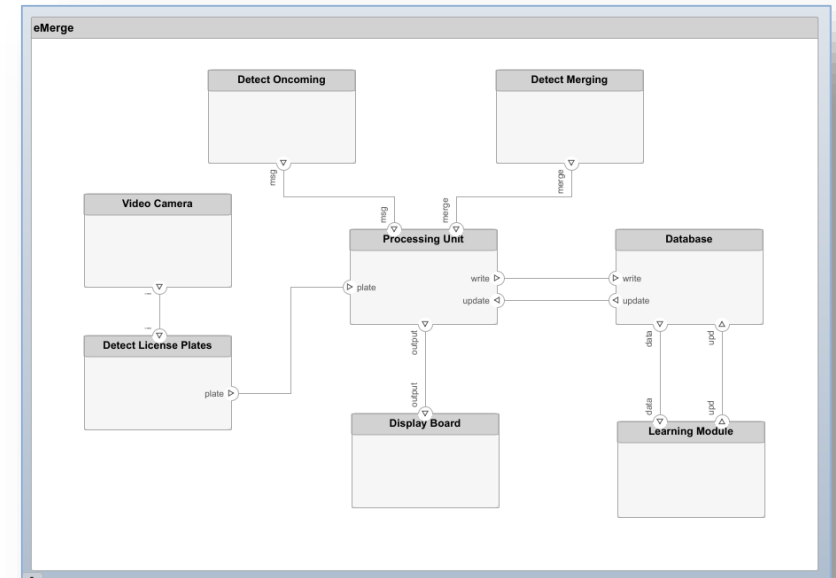
System Composer

Intuitively design system and software architectures

R2019a



Description
==
Architecture



System Composer

Perform trade studies based on data driven analysis to optimize architectures

Add custom data

Architecture	Info
NAME	VALUE
▼ Main	
Name	Power Unit
Stereotype	Add..
▼ OnboardElement Select	
Mass	0.217 kg
Power	0 mW
RFHarnessLength	0 cm

Create analysis model

Instances	Mass(kg)
SmallUAV	0
Airframe	0
Fuselage	1.7
LandingGear	1.65
Tail and Boom	2.7
Wings	3.2
Flight Support Components	0
ADSB Module	0
ABDSB Antenna	0.058
ADSB Board	0.098
GPS Module	0
GPS Antenna	0.128
GPS Board	0.27
Pitot Tube Module	0.075
FlightComputer	0
Main Board	0.145
Protective Case	0.195

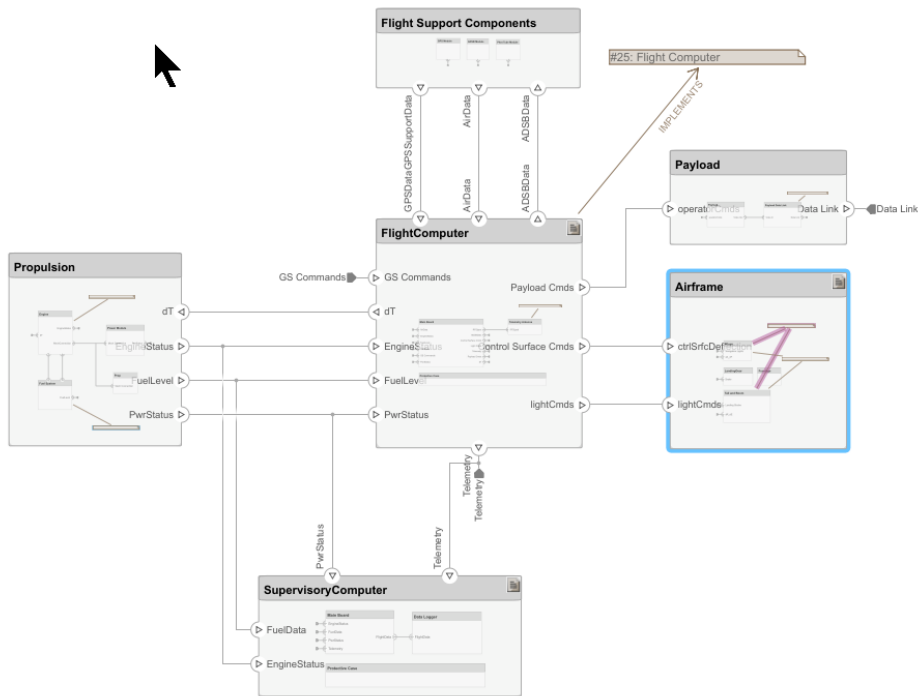
Calculate mass roll-up data

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

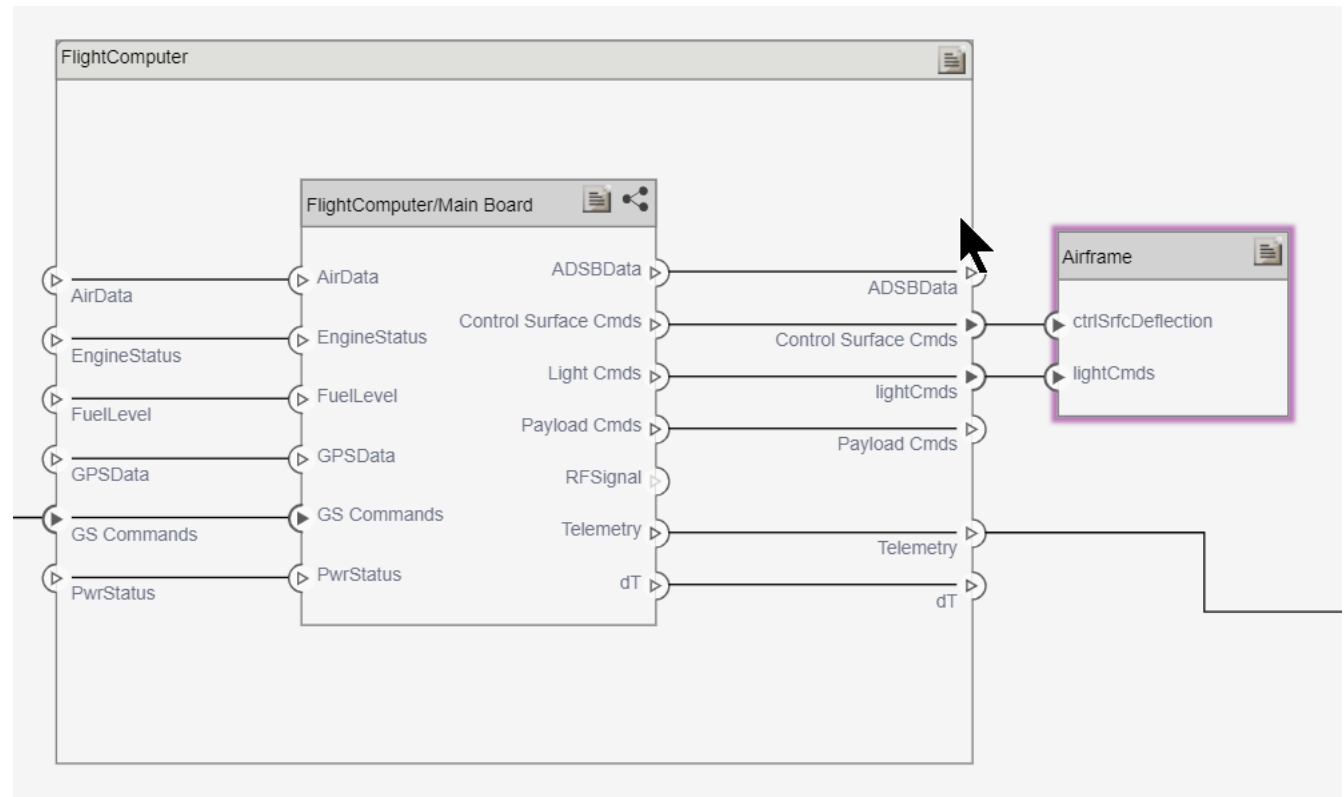
System Composer

Tackle Architecture complexity with spotlight views

Composition



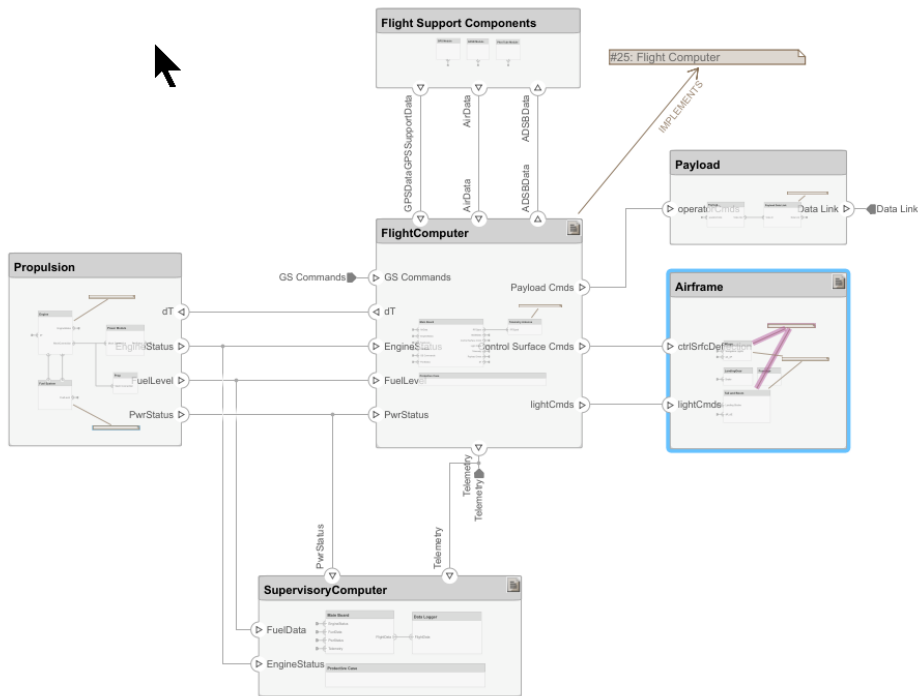
Spotlight



System Composer

Tackle Architecture complexity with views

Composition



Views

The screenshot shows the 'Views Gallery' for a project named 'KeylessEntryArchitecture'. The interface includes a toolbar with actions like 'New View', 'Save', 'Edit View', and 'Delete View'. A 'VIEW BROWSER' on the left lists various views, with 'Door Lock/Unlock System' selected. The main canvas displays a detailed view of the 'Door Lock System Supplier Breakdown', showing a 'Door Lock Controller' connected to three suppliers (A, B, and C), each with its own set of 'Door Lock' components. On the right, the 'COMPONENT PROPERTIES' panel shows details for the selected 'Door Lock/Unlock System'.

