neovendi Akademie

MBSE Trainings

Five-day training on model-based systems engineering (MBSE)

Target group

1. Railway engineers
   (No previous knowledge required).
2. Railway project managers
   (No previous knowledge required).
3. Students
   (No previous knowledge required).

Language

English

Location

physically on site

General goals

1. Increase awareness of the importance of MBSE in the railway sector.
2. Increase acceptability towards the MBSE approach in the railway sector.
3. Establish a community that promotes the MBSE approach in European Railways.

Short description

A five-day comprehensive training on Model-Based Systems Engineering (MBSE) applied in the Railway sector. The training is specifically designed to give a basic understanding of general concepts of MBSE and how these concepts are applied in various railway projects. Our training has been developed by experts having several years of experience in applied Systems Engineering on Railway projects (DB Netze). Take advantage of our training to experience the know-how of MBSE and become a part of the great community!

Learning objectives

By attending this training, participants will be able to:

1. Explain (What, Why and How) of MBSE approach.
2. List the three pillars of MBSE (Tools, Language and Methodology) with correct explanation.
3. Identify the difference between specific and generic methodology of the MBSE approach.
4. Relate the general concepts of MBSE applied in specific railway projects.
5. Correctly interpret a MBSE specification.
6. Successfully apply modeling concepts using a tool.
7. Explain the know-how of V&V techniques as a part of the MBSE process.

Content Description

Day 1 The training kicks off with an Introduction to Systems Engineering and why it is so relevant in the current challenges faced in the various Railway projects.

Introduction (Why what and how)

Introduction: tries to answer three basic questions - Why What and How. An example is introduced as an activity (Hands-on) to explain the lifecycle of a product or system and the importance of Systems Engineering in the lifecycle of a system and its application.

Learning objectives

At the end of the session, participants will be able to:

1. Identify the need for MBSE in Railway sector – Complexity management
2. List the stages of the lifecycle for a system or a product.
3. Describe briefly the activities involved in the stages of the lifecycle for a system.

Note – This session includes general introduction, goals, objectives, and overview of the training

MBSE (Methodology, Language and Tools)

Second session: is followed by an in-depth dive into the concepts of MBSE and its three pillars – Methodology, Language and Tools. The general concepts are relayed in this session.

Learning objectives

At the end of the session, participants will be able to:

1. articulate knowledge about Basics of Systems and Systems Engineering Concepts.
2. articulate knowledge the SE processes and methods to systematically develop a
3. complex system (e.g., Railways) based on industry standards.
4. articulate knowledge MBSE as an application of SE, benefits and challenges of MBSE.
5. Develop a comprehensive knowledge of the key aspects of the Systems Engineering.
6. Develop comprehensive knowledge about the concepts, methodologies, models and
7. tools needed to implement a life-cycle approach.

Railway projects (EULYNX, RCA and OCORA)

Third session: introduces Railway projects that are applying Model-Based Systems Engineering. For example - European initiatives like EULYNX, RCA, and OCORA.

Learning objectives

At the end of the session, participants will be able to:

1. describe purpose of EULYNX and what to achieve with EULYNX
2. correctly interpret EULYNX architecture and interface
3. relate founding reason of RCA and its purposes
4. state basic structure of RCA architecture
5. explain how to model in RCA and EULYNX methodology
6. relate importance of RCA modelling rules
7. identify what Ocora`s goal and its architecture
8. differentiate the architecture and goals between EULYNX, RCA and OCORA

Systems Modeling Language (SysML) – Part 1

Last session: focuses on one of the pillars of MBSE - Language. Systems Modeling Language (SysML) is demystified by dividing into two sessions with hands-on activities after each concept introduction. For example - Requirement diagrams, Structural diagrams, etc.

Learning objectives

At the end of the session, participants will be able to:

1. Identify the need for a language for systems engineers (SysML).
2. Define the goal of SysML language.
3. Recognize the components of the language – Semantics and Notations
4. List the four pillars of SysML and explain its importance.
5. Explain the basic concepts of architecture description – Views and Viewpoint.
6. List the different kind of diagrams offered by SysML.
7. Describe the syntax for writing a requirement.
8. List the requirement elicitation process.
9. Explain Block Definition diagrams and their relationships with hands-on example.

