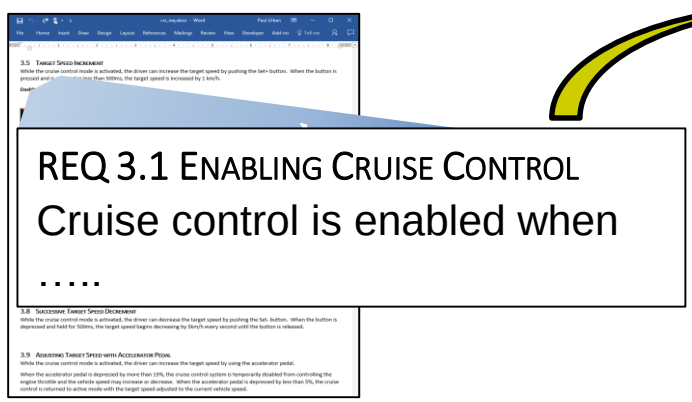
MATLAB EXPO 2019

요구사항부터
아키텍쳐 설계와 시뮬레이션까지
시스템 엔지니어링을 위한 방안

류성연

Key Takeaways

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



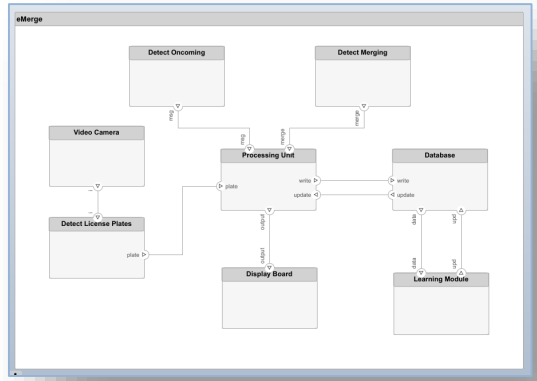
REQ 3.1 ENABLING CRUISE CONTROL
Cruise control is enabled when
…..

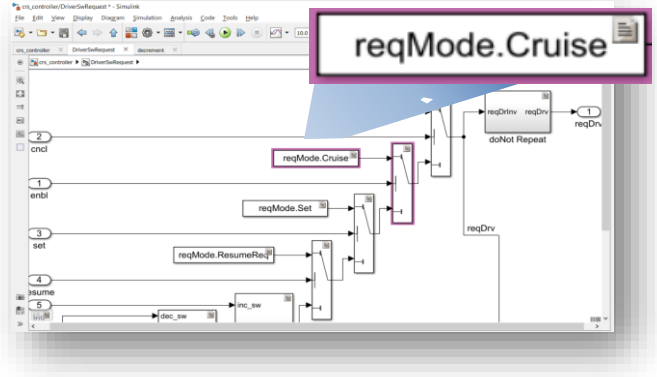
Derives

ENABLE SWITCH DETECTION
If the Enable switch is pressed
……

Implemented By

Implemented By

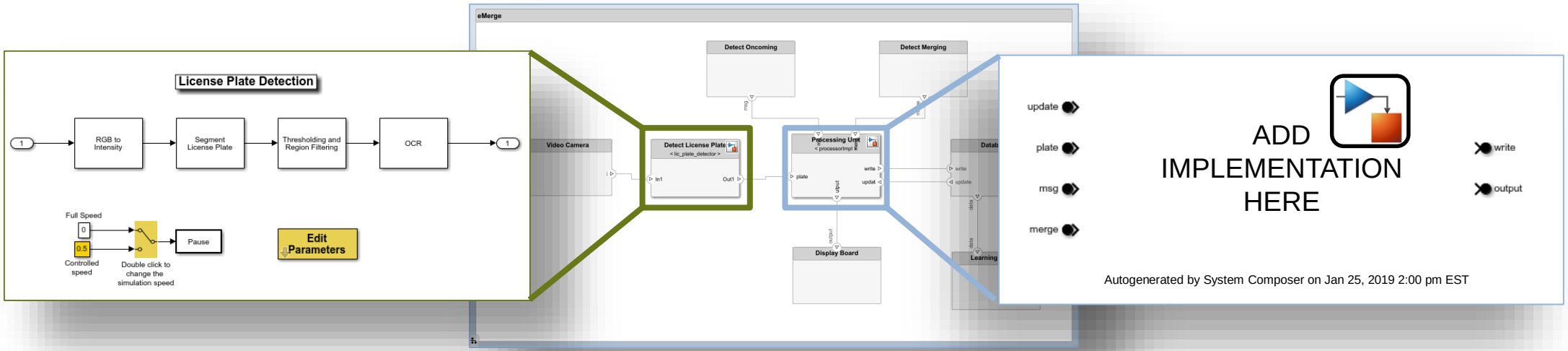




Key Takeaways

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

- Connected environment for designing and analyzing architectures and designs

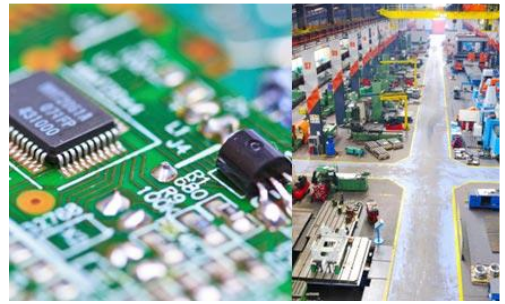


Key Takeaways

- 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

State Machines

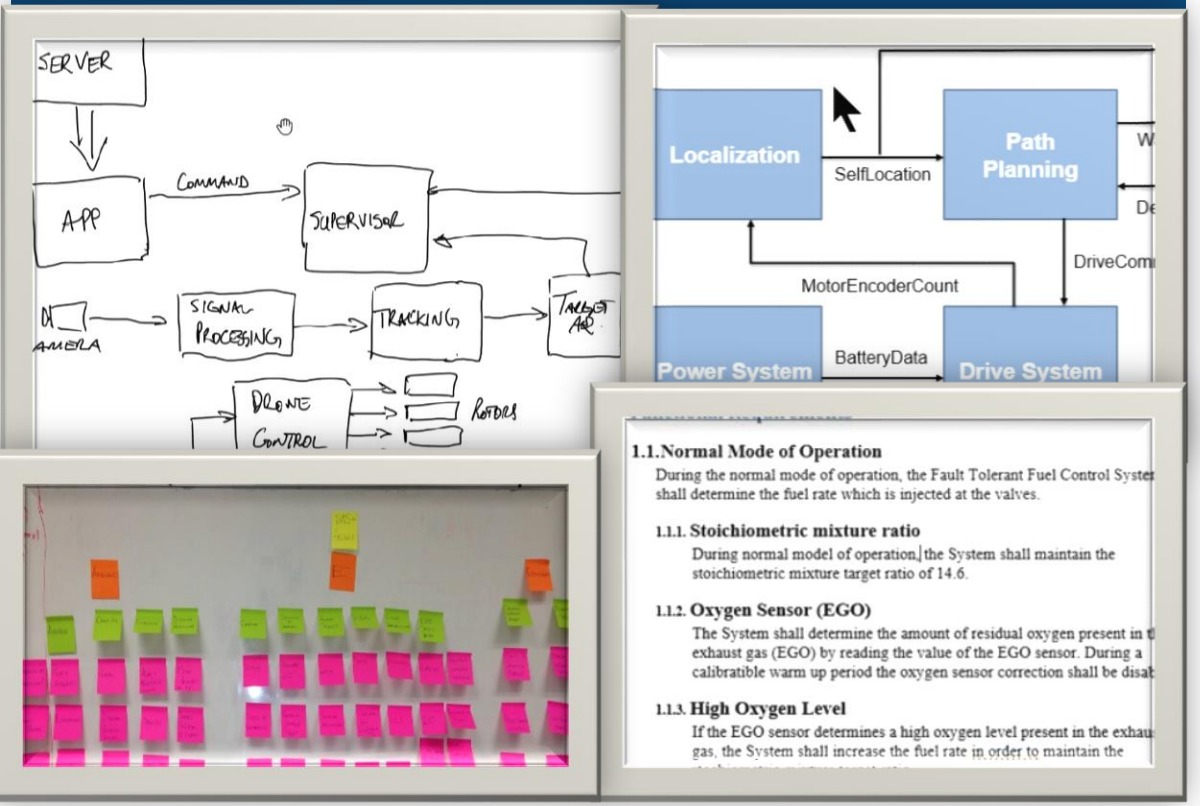


Discrete-Event

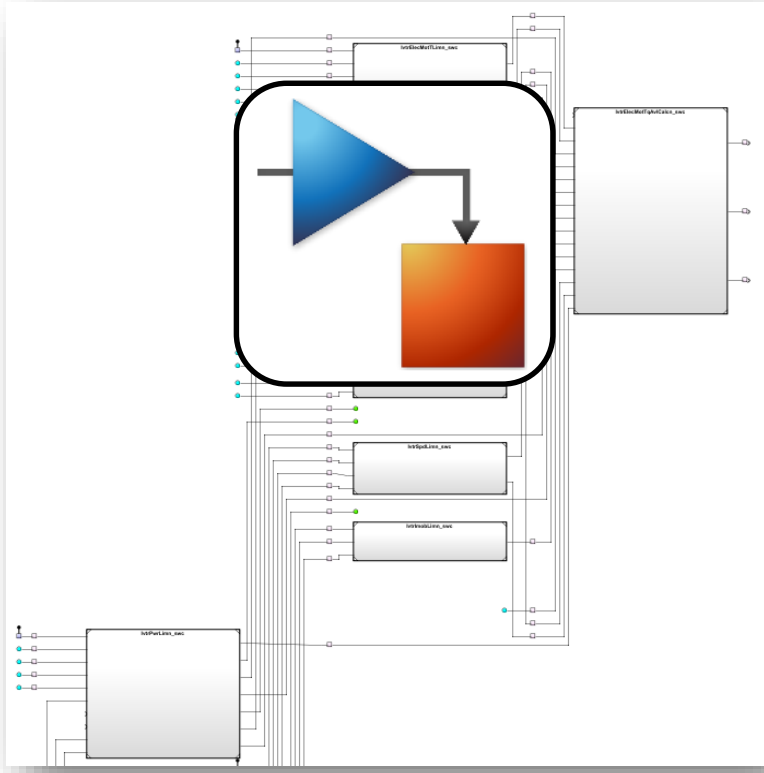
Physical Modeling

What does that mean?

Early in the Process
Concepts/Descriptions

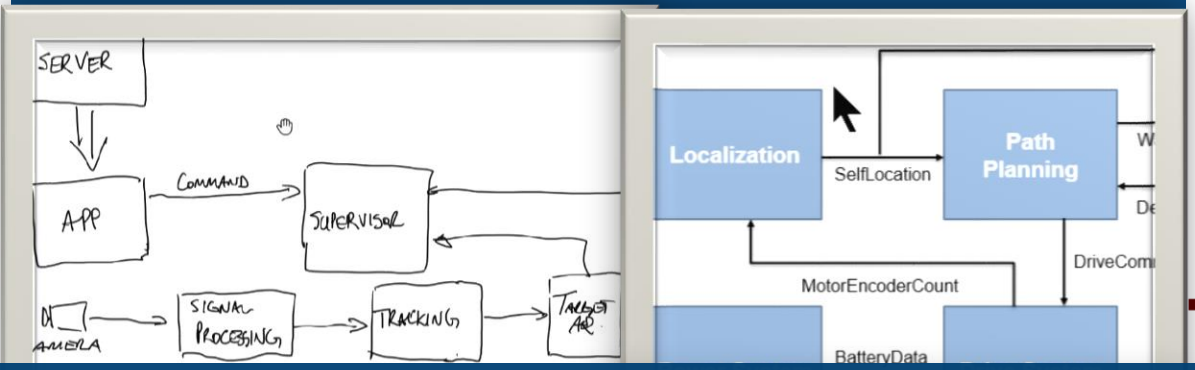


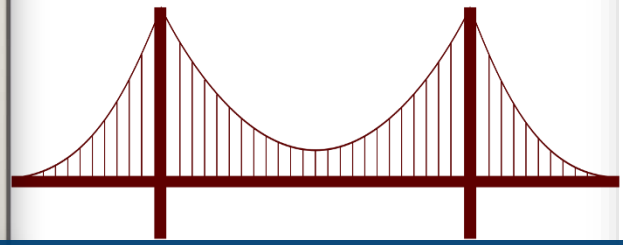
Later in the Process
Models



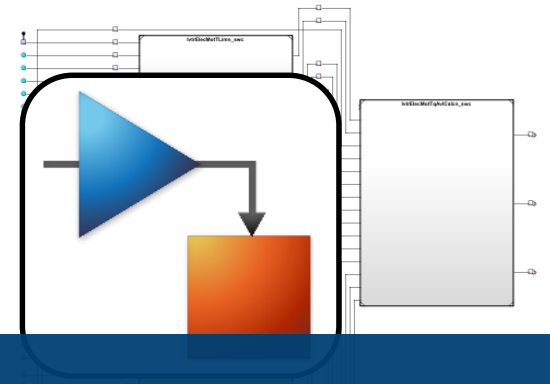
What is the Gap?

Early in the Process
Concepts/Descriptions





Later in the Process
Models



Digital Thread
Connected Environment
Analysis & Simulation Platform

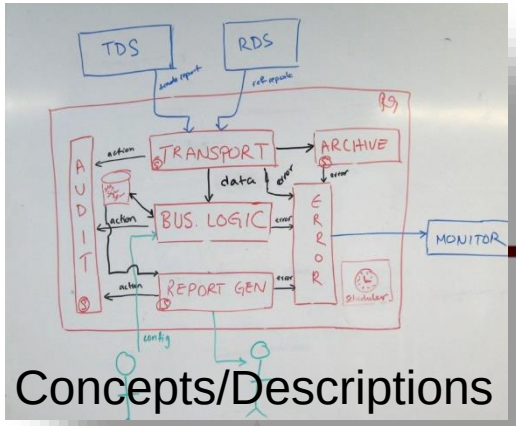
What goes into the bridge?

Be Intuitive

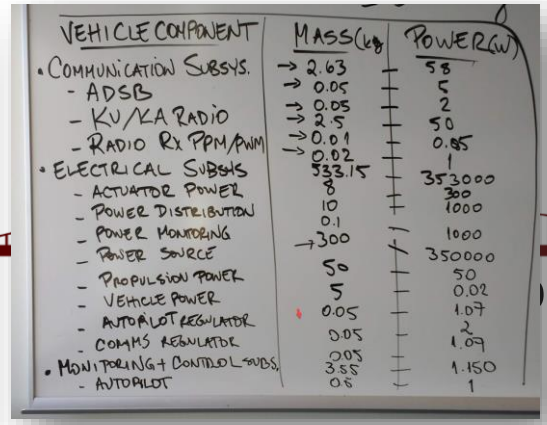
Facilitate Analysis

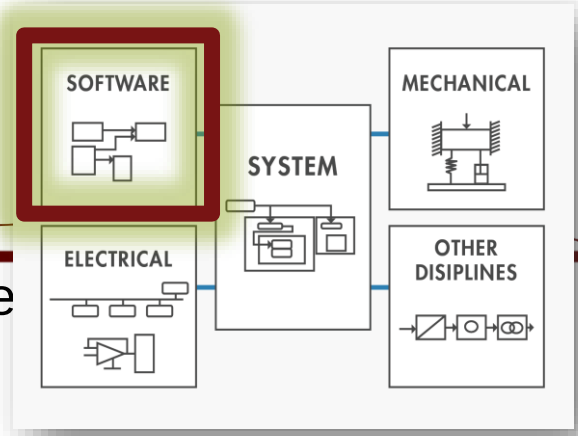
Tackle Complexity

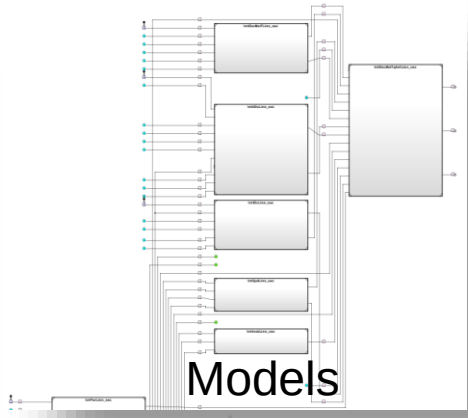
Enable Implementation



Concepts/Descriptions

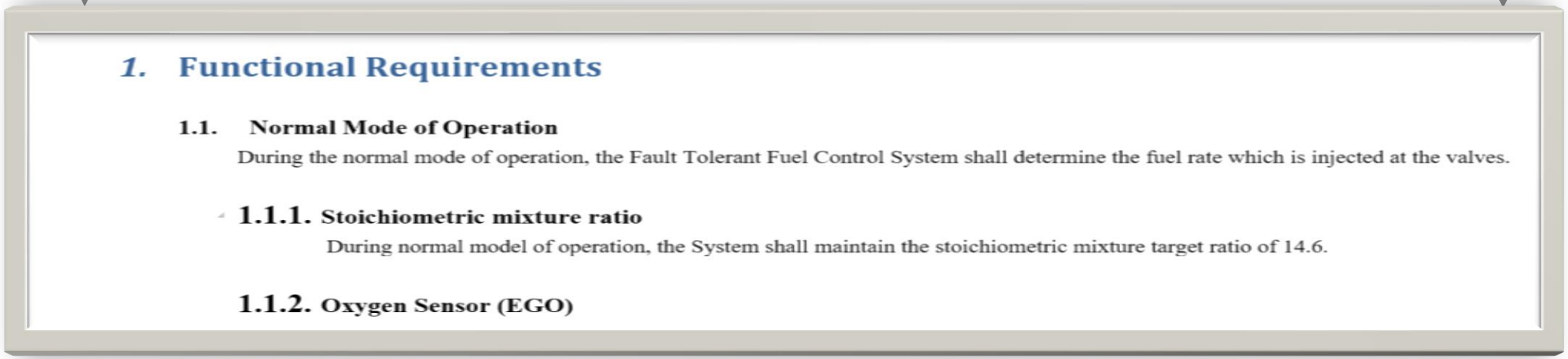






Models

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.

