



REAL WORLD APPLICATION OF

MBSE AT BOMBARDIER TRANSPORTATION

Event: SWISSED 2015

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BOMBARDIER
the evolution of mobility

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BOMBARDIER TRANSPORTATION

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SYSTEM ENGINEERING CHALLENGES & GOALS

3

MBSE AT BOMBARDIER TRANSPORTATION

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LOOKING FORWARD

BOMBARDIER

Overview



Bombardier is the world's largest manufacturer of both planes and trains, with a worldwide workforce of **74,000*** people.

Bombardier is headquartered in Montréal, Canada. Our shares are traded on the Toronto Stock Exchange (BBD) and we are listed on the Dow Jones Sustainability World and North America indexes. In the fiscal year ended December 31, 2014, we posted revenues of **\$20.1 billion USD**.

3 * As at December 31, 2014, including contractual and inactive employees

BOMBARDIER

Our evolution

1942-1973



- Company start-up
- Development of passenger and personal snowmobiles
- Vertical integration
- Energy crisis provoked market collapse

1974-1985



- Diversification into mass transit market
- Learning of new industry
- 1982 New York metro contract secured strong position in American market

1986-1993



- Entry into aerospace through Canadair acquisition
- Consolidation of North American mass transit position and reinforcement of presence in Europe

Strategic Acquisitions



- Aerospace: Short Brothers (UK), Learjet (US), de Havilland (CA)
- Transportation: BN (BE), ANF (FR), Deutsche Waggonbau (DE), Concarril (MX), Talbot (DE), Adtranz (DE)

1993-2003



- CRJ Series, Global Express, Challenger 300
- Tilting train, AGC (Autorail Grande Capacité)
- Sale of Recreational products business unit

2003-



- CRJ NextGen family, Learjet 85, Q400 NextGen, CSeries, Global 7000, Global 8000
- Hybrid AGC, ZEFIRO, ECO4
- Transportation's expansion into emerging markets



System Engineering Challenges & Goals

System Engineering Challenges & Goals

With respect to technology

Reduce development costs while increasing quality of the design artefacts.

Challenge

Goal

Complex products

Manage complexity



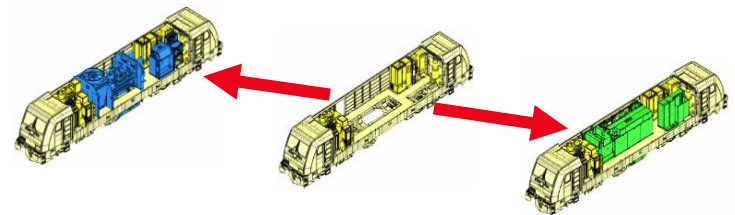
Distributed information sources

Share centralized information



Opportunistic, isolated reuse (copy past)

Managed, integrated reuse of development artifacts



System Engineering Challenges & Goals

With respect to people

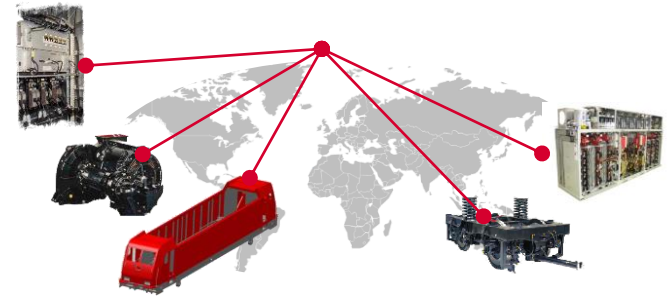
Reduce development costs while increasing quality of the design artefacts.

