Two Variant Modeling Methods for MBPLE at Airbus

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Tim Weilkiens, oose

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AGENDA

00 Introduction

01 Airbus Context

02 MBPLE

03 Variant Modeling Methods

04 Conclusion

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INTRODUCTION
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MARCO FORLINGIERI

Italian based in Germany, Marco leads at Airbus the MBPLE adoption. He has 10 years of experience in the field of MBSE and PLE mainly within aerospace, defense, automotive and railway industries in Europe, China and North America. His role within Airbus consists of producing and implementing PMT capabilities for the development of product lines across different functions and programs. Since April 2022, he co-chairs the INCOSE PLE WG.

“At Airbus we boost MBSE with PLE and the other way round”

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TIM WEILKIENS

Tim is a consultant and executive board member of oose. He has more than 20 years experience in the field of MBSE. He is one of the developers of SysML v1 and SysML v2. Tim published many books about modeling and he is author of the MBSE methodology SYSMOD. With VAMOS he published a tool-independent approach for modeling variants with SysML.

“Modeling is the art of becoming concrete on an abstract level.”

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WHAT IS (MB)PLE?

Credit: The Walt Disney Studios

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AIRBUS CONTEXT
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AIRBUS ZEROemission

At Airbus, we believe **hydrogen** is one of the most promising **zero-emission technologie**s to reduce aviation's climate impact. This is why we consider hydrogen to be an important technology pathway to achieve our ambition of bringing a zero-emission commercial aircraft to market by **2035**.

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DDMS

FIVE PILLARS

The 5 pillars provide capabilities to the business to create values on the programme

Modeling and Simulation

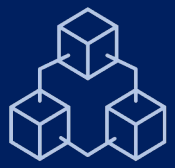
Allow to have a virtual world to be able to model and simulate the A/C, the industrial system and services.

Co development & Integration

Make all the disciplines (engineering, manufacturing, customer services, supply chain of the partners) working together in a single process and single environment.

Digital Continuity

Every time you change a data everybody get access to this data and know what is the impact of the modification we have done on the complete tool chain.



Product Line

Reduce non-added value variability and stop variability propagation through modularization & standardization.

Enforce reuse in product, industrial & services.

Transformation & Competences: Identify and develop key skills and competences to the business and existing programmes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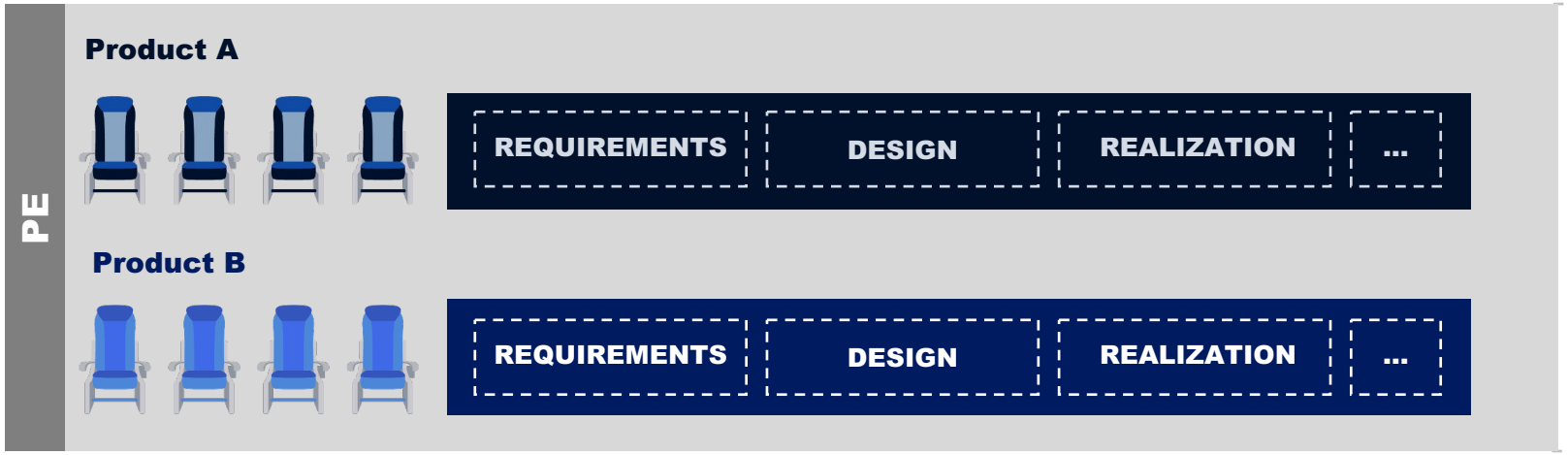
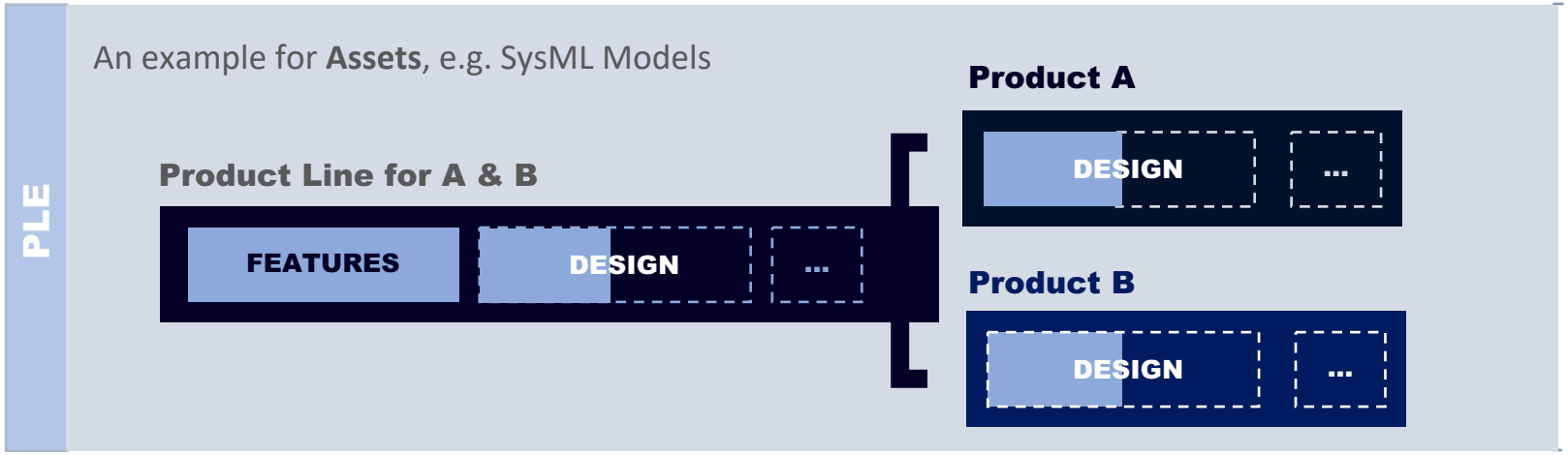
From Product Engineering (PE) to PLE



> Copy & Paste of assets between products

> No unique source of information for common and variable assets



> Managed reuse of common assets across different products

> Unique source of information for common and variable assets

WHY COMBINING MB(SE) WITH PLE IS ESSENTIAL?

Model Based Product Line Engineering is a new discipline that combines together the feature-based Product Line Engineering and Model Based Systems Engineering.

It enables the definition and management of variability within several architecture layers and the re-usability of the SysML models and other domain-specific assets.

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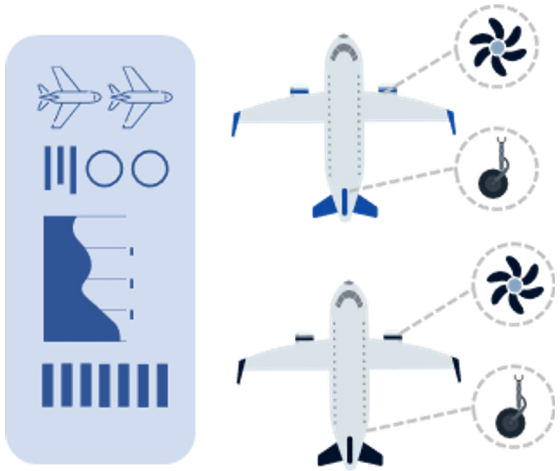
MB+PLE

Although PLE can be performed without an MB (SE) approach, combining MB with PLE effectively can lead to extremely efficient, manageable and capable product design and development.

The combination of MB and PLE enables a full advantage in **engineering the products commonalities while managing their differences** towards realizing a significant return on investments.

