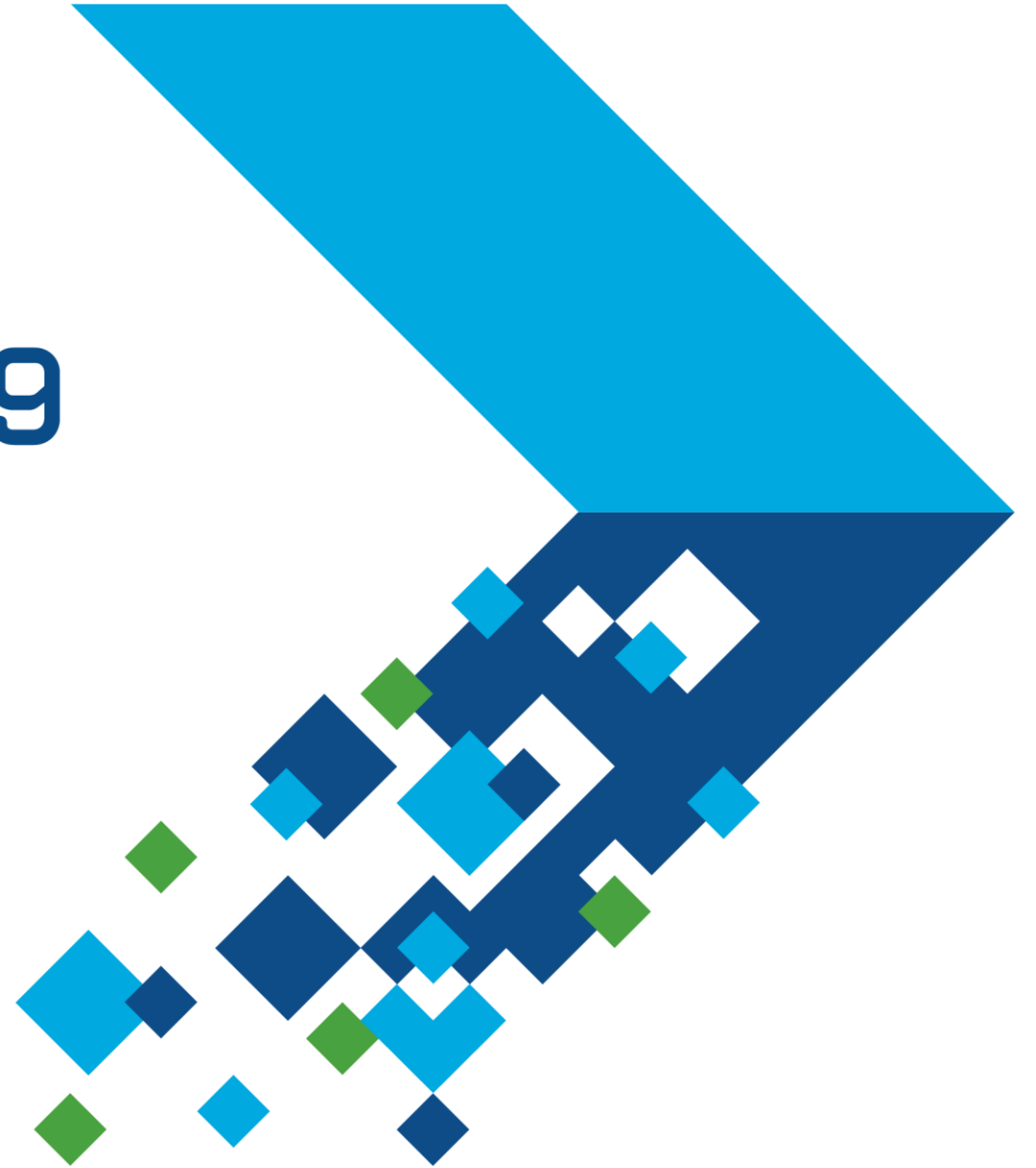


MATLAB EXPO 2019

Systems Engineering
Requirements to Architecture to
Simulation

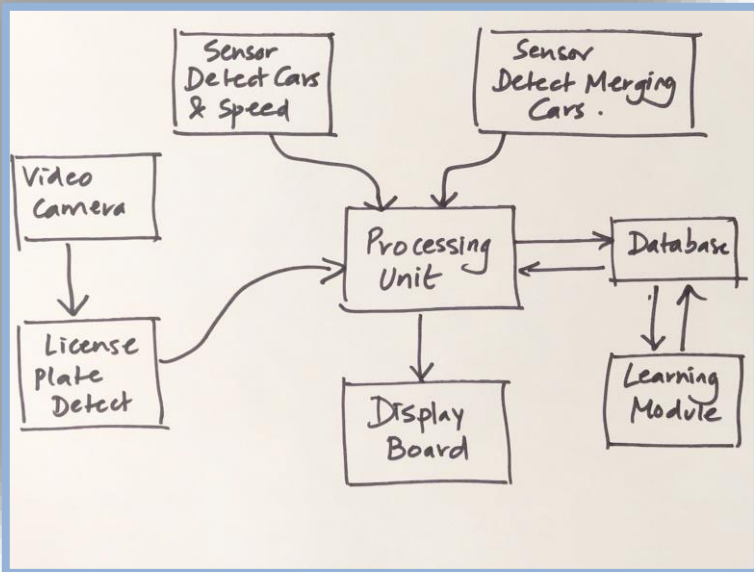
Mark Walker



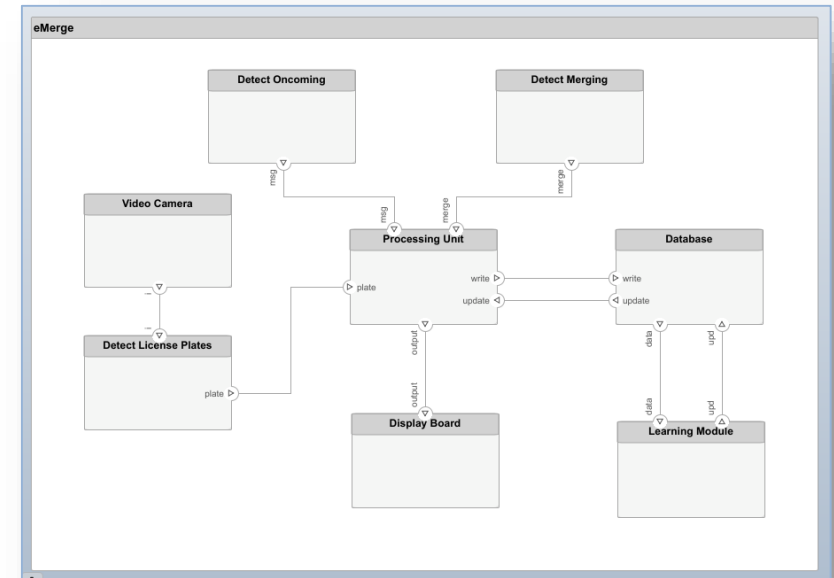
System Composer

Intuitively design system and software architectures

R2019a



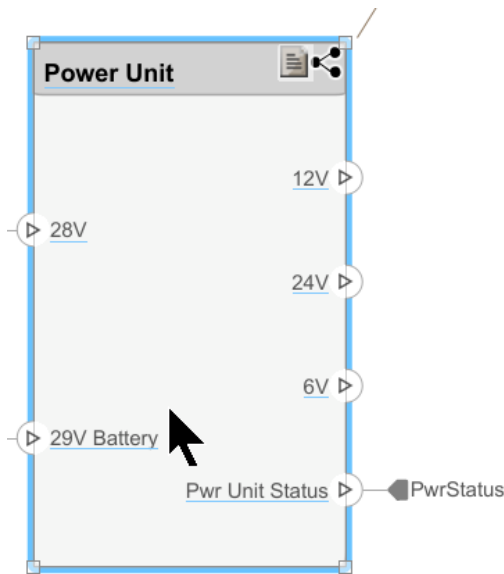
Description
=
Architecture



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

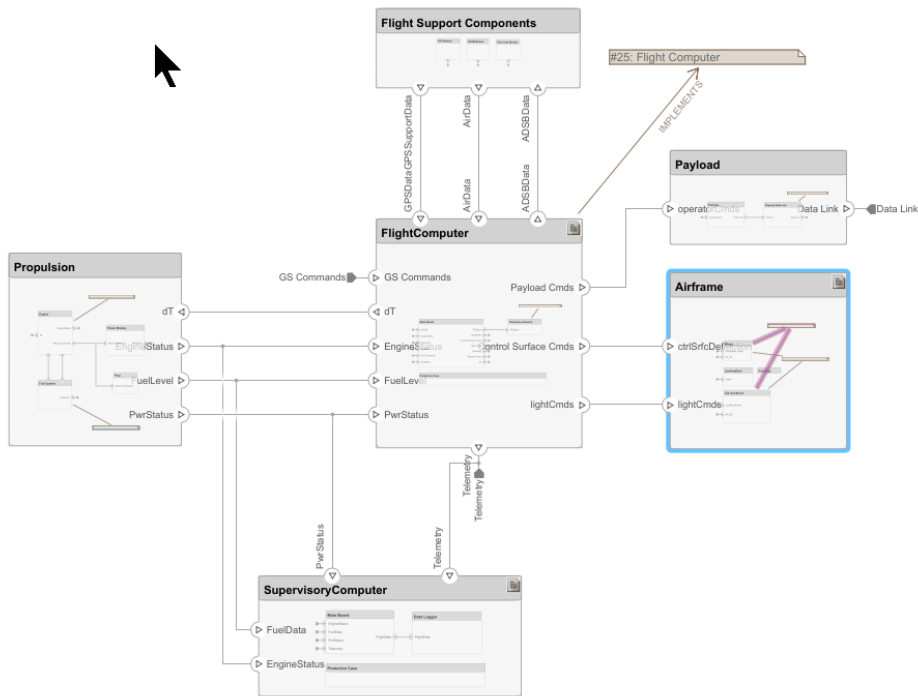
Calculate mass roll-up data

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

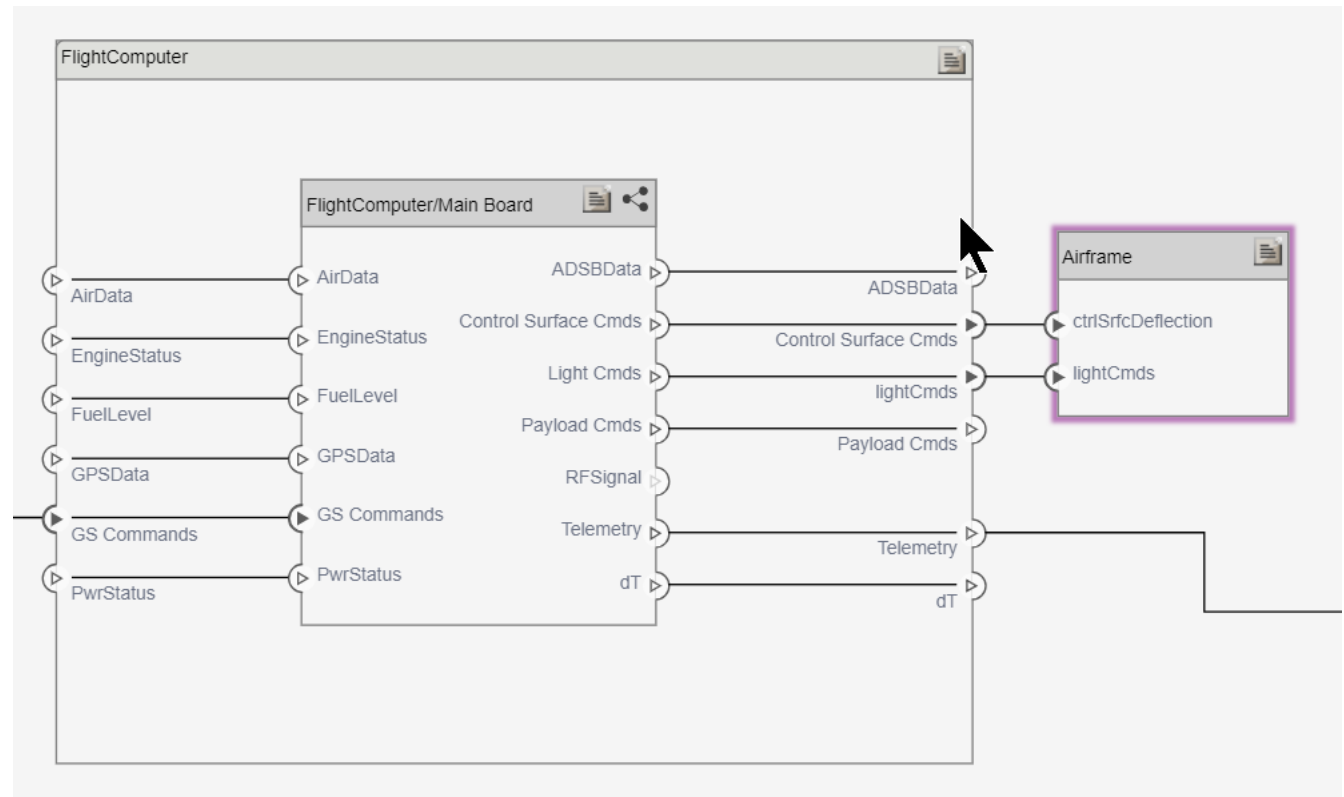
System Composer

Tackle Architecture complexity with spotlight views

Composition



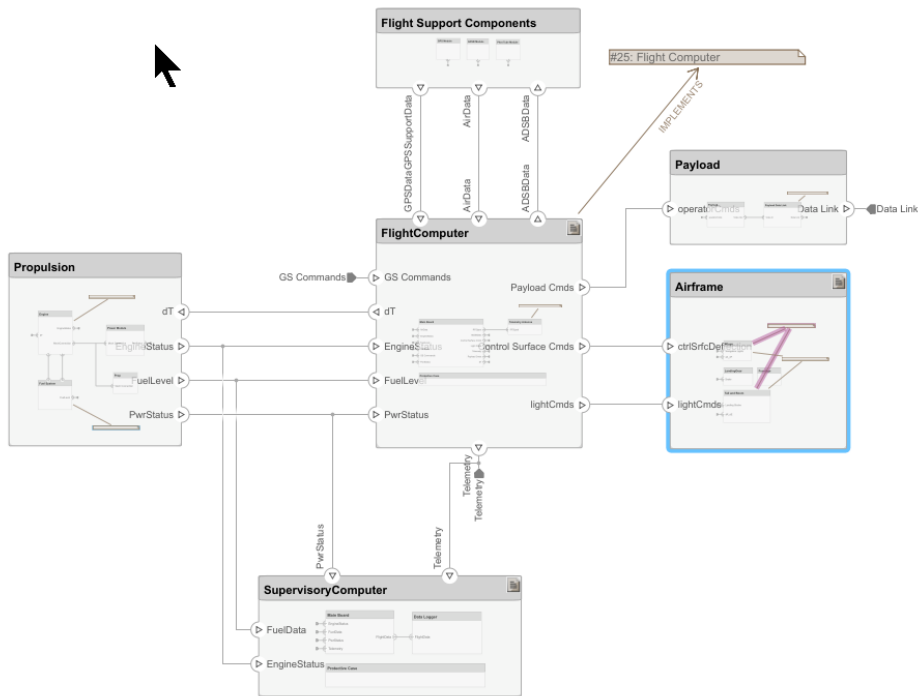
Spotlight



System Composer

Tackle Architecture complexity with views

Composition



Views

The screenshot shows the MathWorks System Composer interface with the 'Views Gallery' open. The gallery lists various views, including 'Key FOB Position Dataflow', 'Door Lock System Supplier Breakdown', and 'Door Lock/Unlock System'. The 'Door Lock/Unlock System' view is selected and expanded, showing a detailed breakdown of the system into three suppliers (A, B, and C) and a central 'Door Lock Controller'. Each supplier has its own sub-view showing detailed door lock components like 'Front Drive Door Lock', 'Rear Drive Door Lock', and 'Front Pass Door Lock'.

