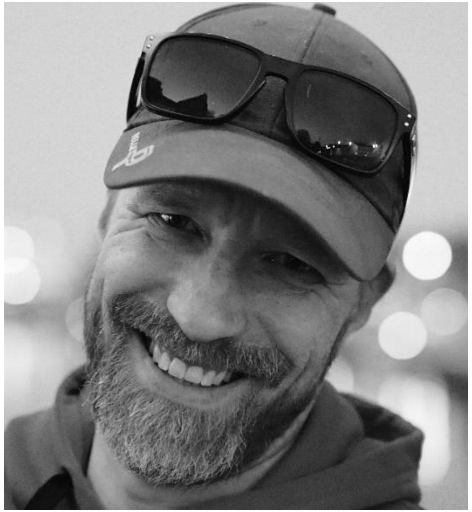
MODEL BASED SYSTEMS ENGINEERING – WHAT IT IS

This is the sub-title of the presentation

WHO AM I?



Matti (Masa) Koskipaa

EURONORTH Industry Process Consultant Senior Manager

- 20+ years of experience in the PLM domain
- 10+ years of experience with MBSE
- 3+ years leading the Euro-North MBSE Team

OUR COMPANY

A purpose-driven company

Combining Art, Science & Technology
for a more sustainable world

~25,000 passionate people

188 sites
One global R&D / 77 labs

Long-term driven

Majority shareholder control
Revenue: €6.24 billion*
Operating margin: 32%*

*Figures as of FY 2025 / Non-IFRS

390,000+ customers

In 155 countries
12 industries
45+ million users, 12 million students
Game-changing
3DEXPERIENCE platform

A highly dynamic network

18,000+ individuals in our commercial partner ecosystem
200+ scientific and research partners
25,000 startups and a community of 120,000 makers

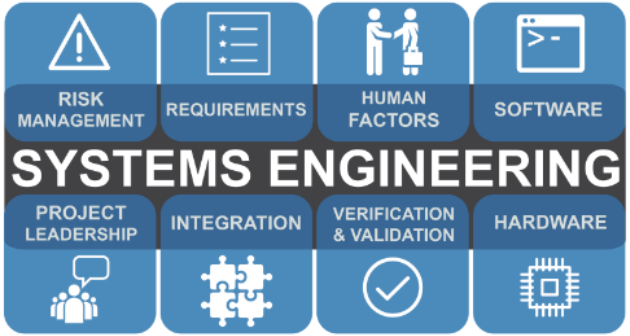
WHAT IS SYSTEMS ENGINEERING

SYSTEMS ENGINEERING - TRANSFORMING NEEDS TO SOLUTIONS

- **Systems engineers** are at the heart of creating successful new systems.
- **Responsible** for the **system concept**, **architecture**, and **design**.
- **Analyze** and **manage** complexity and risk.
- **Decide** how to measure whether the deployed **system actually works as intended**

- **Systems engineering** is **the discipline** that makes **success possible** by their tools, techniques, methods, knowledge, standards, principles, and concepts.

The launch of successful systems can invariably be traced to innovative and effective systems engineering.



INCOSE.org

DEFINITION OF SYSTEMS ENGINEERING

Systems Engineering

- Systems Engineering *is a **transdisciplinary** and **integrative** approach to enable the successful realization, use, and retirement of **engineered systems**, using **systems principles and concepts,** and scientific, technological, and management methods.*

Transdisciplinary approach

Transdisciplinary is described as an approach which "crosses many disciplinary boundaries to create a holistic approach."

Integrative approach

The integrative approach usually involves either interdisciplinary (e.g.. integrated product teams) or multi-disciplinary (e.g.. joint technical reviews) methods.

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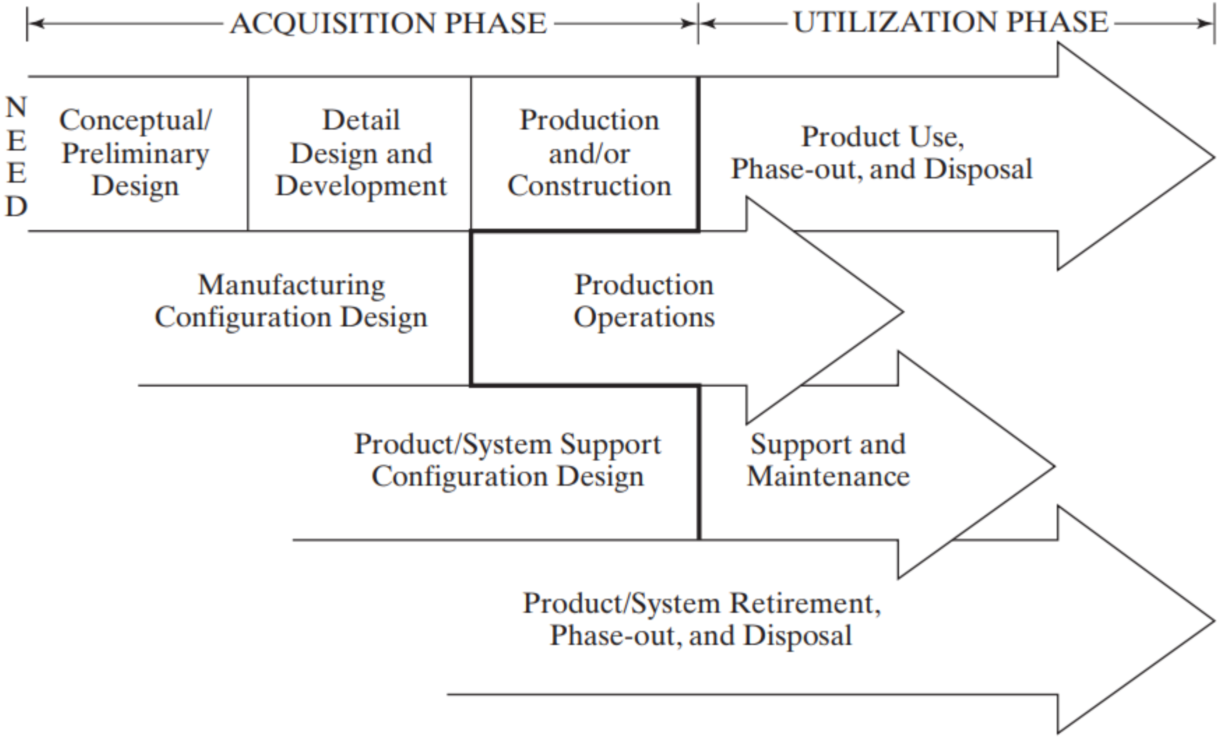
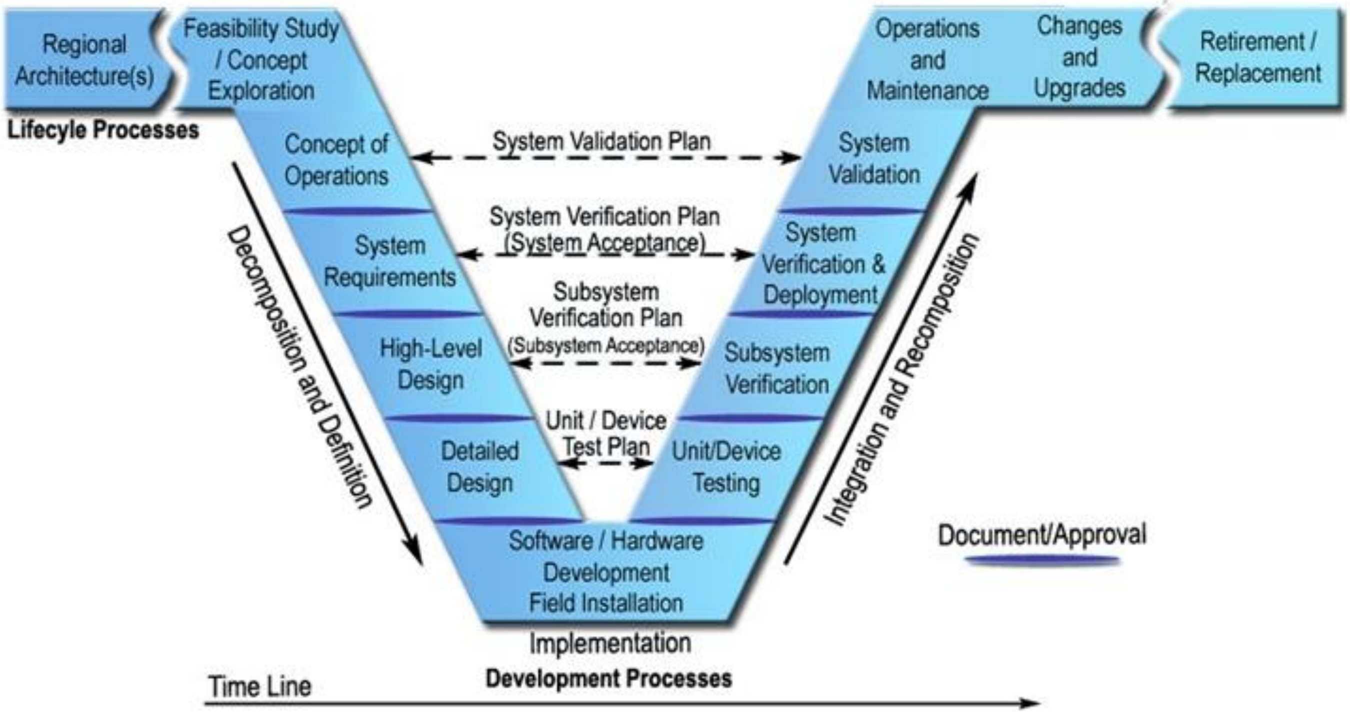
LIFECYCLE OF A SYSTEM

