International Council on Systems Engineering
A better world through a systems approach

MBPLE Adoption in the European Aviation, Defense and Automotive Industries

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Agenda

- Icebreaker
- Introduction
- 3 European Industries: Aviation, Defense and Automotive
- Model-Based Product Line Engineering (MBPLE)
- MBPLE Adoption Framework
- Airbus Case
- MBDA Case
- Iveco Group Case
- What we have learned from the 3 MBPLE Adoption Cases
- Conclusion & Future Outlook: What´s Next?
- MBPLE book & PLE Exchange

NH90: €292 M invested, 12 years of operation and…

The NH90 helicopter has faced numerous customization problems, leading to significant operational and logistical challenges for several countries. These issues include limited ground clearance, weight restrictions for troops and cargo, insufficient space for equipment and weapons, and difficulties in deploying troops rapidly.

Norway Is Done With Its Unreliable NH90 Helicopters, Wants $500M Back

No amount of money, spare parts, or maintenance time will get the Airbus-built rotorcraft flying reliably, Norwegian defense officials say.

DAN PARSONS / JUN 10, 2022 3:10 PM EDT / 273

Belgium retiring NH90 helicopters due to maintenance costs, 'bad purchase'

AIR

14 JULY 2025 | By: Robert Dougherty

Australia's NH90 Helicopter Nightmare Is Finally Ending

Australia has dumped its NH90s after years of budget blow-outs, low availability, defects, mission failures and the tragic loss of aircrew.

JOHN HUNTER FARRELL / OCT 3, 2023 12:41 PM EDT / 277

Despite its modularity promise, the NH90 ended up with 23 national variants. Logistical fragmentation followed. The lack of standardized spare parts, prolonged maintenance cycles, and disproportionately high operating costs (€15,000 per flight hour) rendered the platform tactically unreliable and economically unsustainable.

Introduction: MBPLE as logical evolution of PLE and MBSE

Axiom 1: GIVEN THAT systems engineering has as focus a single system of interest (SOI). (INCOSE Handbook V)

WHEN an organization develops more than one system.

THEN systems engineering shall have a Family of Systems as SOI.

Axiom 2: GIVEN THAT "MBSE will become the norm for systems engineering (Previous INCOSE Visions)

THEN Model-Based Product Line Engineering will become the norm for feature-based PLE!

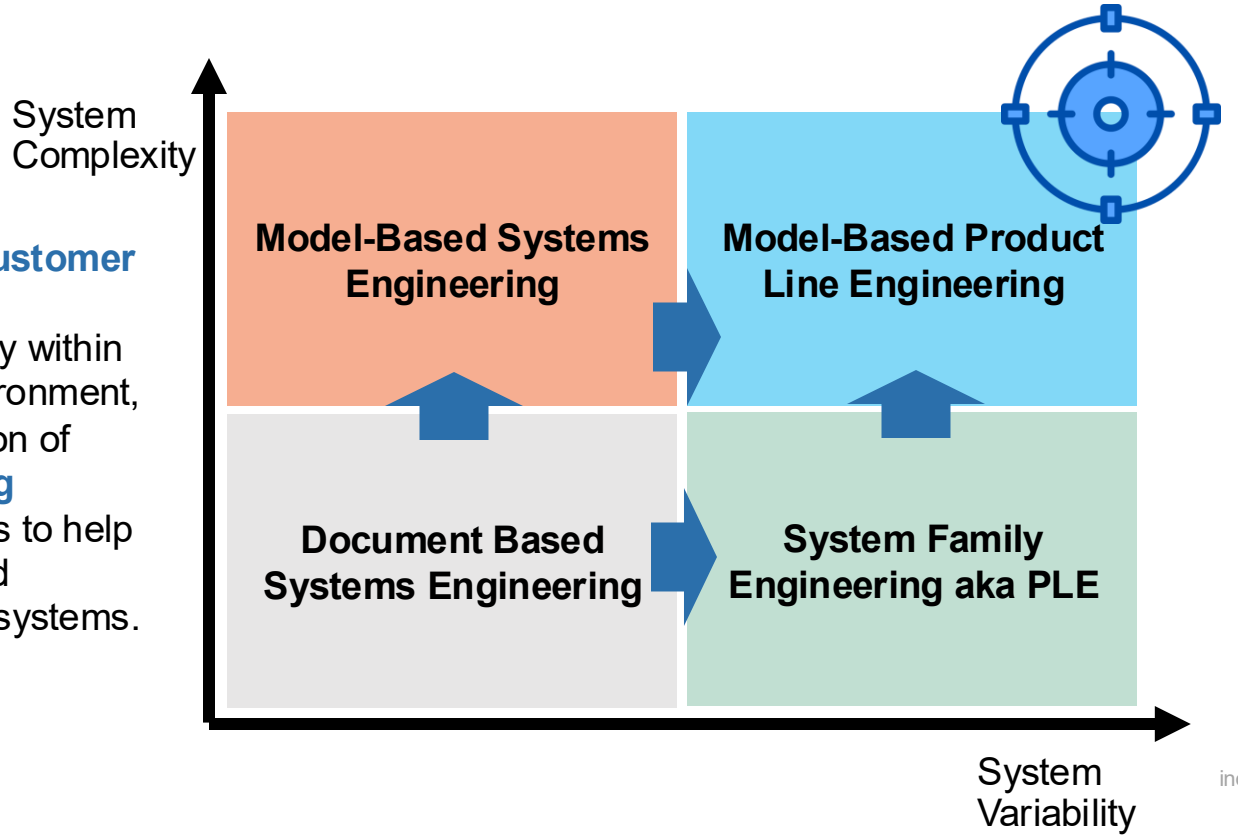
AIRBUS MBDA IVECO • GROUP

*are pioneering this **"new" paradigm** in their industries, **sharing commonalities** and **differences** in its adoption!*

