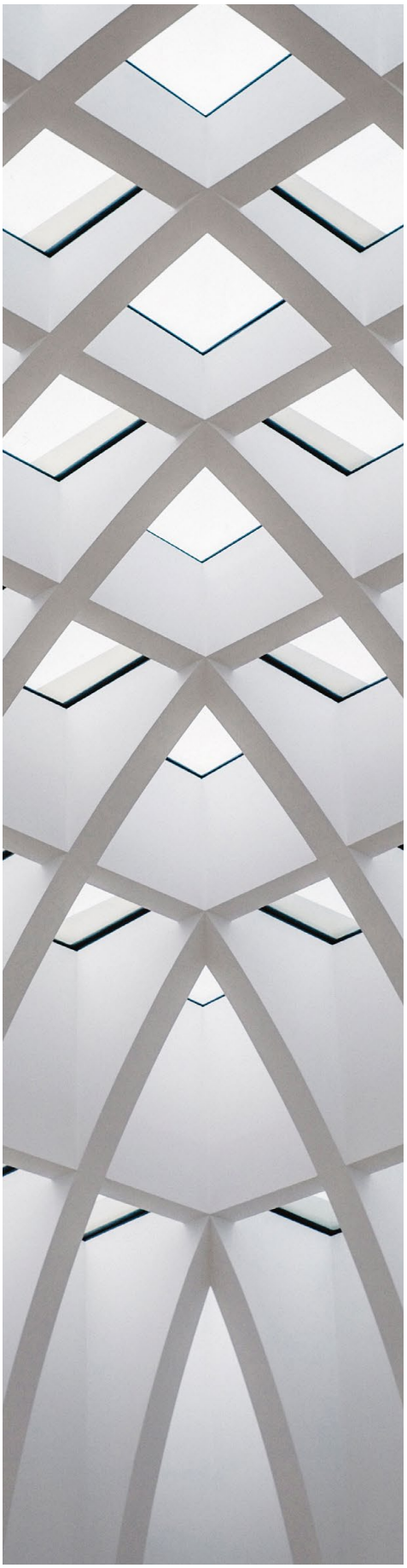
Product Complexity, Digital Transformation, and the Innovation Imperative

The race to reinvent how complex products are developed is here

aras | White Paper



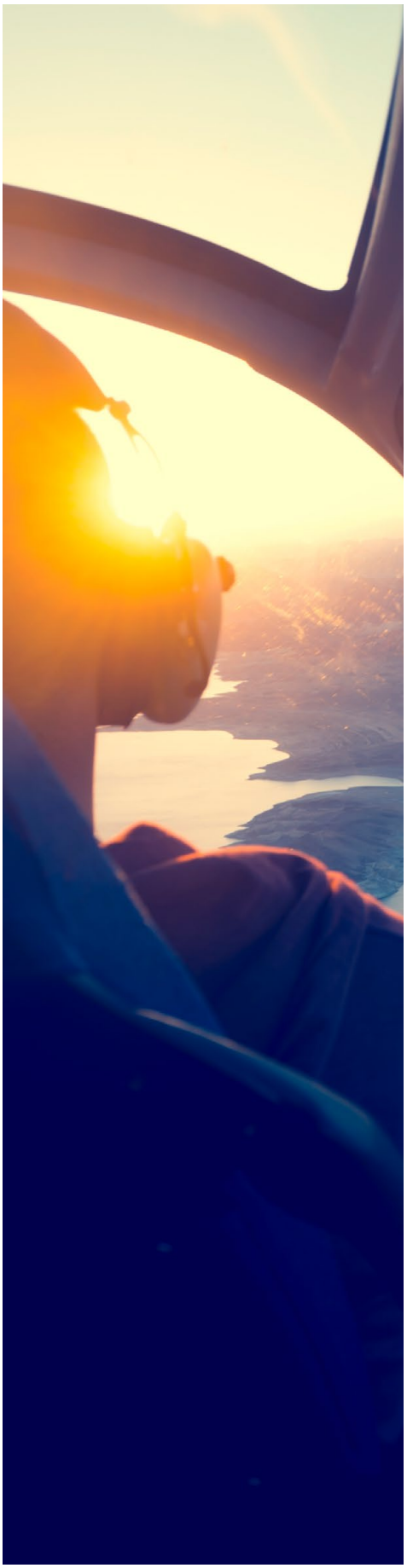
Key Takeaways

- Manufacturers are at a critical juncture. They need to evolve their product processes or be disrupted by new competitors that have been built from the ground up to develop complex systems and products defined by software.

- Manufacturing acumen alone no longer conveys competitive advantage; success lies in the ability to efficiently and effectively engage teams across the full product lifecycle, including those outside the enterprise.

- Opportunities emerge in Digital Twin, Digital Thread, and systems engineering for first movers with the boldness to go beyond legacy systems to pursue digital transformation now.

- The new industry standard will be Product Innovation Platforms that create an enterprise-wide foundation to engage all producers and consumers of product lifecycle information.



Introduction

Henry Ford forever changed the automotive industry over 100 years ago with the introduction of moving assembly lines. Today, disruption is taking hold once again across manufacturing industries. Yet, this time, disruption is not due to a single advancement but rather, to the cumulative effect of technology innovation, new business models, and supply chain evolution.

As an example, consider how Tesla is foreshadowing the fundamental changes to come in product development, not just in the automotive industry, but in all product industries. Tesla invests far more resources in software than hardware and, at the same time, is able to rely far less on mega-physical assets to gain scale. This disruptive approach makes the company more agile than traditional manufacturers.

Manufacturers across all industries should heed the winds of change and begin to overhaul the systems and processes they use to develop, manufacture, and support new products. Those who continue to rely on their opaque and inefficient development processes based on decades-old systems and tools, supplemented by the ad-hoc use of spreadsheets and email, will simply fade from their industry-leading positions over the next decade. They need a new approach along with the boldness to take the first steps down this road.

The Changing Manufacturing Landscape

For decades, manufacturers have leveraged their engineering prowess, mega-physical assets, and well-honed business practices to maintain a competitive advantage and block new competitors from entering the market. But today, that is not enough to hold a market-leading position. Complexity is increasing dramatically, transforming once-straightforward products into systems of systems, requiring a new approach to product development, manufacturing, and supply chain management.

Mounting product complexity necessitates a new approach to foster innovation and streamline collaboration during product development and manufacturing. And even after the product is shipped, manufacturers are able to stay involved with in-service updates, especially software, and Internet of Things (IoT) condition monitoring to predict maintenance issues. Yet, the reality is, most traditional product lifecycle management (PLM) systems lack the capabilities to help engineering organizations meet their current objectives, much less address new market demands.

