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Navigating the Rise in Product Complexity

WHITE PAPER

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The world runs on increasingly complex systems. Organizations face critical challenges in designing, managing, and optimizing these systems for the rapidly changing products of tomorrow. Consumers' connectivity demands are changing at an unprecedented rate, driving companies in every industry to build more complex and more interconnected products and services.

While technological advances make it possible to meet these demands, they do so at the expense of increased complexity for the manufacturer. The growth of electronics and embedded software makes cross-discipline collaboration essential. As products become systems of systems and the amount of electronics and embedded software increases, controlling the variability becomes increasingly complex. The same trends put an increased focus on Systems Engineering and in-service product updates—especially software updates.

Increasing Product Complexity

Product complexity is causing global manufacturers to rethink the tools and methods used to manage systems engineering, the continually accelerating number of product variants, constantly changing configurations, and change management throughout the product lifecycle.

In today's hypercompetitive business environment, future-ready enterprises must be able to plan better and manage their product portfolios, increase the level of commonality, control the variability of their product line, deliver multi-disciplined products throughout the lifecycle, and implement new levels of connectivity to engage and satisfy their customers. Market leaders will have to control this complexity while reducing costs, making better use of high-paid resources, and increasing their product quality to gain a competitive advantage, all while driving revenue growth and profitability.

Uncovering the Challenges of Product Complexity

Managing complex products throughout the lifecycle is becoming increasingly challenging. Without proper configuration management, variant and option management, and systems engineering, the lack of control and traceability can cause unintended consequences. Errors found late in the process can result in delays, cost of quality issues, expensive rework, inefficient use of resources, liquidated damages, and product recalls.

Today, most companies use separate tools to control the complexity of their product development. Many companies think of their product lifecycle management (PLM) systems as the core support for the product lifecycle. But, in reality, these systems are primarily focused on mechanical parts. In addition, separate systems are used for managing electrical and electronic designs, plus Application Lifecycle Management (ALM) systems are used to manage embedded software development. Then, various configurators are often used in different groups, such as sales/marketing and engineering, without considering the optimal process where there is a systems engineering effort. Tools such as Model-Based Systems Engineering (MBSE) tend to be used in the conceptual phase, disconnected from mainstream engineering and the rest of the enterprise.

The result is that the flow of product information is often isolated in separate functional data silos, thus creating a fragmented, disconnected process with little to no real traceability back to simulations, quality documentation, etc.

None of this is new, and organizations have been able to keep their processes running only by resorting to countless spreadsheets, emails, phone calls, and ad hoc meetings. But as product complexity inexorably increases, this inefficient approach is impacting business performance in many ways.

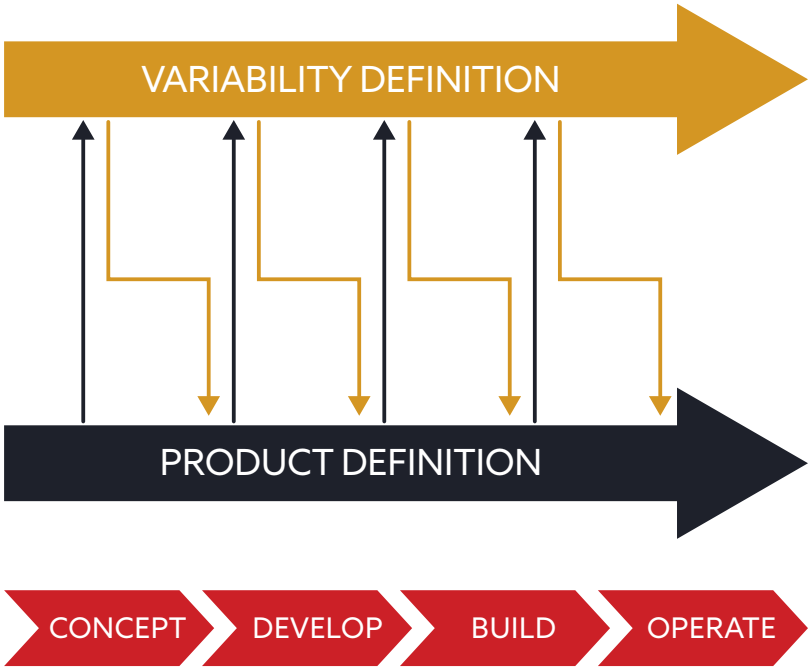
Managing Change and Variation Simultaneously