Day 2

Systems Modeling Language (SysML) – Part 2

First session: completes the introduction to major concepts of Systems Modeling Language and its application of the different diagrams.

Learning objectives

At the end of the session, participants will be able to:

1. Explain the importance of use cases and use case diagram with its relationships.
2. List the important parts of a use case specification.
3. Apply use case diagram using an example.
4. State the usability of sequence diagrams in a MBSE specification.
5. List the important parts of a sequence diagram – Types of messages and combined fragments
6. Apply sequence diagram using an example.
7. Identify the importance of using use case diagram in combination with a sequence diagram in a MBSE specification.
8. Explain the usage of combined fragments and operators in a sequence diagram.
9. Articulate the importance of state machine diagrams and its components.

Activity with an application example – Parking Distance Control System (PDS)

Second session: is followed by an activity where the learned concepts are applied in an example to consolidate further.

Learning objectives

At the end of the session, participants will be able to:

1. Apply concepts of SysML using the PDS example.

MBSE Methodology and Tools (ARCADIA, ARCH Process, Capella Tool)
Third session: begins to focus on the other pillars of MBSE - Methodology, and tool. This session introduces ARCADIA methodology and its principles. Concepts like architecture layers and diagrams are also covered in the session. The ARCH process which is a specific methodology used in RCA is introduced. The session is concluded with an introduction to an MBSE Tool - Capella.

Learning objectives
At the end of the session, participants will be able to:
1. Identify the need for a methodology for systems engineering.
2. Define the goal of Arcadia.
3. List the four layers of Arcadia architecture and explain its importance.
4. Explain the basic concepts of architecture description.
5. List the different kind of diagrams offered by Arcadia.

Hands-on session (Capella Tool)
Last session: is a hands-on session on the tool - Capella where the participants try to model a simple example from the concepts introduced in the previous session.

Learning objectives
At the end of the session, participants will be able to:
1. Get familiar with the tool and principals of the tool.
2. Create a simple model using the tool.

Day 3

As the days progress, the focus moves from general concepts to the application of MBSE in the Railway domain.

Application of MBSE in EULYNX (Introduction) **First session:** is an introduction to the application of MBSE in EULYNX. The goals, objectives, and characteristics of EULYNX systems are discussed along with the specification development strategy.

Learning objectives
At the end of the session, participants will be able to:
1. Understand and explain the goals of MBSE in EULYNX.
2. Understand and explain the purpose and structure of the EULYNX/RCA architecture framework and the interaction between analysis model and specification model.
3. Understand and explain the purpose and structure of the EULYNX MBSE Specification Framework (MBSE SF) and its components (AM MBSE, MBSE Process, etc.).
4. List and explain the abstraction levels, viewpoints and crosscutting properties of the EULYNX Architecture model MBSE (AM MBSE).
5. Explain the term model view.
6. Understand and explain the characteristics of EULYNX systems.
7. Understand and explain the principles of the specification approach used in EULYNX (stimulus-response specification, operational specification, use case-based approach).

EULYNX methodology (requirement specifications using MBSE)

Second session: is a deep dive session into the EULYNX methodology developed and its various concepts like - structural model elements, model views, interfaces, etc. These concepts are used to develop a requirement specification for EULYNX models using MBSE.

Learning objectives

At the end of the session, participants will be able to:

1. Understand and explain the interface-centric specification approach applied in EULYNX.
2. List and explain the basic structural model elements.
3. List and explain the model views required for the specification of an EULYNX system element.
4. List and explain the model views required for the specification of an EULYNX interface.
5. Explain the defined requirement types (Req, Def, Info and Head).
6. Identify the requirement types for the different model elements and allocate them accordingly.

PTC Windchill Modeler (toolchain introduction)

Third session: focuses on the introduction to Toolchain used by the EULYNX project. The toolchain consists of the PTC Windchill Modeler with synchronization to an RMT tool - IBM DOORS.

