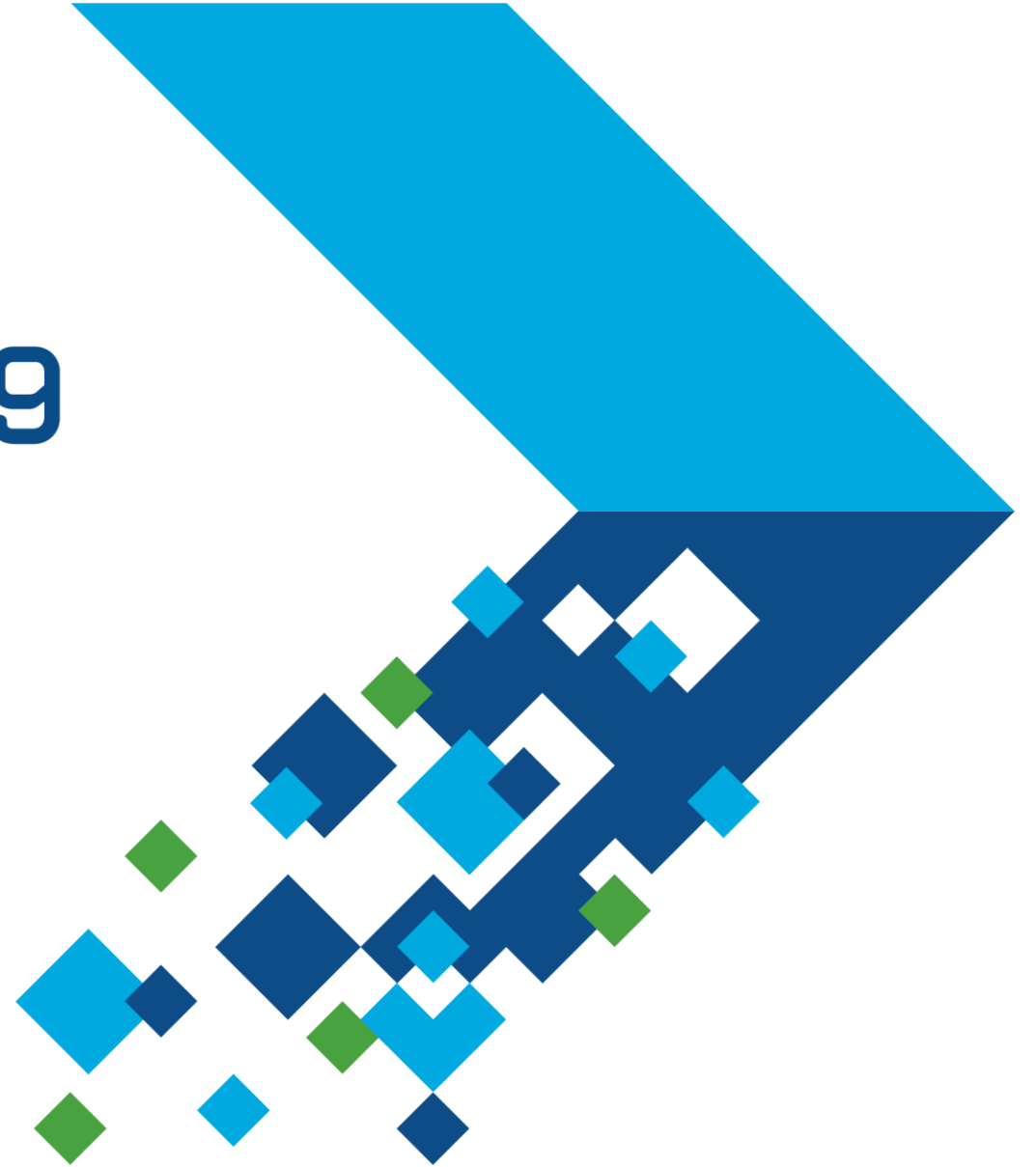


MATLAB EXPO 2019

Ingegneria dei Sistemi

Dai Requisiti all'Architettura alla
Simulazione

Vincenzo Petrella

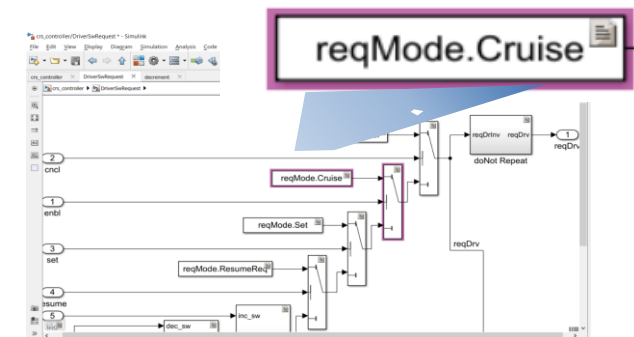


-
- The image shows a presentation slide with a blue header bar containing navigation icons and a title bar. The slide content includes a diagram of a car on a road, a large title 'REQ 3.1 ENABLING C Cruise control is', a bulleted list of three requirements, and a detailed description of the third requirement.
- # REQ 3.1 ENABLING C Cruise control is
- -
 -
- 3.1 Successive Target Speed Increase**
- When 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 300ms, the target speed (target speed) decreases by 30% every second and the button is released.
- 3.1.1 Accelerate Target Speed with Acceleration Point**
- When the cruise control mode is activated, the driver can increase the target speed by using the acceleration pedal. When the acceleration pedal is depressed by more than 10%, the cruise control system is temporarily disabled from controlling the target speed. When the acceleration pedal is released, the target speed is gradually depressed by less than 10%, the cruise control is returned to its mode with the target speed adjusted to the current vehicle speed.

Derives

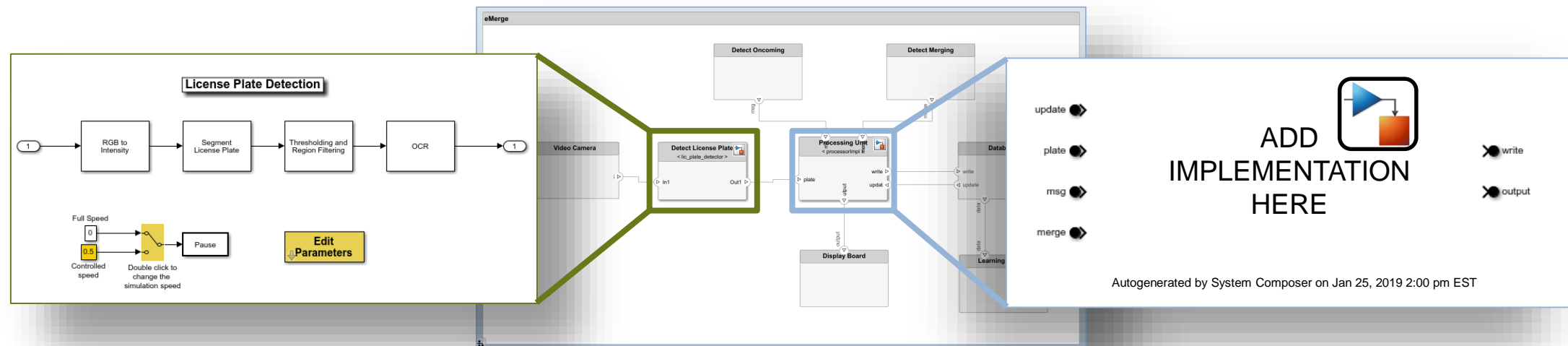
Implemented By

Implemented
By



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
MATLAB EXPO 2019



State Machines



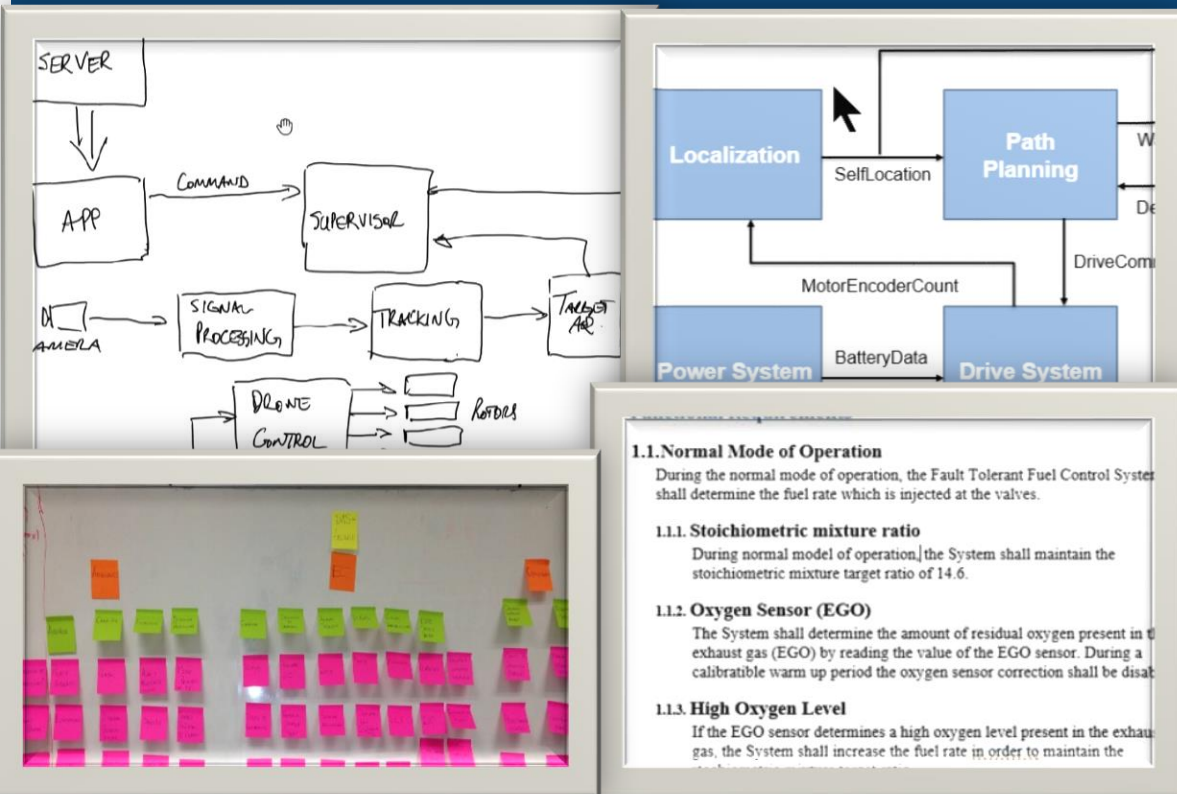
Discrete-Event



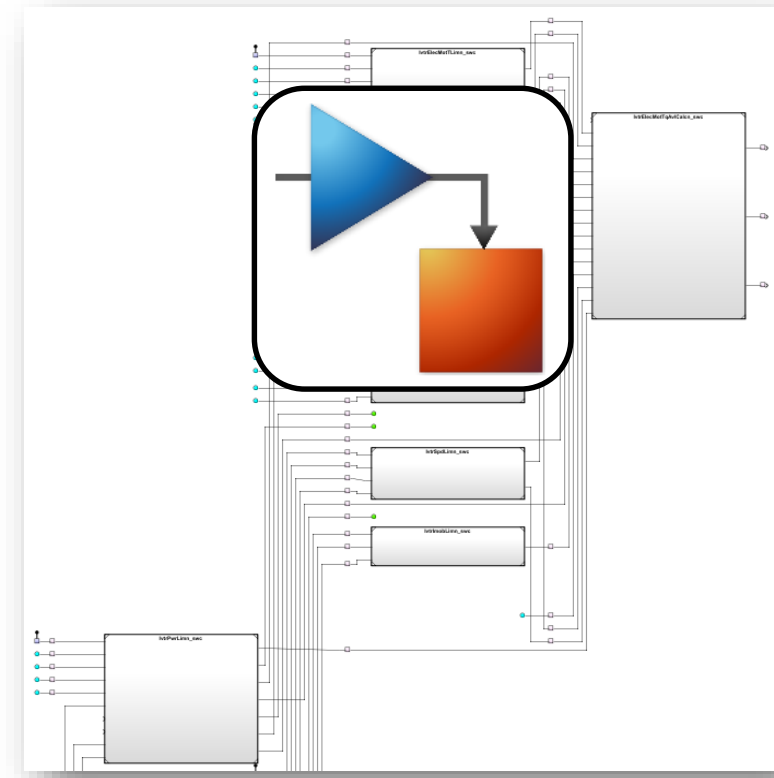
Physical Modeling

What does that mean?