Name	Value
Name	Door Lock/Unlock System
Stereotype	Add..
System	
Cost	0 USD

The 'REQUIREMENT LINKS' panel shows the following implementation links:

- Implements:
- #1 Should unlock door
- #2 Should lock door

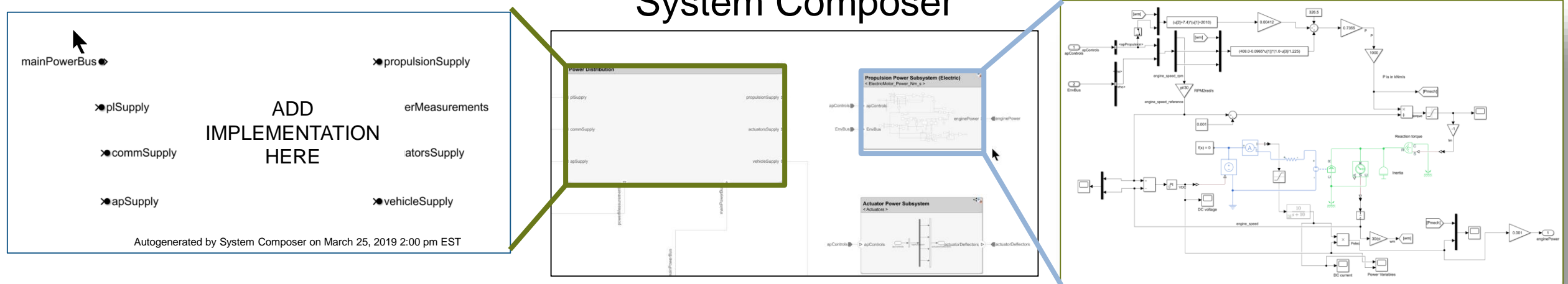
System Composer

System and software architectures connected to implementations in Simulink

Generate Simulink models from architecture components

Link Simulink models to architecture components

System Composer



System Composer

Link system models to Simulink Requirements

The screenshot shows the Simulink System Composer interface. The main workspace displays a block diagram of the 'Propulsion Power Subsystem' (labeled '< Engine_Power_Nm_s >') with inputs 'apControls' and 'EnvBus', and output 'enginePower'. A requirement '#35: Propulsion Power' is linked to this subsystem via an 'IMPLEMENTS' relationship.

The 'Requirements - UAS_reference_architecture' pane at the bottom shows a table of requirements:

Index	Summary	Implemented
1.4	Construction	<input checked="" type="checkbox"/>
1.4.1	Modularity	<input checked="" type="checkbox"/>
1.4.2	Propulsion Power	<input checked="" type="checkbox"/>
1.5	Flying Qualities	<input checked="" type="checkbox"/>
2	Ground Station Capabilities	<input checked="" type="checkbox"/>

The 'Property Inspector' on the right shows details for requirement '#35: Propulsion Power':

- Requirement: #35
- Type: Functional
- Index: 1.4.2
- Custom ID: #35
- Summary: Propulsion Power
- Description: The original gas engine of the aircraft shall be replaced by an equivalent output electrical motor, able to supply at least 350 kW of mechanical power at 2,300 RPM.

The 'Links' section in the Property Inspector shows the link to the 'Propulsion Power Subsystem' with a warning: 'Change issue found for this link. Go to Links view'.

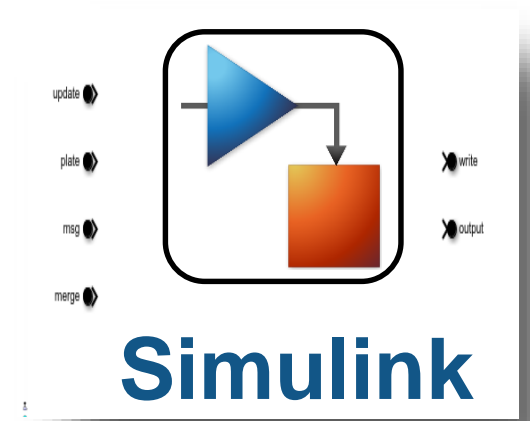
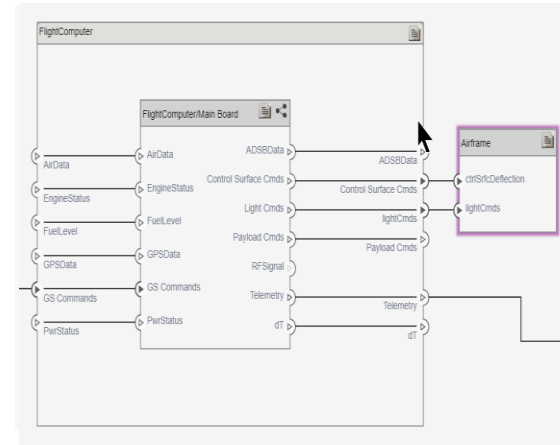
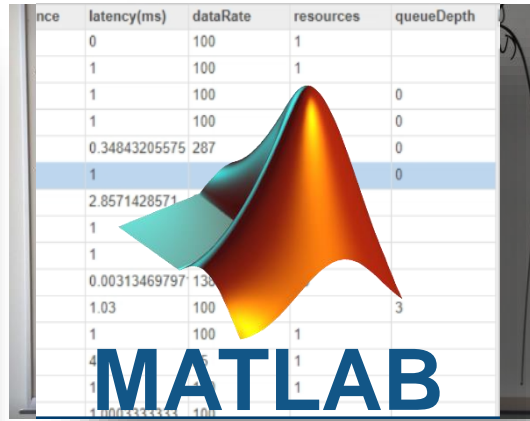
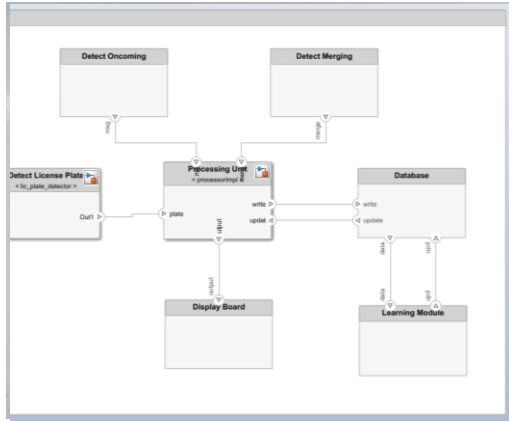
System Composer

Be Intuitive

Facilitate Analysis

Tackle Complexity

Enable Implementation



Digital Thread for Requirements Coverage Reporting and Impact Analysis

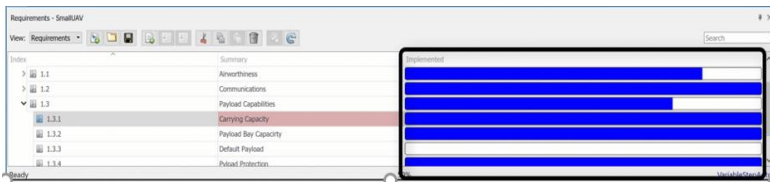
Simulink Requirements

Index	Summary	Implemented
1.1	Airworthiness	[Progress bar]
1.2	Communications	[Progress bar]
1.3	Payload Capabilities	[Progress bar]
1.3.1	Carrying Capacity	[Progress bar]
1.3.2	Payload Bay Capacity	[Progress bar]
1.3.3	Default Payload	[Progress bar]
1.3.4	Payload Protection	[Progress bar]