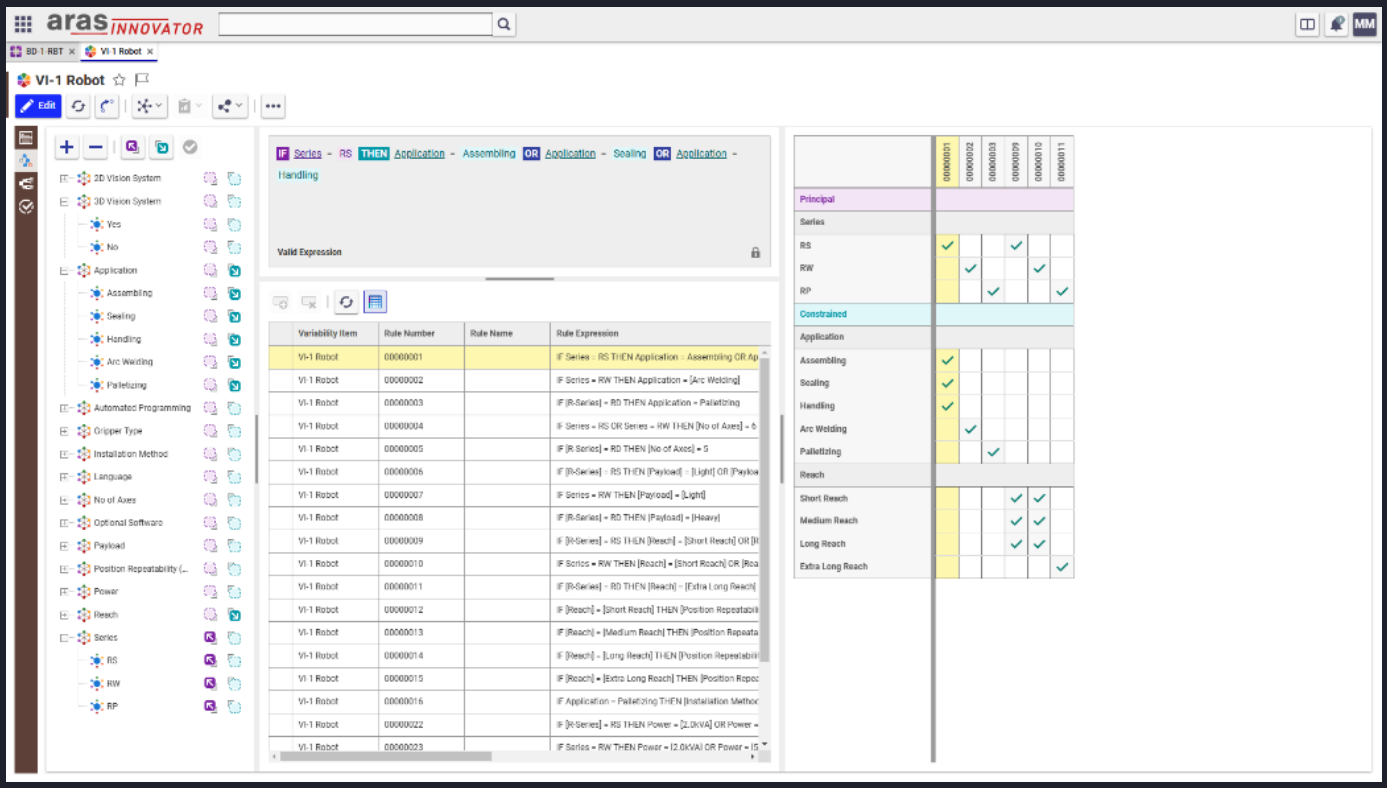
With this increasing complexity and demand for customization comes the challenge of managing complexity across diverse product lines, and a growing number of product feature variants.

Companies must tackle both the variability and configuration of the product as it evolves. For example, as the product progresses through its lifecycle, companies need to incorporate changes to the product definition based on some type of effectivity (e.g., date, serial, batch, unit, lot, etc.). When a new variant or option is added, companies need to make sure it resolves to a valid technical solution in the product definition.