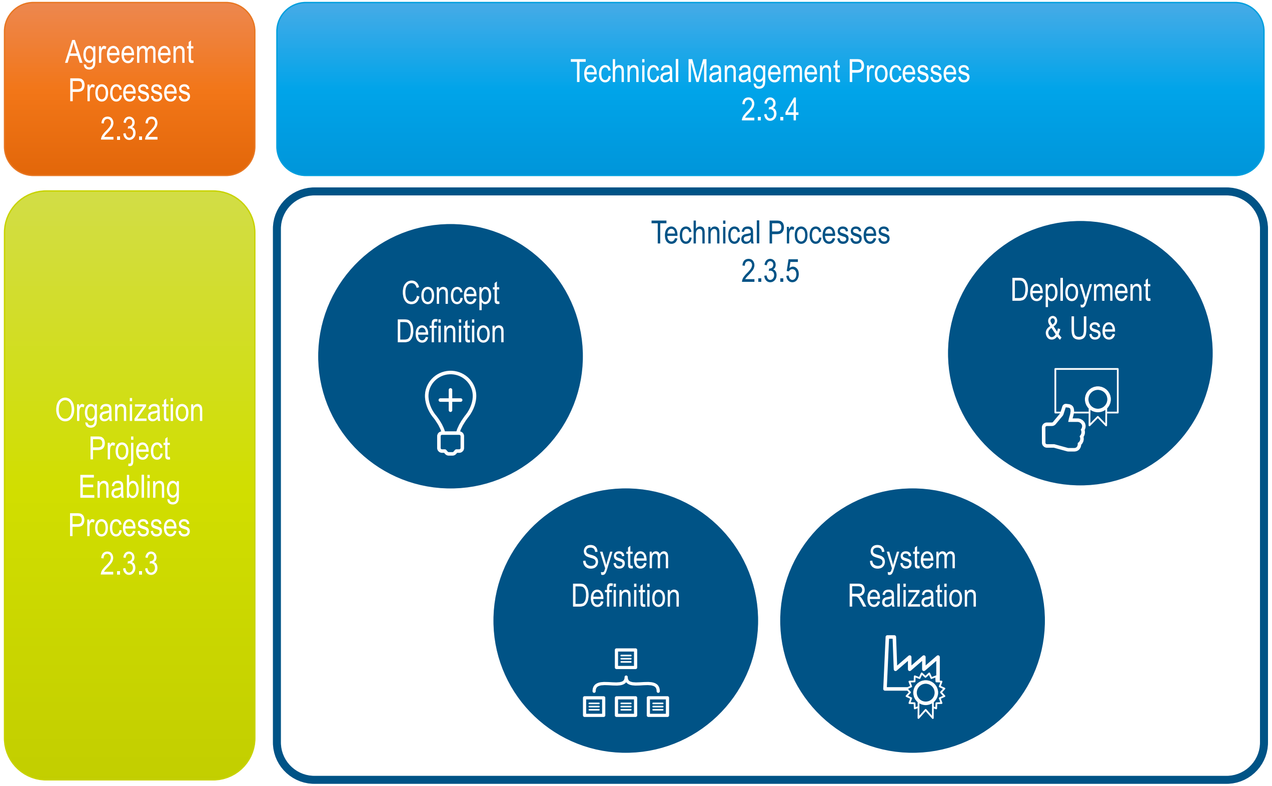


Systems Engineering and Analysis - Blanchard Fabrycky - Fifth Edition

SYSTEMS ENGINEERING LIFE CYCLE

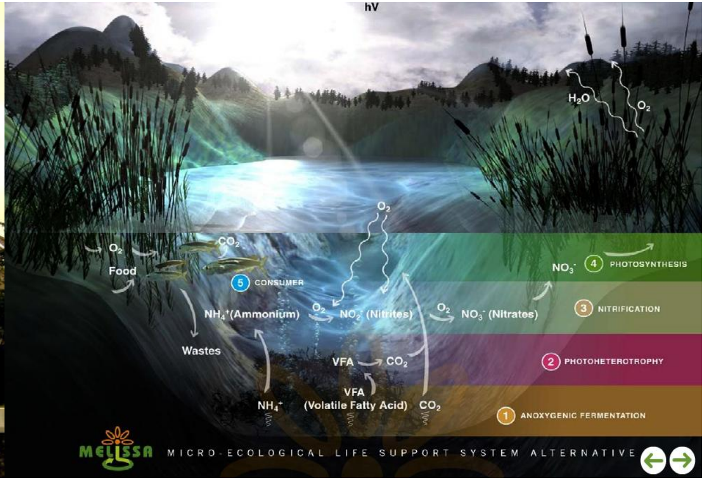


ISO 15288 & SE HANDBOOK



WHAT IS A SYSTEM?