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To fully grasp the rationale of a new approach to product development, it is important to understand the most salient market dynamics impacting product development processes today as well as the difficulty systems built on different technology stacks have meeting these demands.

Dynamic #1: Increasing Product Complexity—Not Just Mechanical

Purely mechanical designs are becoming rare. The proliferation of sensors and software, driven by demand for smart, connected products and IoT, has raised the stakes for manufacturers. They need to incorporate electronics and software, integrate products into system designs, and often create systems of systems. However, this increased complexity is balanced by the new revenue opportunities presented by smart products such as in-field product support and unique maintenance, repair, and operations (MRO) business models.

Reliance on Suppliers The growing reliance on partners and suppliers for both the design and manufacture of critical product components tests the limits of existing business processes and systems. While component designs might be proprietary to suppliers, OEMs must orchestrate and track all design work in progress to bring together all the elements necessary to meet stated design goals.

Extended Lifecycle Responsibilities Connecting products and services to the cloud enriches the possibilities for the customer—and sets the stage to close the long-standing open loop in the product lifecycle. Real-time data streaming from cloud-connected products can inform the design, build, service, and operate phases of the product lifecycle in new ways. And in-service software updates can improve customer satisfaction and create new revenue opportunities, as Tesla does with its electric cars.

New and Increased Competition Manufacturers face heightened global competition, both from the traditional ranks and from tech-savvy disruptors, which have the potential to undermine existing business models. They risk the same fate as Nokia, Motorola, and Blackberry, who were caught unaware by the rise of smartphones, were rapidly and suddenly usurped by Apple and Samsung, and were decimated in less than a decade.

Regulation Increased activity on the regulatory front across most industry sectors has put pressure on manufacturers to maintain visibility on product configuration throughout the entire lifecycle to ensure compliance with all safety, quality, and disposal rules and standards. Many regulations for emerging connected products such as autonomous vehicles and aerial drones have yet to be written.

Systems Engineering Approach To develop the next generation of complex products, manufacturers are increasingly being guided by the systems engineering 'v-model' (see Figure 1). This approach begins with the development and simulation of a systems-level definition of the product based on its requirements. The model provides input for detailed design and simulation by hardware, software, systems, and services specialists. The work from these individual disciplines is integrated to conduct tests that verify product requirements and validate that customer needs have been met.

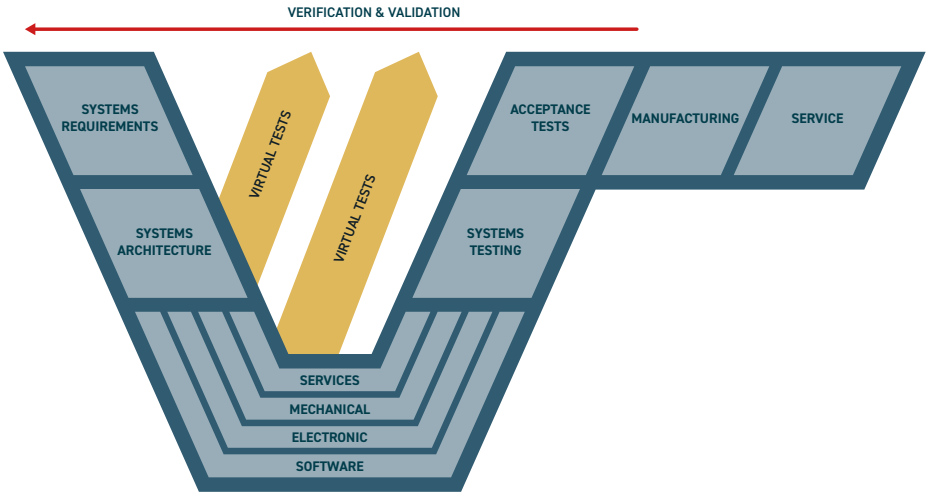


Figure 1: Systems Engineering V-Model
TU Kaiserslautern (modified)

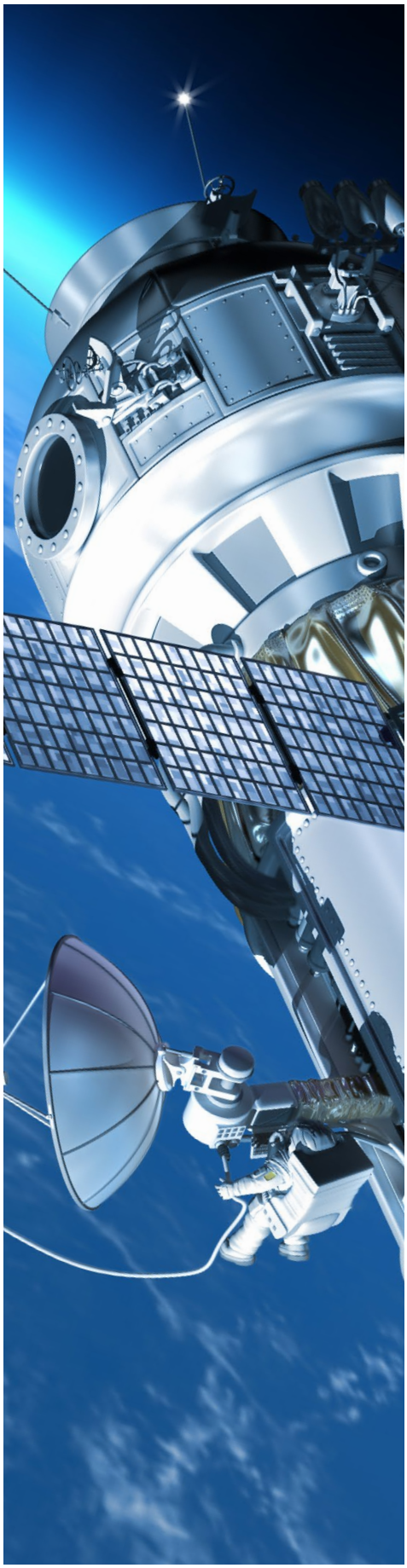
Dynamic #2: Legacy PLM Cannot Manage Current Product Complexity

More than 20 years ago, major manufacturers, especially automotive and aerospace, began implementing PLM systems. PLM software was meant to provide the product data repository and workflow methods that help people connect to critical information as well as collaborate across disciplines and with the extended enterprise throughout the product lifecycle, from design and manufacturing, to service and repair.