The problem with traditional approaches to managing variants is that, with the increase in product complexity, comes an increase in variability that can scale combinatorially, spiraling out of control with the number of features and rules.

This is compounded by the complexity of the systems of systems required to handle not only a multidisciplinary product but all of the different structures that must relate to each other, such as requirements, functions, logical, and physical (RFLP) structures. This gets even more challenging across the product lifecycle, where designing the product, manufacturing the product, testing the product, and servicing the product all have different needs.





Aras Variant Management Validating Product Configurations

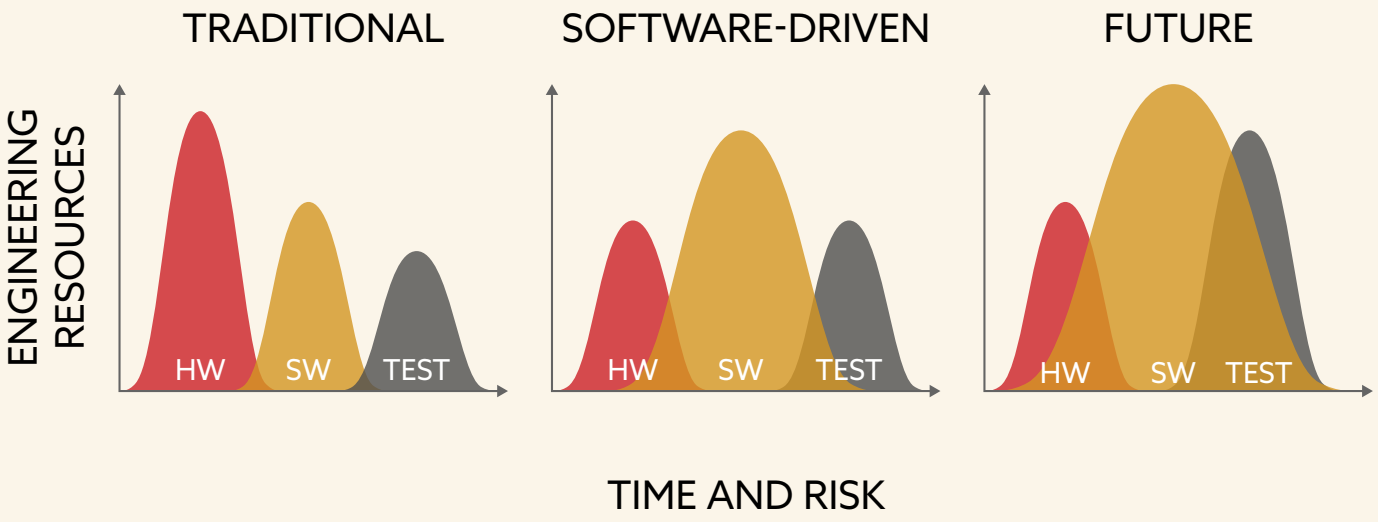
Maturity of Disconnected Systems Architecture

As products increase in complexity, particularly if they incorporate a significant amount of embedded software, the need for cross-functional systems engineering becomes increasingly important. Today, these efforts are usually disconnected from the product lifecycle's mainstream product development, build, and operational phases. This results in errors not being caught until late in the development process. This slows development activity, leads to rework, impacts time to market, and can lead to significant customer dissatisfaction.

One way modern solutions address these issues is to invest in advanced product line management applications to systematize product configurations and variability, ensuring only valid product configurations with the correct data are generated. These flexible platforms can adapt to an organization's specific business processes and facilitate tight collaboration between functional areas, streamlining product development, increasing product standardization, managing product variability, and optimizing product designs.

Hardware and Software Challenges

As products become more interconnected, software is no longer an add-on feature but a critical system in many products, if not the most important differentiator. According to Siegmar Hassis, Daimler R&D CIO, ***"80% of Product Innovation and differentiation is now electrical, electronics, and software. Not mechanics."*** Today's typical development sequence is hardware, followed by software, and then integration testing. Over time, this is not sustainable as more and more of the products and resources are dedicated to software. The trend is clearly toward a convergence of hardware and software overlapping in the product lifecycle, as seen in the diagram below.