System Composer and Model-Based Design

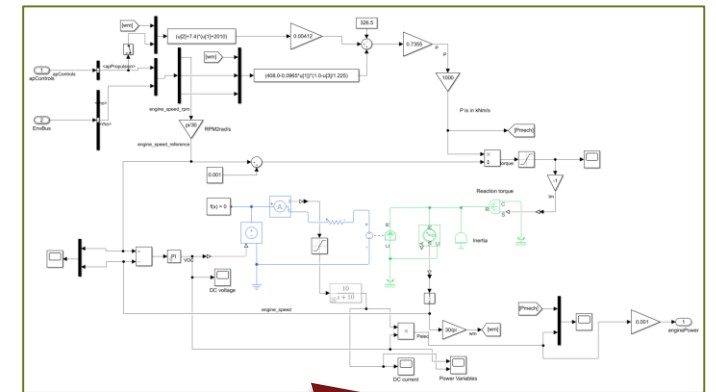
A Systems Engineer

Simulink Requirements



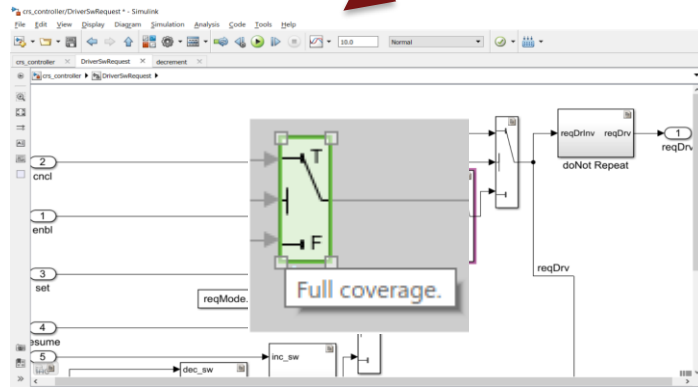
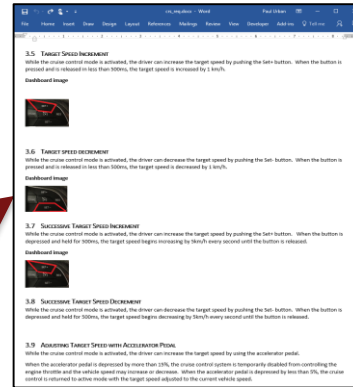
Systems engineering techniques are used in complex projects: spacecraft design, computer chip design, robotics, software integration, and bridge building. Systems engineering uses a **best of tools** that include **modeling and simulation**, **requirements analysis** and scheduling to manage complexity.

Simulink Models

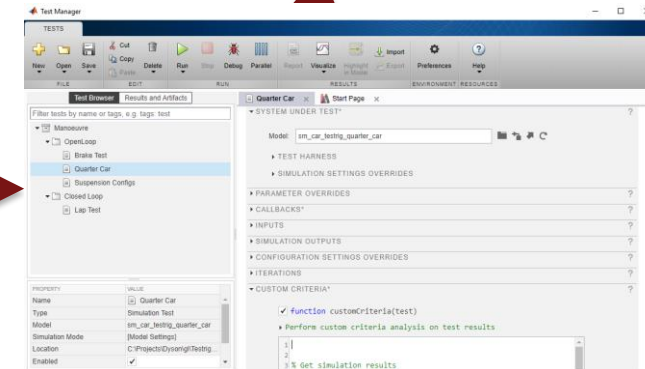


Requirements, Models and Tests – Bottom-up

Requirements

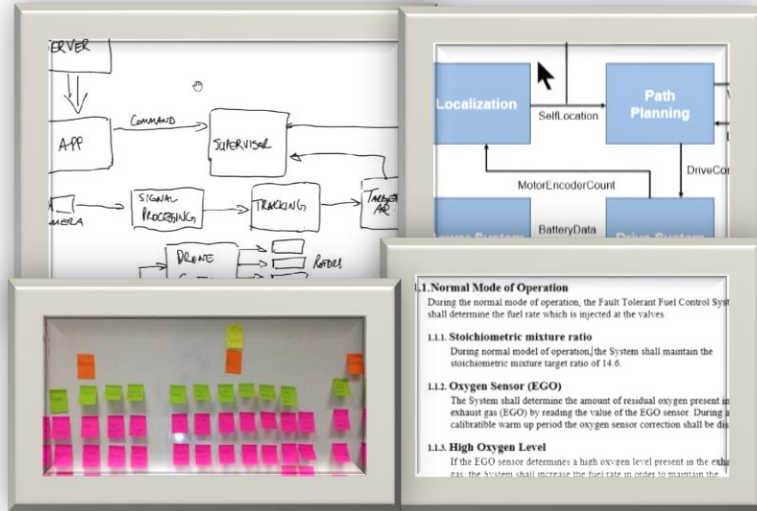


Models



Tests

Systems Engineering and Requirements – Top Down



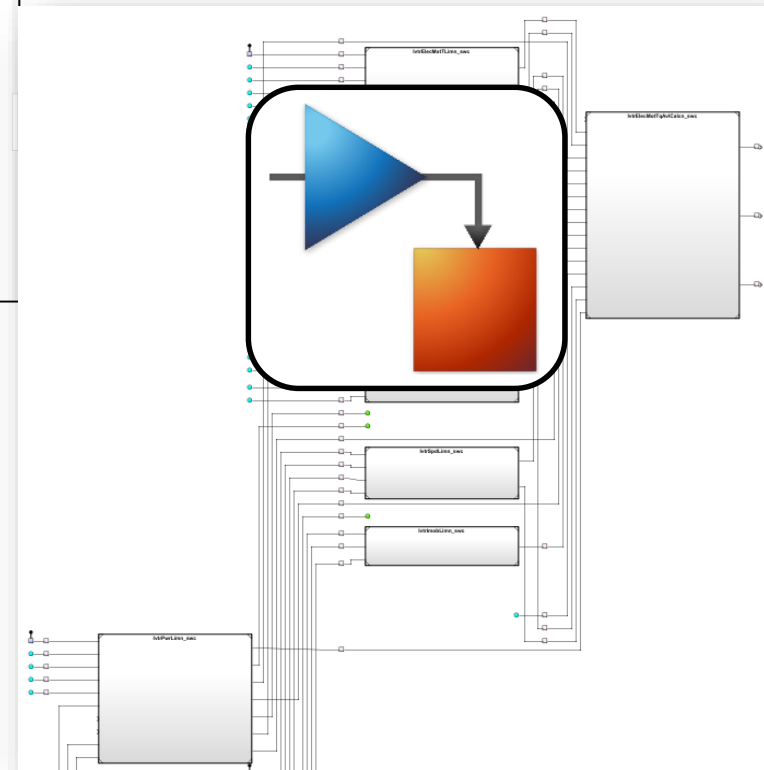
3.5. TARGET SPEED INCREMENT
While the cruise control mode is activated, the driver can increase the target speed by pushing the Set button. When the button is pressed and is released in less than 100ms, the target speed is increased by 1 km/h.Dashboard Image

3.6. TARGET SPEED DECREMENT
While the cruise control mode is activated, the driver can decrease the target speed by pushing the Set button. When the button is pressed and is released in less than 100ms, the target speed is decreased by 1 km/h.Dashboard Image

3.7. SUCCESSIVE TARGET SPEED INCREMENT
While the cruise control mode is activated, the driver can increase the target speed by pushing the Set button. When the button is depressed and held for 3 seconds, the target speed begins increasing by 5 km/h every second until the button is released.Dashboard Image

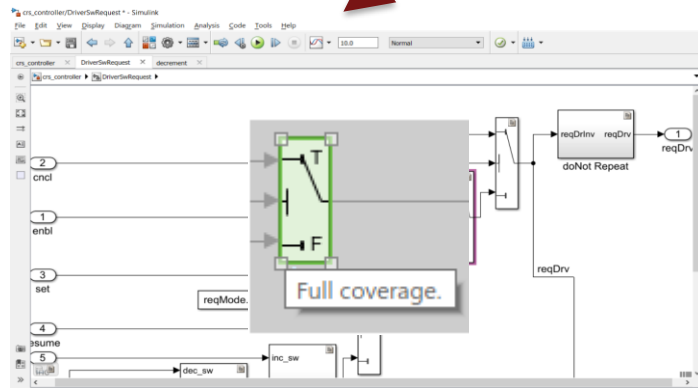
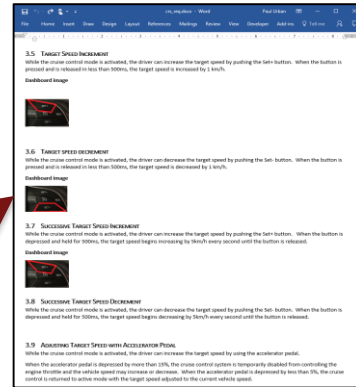
3.8. SUCCESSIVE TARGET SPEED DECREMENT
While the cruise control mode is activated, the driver can decrease the target speed by pushing the Set button. When the button is depressed and held for 3 seconds, the target speed begins decreasing by 5 km/h every second until the button is released.Dashboard Image

3.9. ADJUSTING TARGET SPEED WITH ACCELERATOR PEDAL
While the cruise control mode is activated, the driver can increase the target speed by using the accelerator pedal. When the accelerator pedal is depressed by more than 10%, the cruise control system is temporarily disabled from controlling the engine throttle and the set speed may increase or decrease. When the accelerator pedal is depressed by less than 5%, the cruise control system resumes controlling the target speed adjusted by the current vehicle speed.Dashboard Image