This is what this presentation and paper is about…

Introduction: System Complexity & Variability

Addressing **specific customer needs** and **increasing complexity**, particularly within a highly regulated environment, requires the combination of **advanced engineering practices** and methods to help balance **variability** and **complexity** in today's systems.



3 European Industries: Aviation, Defense and Automotive

Defense

Development spanning **over** a **decade, rapidly evolving geopolitical threats** now demand **faster delivery** of new capabilities

Requires **advanced engineering methods** to manage their **complex design**

Relies on **highly specialized Engineering-to-Order (ETO)** further **extending development time**

3 European Industries: Aviation, Defense and Automotive

Aviation

Safety is the primary driver for **development** and **operation**

Highly complex and **regulated products, lower production rates, high customization,** and **long-life cycles** spanning decades

Diverse operational **environments** and varying **customer needs**

3 European Industries: Aviation, Defense and Automotive

Automotive

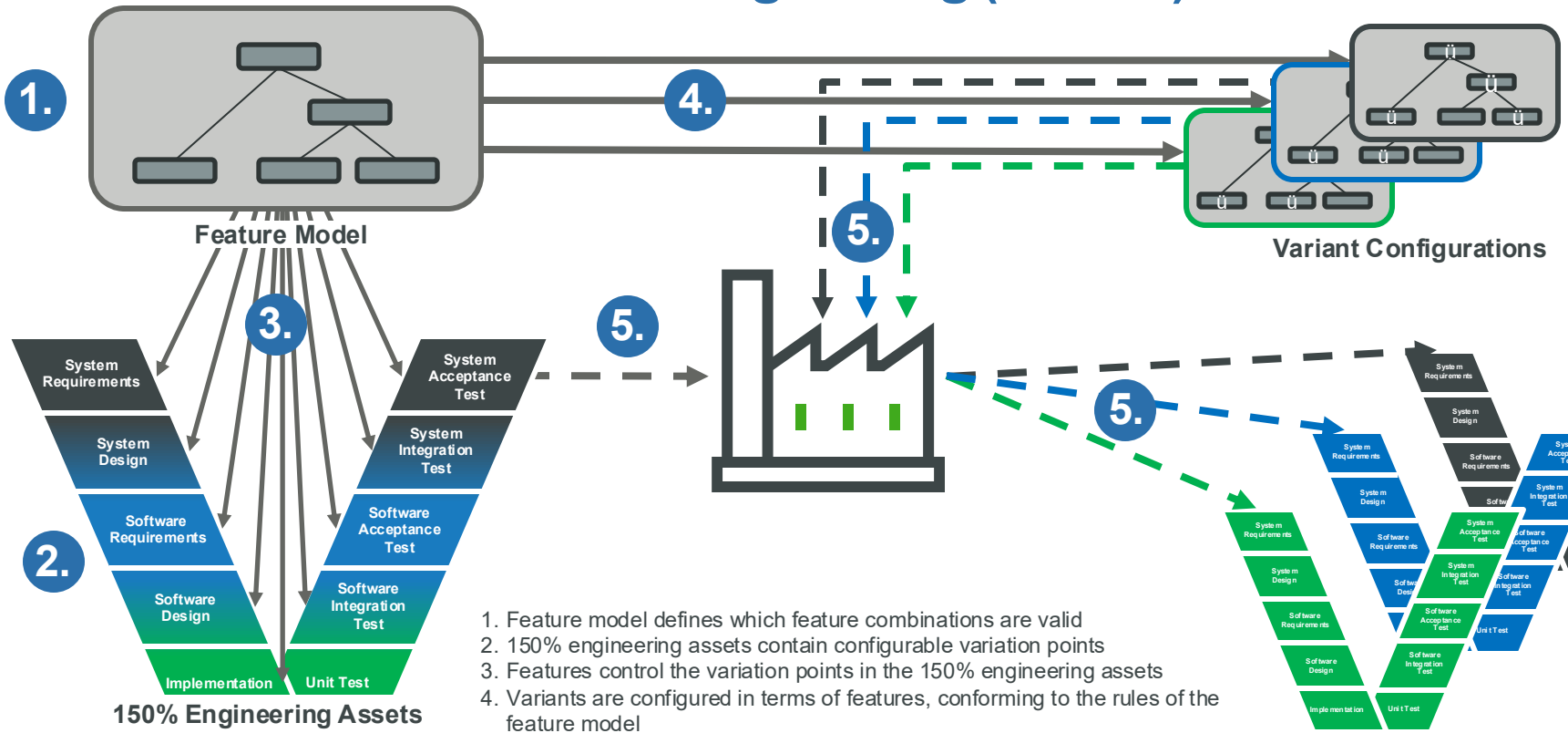
Commercial vehicles require **customized solutions tailored** to **specific demands** for **different customers** and **markets**