Early in the Process Concepts/Descriptions

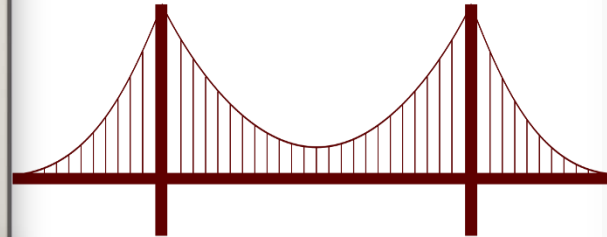
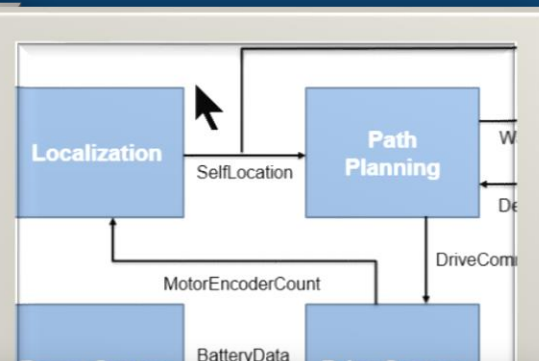
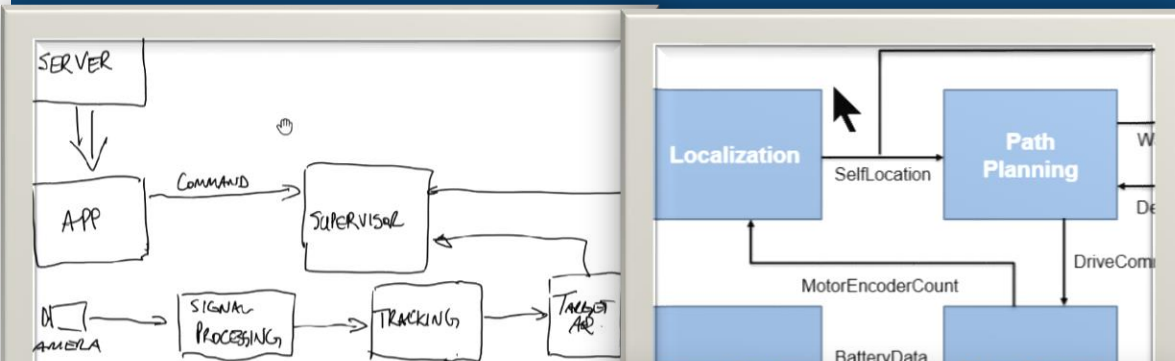


Later in the Process Models

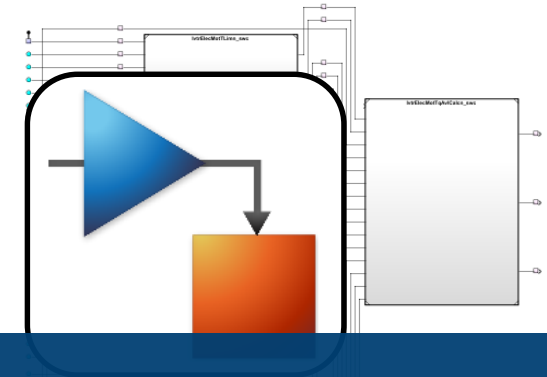


What is the Gap?

Early in the Process
Concepts/Descriptions



Later in the Process
Models



Digital Thread
Connected Environment
Analysis & Simulation Platform

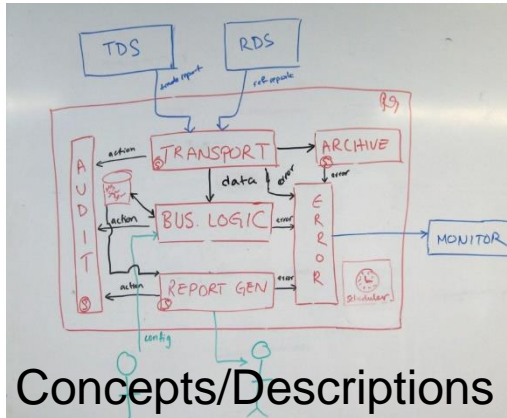
What goes into the bridge?

Be Intuitive

Facilitate Analysis

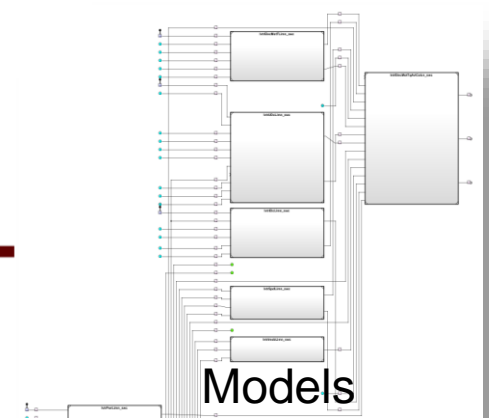
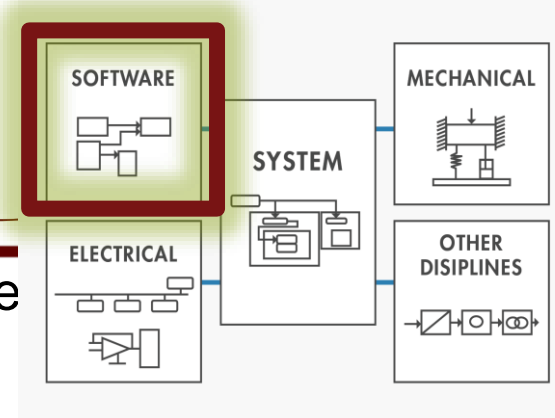
Tackle Complexity

Enable Implementation



VEHICLE COMPONENT	MASS(kg)	POWER(W)
• COMMUNICATION SUBSYS.	→ 2.63	58
- ADSB	→ 0.05	5
- KU/KA RADIO	→ 0.05	2
- RADIO RX PPM/PWM	→ 2.5	50
	→ 0.01	0.85
	→ 0.02	1
• ELECTRICAL SUBSYS.	→ 533.15	353000
- ACTUATOR POWER	8	300
- POWER DISTRIBUTION	10	1000
- POWER MONITORING	0.1	1000
- POWER SOURCE	→ 300	350000
- PROPULSION POWER	50	50
- VEHICLE POWER	5	0.02
- AUTOPLOT REGULATOR	0.05	1.07
- COMMS REGULATOR	0.05	1.07
• MONITORING + CONTROL SUBS.	→ 0.05	1.150
- AUTOPLOT	0.5	1

onne



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.

I

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)

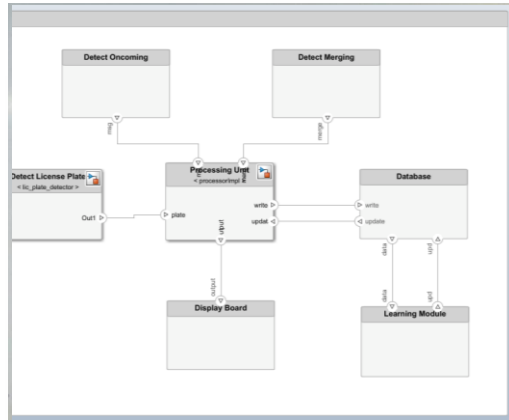
MathWorks Solution: System Composer R2019a and

✓ Be Intuitive

✓ Facilitate Analysis

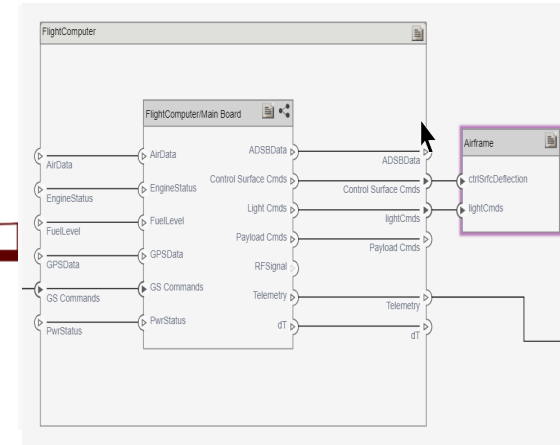
✓ Tackle Complexity

✓ Enable Implementation



VEHICLE COMPONENT

	MASS(kg)	POWER(W)
• COMMUNICATION SUBSYS.	→ 2.63	58
- ADSB	→ 0.05	5
- KU/KA RADIO	→ 0.05	2
- RADIO RX PPM/PWM	→ 2.5	50
	→ 0.01	0.85
	→ 0.02	1
	533.15	353000
• ELECTRICAL SUBSYS		
- ACTUATOR POWER	8	300
- POWER DISTRIBUTION	10	1000
- POWER MONITORING	0.1	1000
- POWER SOURCE	→ 300	350000
- PROPULSION POWER	50	0.02
- VEHICLE POWER	5	1.07
- AUTOPLOT REGULATOR	0.05	2
- COMMS REGULATOR	0.05	1.07
- COMMS REGULATOR	0.05	1.07
• MONITORING + CONTROL SUBS.	→ 0.05	1.150
- AUTOPLOT	0.5	1



Requirements Coverage Reporting and Impact Analysis

Simulink Requirements



Now let's see it in action



Requirements Editor

File Edit Display Analysis Report Help

View: Requirements

Index	Summary
UAS_reqs*	
1	Aircraft Capabilities
2	Ground Station Capabilities
3	BLOS Capabilities

