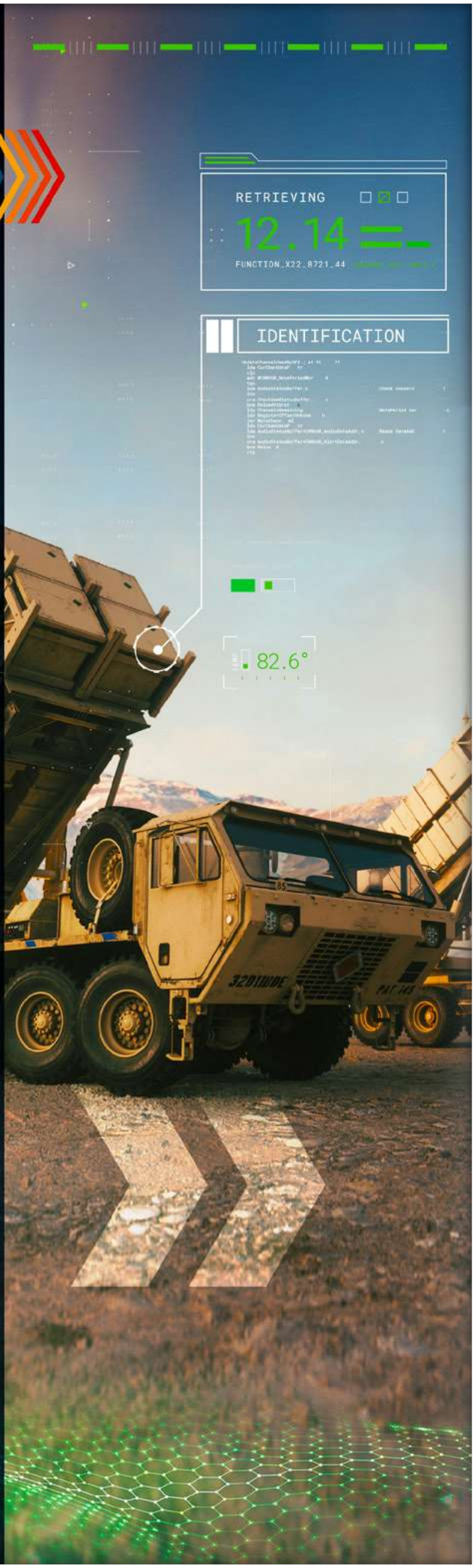
ptc®

FROM COMPLEXITY TO COMMAND



WHITEPAPER 2025

INTRO

Commanding a Shifting Global Landscape in the Era of Complexity

The defense and aerospace industry are at an inflection point. Organizations - whether military, NATO, aerospace or allied export partners - have different mission profiles, compliance needs, and performance expectations. But, in today's shifting global landscape, leaders must also contend with escalating geopolitical uncertainty, rapid technological advancements, and rising pressure to deliver mission-ready systems at unprecedented speed and scale.

Systems are no longer standalone. Today's platforms - whether radar systems, airborne surveillance, ground vehicles, or missile defense - are interconnected, digitally enabled, and expected to operate in diverse environments with maximum adaptability. And while these growing demands point to opportunity, they also expose a critical weakness in how most organizations engineer their systems today.

Despite building entire fleets and product families, many defense OEMs still approach product development as if each program were completely unique. The result:

- **Engineering teams are tasked to repeatedly solve the same problems.**
- **Compliance and traceability are reinvented for each project.**
- **Interoperability with suppliers and partners is a constant challenge.**

1. VARIABILITY HAS BECOME A BARRIER TO AGILITY

Every product in the defense and aerospace industry is unique, due to different mission profiles, regional regulations, operational constraints, or customer-specific features. This variability is essential - but it is also the root cause of duplication, inefficiency, and engineering fatigue.

Without a unified strategy to manage variability, reuse becomes a liability rather than an asset. Project teams' resort to "clone-and-own" practices, copying past designs and modifying them ad hoc. Over time, this leads to a proliferation of loosely related systems that are:

- **Hard to manage**
- **Difficult to certify**
- **Expensive to maintain**

Worse yet, every new contract triggers a new program - with its own risks, learning curve, and duplication of effort. Talent is spread thin. Institutional knowledge is fragmented. And the organization loses the ability to scale.

For defense and aerospace leaders, the implications are clear: Without transformation, engineering becomes a bottleneck to mission delivery.

2. FEATURE-BASED PRODUCT LINE ENGINEERING

Product Line Engineering (PLE) is not simply an engineering optimization—it is a strategic transformation. Despite increasingly dynamic requirements, regulations and growing systems complexity, feature-based PLE empowers defense and aerospace organizations to engineer entire product lines, not just isolated one-off systems.

Instead of designing each system variant from the ground up, feature-based PLE creates a controlled, automated process for defining and assembling system configurations from a common, validated asset base.

At its core, PTC's feature-based PLE solution, Pure Variants, establishes a model for system engineering, structured around four foundational elements:

SHARED ASSETS: All digital artifacts - software modules, hardware schematics, documentation, verification data - are consolidated into a superset that includes embedded variation points. These assets represent the reusable core of the product line.