Challenge

Goal

Distributed development

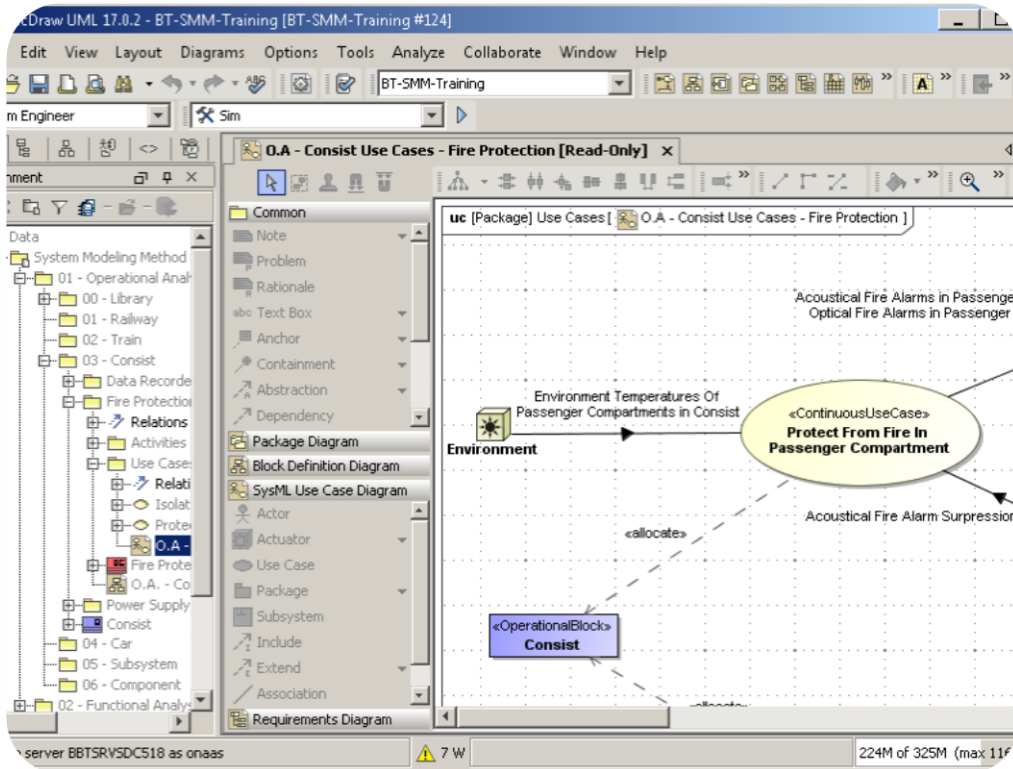
Enable collaboration



Multicultural teams

Improve correct understanding

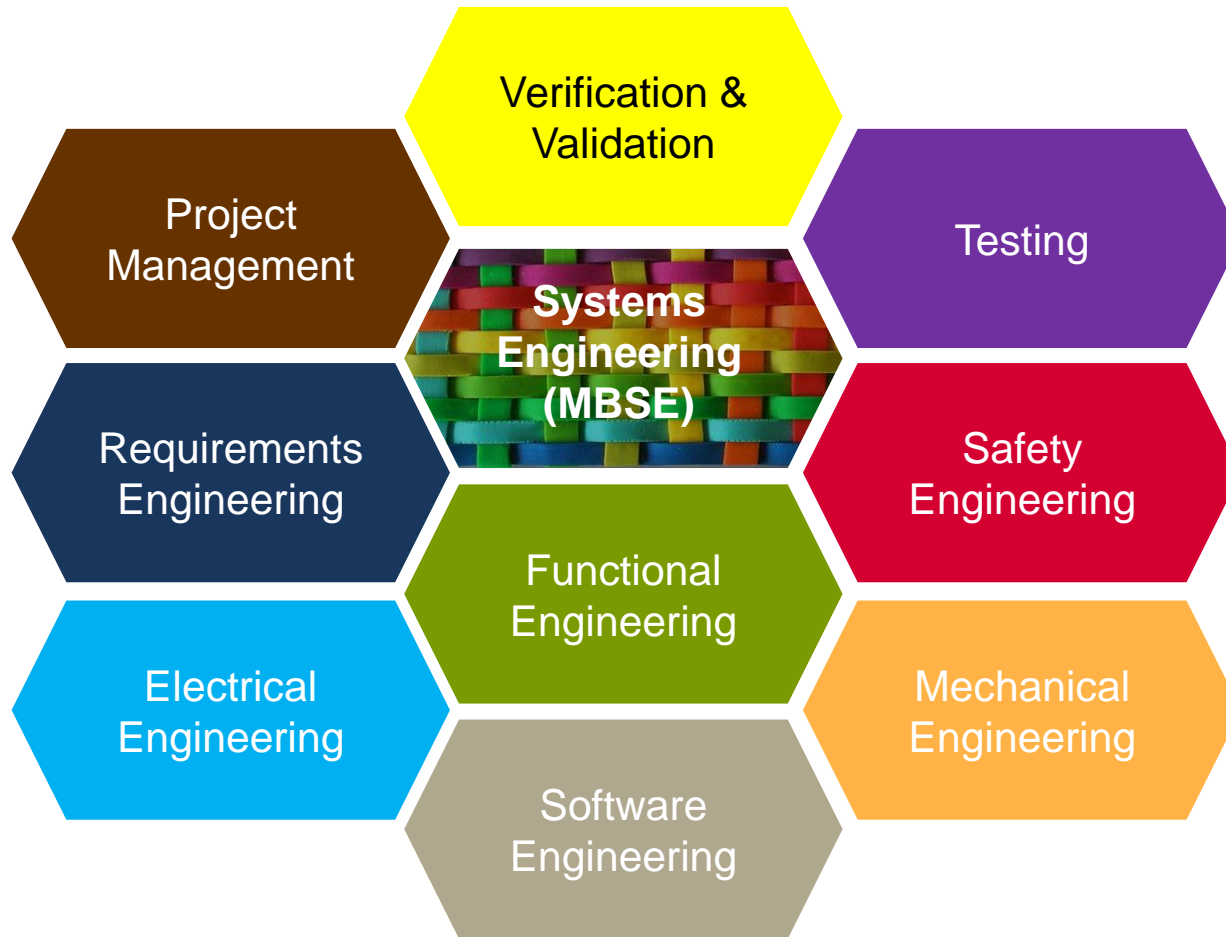




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Engineering Domains

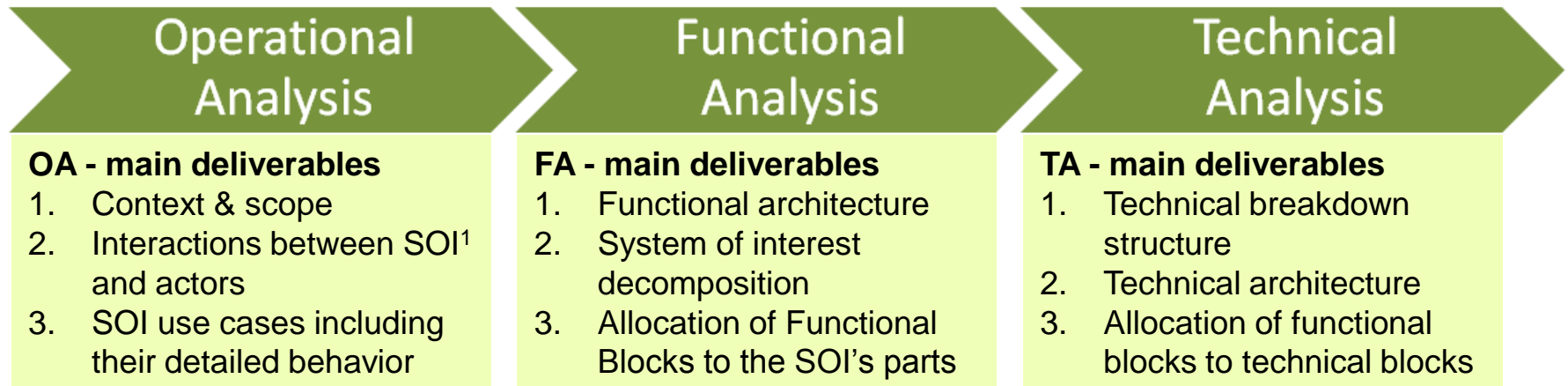


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BT System Modeling Method at a glance

The BT System Modeling Method describes **how** BT engineers shall analyze, define and represent their system of interest using a Model-Based Systems Engineering approach. The purpose of the method is to manage complexity and increase quality of the design artefacts to reduce development costs.

