CIMdata eBook
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Leveraging the Cloud for Global Market Success

Streamlining the path to digital transformation

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An Era of Accelerated Change

Speeding toward a smart, connected world

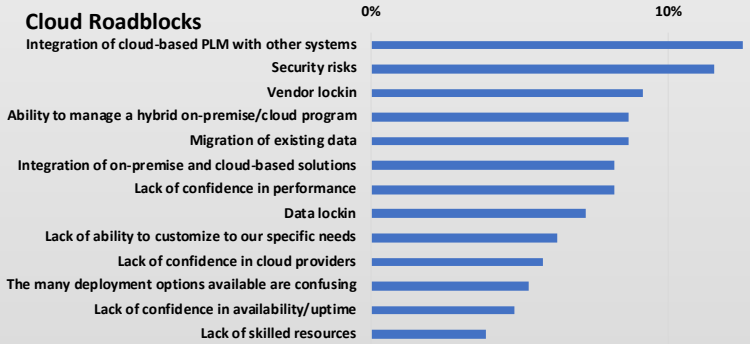
Manufacturers around the world are accelerating their responses to key societal, technological, and customer trends. Manufacturers must deal with ever-expanding complexity in their businesses. Customers are demanding products and solutions tailored to their unique needs that are smarter, more connected, and more eco-friendly, as well as often being able to operate autonomously. These products and systems are becoming more complex, part of a "system of systems" ecosystem, with functionality and differentiation now being driven by software and electronics. This necessitates more intelligent product development and production environments as well as expanding in-service management requirements.

Business evolution is also necessary for survival—today's complex, smart, connected products require manufacturers to digitally evolve within the context of their extended enterprise value networks. For example, Work from Home (WFH) and improved remote collaboration are necessary responses to the COVID-19 pandemic—and in many cases these changes will be permanent. Companies will need to support new ways of working and remotely managing their distributed personnel, partners, suppliers, and customers.

To meet these needs, technology is evolving rapidly in multiple areas, e.g., the Internet of Things (IoT) and Industrial Internet of Things (IIoT), science and engineering algorithms, social media, mobility, data analytics, cloud delivery, software-as-a-service (SaaS), and low/no-code application development and integration. Additionally, technology convergence across the product lifecycle—Information Technology (IT), Operational Technology (OT), and Engineering Technology (ET)—is providing new capabilities and requiring companies to transform how they organize and work. This evolution and convergence is driving market disruption and must be incorporated into products and business processes faster than ever.

Multiple initiatives drive the need for manufacturing companies to undergo a digital transformation. One of the most widely known is Industry 4.0, defined in 2011 by a project on the high-tech strategy of the German government to promote "computerization of manufacturing." Also referred to as the Fourth Industrial Revolution, it is the ongoing automation and digitalization of manufacturing and industrial practices, using modern, smart technology. Large-scale machine-to-machine communication (M2M) and the IoT and IIoT are closely related to Industry 4.0 and are driving increased automation, improved communication, self-monitoring, and production of smart machines and systems that can autonomously analyze and diagnose issues for both performance management and predictive maintenance.

Companies wanting to be market leaders recognize the need to transform how they operate—they need to go far beyond just automating and digitizing (i.e., paper to digital); they need to commit to a digital transformation. CIMdata worked with leading product lifecycle management (PLM) solution providers to conduct a global survey of industrial companies to better understand the needed changes. As shown in the chart below, our survey respondents are facing complex issues with their planned move to the cloud.



Industrial Companies are Responding

Cloud technology is providing a force multiplier

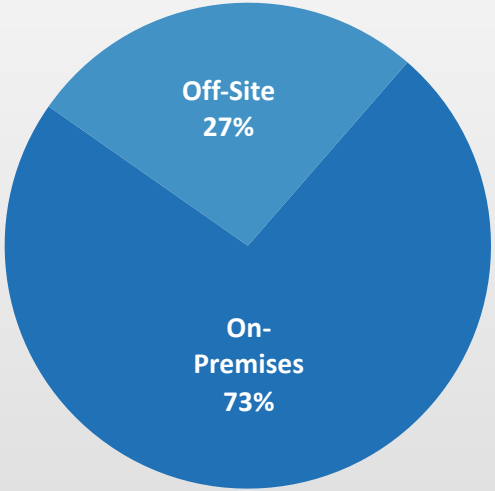
The need for enhanced business agility and resiliency is necessitating changes in how companies operate internally, and how they interact with value chain and network partners. Effective value network collaboration requires that users at all levels anywhere in the network have rapid access to clear, concise, up-to-date, and valid information presented to them in context so they can more quickly make better-informed decisions.