Complicated *vs* *Complex*

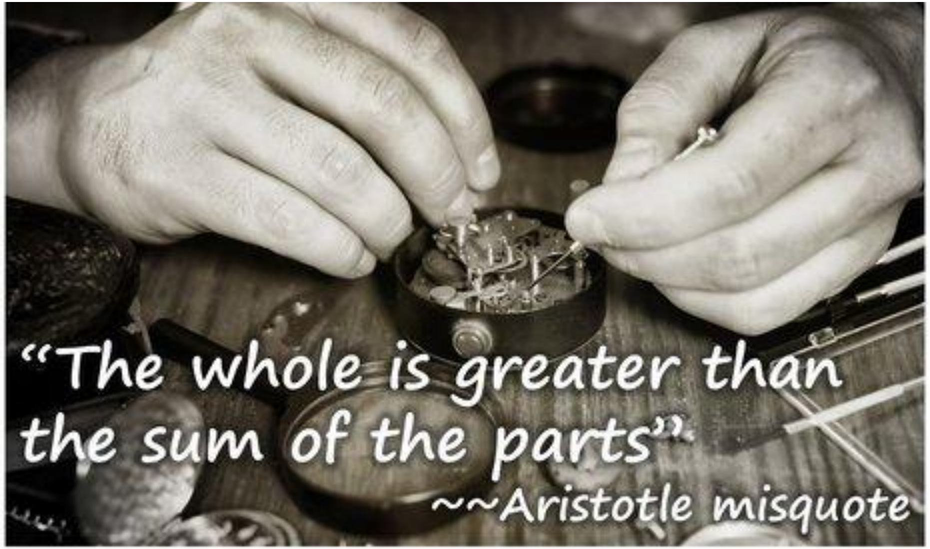


Size effect

Inter-relations

DEFINITION OF SYSTEM: GENERAL CASE

- *A **system** is an arrangement of parts or elements that together exhibit behaviour or meaning that the individual constituents do not.*



EXAMPLES : WHICH ONE IS A SYSTEM?

WHY CONSIDERING THIS HARVESTER AS A SYSTEM?

What is the difference with a large assembly?

A system exists through its relation to its environment

BASICALLY 1 + 1 = 3

INCOSE definition

- *A combination of interacting elements organized to achieve one or more stated purposes*

Scanner

+

Interrelations

Printer

=

Printer
Scanner
Copier

Emergent functions → Impact the architecture!

"A system is a collection of elements that, when working together, produce an effect that the individual elements operating on their own cannot produce."

Holism

A complex system not being able to be analyzed in details, a systemic approach is an efficient manner to manage complex problems: it is studied "as a whole".
System engineering has to integrate multiple view points in a **global, holistic view,** distinguish problem domain from solution domain, separate elements, interactions among the elements and analyze how combined elements behave.

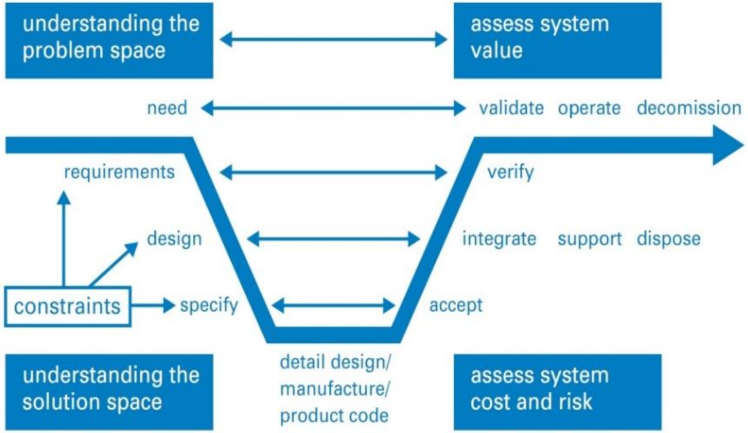
Emergence

The properties of a complex system does not result only of the properties of its elements individually but are related to the interactions of these elements.
Complexity is also linked to emergence of properties of the whole from the organization of the components and the interrelations.

WHAT IS SYSTEMS ENGINEERING?

Systems engineering is a holistic and systematic interdisciplinary approach and means to enable the realization of successful systems in large projects and connected worlds
Based on multi-industry best practices framework: ISO15288

- Understanding the problem before jumping into the solution (stakeholder needs, context, use cases, behavior)
- Strong focus on customer needs and required functionality for all product lifecycle phases
- Considering the complete problem incl. operations, performance, test, manufacturing, cost & schedule, training & support, maintenance, disposal
- Reducing complexity by decomposing the system of interests into subsystems with clearly defined functions, interactions, responsibilities,…



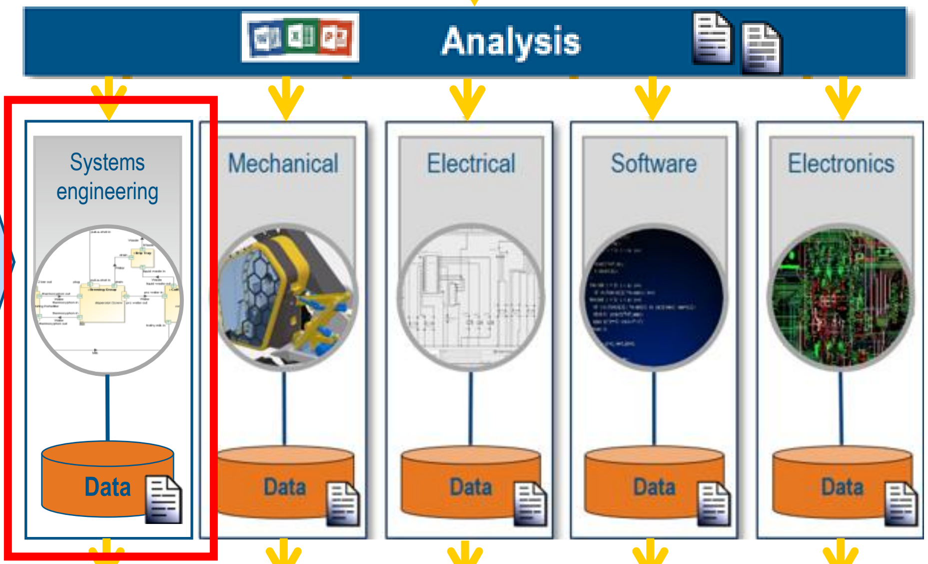
Source: INCOSE

SYSTEMS ENGINEERING AND SILO WORKING

Market Needs

The Issue

- Discipline focused
- No digital continuity
- File based approach
- Different data sources
- Lack true of traceability



The Consequences

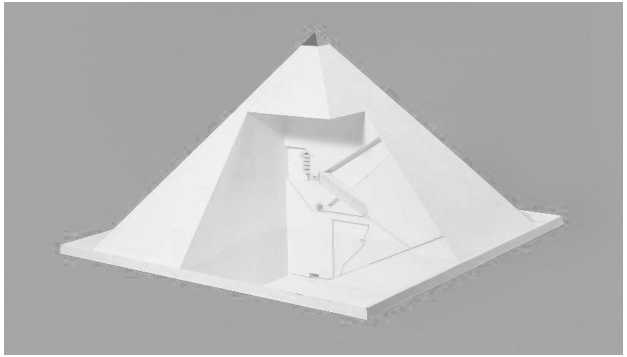
- Time spent on non added value tasks
- Misunderstanding among stakeholders
- Still Product quality issues
- Still Project delays

Product Lifecycle

MODEL BASED SYSTEMS ENGINEERING

WHAT IS A MODEL?