Properties

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

Revision: 23

Created by: mlizarra

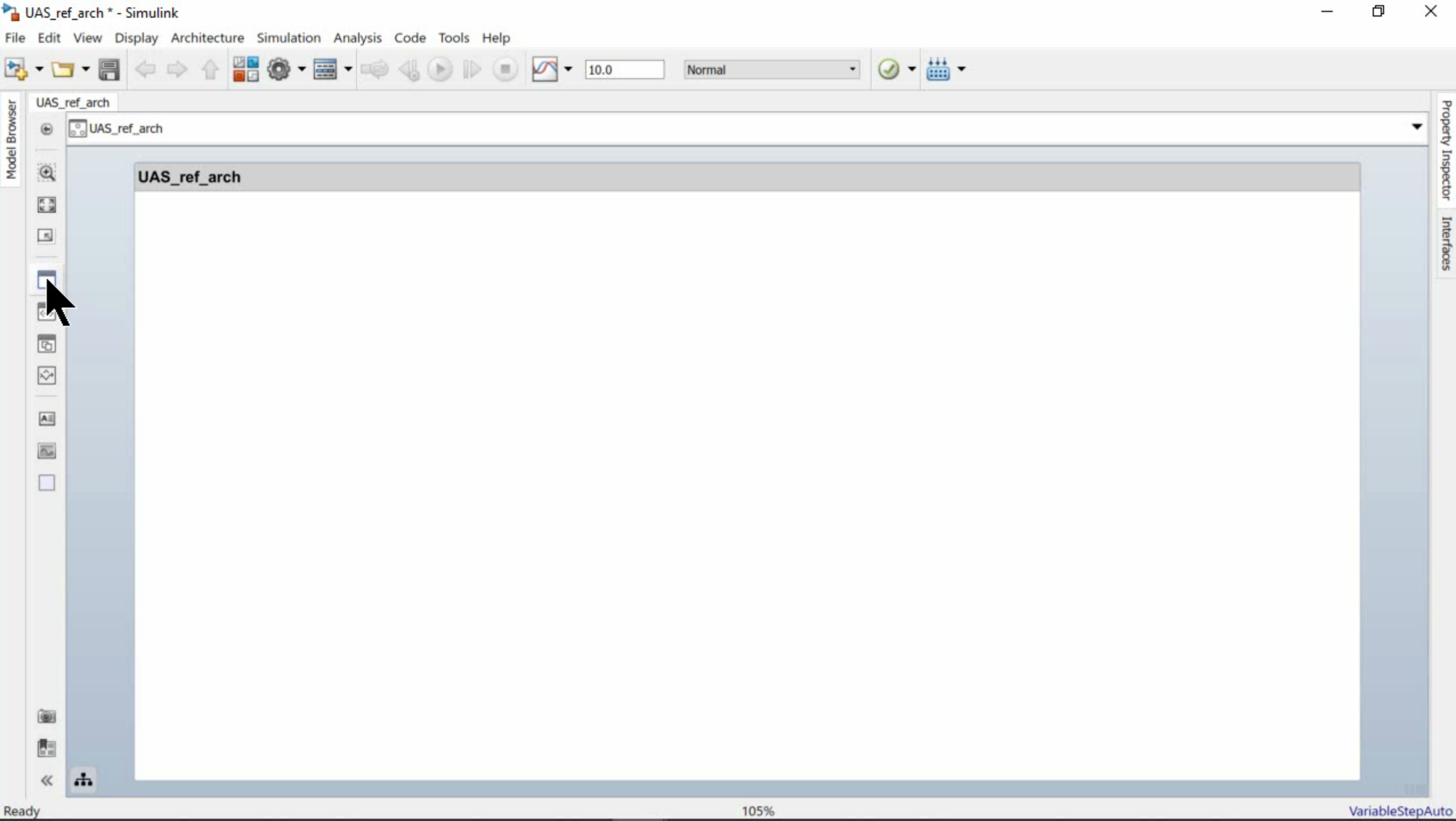
Created on: 07-Dec-2018 15:50:34

Modified by: gdrayera

Modified on: 12-Mar-2019 15:36:22

Description:

Custom Attribute Registries



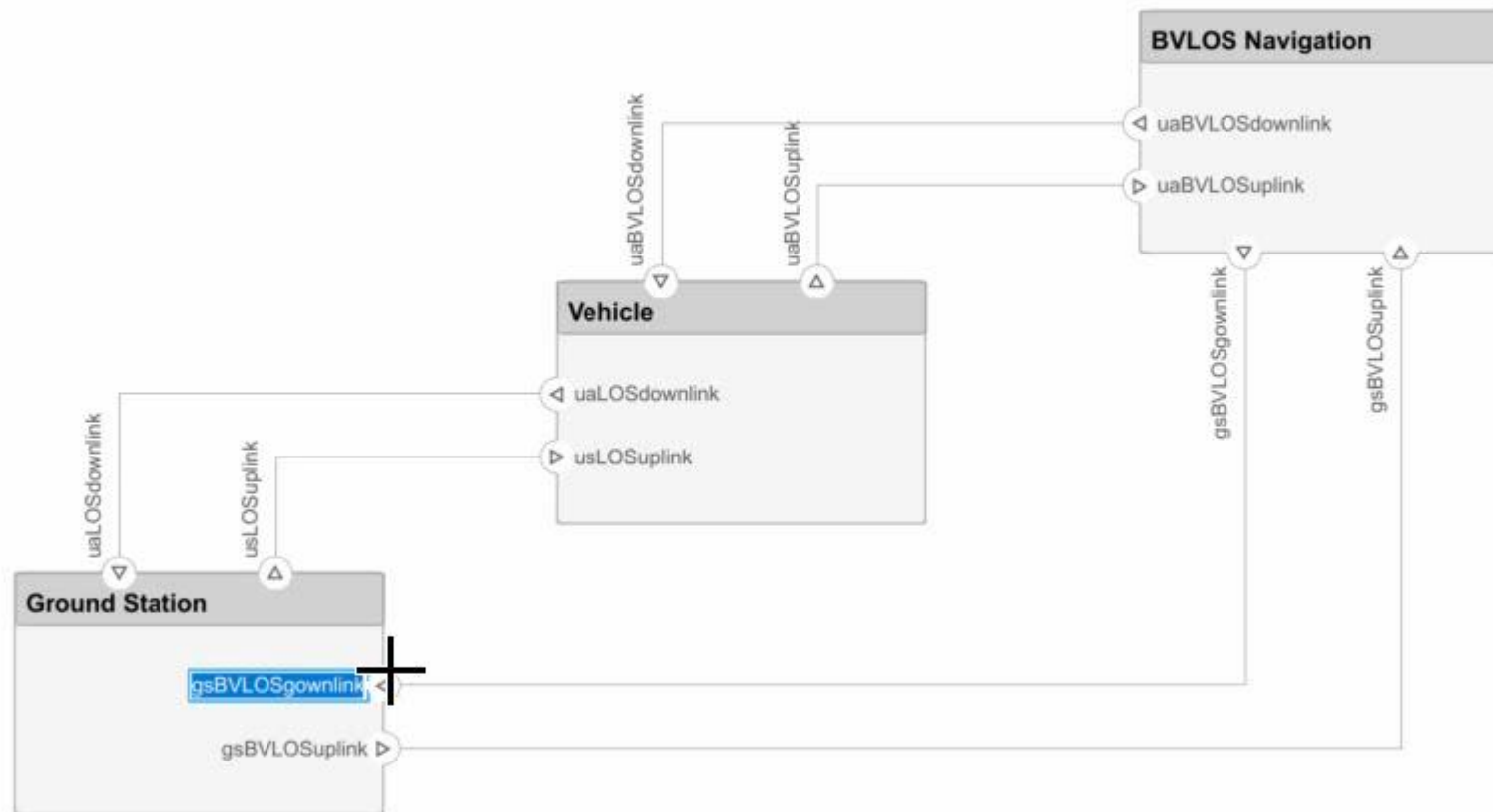


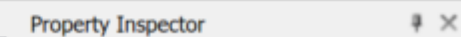
UAS_ref_arch

UAS_ref_arch ▶



UAS_ref_arch





Details

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

Created by: mlizarra

Modified by: rboldt

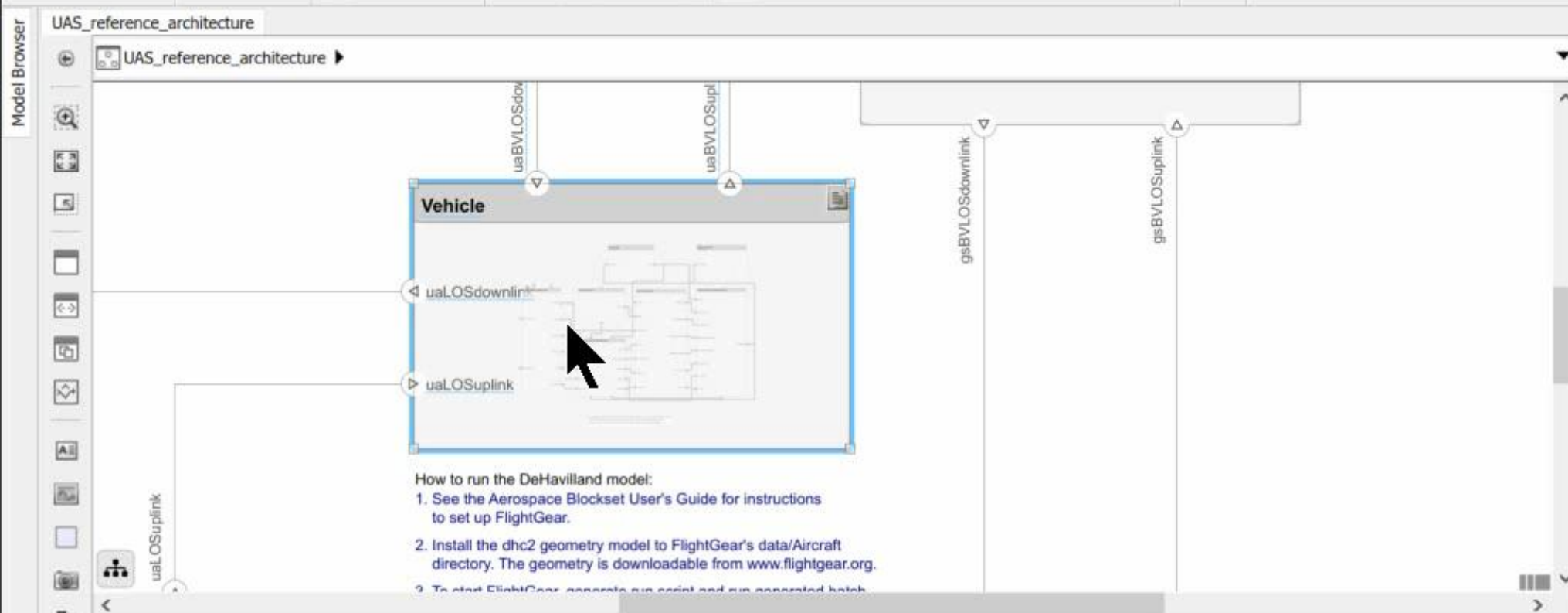
Description:

[illegible]