MB

PLE



Model Based

An MB(SE)approach to ensure:

- **TRACEABILITY // CONSISTENCY**
- **EFFICIENCY // COLLABORATION**
- **MANAGED COMPLEXITY**

Product Line Engineering

A PLE approach to enable:

- **SYSTEMATIC ASSETS REUSE**
- **MANAGED VARIATION & VARIANTS**
- **SINGLE SOURCE OF VARIABILITY**

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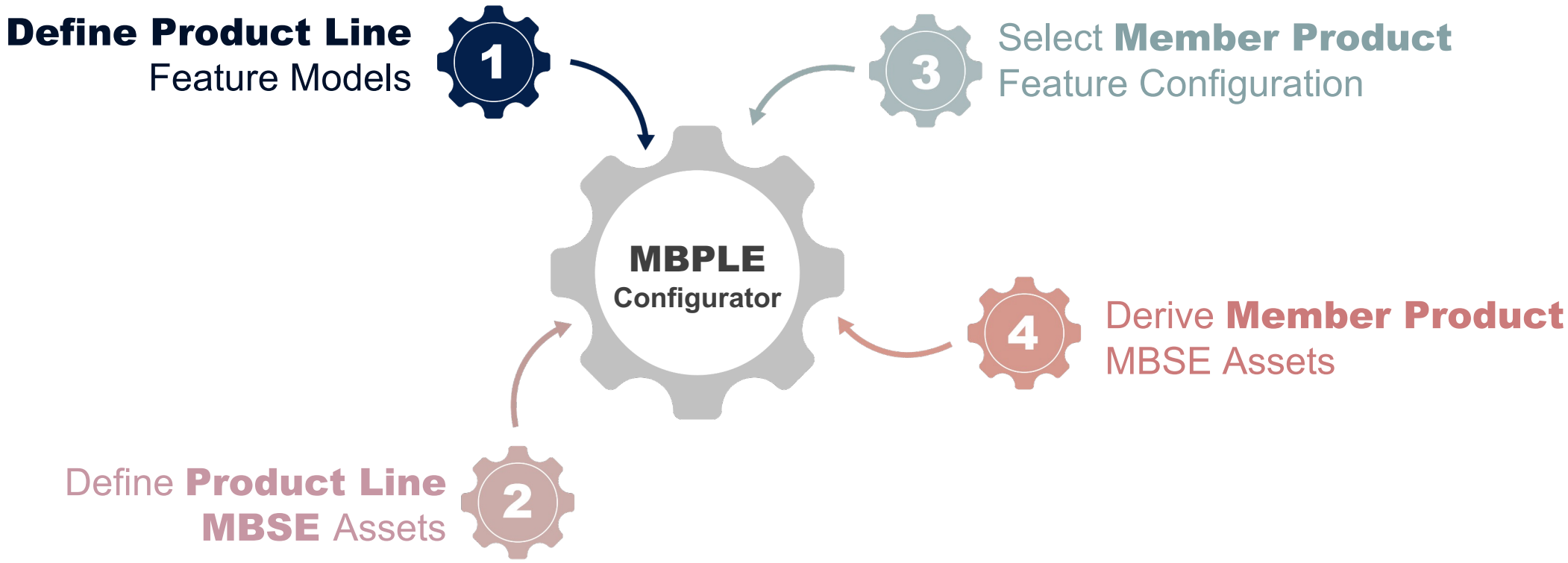
MBPLE Approach

The first steps to tackle the Method aspect consisted of analyzing different solutions and approaches in formalizing variability in both feature models and in SysML exploring different modeling techniques.



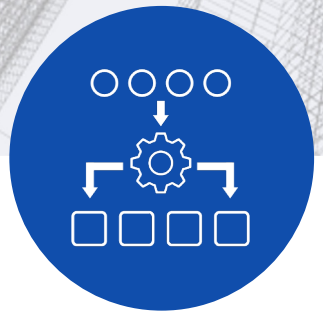
DDMS MBPLE FRAMEWORK

The aim of the DDMS MBPLE Foundation is to form the needed backbone for adopting MBPLE at Airbus.

It is composed of the following elements:

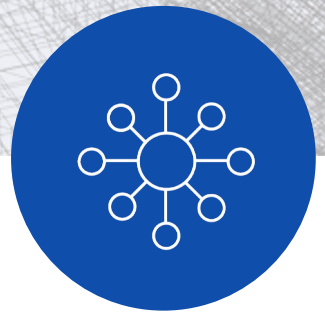
Process

Methods & Handbooks



Information Model

Tools



Environment

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MBPLE Foundation

MBPLE Process is based on existing standards

> ISO standards:

The ISO/IEC 26580:2021 is a specialization of the more general reference model for software and systems products line engineering and management described in **ISO/IEC 26550.**

The ISO/IEC 26580:2021 addresses a class of methods and tools referred to as feature-based software and systems product line engineering, or feature-based PLE, which has emerged as a proven and repeatable product line engineering and management (PLE) practice supported by commercial tool providers.

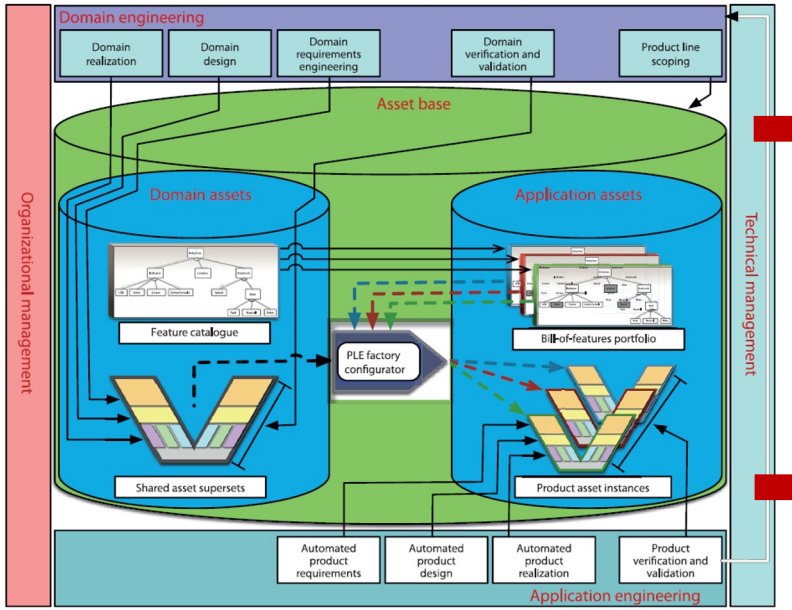
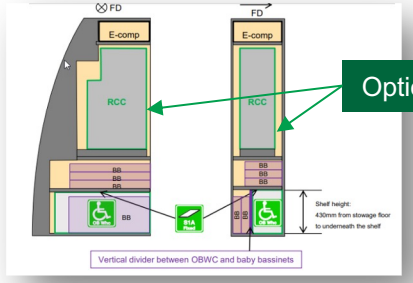


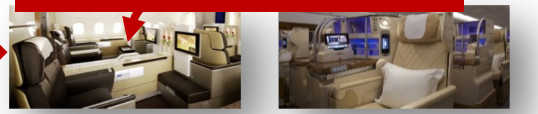
Figure 2 — Feature-based specialization of ISO/IEC 26550



Optional

Cabin Assets (standard and optional assets)