FEATURE CATALOGUE: A structured model that captures the complete set of product features, such as mission-specific capabilities, export restrictions, compliance standards, and configuration options. This catalogue provides a common vocabulary for managing variability across the entire organization.

BILL-OF-FEATURES: Each individual system variant is described using a Bill-of-Features - a precise specification of selected features based on customer, mission, or regulatory requirements. This acts as the blueprint for generating tailored configurations.

AUTOMATED INSTANTIATION: This applies selected features to shared assets, automatically producing the correct set of artifacts for a given product variant. This tight integration significantly reduces time, errors, and manual overhead.

This PLE approach, based on international standards like ISO/IEC 26580:2021, enables organizations to:

- **Move from a reactive, project-based model to a proactive, product-line-centric strategy.**
- **Ensure traceability, consistency, and compliance across all variants and lifecycle phases.**
- **Scale across domains and disciplines - from embedded software to mechanical systems to documentation.**

Once PLE is established, engineers collaborate on evolving the shared asset base and the Feature Catalogue, rather than duplicating work across isolated programs. Changes are governed and propagated systematically, and the creation of new system configurations becomes an instantiation process - not a new development effort.

This shift not only delivers faster, higher-quality results, but also creates strategic alignment between engineering, program management, suppliers, and regulators.

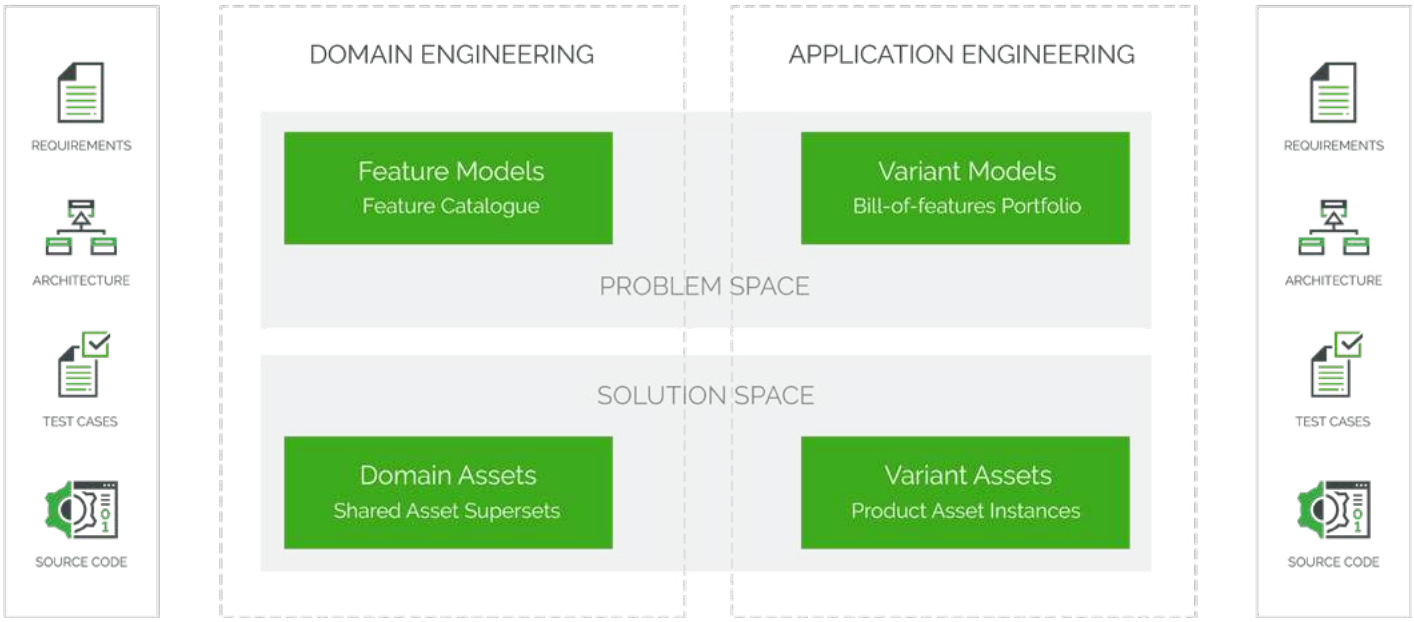
3. STRATEGIC BENEFITS FOR DEFENSE AND AEROSPACE

- **Faster Time-to-Mission:** Rapidly configure systems for new customers, use cases, or theaters of operation.
- **Reduced Risk:** Reuse of validated components means fewer surprises during integration, testing, or audit.
- **Improved Quality:** One fix propagates across all systems—ensuring consistency and traceability.
- **Engineering Focus:** Free top talent from repetitive tasks and let them drive innovation where it matters.
- **Stronger Supply Chain Interoperability:** Suppliers work from the same digital logic and variability model.