PLM systems have historically managed mechanical and some electrical parts, while software was managed separately in an ALM system. In practice, it has been hard to reconcile the two due to differences such as separate methods for configuration management. More recently, there has been a shift in software being developed concurrently with hardware. This change has also led to a shift of software testing beginning before either is completed.

Strategic Reuse

Another challenge impacting manufacturers is implementing a sustainable approach to high-level reuse—sometimes called strategic reuse. For example, automotive companies have long used the same platform as the basis for multiple vehicles. Some companies have adopted a product-centric development approach, where each individual product evolves independently from other product lines. This often starts out as a cloned copy of a similar product and is then modified to fit a new product's requirements. The downside of this approach is that it does not take advantage of commonalities across a product portfolio or platform.

This product-centric development methodology does not scale well. As the number of requisitions or units shipped grows over time, productivity, product quality, and the economies of scale in production degrade quickly. The organization then becomes swamped in engineering complexity, risking a dangerous impact on quality and missed innovation opportunities as the organization is forced to allocate more of its key resources toward heroically trying to ship or service ill-planned products.

A Platform-Based Approach to Tackle Complexity

The increase in product complexity is causing global manufacturers to rethink:

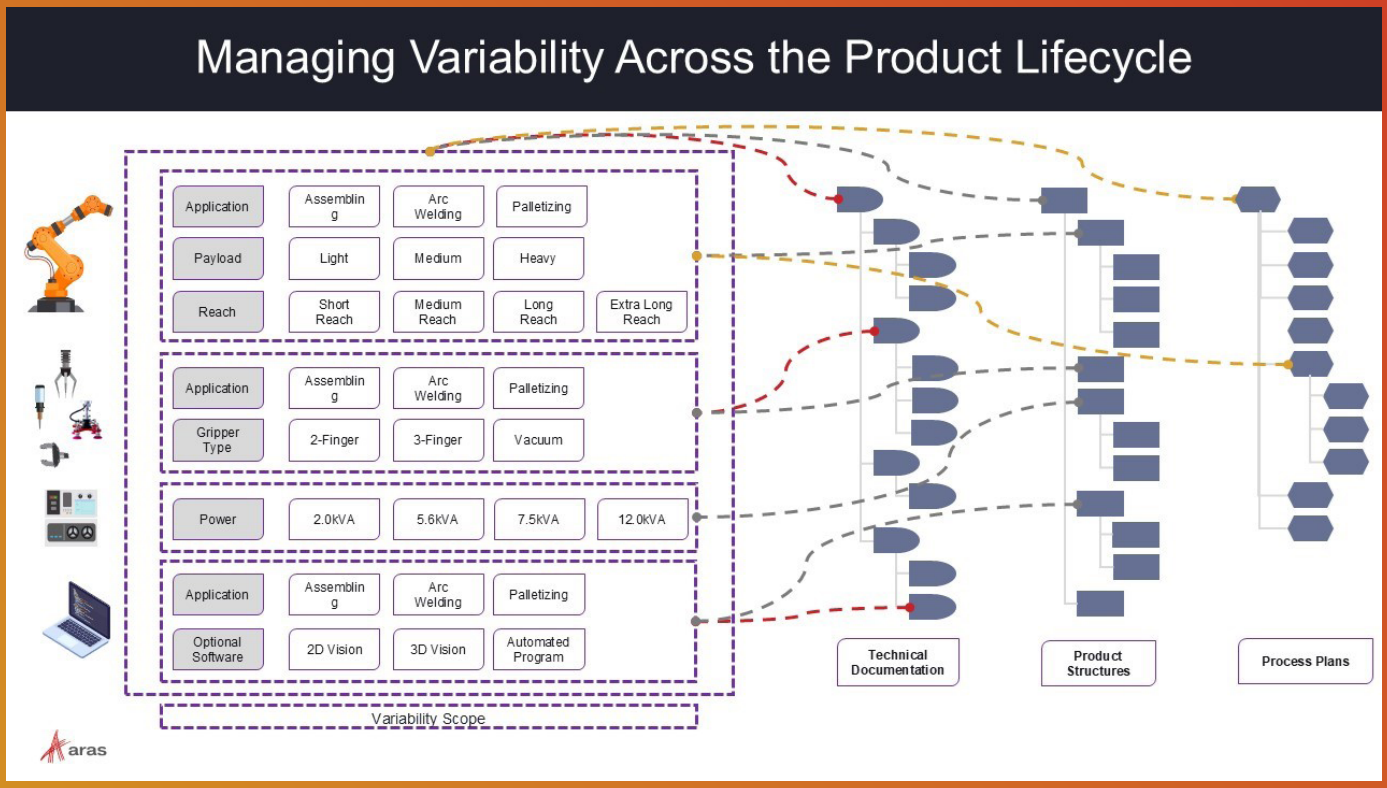
1. The systems engineering tools and methods used to manage multi-disciplines
2. The continually accelerating number of product variants
3. The constantly changing configurations, and
4. Change throughout the product lifecycle.