Reuse of the PL Assets Base elements



A380 Business Cabin Lufthansa

A380 Business Cabin Emirates

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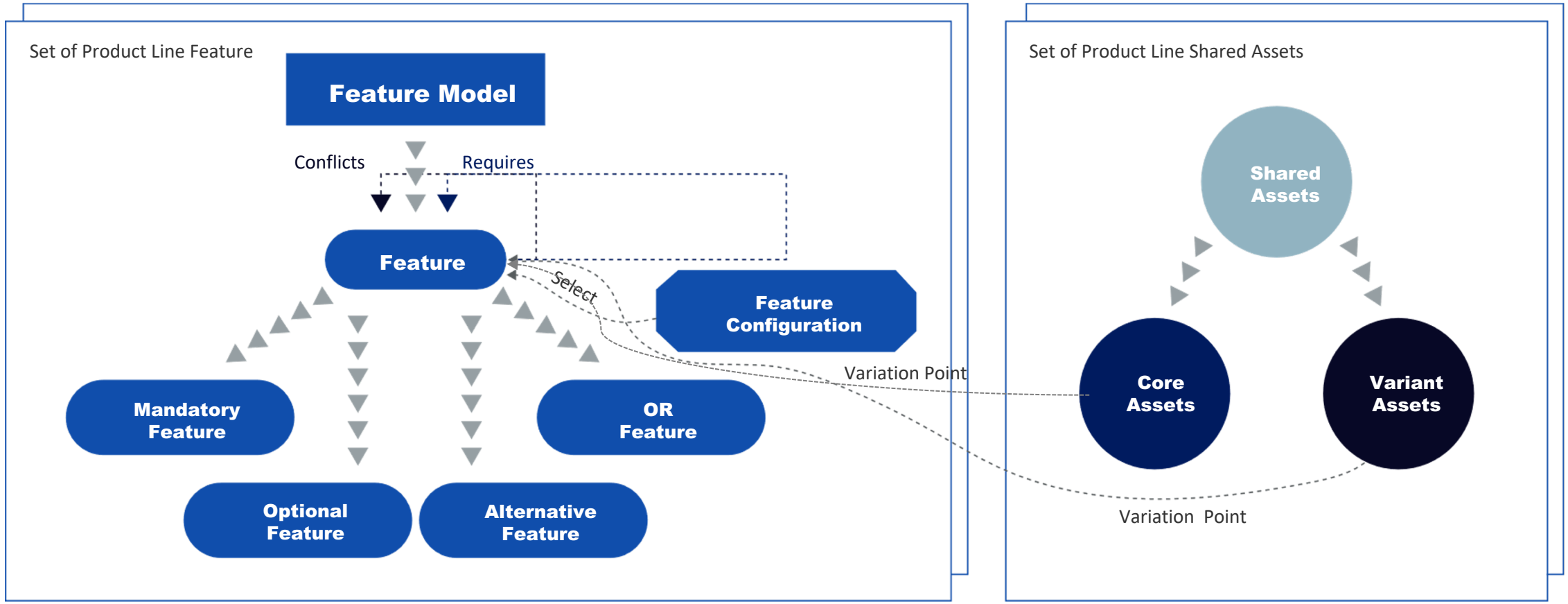
Basic Information Model

We started with a simple information model to bring all the key stakeholders together without focusing on a specific tool-notation.



variationPoint = Point at which you must make a decision based on the selected feature set

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Current Tools

Tactical MBPLE Toolchain

Current toolchain represents a **tactical solution** to enable deployment of MBPLE in PoCs and test solution.

Systems Modeling Tool
System modeling solution for product line architecture SySMl assets

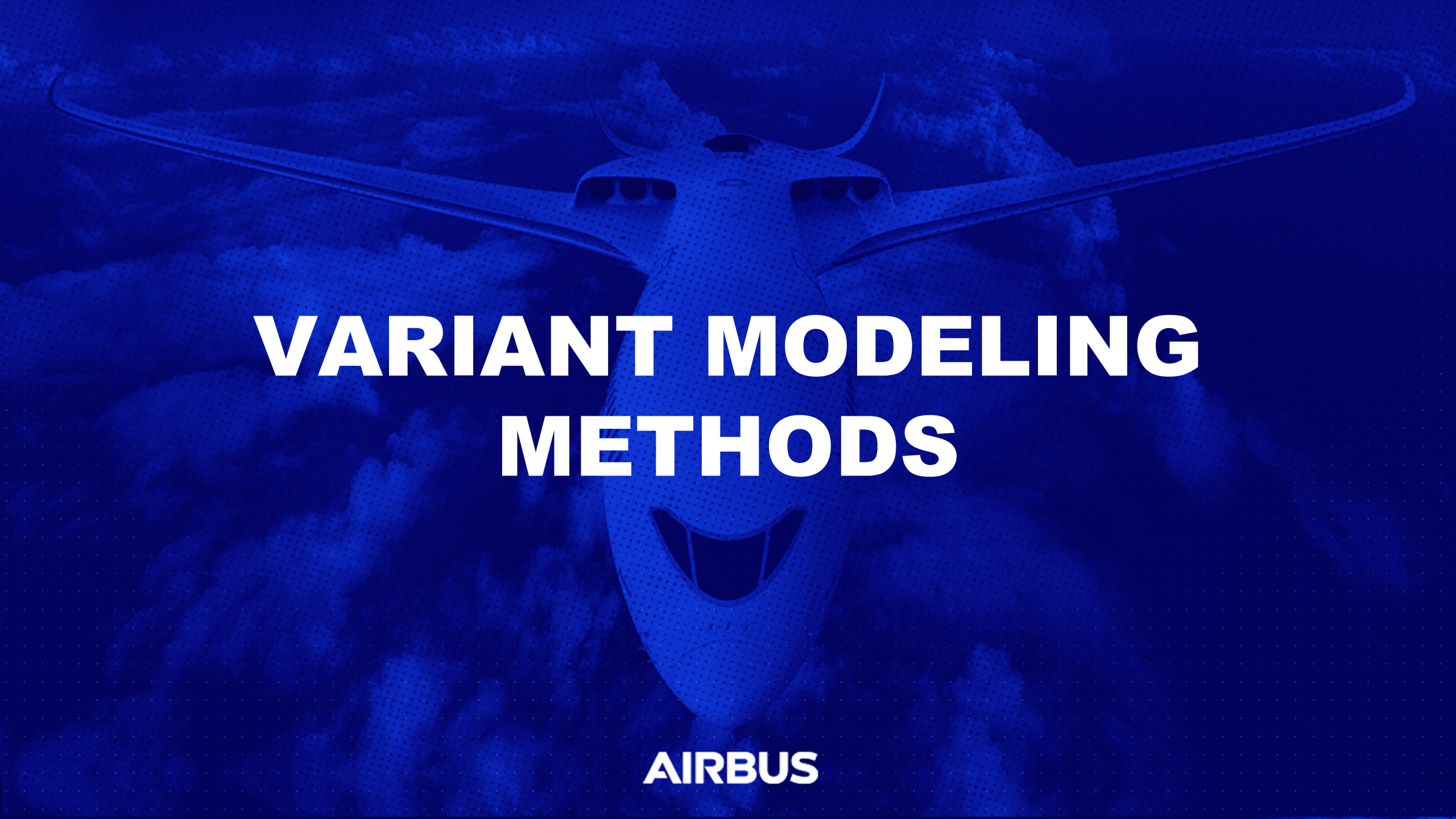
PLE Tool
Variant Modeling solution to control and transform 150% models into 100% models.

Cameo Modeler Plugins
In-House Feature Modeling solution in Cameo synchronized with PureVariants to faciliate varianbility elicitation.

Requirements Management Tool
Requirements management and Requirements engineering solution for product line.

Assets Repository ManagementI
Repository and Collaboration solution for managing SysMl assets.

Feature Repository Management
Repository and Collaboration solution for managing Feature Model files.


VARIANT MODELING
METHODS
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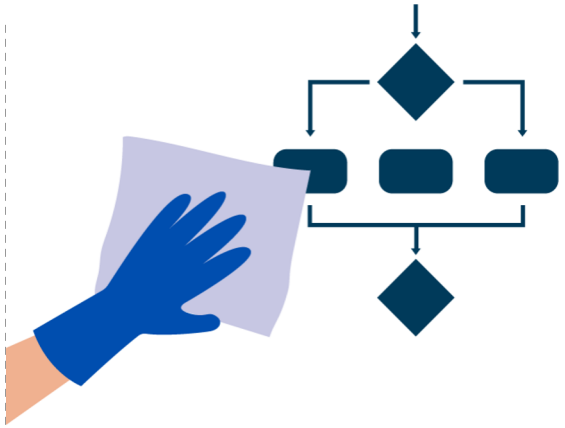
Why Two Variant Modeling Approaches?

Direct & Clean

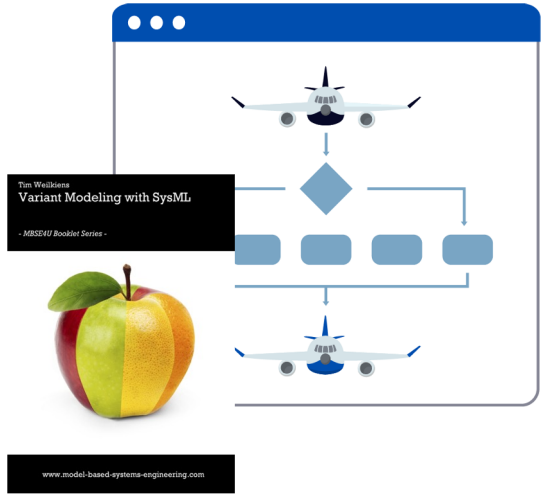
In the early phase of method definition, we analyzed different solutions and approaches in formalizing variability in both feature models and in SysML.

This led us to the formalization of two methodological approaches that for simplicity we called “Direct” and “Clean”. Both approaches resulted to be valid and we decided to let key users test both.



