ptc

The State of Digital Thread

How Companies are Closing the Loop Between Digital and Physical

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WHITE PAPER

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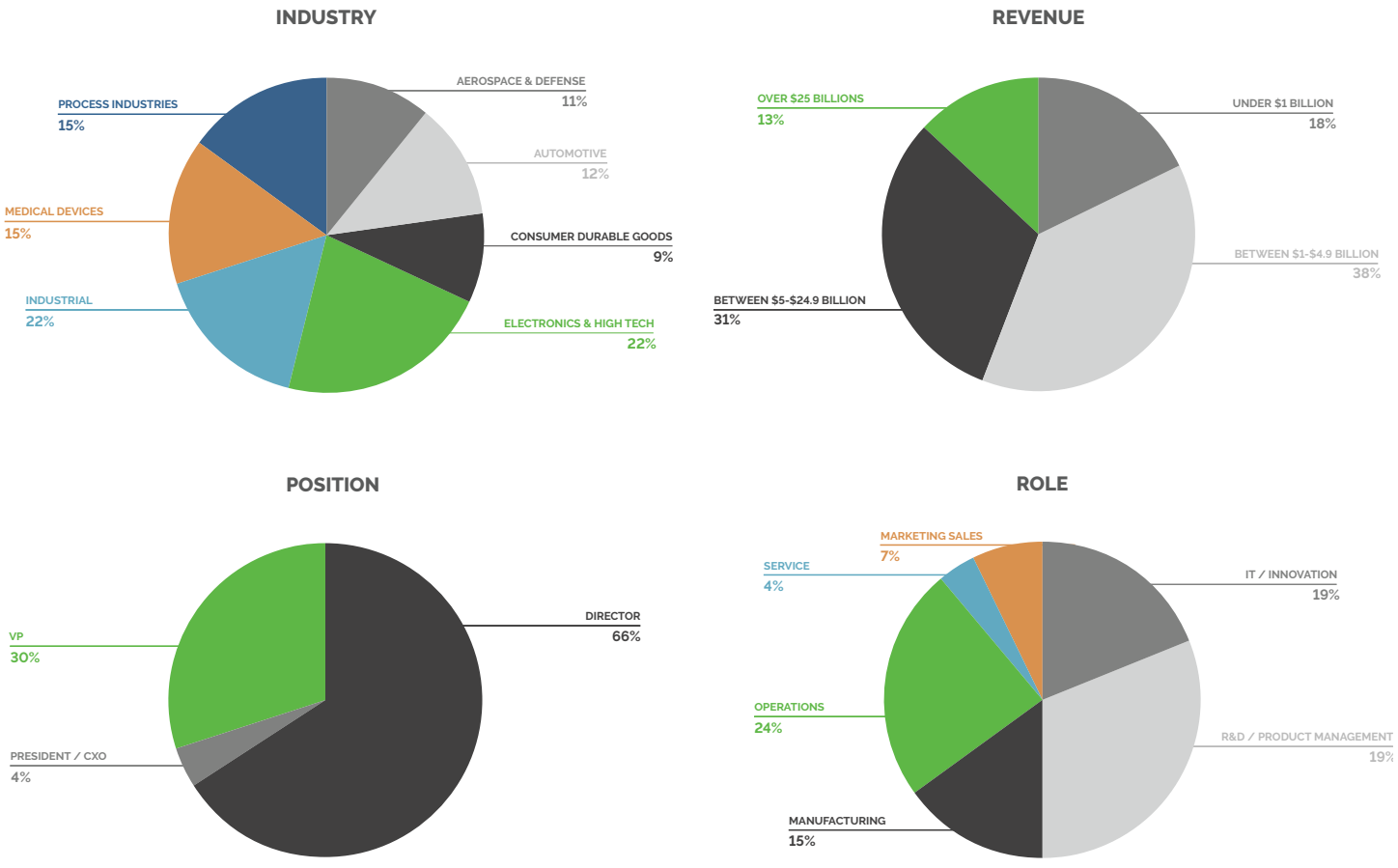
Introduction

Today's industry leaders consider digital thread initiatives a top priority. When stacked up against fifteen other technologic, strategic, and economic trends, participants of PTC's State of Digital Thread survey identified digital thread as the second most impactful, trailing only supply chain agility and ahead of typical headliners like artificial intelligence, cybersecurity, the evolving workforce, and digital twins.

PTC's digital thread research, which includes a market survey of 150 engineering, manufacturing, service, and IT department leaders, explores the notion of digital thread in detail: what it means in concept, how it manifests in practice, the value it provides companies today, and the challenges they face in implementation. In this paper we share our findings.