► Custom Attribute Registries

View: Requirements

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100																																																																																																																																																																																																																																	
Population	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.7	10.9	11.1	11.3	11.5	11.7	11.9	12.1	12.3	12.5	12.7	12.9	13.1	13.3	13.5	13.7	13.9	14.1	14.3	14.5	14.7	14.9	15.1	15.3	15.5	15.7	15.9	16.1	16.3	16.5	16.7	16.9	17.1	17.3	17.5	17.7	17.9	18.1	18.3	18.5	18.7	18.9	19.1	19.3	19.5	19.7	19.9	20.1	20.3	20.5	20.7	20.9	21.1	21.3	21.5	21.7	21.9	22.1	22.3	22.5	22.7	22.9	23.1	23.3	23.5	23.7	23.9	24.1	24.3	24.5	24.7	24.9	25.1	25.3	25.5	25.7	25.9	26.1	26.3	26.5	26.7	26.9	27.1	27.3	27.5	27.7	27.9	28.1	28.3	28.5	28.7	28.9	29.1	29.3	29.5	29.7	29.9	30.1	30.3	30.5	30.7	30.9	31.1	31.3	31.5	31.7	31.9	32.1	32.3	32.5	32.7	32.9	33.1	33.3	33.5	33.7	33.9	34.1	34.3	34.5	34.7	34.9	35.1	35.3	35.5	35.7	35.9	36.1	36.3	36.5	36.7	36.9	37.1	37.3	37.5	37.7	37.9	38.1	38.3	38.5	38.7	38.9	39.1	39.3	39.5	39.7	39.9	40.1	40.3	40.5	40.7	40.9	41.1	41.3	41.5	41.7	41.9	42.1	42.3	42.5	42.7	42.9	43.1	43.3	43.5	43.7	43.9	44.1	44.3	44.5	44.7	44.9	45.1	45.3	45.5	45.7	45.9	46.1	46.3	46.5	46.7	46.9	47.1	47.3	47.5	47.7	47.9	48.1	48.3	48.5	48.7	48.9	49.1	49.3	49.5	49.7	49.9	50.1	50.3	50.5	50.7	50.9	51.1	51.3	51.5	51.7	51.9	52.1	52.3	52.5	52.7	52.9	53.1	53.3	53.5	53.7	53.9	54.1	54.3	54.5	54.7	54.9	55.1	55.3	55.5	55.7	55.9	56.1	56.3	56.5	56.7	56.9	57.1	57.3	57.5	57.7	57.9	58.1	58.3	58.5	58.7	58.9	59.1	59.3	59.5	59.7	59.9	60.1	60.3	60.5	60.7	60.9	61.1	61.3	61.5	61.7	61.9	62.1	62.3	62.5	62.7	62.9	63.1	63.3	63.5	63.7	63.9	64.1	64.3	64.5	64.7	64.9	65.1	65.3	65.5	65.7	65.9	66.1	66.3	66.5	66.7	66.9	67.1	67.3	67.5	67.7	67.9	68.1	68.3	68.5	68.7	68.9	69.1	69.3	69.5	69.7	69.9	70.1	70.3	70.5	70.7	70.9



Property Inspector

Component	
Architecture Info	
NAME	VALUE
Main	
Name	Vehicle
Stereotype	Add..

Requirements - UAS_reference_architecture

View: Requirements

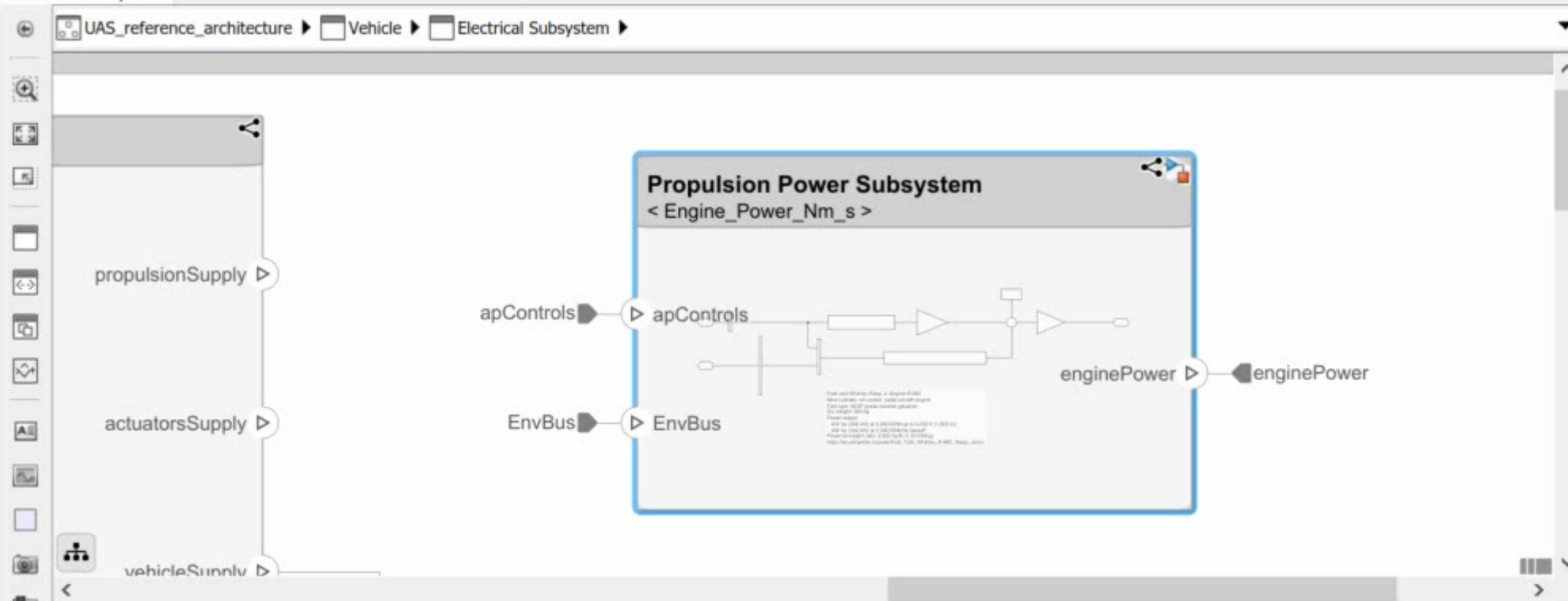
Search

Index	Summary	Implemented
> 1.2	Communications	<div></div>
> 1.3	Payload Capabilities	<div></div>
1.4	Construction	<div></div>
1.4.1	Modularity	<div></div>
1.4.2	Propulsion Power	<div></div>
> 1.5	Flying Qualities	<div></div>



Model Browser

Electrical Subsystem



Property Inspector

Requirement: #35

Details

▼ Properties

Type: Functional

Index: 1.4.2

Custom ID: #35

Summary: Propulsion Power

Description Rationale

Arial 14 B I U

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:

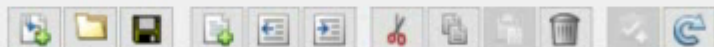
▼ Links

No links

► Comments

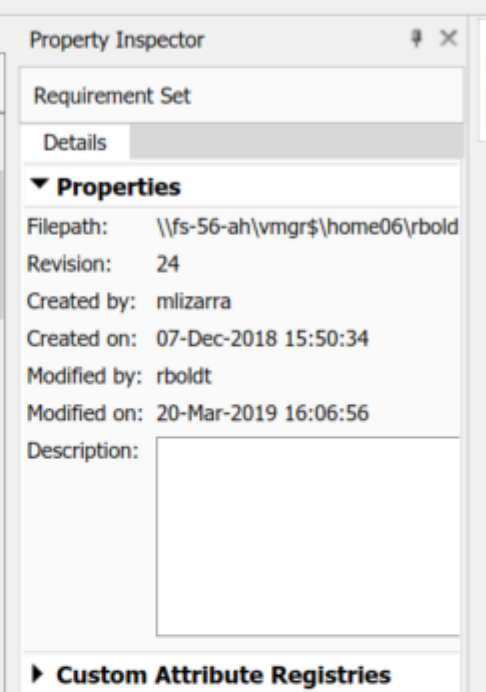
Requirements - UAS_reference_architecture

View: Requirements

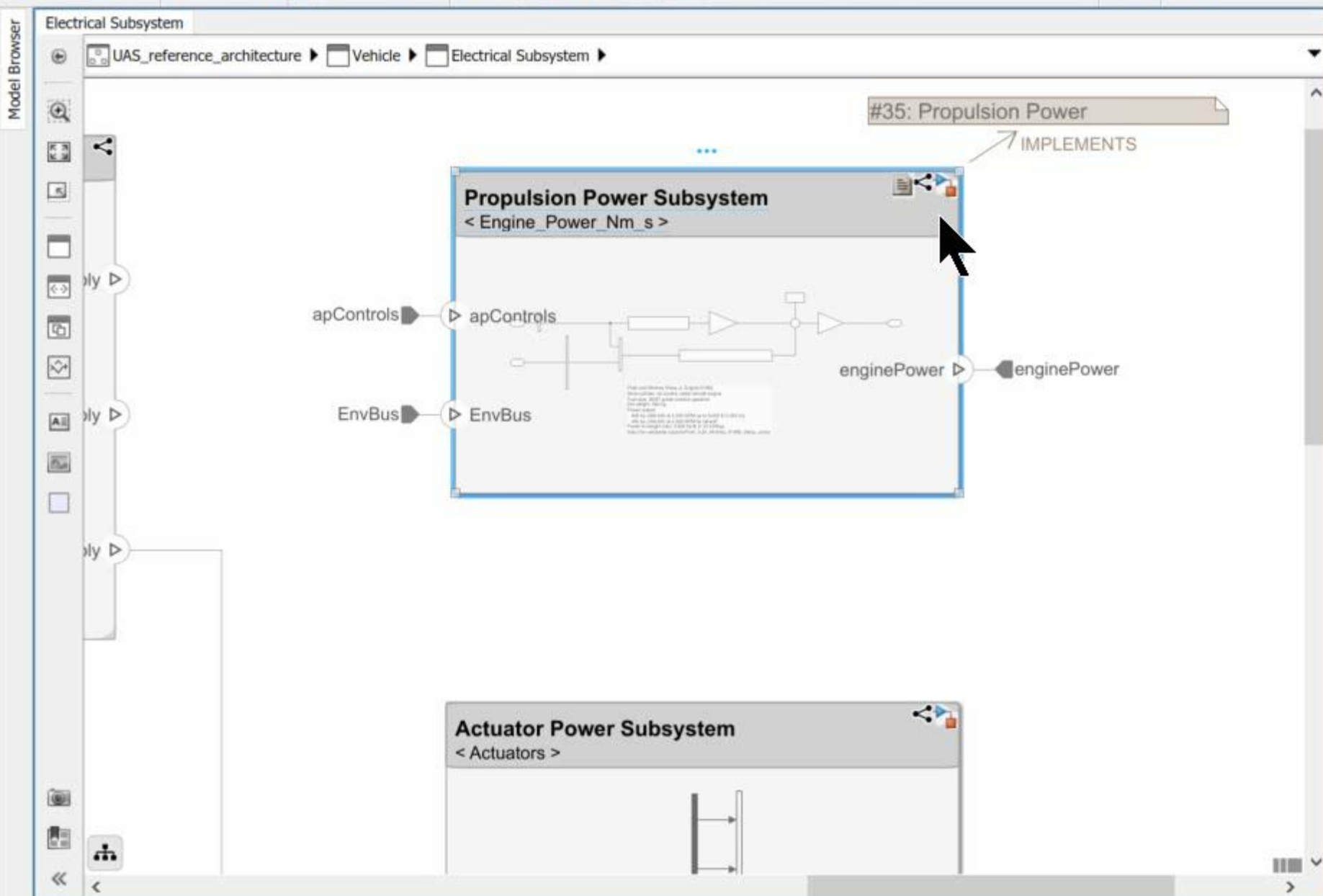


Search

Index	Summary	Implemented
> 1.2	Communications	<div></div>
> 1.3	Payload Capabilities	<div></div>
▼ 1.4	Construction	<div></div>
1.4.1	Modularity	<div></div>
1.4.2	Propulsion Power	<div></div>
> 1.5	Flying Qualities	<div></div>



