Leveraging Product Line Engineering (PLE) for Enhanced Digital Continuity in Systems Engineering

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1 Introduction

In the context of modern systems engineering, the increasing complexity and variety of products demand a more scalable and structured approach to managing variability. Feature based **Product Line Engineering (FbPLE)**, as defined by **ISO 26580** and further detailed in the **AFIS guide** on product line systems engineering, provides a robust methodology for managing product variations through feature-based design. Despite advancements in FbPLE and **Model-Based Systems Engineering (MBSE)** frameworks, industries like defense, aerospace, and manufacturing face challenges in implementing end-to-end digital continuity. This approach can be extended to end-to-end model-based engineering for FbPLE become Model base Product line engineering (MBPLE)

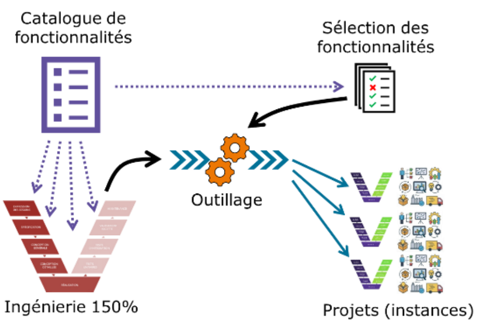
Through its **Greater Engineering Transformation (GET) improvement program**, MBDA has identified 60 key levers of improvement, of which one of the critical aspects is the modernization and adaptation of tools and processes. The **Feature Team 9** (FT09) in charge of **Product Line Engineering** initiative aims to formalize and extend the application of FbPLE within MBDA by addressing variability at multiple levels and aligning it with a **global configuration management strategy.** This paper explores how MBDA is using PLE, integrated with advanced MBSE tools, to achieve digital continuity across its product lifecycle.

State of the art :

Current research on FbPLE emphasizes its potential to revolutionize product design by allowing organizations to manage a 150% engineering approach, supporting the development of various product variants from a single repository of **Features**. Tools like **IBM Jazz ELM**, **Pure::Variants**, and the **SysML** (**Rhapsody** or **Capella modeling tool)** have enabled industries to push forward digital continuity across product lifecycles. However, many organizations still struggle to achieve full integration between MBSE practices and PLE-driven configurations, particularly in complex environments like defense, where multiple product lines may need to be aggregated for specific customer opportunities.

2 Methods

MBDA's approach integrates PLE within its existing systems engineering framework, particularly through the exploitation of **IBM's Jazz ELM platform** for requirements management and **Pure::Variants** for managing product variability. Our methodology leverages **global configuration management** to create a seamless link between product feature definitions, requirements, testing, and **SysML** modeling efforts using tools like **Rhapsody** and **Capella.** This approach aligns with **ISO 26580** (as well as AFIS guide « Ingénierie Système Lignes de Produits » | Tome 1 : Principes & Concepts), which promotes the standardization of PLE concepts.



The FT9 team developed a **multi-line product strategy**, where customer requirements drive the aggregation of product lines, creating new product configurations on-demand. The core processes, supported by in-house guidelines **PLE Guidance - Volume 1 to 3**, have been tailored to the MBDA environment, ensuring that tools and methodologies support a fully digital, feature-based product lifecycle.

Implementation and Deployment :

Due to the nature of its products, MBDA has chosen a product line approach that can be described as "Multi-product lines by opportunity": Each SOI (System of Interest) is a product line, but it aggregates based on customer needs. Thus, through a form, the customer specifies and clarifies their needs. The aggregation of each SOI as defined in this way results in a "new" product. Therefore, global configuration has to be optimized.

We have worked on the customer form, a necessary element for gathering requirements. We have primarily focused on developing guidelines to define PLE for MBDA at multiple levels:

- **PLE Guidance - Volume 1 – Concepts**: We focused on leveraging the ISO 26580 standard to adapt it to the MBDA context.
- **PLE Guidance - Volume 2 - PLE MBSE**: Once these core concepts were defined, we applied them within the company's MBSE processes (covering needs, requirements engineering, and modeling). Annexes describe the tool specific implementations.
- **Feature-based PLE Guidance - Volume 3: PLE Factory**: Here, we concentrated on implementation through MBDA's tools: Utilizing IBM's ELM JAZZ platform, with DNG for requirements management, ETM for associated testing, and Rhapsody and Capella for modeling. Variability management was handled using Pure::Variants, with configuration management integrated via JAZZ's Global Configuration. Annexes describe the tool specific implementations.

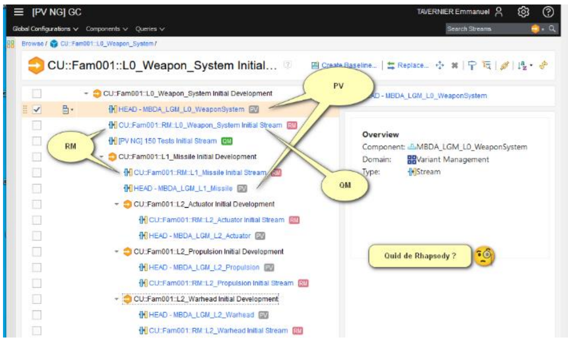


Figure 1 - Global Configuration Example through IBM ELM JAZZ®

We also focused on building a coherent, end-to-end example throughout the entire toolchain and across V-cycle.

3 Results

Although the implementation of MBDA's FT9 initiative is ongoing, early results show promise in achieving significant improvements in variability management and digital continuity. By formalizing FbPLE through **multi-level guidelines** and tool integrations, MBDA has established a framework that allows for more flexible and customer-centric product development. Preliminary examples, such as the **Global Configuration tool integrated with IBM ELM Jazz**, have demonstrated the potential for creating coherent, end-to-end workflows across the product lifecycle, with notable improvements in configuration management and feature reuse.

4 Discussion

MBDA's experience in integrating FbPLE into its MBSE practices illustrates the significant gains in managing complex product variations. By implementing FbPLE at multiple levels of the product lifecycle and combining it with state-of-the-art tools like **Pure::Variants (for managing FbPLE)** and **IBM Enginieering suite (for MBSE development)**, MBDA has laid the foundation for achieving the first part of the digital continuity. The ability to respond quickly to customer-specific configurations through a robust, feature-based approach holds the potential for widespread industry application.

However, challenges remain, particularly in scaling this approach across multiple product lines and ensuring that all aspects of digital continuity—from requirements to production—are maintained seamlessly. Future work will focus on expanding the scope of PLE beyond MBSE, further refining tools integration, and scaling the methodology across MBDA's broader product portfolio.

References

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