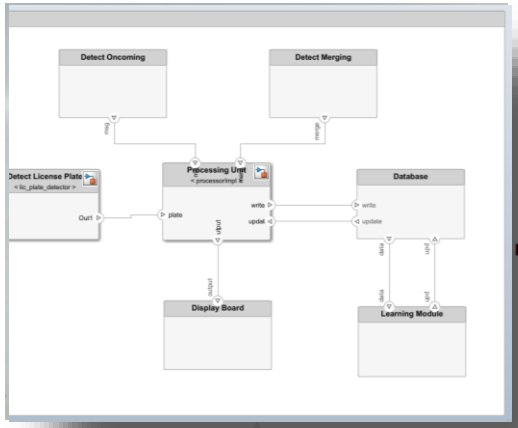
1.1.1. Stoichiometric mixture ratio

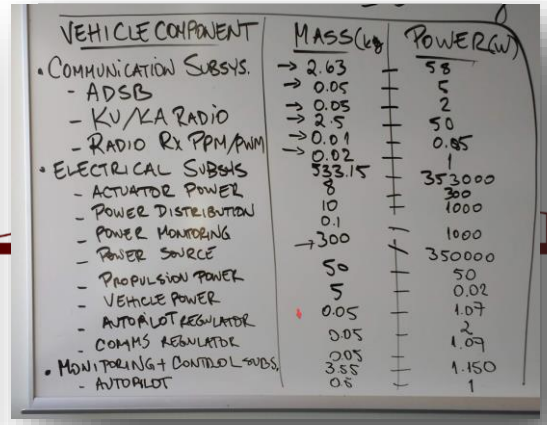
During normal model of operation, the System shall maintain the stoichiometric mixture target ratio of 14.6.

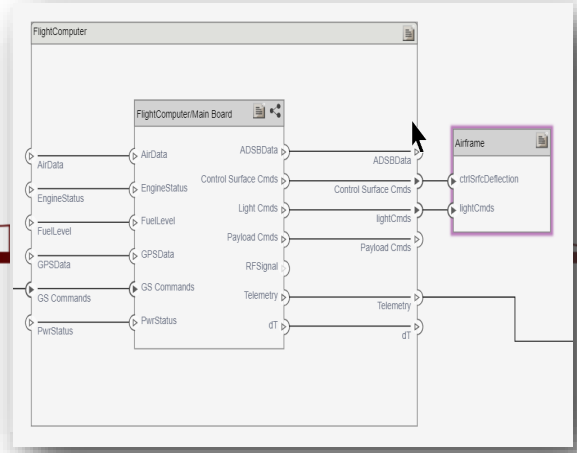
1.1.2. Oxygen Sensor (EGO)

MathWorks Solution: System Composer R2019a and …

✓Be Intuitive ✓Facilitate Analysis Tackle Complexity ✓Enable Implementation







Requirements Coverage Reporting and Impact Analysis

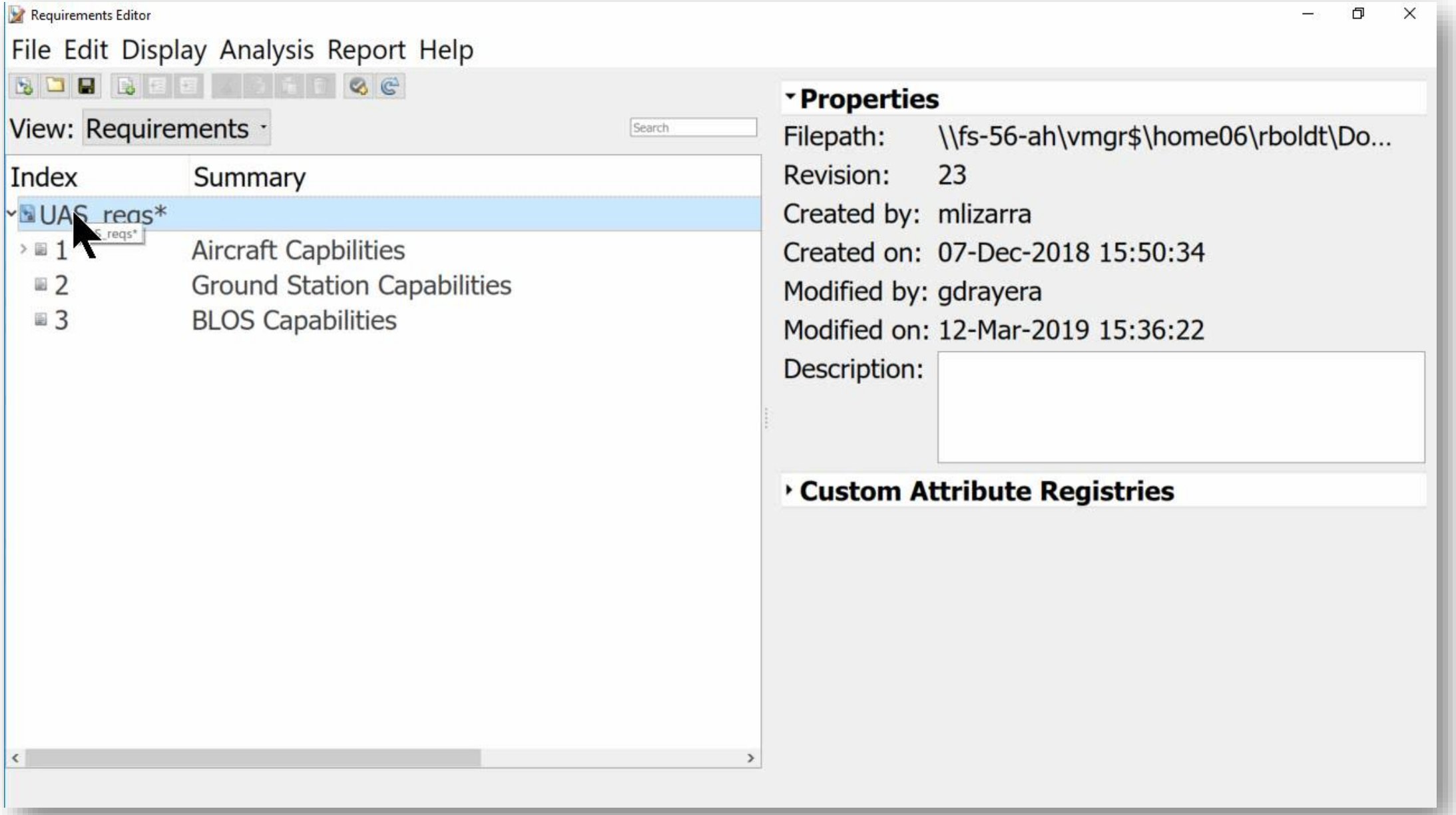
Case Study: electrifying propulsion system

- System architecture using System Composer
- System requirement traceability
- Simulink modeling from system architecture
- System update for electrification
- Trade studies