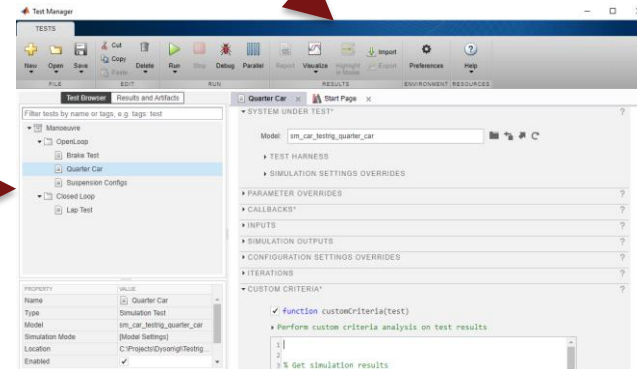


Independence Forced by Tooling

Requirements



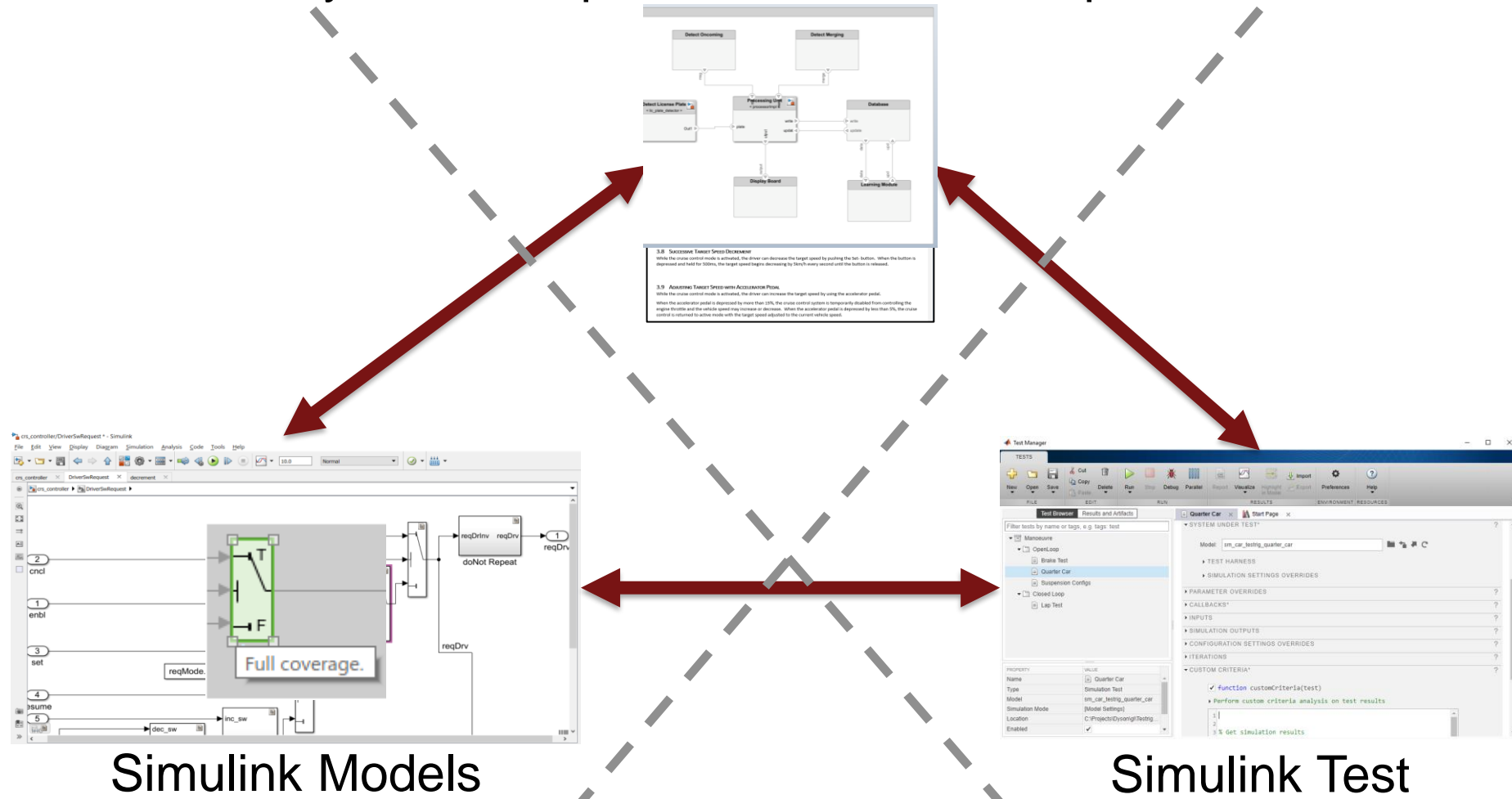
Models



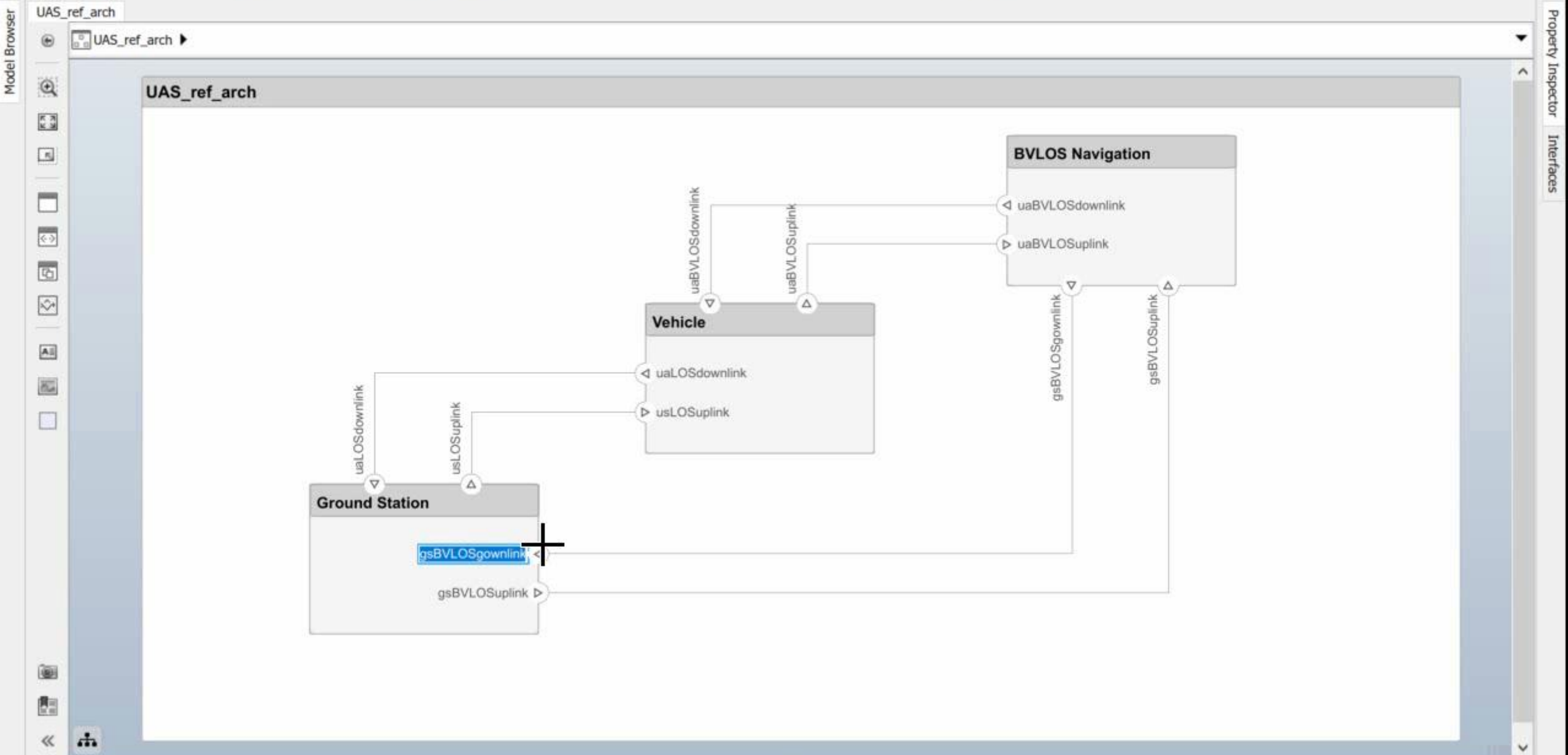
Tests

Flexibility between Systems and Software

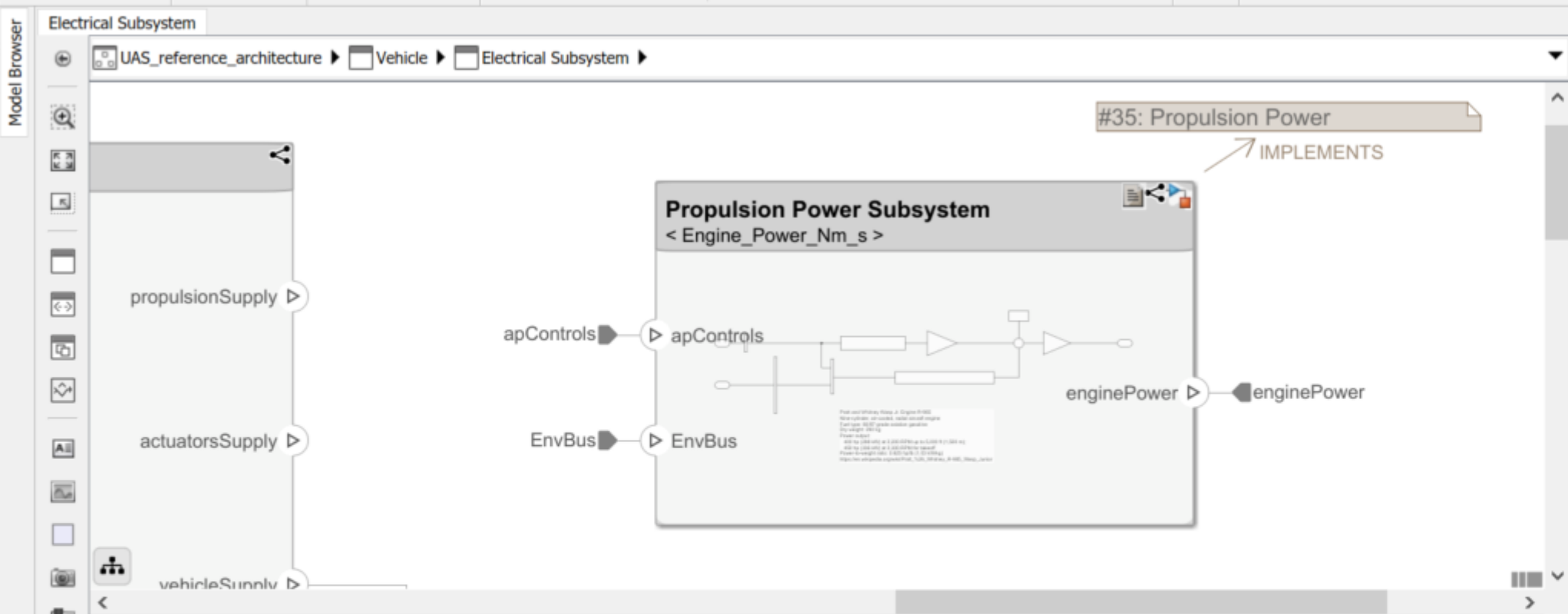
System Composer Models and Requirements



Now let's see it in action



60 Normal



Property Inspector

Requirement Set

Details

Properties

Filepath: \\fs-56-ah\vmgrs\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