But these systems and related processes were designed for a simpler era and are being stretched by current-day product development processes and requirements. PLM has been criticized for taking too long to implement, being almost impossible to upgrade and, ultimately, too narrowly focused.

According to a CIMdata survey[1] of companies in the Aerospace & Defense industry, over a third of current PLM implementations have more than three years of development remaining, and another third have not been upgraded in more than five years. As a result, CIMdata observed that, although the vision of PLM has increased over the last 20 plus years, the value delivered by implementations has hardly changed (see Figure 2).

[1] CIMdata: Aerospace and Defense Industry, PLM Value Gap Survey, March 2013



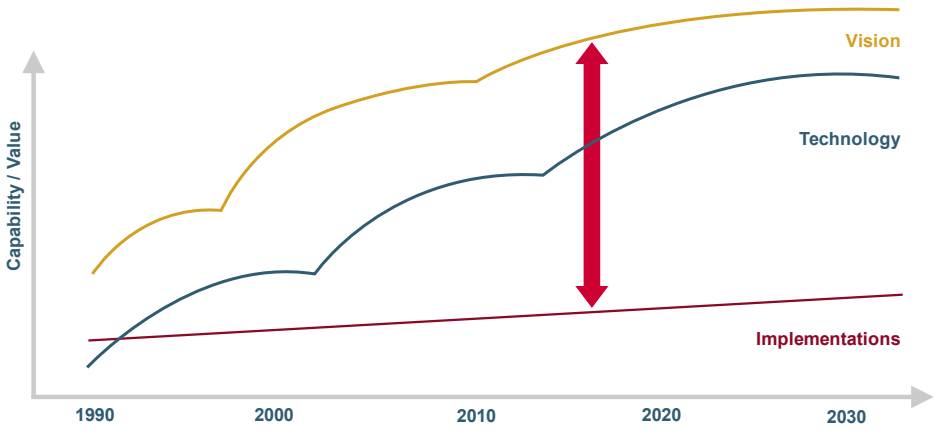


Figure 2: Gap Between PLM Vision and Implementations

PLM has been criticized for taking too long to implement, being almost impossible to upgrade and, ultimately, too narrowly focused.

The deficiency of older PLM technologies is not related to a single feature but rather to multiple limitations in scope, architecture, and capability.

Inflexibility Traditional PLM typically requires heavily customized data models and workflows making it extremely difficult to implement user-driven changes. Traditional PLM's hard-coded technology and closed architectures simply make it impossible to keep pace with innovators. Data can be lost and workflows break every time the company establishes a new process to support innovation or evolving market requirements.

Difficult to Scale In addition, the fragmented architecture of traditional PLM systems has forced organizations to deploy multiple systems to support business processes. This combined with expensive licensing schemes has made it difficult to scale across the enterprise.

Expensive to Upgrade For the same reasons, it becomes hard to keep the PLM system current with on-going vendor upgrades and enhancements. This can eventually lead to increased vendor support costs, and compatibility issues with operating environments, browsers and other software.

Focus on Mechanical Design Many of today's products are complex systems of systems, creating process challenges beyond the abilities of legacy PLM systems based on multiple technology stacks. The reality is that these

systems have largely remained focused on 3D computer-aided design (CAD) data management and have failed to successfully make the leap to address broader business-related concerns. They are not adequately equipped to coordinate global collaboration among engineers in different disciplines spanning mechanical, software, and electrical/electronics.

Ineffective Configuration Management Systems built on different technology stacks also lack capabilities for managing product configurations and facilitating processes that span the entire product lifecycle. Given the fragmented architectures of legacy PLM systems, manufacturers struggle to synchronize product configurations across different groups of users, for example hardware and software developers. This is especially of concern for field maintenance and support, which is an increasingly important element of the lifecycle of smart, connected products.

The Broken V Model

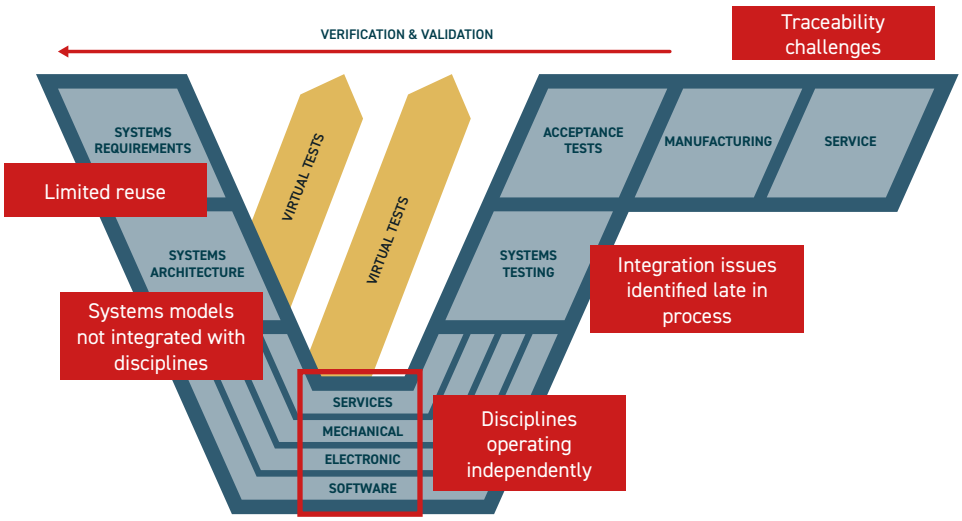
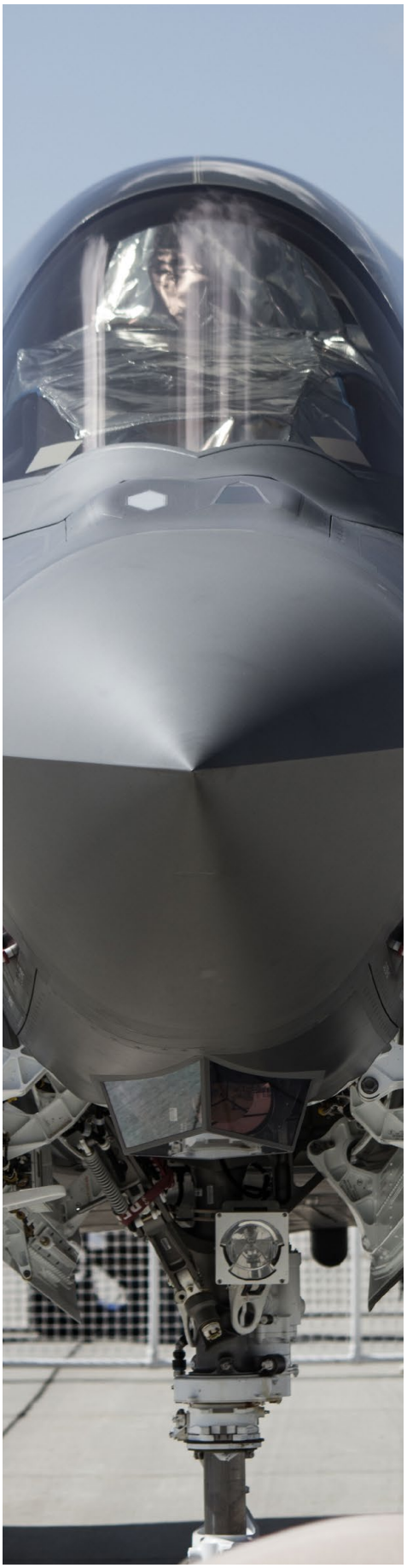