Emergent technologies on connectivity, ADAS, electrification, and new HMI **increase** the **technical complexity of the product**

Without a systematic and structured **approach,** dealing with a **significant number of product variants becomes complex** and **risky.**

Model-Based Product-Line Engineering (MBPLE)

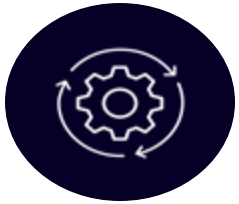
ISO 26580



1. Feature model defines which feature combinations are valid
2. 150% engineering assets contain configurable variation points
3. Features control the variation points in the 150% engineering assets
4. Variants are configured in terms of features, conforming to the rules of the feature model
5. Controlled by the variant models, Pure Variants takes the 150% engineering assets as input to produce the 100% engineering assets for every variant.

MBPLE Adoption Framework

Like for MBSE, the **adoption** of **MBPLE requires** careful **planning** and **clear definition** of its **key pillars** and enablers.

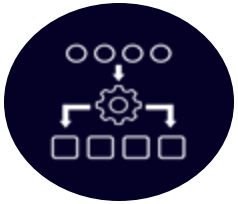


Process

Impact on **Technical and Technical Management Processes**, as outlined **in ISO/IEC 15288**, but also broader **Business** and **Procurement Processes**

Methods

How to **define Feature models** and **asset variations** should remain consistent with **ISO/IEC 26580**, but different methods can be applied to manage **variability in specific domains**.

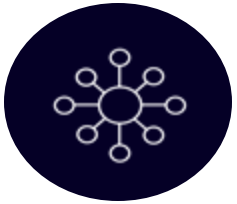


Information Model

More than just the **modeling language**; it requires an **information model** that i**ntegrates** all **relevant domains**. This ensures **consistency** and **supports tool independence** across different methods.

Tool Chain

The PLE solution is the “engine”. However, a holistic **toolchain should also include** the **MBSE tool** and other key solutions such as **ALM, PLM** and the overarching **Configuration Mgmt**.



Organization

Aligning all sectors, divisions and functions around a **common delivery approach**. **Adapting** the **organization** to being able to develop a product line and derive products from it

Airbus – Motivation & Context

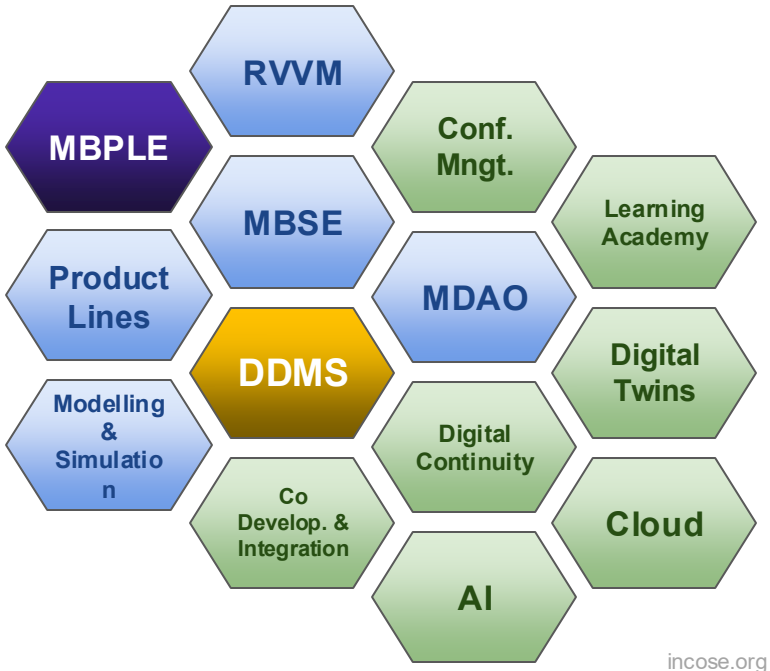
Addressing aerospace challenges through a model-based, product line approach

High Complexity & Regulation
Safety, long life cycles, diverse ops.

Growing Customization
Tailoring products, market needs.

Economic Pressures
Cost, fuel efficiency, time-to-market.

Legacy Systems
Integrating new with existing designs.



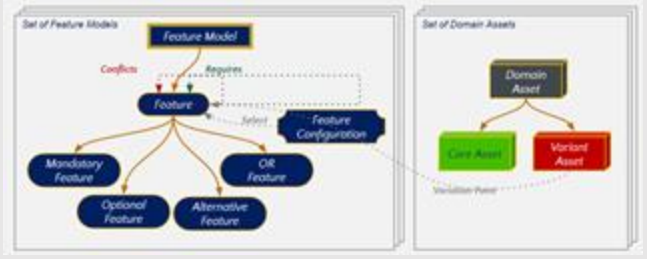
Airbus – MBPLE Adoption Framework

5 Pillars to establish MBPLE

Process

- ISO 15288
- ISO 26550
- ISO 26580
- Airbus BMS

Information Model



Methods & Handbooks

- Feature Modelling
- R-MOFLT
- REM
- Product Line Engineering

Tools

- Cameo Systems Modeller (MBSE)
- 3DX (3D, **RVVM*, **Elec, *PLE Factory*)
- IBM DOORS (RVVM)
- Pure Variants (PLE Factory)
- **Software and Control Systems*