- A model is (always only) a limited representation of the reality
- All models are wrong, but some are useful



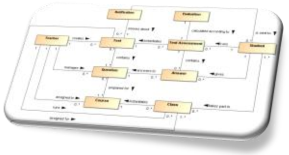
- Models always should have a purpose and are used to:
  - challenge/ proof our thinking
  - Communicate/exchange with others
  - early Verification & Validation of requirements, concepts, architecture, behavior, ...

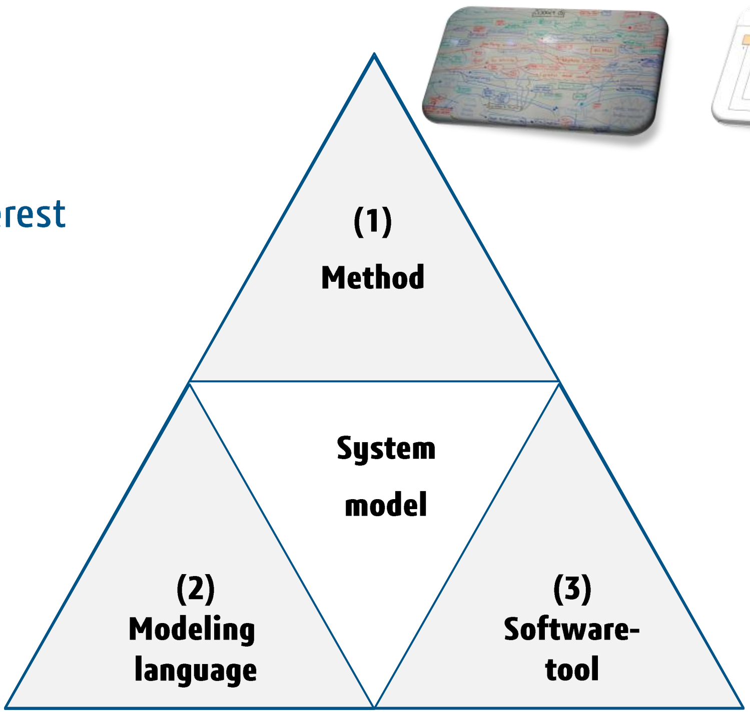
WHAT IS MODEL BASED SYSTEMS ENGINEERING?

MBSE needs:

- A holistic modeling approach
- A central model for the whole System of Interest (System model)
- A unified modeling language (SysML)
- A modeling framework (method, rules)
- A modeling tool
- Qualified and motivated employees

PICTURE ≠ MODEL

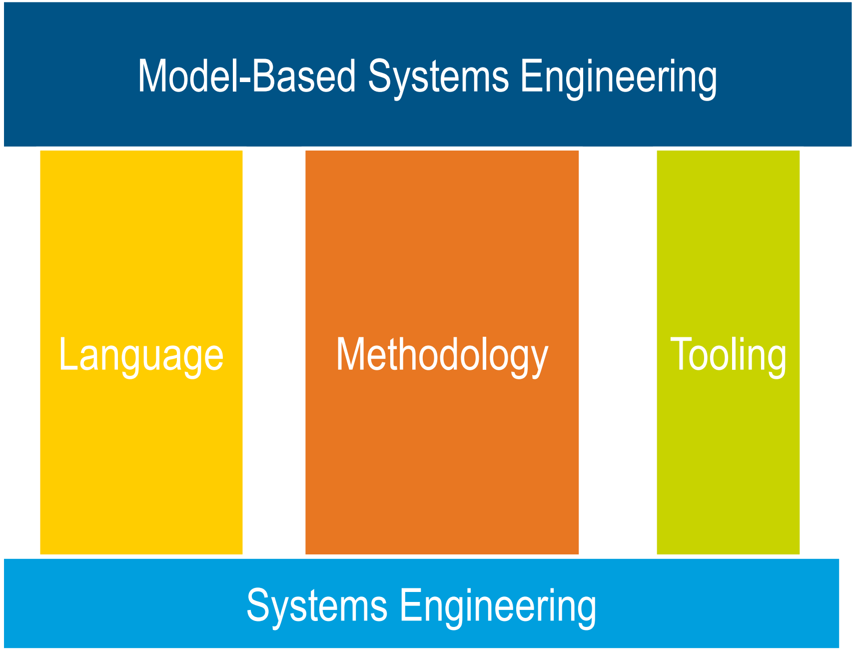




3 PILLARS OF MBSE

Model-Based System Engineering has 3 key pillars

- Model-Based Systems Engineering is not stand alone but built upon the foundations of Systems Engineering methods before.
- Using a foundation of Document-Based Systems Engineering
- We can:
  - Define an appropriate model description Language
  - Create a model with a defined Methodology
  - Implement in a modelling Tool
- All three pillars build on the foundation to provide Model-Based Systems Engineering



MBSE PLANNING - WHY PLAN FOR MBSE

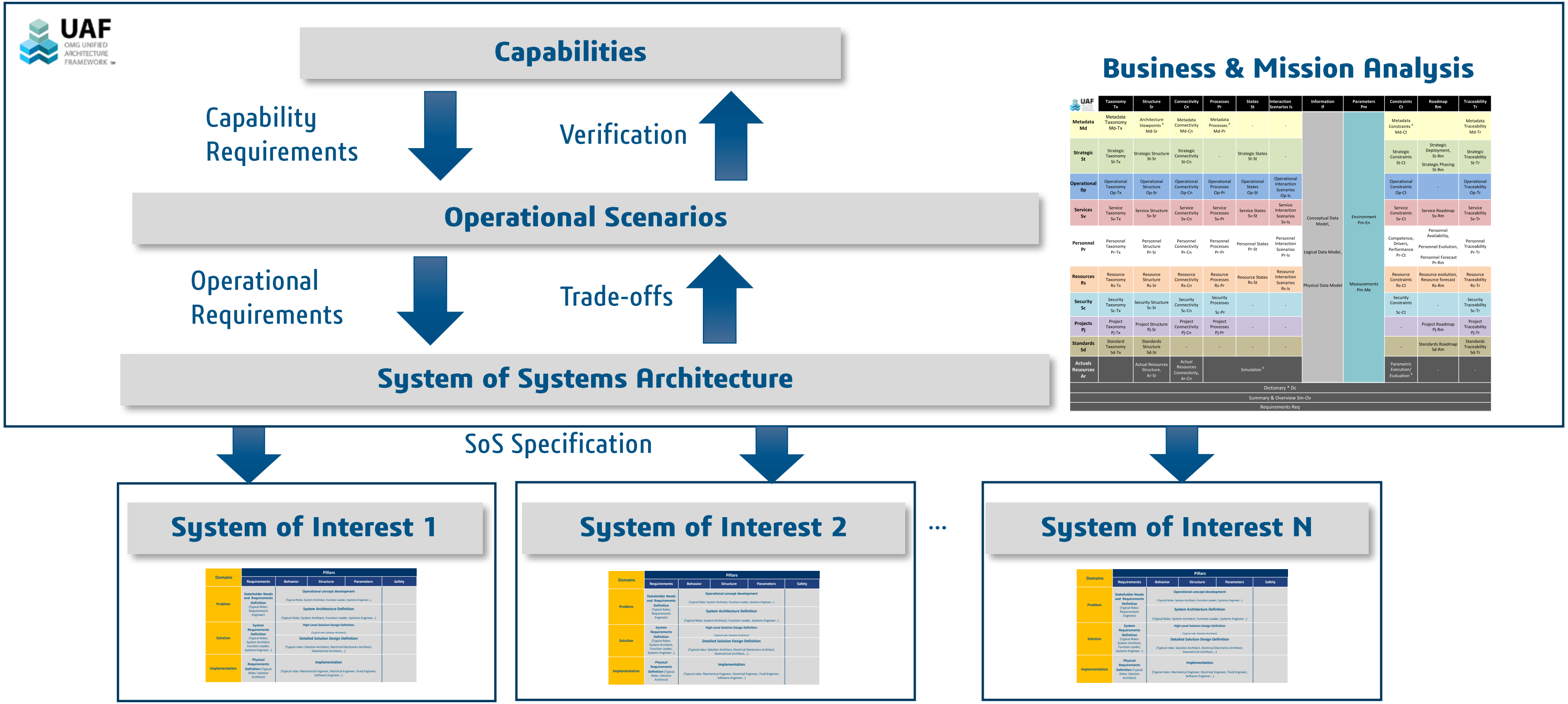
- Many reasons to plan MBSE before starting, it doesn’t have to take a long time but it makes life much easier.