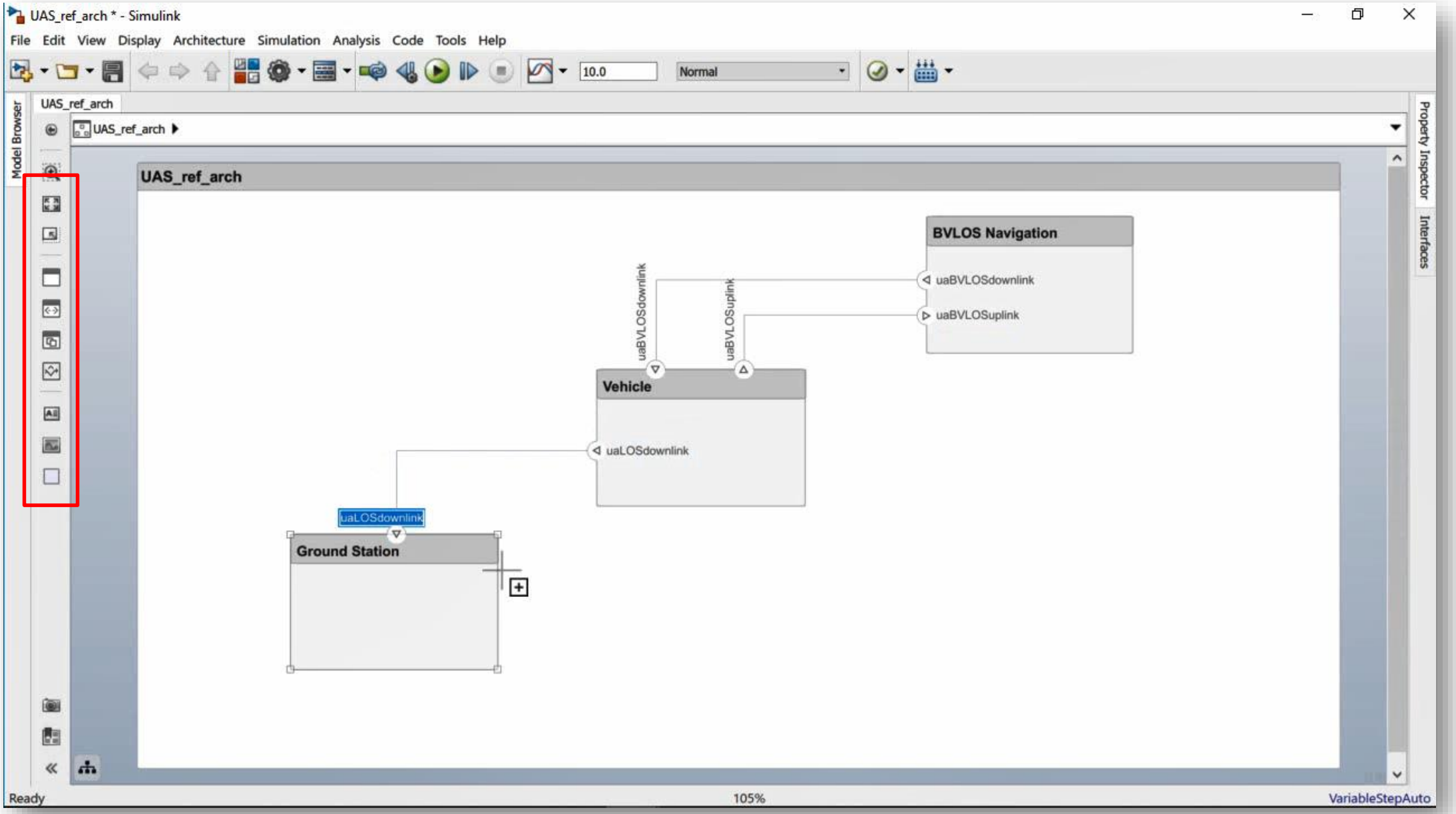
Demo: De Havilland "Beaver" Airplane

- Target: Electrifying propulsion system

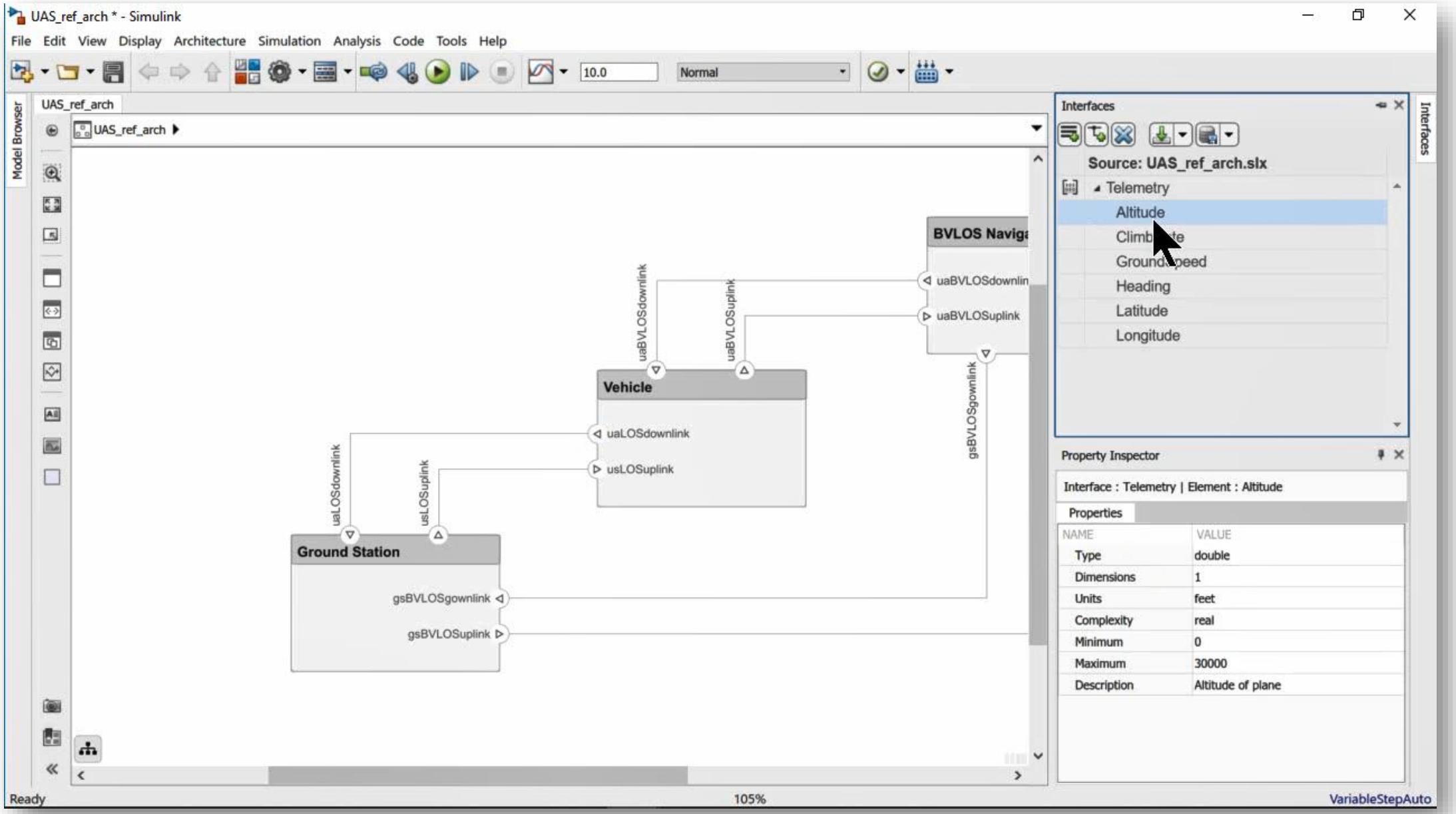
Start from Requirements



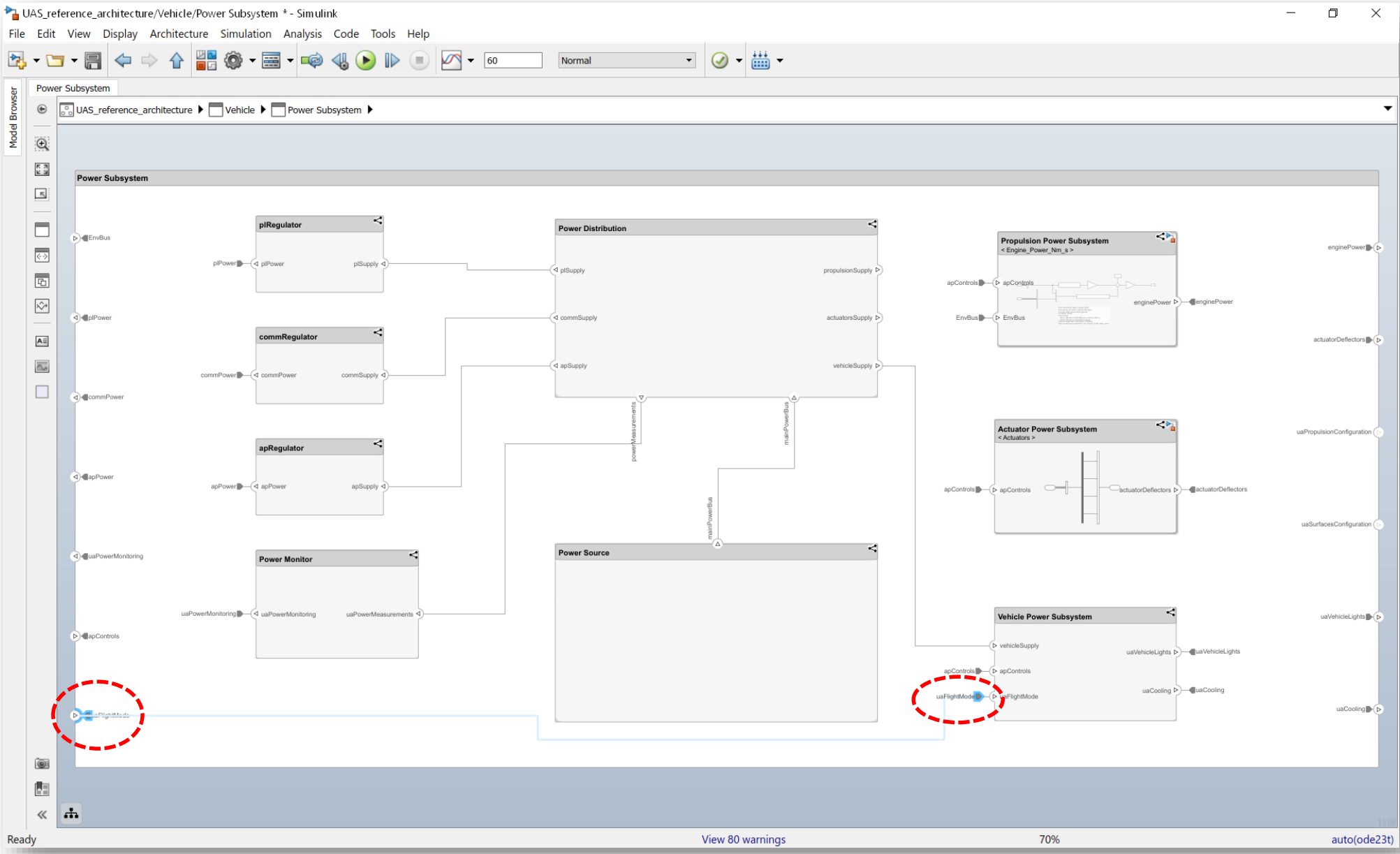
Easy to Design at a High Level of Abstraction



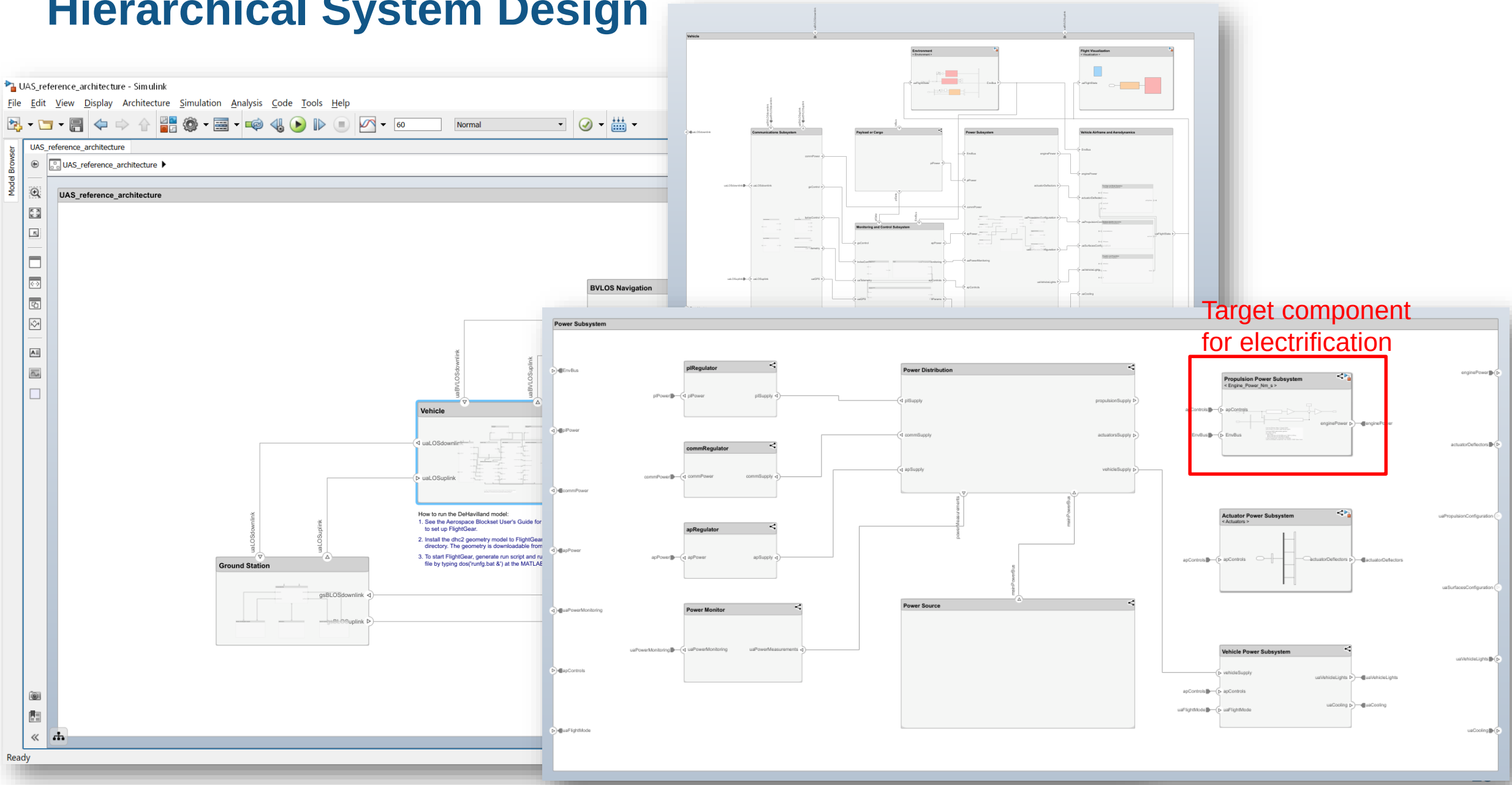
Add Details for Interfaces



Automatic Simplified Signal Routing



Hierarchical System Design



Case Study

- System architecture using System Composer
- **System requirement traceability**
- Simulink modeling from system architecture
- System update for electrification
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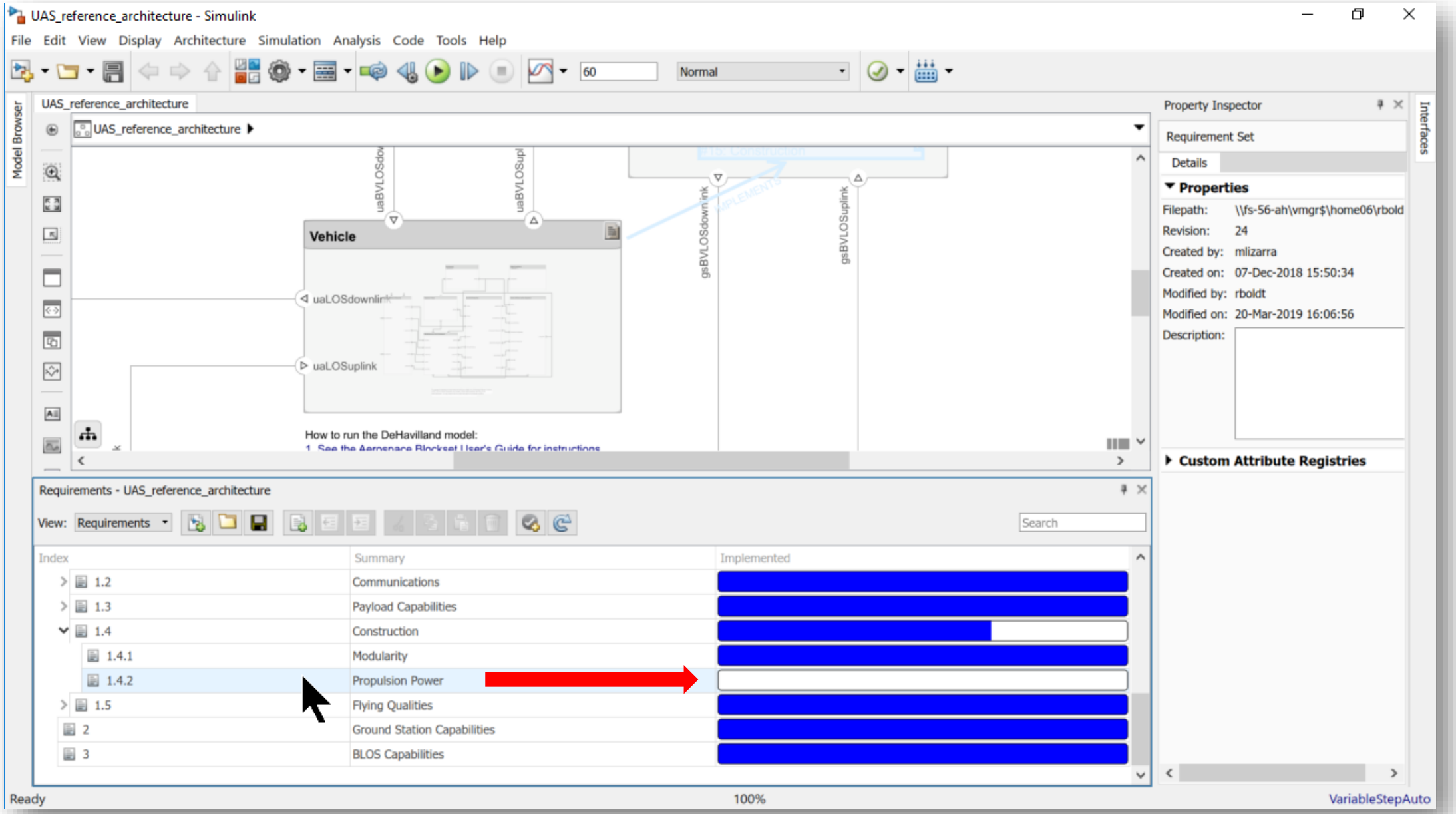
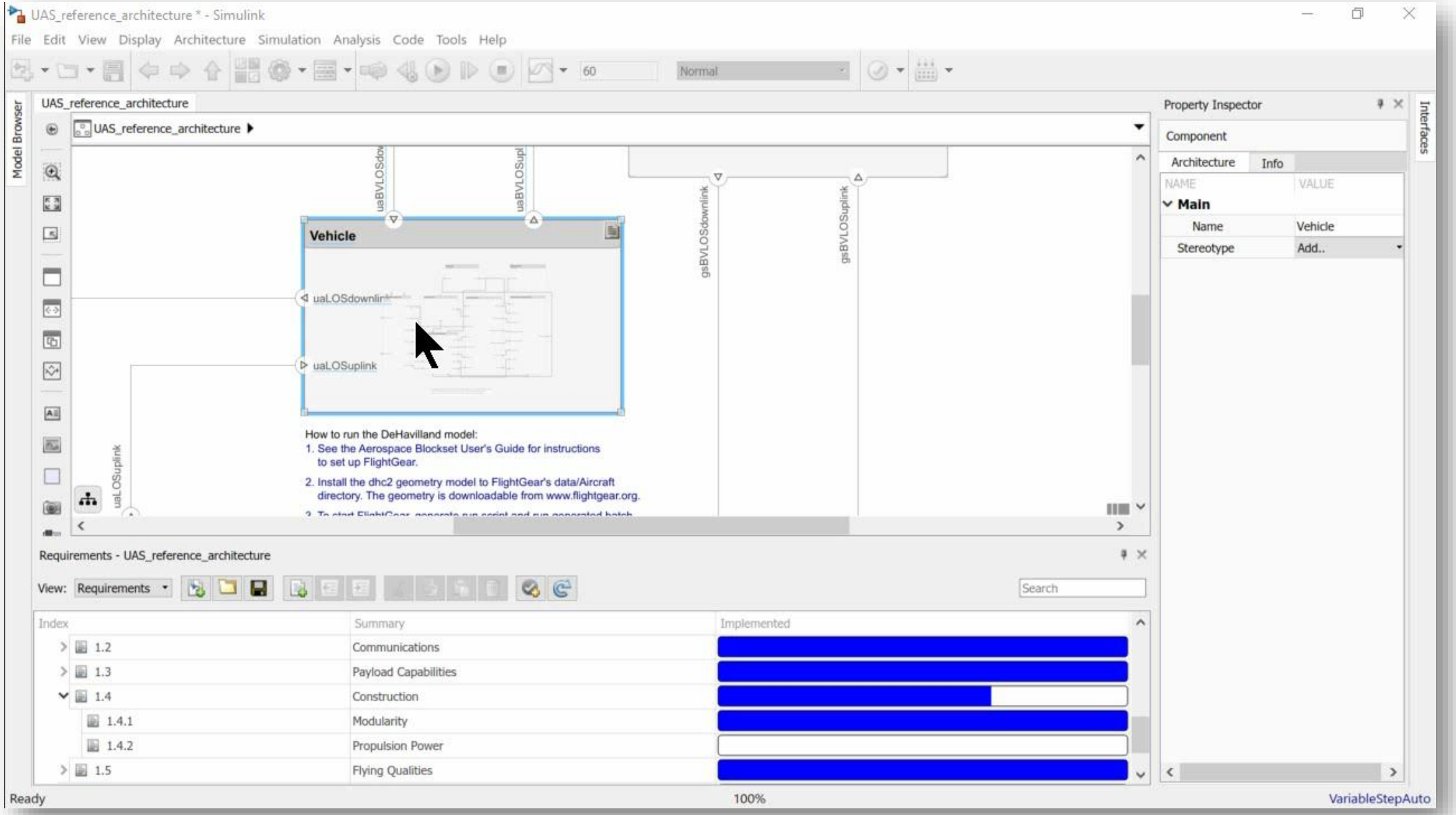
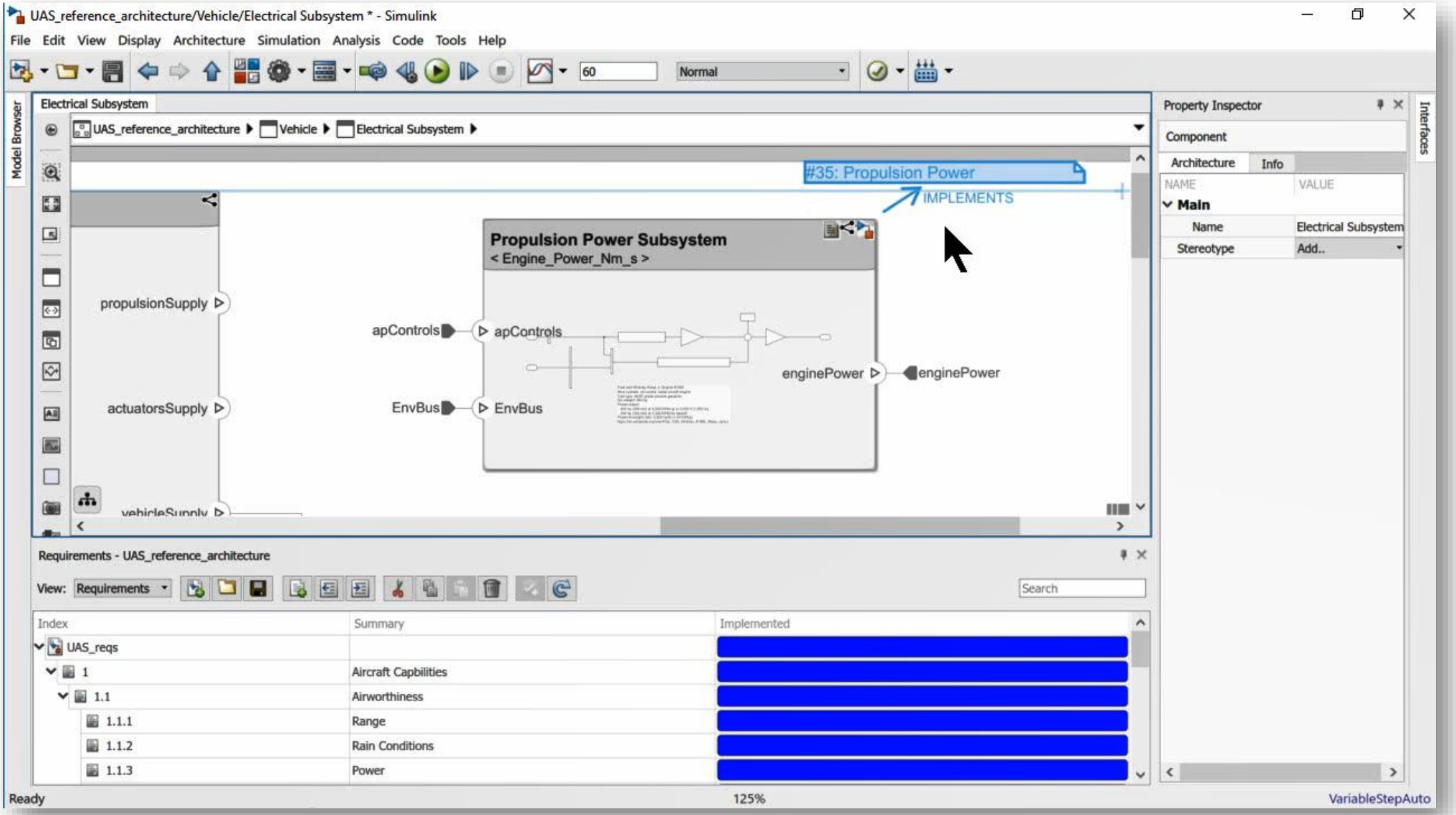
Traceability with Simulink Requirements