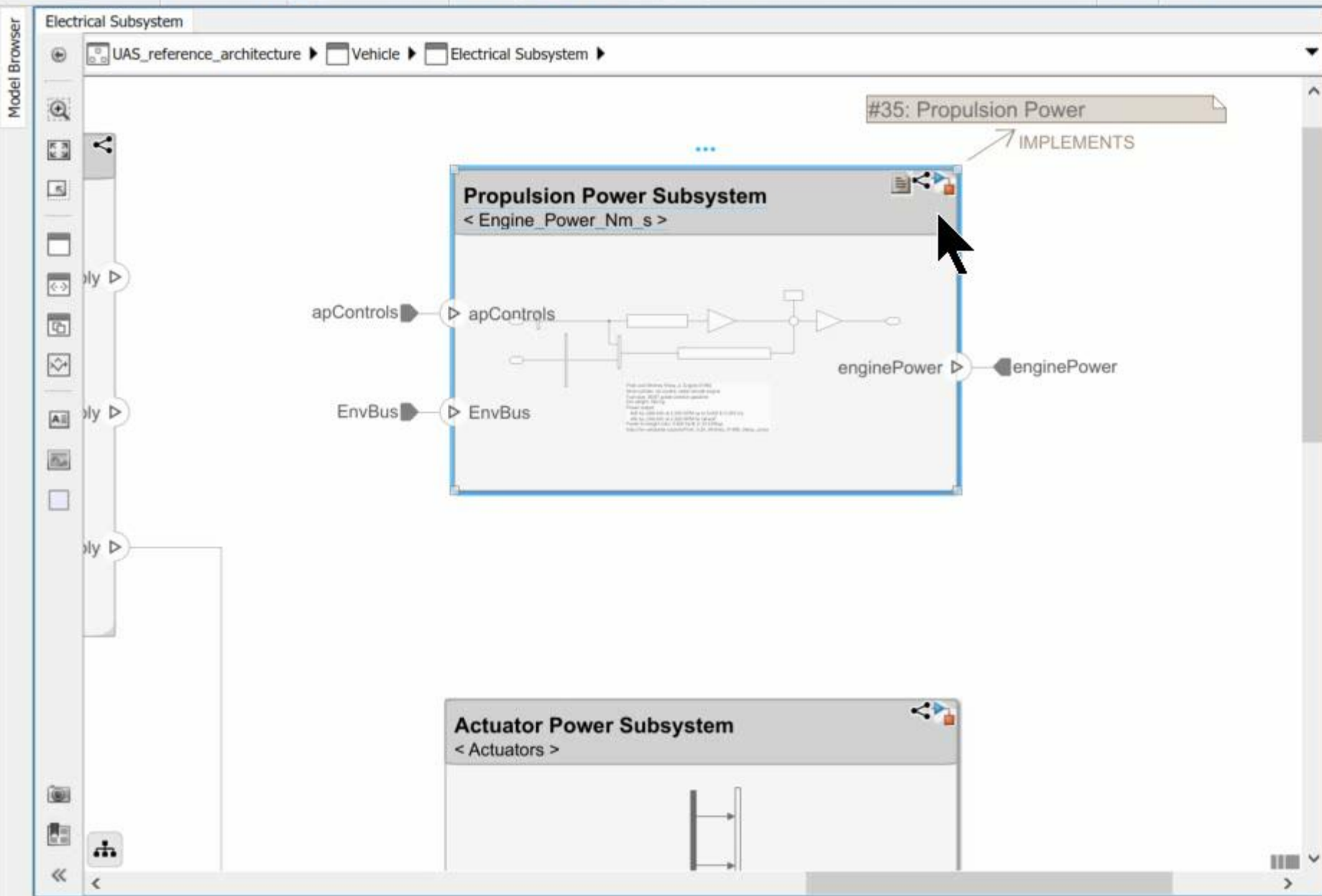
Description:

Custom Attribute Registries

Requirements - UAS_reference_architecture

View: Requirements

Index	Summary	Implemented
UAS_reqs		
1	Aircraft Capabilities	Implemented: 27, Justified: 0, None: 0, Total: 27
1.1	Airworthiness	
1.1.1	Range	
1.1.2	Rain Conditions	
1.1.3	Power	



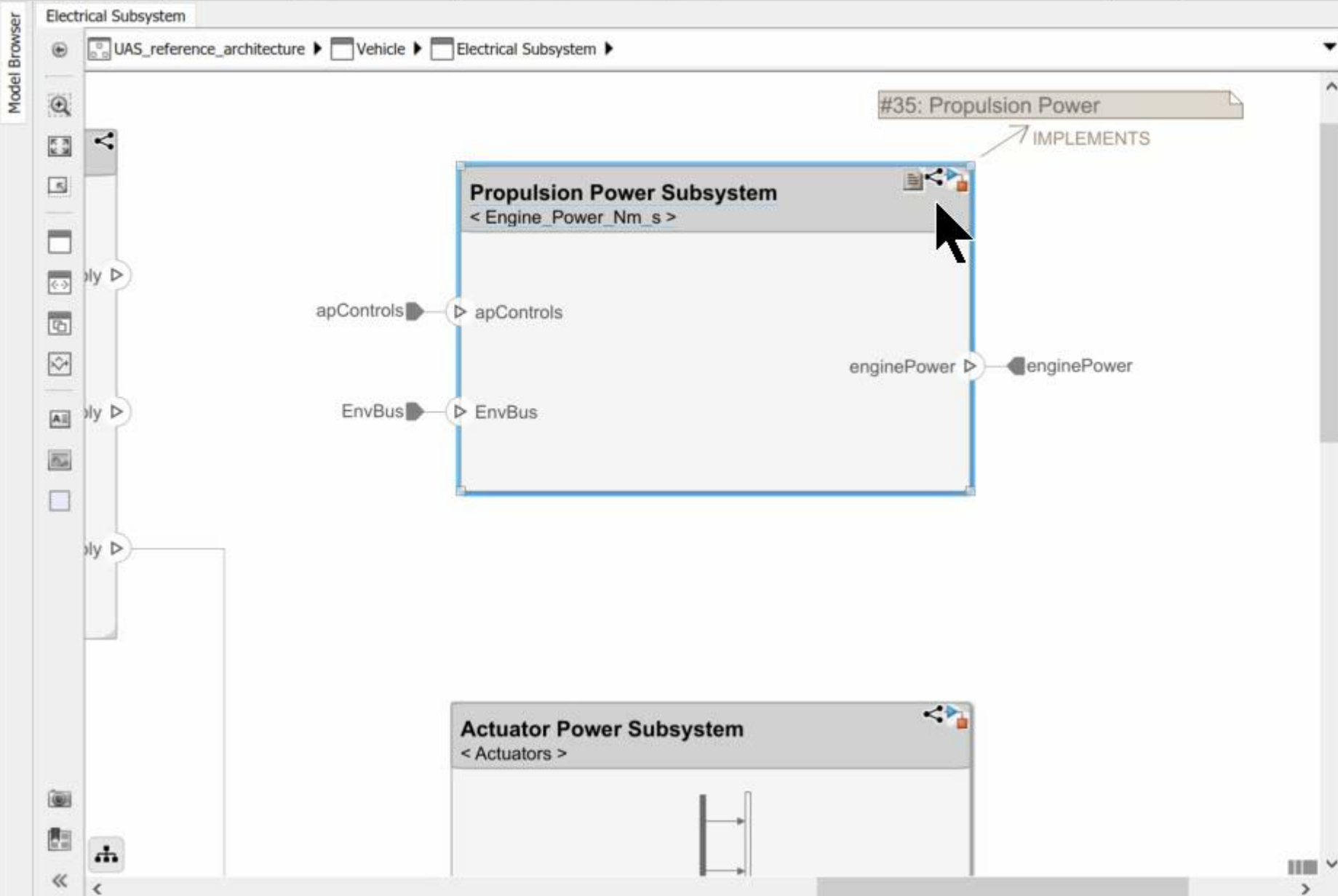
Property Inspector

Component

Architecture Info

NAME	VALUE
Main	
Name	Propulsion Power Subsystem
Stereotype	Add..
SubsystemBudget	
	Select