The BT System Modeling Method consists of three main tasks. Each of them to analyze the system of interest on a different abstraction level.



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BT System Modeling Method – Operational Analysis Example



Operational
Analysis

Functional
Analysis

Technical
Analysis

Definition of:

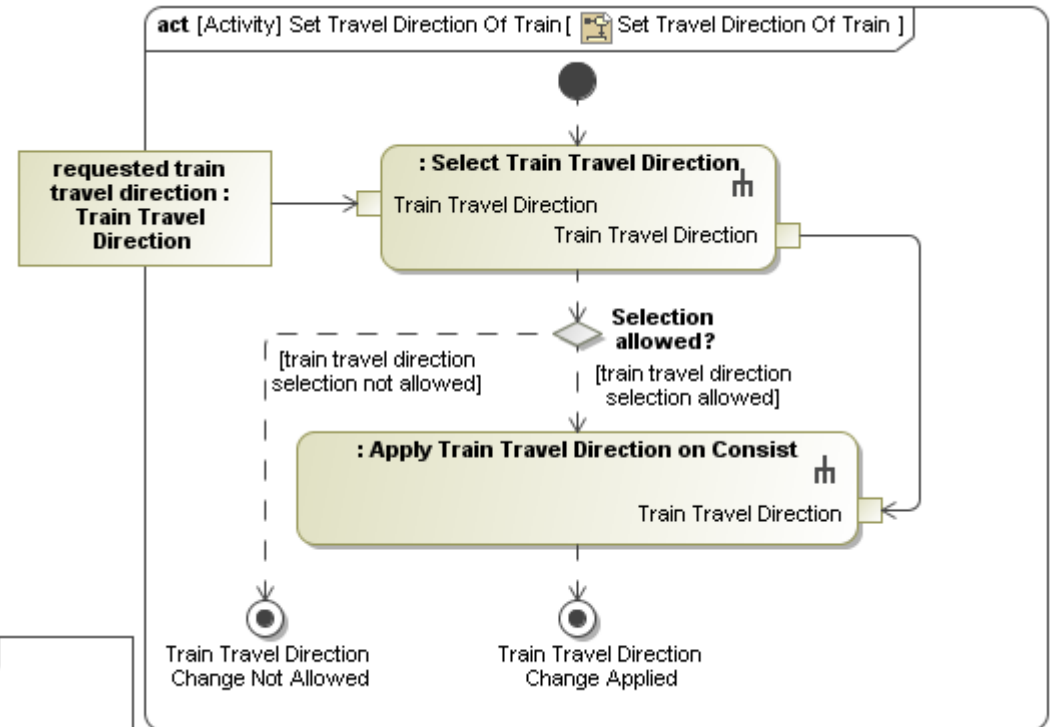
- Use cases
- Associated actors
- Use cases detailed behavior with their activities

uc [Package] Use Cases [O.A. - Train Use Cases - Travel Direction]



