



Digital Thread in Aerospace and Defense

Poised for Rapid Growth

Sponsored by PTC



Topics

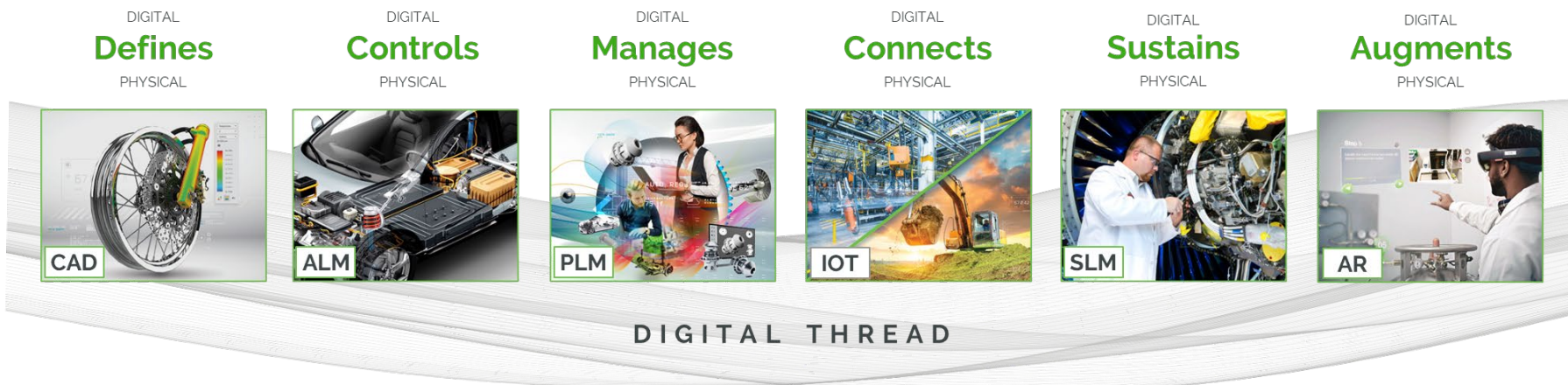
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A&D Research

Recent CIMdata research on behalf of the Aerospace and Defense PLM Action Group member companies in collaboration with PTC clearly indicates that digital thread investment within the ecosystem of industrial users, their customers, suppliers, and solution providers is poised for rapid growth.

Initial implementations of targeted digital thread solutions have provided proof points of value and essential learnings. Now rounds of investment are ramping up, guided by these early achievements and with expectations driven by the value potential revealed.



Courtesy of PTC

Digital Thread's Rise to Prominence

The concept of a digital thread providing automated linkage of multiple representations of a product, each tuned to the needs of various creators and consumers along the lifecycle, is very powerful. Until recently, tracing these linkages has been primarily a manual process, extracting product information from myriad heterogeneous systems and relating them in ad hoc reports. But now, with recent advances in commercial PLM solutions, the digital thread, with automated linkages and traceability, has become a practical possibility, even for industries with complex products, such as aerospace & defense.

In response, industry leaders have implemented targeted digital thread solutions and envision expanding these solutions throughout the product lifecycle. With the newness of this approach there is not much available in the way of lessons learned or value achieved. This lack of real data is a barrier to broader investment within industry. On the solution side, providers are constantly seeking additional insight into investment drivers within industry.

Recent research by CIMdata on behalf of the Aerospace and Defense PLM Action Group (AD PAG) in collaboration with PTC has provided critical insights, which inform the content that follows. Information was gathered through thought leader interviews and responses to an online survey. The majority of respondents were from A&D, but the results are relevant across all industries with complex and regulated products.

What is Driving Interest in Digital Thread?

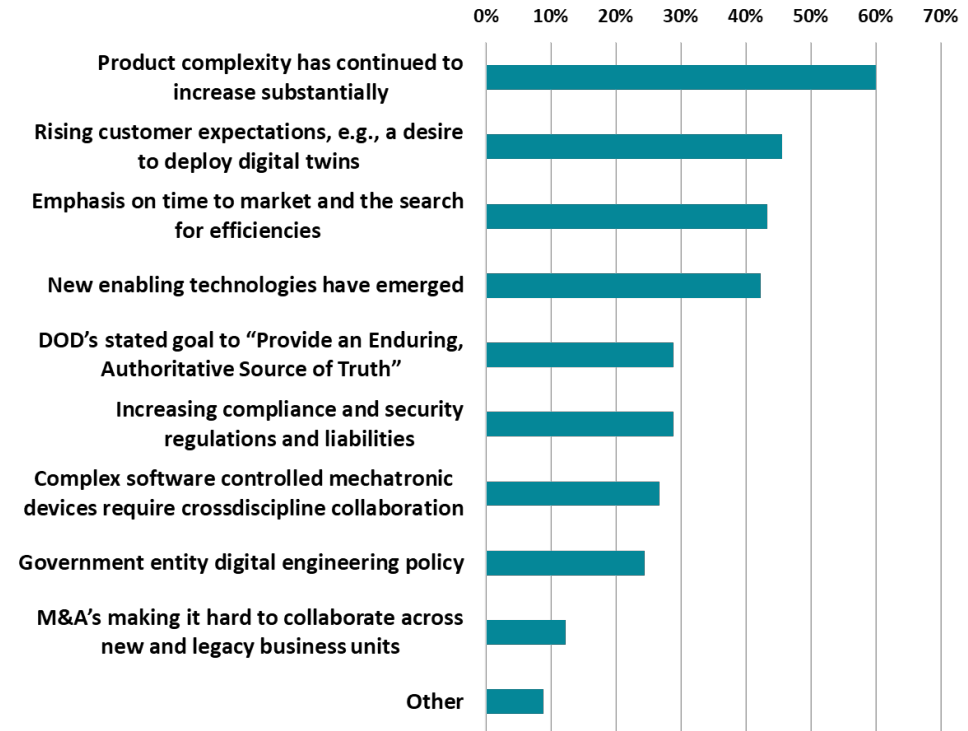


Figure 1—Reasons for Digital Thread's Rise to Prominence (% of respondents)

PTC Defines the Digital Thread

A digital thread creates a closed-loop between the physical and digital worlds that spans the entire product lifecycle, ensuring accurate product and process information is available to the right person, at the right time, and in the right context.