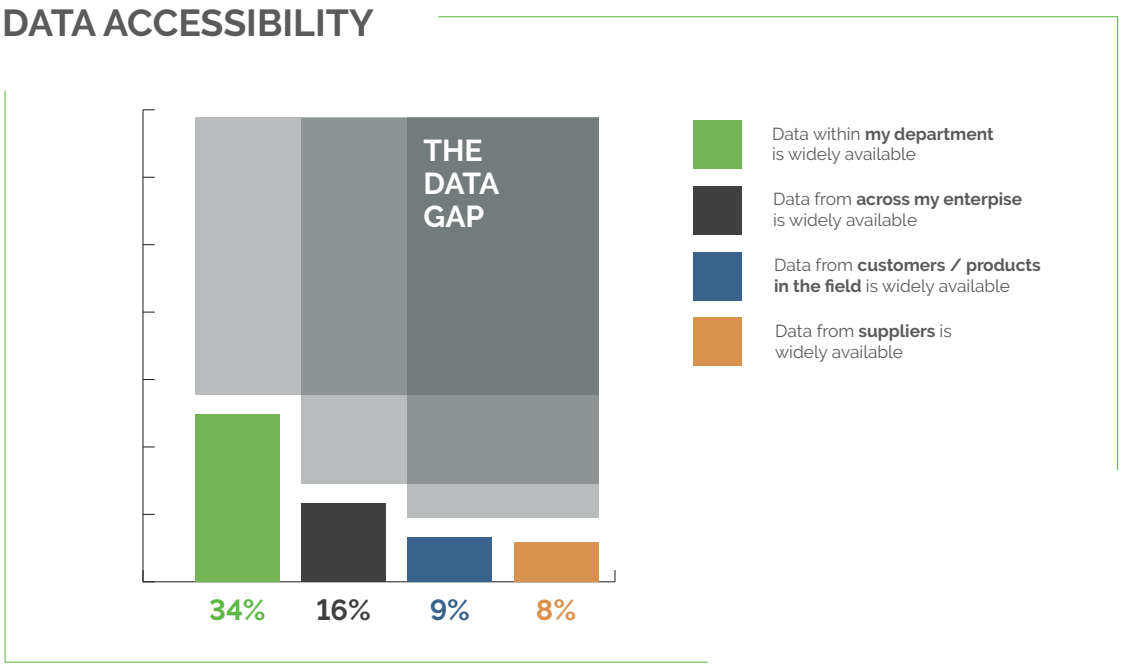
Survey Firmographics



Survey respondents N=150, USA

The Data Gap

To be competitive today, companies need to be agile yet scrupulous in their decision making and responsive and flexible in operations, which means information needs to be available, comprehensive, and in-context. Seventy-four percent of leaders who participated in PTC's recent State of Digital Thread survey cite improving their ability to leverage data across the enterprise would be effective or highly effective at addressing disruption. However, less than 34% say that data created within their department is widely available on their enterprise systems. This drops to 16% for company data generated outside their department, 9% for data from customers or products in the field, and 8% for data from suppliers. This lack of data accessibility suggests a tremendous gap between the perceived value of data and the ability of companies to recognize that value.



Q: Please select the option which best describes your organization's ability to access data from various sources through it's enterprise systems.
Survey conducted in 2021. n=150

Whether due to poor data governance, security concerns, or informal/ad hoc data sharing processes, the inability for employees to quickly access trusted, relevant data can present risk and missed opportunity. For example, a manufacturing technician who is looking at work instructions that don't reflect the latest changes from engineering may take actions that result in unnecessary scrap and rework. Similarly, an engineer in product development, who lacks field data to guide their decision making, could easily miss an opportunity to create a more customer-centric design.

The impact of these and other risks or missed opportunities is increasingly acute as adoption of digital technology provokes rising customer expectations and enables innovation of products and processes across the product lifecycle. Companies that fail to utilize their data better and more efficiently across functions and departments are at a significant disadvantage to those who do. But when so many acknowledge the potential value of their data, what is stopping them from bridging their data gap and realizing that value? The answer is almost always tied to the shortcomings of siloed information systems and their impediment to cross-organizational coordination.

The Universal Pain Points of Siloed Systems

Siloed information systems and the processes that result from their architecture can no longer keep pace with innovation nor expectations of quality and efficiency. Traditional siloed systems and the processes that span them inherently create friction and quality issues due to duplicated efforts, multiple sources of truth, and data inaccessibility at nearly every stage of the product lifecycle.

Duplicated Efforts: The manual transfer of information between departments and across systems is time consuming and error prone. No manufacturer would tolerate a production line where a product must be assembled twice, and yet so many information processes that span departments require data be duplicated, often manually, so that each system is up-to-date. The notion of relaying data, manually, from one system to another is a non-value added step but often done by people since it requires some flexibility to adapt the data from system A to B to C. These activities distract employees from their primary roles, they eat up tremendous time, and risk jeopardizing the integrity of the data being handled.

Multiple Sources of Truth: When data must be duplicated across siloed systems the result is multiple sources of truth and therefore multiple opportunities for misalignment of goals and activities across departments and organizations. At best these "sources of truth" can represent a snapshot of the truth at a point in time. But the truth constantly changes: Bills of material change, drawings change, customer requirements change, service procedures change, and so forth. Without a digital process ensuring consistency across systems, every activity that accesses one of many "sources of truth" risks working from out-of-date or entirely false information.

Data Inaccessibility: Siloed systems inhibit timely access to data that can improve and accelerate decision making. In some cases, this is a result of security protocol restricting data access to specific roles or functions. This approach can in effect turn any function within the product lifecycle into an information bottleneck and rogue data governance officer. For example, an engineer responsible for making design updates may send new drawing revisions via email to suppliers, customers, manufacturing engineers, and quality engineers, trying to ensure every stakeholder is brought up to speed. There is no traceability, security, or data integrity assurance.

In other cases, inaccessibility is a result of obscurity. Functions might not realize that data exists within their enterprise that could improve their decision making. Alternatively, they might know it exists but in a form that doesn't accommodate their unique needs. For example, a maintenance technician might require several trips to and from a production line to collect the necessary product data, process data, parts, or tools to make a repair.

The pain points of siloed systems manifest in some form or another in nearly every function within a manufacturing organization. Without a strong connection to engineering, purchasing managers might fail to leverage volume and increase inventory handling by ordering like parts from multiple suppliers rather than consolidate with a preferred supplier. Lacking support from service and manufacturing, supply chain managers might make poor inventory decisions, leading to low part reuse and high inventory levels. Absent close collaboration with new product development teams, factory planners might respond slowly to changes in product design and fail to meet release dates. These types of complications are not the failure of the individual, but of the system and processes that are meant to bridge those siloes. They are pervasive and frequent and have an enormous impact on the quality and efficiency of activities across an enterprise.