Trigger: «signal» Train Travel Direction Request

Result: The train travel direction which has been selected by the driver is applied in all consists of the train



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BT System Modeling Method– Functional Analysis Example



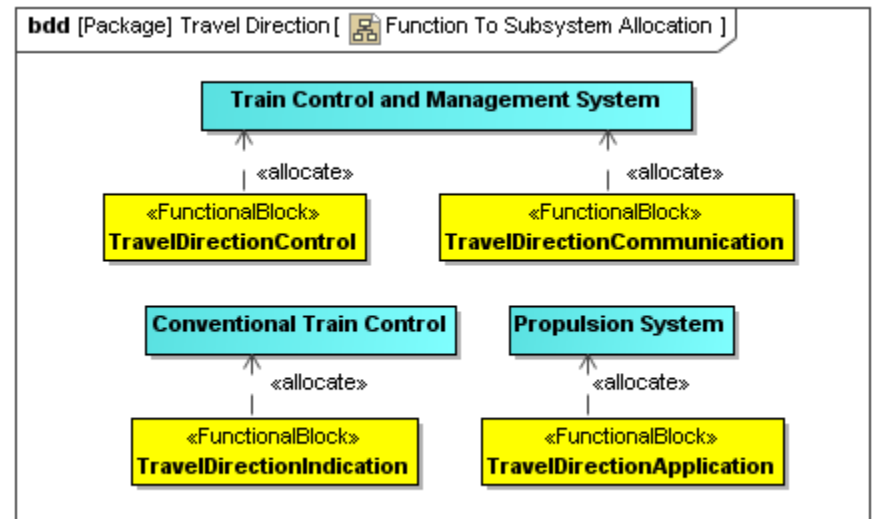
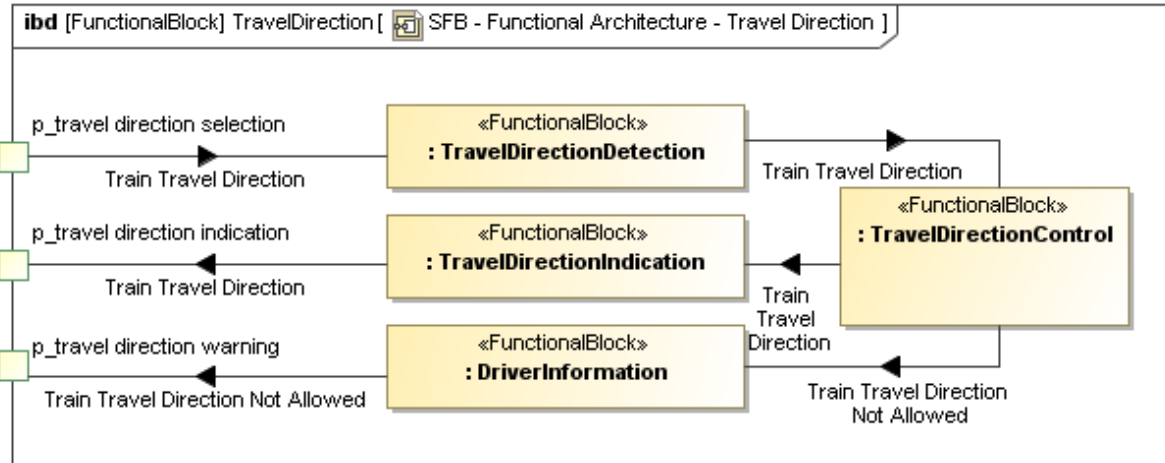
Operational
Analysis

Functional
Analysis

Technical
Analysis

Definition of:

- Functional Blocks
- Functional Block behavior
- Interfaces between Functional Blocks
- Allocation of Functional Blocks to the subsystems



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BT System Modeling Method – Technical Analysis Example