Direct:

Inspired by current tool-based solutions



Clean:

Inspired by VAMOS

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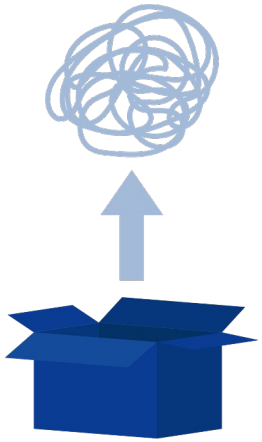
Setting the Boundaries

SysML and Product Line Modeling - A Challenging Liaison

Although SysML enables the modeling of a wide range of systems engineering tasks, it is not a language developed specifically for product line modeling…

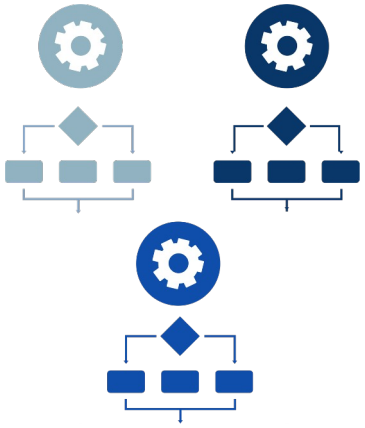


MBPLE Out-of-the Tool

Today´s modeling approaches are mainly driven by tool solutions. No so much thinking on the formalization method.

Features as Single Source of Variability

when a product line development life-cycle produces multiple assets, there is a great advantage in having the feature model, as a single source of variability, developed and managed independently from any of the assets



Method and Tool - Keep it close, Keep it separate

At Airbus, the method formalization is kept separate by its implementation with a specific tool or tool-chain.

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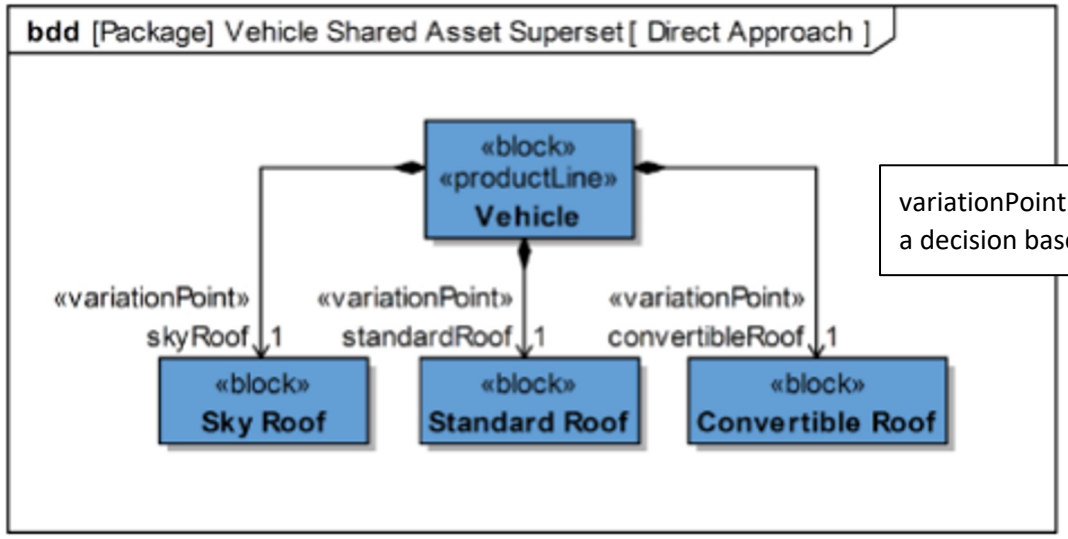
Two Variant Modeling Approaches

> **DIRECT:** Focus on easy modeling leads to a 150% model

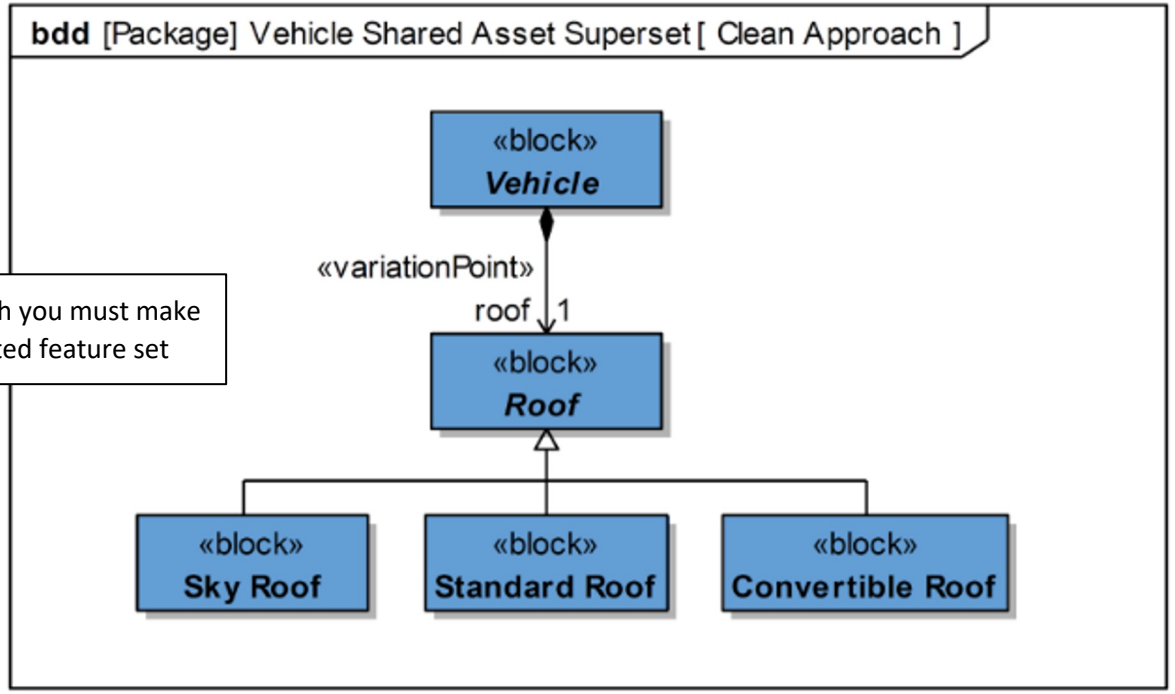
> **CLEAN:** Focus on modeling of common concepts leads to reusable abstract concepts

Direct



variationPoint = Point at which you must make a decision based on the selected feature set

Clean



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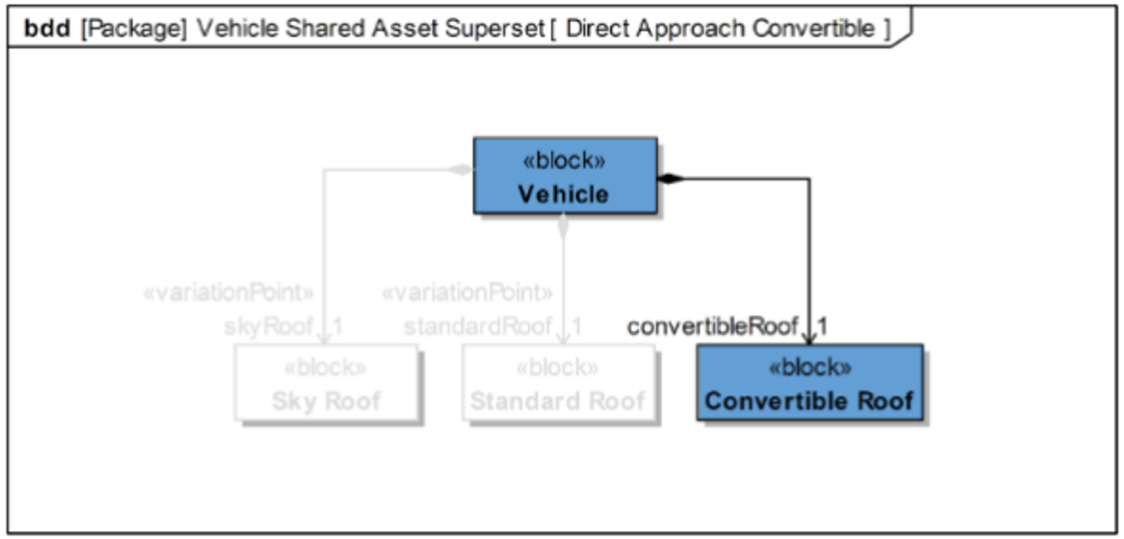
Two Variant Modeling Approaches: Member Product