Figure 3: Traditional PLM Can't Support the V-Model
TU Kaiserslautern (modified)



From a systems engineering perspective, there are serious ramifications of older or legacy PLM systems' shortcomings (see Figure 3):

- Companies face more risk when poor cross-discipline communications between hardware engineers and software developers compromise design integrity.
- Lack of an integrated product configuration record creates confusion at critical hand-off points between engineering, manufacturing, suppliers, and field support.
- Meanwhile, fragmented data and processes make supporting new opportunities, such as connected products or product-as-a-service, nearly impossible.

Moreover, unanticipated costs and disruptions create avoidable quality problems that result in product recalls, warranty claims, and liability issues. Over-reliance on silos of product knowledge leads to losses of business, financial losses, and long-term weakening of competitive positioning.

Dynamic #3: Digital Transformation of Manufacturing is Underway

First, the Internet disrupted services industries—think Amazon in retail. Already tech-savvy manufacturers are digitally transforming their businesses—replacing older systems and ad hoc processes with collaborative technology that enable teams to work together more effectively across the value chain. Multiple technologies such as social, mobile, analytics, cloud, and IoT are rapidly maturing and forming the basis of what analysts like IDC are calling the 3rd platform, replacing manual processes and retiring outdated systems.

The potential business benefits of this transformation are massive: more efficient product design and development, new revenue streams based on services and predictive maintenance, robust compliance and regulatory tracking, and more. The combination of customer demand for smart, connected products, the data those products can collect, and access to nearly unlimited computing power to analyze that data is creating huge pressure on manufacturers to accelerate the digital transformation of their product lifecycle management processes.

Working in Silos The inability to scale PLM has led different teams across the organization to work within their own silos. With everyone using different tools, collaboration has actually become more difficult, and the problem is now multi-dimensional:

- Across functions—design, analysis, quality, planning, manufacturing, service, etc.
- Across disciplines—systems, mechanical, electronic, software
- Across the extended enterprise to suppliers, partners, and customers

PLM Underground PLM's failure has also given rise to a quiet rebellion, often referred to as the 'PLM Underground" by PLM or IT practitioners. Without adequate enterprise tools to effectively deal with product complexity, engineers have been forced to use whatever tools and manual processes they have available. Instead of collaborating within shared systems, engineers are forced to rely on email, phone calls, meetings, and thousands of Excel spreadsheet to collaborate on designs and manage product-related data.

These manual processes lead to poor visibility of critical information and undocumented workflows, requiring engineers to spend more time putting out fires, issuing workarounds, and fixing problems—all of which limits their ability to innovate and maintain a competitive edge. This has been going on for so long that for many engineers the PLM underground is "just another day at the office".

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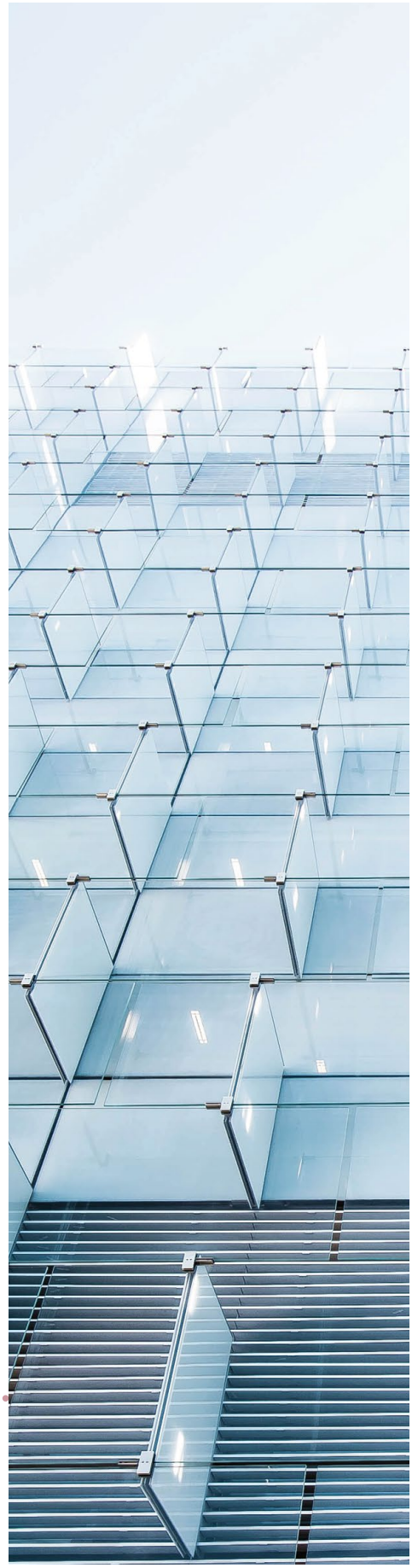


The Aras Innovator Platform

As part of the digital transformation, manufacturers frustrated by disconnected PLM and struggling to develop smart, connected products can take advantage of a new approach—the Aras Innovator Platform. The analysts are pretty clear that this is the path manufacturers need to take:

- Gartner predicts a product innovation platform will disrupt the way product lifecycles are managed
- IDC believes it will allow for better decision-making
- CIMdata identifies the key platform elements: productivity tools, lifecycle management, and collaboration across functions

Aras' mission critical low-code platform (as shown in Figure 4) provides a unified environment that allows all users of product information to collaborate around a single set of processes spanning systems engineering, hardware and software development, variant and option management, part release, manufacturing planning, quality, technical documentation, and program management. Aras Innovator delivers end-to-end lifecycle management at the enterprise level, along with cross-functional collaboration capabilities and through-life configuration management.