Operational
Analysis

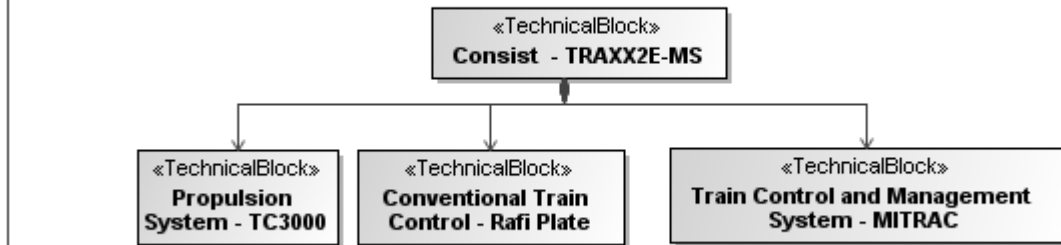
Functional
Analysis

Technical
Analysis

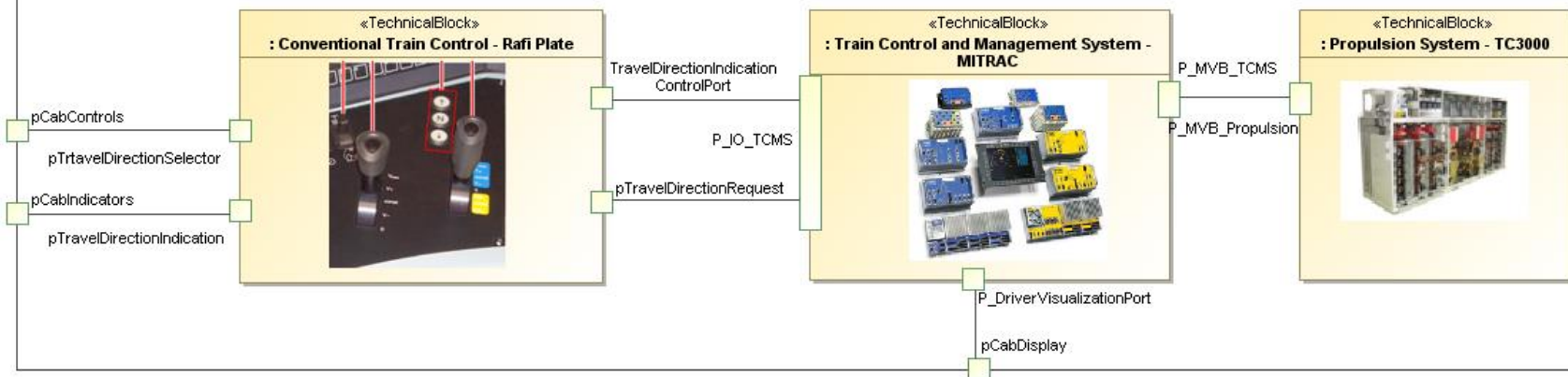
Definition of:

- Technical Blocks
- Technical Blocks breakdown
- Technical Blocks interfaces

bdd [Package] 05 - Subsystem [T.A. - Technical Breakdown Structure - Consist - Travel Direction]