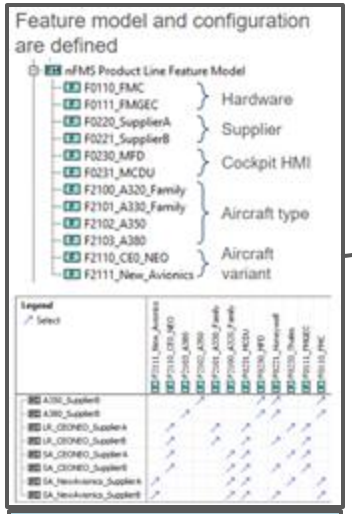
** under investigation*

Scope

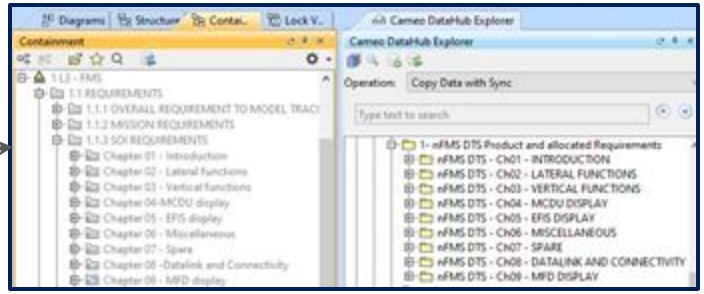
- Product, Industrial & Services
- Commercial, Helicopters, Defense & Space
- A/C, FAL, Components & Assemblies, Sub-Systems

Airbus – Example

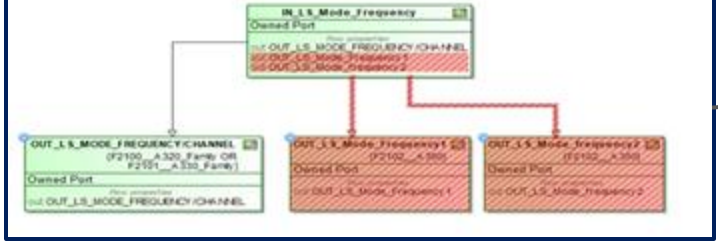
From Real World- New Avionics Simplified Workflow



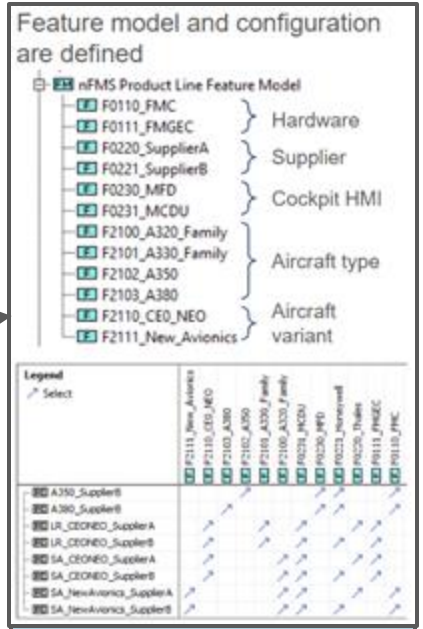
1. Define Feature Model and Feature Configurations



2. Import DOORS Requirements in Cameo



3. Functional Analysis using MOFLT, definition of Variation Points using Pure Variants, and use of MBPLE automation to cascade variation points from functions to imported requirements