Ready	125%	VariableStepAut
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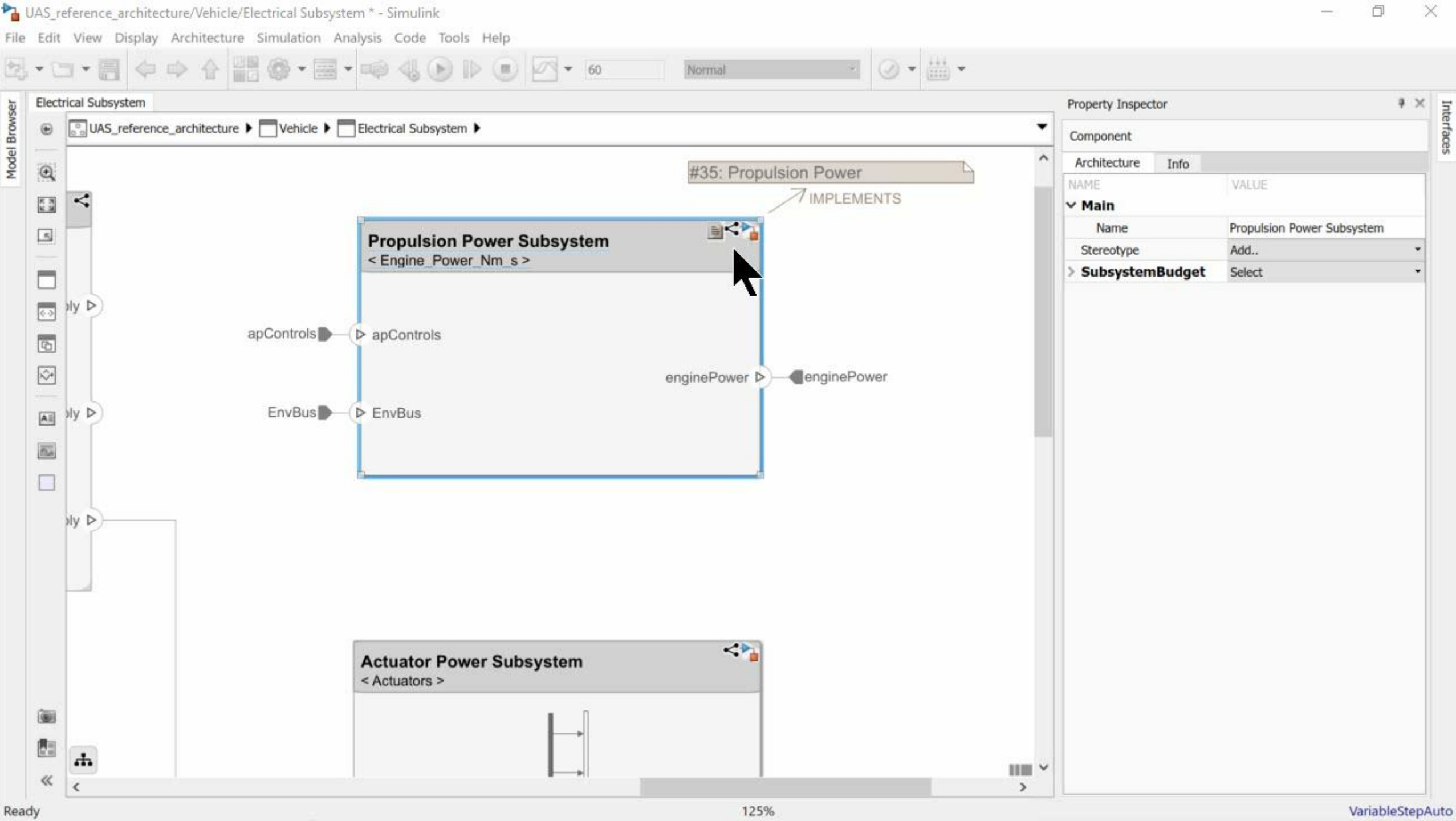