The key to reducing these complexities is a well-architected system that can manage the configuration of multidisciplinary domains while simultaneously managing the definition of variability across a portfolio of products. The system can also reconcile the change to the product configuration and the features and options of the valid variants throughout the product's lifecycle.

APPLYING A COMMON VARIABILITY MODEL

In addition to the typical configurator use cases of presenting product options to customer-facing UI, and the transformation of a 150% product BOM to an eBOM, a configurable Product Breakdown Structure containing all possible configurable components, assemblies, and other assets needed to build product variants is utilized. In its simplest form, options and variant capabilities generate variants directly within a Product Breakdown Structure. As the number of features, options, rules, and dependencies grows, so does complexity.

The Aras Variant Management application streamlines and automates the process by defining and consuming rules to generate valid product variants from the Product Breakdown Structure by selecting allowed variant option combinations. The Aras Variant Management application and Aras configurator platform services support different configurator use cases, including applying a common variability definition and rule set to data structures such as requirements, technical documents, EBOM, MBOM, and manufacturing process plans.



A PLM platform can solve these four degrees of complexity by holistically managing the growing complexity of product portfolios, configuration management across multidisciplinary domains, product variants, and change throughout the entire lifecycle.

Systems Engineering

A platform approach enables users to build system models that define the systems' structure, behaviors, and fundamental organization. It does this along with the relationships and behaviors of each of its components to each other and their environment, as well as the guiding principles governing their design and evolution. It allows users to define how systems and subsystems operate, and how they are tested and supported. It is designed to be used and accessed by users at all levels of the enterprise, in all disciplines, and throughout all lifecycle phases. This complements any Model-Based Systems Engineering tools already in place.

Advanced Product Line Management

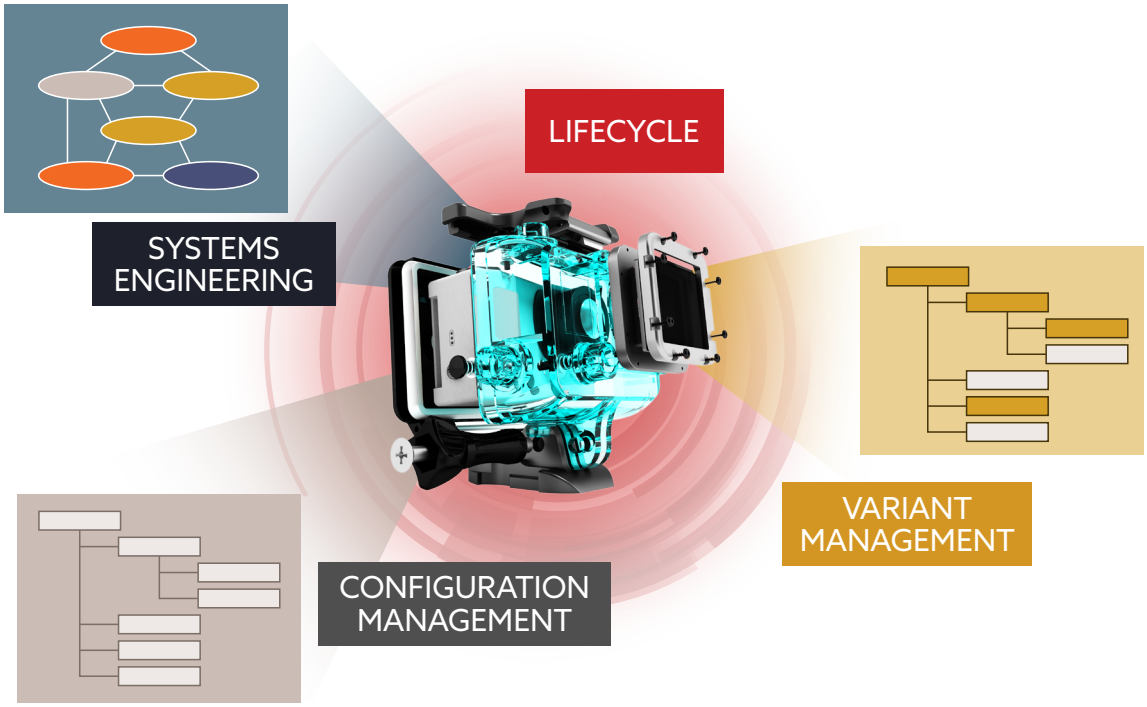
A PLM platform can manage strategic reuse across multiple product lines spanning the entire product lifecycle. Advanced Product Line Management centralizes the variation description in one place and applies it across a portfolio of products in a multidisciplinary approach (mechanical, electrical, electronic firmware, and software).

