요구사항부터
아키텍처 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

ENABLE SWITCH DETECTION
If the Enable switch is pressed

Derives

Implemented By

Implemented By

reqMode.Cruise

MATHWORKS
MATLAB EXPO 2019
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

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 R2019a and ...

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

Requirements Coverage Reporting and Impact Analysis

Simulink

Simulink Requirements
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

Target component for electrification
Case Study

- System architecture using System Composer
- System requirement traceability
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- Trade studies
Traceability with Simulink Requirements
Drilling Down to Propulsion Power Subsystem
Linking Requirement to Propulsion Power Subsystem
Case Study

- System architecture using System Composer
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- Trade studies
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

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.
Spotlight Views

- Needs for analyze large and complex system
  - Generating simplified spotlight with filtering
  - Capturing upstream and downstream dependencies
Spotlight View Change to Another

-(black): Components connected in same level
-(grey): Components connected in different level
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
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)
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 those 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

==

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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