- For the Project Manager, Customer & Managers
  - Want to know defined goals
  - Want to be able to track and see progress
  - Want to know that there is an end goal in mind

- For new starters
  - Helps them understand why all this is being done in the first place
  - Provides direction and meaning for work being done
  - Knows what is expected and by when

- For the team
  - Gets everyone engaged and involved
  - Defines purpose and goal – Something to work towards
  - Reduces sceptics doubting your work
  - Reduces amount of redundant work

Model Based System of Systems Engineering



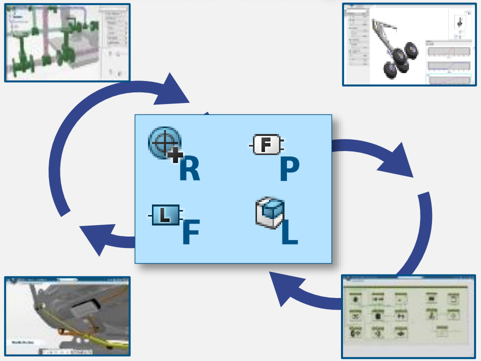
DASSAULT SYSTÈMES SYSTEM ENGINEERING

STRATEGY

1 Multi-scale Systems

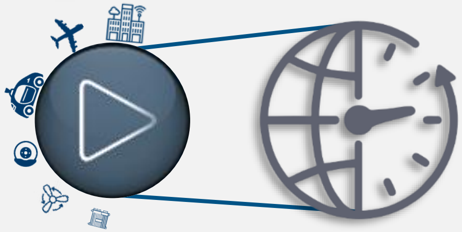
Speed-up time to market agility
Improve specification completeness and quality

2 Connected Disciplines



Accelerate multi-disciplines design
Improve engineering productivity

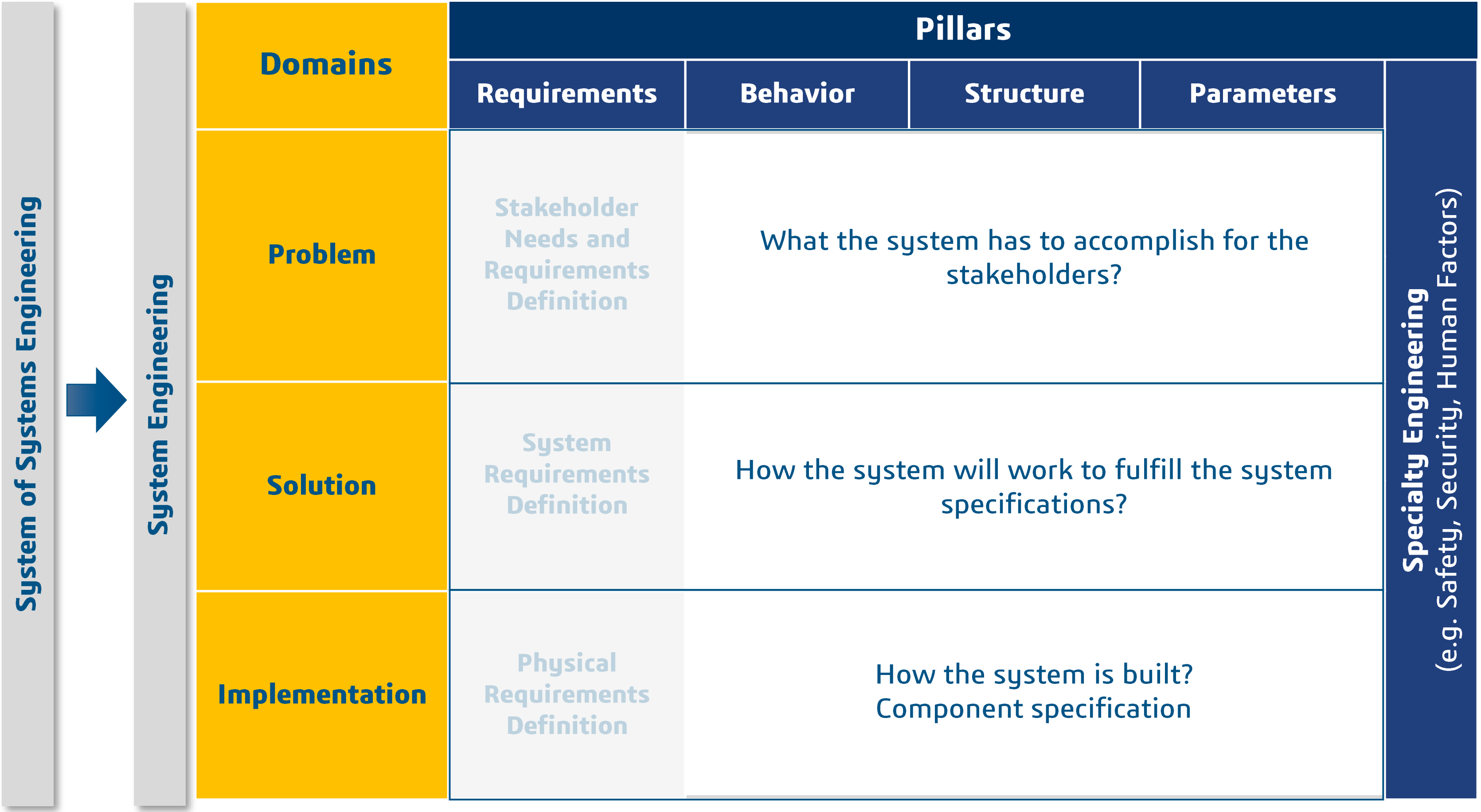
3 Simulate Anytime In the Process



Detect integration errors
Decrease physical testing cost

4 Openness, Governance & Traceability

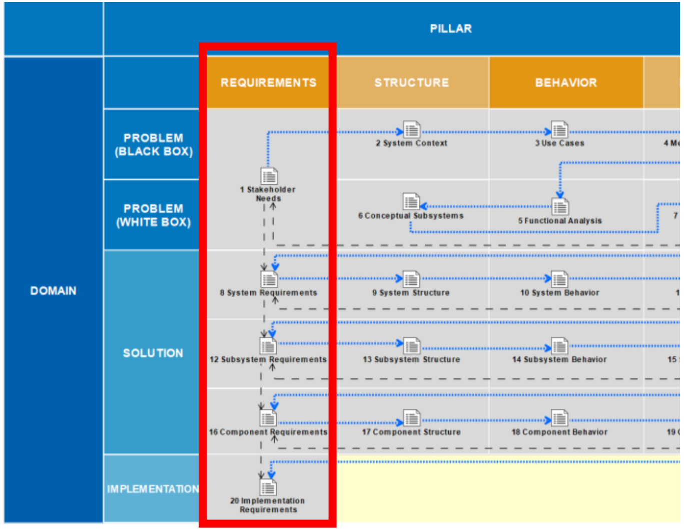
Accelerate MBSE adoption
Maximize module re-use
Decrease rework
Manage Traceability