Drilling Down to Propulsion Power Subsystem



Linking Requirement to Propulsion Power Subsystem



Case Study

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- **Simulink modeling from system architecture**
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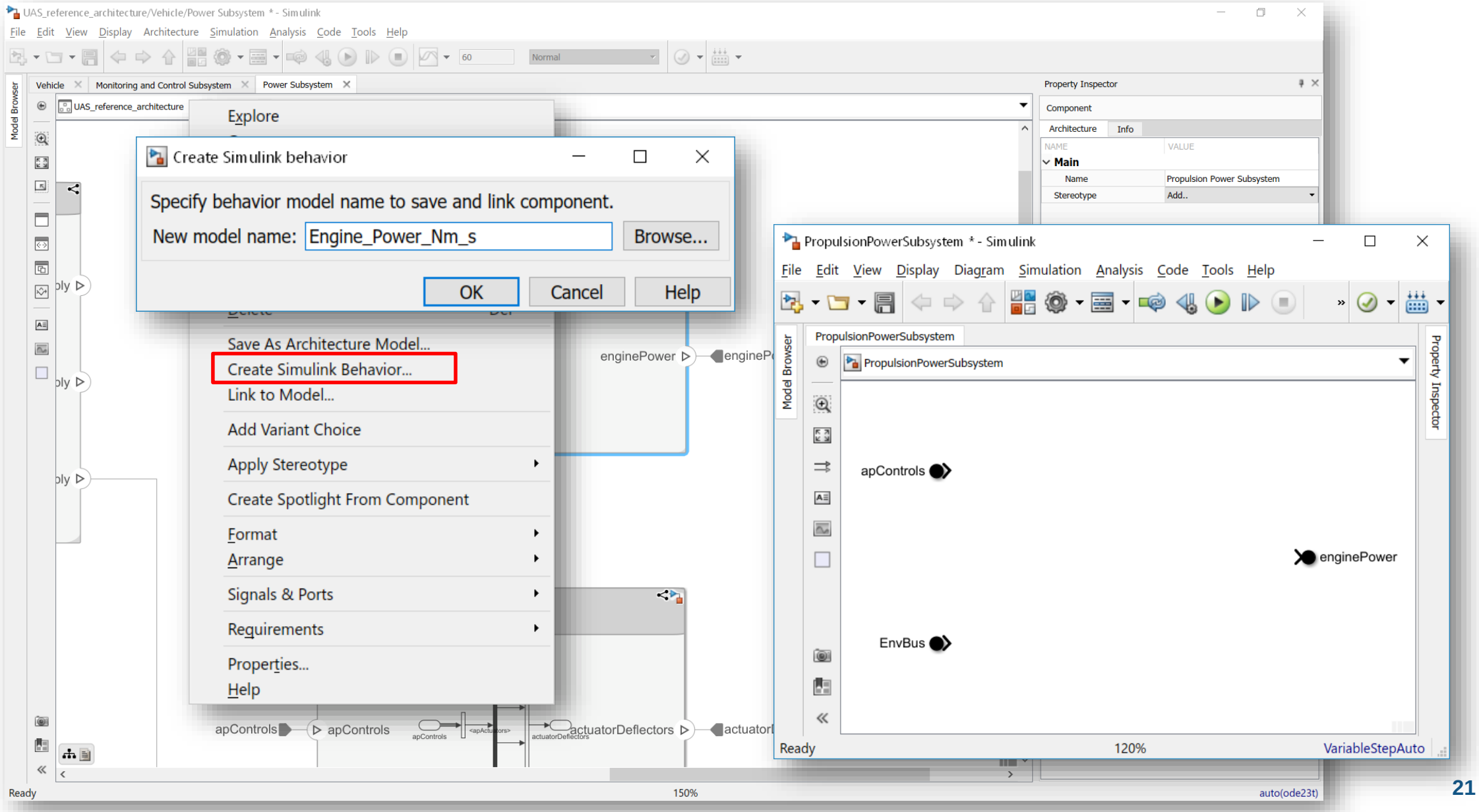
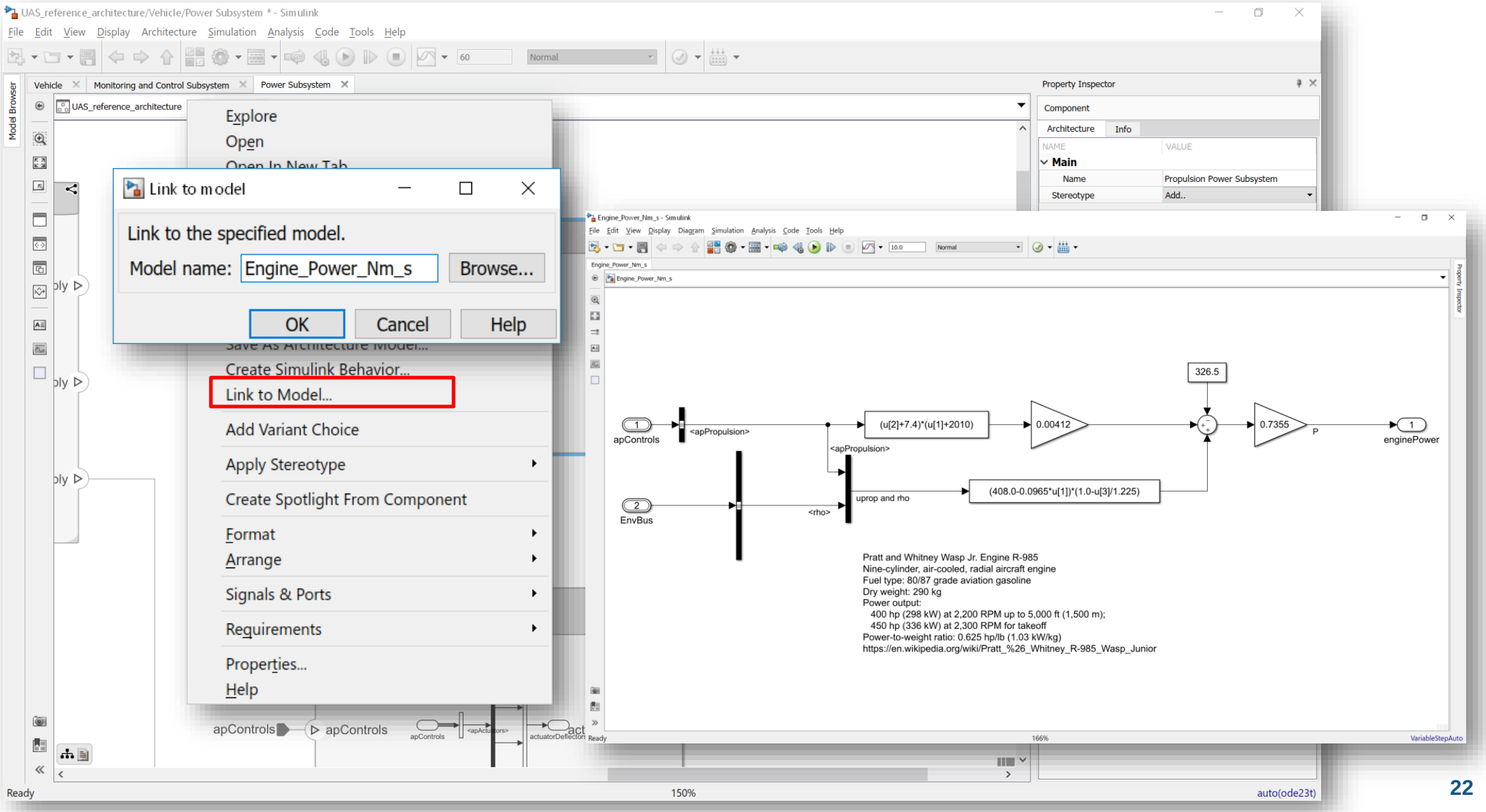
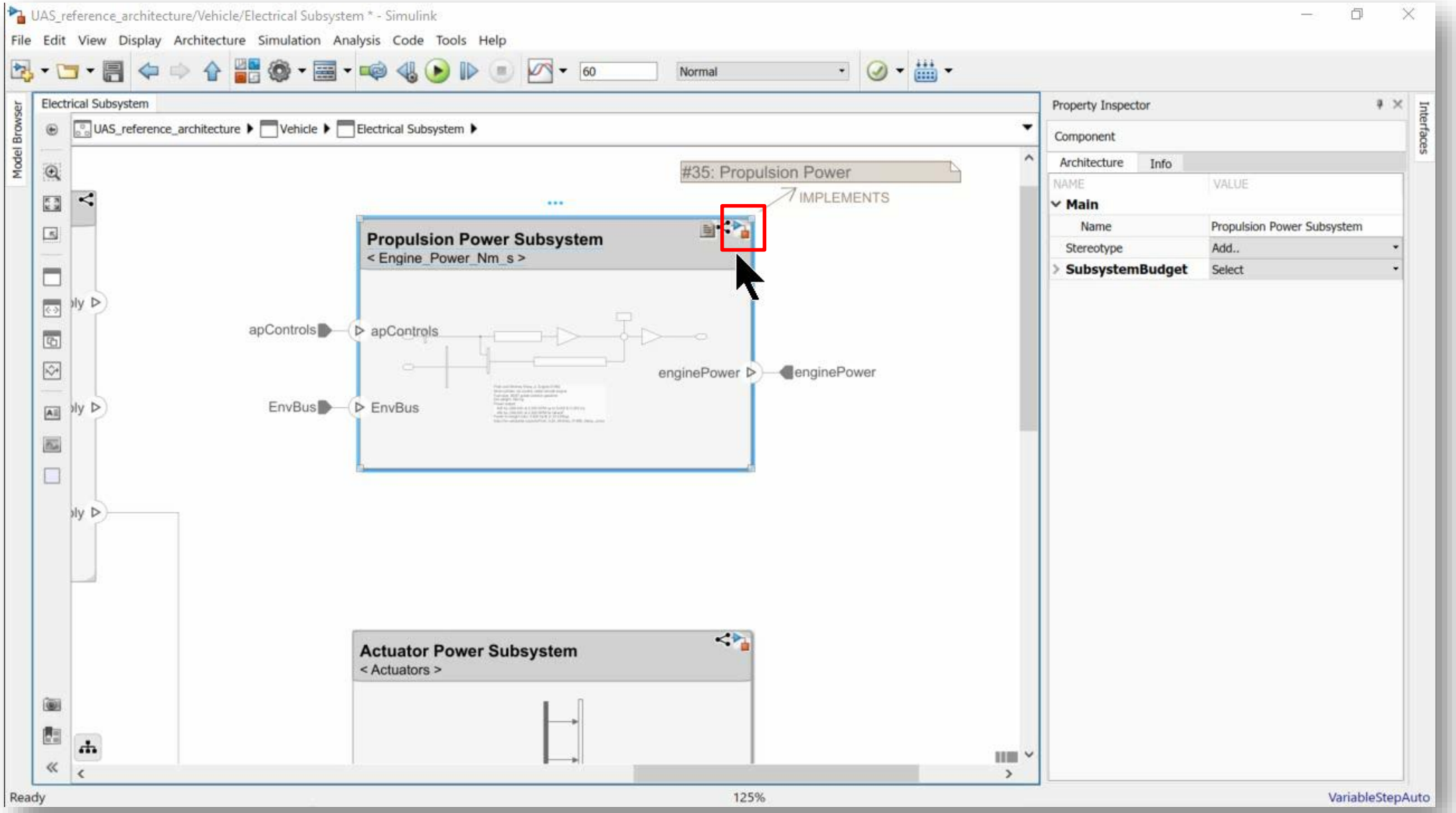
Create Simulink from System Composer



Link Simulink Model to System Composer



Simulink Model Traceability



Define Profiles and Stereotypes for Trade Studies

- Define non-functional properties on elements in an architecture model to verify structural and functional requirements