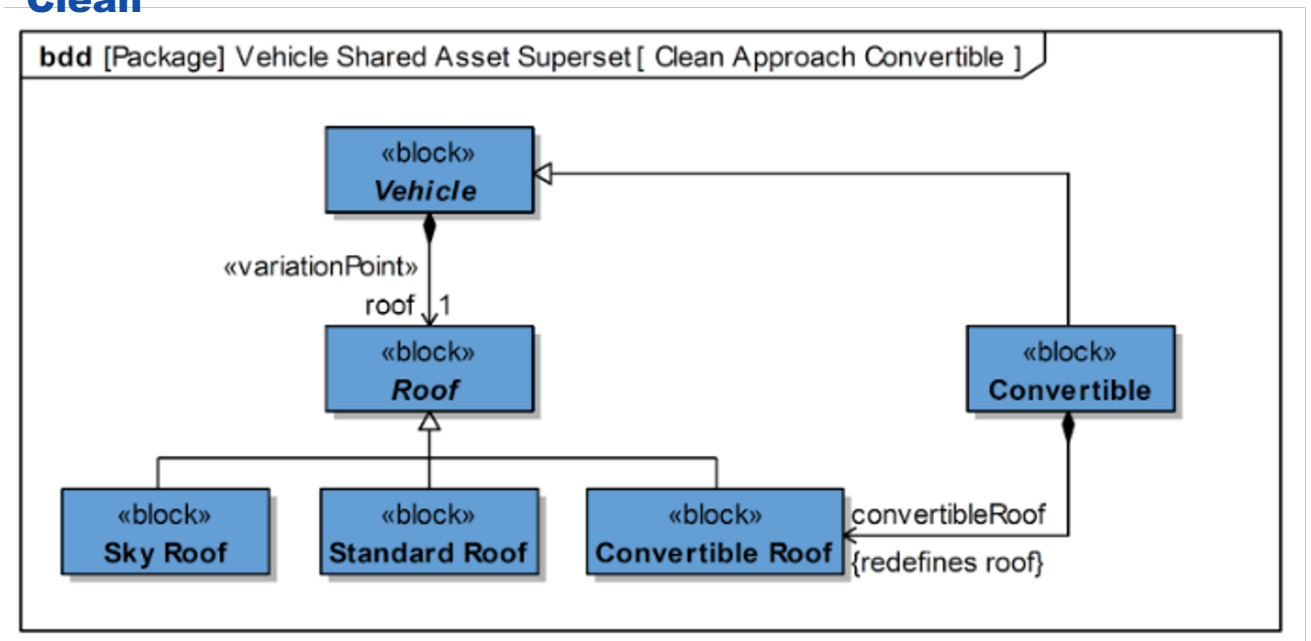
> **DIRECT:** Create a member product model by a model2model transformation

> **CLEAN:** Create a member product by specialization and redefinition of common concepts

Direct



Clean



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Practical Example

Full-height Stowage

The example used in this work to illustrate the two modeling approaches consists of the Full-height Stowage (FHS) module that is part of the cabin of different Airbus aircrafts (e.g. A350). The FHS module was selected because it is a relatively simple system that includes a certain level of variability and it allows us to show the key aspects of the two methods without entering complex aeronautical systems.

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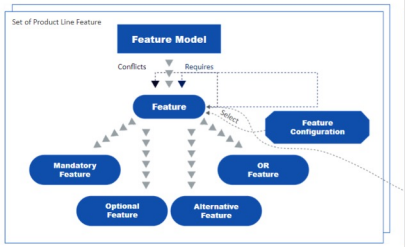
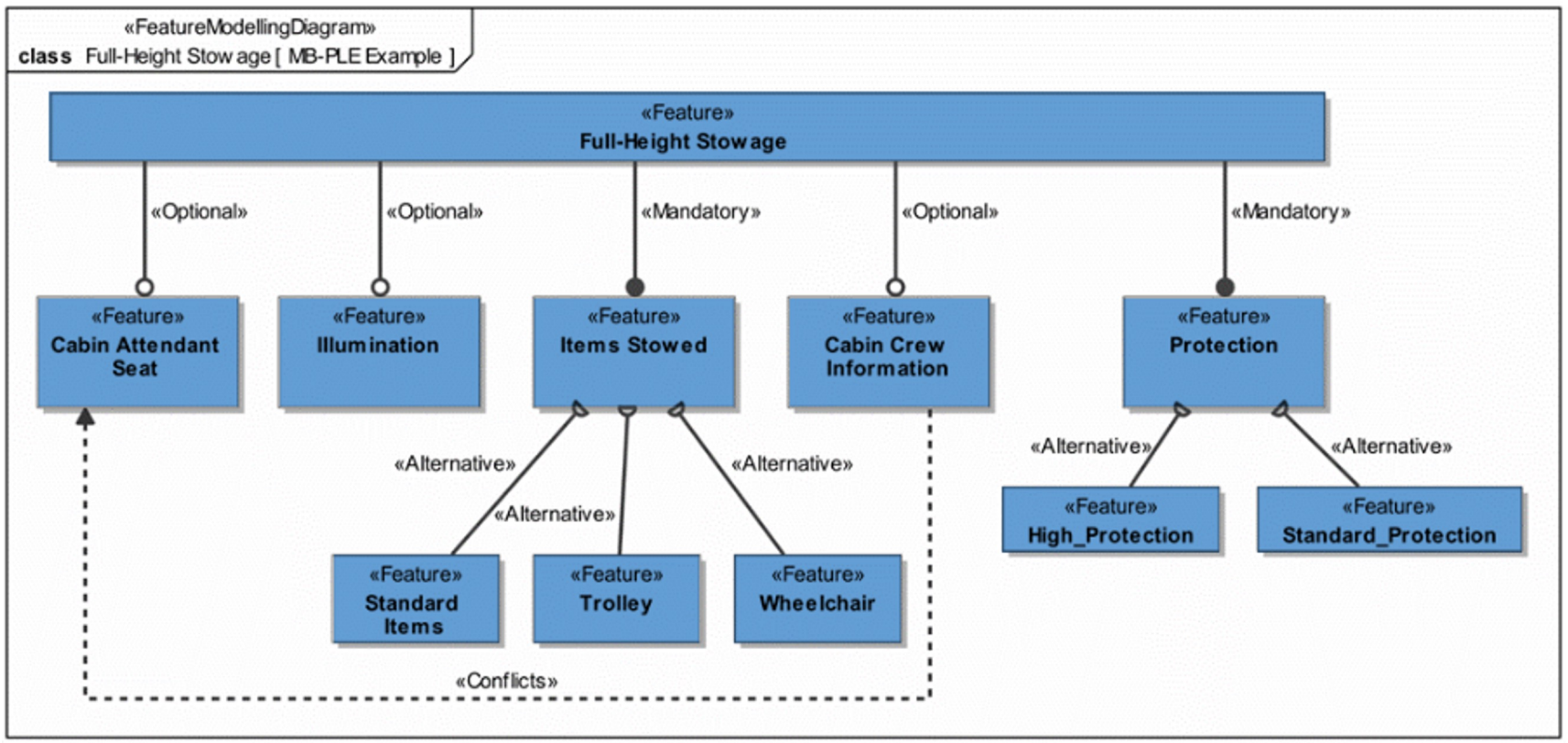
Features & Configurations



The first step is to define the feature model including the allowed configurations. SysFM was used here.



Model Elements	Level	FullHeightStowageStandardWithLight	FullHeightStowageStandardWithoutLight
FullHeightStowage			
FullHeightStowage		✓	✓
CabinAttendantSeat	1	☐	☐
CabinCrewInformation	3	☐	☐
Illumination	2	☑	☐
ItemsStowed	4	✓	✓
Protection	5	✓	✓