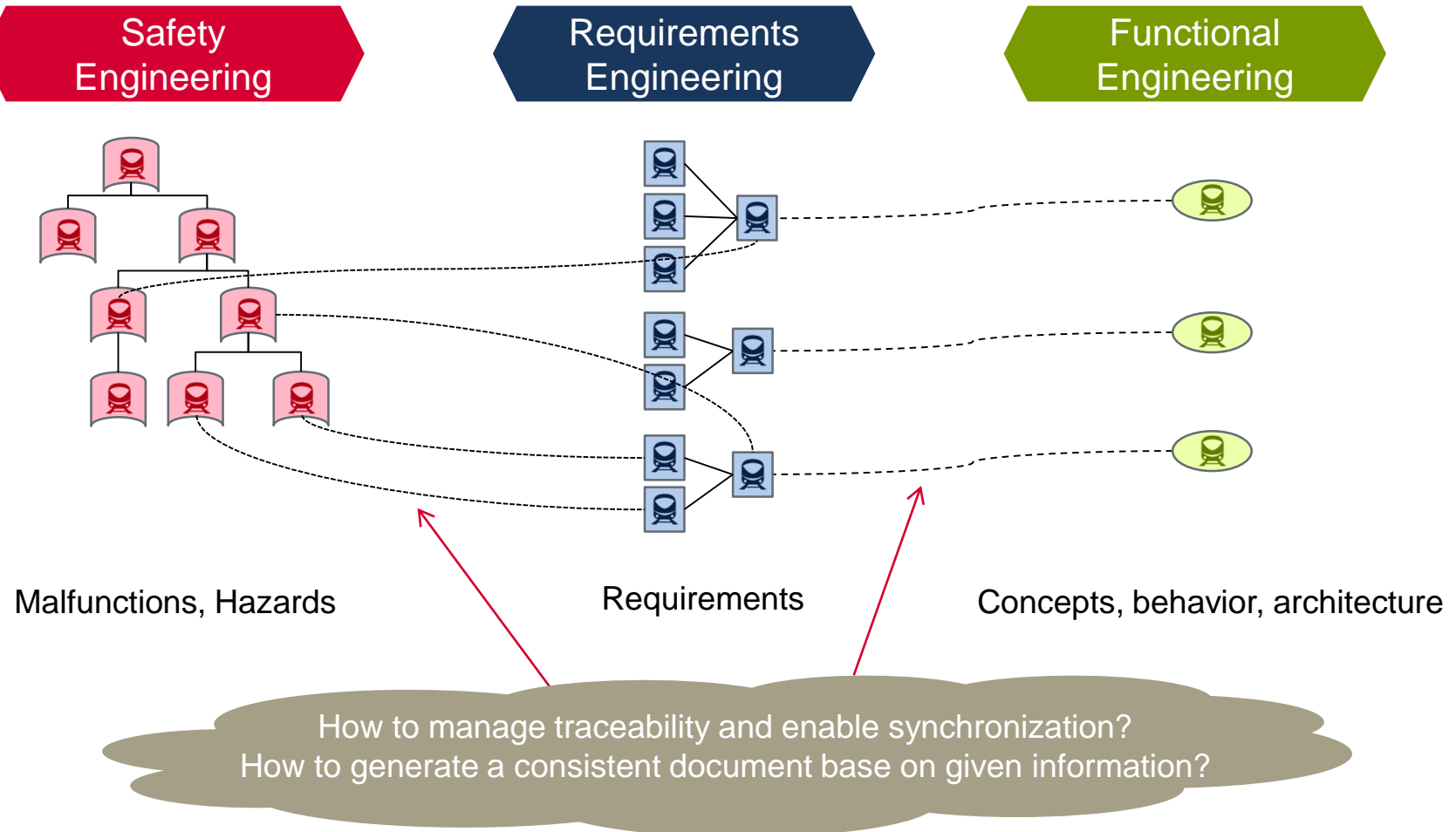


ibd [TechnicalBlock] Consist - TRAXX2E-MS [T.A. - Technical Architecture - Consist - Travel Direction]



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Integrated Engineering Approach



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Integrated Tool Chain

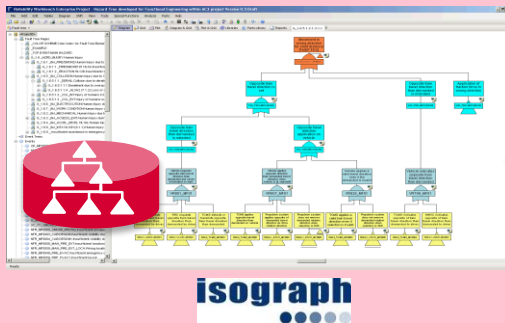
Linking hazard trees to requirements in doors and synchronizing safety information with **Datalink Manager**

Requirements in **DOORS**

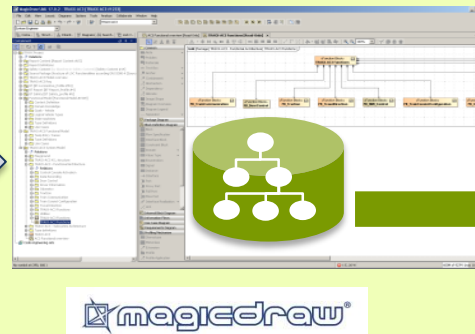


Linking and synchronizing requirements from DOORS into MagicDraw in **Cameo DataHub**

Hazard Analysis in **Reliability Workbench**



System Modeling in **MagicDraw**



Requirement

Hazard

Function

Document

Automatic document generation in **MagicDraw**

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MBSE is an integrated approach – Example

Definition of requirement in DOORS (visualized safety attributes)

Object Identifier	IE Object Type	ScopeID	Technical Requirements Specification	SIL requested	THR requested	Malfunction Description	Variants
2F TRS.-.TRAXX-AC3.801	Requirement	2F_HE CCD	GIVEN the vehicle speed is below <direction selection speed limit> AND the vehicle is leading AND no traction demand from driver WHEN the driver requests a new train travel direction on the active control console THEN the vehicle shall send the demanded train travel direction to the train.	SIL 2	3.0x10-7	Vehicle requests opposite train travel direction than demanded and sends information to train.	TRAXX-AC3

DOORS

Definition of safety attributes in Reliability Workbench based on requirement

Vehicle requests opposite train travel direction than demanded and sends information to train

VR801_MF01

State Properties - VR801_MF01 : Vehicle requests opposite train travel direction than de...