Learning objectives

At the end of the session, participants will be able to:

1. Understand the structure of Windchill Modeler and its components and how to start with using it.
2. To use Windchill Modeler to view model information.
3. To use Windchill Modeler to create system models.
4. Create an example model according to the EULYNX MBSE approach.

Verification and Validation (V&V) – Part 1(EULYNX toolchain)

Last session: demonstrates the use of the EULNYX toolchain and how a simple example can be modeled and simulated as a part of the Verification and Validation (V&V) process.

Learning objectives

At the end of the session, participants will be able to:

1. Understand and explain the EULYNX V&V process.
2. Understand the structure of Windchill Modeler SySim and its components and how to start with using it.
3. To use Windchill Modeler SySim to create simulations and perform simulation-based V&V.
4. Create an example simulation and perform V&V.

Day 4

Verification and Validation (V&V) – Part 2
First session: introduces Verification and Validation (V&V) techniques used as a part of the EULYNX methodology. It is followed by an introduction to the Virtual Testbed platform and its elements. General concepts of the ThingWorx IoT platform are covered which is a part of the Virtual testbed.

Learning objectives
At the end of the session, participants will be able to:
1. Explain the terms Verification and Validation.
2. List the types of V&V techiques used in the industry.
3. Explain the importance of Virtual Testbed Architecture in the context of EULYNX.
4. List the components of the virtual Testbed Architecture.
5. Explain the usage of an IoT platform in the Virtual Testbed Architecture.
6. Describe the basic concepts of the ThingWorx IoT platform.
7. Articulate how the Virtual Testbed architecture components are connected.
8. Describe the goal of using the Virtual Testbed Architecture through an example.

Demonstration (ThingWorx IoT platform)
Second session: highlights how the elements of the virtual testbed are connected followed by a demonstration of the virtual testbed using the IoT platform.

Introduction to Formal methods
Third session: introduces Formal methods and the importance of the application of formal methods in safety-critical systems. The session will also highlight the classification of formal methods.

Learning objectives
At the end of the session, participants will be able to:
1. Understand what are Formal Methods (FM)
2. Explain why to use Formal Methods
3. Understand the classification of Formal Methods
4. List the different applications of Formal Methods
5. Identify the usage of Formal Methods in EULYNX and RCA
6. Understand the benefits of Formal Methods
7. Understand the basic concepts, syntax, and semantics of Event-B formal language
8. Apply formal methods with simple railway examples
9. Understand the transformation of SysML to Event-B (Manual transformation and Automatic transformation) with demonstration.
10. Identify the usage of Formal Methods in the railway domain.

Discussion (EULYNX, RCA and OCORA)
Last session: will discuss formal specification, set theory, and application of formal methods in Railway projects like EULYNX, RCA, and OCORA. Lastly, the benefits of formal methods are highlighted.

Day 5

Demonstration and Discussion (manual transformation, safety requirements)

First session: discusses the process of applying formal methods to EULYNX models. Formal methods on EULYNX models are applied using manual transformation. To understand the transformation, the toolchain along with formal modeling is introduced. The formal verification of safety requirements is demonstrated through a demo. The challenges and benefits of the manual transformation are discussed in the conclusion.

Automatic transformation

Second session: deals with Automatic transformation which is a technique that is an improvement of the manual transformation technique as discussed in the previous session. The session starts with an introduction, objectives, and challenges of automatic transformation. To lay a proper foundation, concepts like - Model-to-Model transformation, Triple Graph Grammars (TGG), etc are introduced. Lastly, the toolchain and the process are explained in detail followed by a demo on a small example.

Learning objectives

At the end of the session, participants will be able to:

1. Understand what are Formal Methods (FM)
2. Explain why to use Formal Methods
3. Understand the classification of Formal Methods
4. List the different applications of Formal Methods
5. Identify the usage of Formal Methods in EULYNX and RCA
6. Understand the benefits of Formal Methods
7. Understand the basic concepts, syntax, and semantics of Event-B formal language
8. Apply formal methods with simple railway examples
9. Understand the transformation of SysML to Event-B (Manual transformation and Automatic transformation) with demonstration.
10. Identify the usage of Formal Methods in the railway domain.