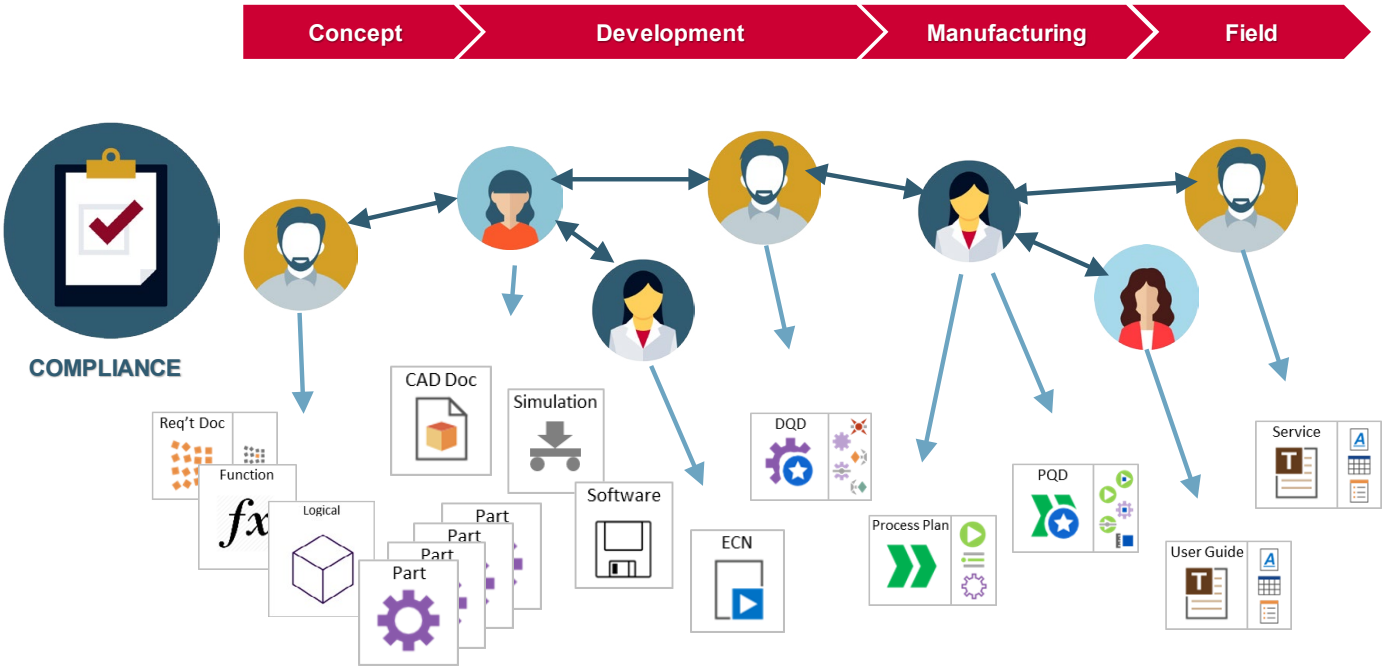
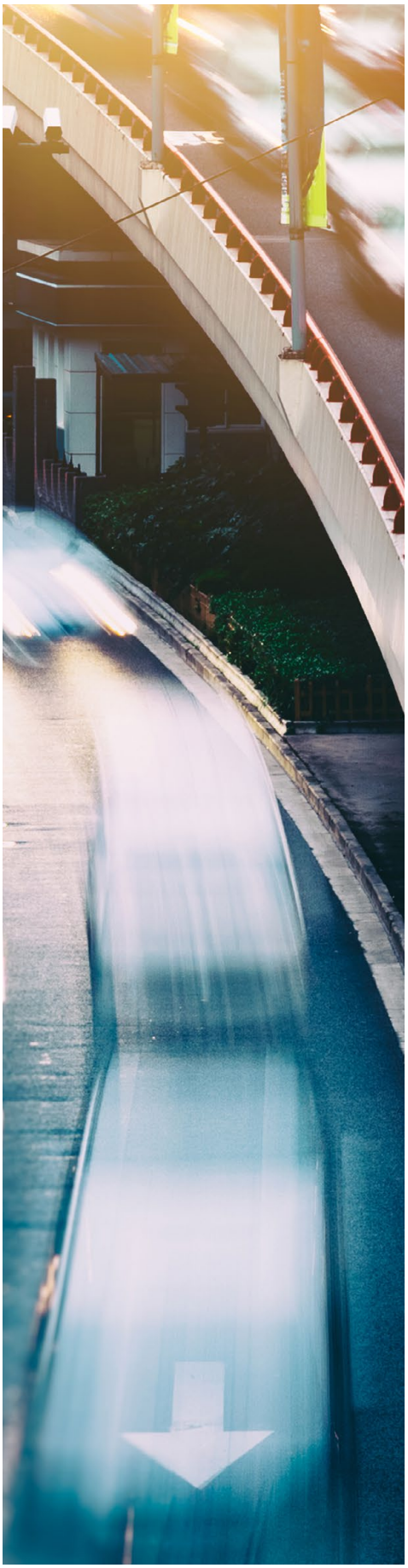


Figure 4: The Aras Innovator Platform



4 Key Features of a Resilient Platform

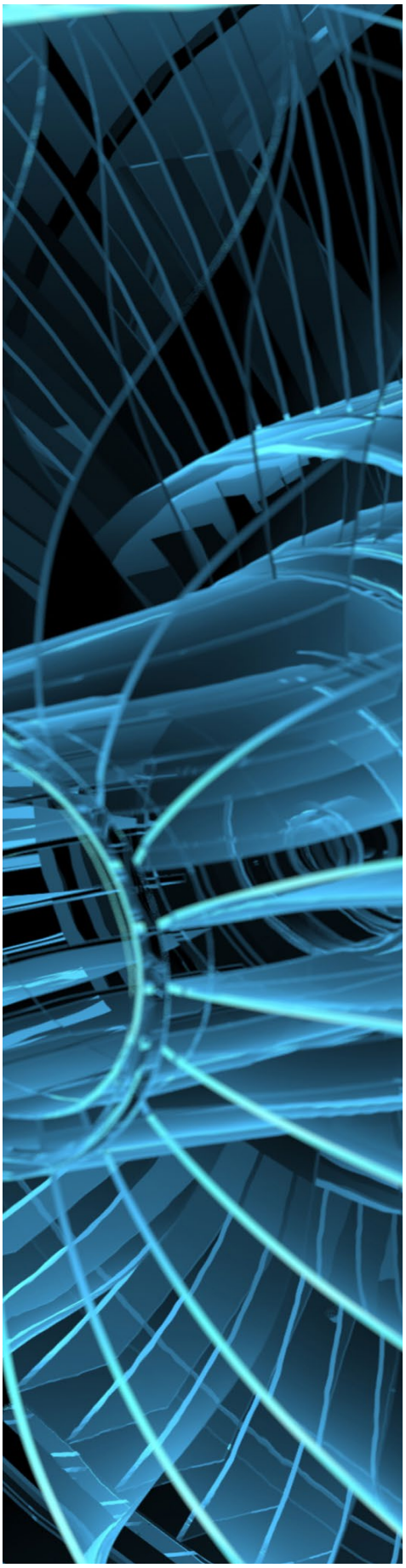
The four key features of a resilient platform demonstrate how they were developed specifically to address digital transformation in manufacturing companies.