General | Appearance | Notes | Hyperlink

Operational Barriers | Justification | TESIP Function | Remarks/References

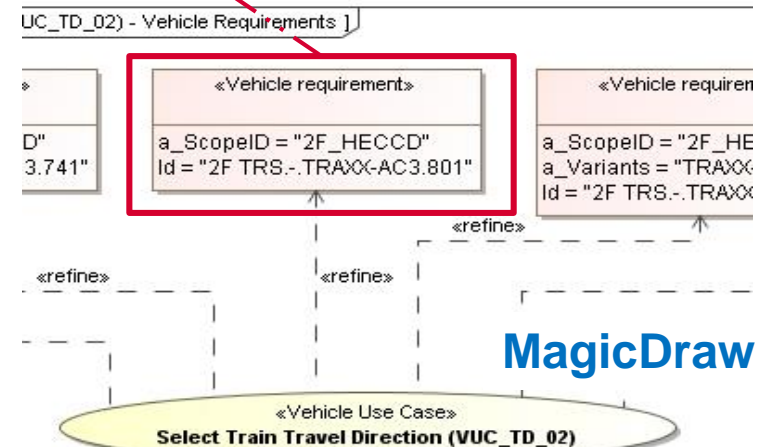
Safety Level Required | THRr | Possible MF Detection/Prevention | Type of Gate