What the Digital Thread Does

The conceptual understanding of digital thread within industry is very immature. Nearly half of the companies surveyed do not have a commonly accepted definition of digital thread. Less than 10% use a published definition. Interviews with 10 industry leaders yielded 10 definitions. Some were long, others brief. Only two were based on definitions published by respected external authorities.

Though there may not be a consistent and widely accepted definition of digital thread, there is a broadly shared perception of what a digital thread **does** and what a digital thread **is**.

Combining the most prominent characteristics of what a digital thread **does** yields a reasonable definition of digital thread, i.e., “Establishes traceability of product information across multiple domains in the lifecycle (mechanical, E/E, software, and firmware) to provide meaningful relationship connections between a product’s digital assets.”

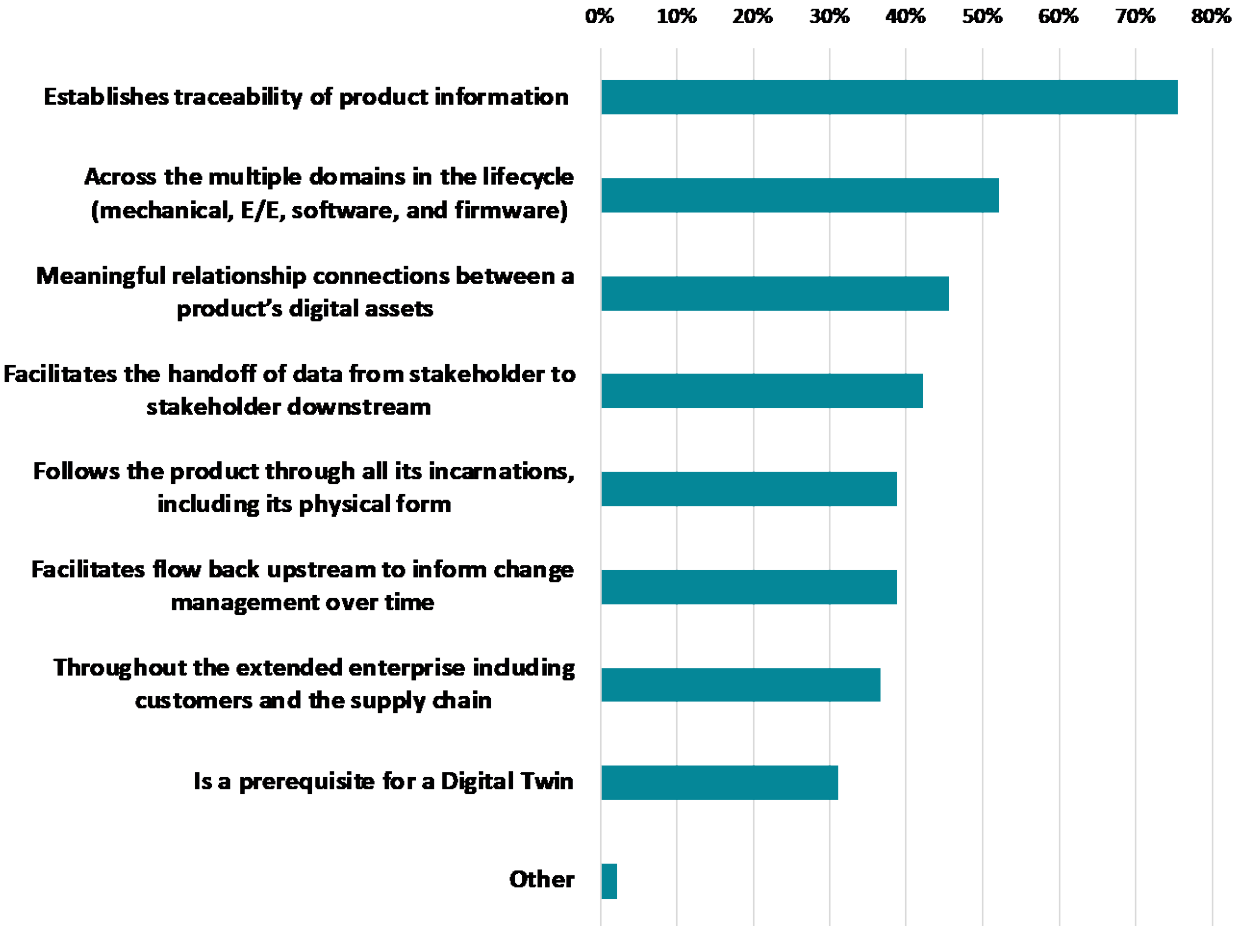


Figure 2—Most Significant Characteristics that Describe What a Digital Thread **Does**

What the Digital Thread Is

The most prominent characteristics of what a digital thread **is** reveal a mature appreciation among specialists in industry of the required capabilities of enabling technologies and appropriate architectural approaches for implementation of a digital thread solution.