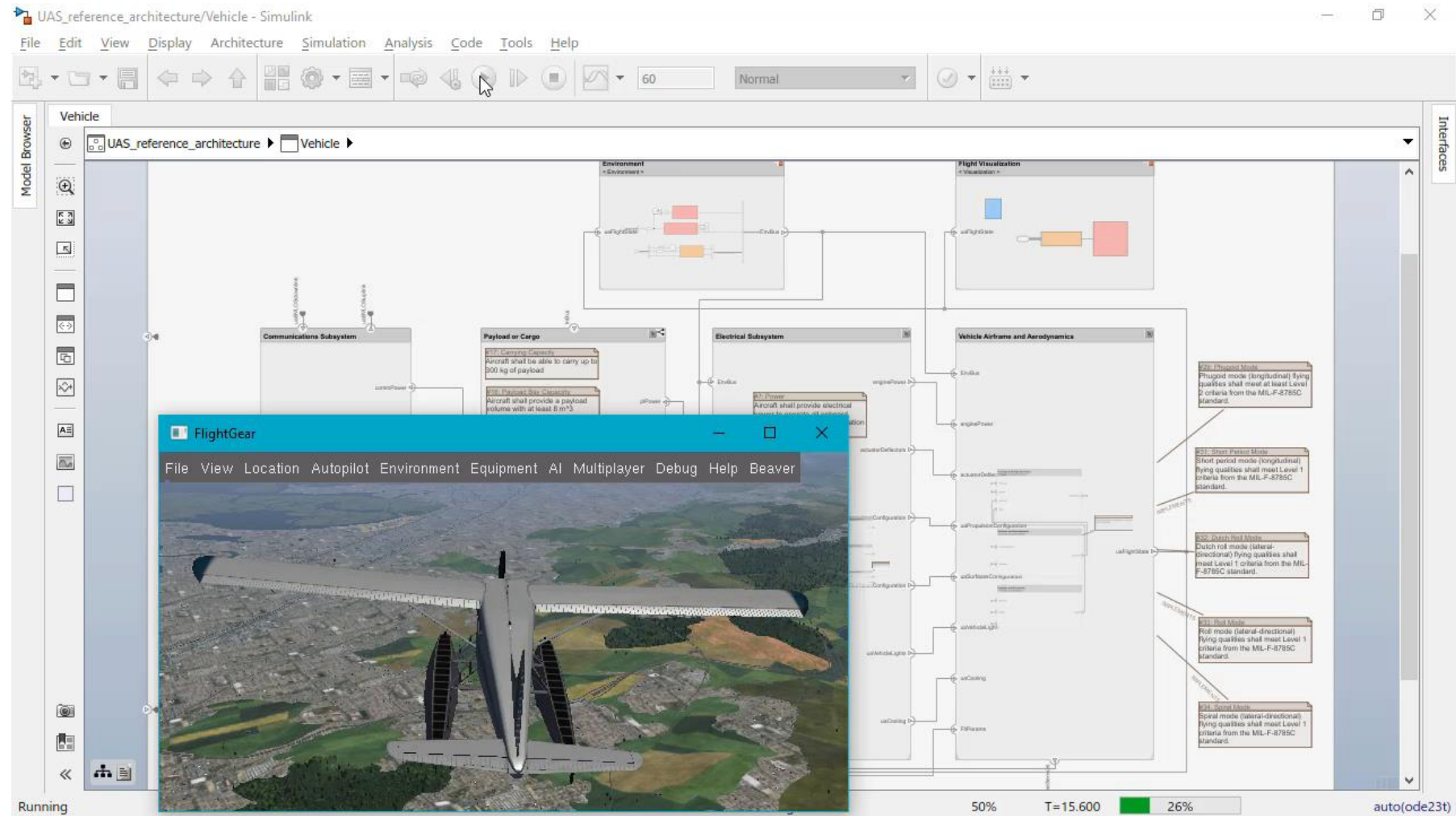
Property Inspector

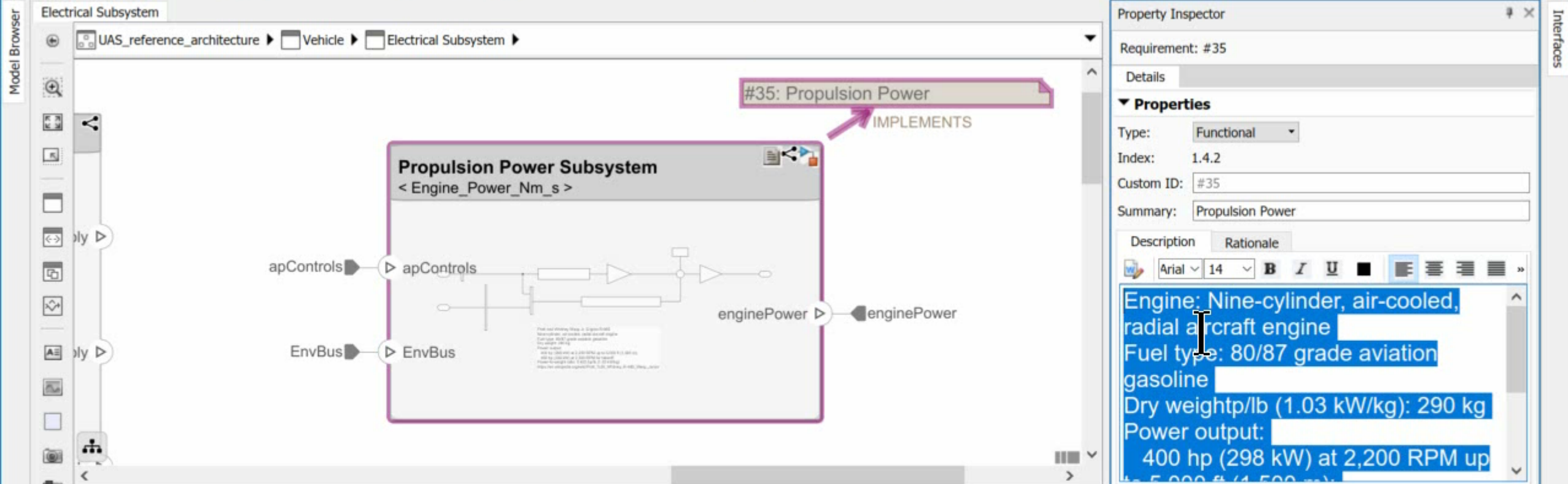
Component

Architecture Info

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







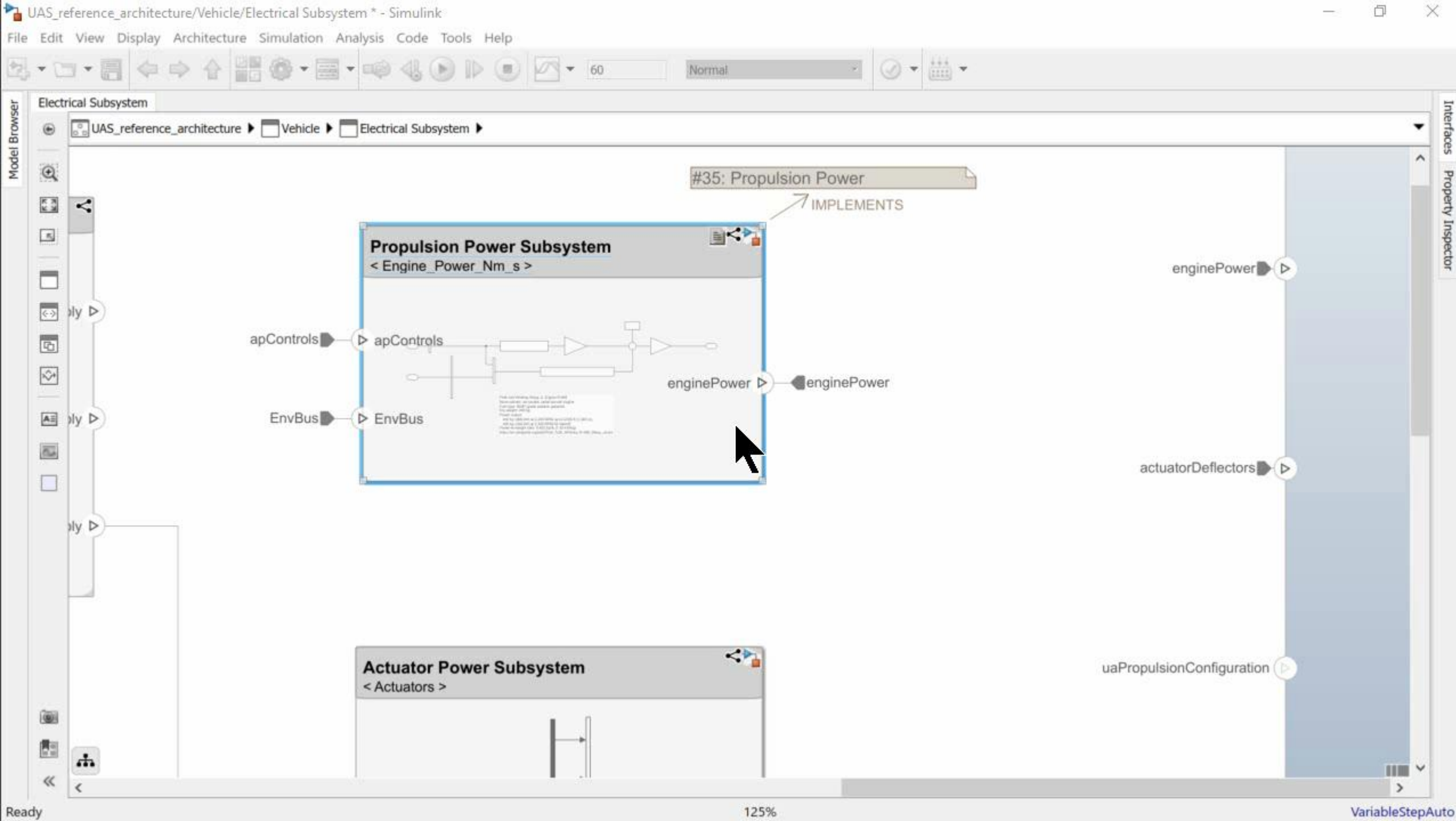
Requirements - UAS_reference_architecture