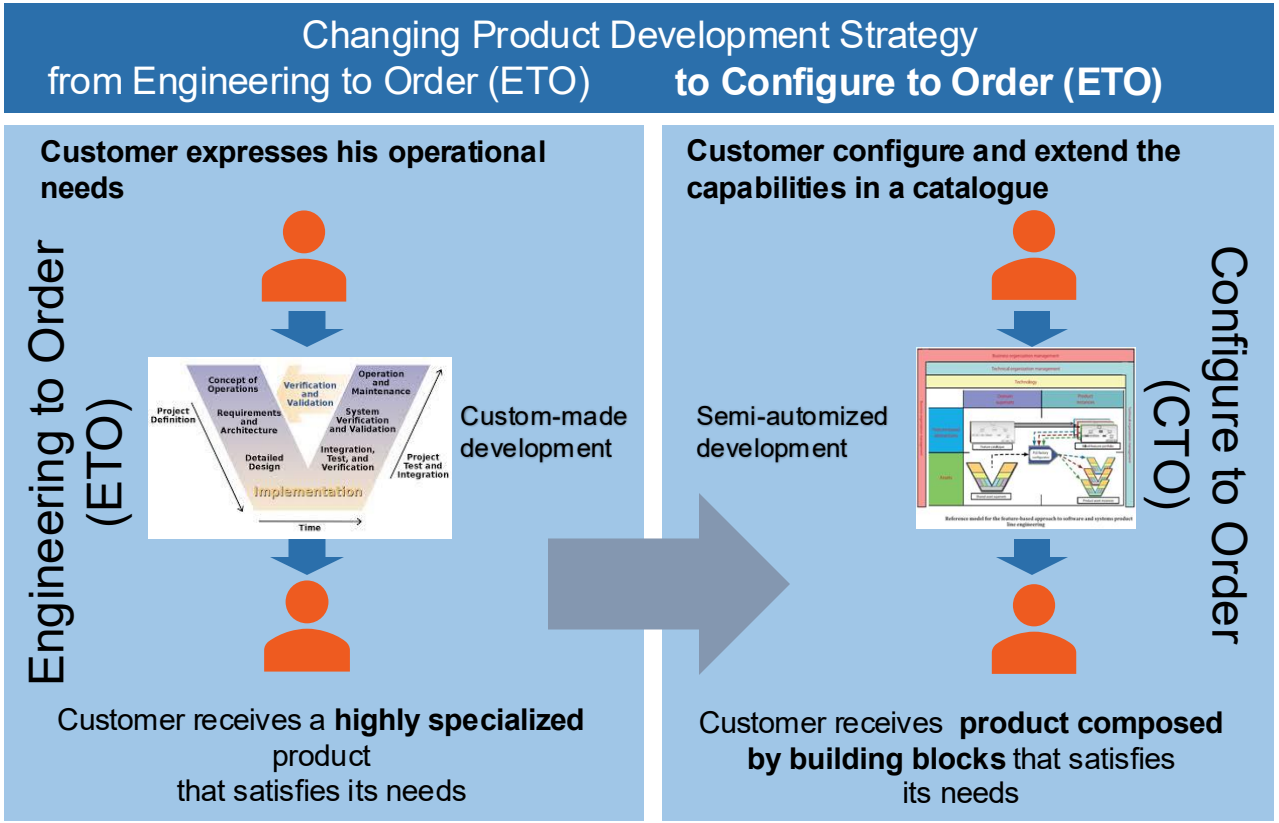


4. Use automation to fill the applicability from the requirements based on Feature Configurations. This allows integration to existing processes.

MBDA – Motivation & Context

From ETO to CTO

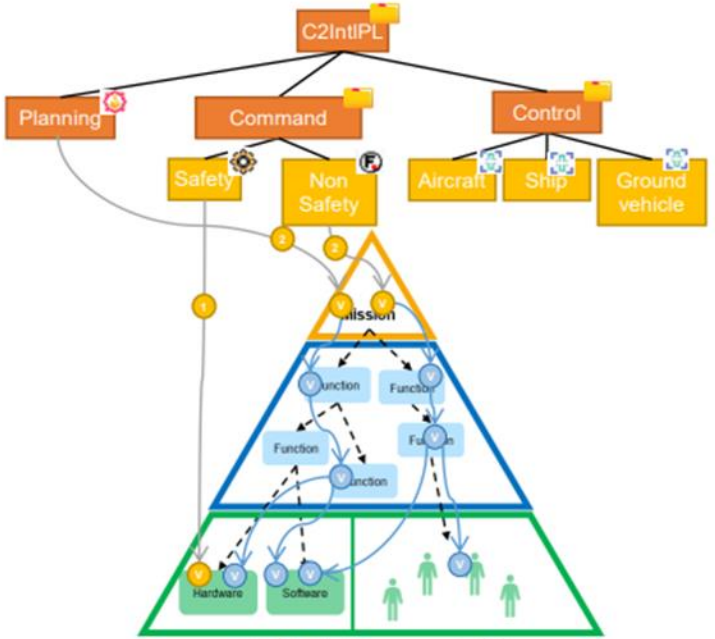
- Projects working in **isolation**
- **No cross-project** exchange
- **80%-90% commonality** in Functions across all products **but not shared**!
- **<10% commonality** in hardware -> specialised solutions



MBDA – MBPLE Adoption Framework

Extending the MBSE Framework with PLE towards – Process – Method – Information Model

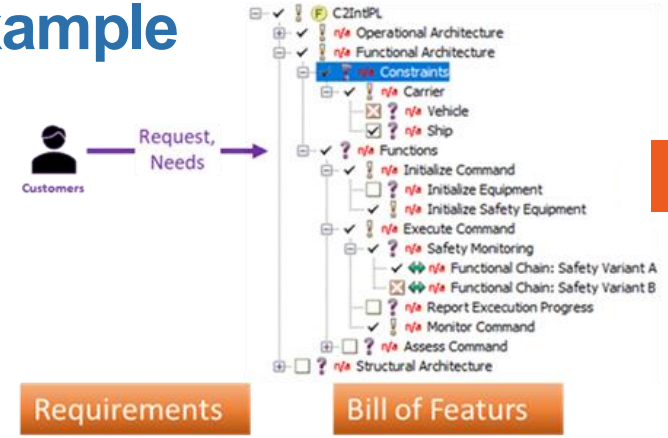
From the perspective of …	Needs and Requirements	States	Core Elements	Scenarios
	Characteristics of the system, necessary for system acceptability	Situations defined by invariant conditions, in which the system can be	The core elements of the systems and their interactions, independently from time	Sequence of interactions for considered situations
Operational architecture Environment	Stakeholder needs and requirements	Contexts	Stakeholders Use cases	Operational scenarios
Functional architecture System Behaviour	Functional requirements	Functional modes	Functions	Functional scenarios
Structural architecture System Structure	Structural requirements	Structural configurations	Sub-systems	Structural scenarios