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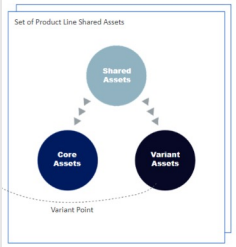
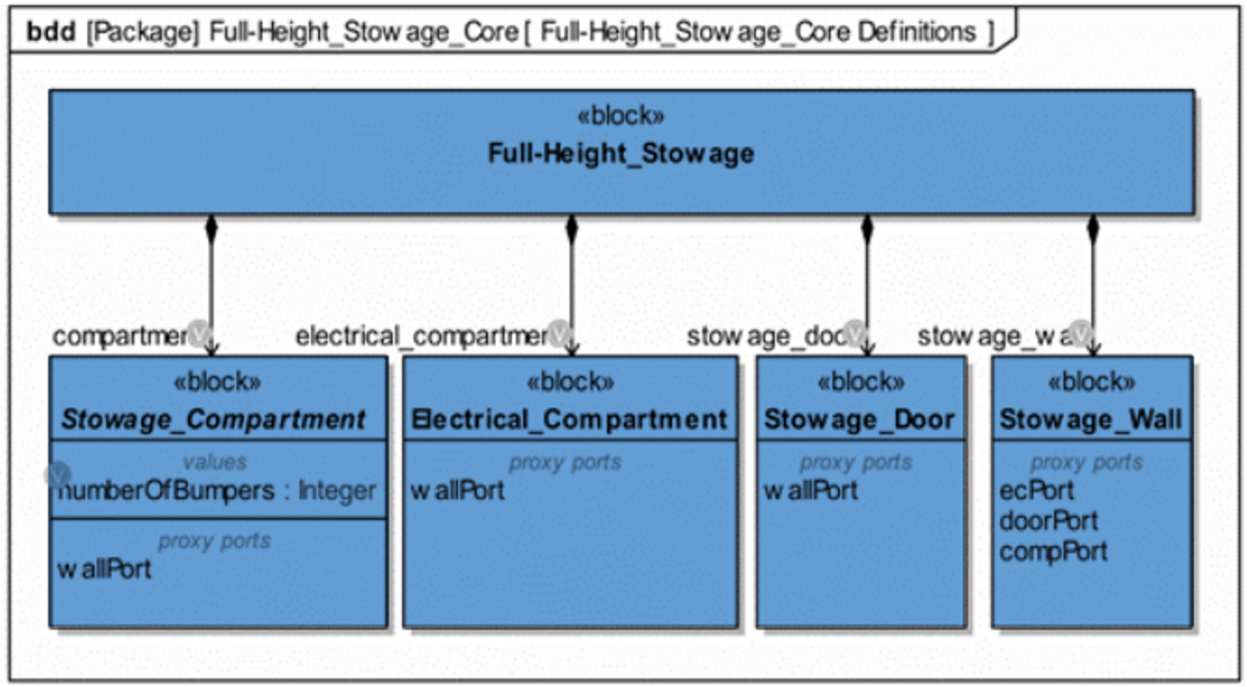
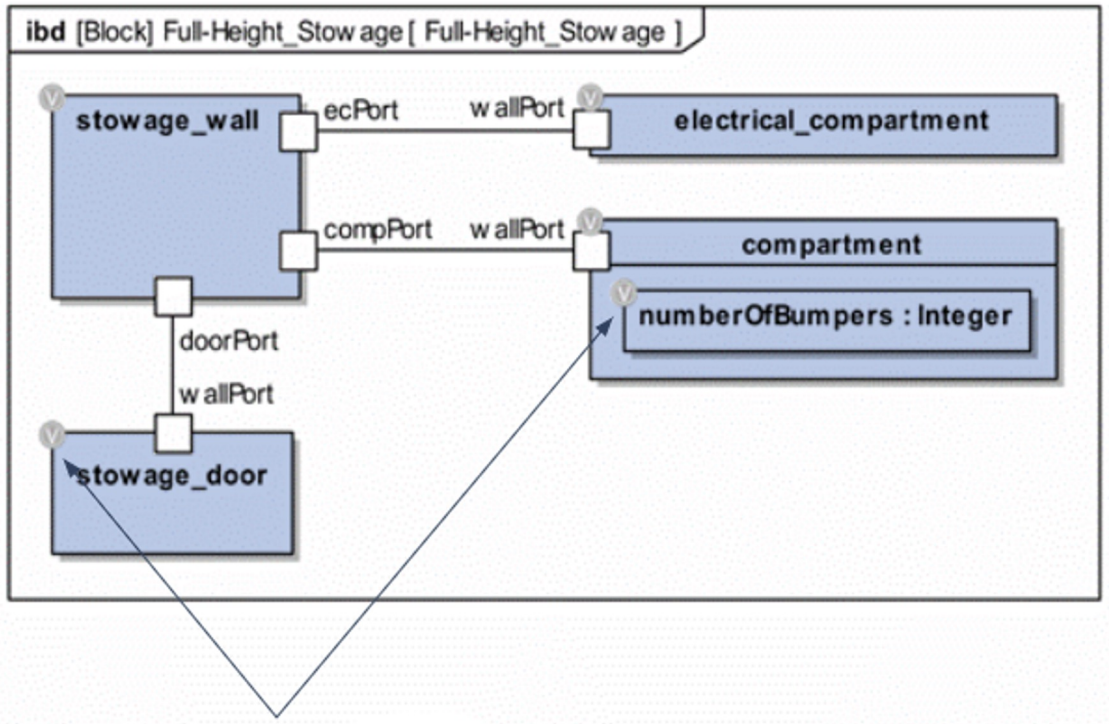
Clean - The Core

The core of the product line model contains all the features that all variants have in common. In the clean approach, they are strictly separated from the variable elements.







Variation points

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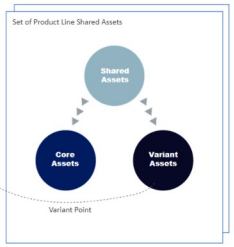
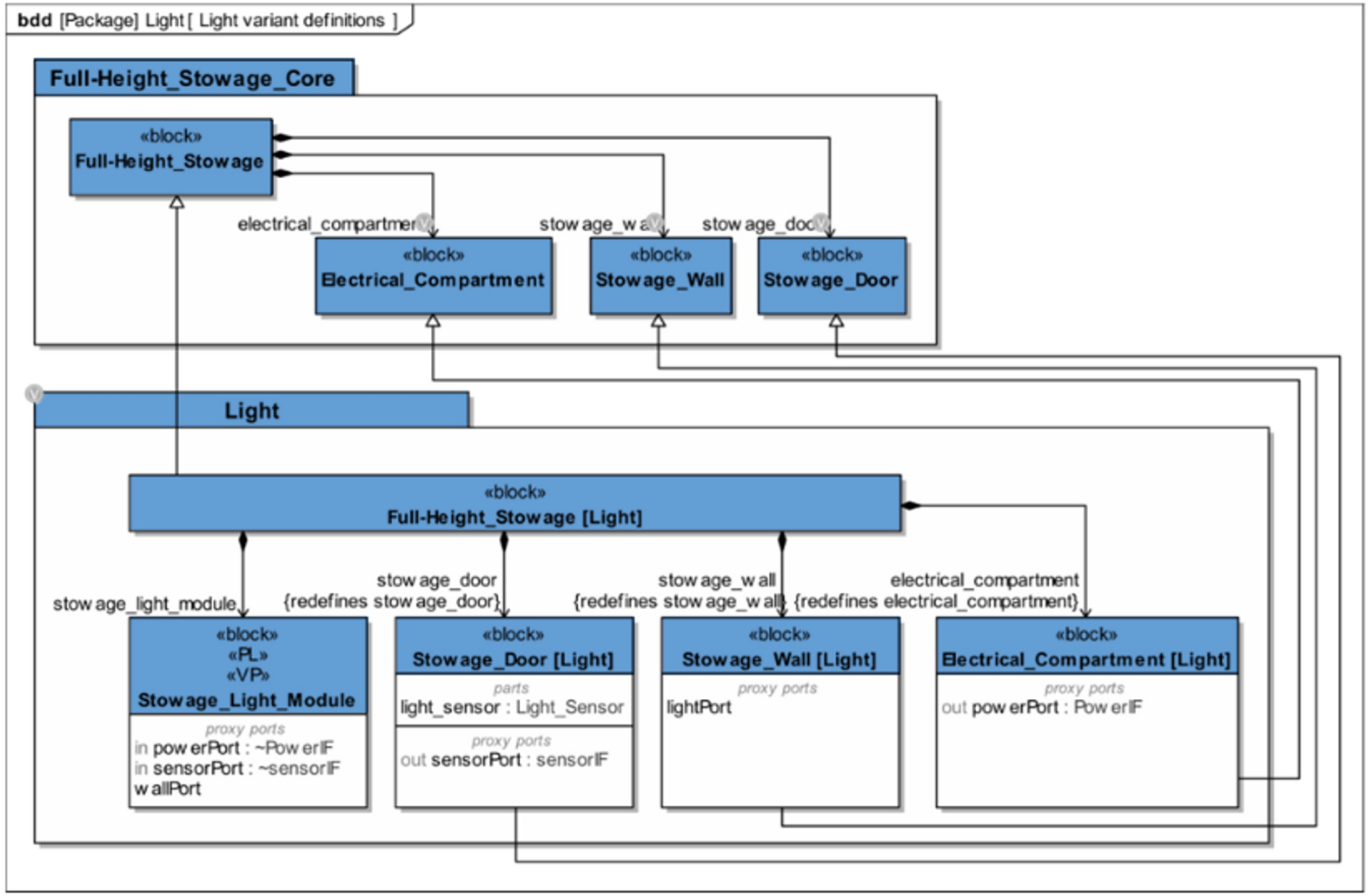
Clean - Modeling of the Illumination Feature

All elements that belong to a feature are in a package.
Some specialize core elements.