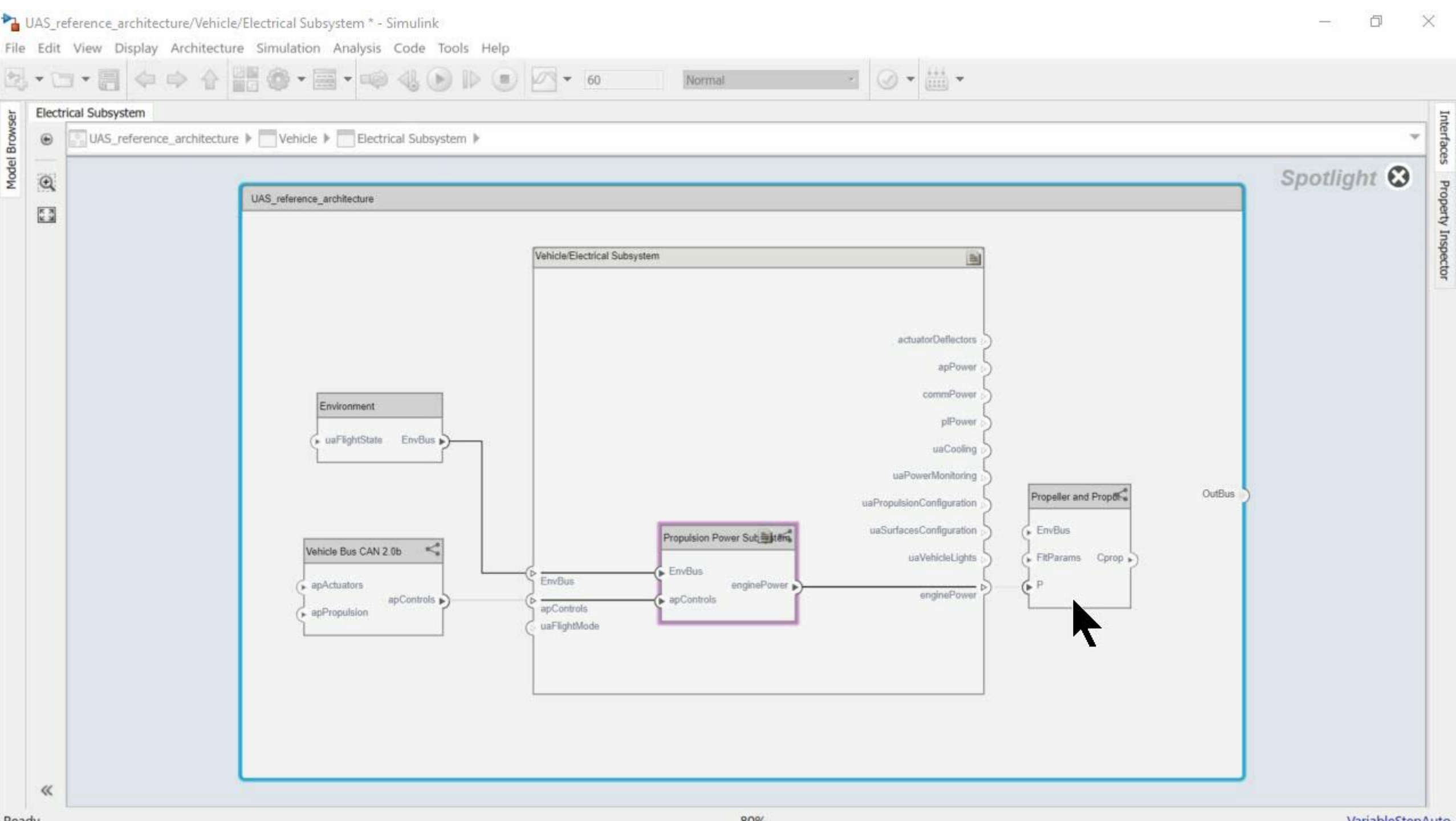
View: Requirements

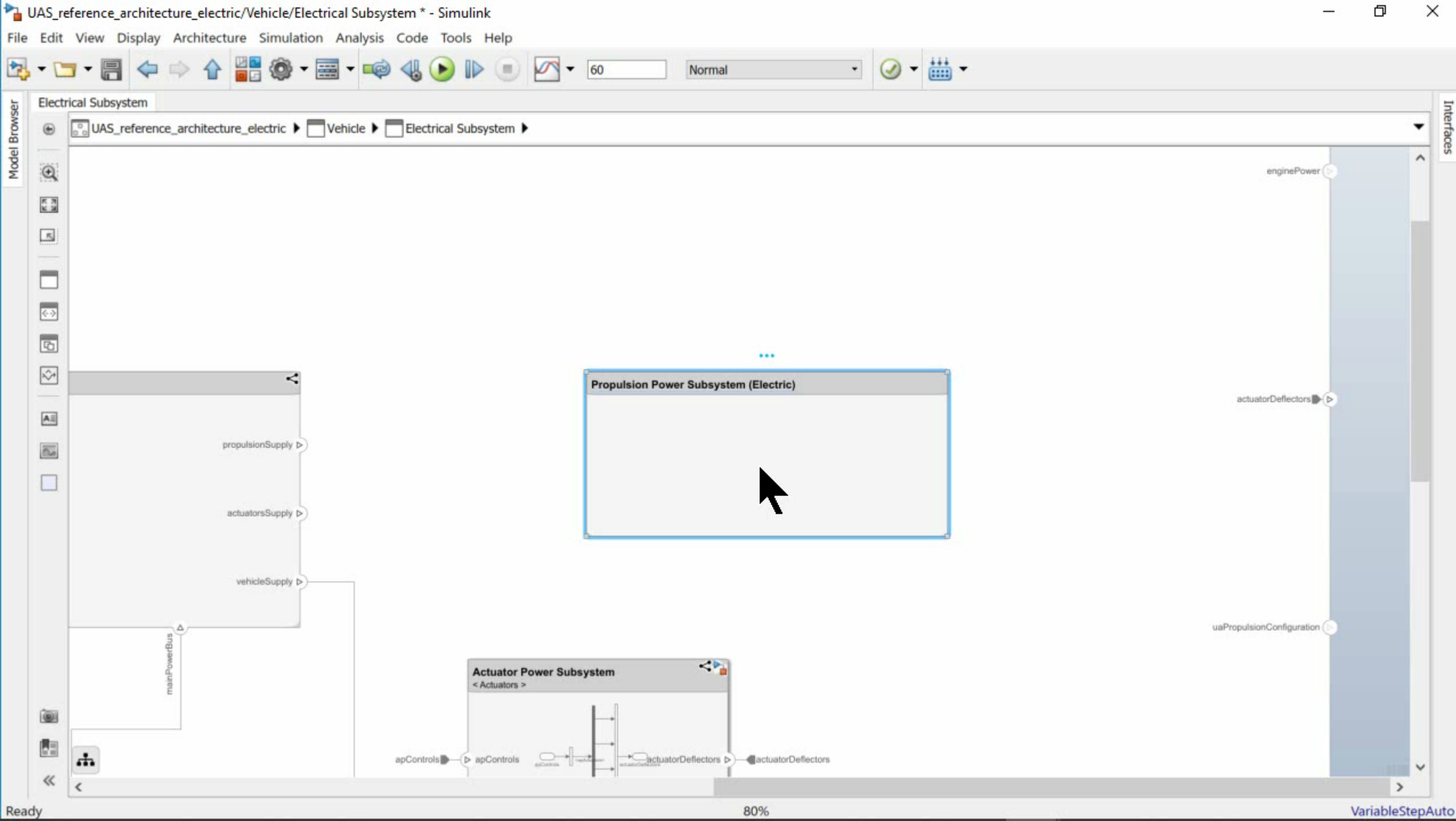


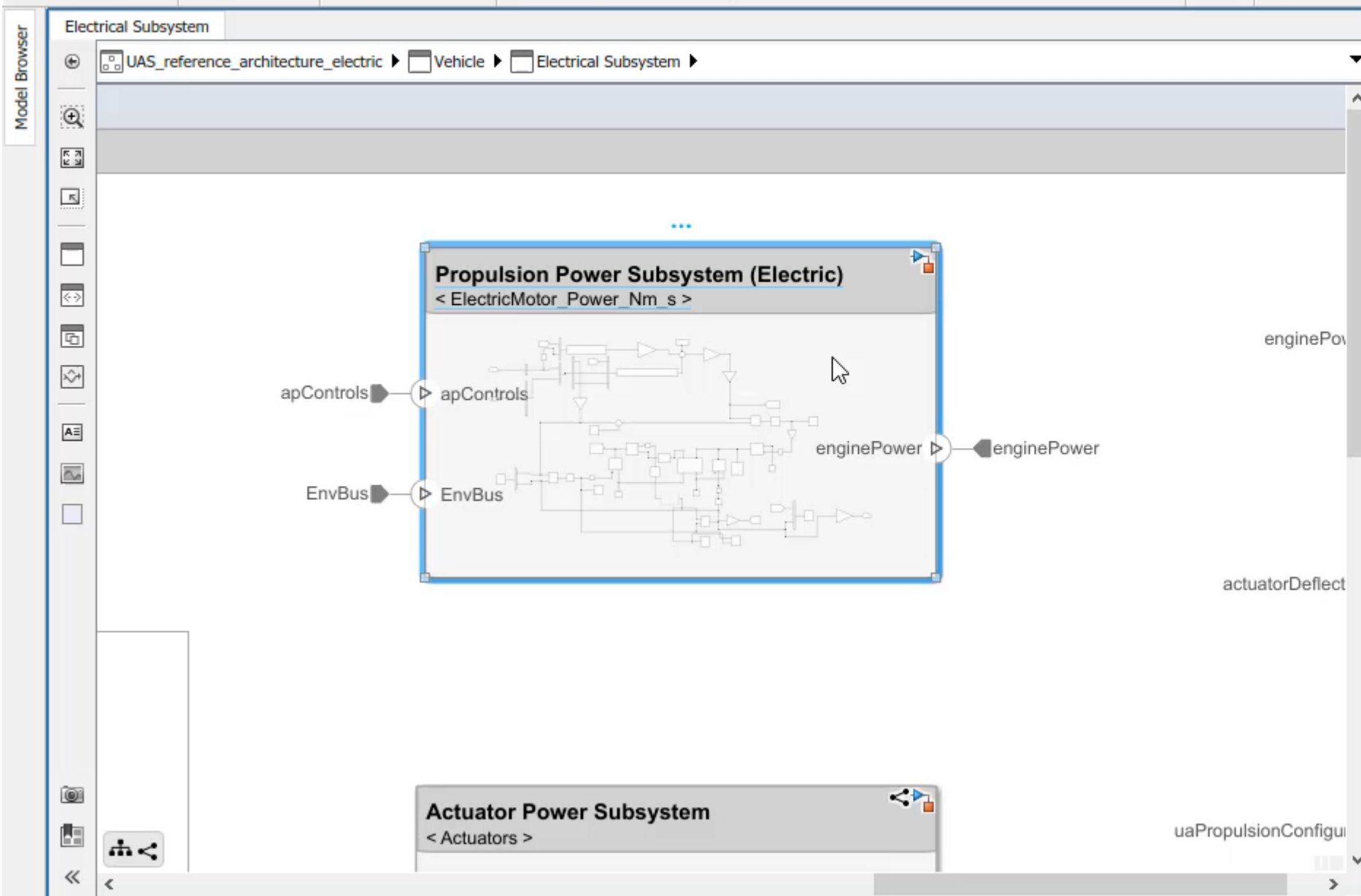
Search

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


Component

Architecture

Info

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

Model Browser



<<

Ready

✕

Interfaces

	2019
Revenue	
Expenses	
Net Income	

NAME	VALUE
------	-------

▼ Main

Name	Propulsion Power S
------	--------------------





Name	Propulsion Power System
Starship	Starship

Stereotype	Add..
------------	-------



SubsystemBudget Select ▼

Mass	100 kg
------	--------


HOME

New Open Save Delete

 ☐ Continuous
 Arguments ▼

Analyze

 ☐ Automatic
☐ Overwrite

Update

INSTANCE MODEL ANALYSIS UPDATE

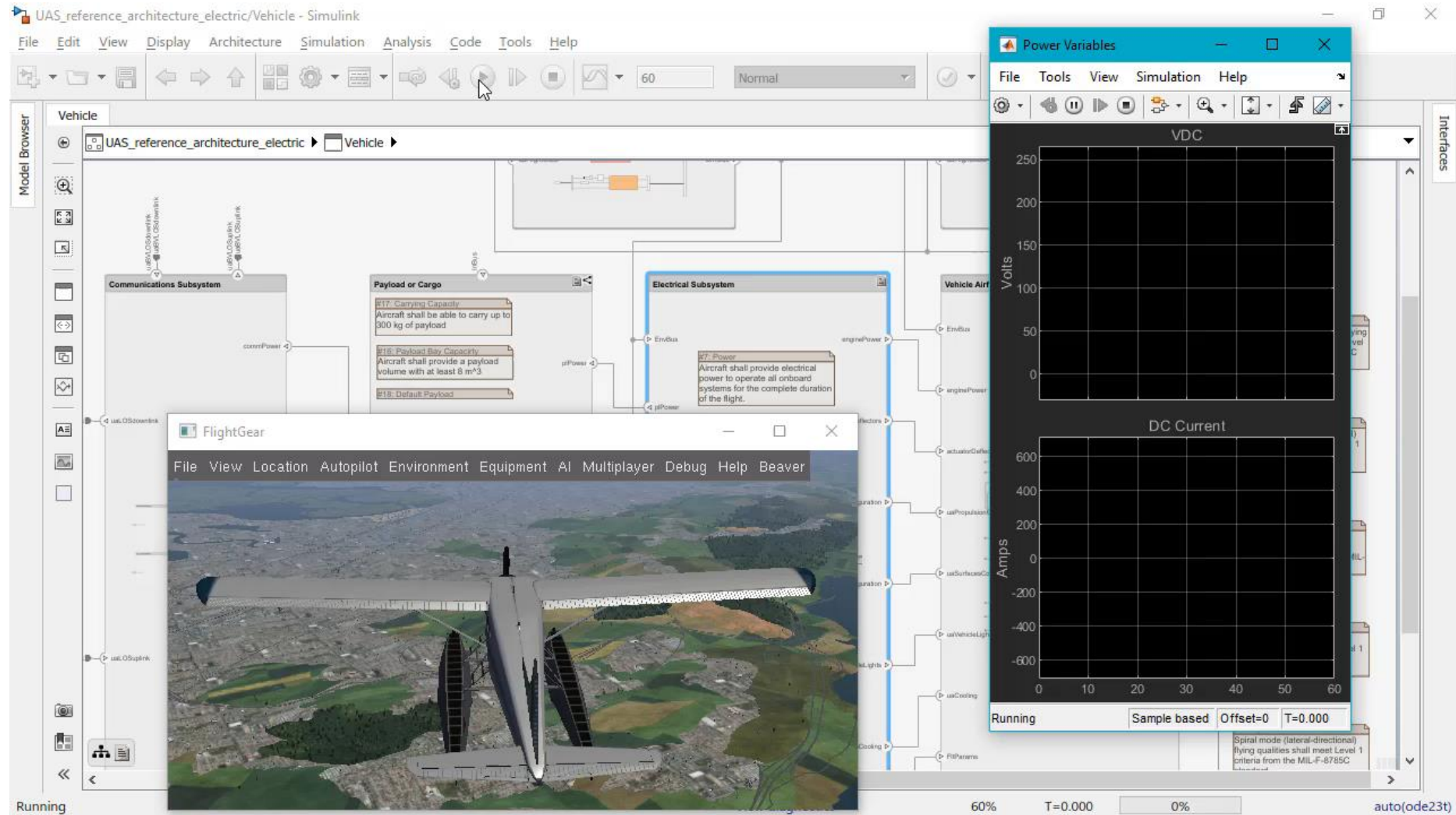
BottomUp ▼

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)

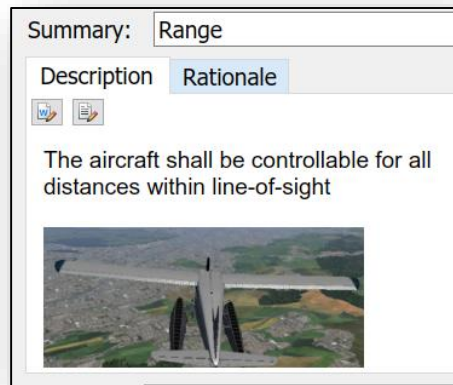
Property	Units	Value	Edit
SubsystemBudget			
Mass	kg	100	
Power	mW	175,000,000	



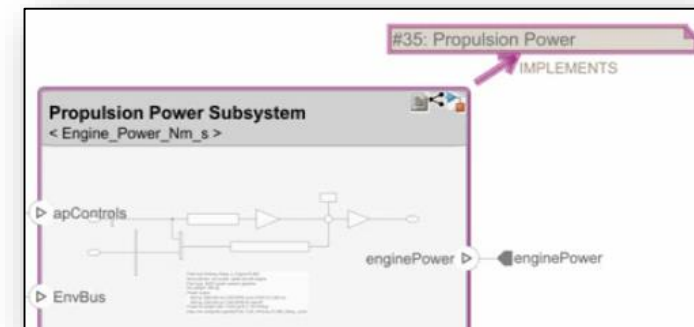
Simulink Requirements

Digital Thread from Requirements to Architecture and Design

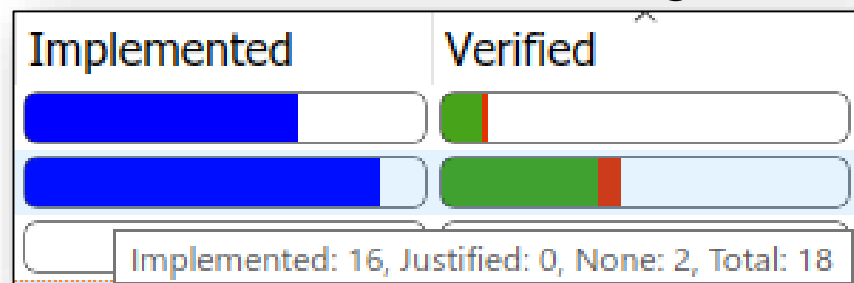
Author requirements or
view from external source



