MBSE and Digital Engineering with SysML v2

From Systems Thinking to Practical Modeling

About Me

20+ years of experience in MBSE, software engineering, software architecture, and project management with a proven track record for designing, developing, managing, and implementing various projects.
A Java and UML/SysML/BPMN/CATIA Magic tools expert, and a seasoned trainer with excellent communication, management, and technology skills.

Publications

- Automated Component-Selection of Design Synthesis for Physical Architecture with Model-Based System Engineering using Evolutionary" Trade-Off, The 28th Annual INCOSE International Symposium
- Encoding Technique of Genetic Algorithms for Block Definition Diagram using OMG SysML™ Notations, The 29th Annual INCOSE International Symposium
- Hatley-Pirbhai Control Flow Diagram with SysML for Early Validation, The 30th Annual INCOSE International Symposium
- A Pragmatic MBSE Approach of Nissan Powertrain Team to Minimizing Document-Based SEA Pragmatic MBSE Approach of Nissan Powertrain Team to Minimizing Document-Based SE, The 32nd Annual INCOSE International Symposium 2022
- Model-Based FMEA & FTA with Case-Based Reasoning, The 33rd Annual INCOSE International Symposium 2022
- Model-Based Product Line Engineering with Genetic Algorithms for Automated Component Selection, Complex Systems Design & Management, Apr 8, 2021

COURSE OUTLINE

Week 01: Introduction to Digital Engineering, Systems Engineering, and MBSE Foundations

- Digital Engineering Vision
- Systems Engineering Fundamentals
- Traditional vs Model-Based Systems Engineering
- Motivation for MBSE
- Strategic Use of MBSE
- MBSE and Digital Engineering Integration
- Foundations for SysML v2
- Course Project Introduction

Week 02: Understanding the System Lifecycle and the MBSE Workflow

- **Deep Dive: Systems Engineering Lifecycle**
- **How MBSE Supports Each Lifecycle Phase**
- **MBSE Workflow Overview**
  - MBSE Practical Workflow Example (Applied to the Drone System)
- **MBSE Tooling Overview**
  - MBSE Tool Selection Decision (SysON selected instead of MBSE IDE)
- **Hands-on Preparation**
  - SysON Setup Instructions (Docker + Offline Package)
  - First SysON Hands-on Exercise (Sample Drone Model Tour)

Week 03: Introduction to SysML V2

- Key Differences in Philosophy vs SysML v1
- Core Modeling Concepts: Elements, Structure, Behavior, Requirements
- Modeling Domains and Metamodel Foundation
- SysML v2 Element Taxonomy Overview
- Tooling Environment Setup and Basic Navigation (SysON)
- Simple Practice: Create First Basic Model (Hands-On)

Week 04: Modeling Stakeholder Needs and Concerns

- Identifying Stakeholders
- Organizing Stakeholders by Role and Influence
- Capturing Stakeholder Needs (using Need, Concern, Feature)
- Stakeholder Need Quality Tips
- Defining Use Cases from Needs
- Simple Practice: Create Stakeholder-Need-Concern Diagram
- Start Modeling Initial Needs for Course Project

Week 05: Structure Modeling (Part I - Part Definitions and Parts)

- Modeling Structure with Part Definition, Part Usage, and Connections
- Defining System Hierarchy
- Composition and Decomposition
- Part Definition vs Part Usage Clarification
- Modeling Internal Connections and Connectors
- Simple Practice: Build a Basic System Architecture Diagram
- Start Creating Structure for the System Project

Week 06: Behavioral Modeling (Part I - Scenarios and Interaction)

- Use Case, Interaction, and Sequence Modeling
- Defining Scenario, Event, and Interaction
- Time and Causality in SysML v2
- Simple Practice: Create a Basic Interaction Model
- Model Behavioral Interactions for the Student Project

Week 07: Modeling Requirements

- How to Define and Refine Requirements in SysML v2
- Functional vs Non-Functional Requirements
- Linking Needs to Requirements
- Requirement Quality Tips
- Requirement Grouping and Organization
- Simple Practice: Create Requirement Model and Traceability Links
- Apply to Student Project

Week 08: Structure Modeling (Path II - Interfaces and Ports)

- Interface Definitions
- Port Types and Connections
- Definition vs Usage of Interfaces Clarification
- Modeling Plug-and-Play Architectures
- Modeling Interface Contracts
- Simple Practice: Build Interface and Connect Parts in SysON
- Apply Interface Modeling to Student Project