Top Five Pain Points of Siloed Enterprise Systems for Manufacturers

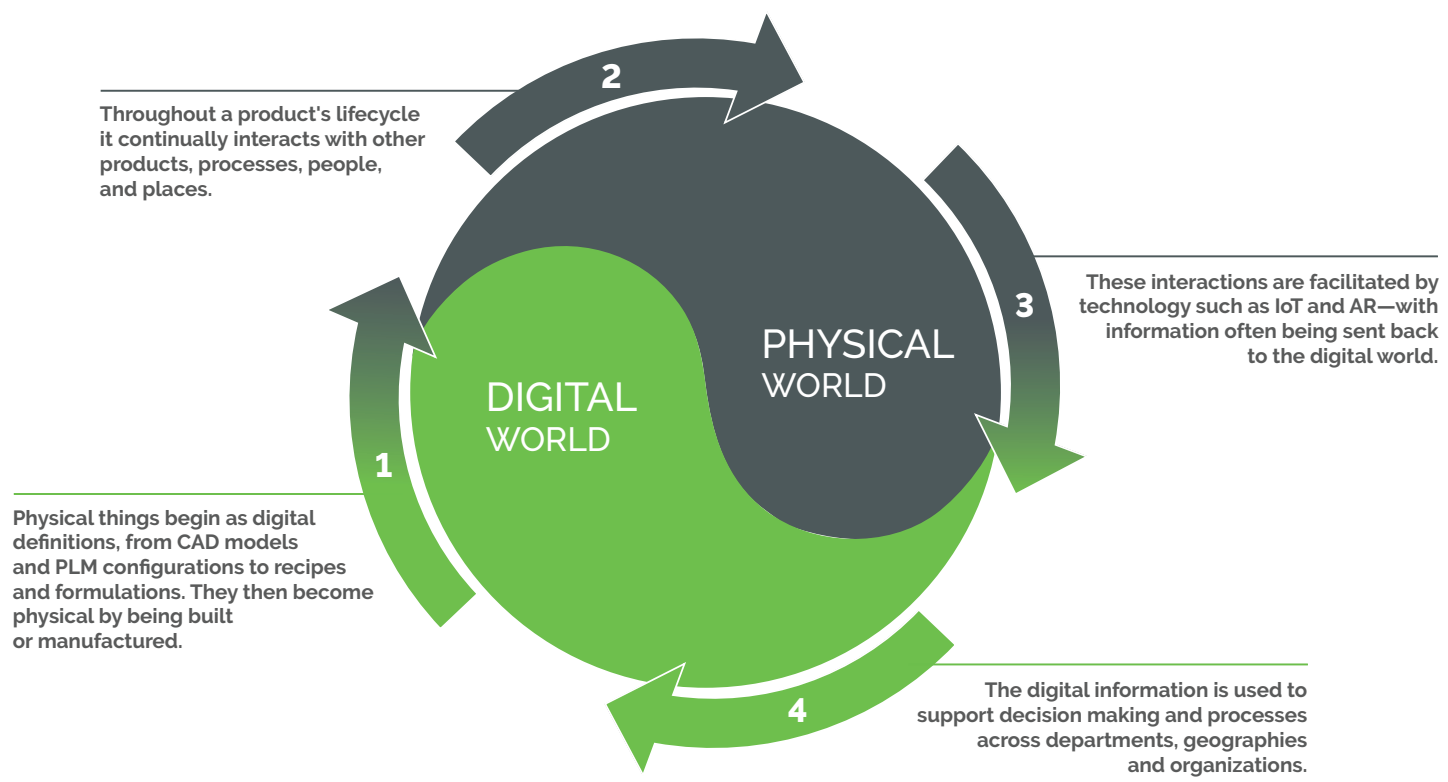
As identified from PTC's State of Digital Thread Survey

- Employees across departments are ill-equipped to leverage product data to deliver customer value and improve customer relationships
- Disconnected product development workstreams result in insufficient or slow digital design and validation capabilities
- Factory employees struggle to access relevant engineering information for faster and more effective decision making
- Poor collaboration capabilities lead manufacturing planning for new products or updated designs to happen too late in project timelines.
- Engineering teams lack easy access to manufacturing data that could influence design improvements.

If systems are siloed, companies can attempt to manage duplicate efforts, multiple sources of truth, and inaccessible data, but they will never be completely resolved. These problems can only be engineered out by creating a digital thread that propagates information across systems.

Closing the Loop with a Digital Thread

A digital thread creates a closed loop between digital and physical worlds to optimize products, people, processes, and places.