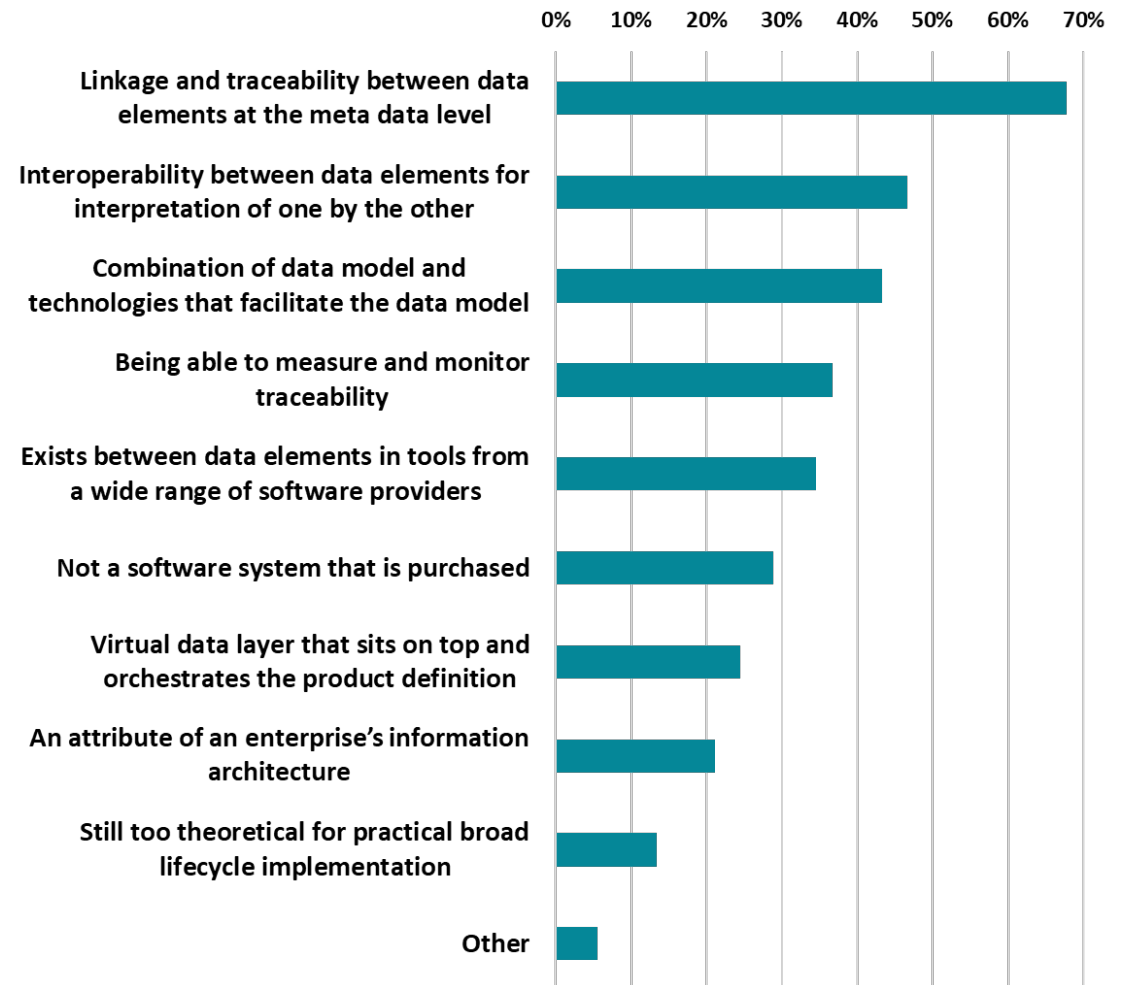


Figure 3—Most Significant Characteristics that Describe What a Digital Thread **Is**

The Digital Thread Value Footprint—Program Stage

Industry leader interviews revealed a wide range of digital thread realities. All of these companies are motivated and moving with a sense of purpose. All have implementations supporting multiple use cases. Most of these use cases are in support of product development, providing some degree of requirements traceability and integration between engineering and production.

Referring to the lifecycle definition from ISO 15288 in Figure 4, survey respondents indicated where and when they were implementing their digital thread solutions.

Investment to date has been concentrated in the Concept and Development lifecycle stages and will shift in the near term to Development and Production, while ramping up in the later lifecycle stages. In the longer term, investment will shift substantially to the later lifecycle stages.

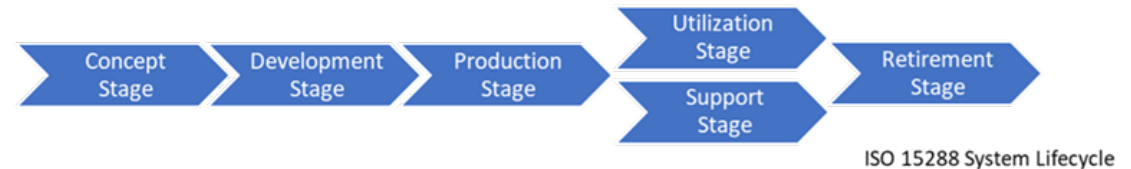


Figure 4—Lifecycle Definition from ISO 15288, “Systems and Software Engineering—System Life Cycle Processes”

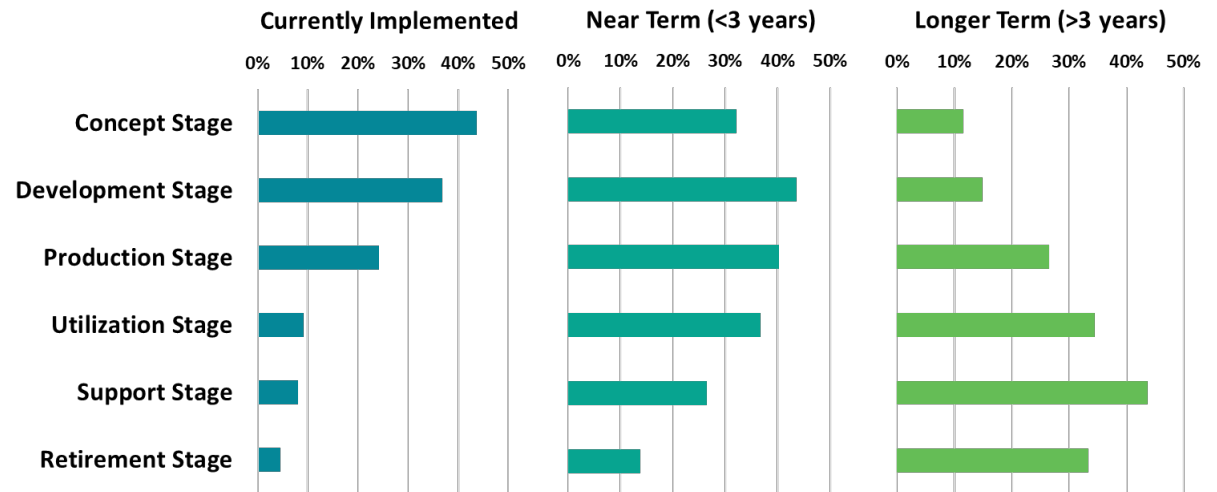


Figure 5—Plans to Expand Current Digital Thread Implementations Within and Across Lifecycle Phases Over Time

The Digital Thread Value Footprint—Data

Delving deeper we explore what data are being linked together and what use cases are being enabled.

Currently, the most prevalent digital thread linkages are between design-related data categories, i.e., needs and requirements data, mechanical design data, E/E design data, software design data, and engineering bill of materials data.

Going forward, investment in establishing linkages between design-related data categories will in the near term be more broadly dispersed across the product lifecycle. In the longer term, investment will shift toward linking data within and between categories associated with the later lifecycle stages.