The interface includes a toolbar with options like 'New View', 'Save', 'Edit View', and 'Delete View'. On the right, the 'COMPONENT PROPERTIES' panel is visible, showing details for the selected 'Door Lock/Unlock System' component.

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

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

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

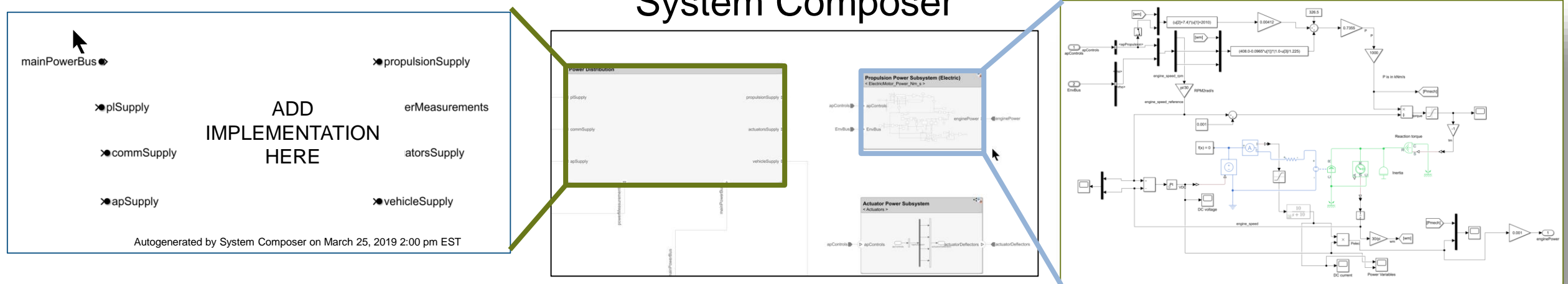
System Composer

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 >'). This subsystem is connected to 'apControls' and 'EnvBus' on the left, and 'enginePower' on the right. A requirement box labeled '#35: Propulsion Power' is positioned above the subsystem, with an arrow pointing to it labeled 'IMPLEMENTS'.

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' pane 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 note: 'Change issue found for this link. Go to Links view'.

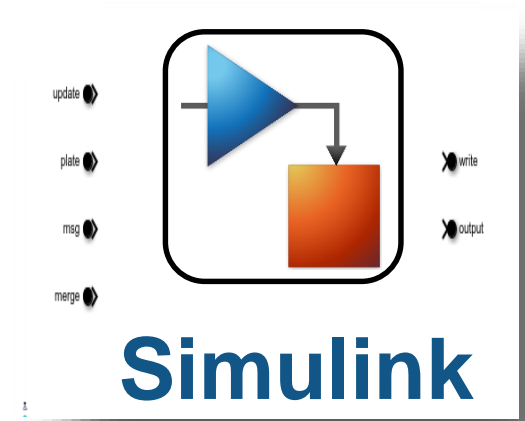
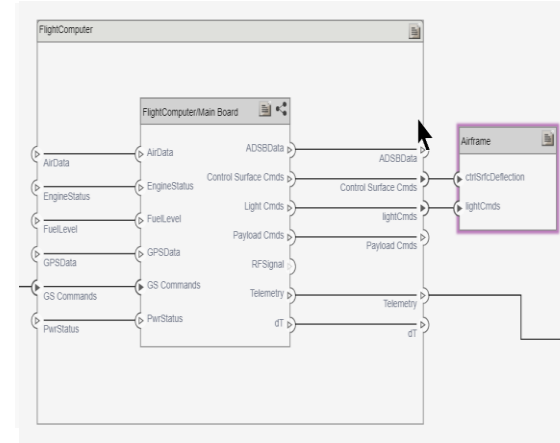
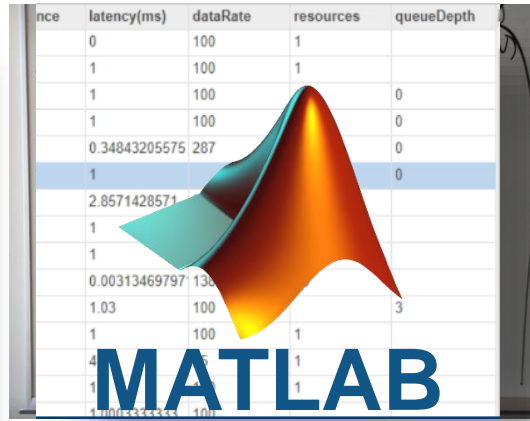
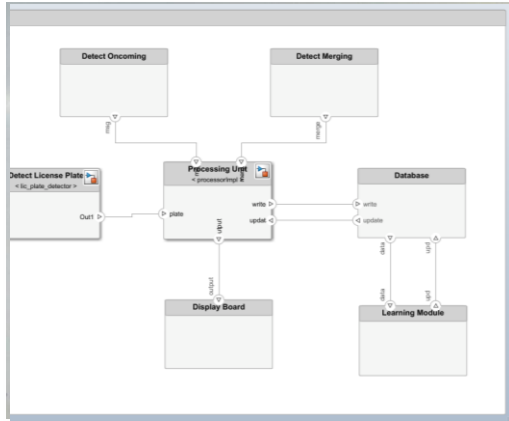
System Composer