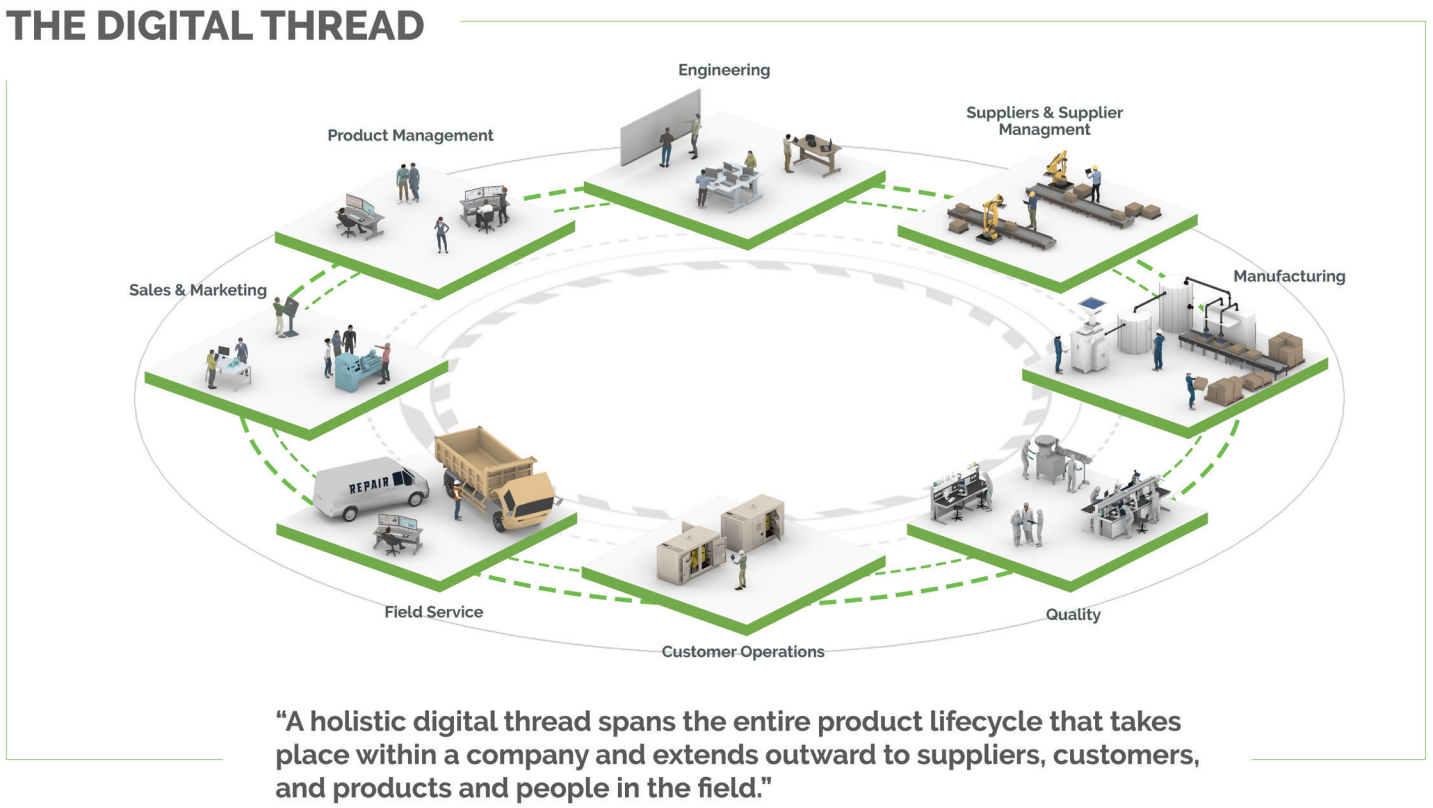


In the digital world, the complexity of the physical world can be distilled down to the pertinent information needed to make decisions. By introducing digital processes to analyze, manage, and communicate this information, decisions can be made faster and more accurately. Finally, when the digital tools and processes that are utilized along the lifecycle of a product are connected, the knowledge gleaned from one activity can be shared upstream and downstream to inform others. This is “closing the loop” and it enables continuity of data across departments and collaboration across functions to improve the product, the physical processes, and empower the people who are involved at every step.

Early conceptions of the digital thread focused on closing the loop between engineering and manufacturing operations. Now, however, IoT makes it possible to collect data on smart connected products in the field and augmented reality enables the activities of frontline workers to be digitized as well. These technologies have extended what can be connected by the digital thread to include products and people. Furthermore, cloud computing and SaaS solutions are enabling more people to connect and collaborate across geographic, department, and even enterprise boundaries. By leveraging these technologies, a digital thread can link the whole value chain. Today, a holistic digital thread spans the entire product lifecycle that takes place within a company and extends outward to suppliers, customers, and products and people in the field.

Organizations that achieve this end-to-end flow of product and process information empower their employees at every level with actionable intelligence at the right time and place, in a way that is easily consumable. To realize this vision, organizations must proceed through the following three steps:

1. Start by organizing their existing silos of product information across the value chain to create visibility into the data. This includes connecting assets in the factory and the field, as well as establishing a strong digital foundation in engineering to unify disparate tools, methods, and processes and establish a single source of truth in the product definition with governance and traceability.
2. Connect the intersection points between functions and departments to propagate information across traditional boundaries and facilitate collaboration. For example, establishing connectivity between engineering and manufacturing and service teams to ensure operators and technicians always have up to date work instructions, provided in context with other pertinent data whether it’s work order data for operators or service history for technicians. With the intersection points connected, the day-to-day pain of siloed systems is resolved.
3. Close the loop, connect the physical world back to the digital, and institute new processes that require continuous feedback across traditionally disparate groups. By enabling closed-loop feedback between the different functions and departments, processes can be established that would otherwise be unmaintainable, prohibitively expensive, or simply impossible. New connected business models, closed-loop quality, and ultimately digital twins are achievable once this stage is reached.



Digital Thread Applications and Benefits

A digital thread bridges the data gap by addressing the woes of siloed systems. They address the issue of data inaccessibility and provide functions with new information to make better decisions. They eliminate the need for duplicated efforts and instead promote collaboration between departments. Finally, by tracing provenance they ensure the integrity of data shared across a company and eliminate the risks of maintaining multiple sources of truth. These broad benefits enable new and improved processes that span departments. Included among those processes are production preparedness, paperless shop floor, collaborative change management, closed loop quality, product innovation, and service optimization.

Production Preparedness

Production preparedness applications of digital threads focus on repurposing the 3D and configuration logic from engineering to avoid rework, accelerate time-to-market, and reduce the cost of poor quality. This is achieved by creating a digital thread between engineering and manufacturing to enable traceability and connectivity from the digital design of the product, through BOM transformation, process planning, and validation.

Paperless Shop Floor

Expanding on production preparedness is the notion of the paperless shop floor: taking that digital engineering data and making it available on the shop floor. This includes delivering digital and augmented work instructions and automatically pushing product manufacturing information (PMI) data to connected tools for workers. It also encompasses making rich 3D data from PLM available on the shop floor. Transitioning from disconnected and poorly

controlled paper work instructions to their connected, digital counterparts drives improved worker productivity, reduced scrap, improved safety, and faster training.