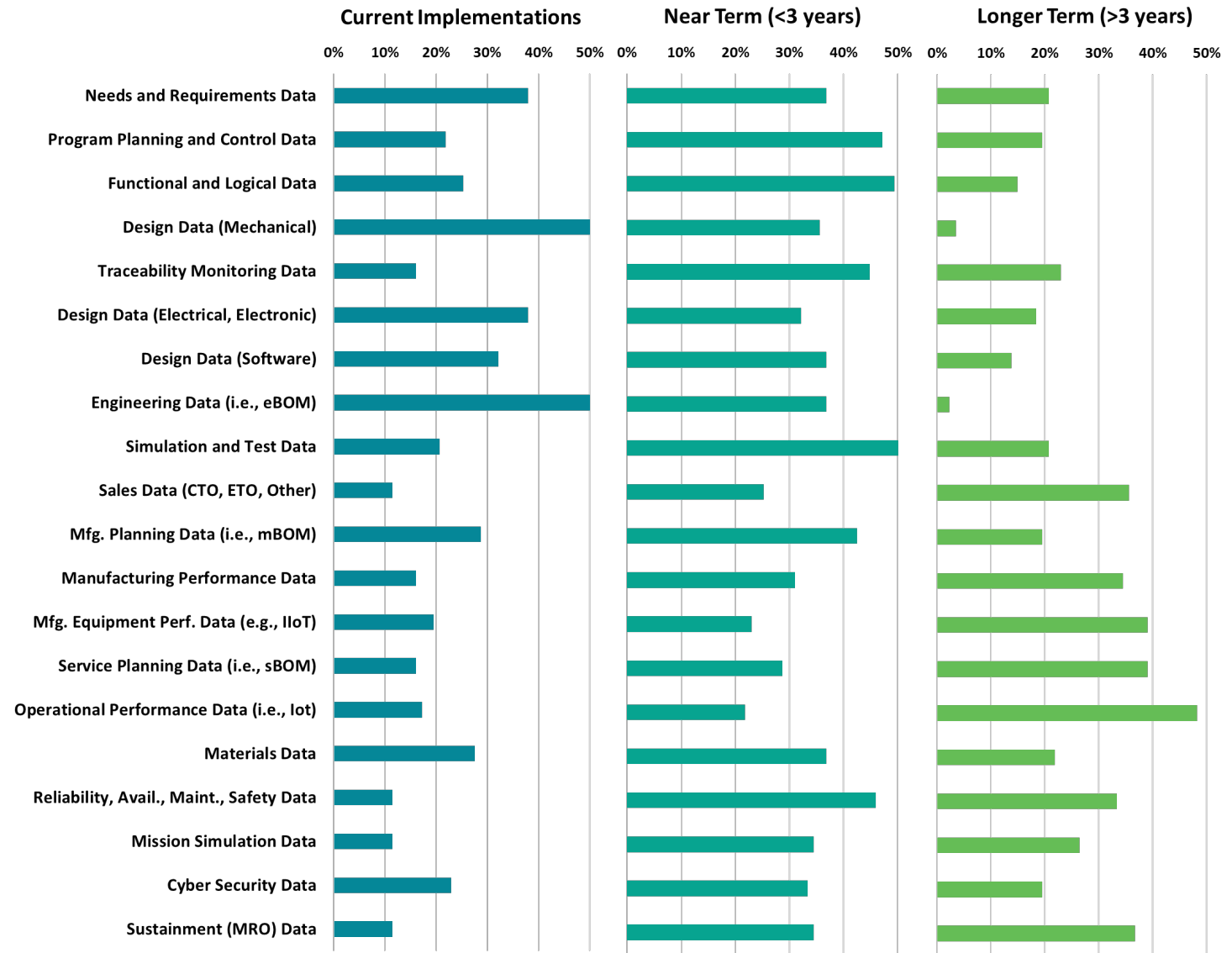


Figure 6—Plans to Expand Current Linkages Within and Across Product Lifecycle Data Categories Over Time

The Digital Thread Value Footprint—Use Cases

Our survey results highlight an inconsistency between the importance of the digital thread to our respondents and their progress to date. The importance assigned to digital thread use cases is surprisingly broad and high. The prevalence of current digital thread use case implementations is surprisingly low. The most striking indicator that digital thread investment is in very early days is the contrast between importance assigned to digital thread use cases and the prevalence of current implementations. For example, lifecycle BOM management is considered essential by 62% and important by 26% of respondents but is currently implemented within only 25% of respondents' companies.