Be Intuitive

Facilitate Analysis

Tackle Complexity

Enable Implementation



Digital Thread for Requirements Coverage Reporting and Impact Analysis

Simulink Requirements

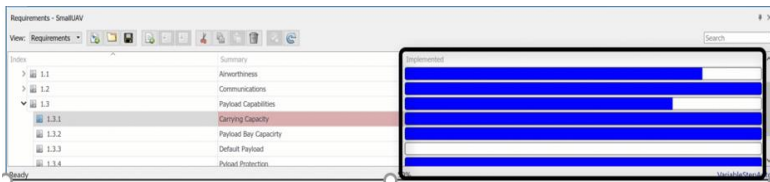
Index	Summary
> 1.1	Airworthiness
> 1.2	Communications
▼ 1.3	Payload Capabilities
1.3.1	Carrying Capacity
1.3.2	Payload Bay Capacity
1.3.3	Default Payload
1.3.4	Payload Protection

MATLAB

System Composer and Model-Based Design

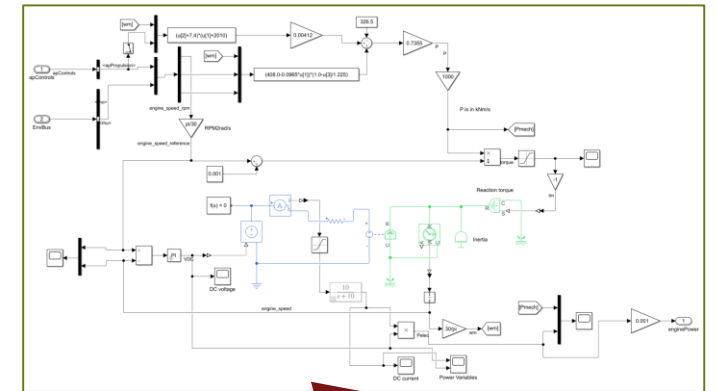
A Systems Engineer

Simulink Requirements



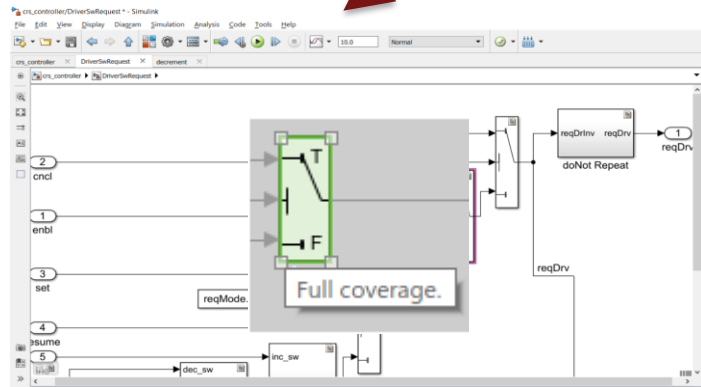
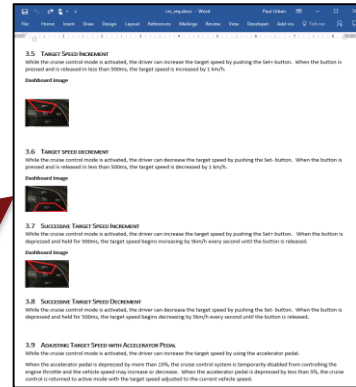
Systems engineering techniques are used in complex projects: spacecraft design, computer chip design, robotics, software integration, and bridge building. Systems engineering uses a **host of tools** that include **modeling and simulation**, **requirements analysis** and scheduling to manage complexity.

Simulink Models

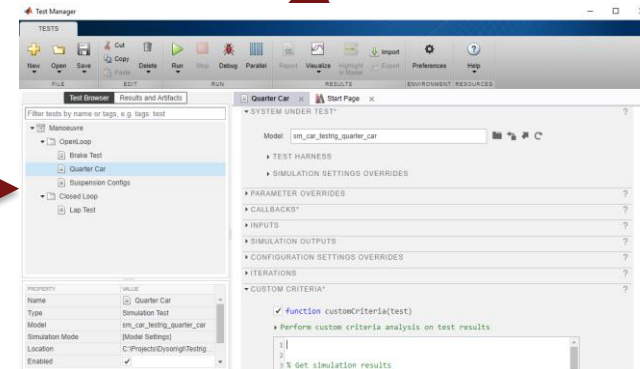


Requirements, Models and Tests – Bottom-up

Requirements

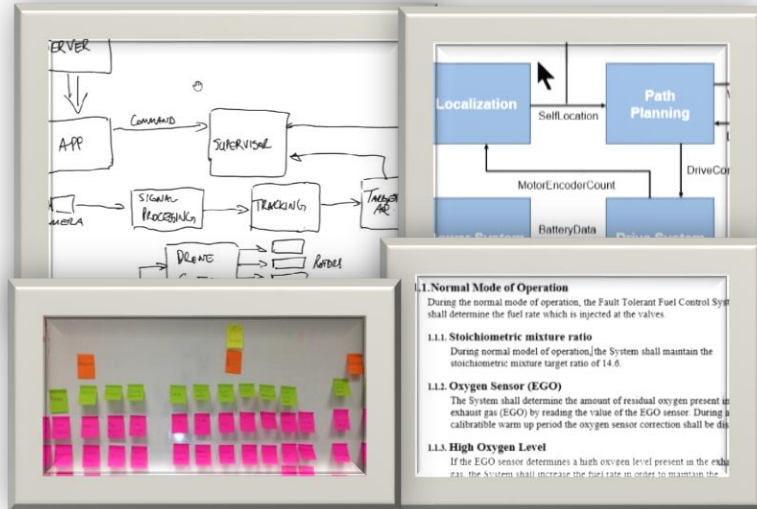


Models



Tests

Systems Engineering and Requirements – Top Down



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 mode of operation, the System shall maintain the stoichiometric mixture target ratio of 14.6.

1.1.2. Oxygen Sensor (EGO)
 The System shall determine the amount of residual oxygen present in exhaust gas (EGO) by reading the value of the EGO sensor. During a calibratable warm up period the oxygen sensor correction shall be disabled.

1.1.3. High Oxygen Level
 If the EGO sensor determines a high oxygen level present in the exhaust, the System shall increase the fuel rate in order to maintain the

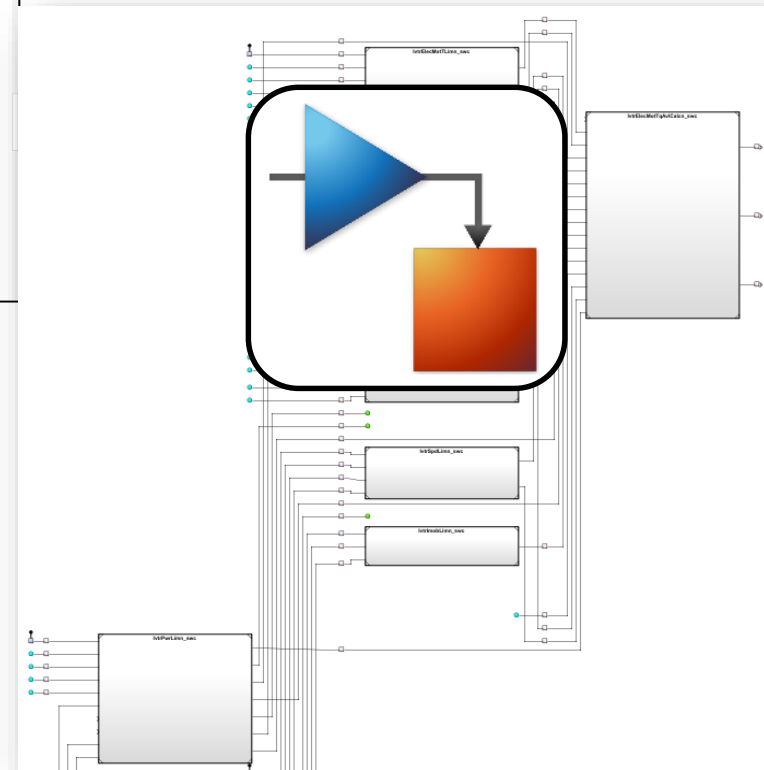
3.5. TARGET SPEED INCREMENT
 While the cruise control mode is activated, the driver can increase the target speed by pushing the Set button. When the button is pressed and is released in less than 100ms, the target speed is increased by 1 km/h.

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.

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 1 km/h every second until the button is released.