Profile: System Standard

Stereotype: System General

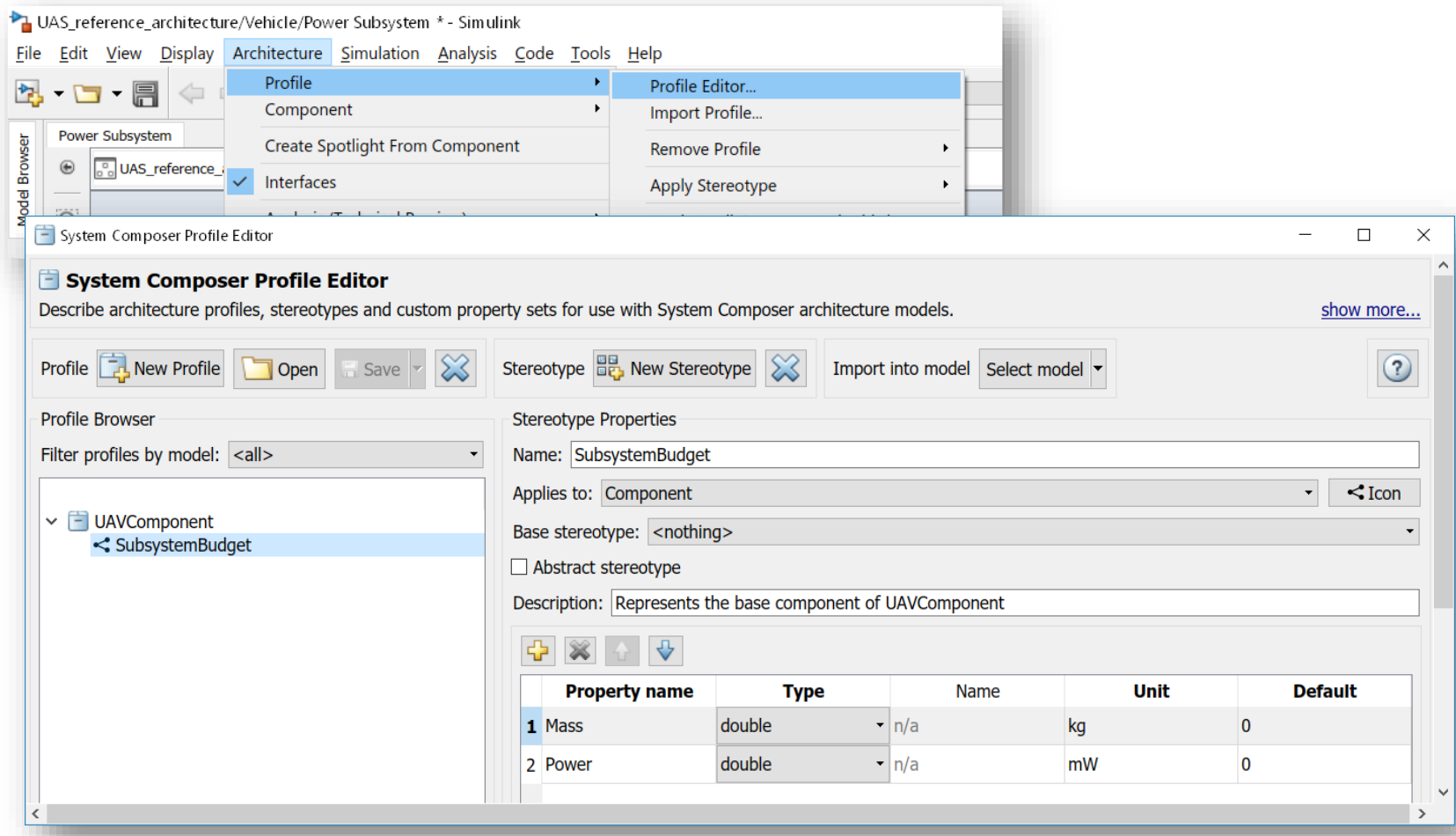
Property: Element ID
Property: Cost

Stereotype: System Component

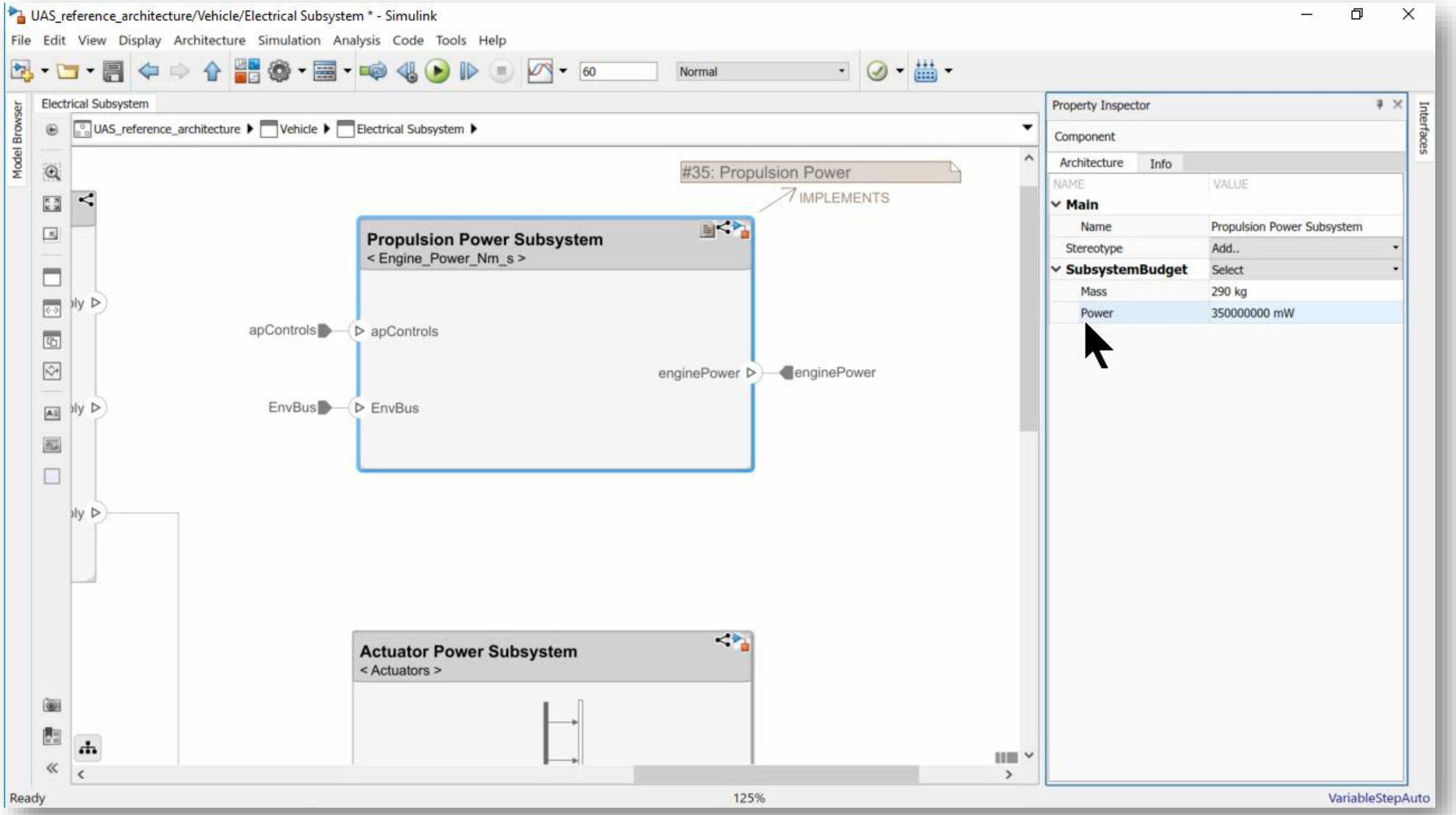
Property: Development cost
Property: Required hardware
Property: Development Time

Stereotype: Physical Connector

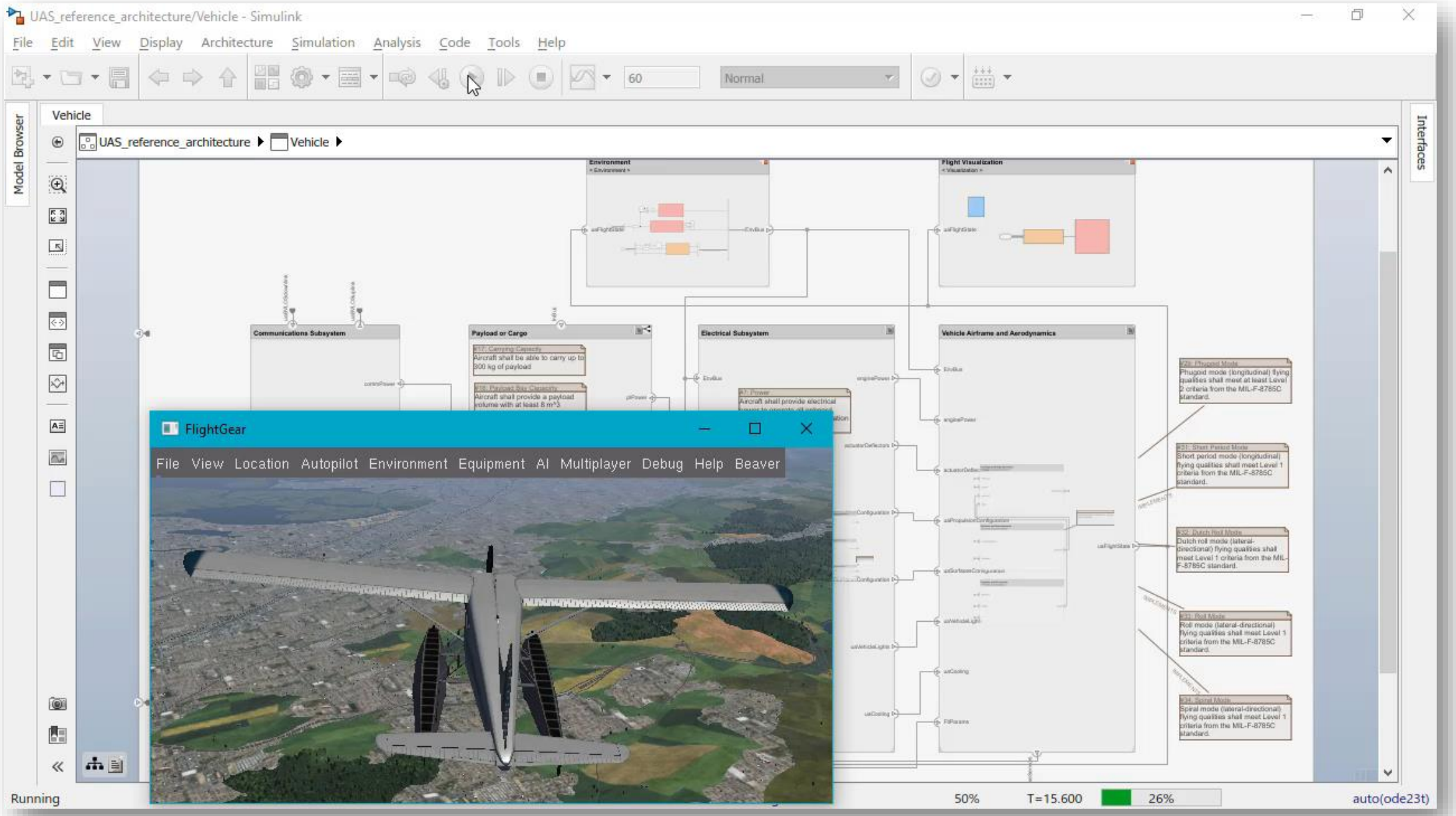
Property: Length
Property: Unit cost
Property: Material



Define Profiles and Stereotypes



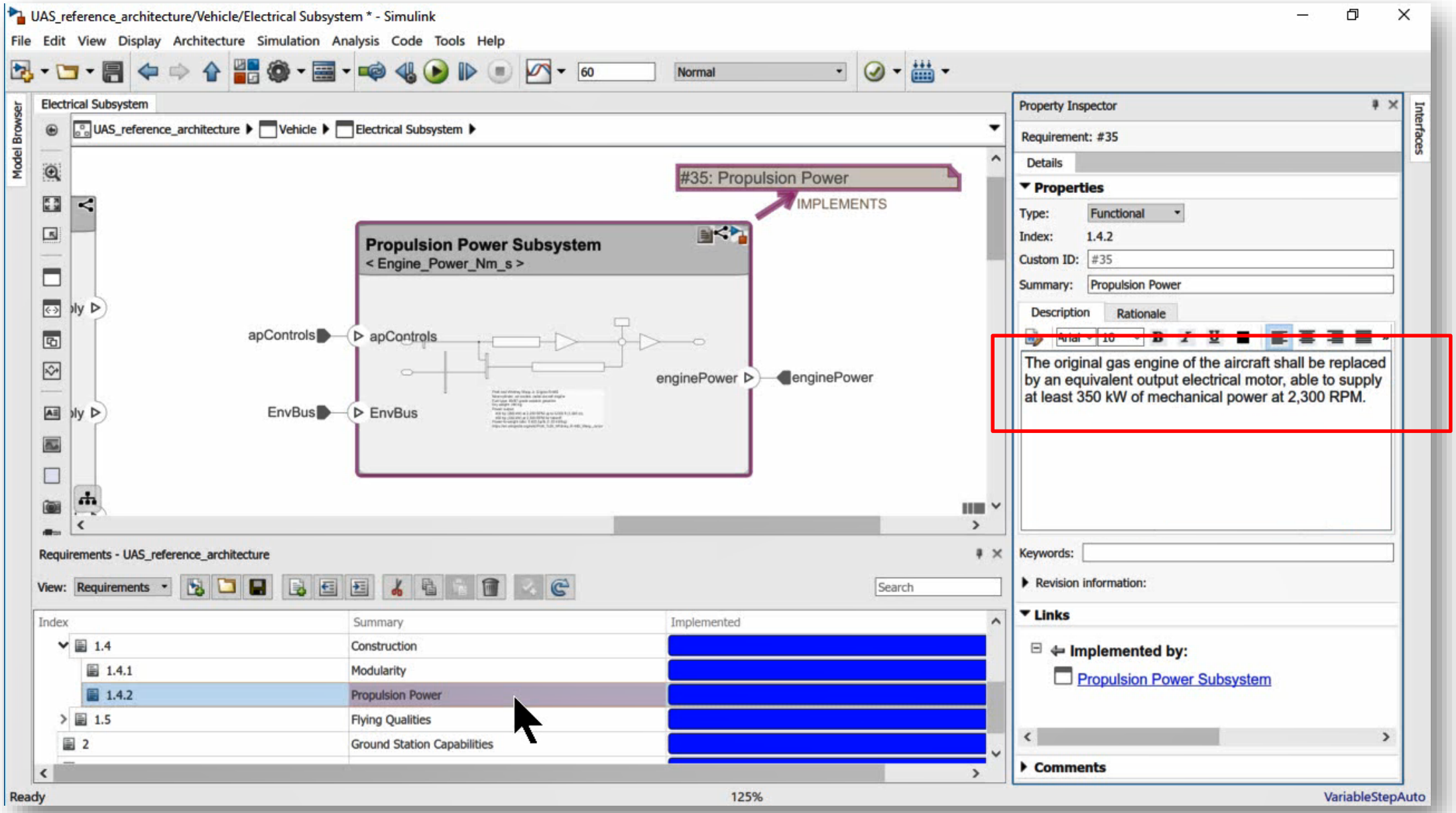
Simulation in System Composer



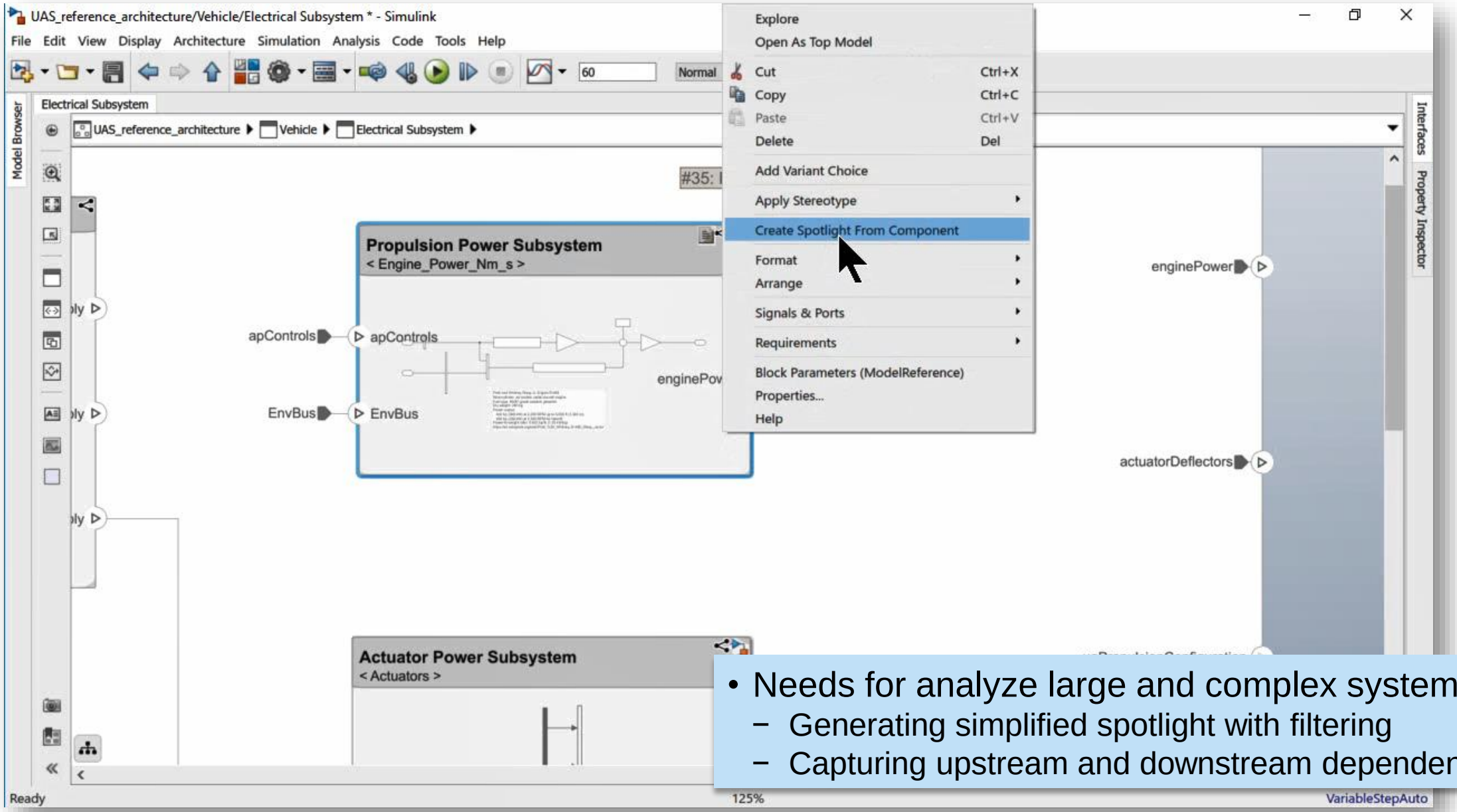
Case Study

- System architecture using System Composer
- System requirement traceability
- Simulink modeling from system architecture
- **System update for electrification**
- Trade studies