SIL 2

Reliability Workbench

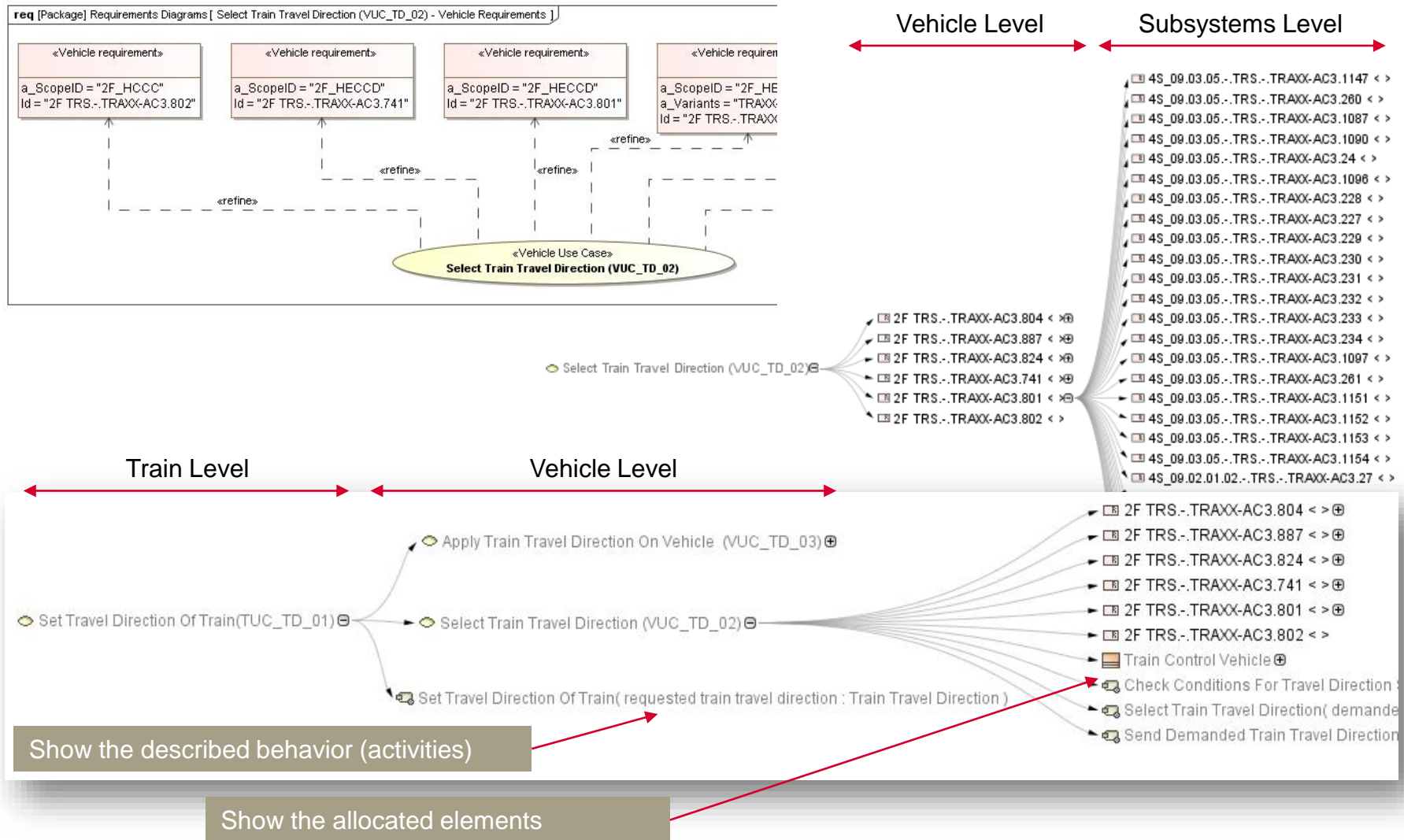
Dependencies... OK Cancel

Synchronized requirement in MagicDraw linked to use case



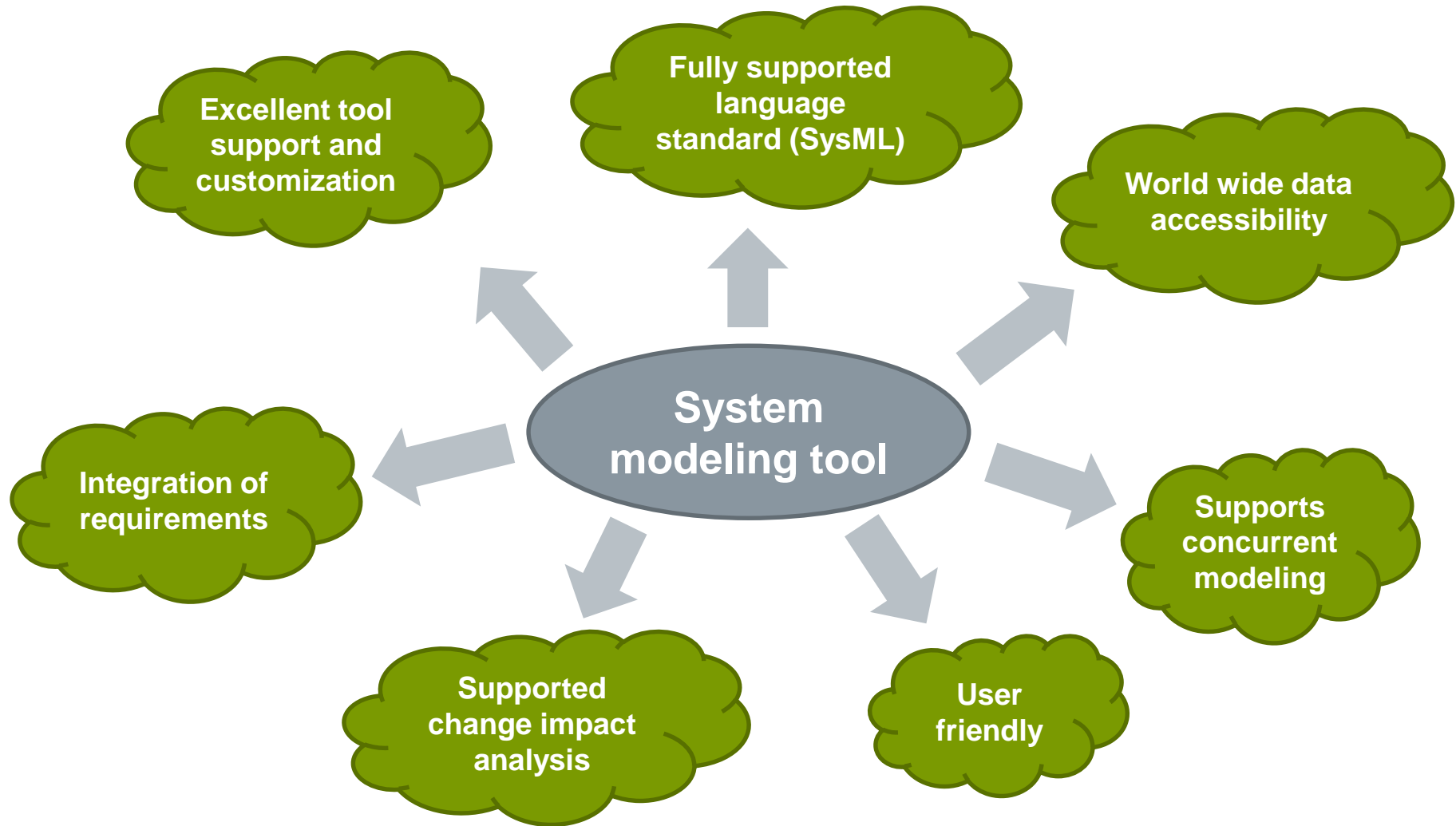
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Change Analysis on Different System Hierarchy Levels



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System Modeling Tool Criteria

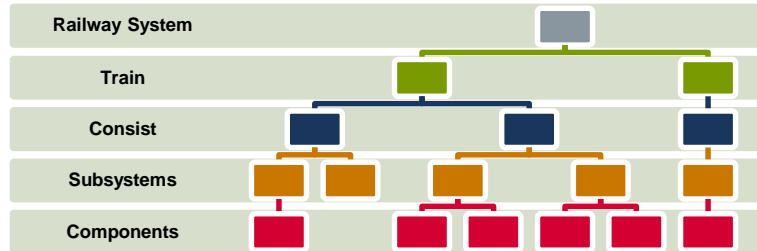


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MBSE Lessons Learned

MBSE Lessons Learned



Provide practice oriented methods

Think big but start small

Provide suitable tools to do the job

Provide trainings, coaching and guidelines



Looking Forward

Looking Forward

BT MBSE Targets





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