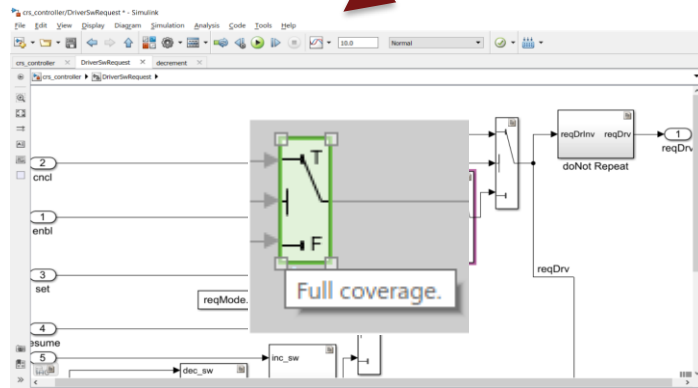
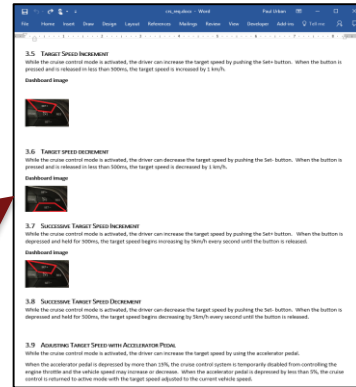
3.8. SUCCESSIVE TARGET SPEED DECREMENT
 While the cruise control mode is activated, the driver can decrease the target speed by pushing the Set button. When the button is depressed and held for 3 seconds, the target speed begins decreasing by 1 km/h every second until the button is released.

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.

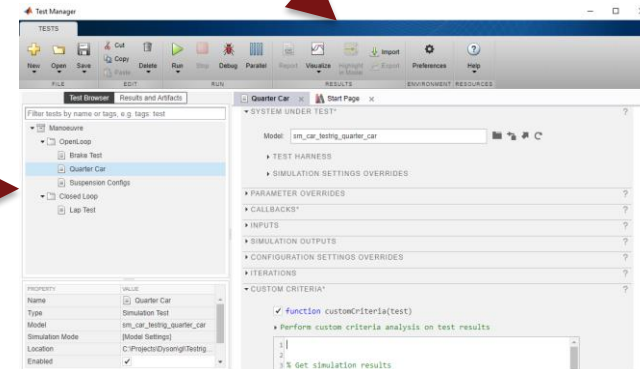


Independence Forced by Tooling

Requirements



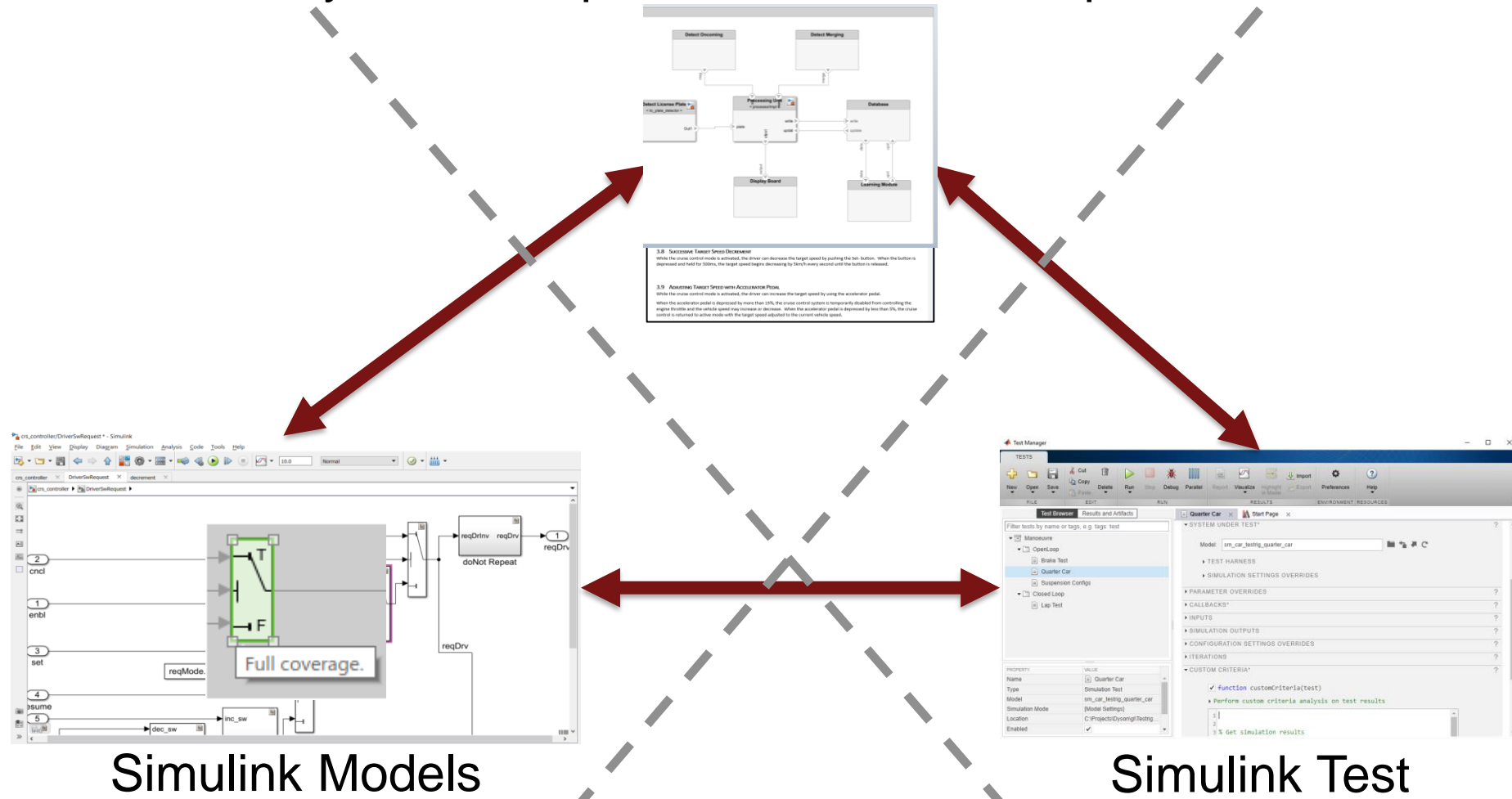
Models



Tests

Flexibility between Systems and Software

System Composer Models and Requirements



Now let's see it in action

Navigation and tool icons including a folder icon, a save icon, navigation arrows, a gear icon, a list icon, a speech bubble icon, a play icon, a stop icon, a waveform icon, a text input field containing '10.0', a dropdown menu showing 'Normal', a green checkmark icon, and a blue grid icon.

Model Browser

UAS_ref_arch
UAS_ref_arch

Model Browser icons: a magnifying glass, a square with a plus sign, a square with a minus sign, a square with a double plus sign, a square with a double minus sign, a square with a left arrow, a square with a right arrow, a square with a double left arrow, a square with a double right arrow, a square with a left arrow and a plus sign, a square with a right arrow and a plus sign, a square with a left arrow and a minus sign, a square with a right arrow and a minus sign, a square with a left arrow and a double plus sign, a square with a right arrow and a double plus sign, a square with a left arrow and a double minus sign, a square with a right arrow and a double minus sign, a square with a left arrow and a double minus sign, a square with a right arrow and a double minus sign, a square with a left arrow and a double minus sign, a square with a right arrow and a double minus sign.