Feature #1: Connect Teams to Contextual Information

This may sound simple. Yet, traditional PLM systems have struggled to do so for more than two decades. In comparison, the Aras Innovator Platform allows users to work across system and functional boundaries such as ERP, MES and MRO, and provide access to mechanical and electronic designs, software, requirements, technical documentation, process plans, and quality documents—a scenario not possible with systems built on different technology stacks due to their fragmented architectures. In addition, information is presented in a usable way, providing consistent access controls, while respecting configuration rules.

Feature #2: Manage Configurations Across Disciplines and Functions

Complex, connected products require a systems approach to design, and a resilient platform can ensure all disciplines and functions are working from the same requirements and systems model. Moreover, it allows hardware and software deliverables to be structured in the same composite Bill of Materials (BOM) ensuring accuracy at critical hand-offs (e.g. Engineering to Manufacturing), enabling multiple engineering disciplines to collaborate with one another in design reviews and adhere to the same change management processes. It also enables traceability. For example, anyone connected to the platform can select a part and instantly view the related CAD model, simulation tests, requirements, change history, manufacturing execution data, and in-service field data. Most importantly, it ensures those linkages persist for years, even after system changes occur.



A Resilient Platform ensures those linkages persist for years, even after system changes occur.

Feature #3: Enable Collaboration Across Teams, Functions, and Disciplines

A resilient platform enables team collaboration to support interactions across functions (e.g., design, analysis, quality, and planning), across disciplines (systems, mechanical, software, and electrical), and across the extended enterprise with suppliers and partners. Both formal and informal collaboration is supported. Informal collaboration, for example, when reviewing a design proposal, supports markup (of all information types), and discussion threads. Formal collaboration, for example, when implementing an engineering change, follows flexible workflows that adhere to the established processes and rules, and create an audit trail that records critical decisions.

Feature #4: Support All Phases of the Product Lifecycle

CAD-focused PLM systems have struggled with functionality beyond design engineering, and thereby have lacked the ability to deliver on PLM's promise of managing the full product lifecycle. In contrast, a resilient platform manages all phases of the product lifecycle, especially the evolving product configuration and associated changes process. This process can begin as early as the requirements and systems modelling stage, flowing through and eventually providing context for Industrial Internet of Things (IIoT) data, and supporting quality, manufacturing planning, and service documentation processes.

Platform Support for the Digital Twin and Digital Thread

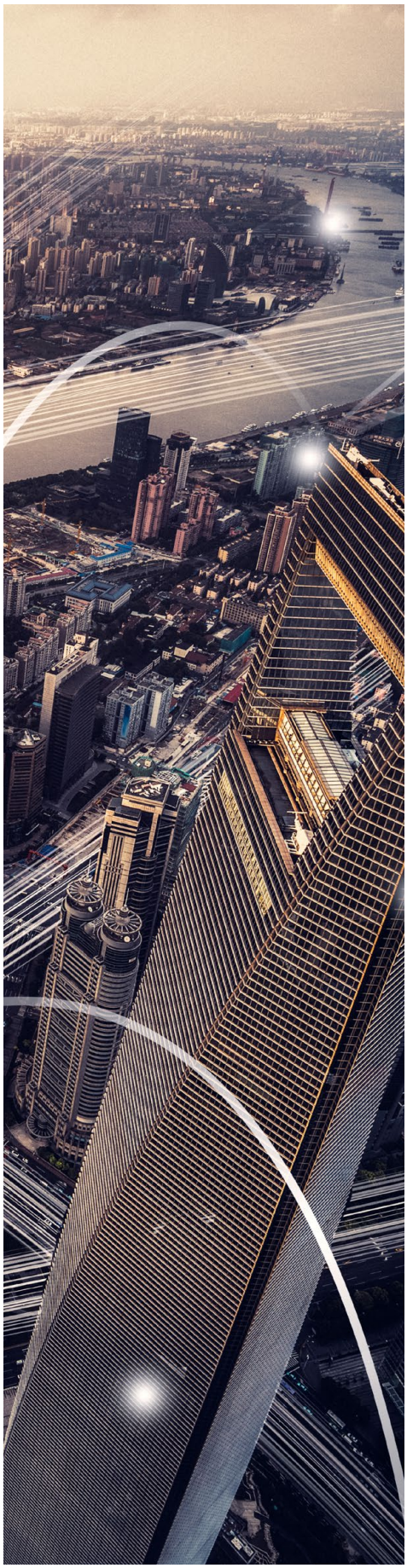
An emerging concept called the **Digital Twin** enables a new way of seeing the product. Whereas, we have historically viewed the product definition in terms of static design information, we can now fuse the real-time view of the product behavior as it is being used in the field with design intent as well as manufacturing and service histories.

IoT data from each in-service product instance can inform us of the product's real-time status, working condition, location, surrounding environment, and so on. By maintaining an up-to-date record of the in-service product configuration, we can associate the insights gained from this data back to the product definition at each phase of its lifecycle, resulting in a much higher fidelity view of its definition.

The Aras Innovator Platform supports the extensive use of modeling, simulation, and analytics to describe the structure and behavior of the product before the first prototype is even manufactured. This can include every possible aspect of the product, including systems models, physical structure (mechanical, electrical, and electronic), software structure, and more.

These models are connected via a **Digital Thread** in such a way that all aspects of the product can be simulated together to more accurately predict the physical product's behavior long before the first prototype is built. Eventually, IoT data can inform and enrich these models and simulations.

The Digital Twin and the Digital Thread are closely related and dependent upon one another to drive full business value (see Figure 6).