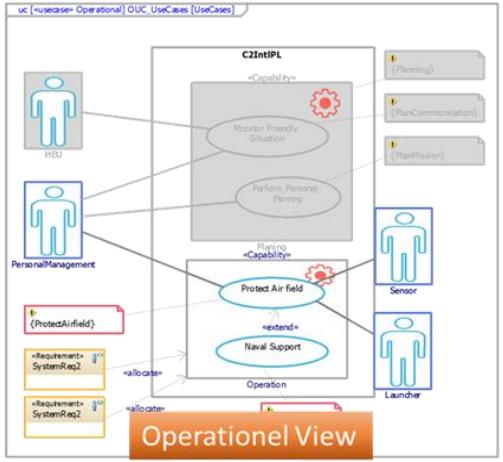


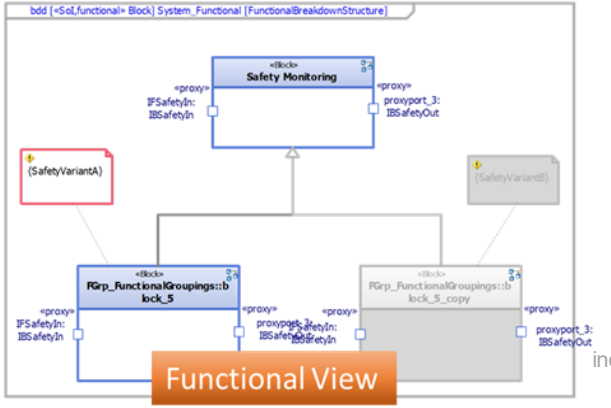
MBSE Model as a part of the Shared asset supersets

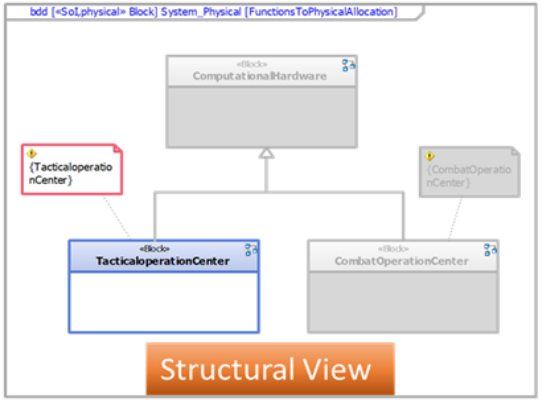
MBDA – Example

From Real World – Command-and-Control international Product Line







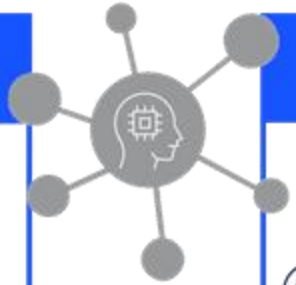


Iveco Group – Motivation & Context

Meting Different Customer Needs & Excelling in addressing market demands with innovative, customizable solutions

Strategic ambitions

- **Rich Product portfolio**, with new ADAS/AD functions, best-in-class in Connectivity and leading energy transition.
- Need for **Innovative** and **Sustainable** solutions with built-in **quality** and optimized **product cost**.
- **Lifecycle & Customer Centric** approach, building world-class **partnerships** and ecosystems.
- Product **Development Acceleration**, going from fixed cycles to continuous release

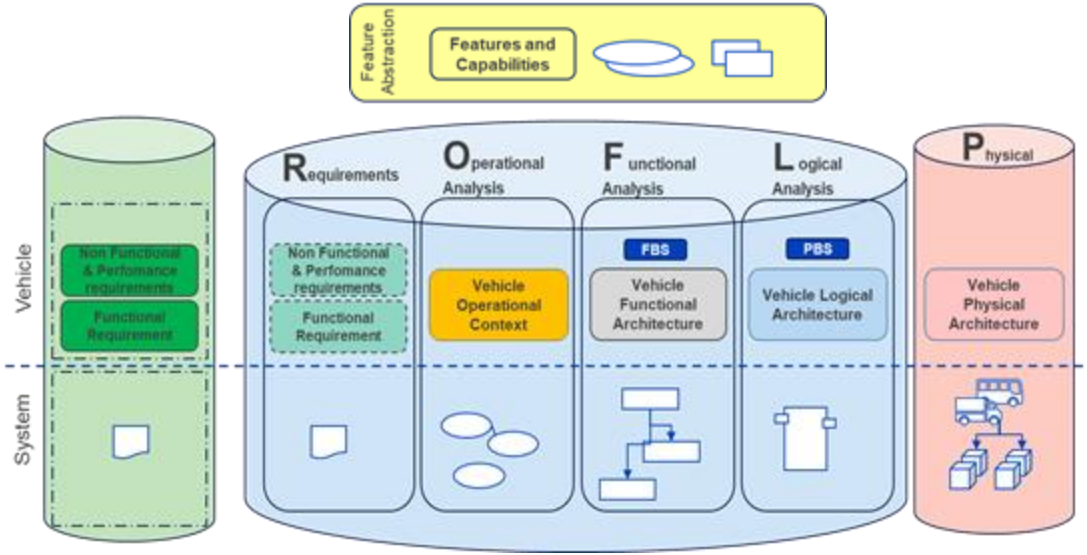


External Challenges

- Customer **Value shifting** from the product itself to the broader ecosystem (services, etc)
- **Regulatory Framework** unclear in constant evolution
- Additional pressure to maintain **affordable** Capital & Engineering **investments**
- **Macroeconomics** and **Geopolitics** uncertainty