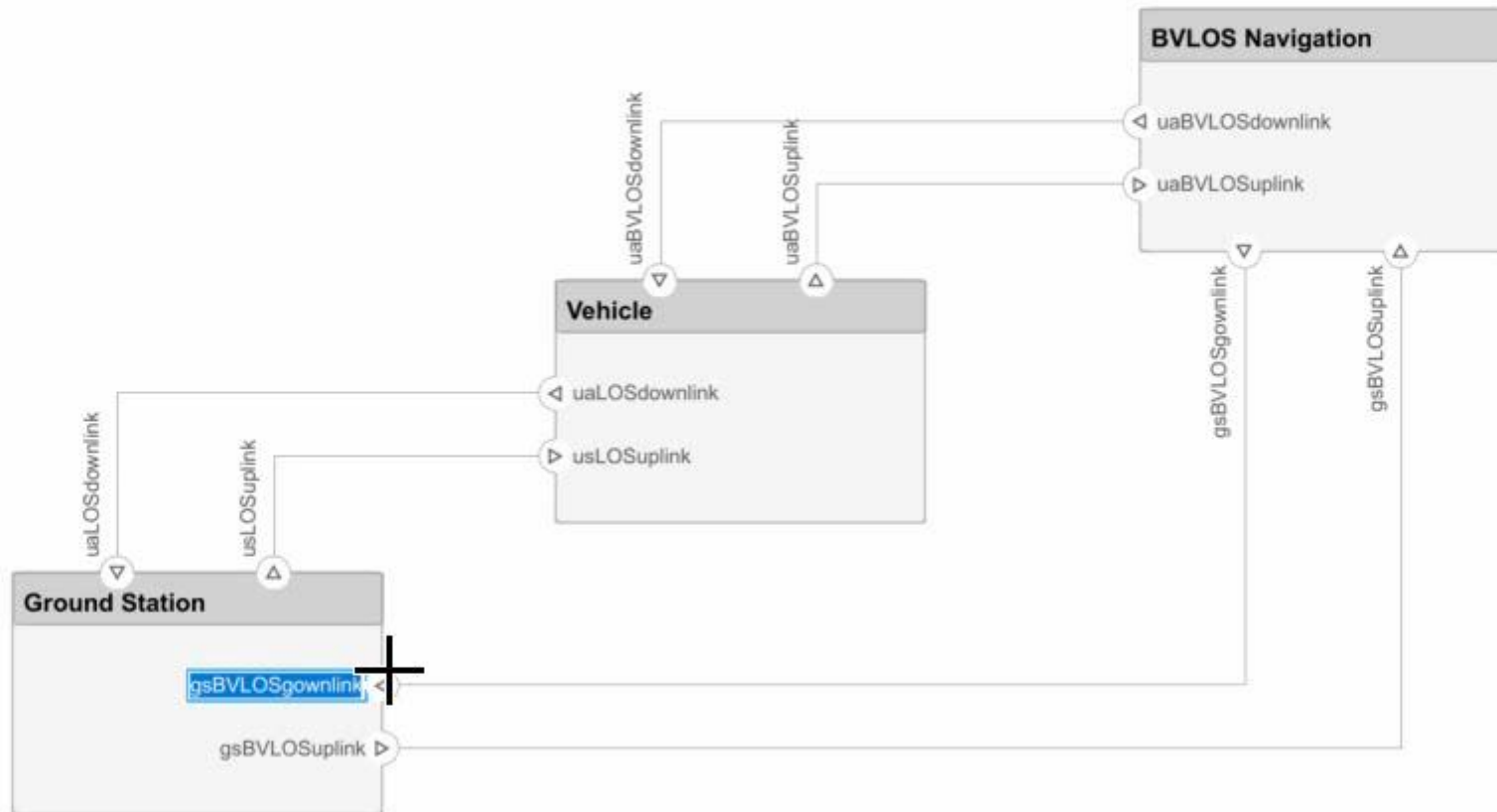


UAS_ref_arch

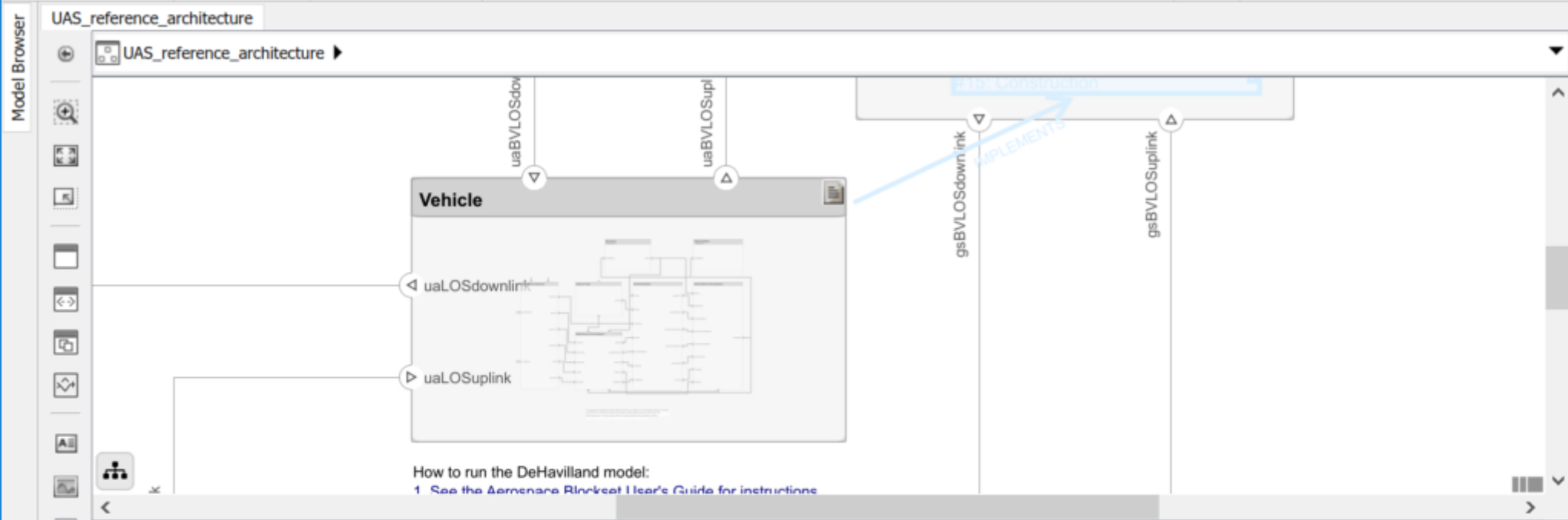
A large empty white workspace area for editing the UAS_ref_arch model.

Property Inspector
Interfaces

UAS_ref_arch



60 Normal



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:

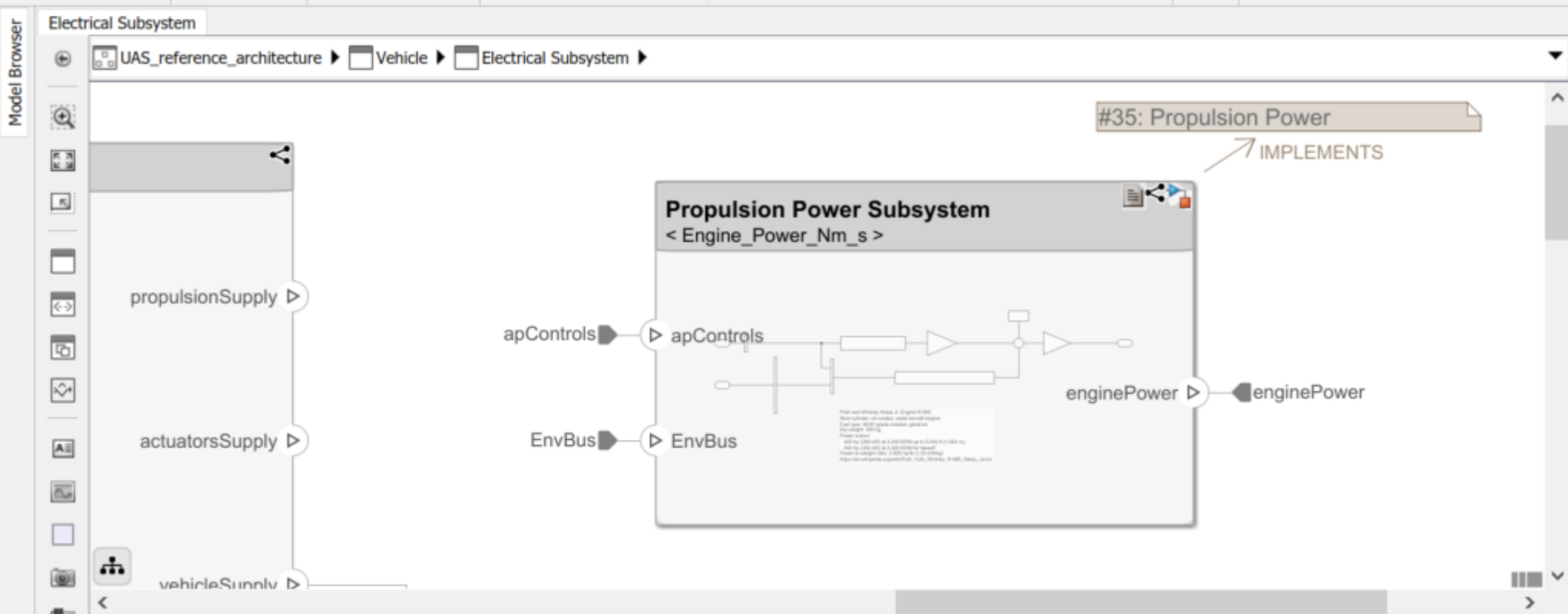
► Custom Attribute Registries

Requirements - UAS_reference_architecture

View: Requirements

Index	Summary	Implemented
> 1.2	Communications	[Blue bar]
> 1.3	Payload Capabilities	[Blue bar]
▼ 1.4	Construction	[Blue bar]
1.4.1	Modularity	[Blue bar]
1.4.2	Propulsion Power	[White bar]
> 1.5	Flying Qualities	[Blue bar]
2	Ground Station Capabilities	[Blue bar]
3	BLOS Capabilities	[Blue bar]

60 Normal



#35: Propulsion Power
 IMPLEMENTS

Property Inspector

Requirement Set

Details

Properties

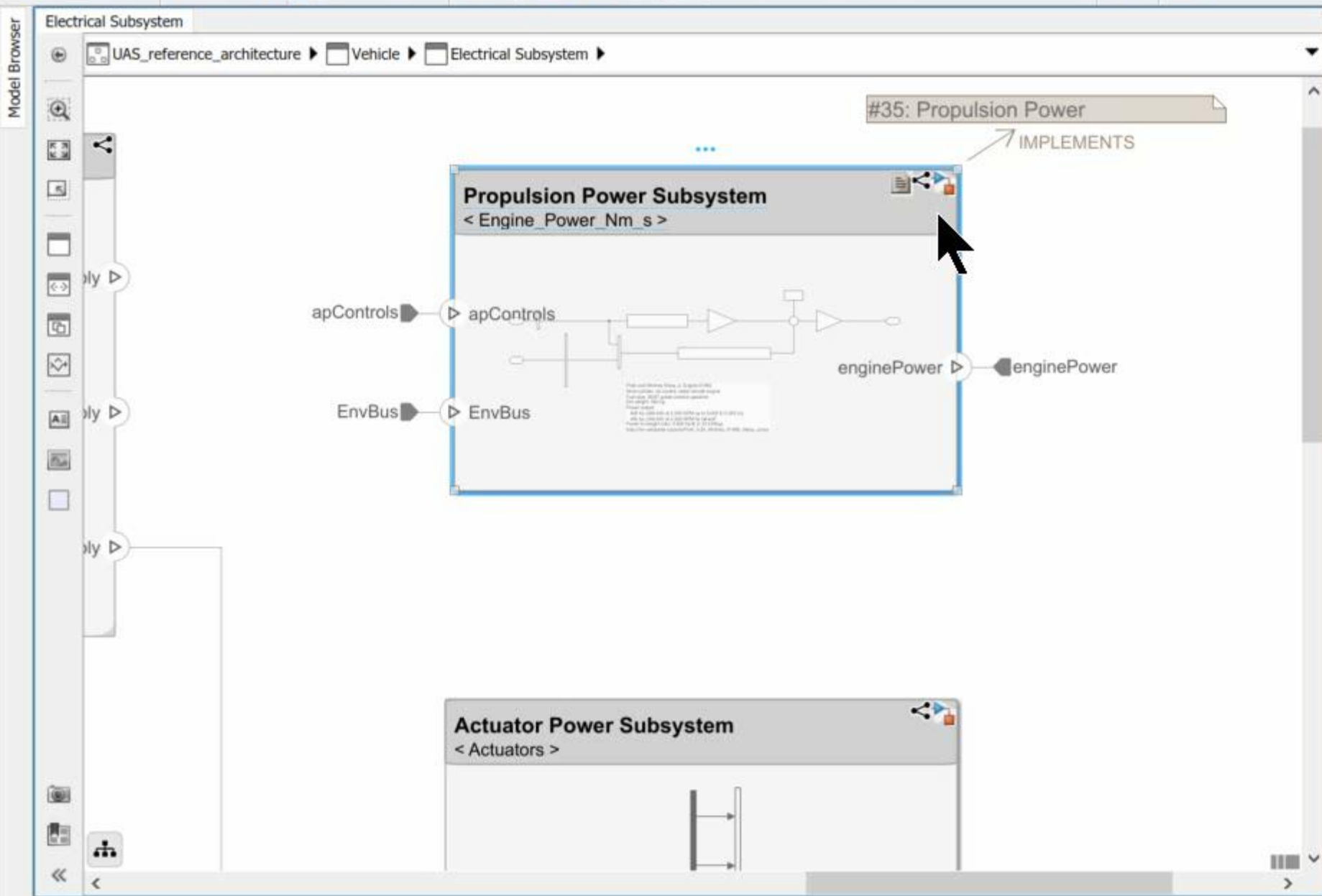
Filepath: \\fs-56-ah\vmgrs\home06\rbold
 Revision: 24
 Created by: mlizarra
 Created on: 07-Dec-2018 15:50:34
 Modified by: rboldt
 Modified on: 20-Mar-2019 16:06:56
 Description:

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	

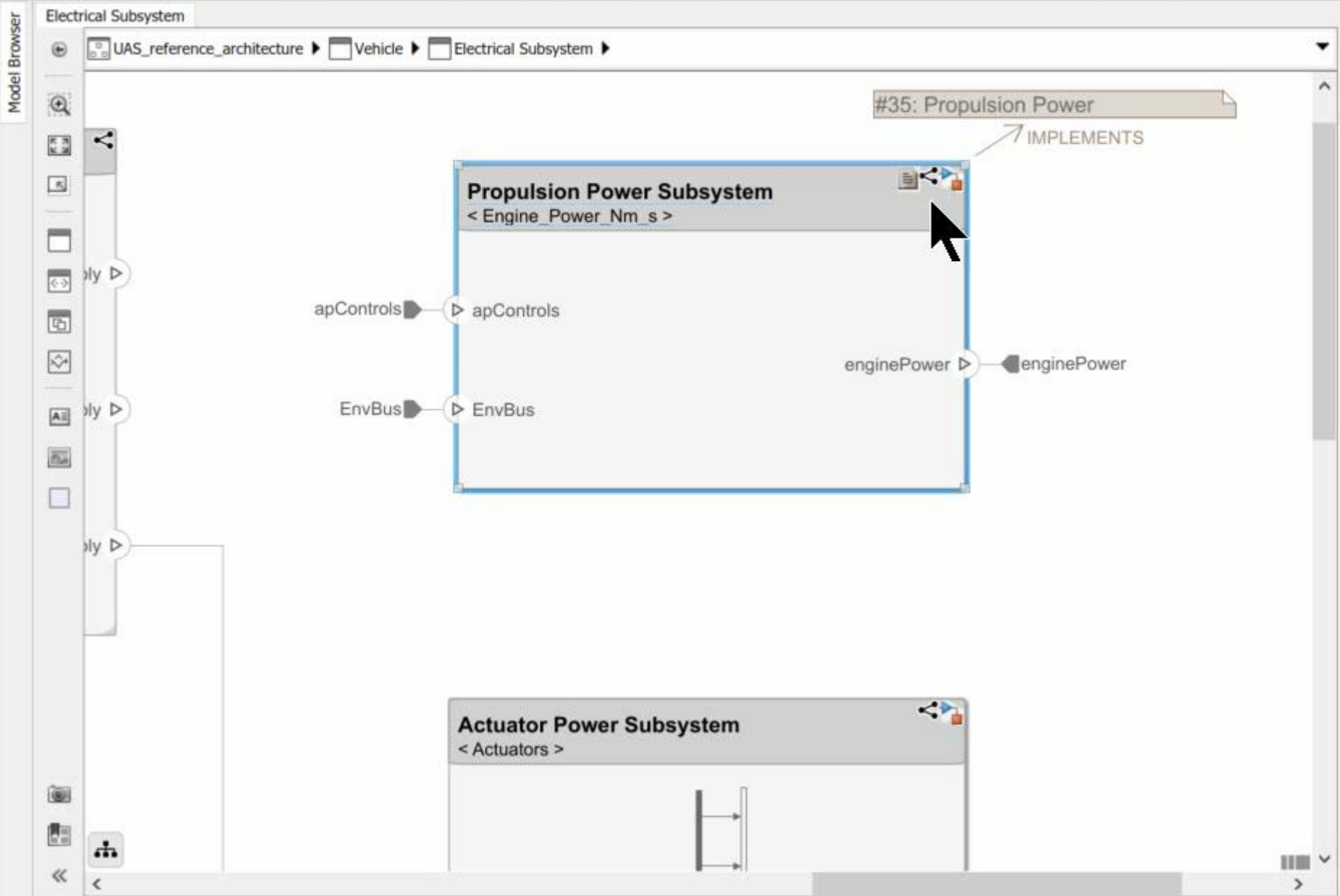


Property Inspector

Component

Architecture Info

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



Property Inspector

Component

Architecture Info

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

Interfaces

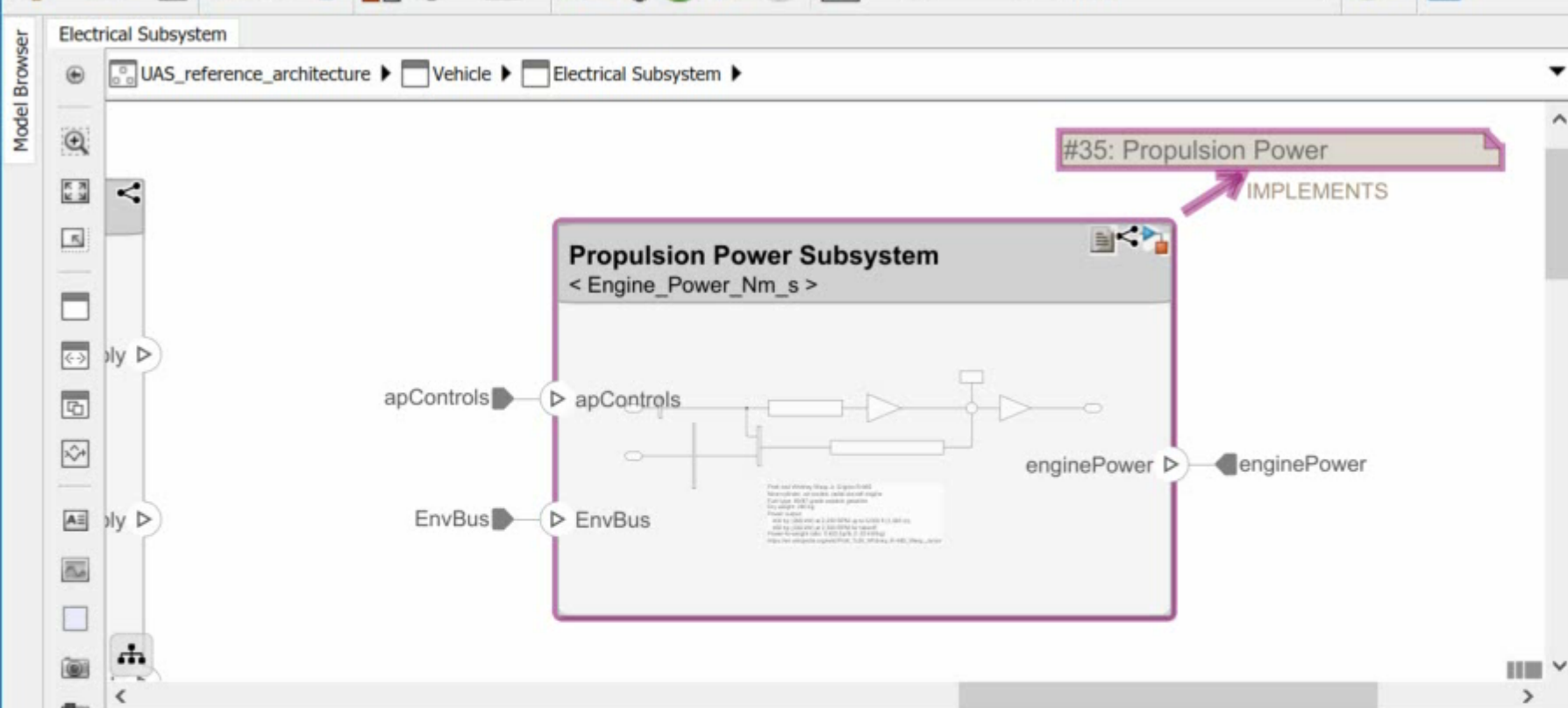
UAS_reference_architecture/Vehicle - Simulink

File Edit View Display Architecture Simulation Analysis Code Tools Help

60 Normal

Model Browser: UAS_reference_architecture > Vehicle

Running 50% T=15.600 26% auto(ode23t)



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:

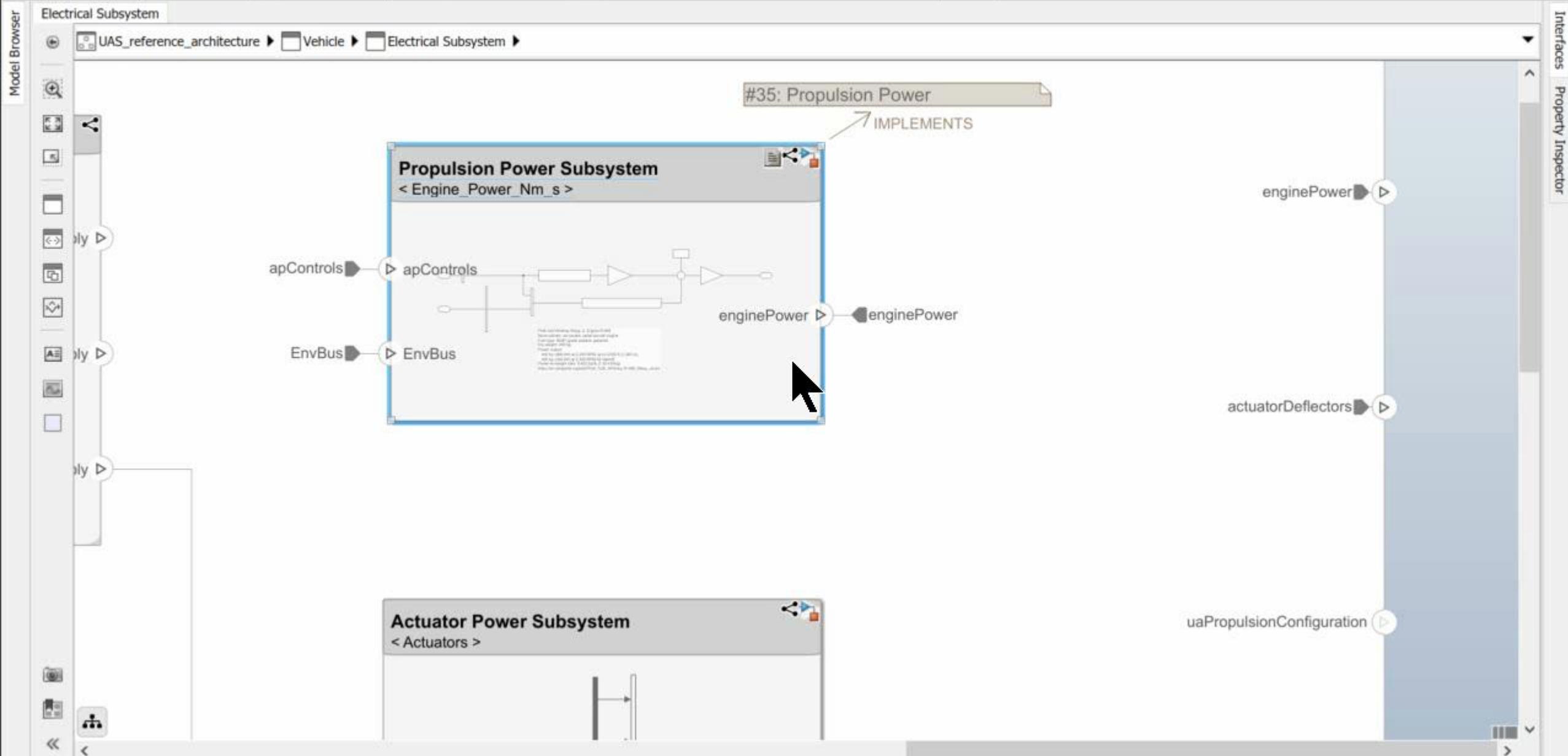
- Propulsion Power Subsystem

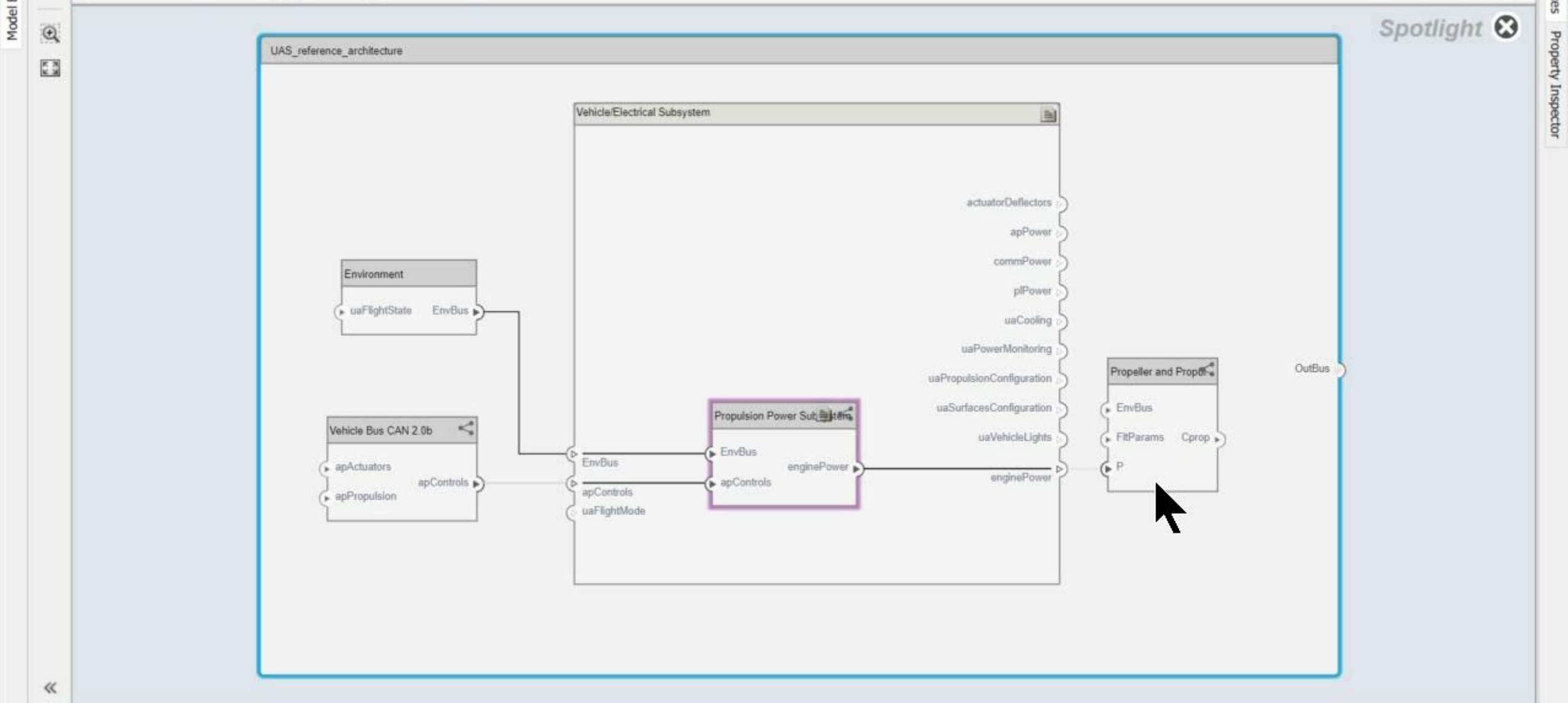
Comments

Requirements - UAS_reference_architecture

View: Requirements

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



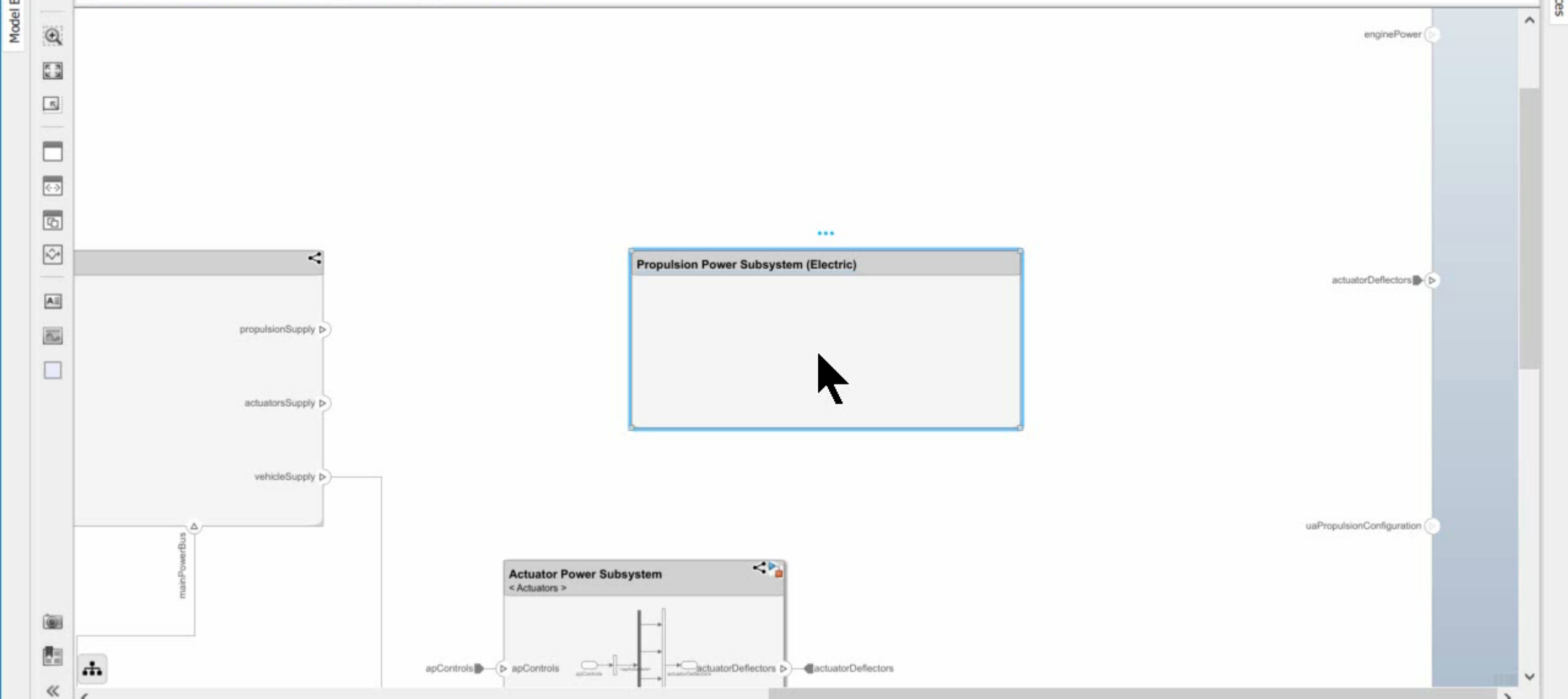


Spotlight

60 Normal

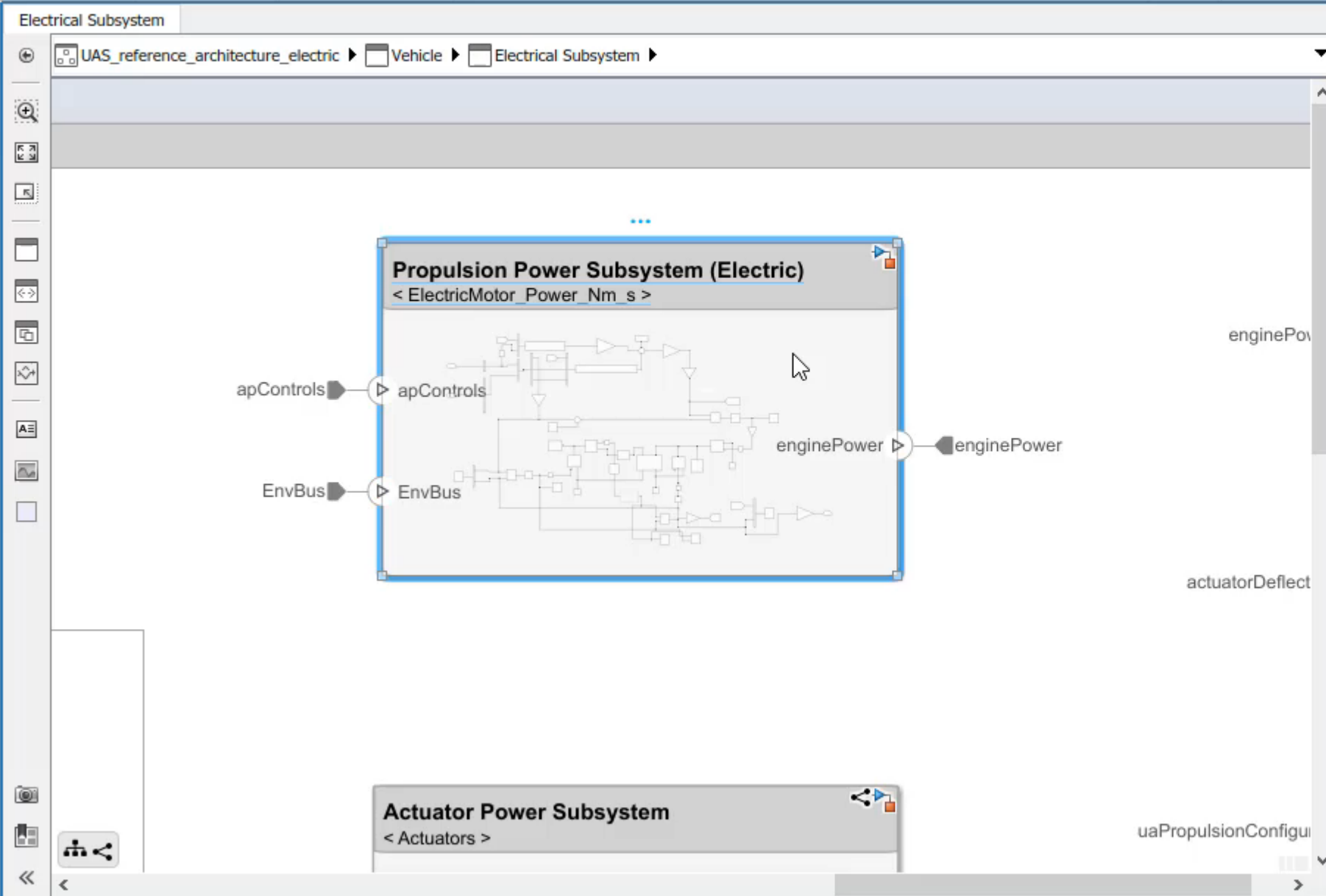
Electrical Subsystem

UAS_reference_architecture_electric > Vehicle > Electrical Subsystem



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

Model Browser



Property Inspector

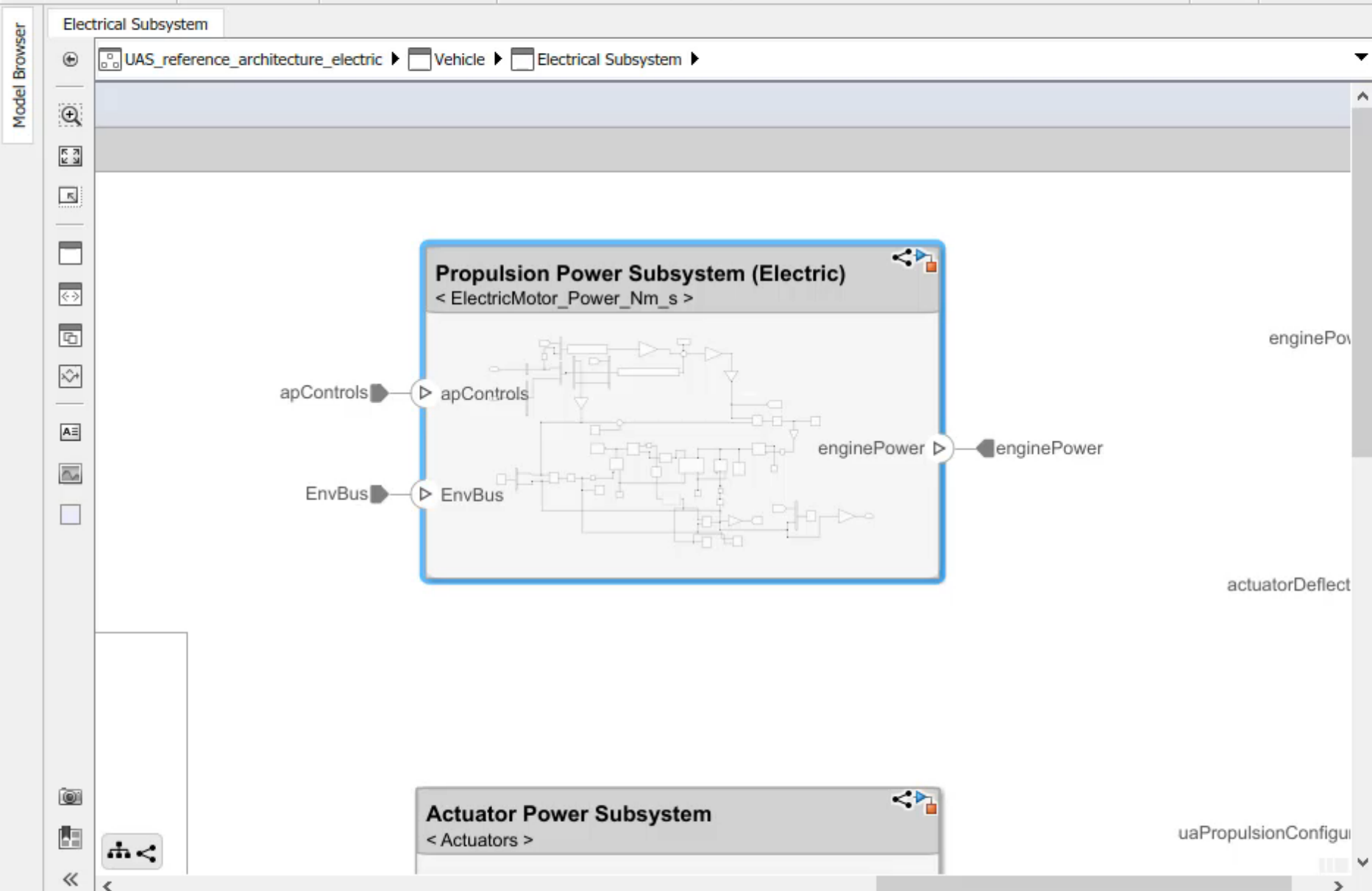
Component

Architecture Info

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