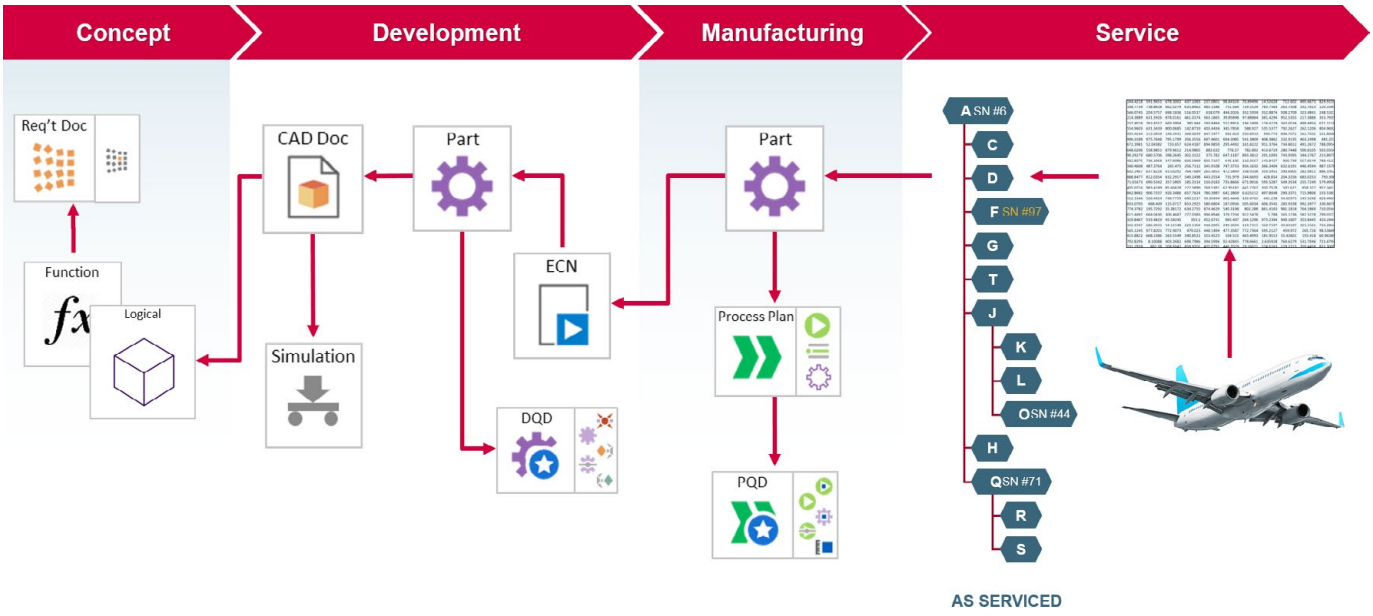


Figure 6: Digital Twin and Digital Thread

The Aras PLM Platform Approach

Aras' Industrial Low-Code Platform features open technology that is flexible, scalable, and upgradable to meet the evolving needs of an extended enterprise (see Figure 7).

At the core of the Aras Innovator Platform is model-based technology and a service-oriented architecture (SOA) that allow companies to develop and modify applications, processes, and workflows far more easily than traditional PLM systems that take a hard-coded approach and struggle to adapt. Applications are built and modified using a visual approach via the Aras Modeling Engine, and models "subscribe" to the services they need, which ensures easier upgrades and the preservation of customizations. In fact, subscribers have their upgrades completed for them by Aras in a matter of weeks. An additional benefit of the Aras Innovator Platform is its Enterprise Open Source model and predictable annual subscription fee, which covers full access to applications and platform features, maintenance, support, training, software updates, and upgrade services. By comparison, traditional PLM typically has a hefty upfront cost to cover modules and per-user fees on top of additional annual maintenance charges. The Aras Innovator Platform also brings flexibility to the deployment model, supporting on-premises, hybrid, or cloud installations (public or private).

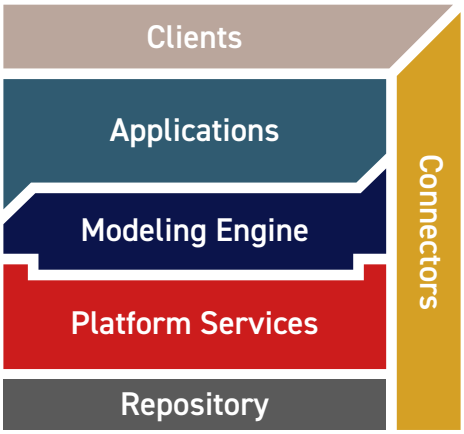


Figure 7: The Aras Innovator Platform Architecture

In addition, it supports an open architecture, including open standards, APIs, and connectors, ensuring

the platform easily integrates with other enterprise applications and legacy PDM/PLM systems. Finally, the open community approach means companies can participate in collaborative, open-source development and innovation, casting a wider net for capabilities that will accelerate and increase the value of their implementations.

When a PLM system has failed to meet its goals, companies have typically had only one choice – "rip and replace" – meaning turn off the existing system and start fresh with a new one. But, the Aras Innovator Platform enables organizations to maintain existing systems that have been heavily customized, yet still keep their environments current with new features.

By overlaying existing PLM environments with the Aras Innovator Platform (see Figure 8), organizations can avoid the short-term costs and risks of migrating older systems while positioning themselves to deliver consistent product innovations. Manufacturers get the benefits of a single, resilient unified platform while keeping existing systems in place as long as it makes sense.

Moving towards a common product platform does not require that all information be stored and managed in a single repository. Quite the opposite. Using Connectors for other systems, manufacturers can leverage their existing investments while focusing on deploying new application capabilities to their users. And by connecting systems across domains – MCAD, ECAD, and software - they can create composite BOMs and synchronize processes across disciplines.