Propulsion System Change to Electrified System

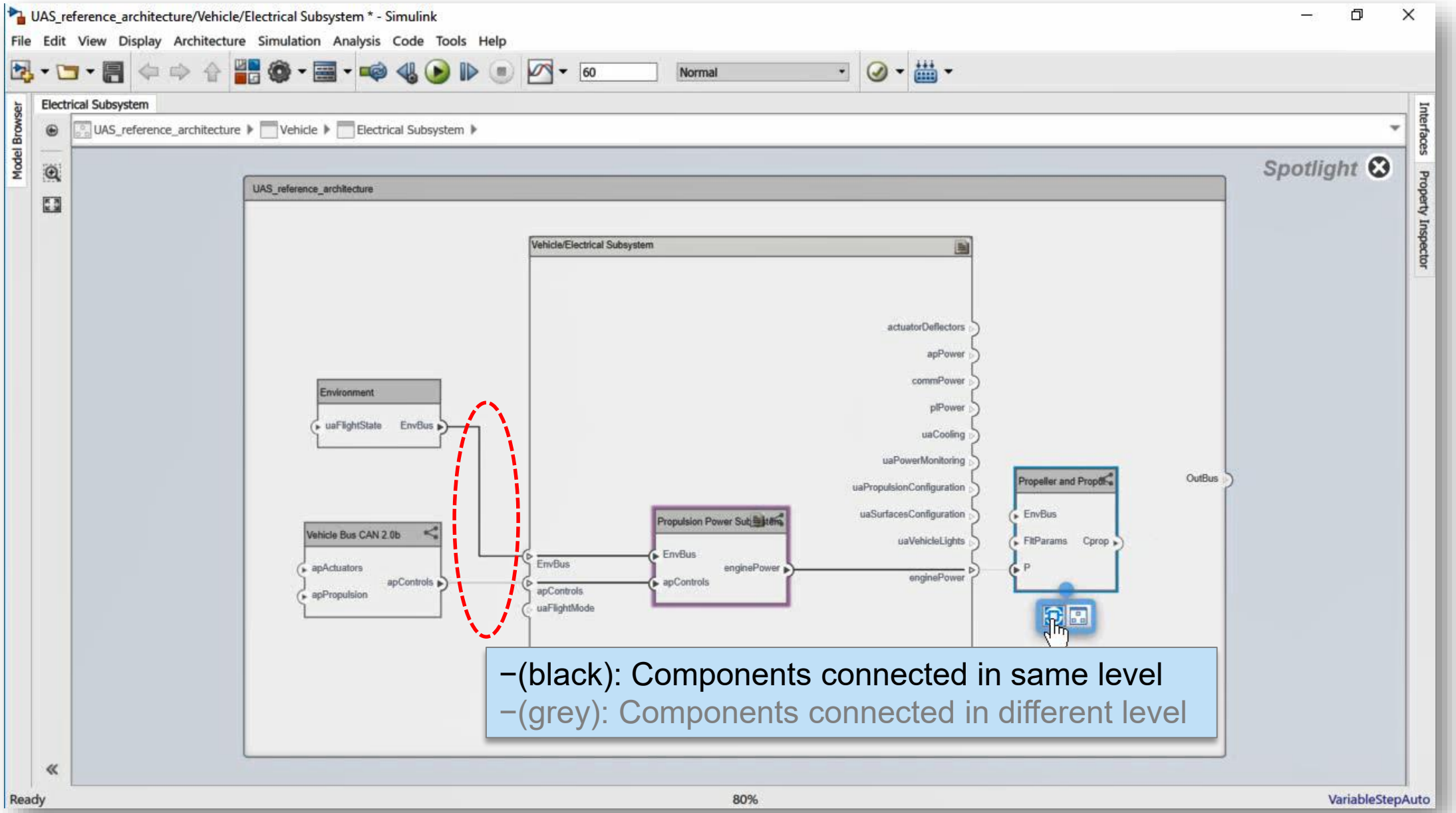


Spotlight Views

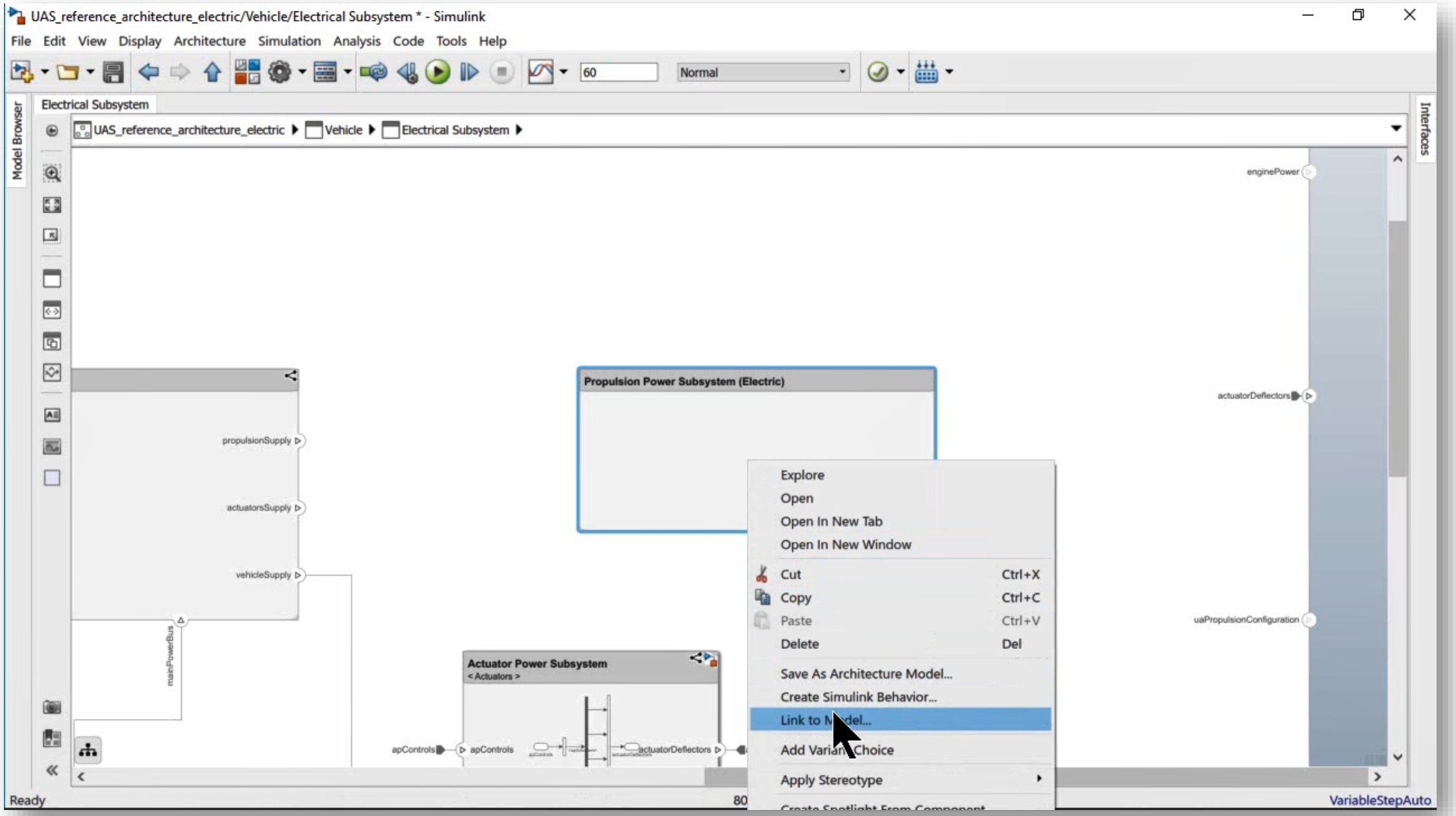


- Needs for analyze large and complex system
  - Generating simplified spotlight with filtering
  - Capturing upstream and downstream dependencies

Spotlight View Change to Another



Replace Simulink Models in System Composer



Case Study

- System architecture using System Composer
- System requirement traceability
- Simulink modeling from system architecture
- System update for electrification
- **Trade studies**

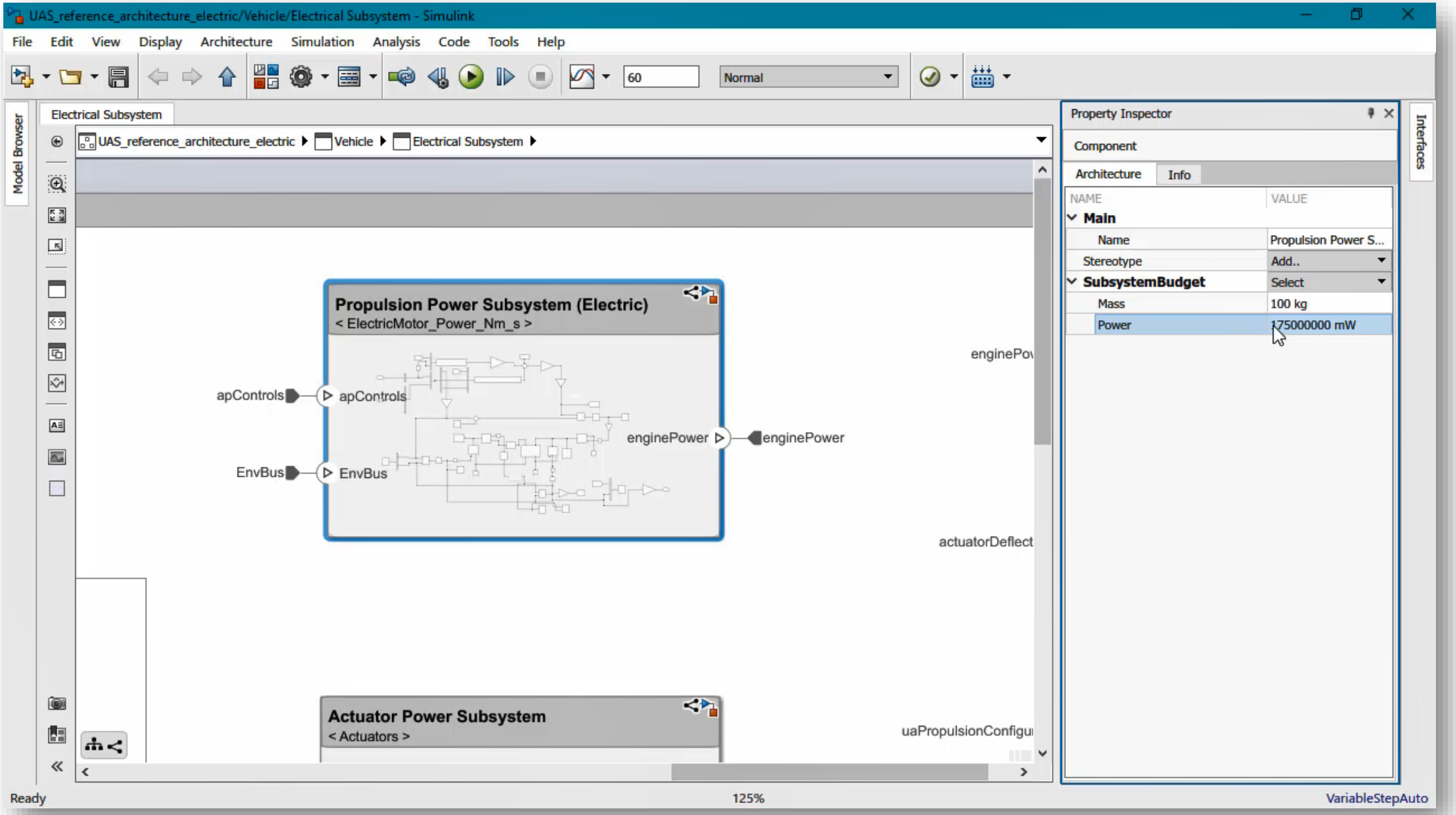
Early architectural decisions often have non-functional implications

+ Electric motor + Battery

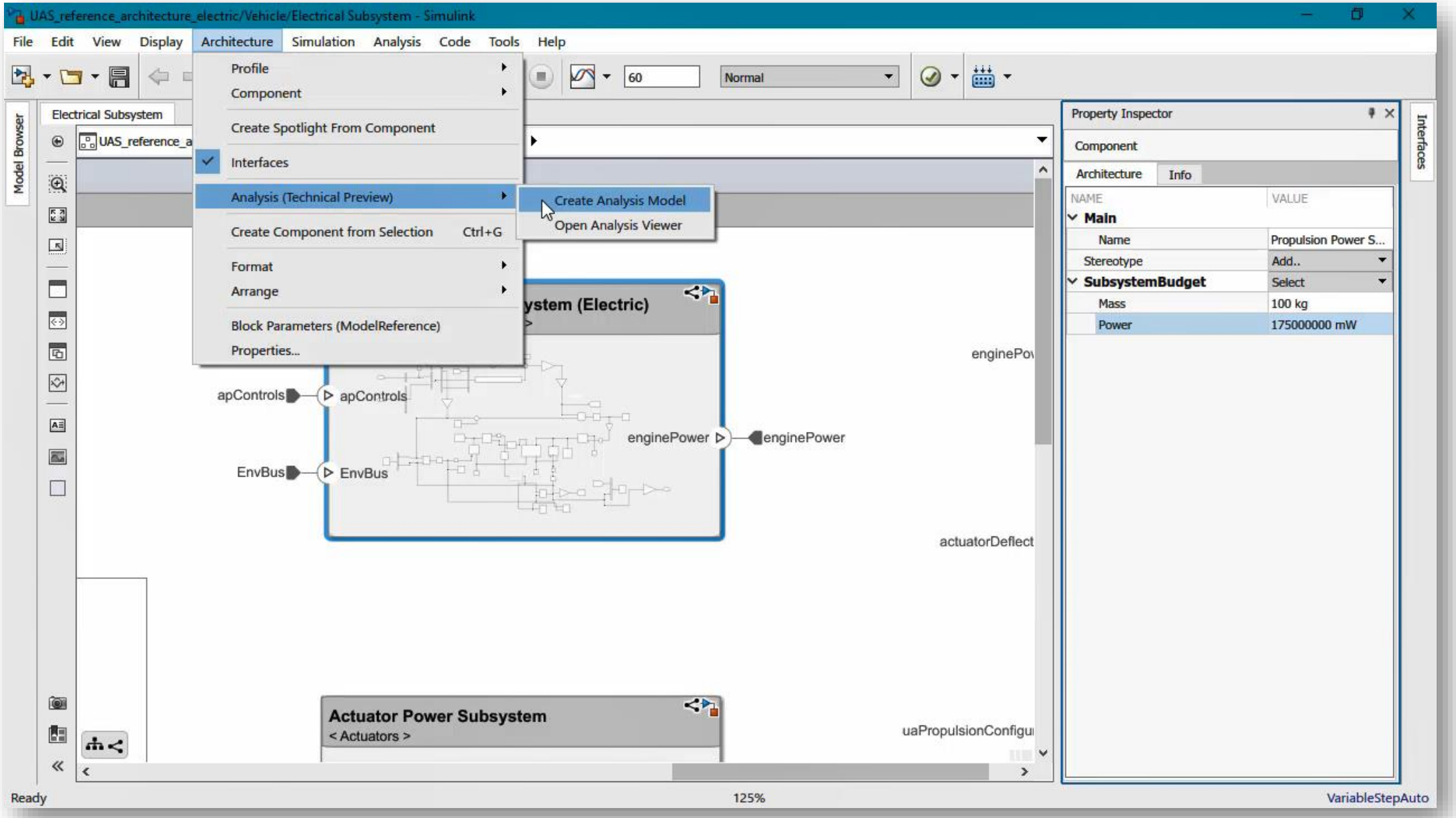
What is the impact of extra **weight** on the **range** of the flight time?