Additionally, this implementation of digital thread also creates opportunities for closed loop feedback. As shop floor execution data is created, it can be fed back to engineering to further refine and optimize production plans and work instructions.

Collaborative Change Management

Collaborative change management is about the governance of the engineering data throughout the product lifecycle. Making sure that all changes and configurations are fully defined and controlled, tasks are delivered to those responsible with repeatable automated workflows, and changes are made and issues are resolved accurately and efficiently. Implementing a digital thread to enable collaborative change management drives down the costs of poor quality, the time to implement changes, and the time for new products to be introduced to market.

Closed Loop Quality

Closed loop quality establishes governance and traceability around a single source of information for quality data from ideation to field service. The digital thread connects historically disparate data sources to help improve first pass yields, scrap and rework, line and field failures, and accelerates corrective and preventative actions.

Product Innovation

A digital thread for product innovation creates a closed loop between products in the field, and functions within the enterprise. In doing so product usage data can be shared back with engineering to optimize product designs and with sales and marketing organizations to drive revenue growth. Furthermore, data can be shared with product management teams to develop and deliver new business models.

Service Optimization

The digital thread can help optimize service by enabling customer self-service, remote service, and improving technician efficiency. Technician efficiency can be improved by making sure technicians have a complete, up-to-date view into the equipment, including as-designed, as-maintained, and as-utilized product data. With this information, service technicians can better troubleshoot problems, identify part numbers based on 3D renderings, and check part inventory and order parts. Remote service enables technicians to be able to remotely diagnose and potentially fix issues enabled by a digital thread of product usage data. Lastly, a digital thread makes it possible to share equipment usage data and diagnostic data with customers, while empowering them with up-to-date service instructions that can be delivered digitally or even with augmented reality.

Delivering Value at the Department Level

The previous examples of processes that are enabled by digital threads span departments and, in some cases, extend beyond the enterprise. They address cross-cutting challenges that impact multiple departments or roles, but the benefits of digital threads can also be quantified at the individual department level:

Engineering:

- Improve quality and first-time yield rates
- Reduce failures in the field, and warranty costs

Manufacturing:

- Improve overall equipment effectiveness and production efficiencies
- Reduce asset downtime and changeover times
- Increase overall throughput and worker productivity

Service:

- Improve technician effectiveness and first-time-fix rates
- Reduce asset downtime, truck rolls, and time-to-resolution
- Enable Product-as-a-Service and outcome-based business models

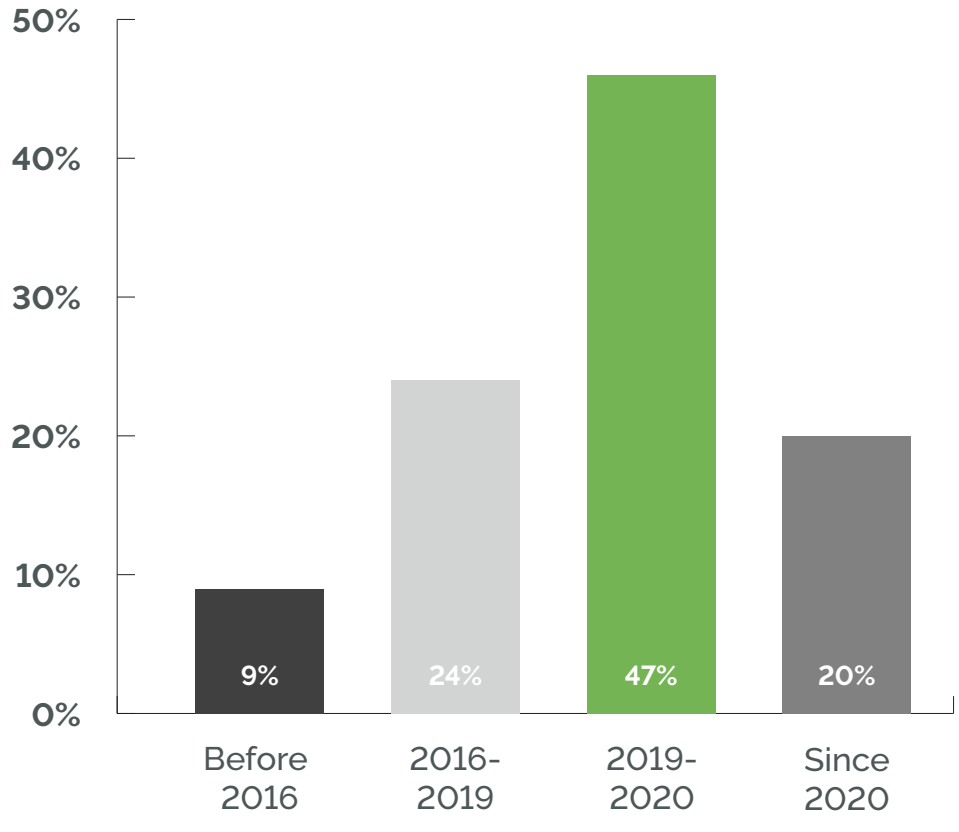
Sales & Marketing:

- Increase net promotor scores, upsell, and cross-sell opportunities
- Improve customer product usage and education

Digital Thread Adoption Trends

Digital thread strategies are impacting the way many companies operate today. Forty-four percent of the survey participants reported that their organizations have already implemented digital thread functionality into their operations and are continuing to expand their capabilities. Altogether, an impressive 94% of survey respondents are actively pursuing digital thread projects, 67% of which have started within the past two years, and despite the headwinds caused by the COVID-19 pandemic, one in five projects were started within the last year.