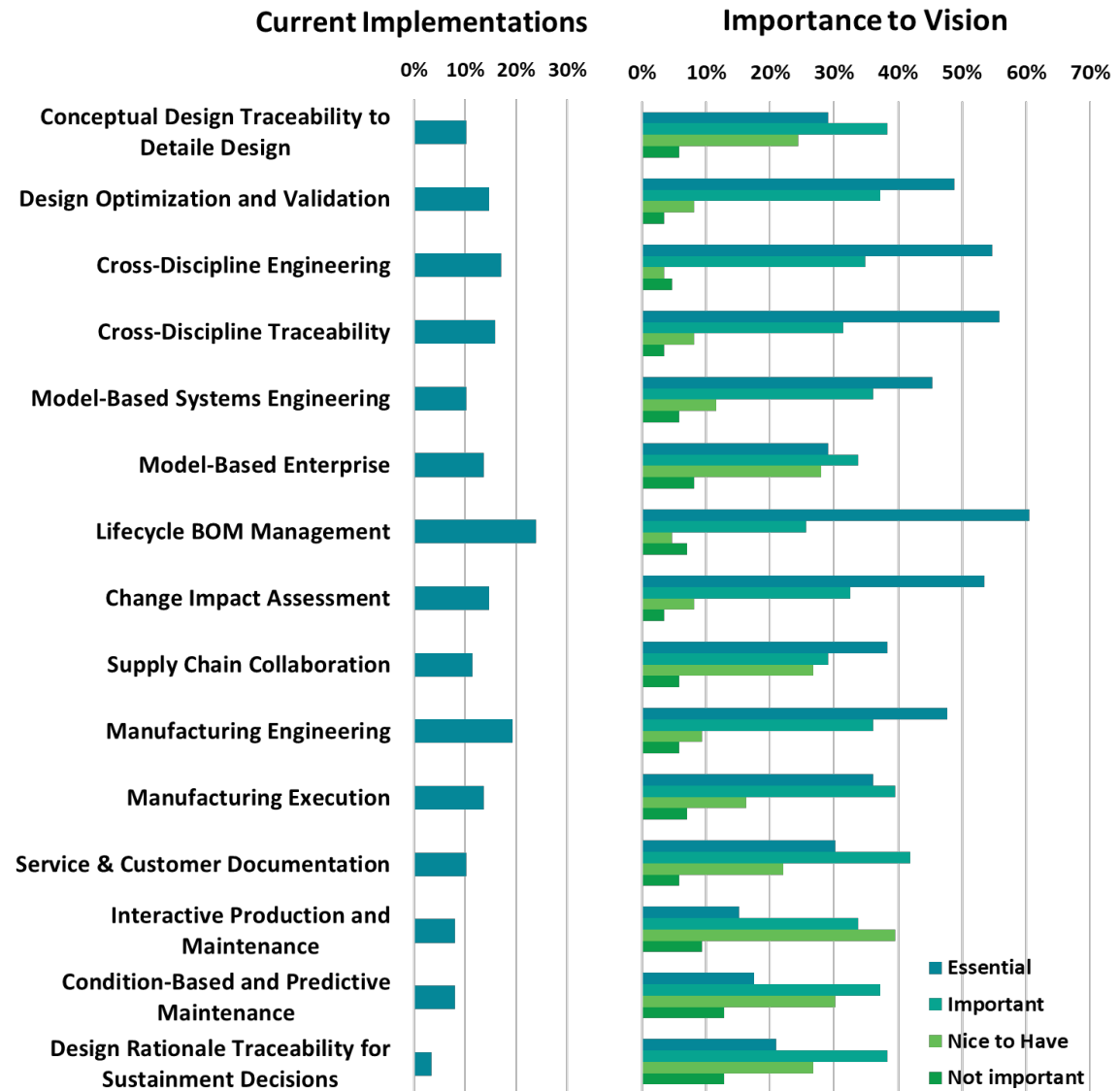


Figure 7—Digital Thread Use Cases Currently Implemented and Importance of Use Cases to Achieving the Digital Thread Vision

Digital Thread Realization

The digital thread is commonly presented as a sequential flow mapped to the product lifecycle. On the left in Figure 8 we show the four principal product structure configurations in lifecycle sequence. In this representation, threads would run left to right between the objects in one structure to the next in line. But if we look at the derivative relationships between these structures as shown on the right, we see that the dependencies are not sequential.

There are many other views of product structure that are relevant to various communities as they contribute their efforts throughout the product lifecycle. CIMdata believes that these product structure configurations are best depicted as a web.

As with all major endeavors, the key to success is to think big but focus on pieces of the total picture. Use cases are the pieces. They define scope and business value. Pick the piece, or use case, to work on next based on business problems to be solved or opportunities to be captured. And as you build out piece by piece, keep in view that bigger landscape so that the pieces fit together.

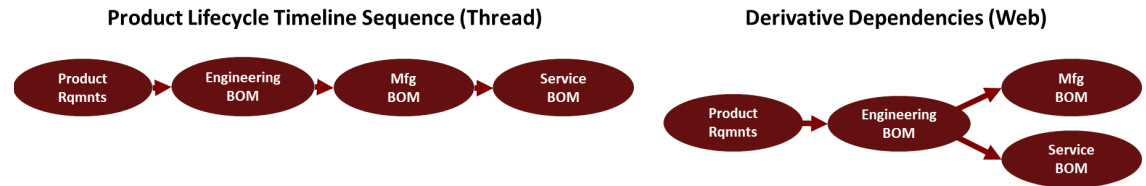


Figure 8—Two Perspectives of Digital Thread Dependencies—Timeline Sequence vs. Derivative Dependencies

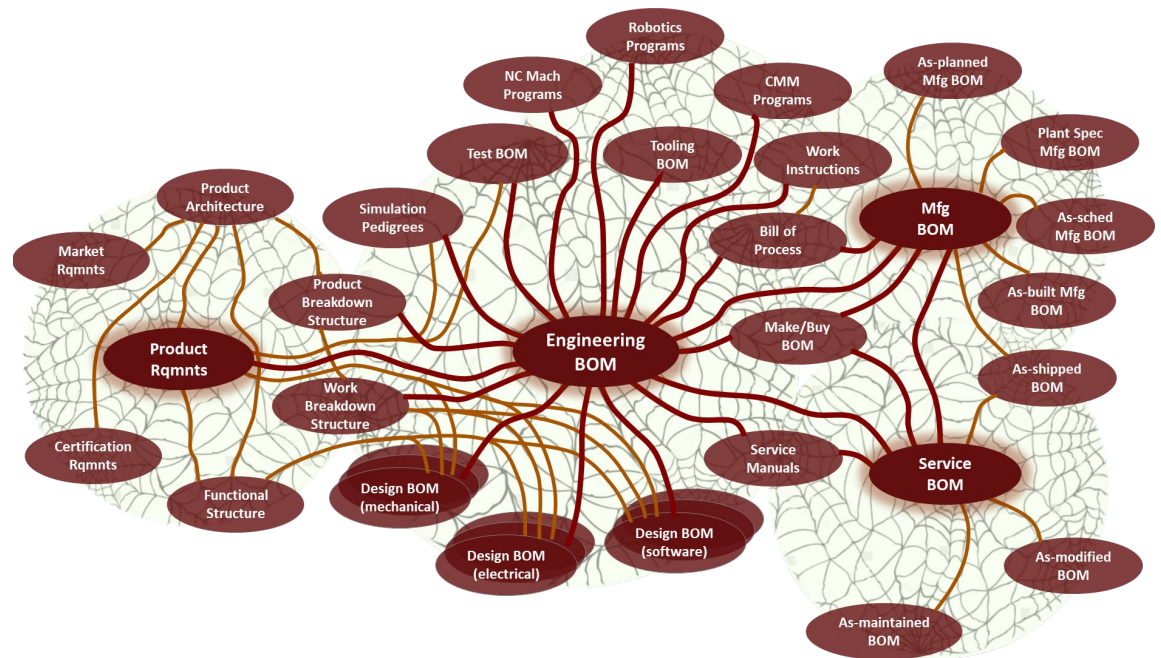


Figure 9—The Digital Thread is Really a Web

Case Study—Heavy Equipment Manufacturer

CIMdata has assisted industrial clients from multiple industries in their journey to build out a digital thread, and we believe the following case study provides a good example of a use case with clearly defined scope and business value.