Week 09: Behavioral Modeling (Part II - State Machines and Activities)

- Modeling Behavior with Action, State, Transition, Activity
- State Machine Modeling Best Practices
- Activity Modeling: Control Flow vs Object Flow
- Combining Behavior and Structure
- Simple Practice: Build a State Machine and an Activity Model
- Apply to System Functions

Week 10: Parametric and Constraint Modeling

- Mathematical Relationships and Constraints
- Using Constraint, Parameter, Value
- Parametric Diagram Overview
- Constraint Propagation Concept
- Trade Studies and Analysis Support
- Simple Practice: Build a Basic Constraint Model
- Apply Constraints to Performance Needs in Student Projects

Week 11: Allocation and Mapping

- Behavior-to-Structure Mapping
- Requirement Allocation and Traceability
- SysML v2 Relationships: refine, satisfy, verify
- Traceability View and Navigation in SysON
- Simple Practice: Create a Traceability Chain
- Apply Allocation to Current System Architecture

Week 12: Verification and Validation Modeling

- Verification Elements in SysML v2
- Modeling V&V Plans
- Linking Tests to Requirements and Functions
- Types of Verification Methods
- Simple Practice: Build a Test Case and Link it
- Apply V&V Modeling to the Project

Week 13: Variability and Configurability

- Modeling Product Lines and Variants
- Introduction to Variation, Choice, Variant Elements
- Capturing Configurable Structures and Behaviors
- Simple Practice: Create a Variant Structure Model
- Apply Variant Thinking to the Project

Week 14: Advanced Topics and Best Practices

- Model Organization and Reuse
- Namespaces, Packages, and Libraries
- Modular Modeling and Views
- Introduction to Profiles (Optional)
- Simple Practice: Organize and Import Elements
- Apply Model Organization to Project

Week 15: Final Project Presentations and Course Wrap-Up

- Student Presentations of Final System Models
- Model Walkthrough and Evaluation
- Reflection on MBSE and SysML v2 Learning Journey
- Discussion: SysML v2 in the Real World
- Next Steps: Certification, Research, Career

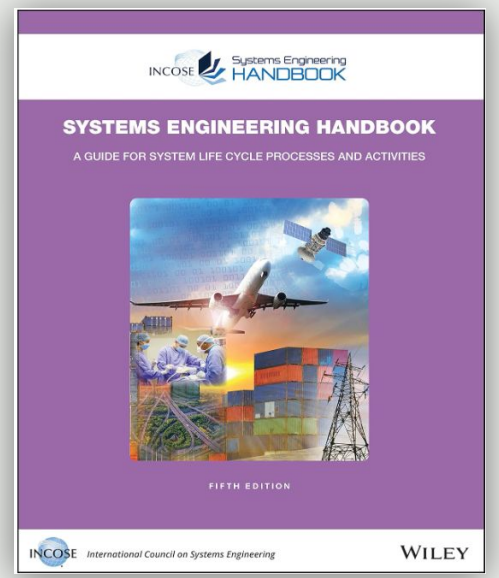
Recommend Reading

SE Book Of Knowledge

https://sebokwiki.org/wiki/Guide_to_the_Systems_Engineering_Body_of_Knowledge_(SEBoK)

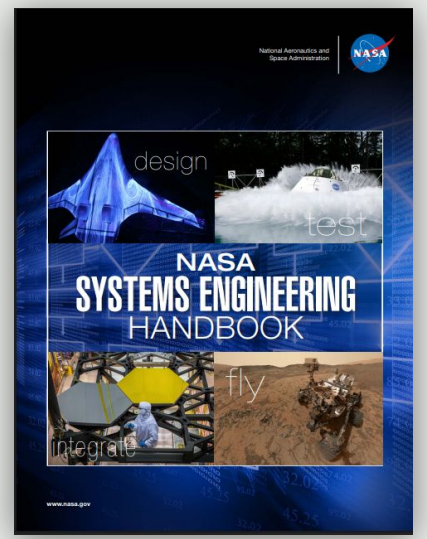
SysML 2.0 Document:
https://github.com/Systems-Modeling/SysML-v2-Release/tree/master/doc

INCOSE Handbook



https://www.amazon.com/INCOSE-Systems-Engineering-Handbook/dp/1119814294

NASA SE Handbook



https://www.nasa.gov/wp-content/uploads/2018/09/nasa_systems_engineering_handbook_0.pdf

QUESTION!