PRODUCT LINE ENGINEERING IN A NUTSHELL:

SEPARATION OF PROBLEM AND SOLUTION SPACE

ISO 26580



4. REAL-WORLD SUCCESS SNAPSHOTS: PLE AT SCALE

Leading defense and aerospace organizations are already proving what's possible:

AIRBUS "Airbus is a market leader in commercial aviation. Keeping itself ahead of the pack is no simple task. Maintaining the current fleet efficiently while innovating for future aircraft is a big challenge that requires strong digitalization efforts. Initiatives focussed on reuse/ optimization, such as Model-Based PLE, are essential to achieving future business and societal objectives." [P. 243*]

THALES "Thanks to the powerful feature-based PLE concepts and their adaptation to our context, we managed to show continuous improvement such as aligning bid data and project, engineering, and service phases, improving quality, reducing the cost and lead time of radars, and above all, remaining attractive in our competitive market segment.

The Ground Master Radar (GMR) product line has succeeded in defining a "delivery" approach based on a product line that has become the common way of conducting business for all functions at Thales Surface Radars". [P. 270*]

MBDA "The Model-Based PLE approach is currently in the rollout phase and has been recently adopted for the first products. [..] MBDA is working on a new business case to transform MBDA into a PLE-enabled company in the long term." [P. 258*]

These aren't just digital transformation initiatives - they are competitive advantages.

Source*: Forlingieri, M., Weilkiens, T. & Chalé-Gongora, H.G., 2025. Model-Based Product Line Engineering (MBPLE): The Feature-Based Path to Product Lines Success. Hoboken, New Jersey: Wiley & Sons, Inc.

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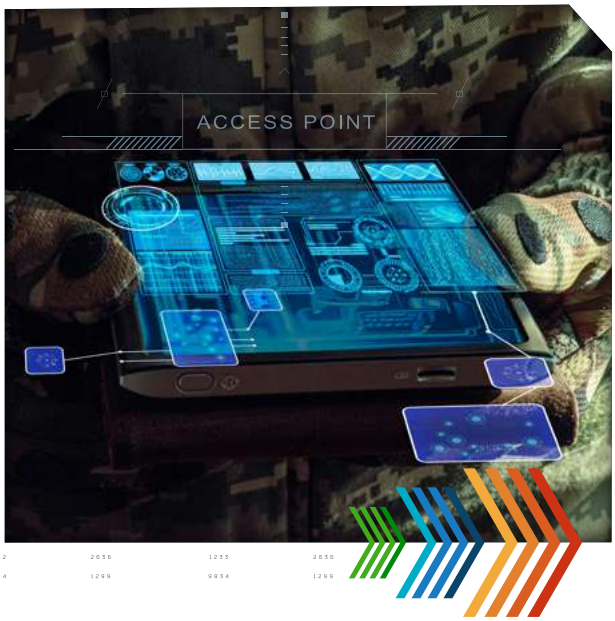

EXECUTIVE SUMMARY: COMMAND THROUGH CONSISTENCY

In aerospace and defense engineering, competitive edge depends on speed to capability insertion, cost efficiency, and the ability to ensure compliance at scale. Traditional engineering approaches, which are fragmented, manual and slow, no longer meet the demands of modern programs or the expectations of government stakeholders.

This whitepaper presents **Feature-Based Product Line Engineering (PLE) as a key strategy to meet the demand for increasingly complex A&D systems** by enabling the reuse of engineering assets, reducing duplication, and managing variability across product families. By shifting focus from individual products to product lines organized around common features, A&D organizations can dramatically reduce duplication of effort, increase quality and consistency, and maintain rigorous traceability across the lifecycle.

Product Line Engineering (PLE) is not just a development method. It's a transformation of your operating model and a mission-critical enabler for the digital era. Instead of building each system from the ground up, teams work from a validated, governed core, achieving speed, precision, and reuse across the product line. This approach accelerates delivery by aligning engineering, program management, and suppliers through a common feature model.

Feature-Based PLE enables true end-to-end reuse - from requirements through design, software, hardware, and testing - empowering teams to rapidly configure, validate, and deliver mission-critical systems that meet evolving customer and regulatory demands. By adopting PLE, aerospace and defense manufacturers gain:

- **Greater agility** to respond to new mission profiles, export restrictions, or customer-specific requirements, without engineering from scratch
- **Strategic reuse across programs and variants,** cutting costs and saving engineering hours
- **Accelerated time-to-delivery** through automated configuration of product variants
- **Built-in compliance and traceability,** lowering risk in every audit and review phase
- **A unified digital foundation** that supports MBSE, PLM/ALM and digital twin initiatives

Feature-based PLE empowers platform-centric engineering teams **to turn complexity into control and variability into value.** It helps organizations **scale innovation, ensure compliance** and **adapt to evolving requirements** – without compromise. Powered by PTC's integrated digital engineering solutions, PLE becomes a force multiplier, driving faster delivery, improved margins and greater confidence across every contract. From advanced radar systems to next-generation ground vehicles, PLE ensures that every variant is delivered right the first time.

Start your journey today. Your next mission begins with consistency and control. Talk to our experts to find out how PLE from PTC helps defense leaders scale with confidence.

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