60 Normal



Property Inspector

Component

Architecture Info

NAME	VALUE
Main	
Name	Propulsion Power Subsystem
Stereotype	Add..
SubsystemBudget	Select

Interfaces

UAS_reference_architecture/Vehicle - Simulink

File Edit View Display Architecture Simulation Analysis Code Tools Help

60 Normal

Model Browser

Vehicle

UAS_reference_architecture > Vehicle

Running

50% T=15.600 26% auto(ode23t)

Interfaces

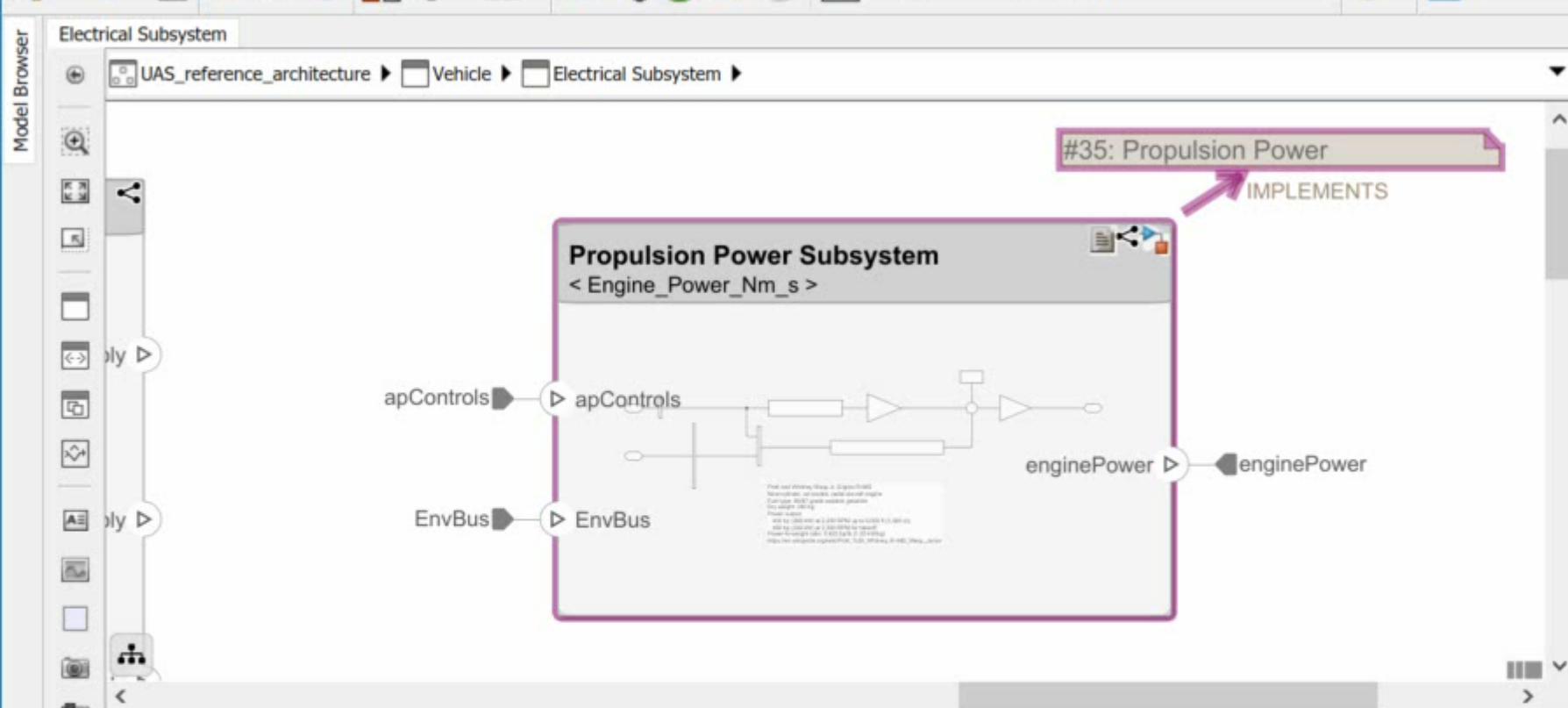
FlightGear

File View Location Autopilot Environment Equipment AI Multiplayer Debug Help Beaver

FlightGear window showing a 3D visualization of a large aircraft flying over a city and landscape.

Requirements list:

- R1 - Transport Mode: Payload mode (longitudinal) flying qualities shall meet at least Level 2 criteria from the MIL-F-8785C standard.
- R2 - Short period Mode: Short period mode (longitudinal) flying qualities shall meet Level 1 criteria from the MIL-F-8785C standard.
- R3 - Dutch roll Mode: Dutch roll mode (lateral-directional) flying qualities shall meet Level 1 criteria from the MIL-F-8785C standard.
- R4 - Roll Mode: Roll mode (lateral-directional) flying qualities shall meet Level 1 criteria from the MIL-F-8785C standard.
- R5 - Spiral Mode: Spiral mode (lateral-directional) flying qualities shall meet Level 1 criteria from the MIL-F-8785C standard.



Property Inspector

Requirement: #35

Details

Properties

Type: Functional
 Index: 1.4.2
 Custom ID: #35
 Summary: Propulsion Power

Description Rationale

Engine: Nine-cylinder, air-cooled, radial aircraft engine
 Fuel type: 80/87 grade aviation gasoline
 Dry weight/lb (1.03 kW/kg): 290 kg
 Power output: 400 hp (298 kW) at 2,200 RPM up to 5,000 ft (1,500 m)

Keywords:

Revision information:

Links

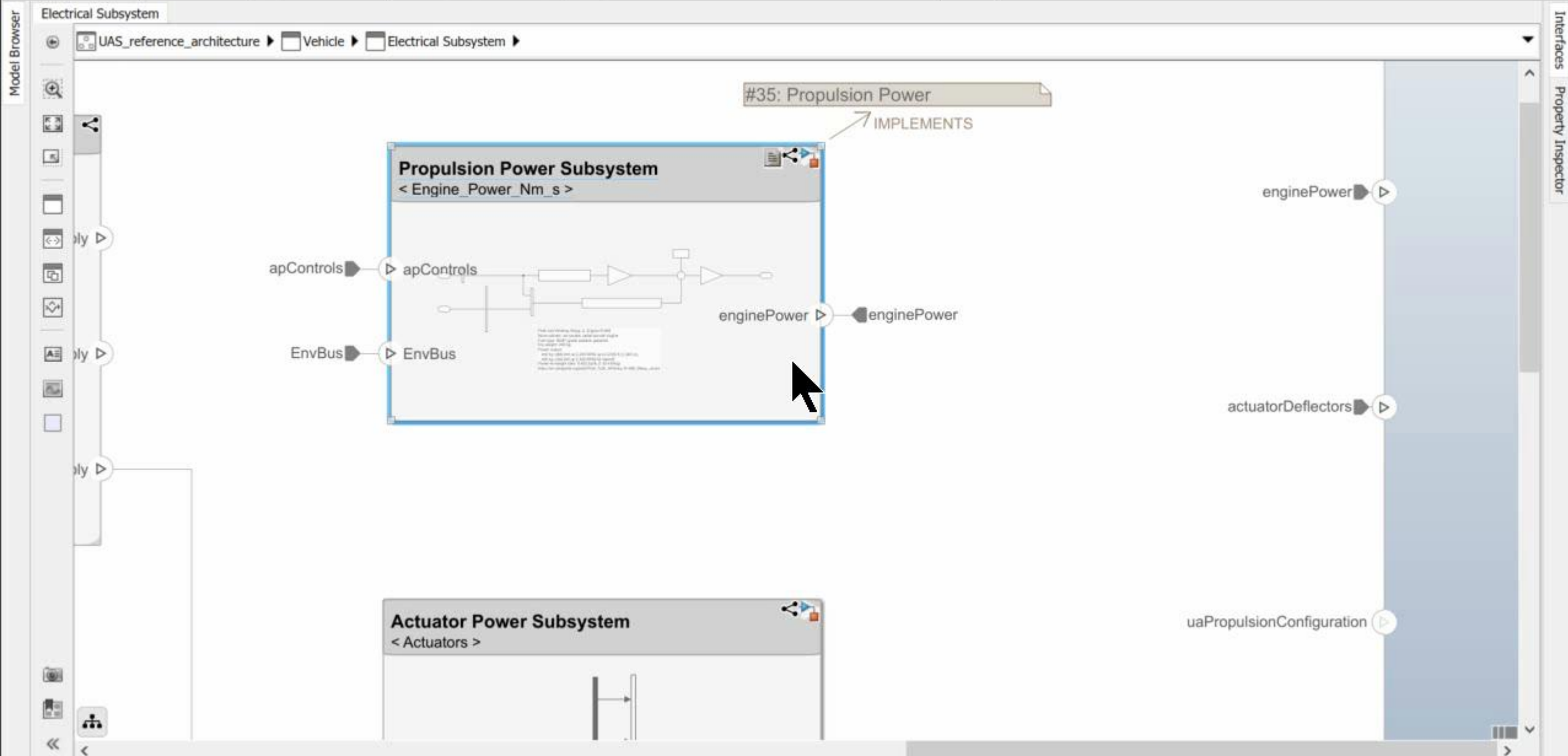
Implemented by:
 Propulsion Power Subsystem