By considering a product line portfolio as a single entity to be managed, as opposed to a multitude of separate products, the platform enables organizations to create, maintain, and evolve an entire product line through each stage of the lifecycle, with a much higher degree of efficiency than has previously been possible. It focuses on the process of enhancing the commonality of new structures by applying control over variability.

Variant (Feature) Management

By employing a PLM Platform, manufacturers can implement a common approach to variability with variants, options, and rules. These can be applied to various structures across multiple disciplines to meet various customer needs.

This approach provides organizations with the flexibility to support different needs and outcomes. It controls the product's variability and complexity, which is now under change management and effectivity control. This includes handling multiple disciplines across the product lifecycle, such as mechanical, electrical, electronics, and embedded software components.



Increasing Product Complexity

For years, PLM deployments have been limited by being little more than engineering-centric PDM systems. But by taking a radically different platform-based approach, combining support for systems engineering, configuration management across multiple disciplines, and configurator services and applying these capabilities across the lifecycle, Aras has delivered flexible solutions that tackle the toughest complexities facing companies today.

Aras Innovator provides advanced product line management with extensive end-to-end lifecycle capabilities by:

- Controlling changes associated with multidisciplinary items in multiple structures from ideation/concept through end-of-life
- Providing a digital thread that works both forward as the product progresses and backward, providing traceability to all connected multidisciplinary items from structures like RFLP and associated simulations, test and quality documents, etc.
- Delivering systems engineering support, not only in the conceptual stage but at any time in the course of the product's lifecycle
- Supporting a variety of variant and option use cases that facilitate systems engineering, marketing, product line engineering, product engineering, manufacturing, and services

Benefits

The Aras PLM Platform addresses the four major problems companies face due to the growing complexity of their products:

- The ability to apply systems engineering to multidisciplinary domains, including embedded software
- Managing the variants of product portfolios and technical details in one place
- The ability to manage configuration and change management
- To do all of this from concept/ideation to disposal across the extended enterprise

Incorporating integrated services inside the Aras Platform is a paradigm shift away from using multiple, disconnected systems through the product lifecycle. It enables organizations to manage the complexity of their products across the product lifecycle and lays the groundwork for accelerating innovation to gain a competitive advantage.

Aras addresses the four degrees of complexity by providing an open, flexible platform. This empowers companies to achieve their digital transformation goals by bringing more complex, innovative products to market faster at reduced costs, with greater quality and operational efficiency, making better use of their high-paid resources, and driving revenue growth and profitability.

About Aras

Aras is a leading provider of product lifecycle management solutions. Its technology enables the rapid delivery of flexible solutions built on a powerful digital thread backbone and a low-code development platform. Aras' platform and product lifecycle management applications connect users in all disciplines and functions to critical product data and processes across the lifecycle and throughout the extended supply chain. Visit **www.aras.com** to learn more and follow us on **YouTube**, **X**, **Facebook**, and **LinkedIn**.