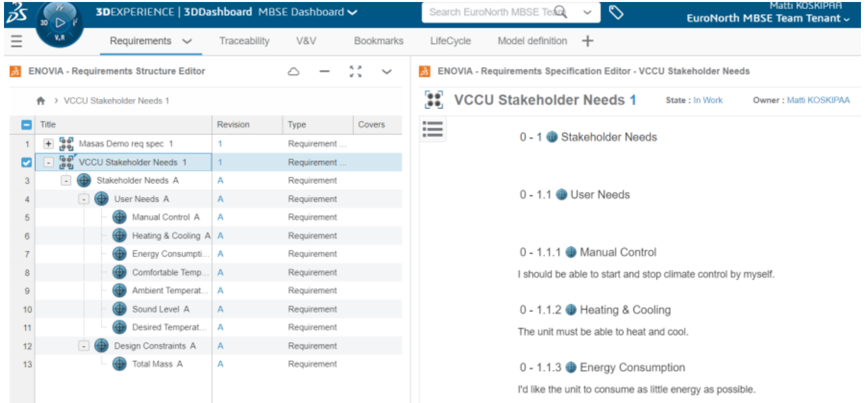

System of Systems Engineering
System Engineering
Domains
Pillars
Requirements
Behavior
Structure
Parameters
Problem
Stakeholder Needs and Requirements Definition
What the system has to accomplish for the stakeholders?
Solution
System Requirements Definition
How the system will work to fulfill the system specifications?
Implementation
Physical Requirements Definition
How the system is built?
Component specification
Specialty Engineering
(e.g. Safety, Security, Human Factors)

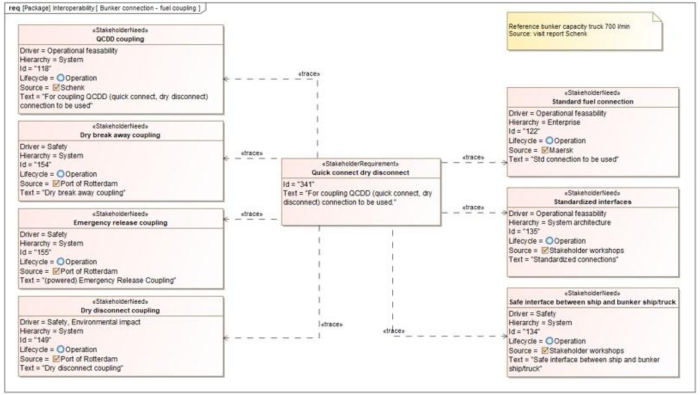
CONNECTED REQUIREMENT ENGINEERING

From requirement management to requirement engineering

- Elicit requirement and convert those into something usable
- Continue to engineer the requirements through out the MBSE process
- Ensure that all parties have the needed requirements and create the link



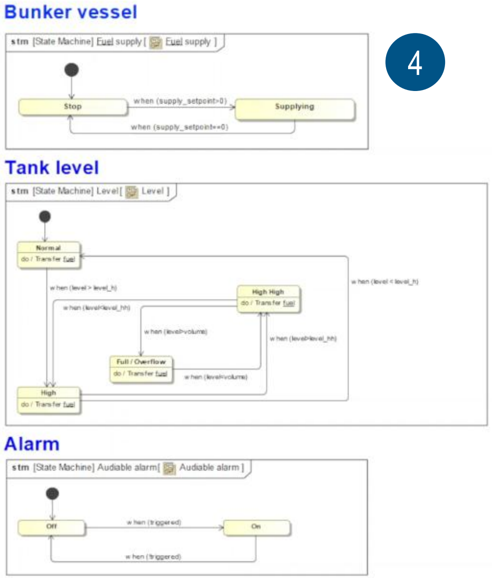


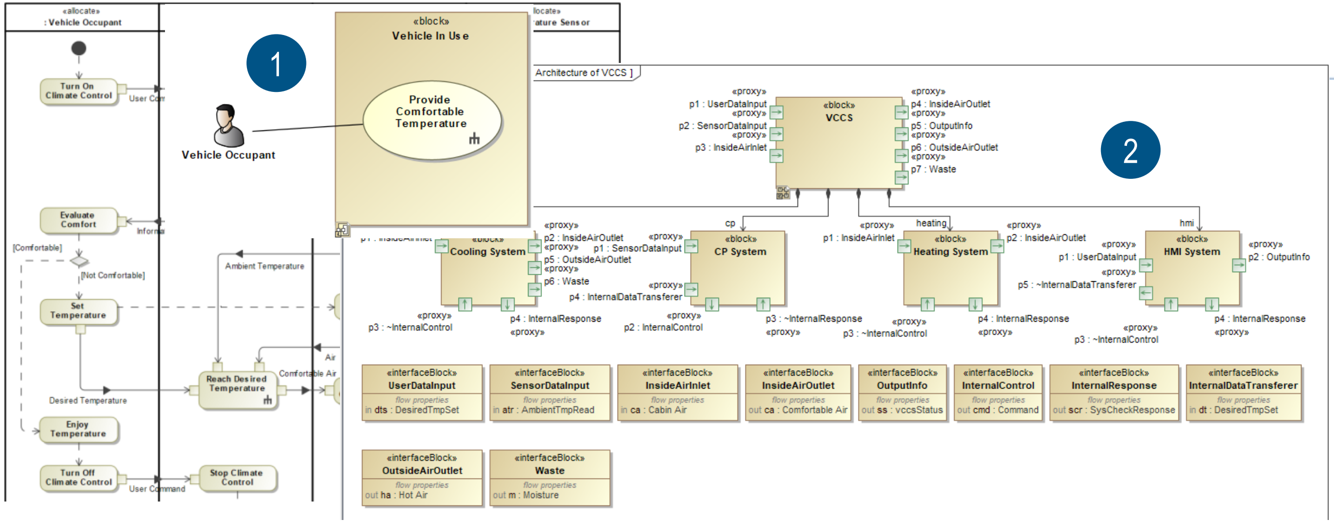


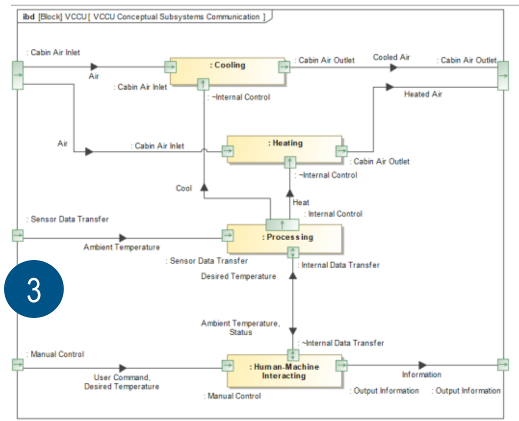
SYSTEM ARCHITECTURE – DECOMPOSING THE COMPLEXITY