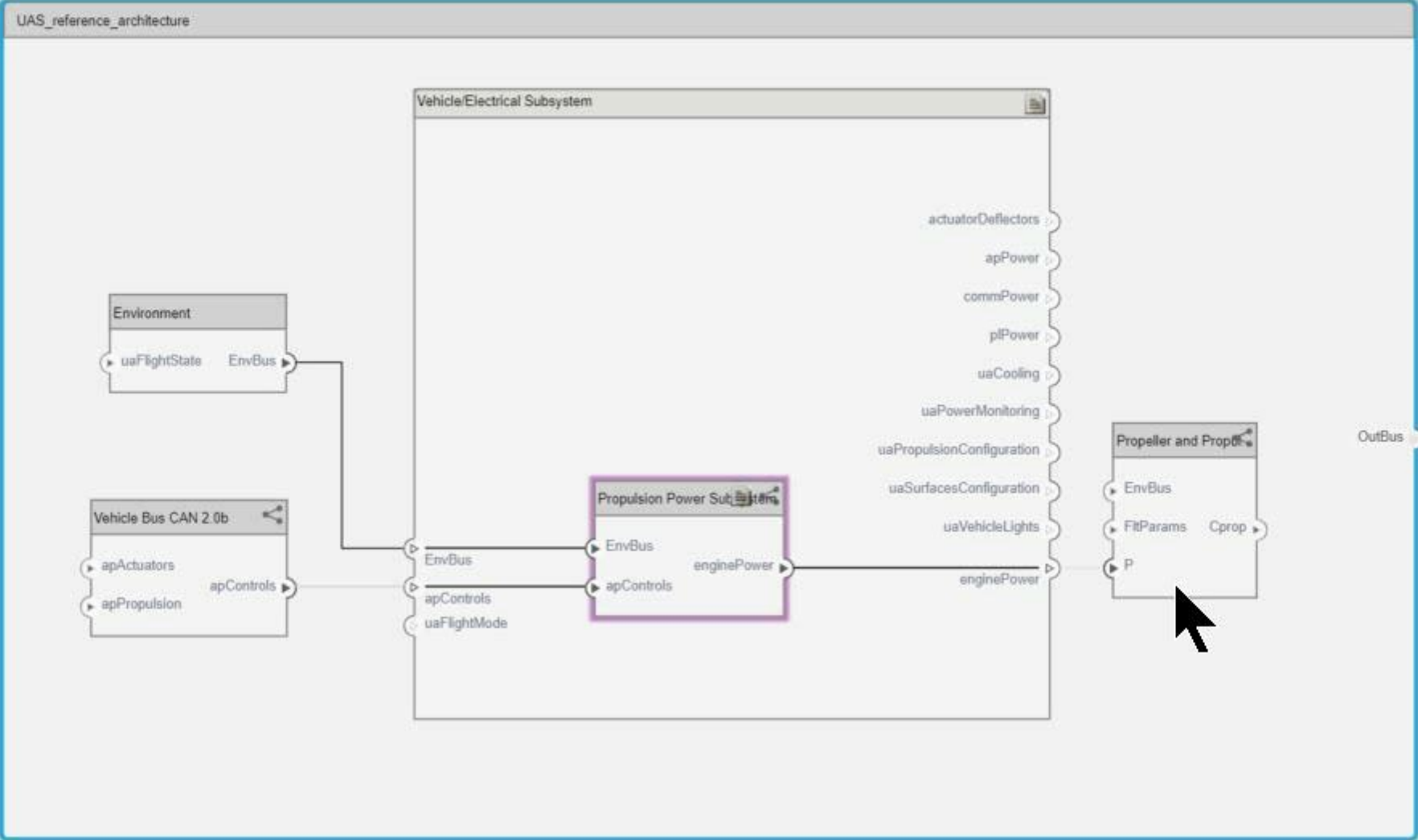
Comments

Requirements - UAS_reference_architecture

View: Requirements

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



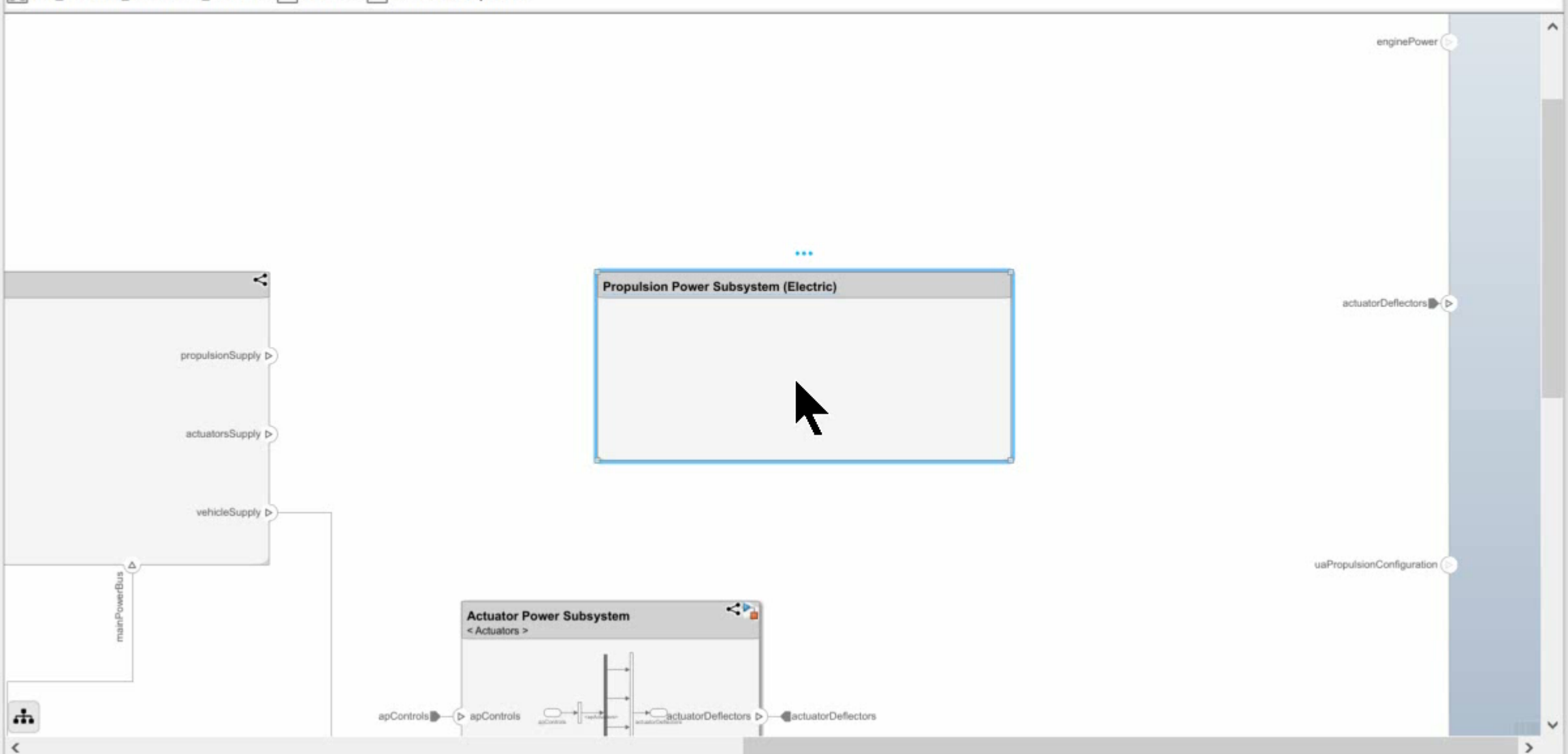


Spotlight

Toolbar with icons for file operations, navigation, simulation, and a numeric input field set to 60. A dropdown menu is set to 'Normal'.