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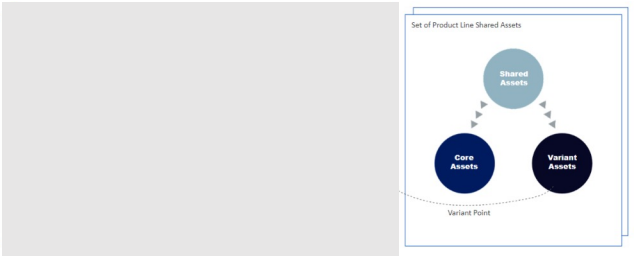
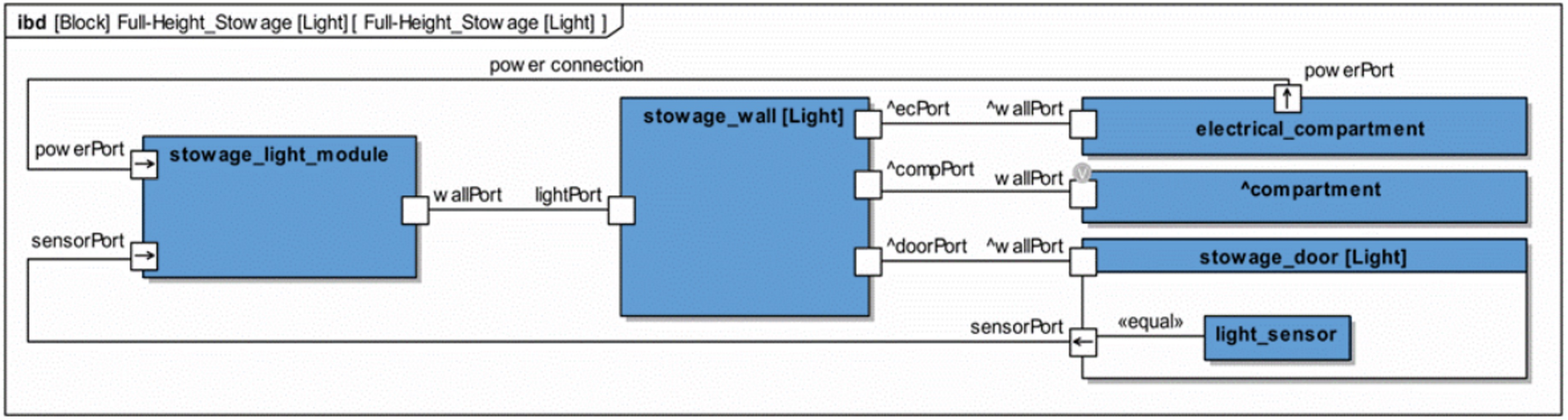
Clean - Modeling of the Illumination Feature

The internal block diagram depicts the connections between the parts.





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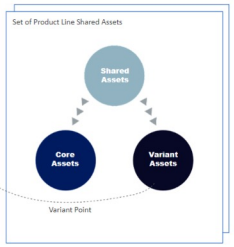
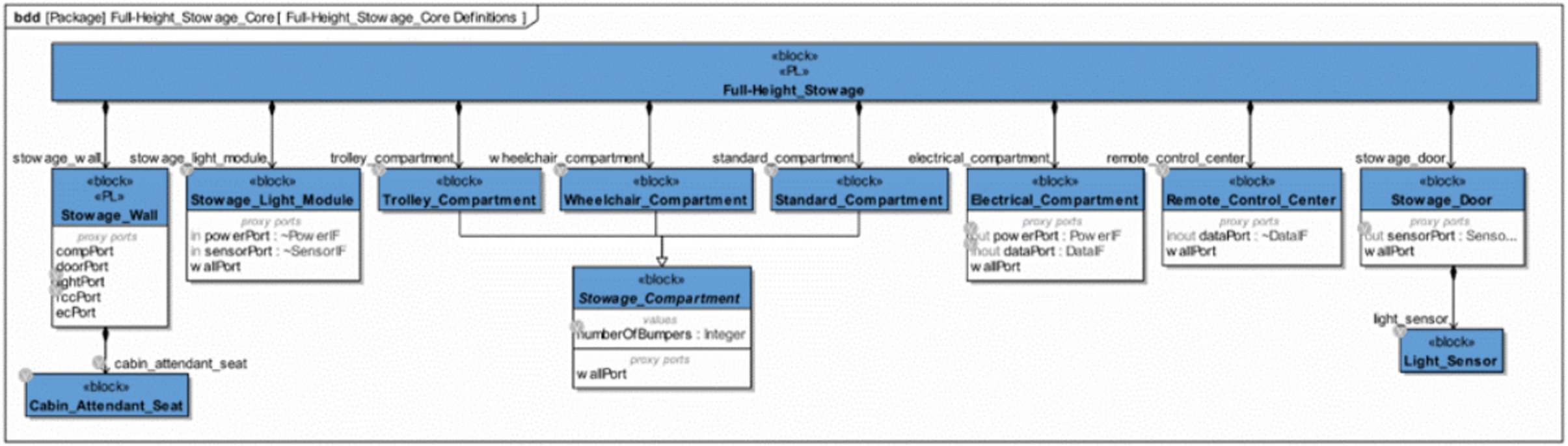
Direct - Definition of the parts

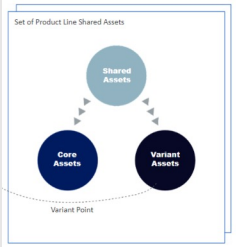
In the direct approach, the elements of all variants are defined together in one system, the product line. This also often called the 150% model, because it represents a 150% system.