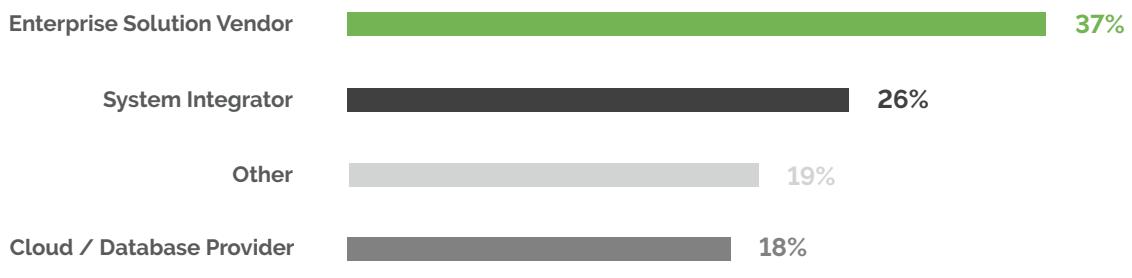
TIMELINE OF DIGITAL THREAD PROJECTS



Q:When did you start your digital thread project/planning?
Survey conducted in 2021. n=150

The data suggests that digital thread is incredibly popular but nascent. A critical implication that industry best practices for digital threads, everything from program management to technology strategy and implementation, have yet to crystallize and disseminate. Without a clear set of standards to model their projects after, these companies are turning to the market for experience and guidance, first to enterprise solution vendors, and then system integrators according to the survey. So, while the survey indicates that two-thirds of these projects are expected to be completed by 2023, there is likely to be high variation in timelines and program success, especially among those companies who go it alone.

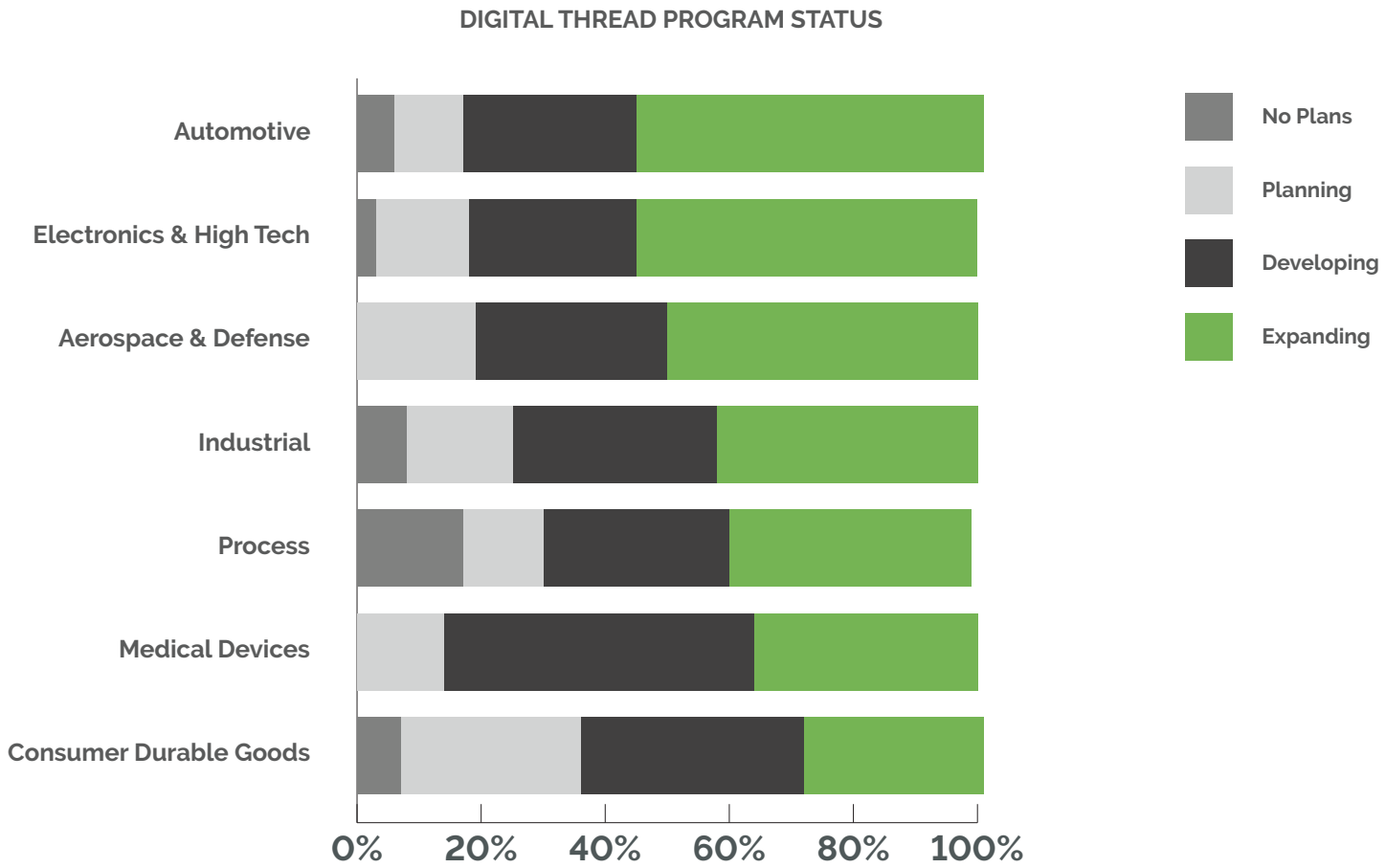
BEST PARTNER TO FACILITATE A DIGITAL THREAD STRATEGY



Q:What other types of organizations do you believe are the best partners to facilitate digital thread technology strategy?
Survey conducted in 2021. n=150

Looking at industry distribution, automotive, electronics and high-tech, and aerospace and defense are leading the digital thread wave. Competitors in these industries have had to grapple with challenges of siloed systems for decades. Their products historically require rigorous engineering to strict specifications, complex manufacturing with high quality requirements, vast supply chains, and even larger service networks. Over the past several years these characteristics have proliferated across industries, proceeding the rise of smart connected products. That, combined with the ever-increasing pressure to develop differentiated products faster, more efficiently, and provide better customer service and experience, is compelling companies in nearly all industries to pursue a digital thread strategy. For example, all twenty-two medical device companies surveyed reported an ongoing digital thread initiative, in large part to better address increasing compliance and regulation requirements.