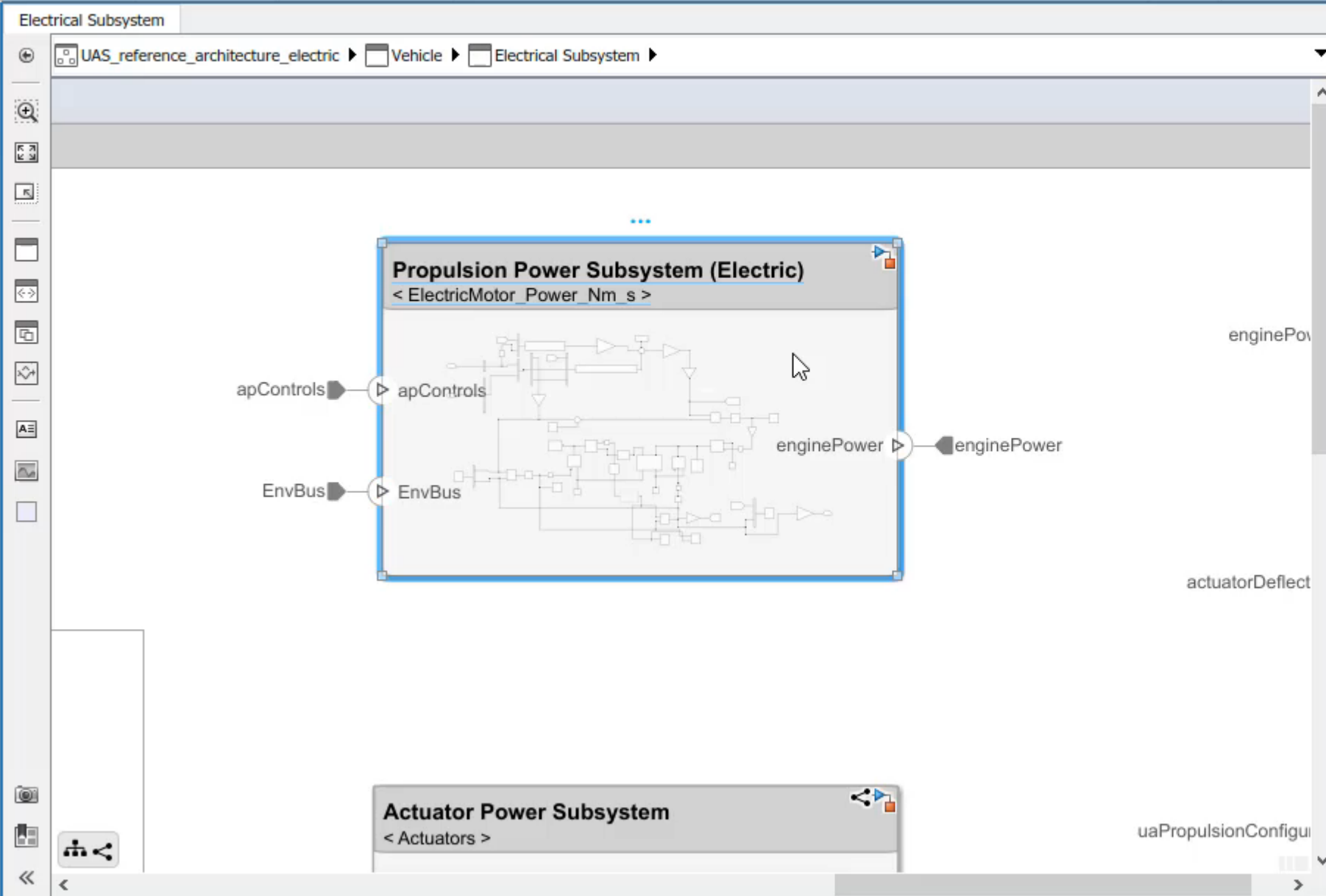
Model Browser: Electrical Subsystem

UAS_reference_architecture_electric > Vehicle > Electrical Subsystem



Navigation icons: Home, Back, Forward, Up, Refresh, Undo, Redo, Play, Stop, Pause, Zoom In, Zoom Out, Zoom Reset, Zoom Value: 60, Style: Normal, Checkmark, Grid.

Model Browser



Property Inspector

Component

Architecture Info

NAME	VALUE
Main	
Name	Propulsion Power S...
Stereotype	Add..

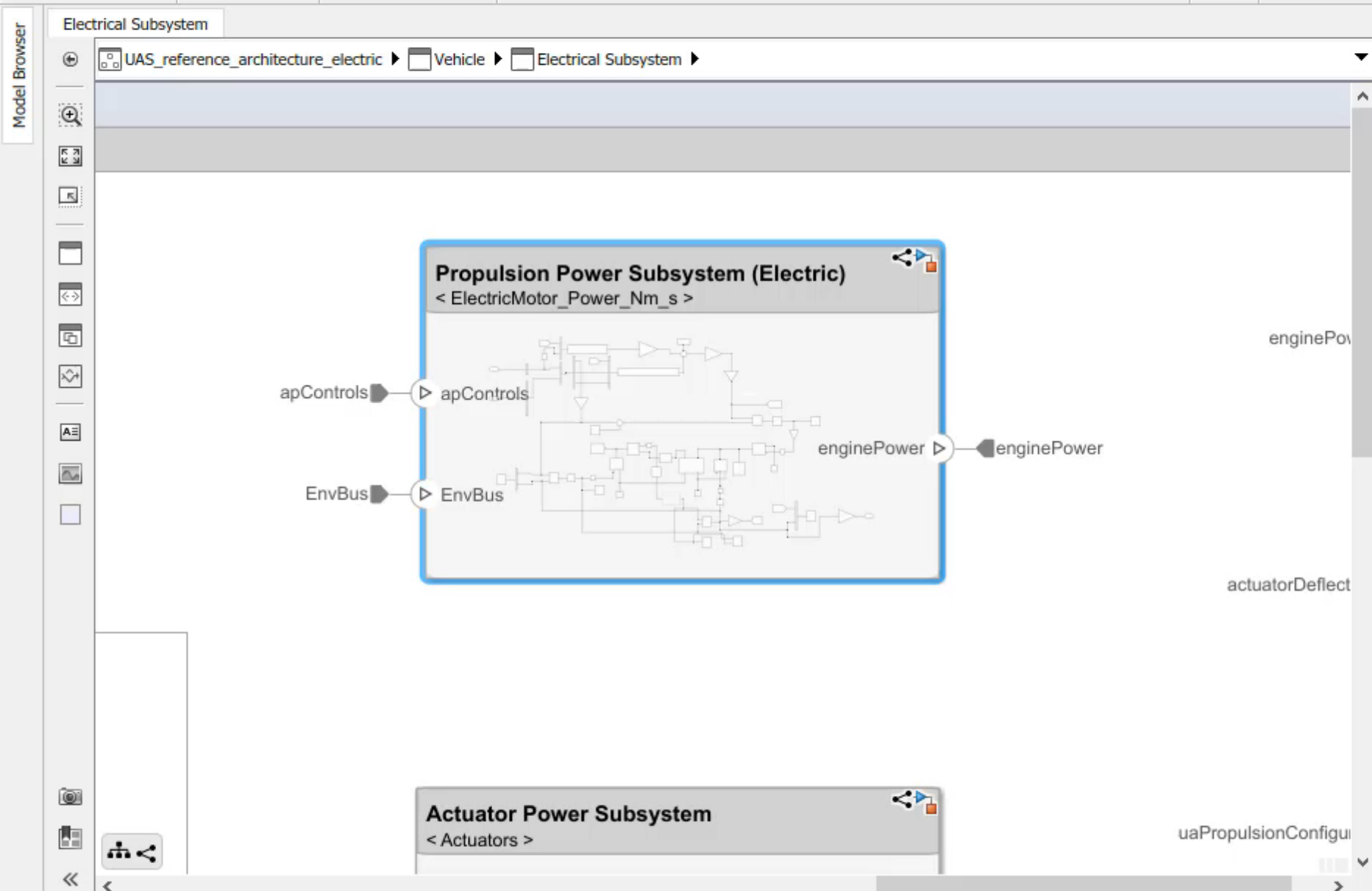
enginePow

actuatorDeflect

uaPropulsionConfigu

Interfaces

Simulation toolbar with icons for save, undo, redo, zoom, and simulation controls. Includes a numerical input field set to 60 and a dropdown menu set to Normal.



Property Inspector window showing the configuration for the selected component.

Component: Propulsion Power S...

Architecture: Info

NAME	VALUE
Main	
Name	Propulsion Power S...
Stereotype	Add..
SubsystemBudget	
Mass	100 kg
Power	175000000 mW

HOME

Continuous

Automatic

Overwrite

Arguments ▾

BottomUp ▾

INSTANCE MODEL ANALYSIS 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
piRegulator	0.05	2000
Environment	0	0

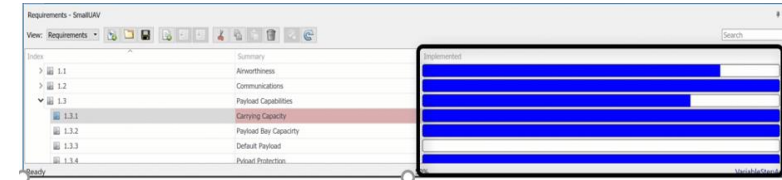
INSTANCE PROPERTIES

NodeInstance: Propulsion Power Subsystem (Electric)

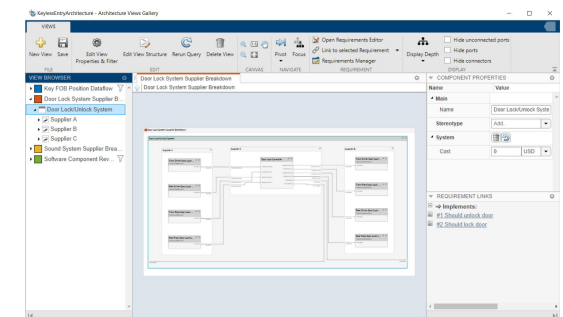
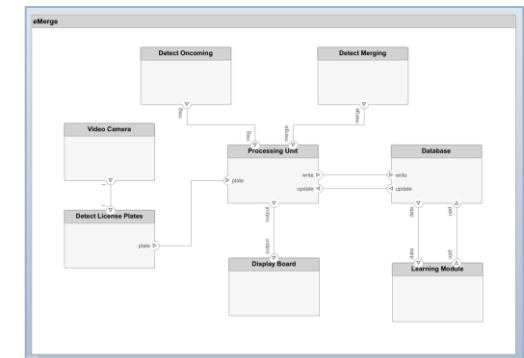
Property	Units	Value	Edit
SubsystemBudget			
Mass	kg	100	<input type="button" value="Edit"/>
Power	mW	175,000,000	<input type="button" value="Edit"/>

Key Takeaways

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



SmallUAV	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
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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](#)