From requirements to sub-systems and discipline architecture definitions

1. Understanding and decomposing the problem into Use Cases and Activities (functions)
2. Using the Functional analysis to create the high level system architecture
3. Defining of the communication with in the architecture: interface and flow definition
4. Early simulation to verify and validate the system behavior



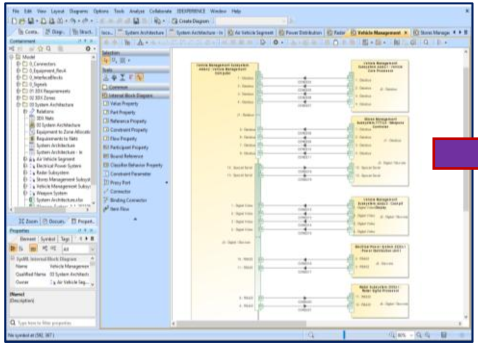


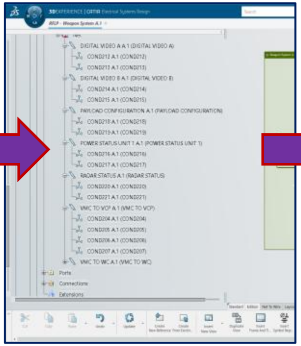


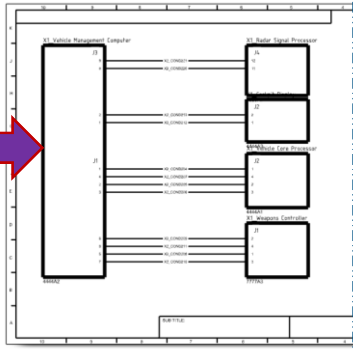
TRANSITION FROM ARCHITECTURE TO DETAILED DESIGN

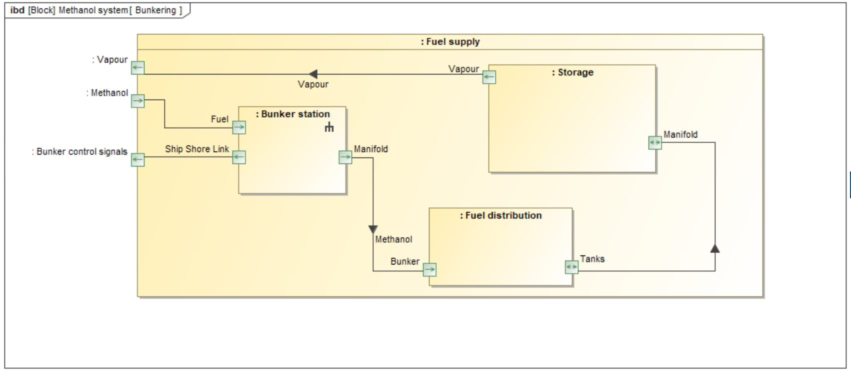
Achieving true digital hand over from architecture to discipline design

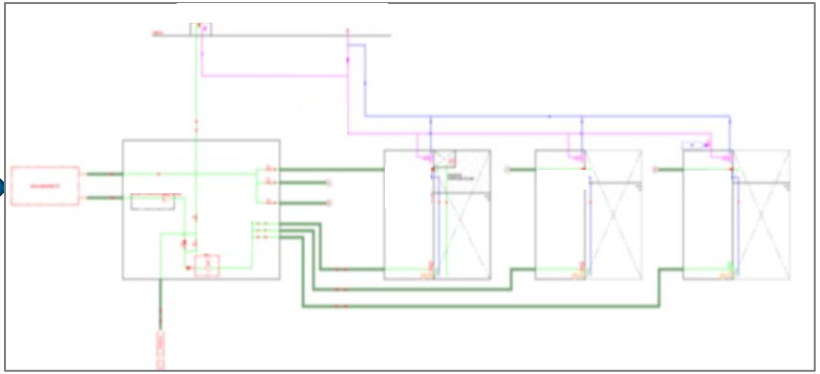
- Create the high level discipline specific functional and logical structures for discipline design teams
- This ensures the digital hand over of the architecture and all needed information to the design teams