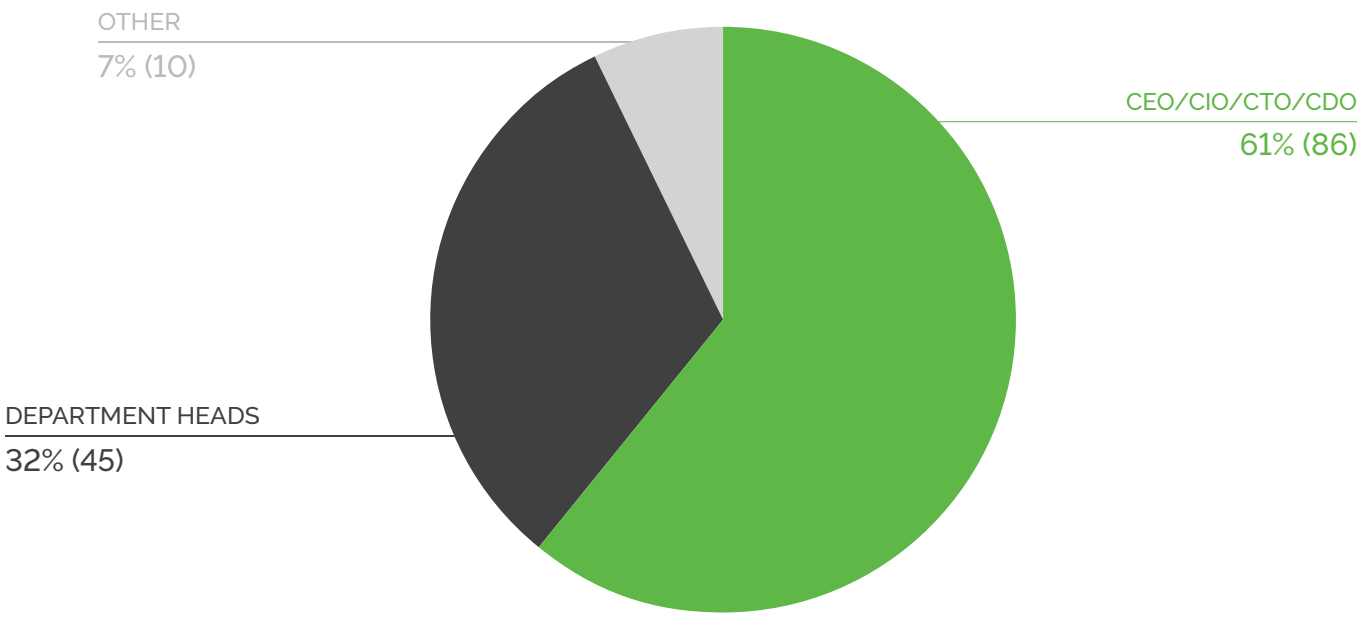
PROGRAM MATURITY ACROSS INDUSTRIES



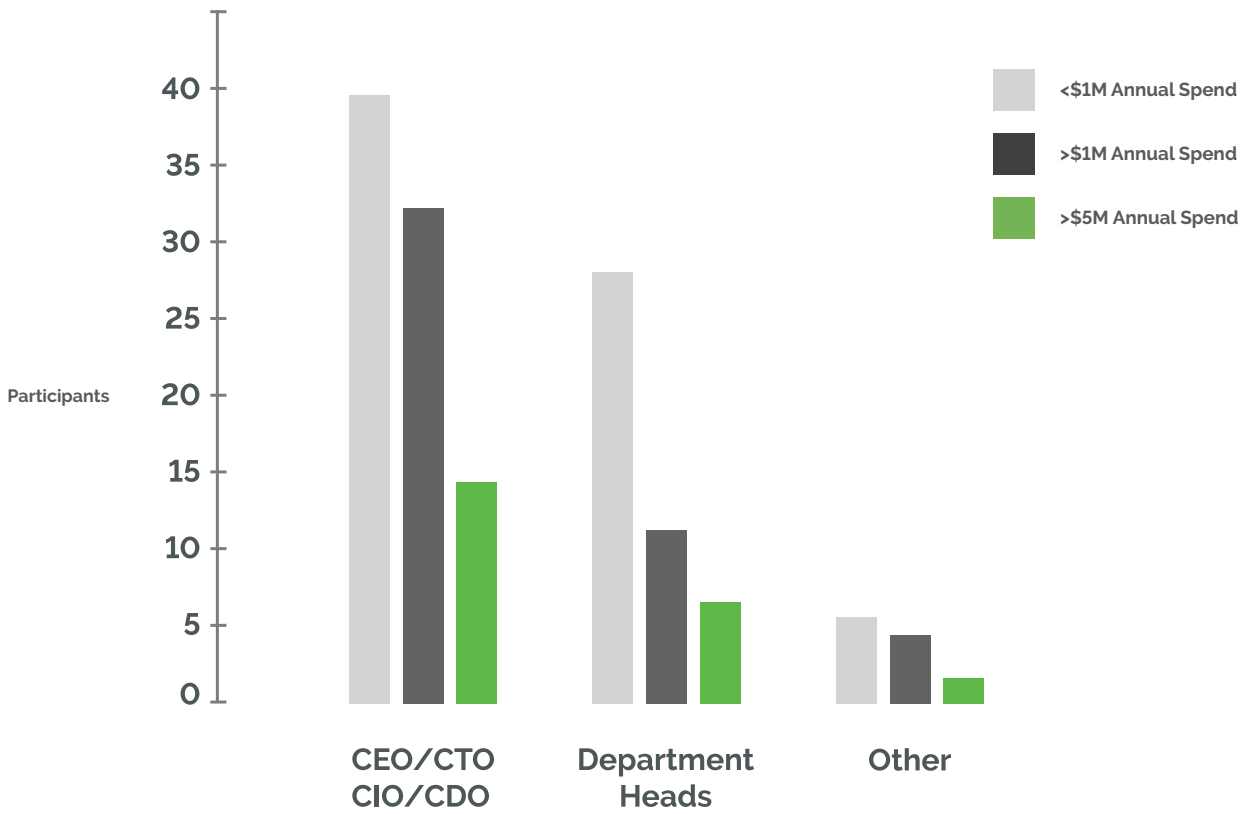
Q:What is the status of your organizations digital thread project or projects?
Survey conducted in 2021. n=150