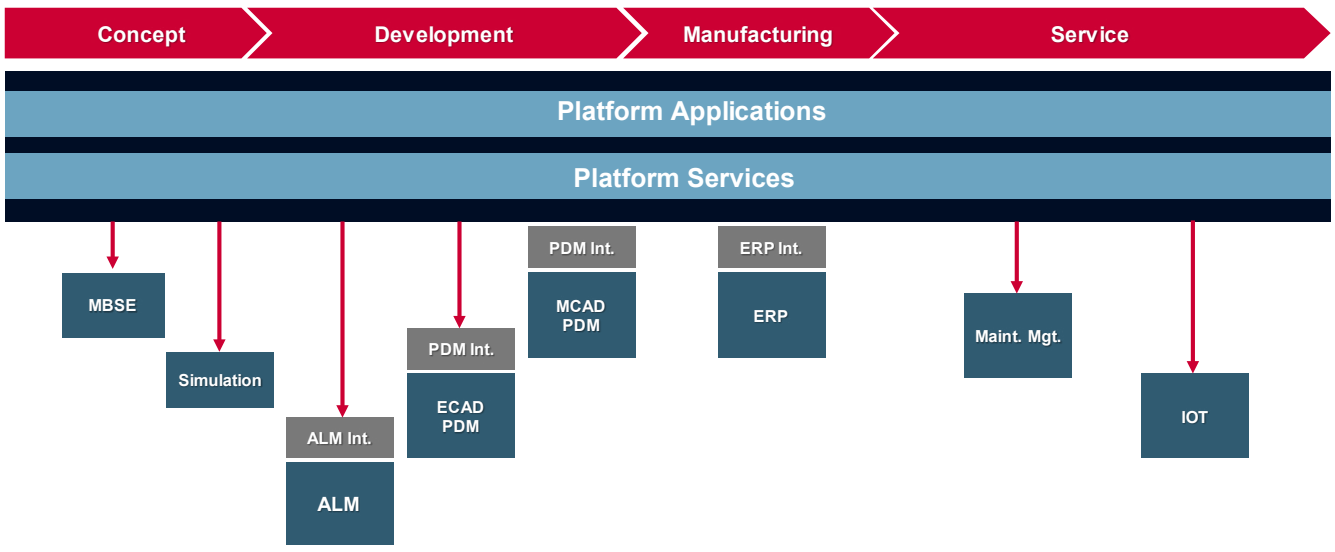


Figure 8: The Aras PLM Platform Overlaying Legacy Systems

Aras' mission critical low-code platform is a proven enabler for product innovation. Many Aras customers have already reported success going beyond the limits of traditional PLM in areas such as:

- Managing MBOM development while maintaining traceability to the EBOM
- Integrating hardware and software configurations
- Integrating with an MBSE tool and linking the logical and physical structures
- Managing the in-service product configuration

CIMdata Platform Assessment

Analysts CIMdata recently published an assessment of Aras Innovator against the criteria they have established to define the Product Innovation Platform[2]. As shown in Figure 9, Aras Innovator achieved top scores in every category measured. In fact, CIMdata believes that Aras Innovator sets the high bar for Product Innovation Platform support.

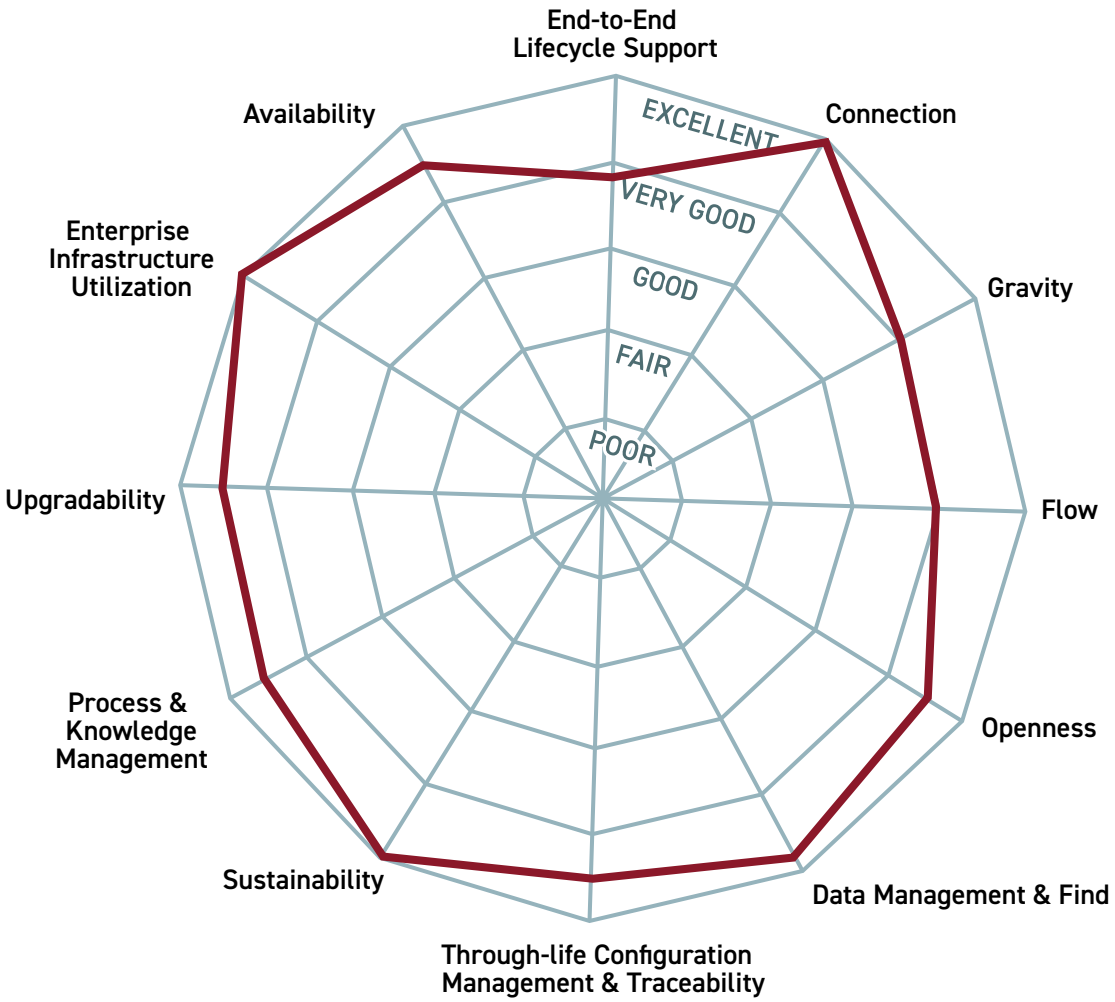


Figure 9: CIMdata assessment of the Aras PLM Platform

[2] CIMdata: Product Innovation Platform Assessment: The Aras PLM Platform, August 2017

Conclusions

As companies grapple with legacy processes and systems while they develop and manage complex connected products, digital transformation becomes a priority in order to maintain a competitive edge.

A resilient platform that is accessible to all producers and consumers of product lifecycle information is fundamental to breaking down barriers and building trust in data so teams can collaborate efficiently and effectively.

The Aras Innovator Platform is a proven solution being used by manufacturers across multiple industries and validated by independent analysts CIMdata.