In this case study, the company engineers and manufactures heavy equipment. An order may be for moderate to large volumes of these items which may be of multiple configurations, and since the equipment is expensive and lasts for a long time, they also sell complex support packages. Preparing proposals was very slow, error prone, and with a high dependence on tribal knowledge. Also, they were leaving money on the table due to their inability to provide a proposal in a timely manner.

The focus for the initiative was the proposal BOM, but root cause analysis quickly focused attention on the engineering bill of material (eBOM). Proposal information came from many disconnected, redundant, and non-synchronized sources. But the eBOM was the original source from which all of the other views were derived. In the original state, the eBOM, manufacturing BOM (mBOM) and service BOM (sBOM) were in separate systems. Make/buy and costing were in spreadsheets.

In step 1 of the transformation, the eBOM, mBOM and sBOM were moved to a single PLM solution, using multi-view BOM capability for automated reconciliation and synchronization.

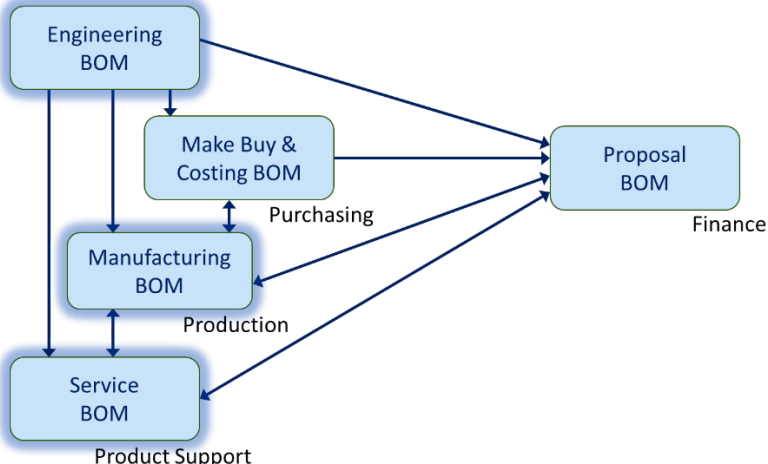


Figure 10—Heavy Equipment Manufacturer Case Study Scope

In step 2, make/buy, costing and proposals are generated on a low-code platform. The Consolidated BOM and the Proposal BOM are no longer Excel spreadsheets, but information mashups stored in the PLM.

Some business benefits identified from this transformation were:

- Reduced turnaround and increased accuracy of proposals
- Reduced level of effort and disruption of normal staff activity to verify product configurations for proposal pricing
- Ability to define service configurations more quickly and accurately

By focusing on a real business need, this company achieved significant payback and is now well positioned to build out more of their Digital Thread.

Case Study—Wind Turbine Manufacturer

Boasting a portfolio of complex, modular products, Vestas, a global leader in wind turbine energy, was looking to improve its largely manual manufacturing process. To execute variable build processes, Vestas operators require detailed work instructions that were traditionally paper-based. This required regular site visits to ensure workflows were up-to-date—creating a lengthy review process and unnecessary travel costs any time changes were made. Adding to delays, workers had to sift through volumes of instructions to find those relevant to their current job, further stifling productivity. All in all, Vestas knew that the methods in place were not sustainable.

Approach

It became clear that the company needed to take a digital-thread approach to manufacturing and reduce their reliance on paper-based instructions. To do so, Vestas adopted an entirely digital turbine production process including everything from CAD design and data management to manufacturing and service. To achieve this the company turned to PTC’s Windchill PLM for its configuration management and BOM transformation capabilities and ThingWorx Operator Advisor, to deliver role- and variant-specific digital work order information and instructions.

Results

The end-to-end BOM and configuration management capabilities of Windchill and ThingWorx enable Vestas to keep

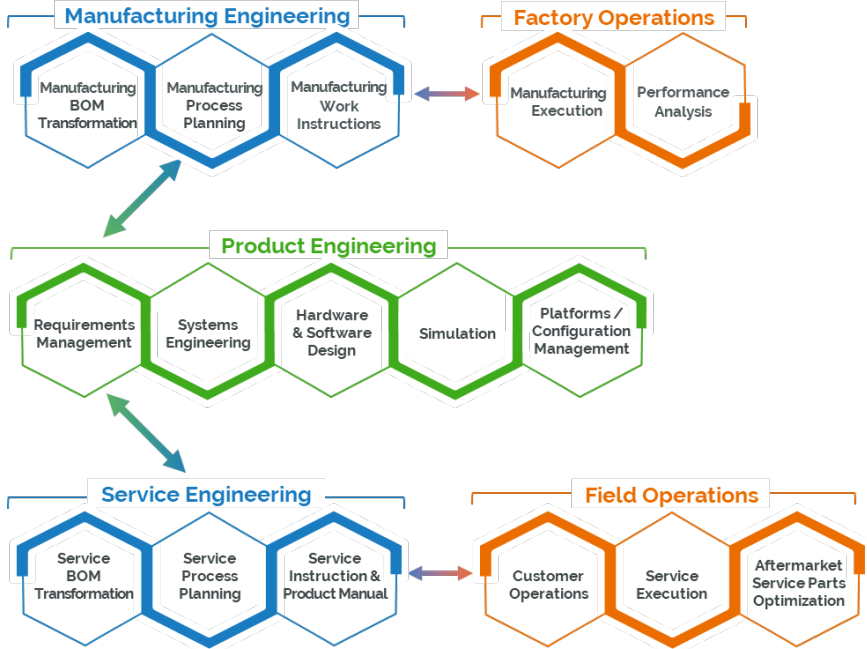


Figure 11—Traceable flow of product data between applications across departments

Courtesy of PTC

Engineering and manufacturing in sync, while eliminating manual handoffs and redundant work. Using Windchill, Vestas created product platforms for their turbine designs with options and variant management. Each variant that is ordered automatically generates derivative documents including mBOMs and work instructions to support downstream activities. This information is then delivered digitally to the shop floor using ThingWorx Operator Advisor. This digital thread ensures Vestas’ employees in the factory and field have access to all of the information needed to complete their work digitally and in real-time. Vestas has experienced a step-function improvement in product and process quality and has significantly accelerated delivery times.