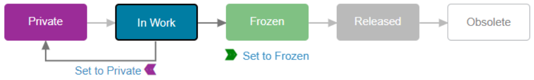




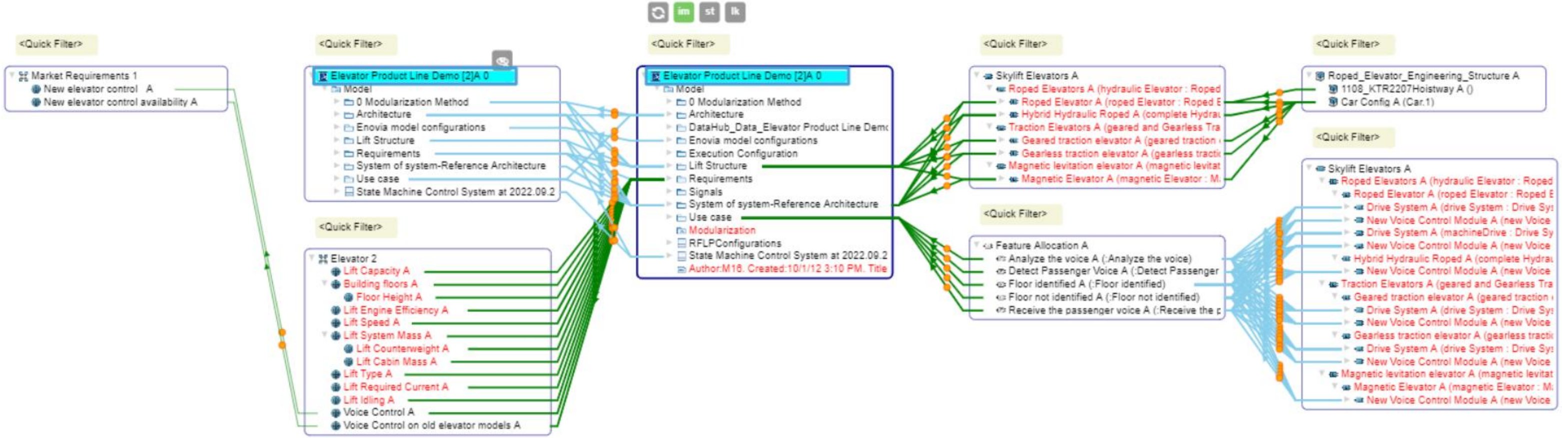


COLLABORATION AND GOVERNANCE

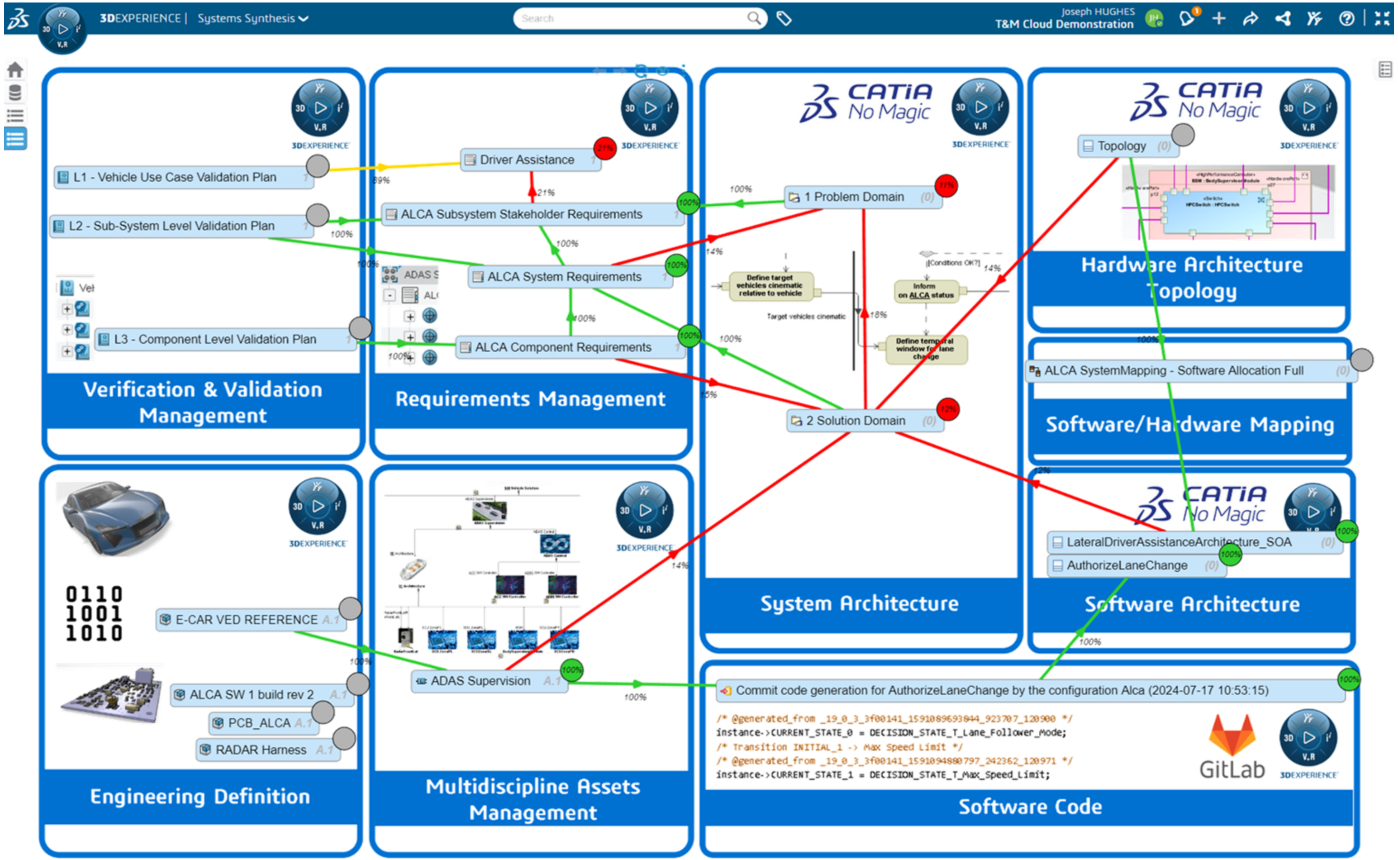
- All MBSE data and information can be stored and managed in 3DEXPERIENCE
  - Version management
  - Branching
  - System model inside a system model
  - Etc.
- Traceability enables to visualize the whole flow of the information across the



Graph		Title	Revis…	Maturity State	Creation Date	Modification Date	Description
		Ship methanol system	2.A	In Work	November 9, 2023 at …	November 9, 2023 at …	
		Ship methanol system	1.A	In Work	November 9, 2023 at …	November 9, 2023 at …	



TRACEABLE SYSTEMS DESIGN



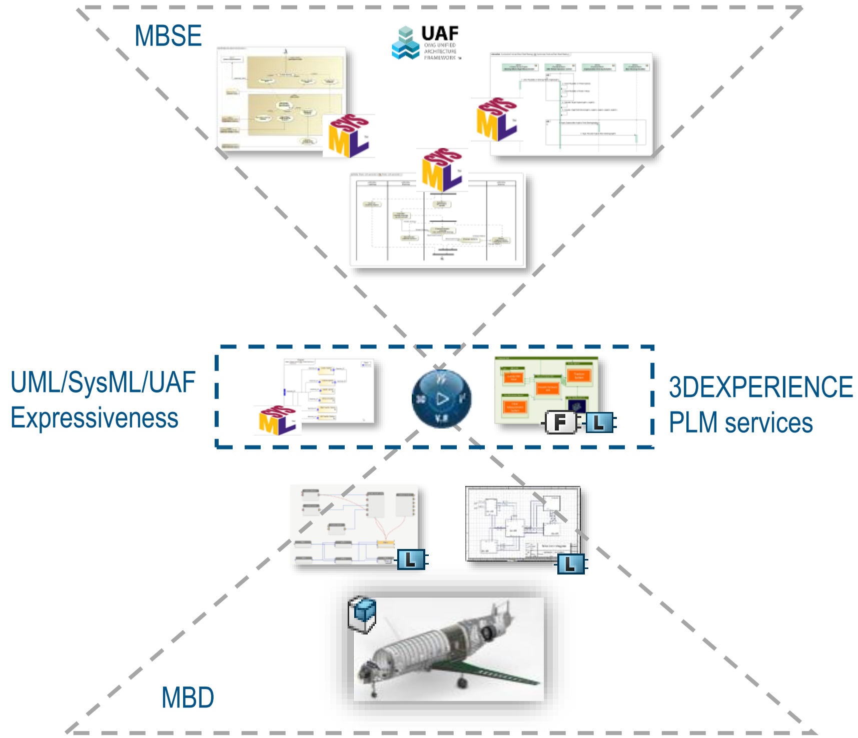
Requirements, architecture, verification and change are connected.

MBSE and MBD in 3DEXPERIENCE

Store and manage a complete UML/SysML/UAF data model in 3DEXPERIENCE *with the right collaboration granularity*

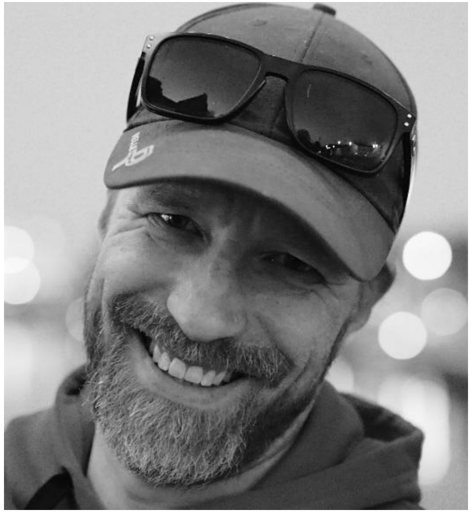
Provide *3DEXPERIENCE PLM services* (versioning, configuration, baselining, etc.)

Extend with 3DEXPERIENCE capabilities (multi-physics simulation, code generation, requirements simulation, etc.)



MAGIC GRID

- MagicGrid is the bridge between the theory and practice, bringing three major MBSE components – method, language, and modeling tool – together.
- Companies needed an unambiguous approach for developing system models using SysML, the critical enabler for MBSE, as defined by the International Council on Systems Engineering (INCOSE).
- The MagicGrid framework has evolved by summarizing the experience of numerous MBSE adoption projects, as a foundation and collection of best practices that can be modified or extended to support specific customer needs. The framework is completely applicable in practice for the following reasons:
  - It is fully compatible with “vanilla” SysML, which means, no extensions for the standard SysML are required.
  - It clearly defines the modeling process, which is based on the best practices of the systems engineering process. It is tool-independent, as long as that tool supports SysML



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- 10+ years of experience with MBSE
- 3+ years leading the Euro-North MBSE Team

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