MATLAB EXPO 2019

Systems Engineering
Requirements to Architecture to Simulation

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What does the typical process involve?

**Early in the Process**
Concepts/Descriptions

**Later in the Process**
Models

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What is the Gap?

**Early in the Process**
Concepts/Descriptions

**Later in the Process**
Models

Traceability
Synchronization
Analysis & Simulation

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Key Takeaways

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

REQ 3.1 ENABLING CRUISE CONTROL
Cruise control is enabled when

ENABLE SWITCH DETECTION
If the Enable switch is pressed

Implemented By

Derives

Implemented By

Implemented By

reqMode.Cruise
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 goes into the bridge?

Be Intuitive

Facilitate Analysis

Tackle Complexity

Enable Implementation

Concepts/Descriptions

Digital Thread for Traceability

Models

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 \textbf{R2019a}

- Be Intuitive
- Facilitate Analysis
- Tackle Complexity
- Enable Implementation

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Requirements Coverage Reporting and Impact Analysis

Simulink Requirements

Simulink

**MATLAB**
Now let’s see it in action
De Havilland DHC-2 "Beaver"

Update the De Havilland "Beaver" airplane to have full electrification of the propulsion system and make it an optionally piloted aircraft.
Requirements imported from Word and captured in Simulink Requirements
Create components for a ground station and beyond-visual-line-of-sight navigation in addition to the vehicle
Interfaces

Add details by defining interfaces
Every requirement except Propulsion Power has been implemented
Drilling down in our component hierarchy we can find the Propulsion Power Subsystem Component
We associate this component to the requirement on Propulsion Power to specify how this requirement is implemented.
We now have implemented every requirement
The Simulink badge tells us that this component is linked to the Engine Power Simulink model.
User-defined properties and their values can be accessed by MATLAB to run various types of analysis.
Electrification upgrade

Simulation is OK, move on to the electrification upgrade
We now change the Propulsion Power requirement to specify that the power must come from an electric motor.
Spotlight view

The spotlight view shows what other components may be directly impacted by the change
The effect this may have on other components can be followed further downstream by creating a spotlight of the Propeller and Propulsion component.
We replace the current Propulsion Power component with a new one with an electric motor Simulink model linked to it.
To see how this change impacts the total mass and power of the plane, we first add the value of mass and power to the new component by applying a stereotype to the component, and set the values of mass and power properties.
Using the Analysis model, we can create an analysis matrix that can be used to perform trade studies. These trade studies will be used to guide us in optimizing the architecture.
We can change the values of properties to run what-if calculations to do trade-offs of the system.
As a next step, running a simulation would allow us to size the battery that will act as the power source for the new electric motor.
Simulink Requirements
Digital Thread from Requirements to Architecture and Design

Author requirements or view from external source

Identify gaps in architecture or design

Link requirements, architectures, design, code and test

Identify impact of requirement changes

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System Composer
Intuitively design system and software architectures

Description

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

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System Composer
Tackle Architecture complexity with spotlight views

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System and software architectures connected to implementations in Simulink

Generate Simulink models from architecture components

Link Simulink models to architecture components

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