Given the prevalence of adoption shown here one might assume that many of these responses represent smaller scale projects or pilots, but just the opposite is true. For the most part, these digital thread projects are enterprise-wide initiatives with nearly half (49%) investing over $1 million annually. The majority of these projects (61%) are being led by a chief information officer, chief technology officer, or chief digital officer, with much of the remainder (32%) being spearheaded by a combination of department heads. These programs are rightly being treated as transformational initiatives and have executive sponsorship given their enterprise-wide scope and cross-functional nature.

WHO LEADS THE DIGITAL THREAD INITIATIVES?



LEADERSHIP & ANNUAL SPEND



Q: Approximately, how much is your organization investing annually on digital thread projects?
Survey conducted in 2021. n=150

Digital Thread Case Studies

The following case studies illustrate two real-world examples where digital threads have transformed operations.

Volvo CE

Volvo Construction Equipment (CE) is a leading international manufacturer of premium construction equipment.

Challenge

Like many companies, Volvo CE faces increasing pressure to shorten product lifecycle and increase product complexity, all while better responding to ever-changing market conditions. However, teams were working in siloed PLM systems, manual handovers led to workflow disruption, delays, and quality issues, and data duplication across systems caused inefficiencies and increased lead times. Thus, to meet their digital transformation goals, Volvo CE had to address its costly and complex collection of legacy systems and processes that had been established over decades of acquisitions and isolated projects.

Solution

Since its initiative began in 2018, Volvo CE has replaced three of its four legacy PLM systems with Windchill, PTC's market leading PLM software, and is currently making progress on replacing the fourth. This monumental undertaking included the implementation of Windchill across fifteen sites, the transfer of over 7 million files, and training of over 3,000 users.

To successfully drive change throughout the organization, Volvo CE first envisioned an end-to-end value flow and established a strong approach to program management to enable it. Volvo CE used Windchill's out-of-the-box capabilities, along with PTC's value-ready deployment methodology, to connect the vision with employees who would be directly impacted by changes to tools and processes.

Impact

In moving to a single unified PLM system as the foundation for its digital thread, Volvo CE can manage complexity and execute concurrent manufacturing. Windchill enables cross-functional product information management and collaboration, from product structure, to system/logical structure, as well as BOM, simulation/testing structure, manufacturing structure, and as-supported structure. It allows Volvo CE to manage digital product definitions through all stages of the product lifecycle, including anything that defines the form, fit, and function of a part, system, or machine. With a digital thread in place, Volvo CE was able to achieve:

- Increased collaboration with one shared system between functions
- Reduced lead time with correct first solutions in early phases of product development
- Manufacturing requirements connected to product, process, and resources and visible for all
- Increased reuse of already existing solutions, to reduce cost and lead-time
- Global governance to control the global product structure

Click here for more detail on Volvo CE's digital thread journey.

VCST

VCST is an automotive supplier of precision-machined powertrain and brake components; mission critical products that have a significant impact on overall vehicle performance.

Challenge

VCST has been committed to digital transformation over the past several years, with a focus on building the factory of the future. When COVID-19 intensified the already high expectations of their industry, VCST responded by identifying several opportunities to implement smart factory initiatives for their facility in Belgium. Their objectives were to reduce costs, increase the quality of their products, fuel innovation, and improve time to market.

Solution

VCST established an end-to-end vision for their transformation efforts, which depended on unifying its IoT and PLM systems of record. VCST recognized it could infuse real-time data and digital solutions across their operations by combining the connect, collect, and analyses capabilities of ThingWorx, PTC's IIoT solutions platform, with the data governance and traceability of Windchill. Ultimately VCST created a digital thread capturing and relating the data of machines and processes in the factory with change management and configuration information. This allowed for precise, coordinated information sharing between manufacturing and engineering to unlock insights and find patterns for continuous improvement of both products and processes.

Impact

VCST is producing higher quality products at a faster rate. With a digital thread connecting its engineering and manufacturing operations, it estimates time to implement change has been improved by 25%. VCST has also made huge strides in quality and customer satisfaction by collaborating with their customers to reduce gear-on-gear noise, a significant and pressing challenge spurred by new international noise, vibration, and harshness (NVH) regulations. By sharing processes data with customers and correlating the customer experience back to its own manufacturing processes parameters, irregularities, and product design, via its digital thread, VCST was able to identify root cause and quickly prescribe and execute corrective actions. This was an early, but substantial win following their digital thread implementation.

Click here for more detail on VCST's digital thread initiative.

Companies today are creating digital threads and transforming their operations by delivering timely, accurate, and in-context data across stages of the product lifecycle. Whether you're at the beginning of your digital thread journey and curious to understand the value one can bring to your organization, executing a digital thread initiative and looking for guidance on strategy, or eager to elevate your established digital thread to the next level of maturity, PTC can help. For more insight on digital threads, Click Here.

PTC, Inc.

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