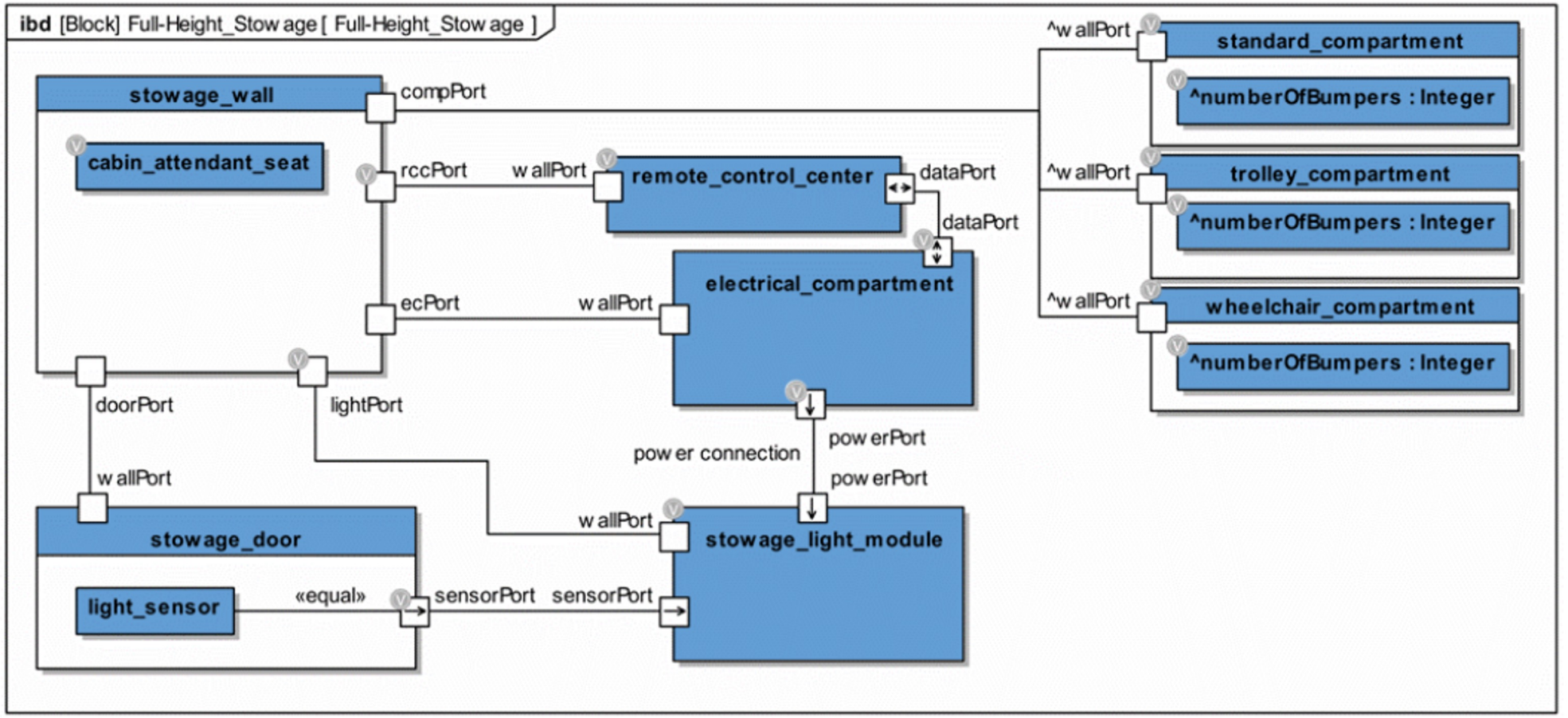




Direct - Modeling of the internal structure

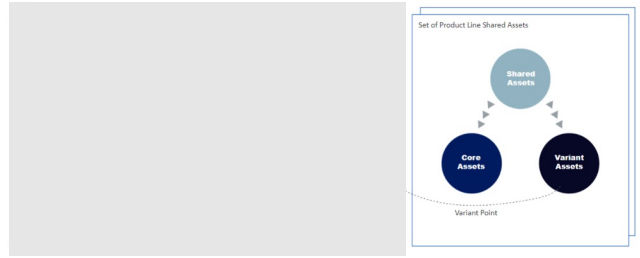
In the direct approach, all connectors of all variants are also modeled.

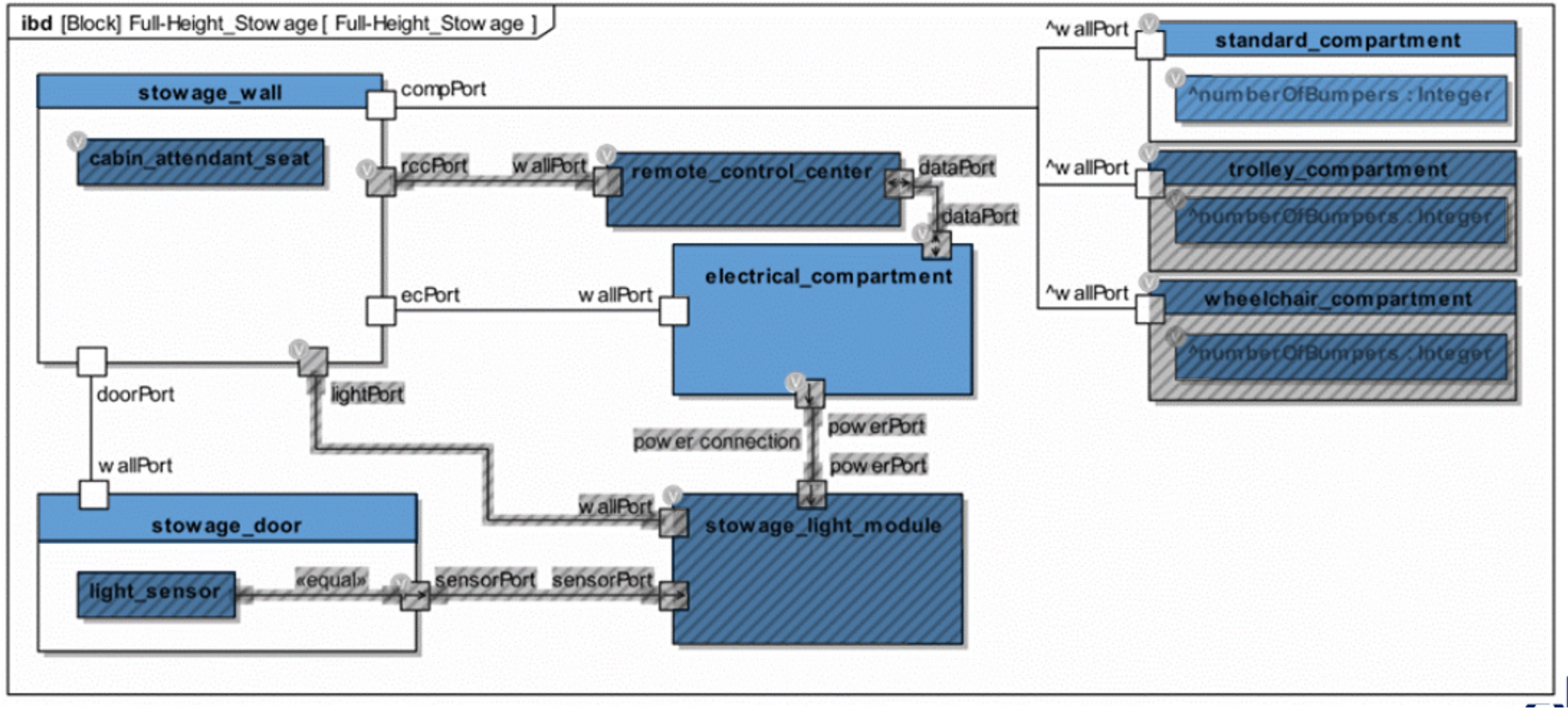




Direct - Derive a member product

Depending on the tool, a preview can show which elements are removed when a model2model transformation is performed to create a concrete configuration. Here it is FullHeightStowageStandardWithoutLight.





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Comparison Clean & Direct

The two methods have advantages and disadvantages depending on the purpose. It is not possible to make a blanket assessment of which of the two approaches is the better one. Both approaches can be used in parallel in the same product line model.

Clean:

Many specializations need to be modeled, which means more effort, but which should pay off if **modularity** is a quality requirement for the model.

Effort increases with the number of variants and allowed combinations. Promotes that product configurations are thought through and defined in advance.

Clean separation of core and variant elements.

X

Direct:

The direct approach is less costly and is thus suitable, for example, in the **early phase** to develop and evaluate different architecture variants.

Provides comprehensive views with all interfaces and connections. Becomes overcrowded with increasing number of variants.

Direct can be transferred to clean. The separation of core and variable elements leads to reusable elements.

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CONCLUSION
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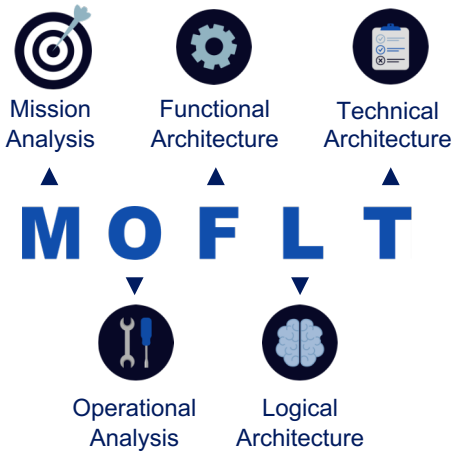
Next Steps



Development of an integrated variant modeling method within the Airbus MBSE Methodology named MOFLT

Optimization of the solution on multiple PoC

Launch the support in the Airbus Next Generation Programs such as ZeroEmission

Exploration and improvement of existing vendor solutions that are not mature yet for an holistic MBPLE approach

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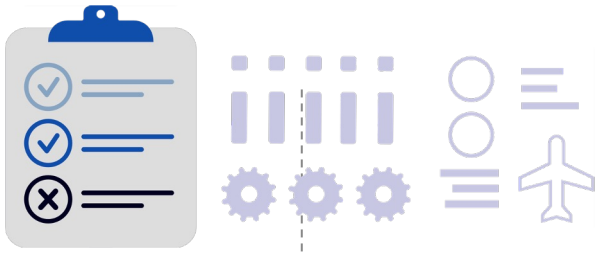
Takeway

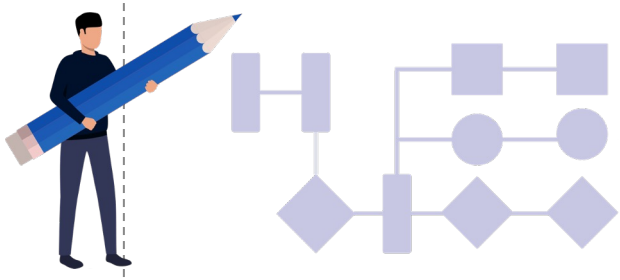


Follow existing Standards and do not reinvent the wheel

Talk to all stakeholders because MBPLE is a transversal topic, but simplify and adapt the language to the audience you have in front of you.

Detach the discussion from the tool and define tool-agnostic concepts and methods.

DRIVE the ***Tool,*** **don't let them *drive* YOU!**



Support the MBPLE adoption with a framework

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THANK YOU!

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