Future Digital Thread Investment Priorities

Looking to the future, industry leaders are taking a broader view of the digital thread’s value potential, with more investment in production and service use cases. They view the next stage as more complex and transformative to their companies. Fortunately, several have been successful in establishing programs that enjoy strong support from a well-informed and motivated senior management. However, many others have not.

All Top 5 pain points being targeted in future implementations relate to accessibility and traceability across data elements, especially traceability of requirements throughout the product lifecycle. Systems engineering is featured prominently in many responses, including ranking as the top new value opportunity being targeted in future digital thread implementations, which aligns with CIMdata’s view that systems engineering is a principal driver of the digital thread.

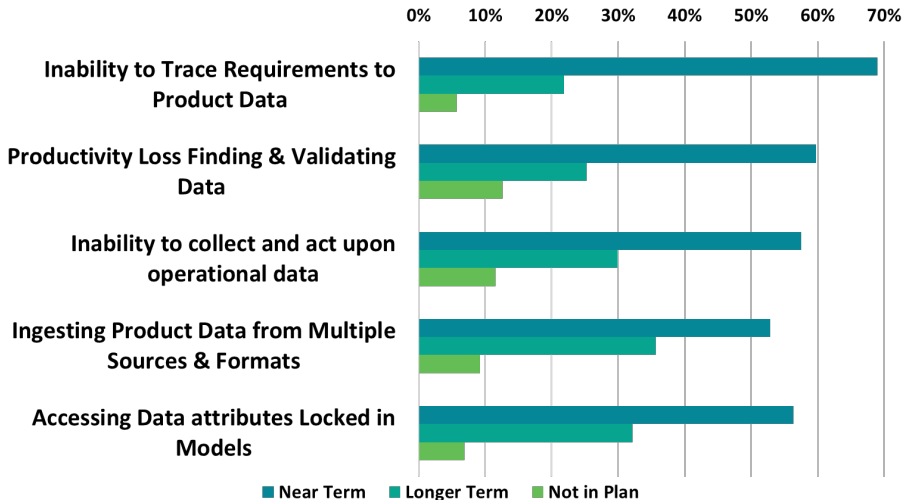


Figure 12—Top 5 Pain Points Being Targeted in Future Digital Thread Implementations

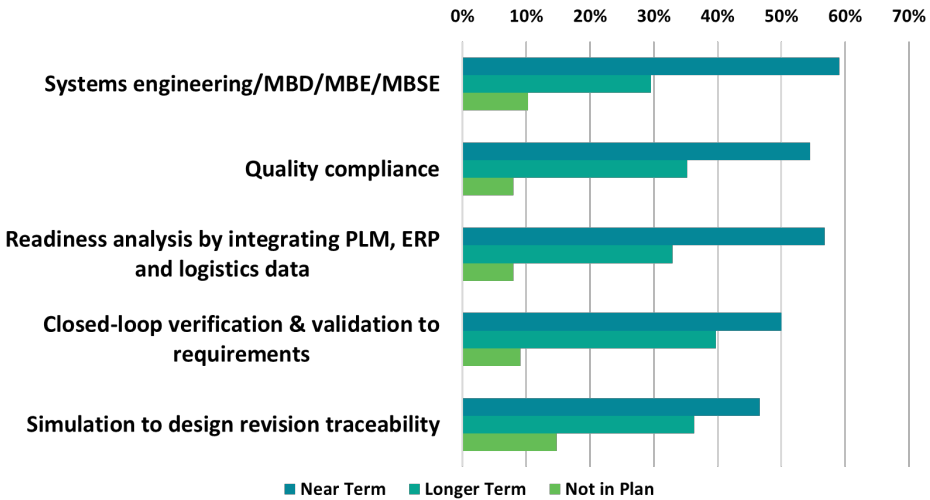


Figure 13—Top 5 New Value Opportunities Being Targeted in Future Digital Thread Implementations

Strategies for Success

An area of divergence between industry leaders is in the focus of their implementations. For some, the focus is providing interfaces to source applications to extract and associate product data artifacts and attributes. For others, the key is the association and traceability of dependencies between artifacts in support of a use case. And for a few, the focus is on data governance, which they believe is foundational for enabling a richer and more extensive set of product lifecycle use cases.

The number 1 inhibitor to formulating and executing a digital thread strategy is “lack of interoperability between different vendors’ tools and systems.” The number 1 proposed means for mitigation is to “increase support of standards.”