Iveco Group – MBPLE Adoption Framework

Synergizing MBSE & PLE: The Dynamic Duo to Ensure Holistic System Integration

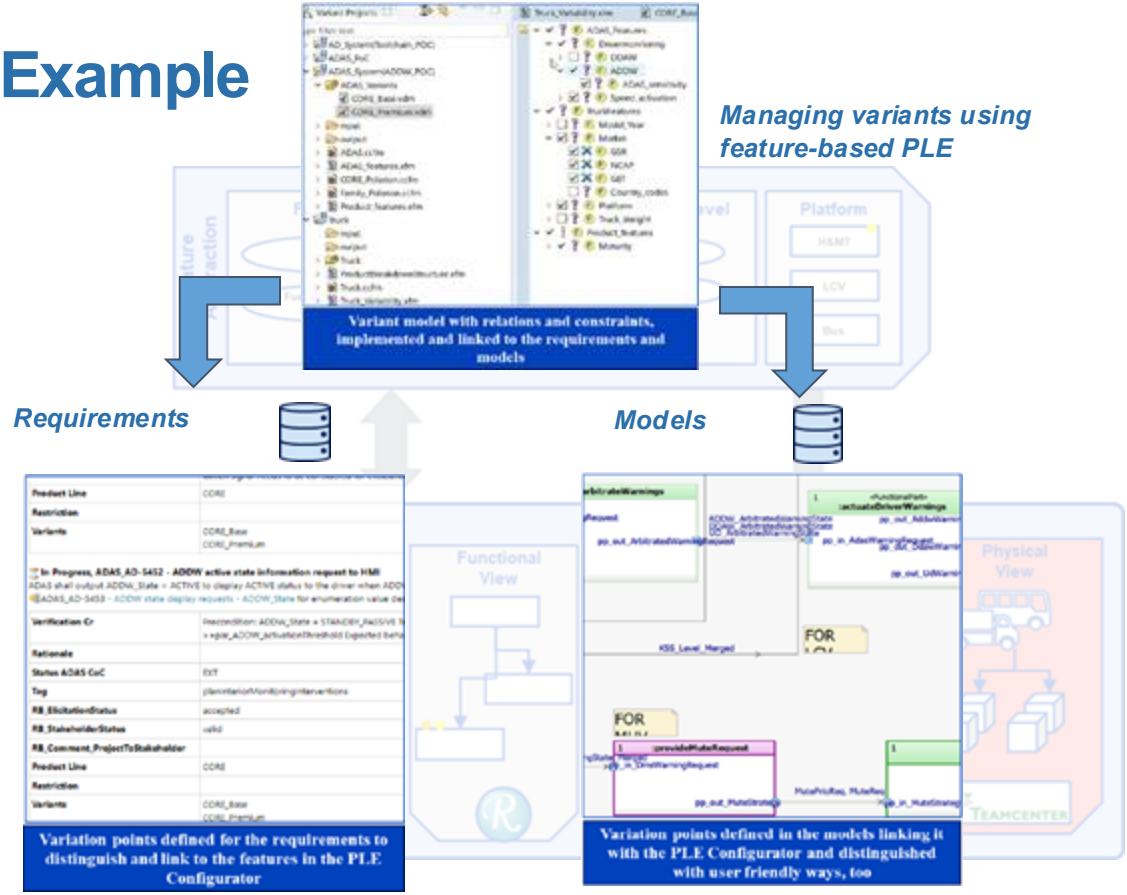


The combination of MBSE and PLE supports **scalable product line architectures** by managing complexity **through hierarchical modeling and modularization**, enabling the efficient development of large families of products.

By integrating MBSE, PLE can benefit from **enhanced configuration management**, where system models serve as the **basis for controlling and tracking variations**, leading to improved consistency and reduction of errors in product development.