Non-Functional Properties

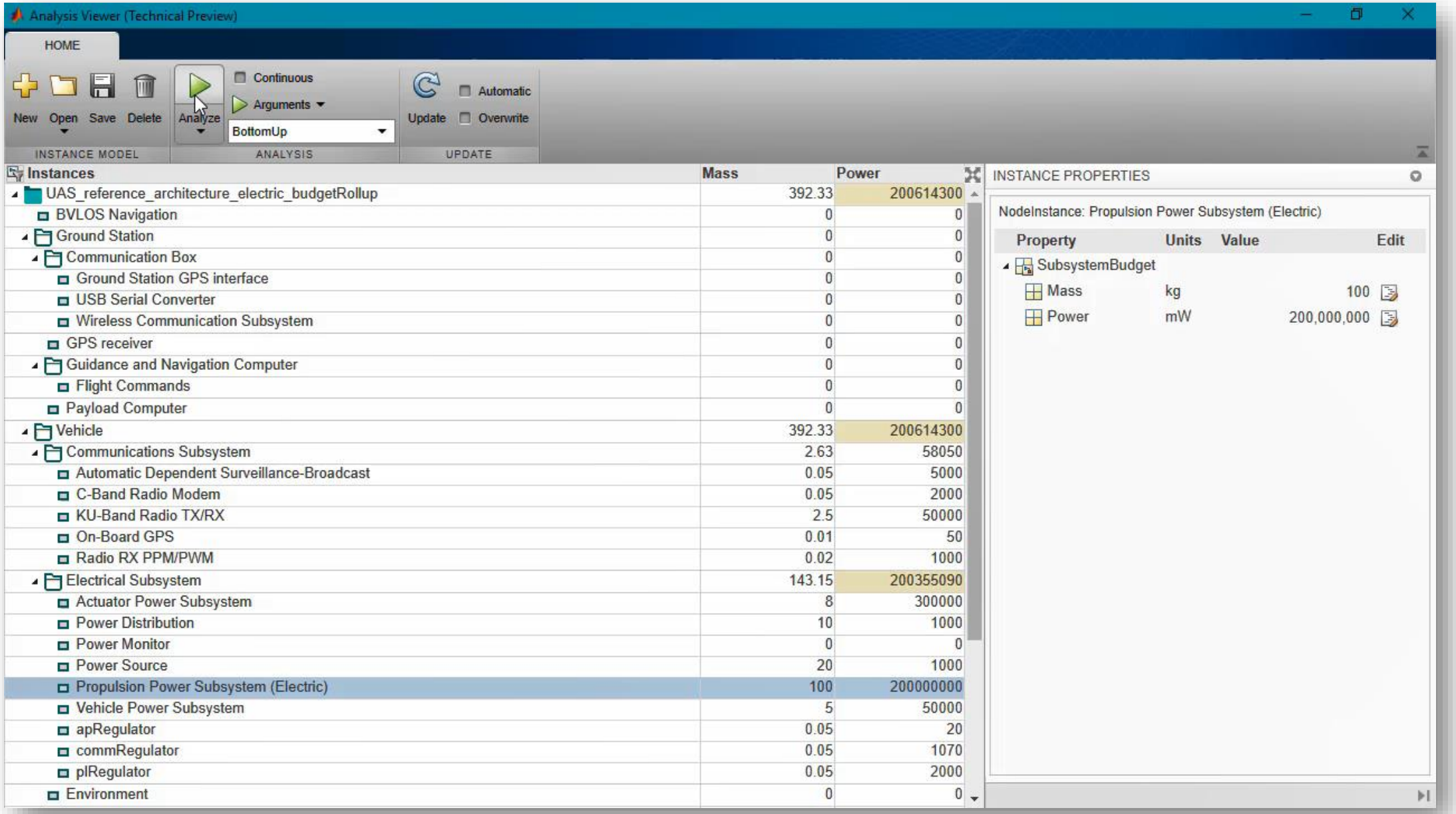
Stereotype Change for Impact Analysis



Trade Studies



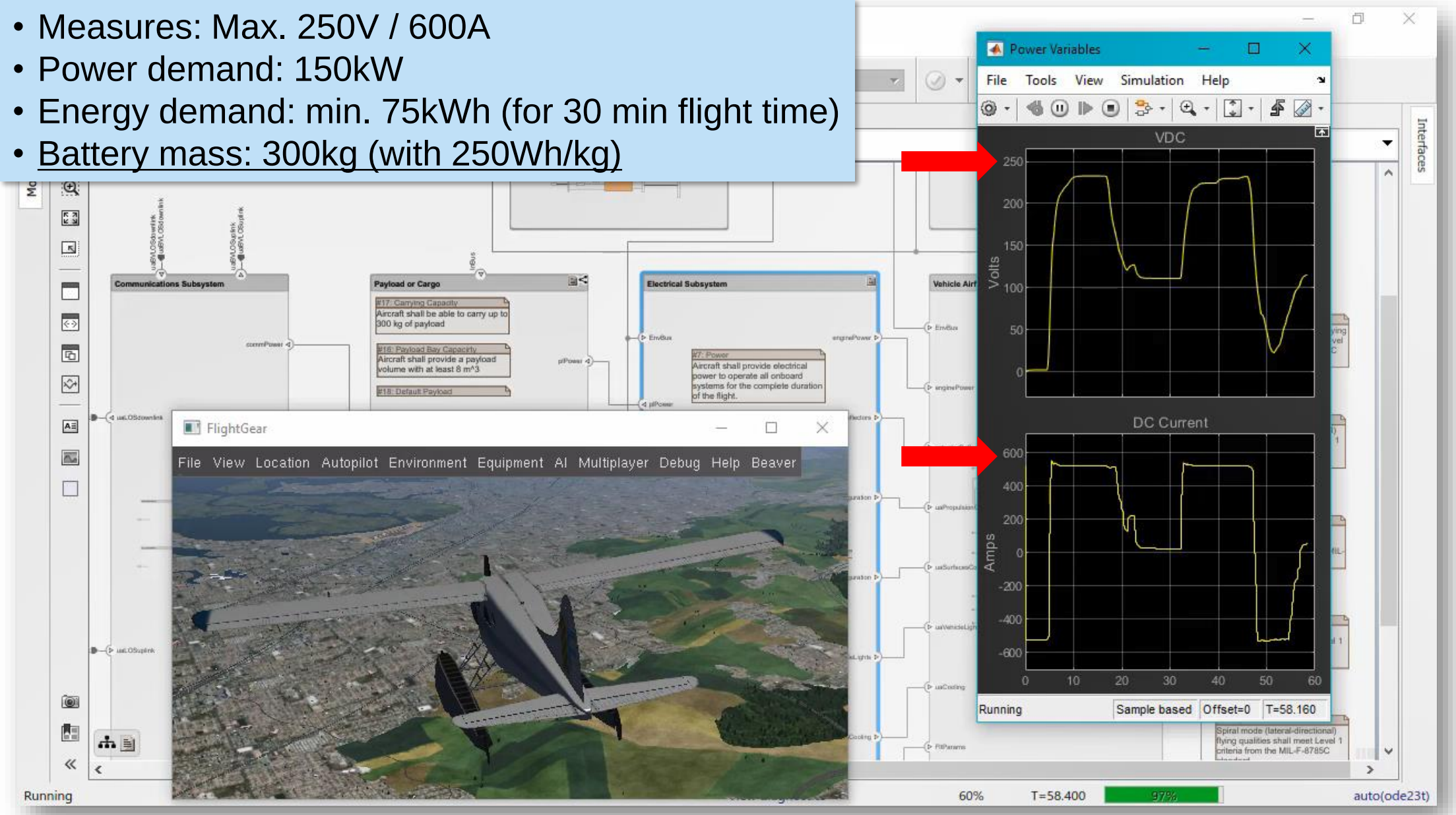
Trade Studies



Instances	Mass	Power
UAS_reference_architecture_electric_budgetRollup	392.33	200614300
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	200614300
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	200355090
Actuator Power Subsystem	8	300000
Power Distribution	10	1000
Power Monitor	0	0
Power Source	20	1000
Propulsion Power Subsystem (Electric)	100	200000000
Vehicle Power Subsystem	5	50000
apRegulator	0.05	20
commRegulator	0.05	1070
plRegulator	0.05	2000
Environment	0	0

Simulation with Electrified Propulsion Power System

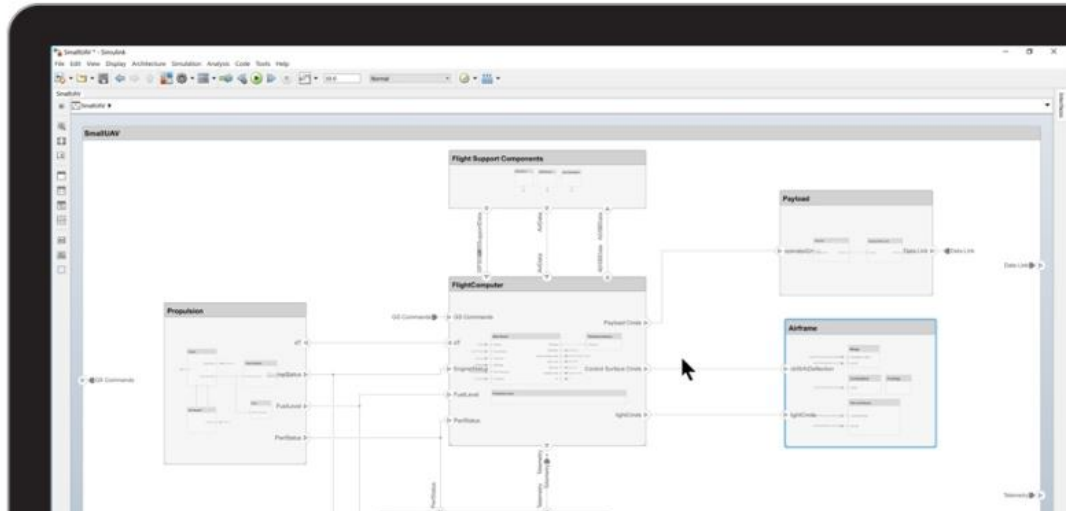
- Measures: Max. 250V / 600A
- Power demand: 150kW
- Energy demand: min. 75kWh (for 30 min flight time)
- Battery mass: 300kg (with 250Wh/kg)



https://kr.mathworks.com/products/system-composer.html

System Composer™ enables the definition, analysis, and specification of architectures and compositions for model-based systems engineering and software design. With System Composer, you allocate requirements while refining an architecture model that can then be designed and simulated in Simulink®.

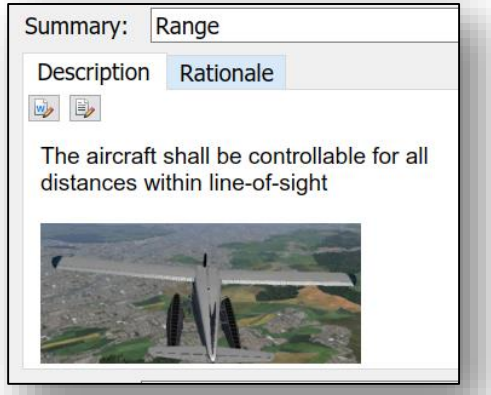
System Composer lets you create or import architecture models that describe a system in terms of components and interfaces. You can also populate an architecture model from the architectural elements of Simulink designs or C/C++ code. You can create custom live views of the model to study specific design or analysis concerns. With these architecture models you can analyze requirements, capture properties via stereotyping, perform trade studies, and produce specifications and ICDs.



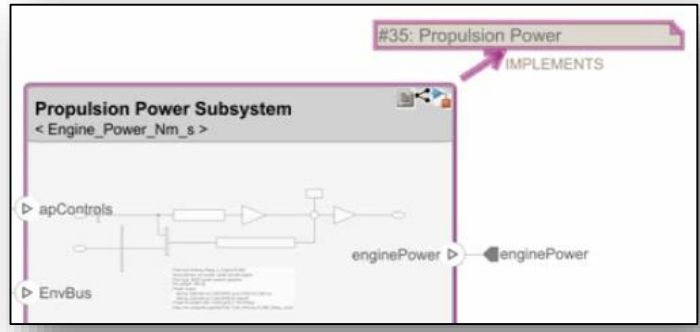
Digital Thread from Requirements to Architecture and Design

Simulink Requirements

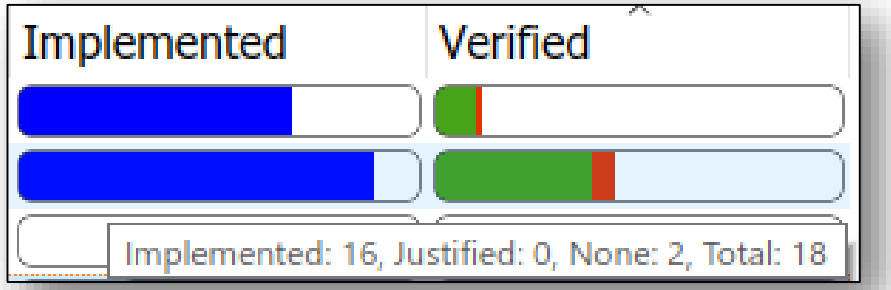
Author requirements or view from external source



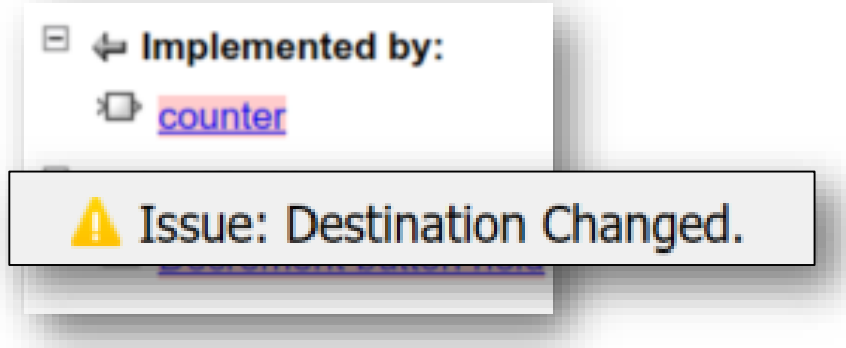
Link requirements, architectures, design, code and test



Identify gaps in architecture or design

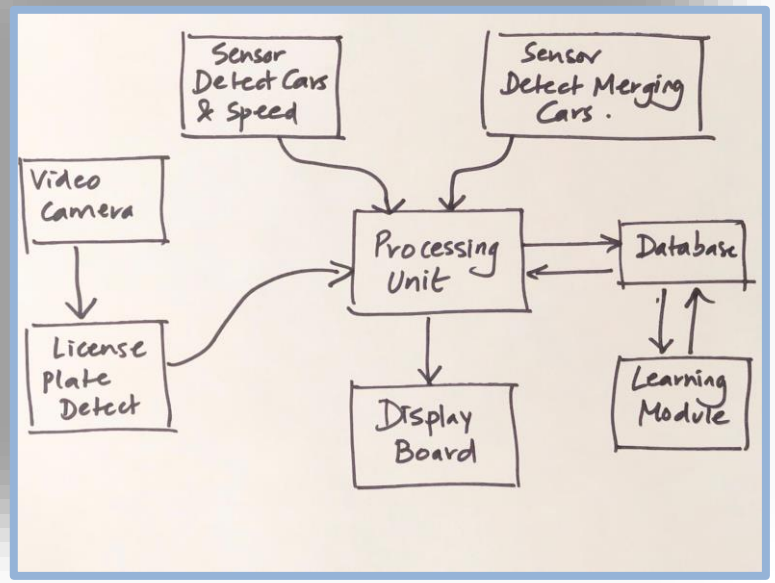


Identify impact of requirement changes



Intuitively design system and software architectures

System Composer



Description

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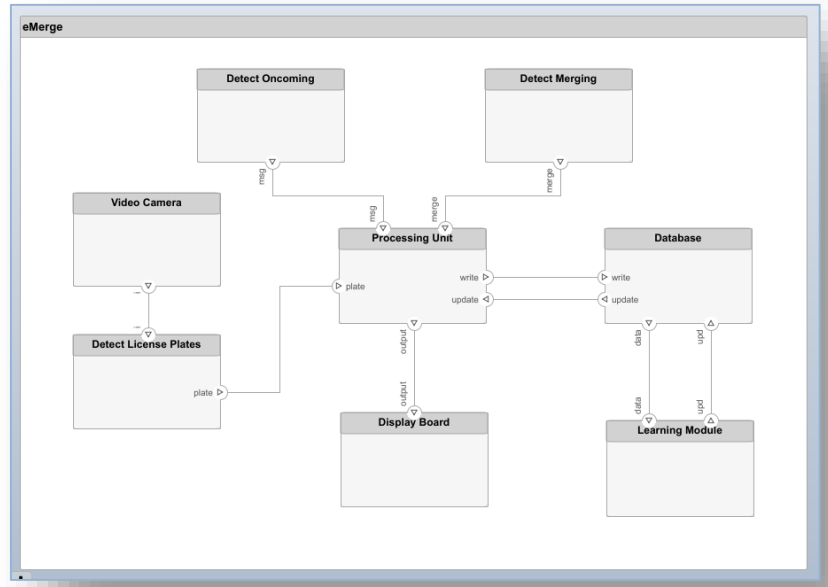
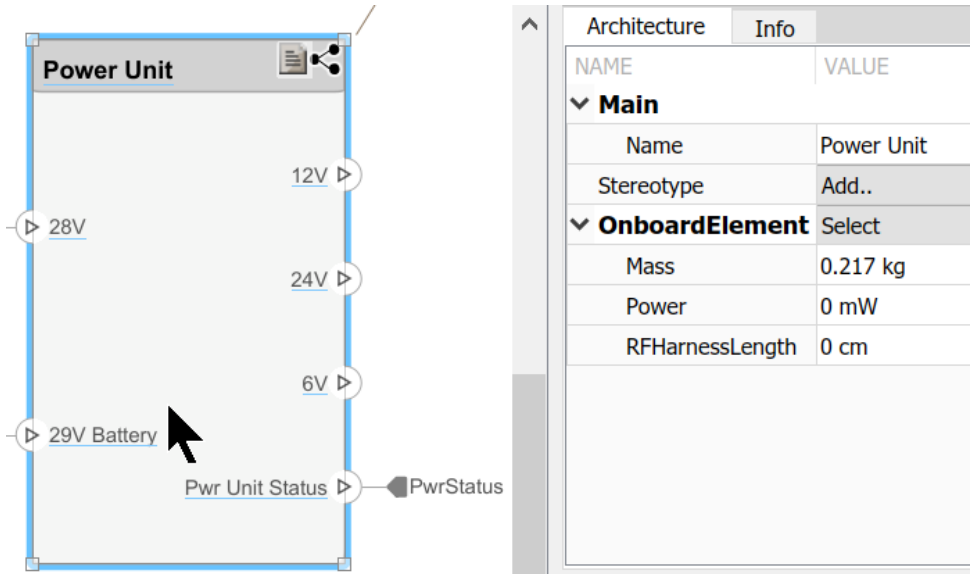
Architecture