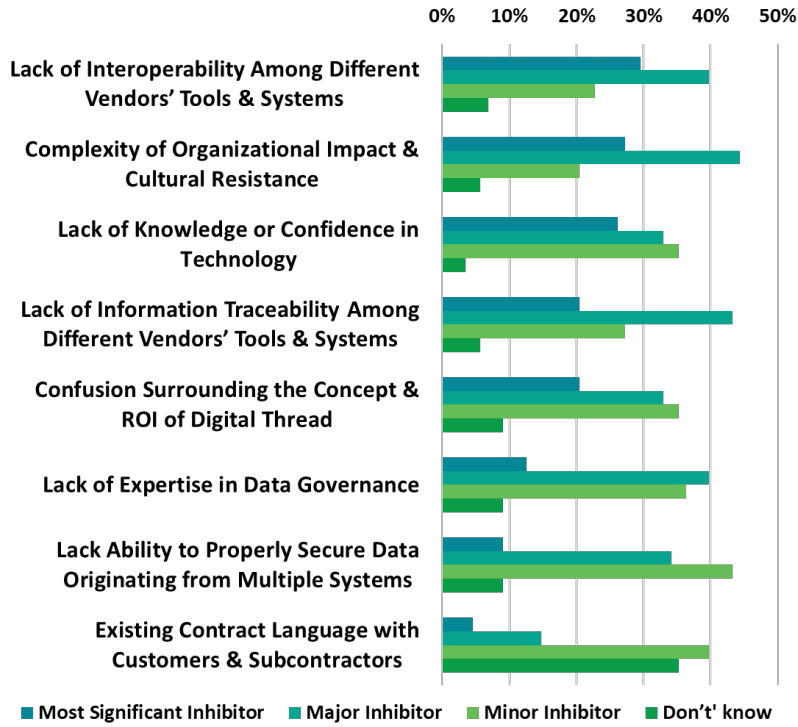


Figure 14—Principal Inhibitors to Formulating and Executing a Digital Strategy

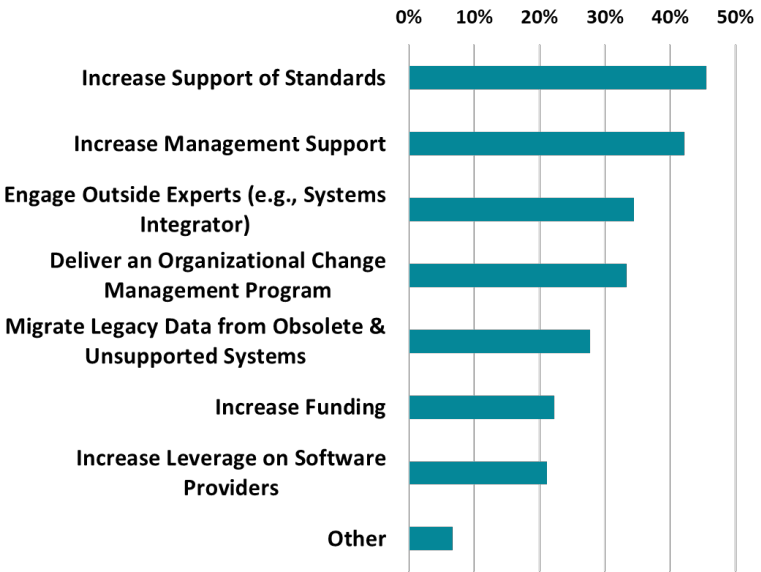


Figure 15—Proposed Means for Mitigation of Inhibitors to Formulating and Executing a Digital Strategy

Solution Technologies

Key Technical Considerations

Core to the value of digital thread is traceability across source and derivative product-related artifacts along the product lifecycle and throughout the extended enterprise.

The digital thread value landscape is distributed across a heterogeneous value chain from customer to OEM to partners and multiple tiers of suppliers. This reality drives the need for data interoperability and elevates the importance of standards and openness of enabling solution architectures.

Proven technical solutions exist for enabling the digital thread, and leading solution providers are investing heavily in research-guided strategies and roadmaps to further strengthen their offerings.

Data is the foundation of the digital thread. This reality elevates the importance of sound data governance and a cleansed repository, especially as use case implementations proliferate and must be interlinked into an extended thread.

Technologies in Use Today

The technologies used to link product lifecycle data segregate into three tiers as shown in Figure 16. The top tier, which has the longest history, includes PLM and PDM, followed by ERP, and custom applications. The middle tier consists of application and data integration tools. These are followed by the third tier of

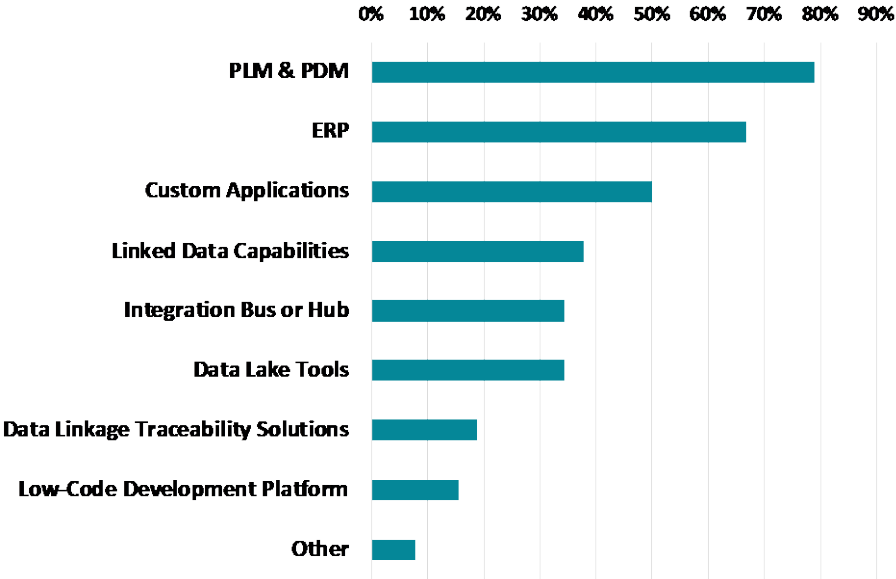


Figure 16—Technologies Currently Used to Link Product Lifecycle Data

newer specialty technologies for combining data from multiple sources and establishing linkages and traceability. We can expect the ranking of these specialty technologies to rise significantly over the next few years.

Solution Capability and Provider Alignment

Attitudes on the topic of solution capability and provider alignment are mixed. Some industry leaders are quite critical, especially regarding data model accessibility and flexibility to comply with a corporate data governance strategy. Other interviewees are somewhat neutral or slightly positive. They feel that some providers are moving in the right direction; some are not. Several feel that solution capabilities have improved significantly overall in the last 5-10 years and that, despite some remaining gaps, are now fully capable. Some express satisfaction that “good partnering” is happening.

About the Aerospace & Defense PLM Action Group

The Aerospace & Defense PLM Action Group is an association of aerospace OEMs and aircraft engine providers within CIMdata's globally recognized Community Program, which functions as a PLM advocacy group to:

- Set the direction for the aerospace & defense industry on PLM-related topics that matter to members (including promoting, not duplicating, the work of standards bodies)
- Promote common industry PLM processes and practices
- Define requirements for common interest PLM-related capabilities
- Communicate with a unified voice to PLM solution providers
- Sponsor collaborative PLM research on prioritized industry and technology topics

CIMdata administers Group operations, coordinates research, and manages the progression of policy formulation.

About PTC

PTC enables global manufacturers to realize double-digit impact with software solutions that enable them to accelerate product and service innovation, improve operational efficiency, and increase workforce productivity. In combination with an extensive partner network, PTC provides customers flexibility in how its technology can be deployed to drive digital transformation—on premises, in the cloud, or via SaaS with Windchill+. At PTC, we don't just imagine a better world, we enable it. To learn more, visit [PTC.com](https://www.ptc.com)

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