Iveco Group – Example

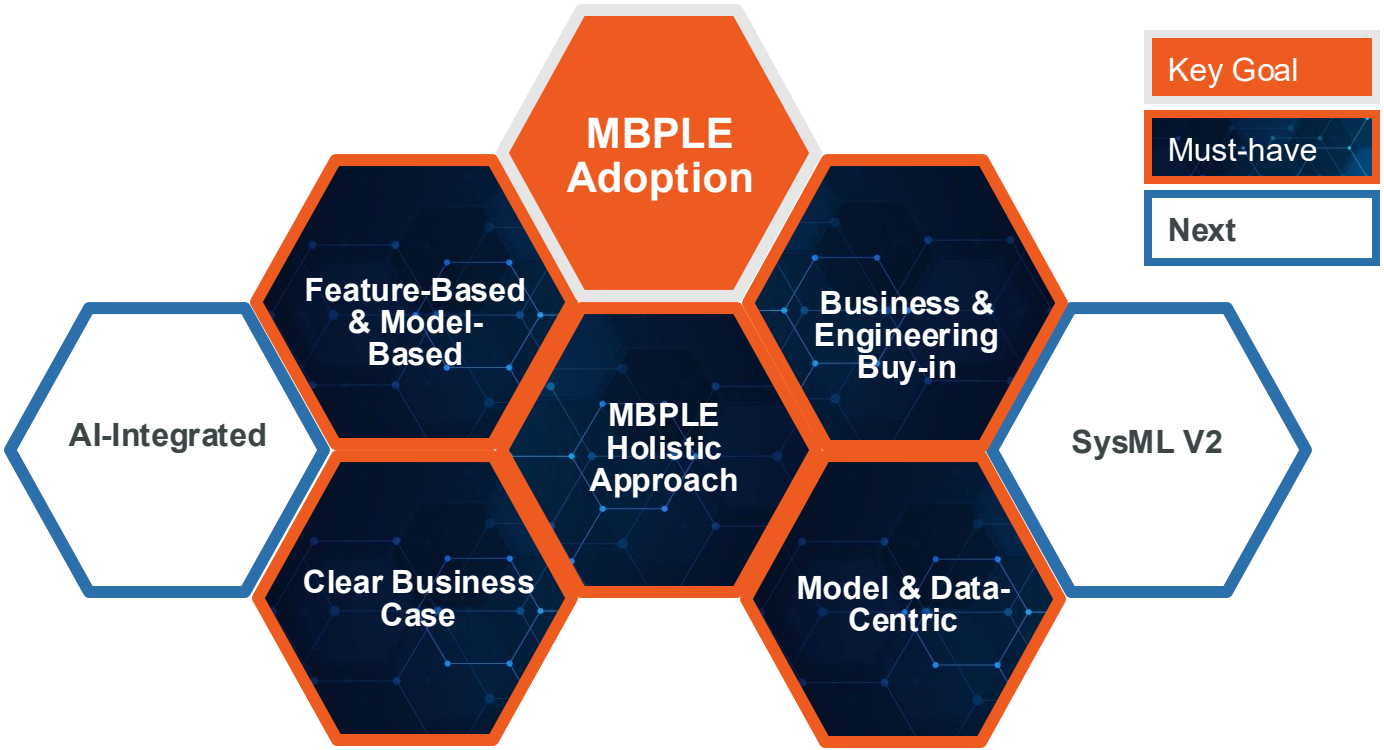
From Real World- ADAS



What we have learned from the 3 MBPLE Adoption Cases

Cross-Industry Motivation to Adopt MBPLE	MBPLE as Enabler of Digital Engineering Transformations	Extending the MBSE Framework with MBPLE	Feature-Based Path to Product Line Success	Balancing Tool Agnosticism and MBPLE Toolchain
Complexity & Variability	In all 3 organizations	MBSE + PLE in action	ISO 26580 as LIghthouse	Pure Variants brings PLE to life

Conclusion & Future Outlook: What´s Next?

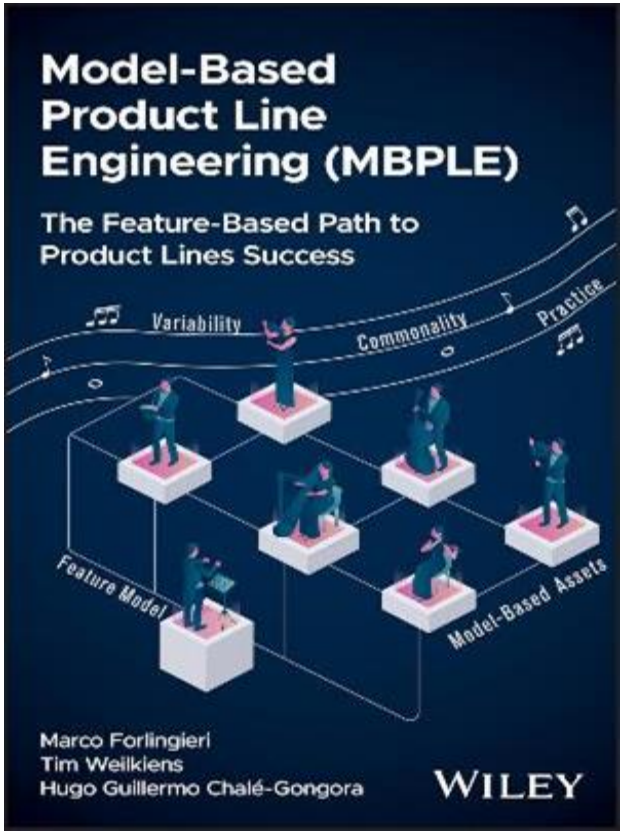


If you want to learn more..

AIRBUS MBDA MISSILE SYSTEMS THALES

Raytheon An RTX Business BELIMO

Thank You
Question Time!



LOCKHEED MARTIN ptc

PRODUCT LINE ENGINEERING IN ACTION

Master complexity and deliver at scale

Week of October 20th

Lockheed Martin Facility, Orlando, FL

Stay tuned for more details and registration information.

- Join fellow architects, software, and systems engineers for a PLE User Group to hear expert insights and best practices from industry leaders.

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