Interfaces

60 Normal



Property Inspector

Component

Architecture Info

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

HOME

New
 Open
 Save
 Delete
 Analyze
 Continuous
 Update
 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

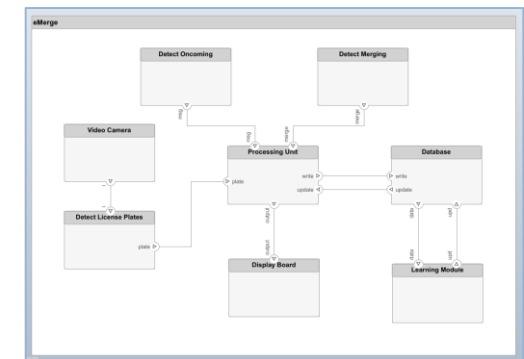
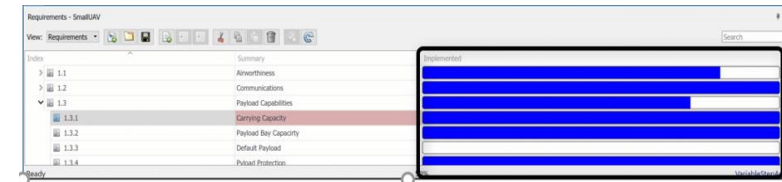
INSTANCE PROPERTIES

NodeInstance: Propulsion Power Subsystem (Electric)

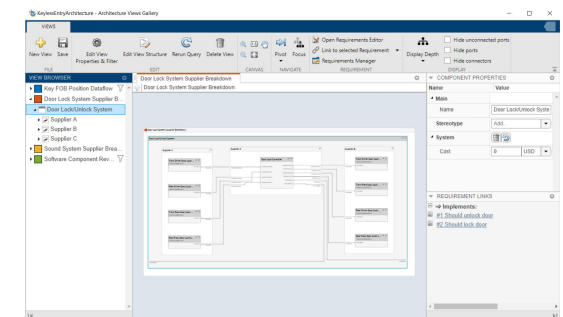
Property	Units	Value	Edit
SubsystemBudget			
Mass	kg	100	
Power	mW	175,000,000	

Key Takeaways

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



SmallUAV	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](#)