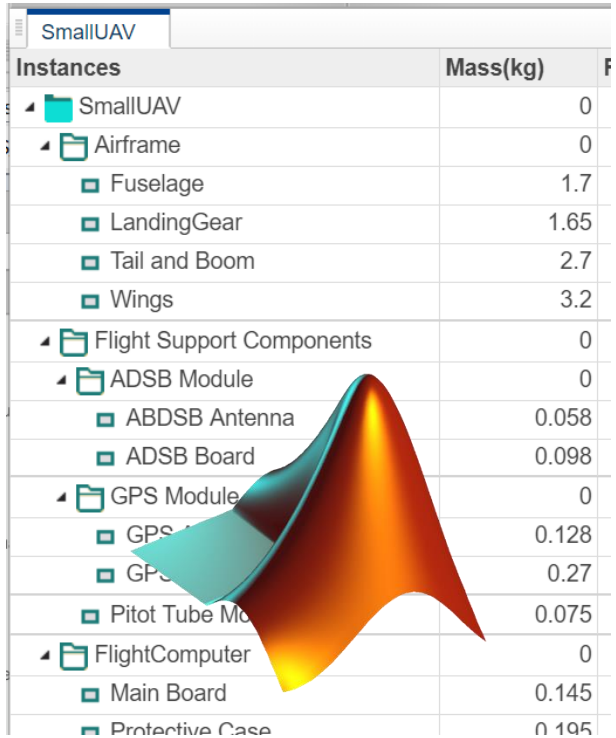


Perform trade studies based on data driven analysis to optimize architectures

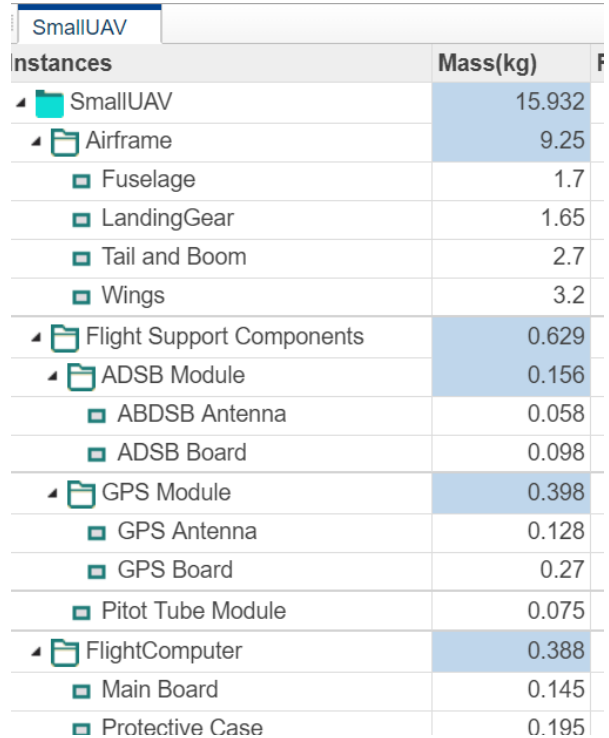
Add custom data



Create analysis model

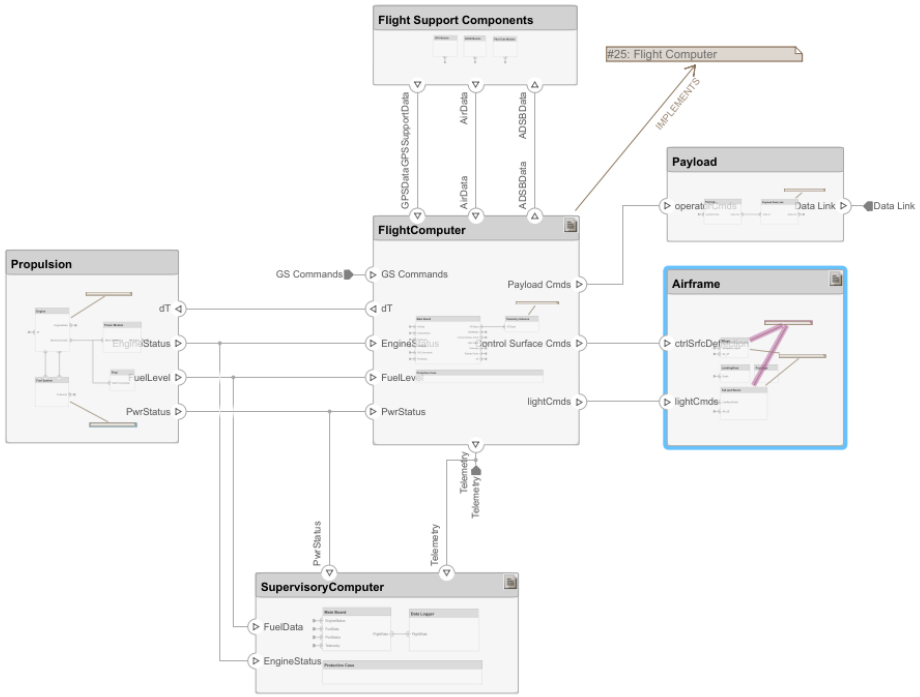


Calculate mass roll-up data

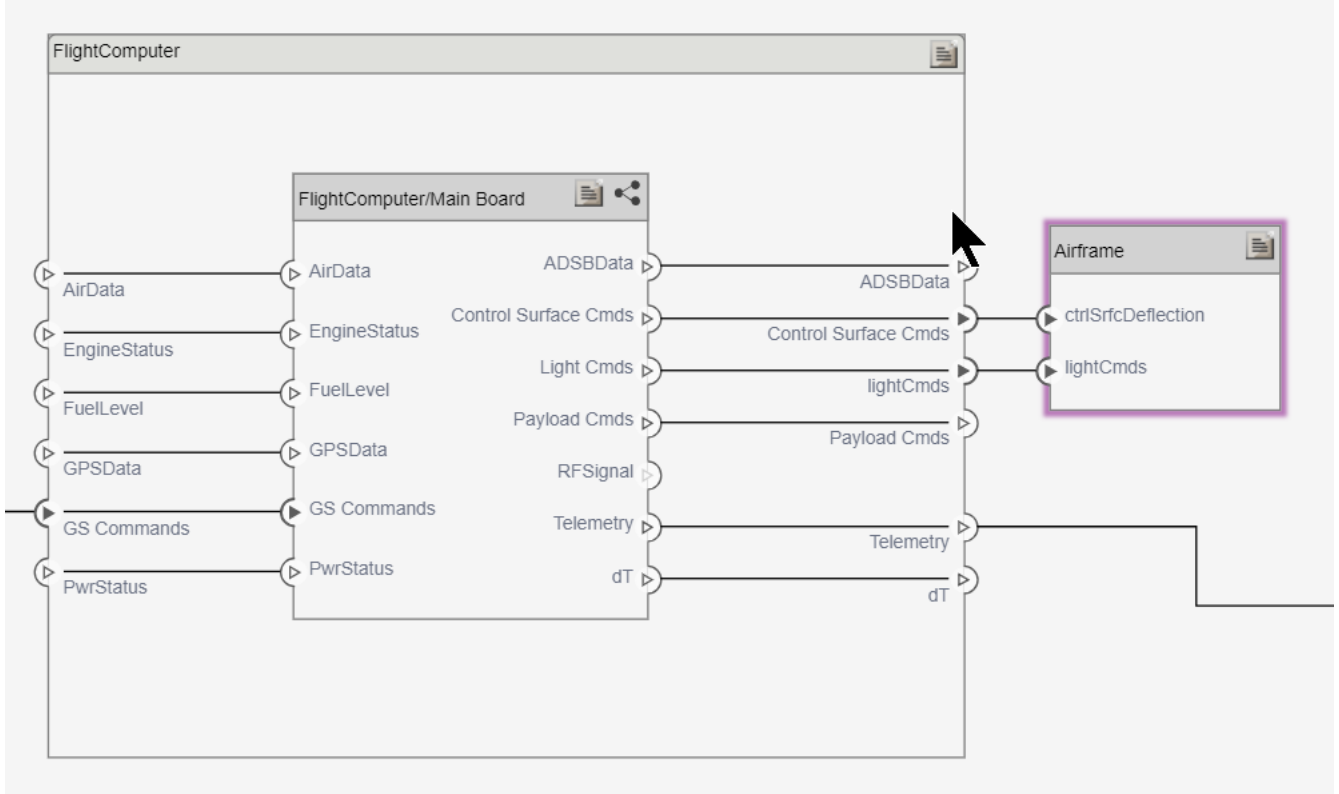


Tackle Architecture complexity with spotlight views

Composition

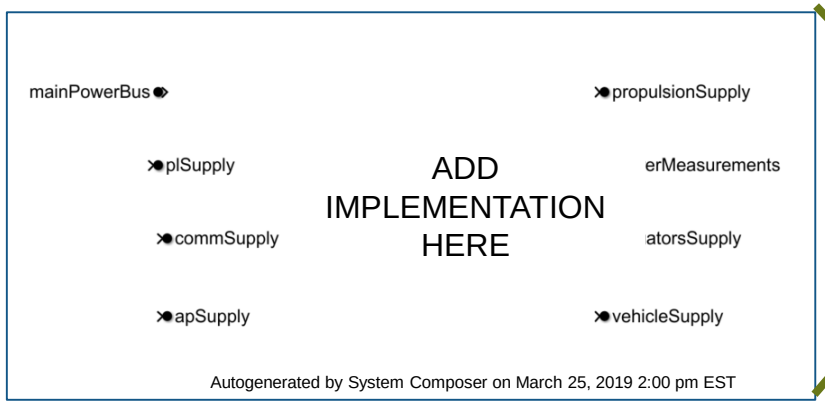


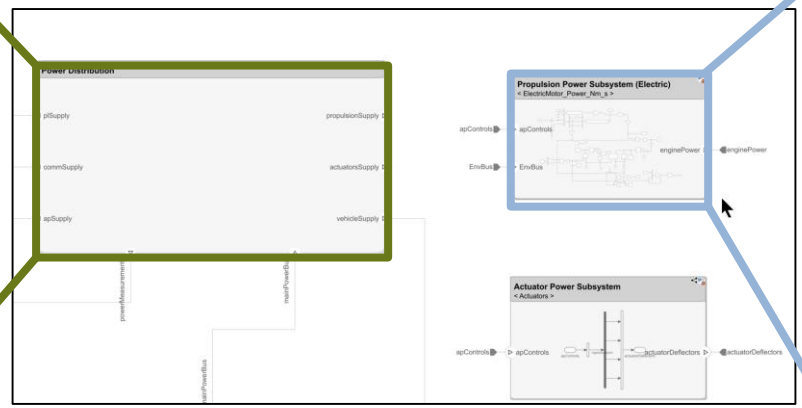
Spotlight



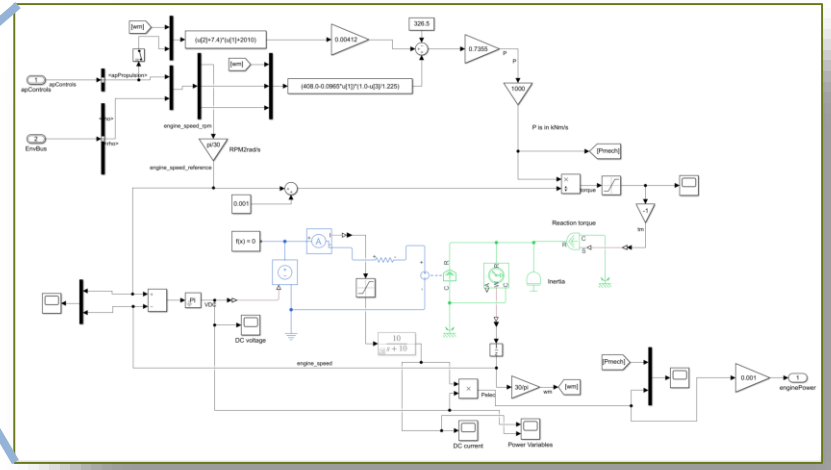
System and software architectures connected to implementations in Simulink

Generate Simulink models from architecture components





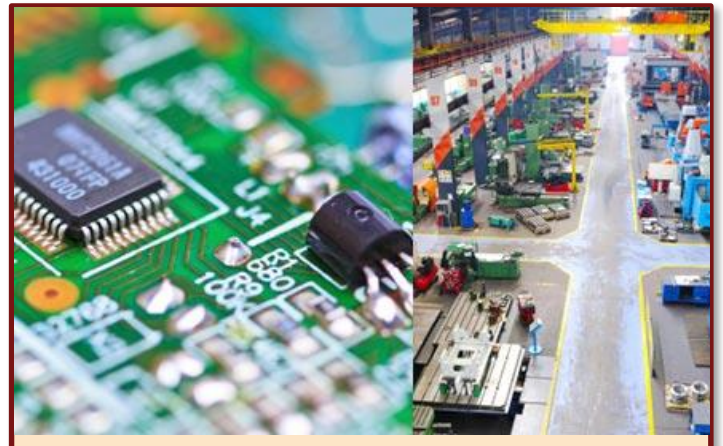
Link Simulink models to architecture components



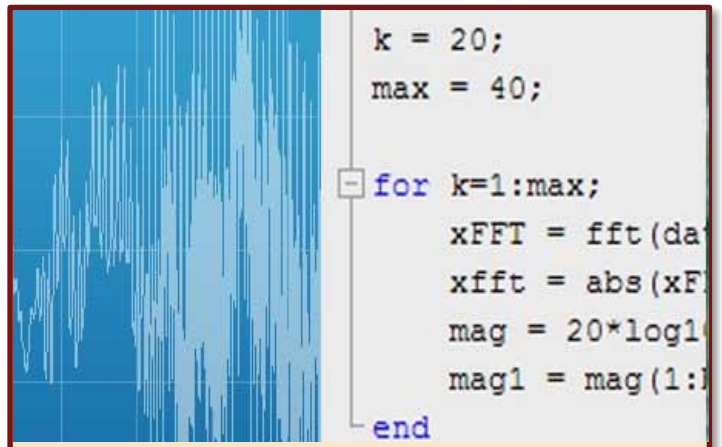
Simulink: A Multi-Language Simulation Environment


Dynamic Systems

State Machines


Discrete-Event Systems


Physical Modeling



Object-Oriented

Learn More

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

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