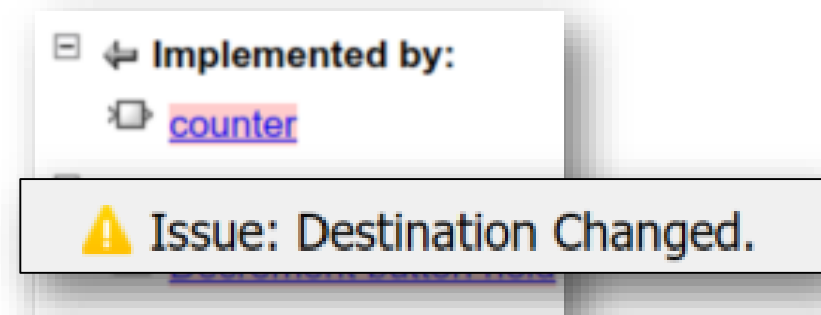
Link requirements, architectures,
design, code and test



Identify gaps in
architecture or design



Identify impact of requirement changes



R2019a

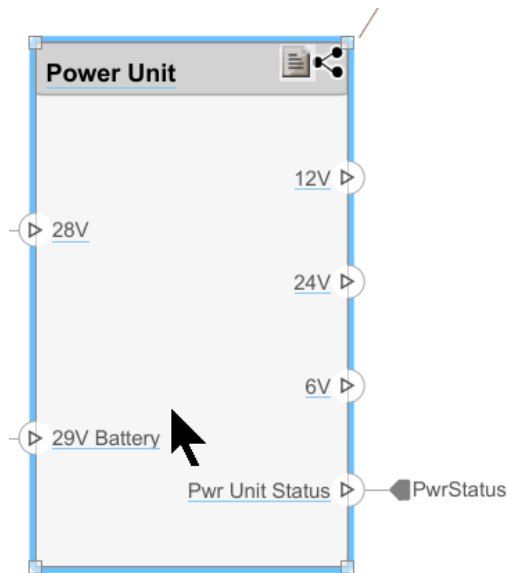


System Composer

Perform trade studies based on data driven analysis to optimize architectures

R2019a

Add custom data



Architecture	Info
NAME	VALUE
▼ Main	
Name	Power Unit
Stereotype	Add..
▼ OnboardElement	
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

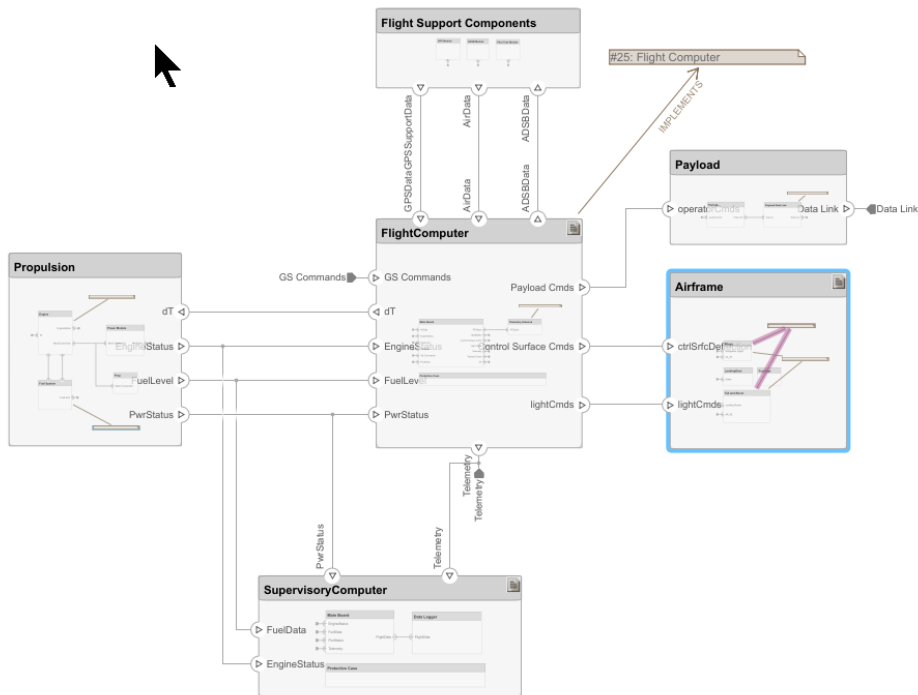
Instances	Mass(kg)
SmallUAV	15.932
Airframe	9.25
Fuselage	1.7
LandingGear	1.65
Tail and Boom	2.7
Wings	3.2
Flight Support Components	0.629
ADSB Module	0.156
ABDSB Antenna	0.058
ADSB Board	0.098
GPS Module	0.398
GPS Antenna	0.128
GPS Board	0.27
Pitot Tube Module	0.075
FlightComputer	0.388
Main Board	0.145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

System Composer

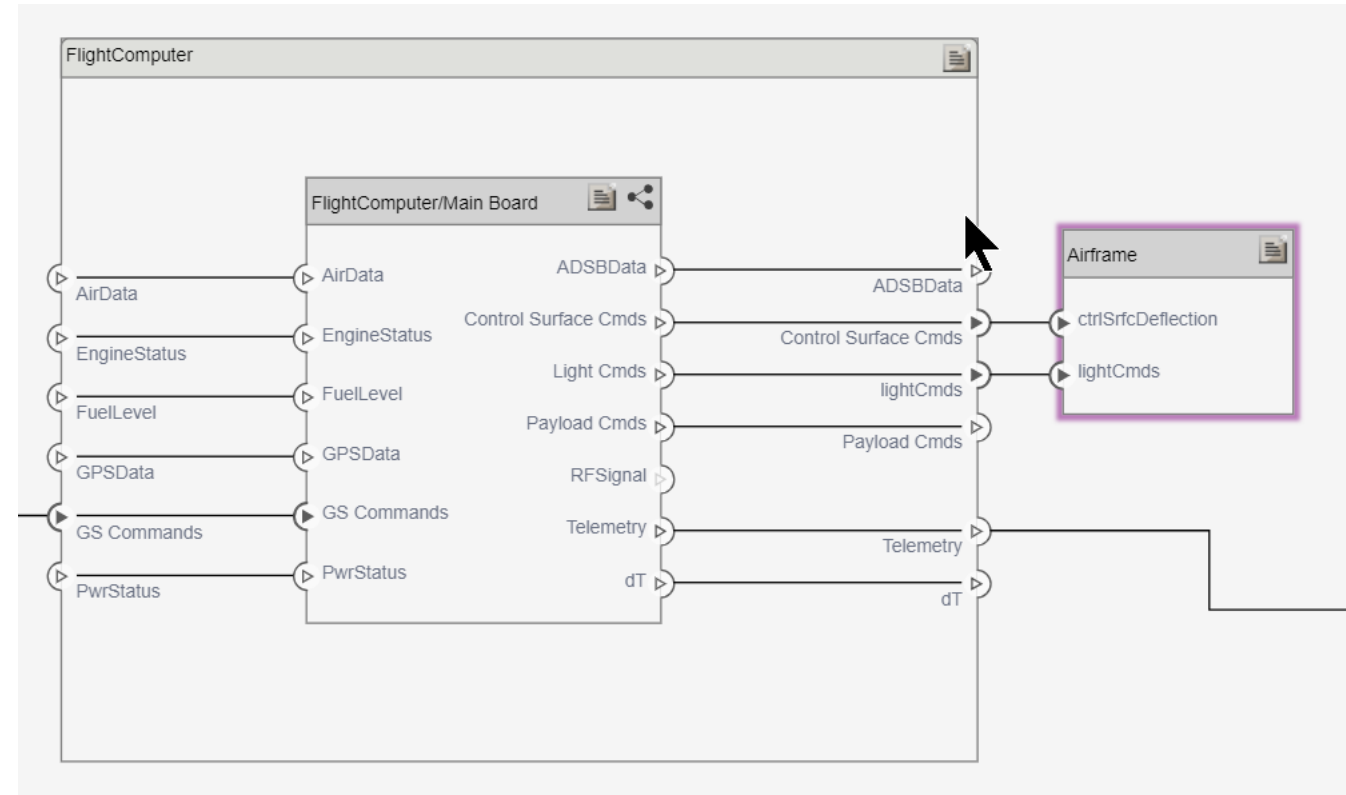
Tackle Architecture complexity with spotlight views

R2019a

Composition



Spotlight



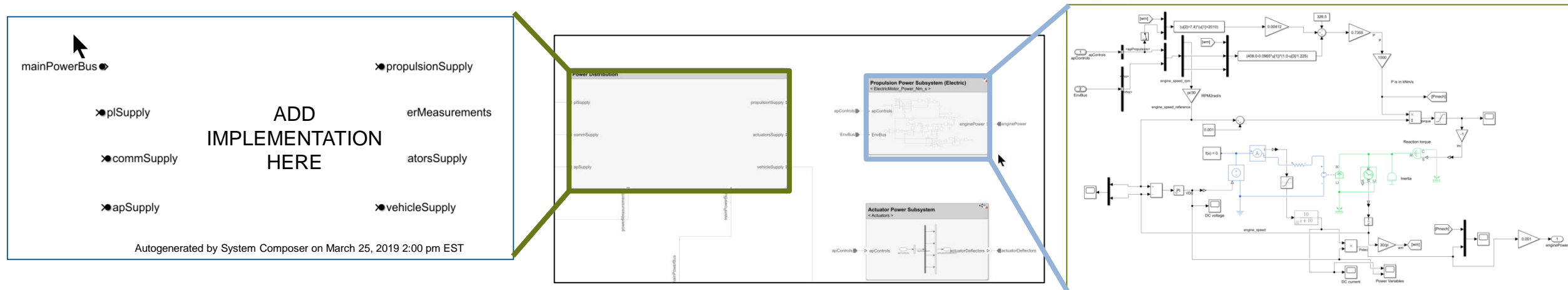
System Composer

System and software architectures connected to implementations in Simulink

R2019a

Generate Simulink models from architecture components

Link Simulink models to architecture components



Simulink: A Multi-Language Simulation Environment



Dynamic Systems



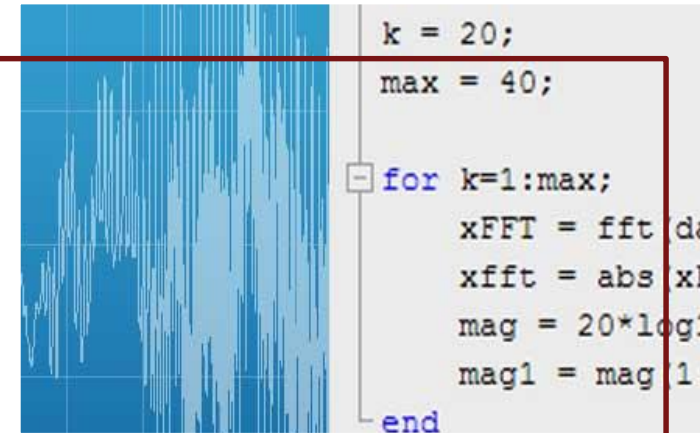
State Machines



Discrete-Event Systems



Physical Modeling



Object-Oriented

Learn More

- [Simulink Requirement Webpage](#)
- [System Composer Webpage](#)
- [System Modeling and Simulation Webpage](#)
- [Trial](#)