Companies are revisiting how they establish global value chains and networks and what solutions can deliver the needed capabilities to support them. This re-evaluation is driving many companies to increase their adoption of advanced technologies, e.g., cloud, IoT/IIoT, mobile, artificial intelligence/machine learning (AI/ML), etc., even faster than suggested by research conducted by CIMdata in 2019. Adopting these new digital technologies provides companies the impetus to change how they manage data and processes.

The need to support frequent business model changes has expanded adoption of cloud solutions which can provide more flexible, adaptable SaaS environments that customers can readily adjust to their specific needs. Adoption of cloud technology and delivery is ramping up faster (in part to meet COVID-19-driven WFH requirements) and is a force multiplier for solution providers, product developers, and their customers—providing operational flexibility and resilience. Personnel located anywhere in the world can, via the cloud, access needed real-time information and collaborate with others to more quickly perform their work tasks.

In order to achieve a more flexible business model, many companies see digital transformation as essential to addressing industry and market trends, technology evolution, customer needs, and trying to stay ahead of their competition.

Another way companies are responding is by moving their PLM implementations from on-premises to off-site solutions leveraging cloud infrastructure. 27% of our respondents are already using such offerings



PLM Being Hosted On-Site or Off-Site

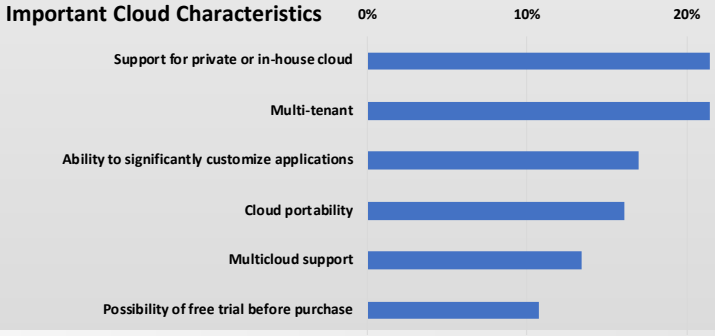
Cloud-Delivered SaaS: Driver for Change

New capabilities—delivering new benefits

Cloud delivery provides a flexible, adaptable, scalable architecture that enables an enterprise to more easily adapt technology, information, and supporting applications and environments to meet changing business needs. Cloud environments reduce infrastructure requirements and capital costs. Using managed services can also reduce the internal support and operational resources companies have historically required to deploy and maintain their product-related development and service capabilities.

Cloud environments can easily and rapidly scale to maintain high availability and changing usage requirements, including high-performance computation. Much of this scaling occurs automatically, invisible to the customer. SaaS solutions can easily scale globally on-demand and enable flexible solution access and use by personnel regardless of location.

SaaS is a software licensing and delivery model in which software is licensed on a subscription basis and is centrally hosted, often using cloud infrastructure. SaaS provides flexible licensing options—you only pay for what you need, while you need it. Functional applications can be added (and removed) on an on-demand basis. It also provides the ability to try before buying a functional solution versus having to contract for on-premises use.



Cloud-delivered SaaS enables fast startup and ease of on-boarding so that companies can quickly get to productive use. Solutions can be made immediately available globally—without requiring long-term, site-by-site roll-outs typical of on-premises solutions. Since users can be added (or removed) immediately, regardless of their organization or location, it significantly reduces the administrative resources and burden required with multi-site, on-premises deployments.

Based on our research and industrial consulting experience, CIMdata believes that the flexibility and scalability of cloud-delivered SaaS solutions can significantly help companies execute their digital transformation plan. All the factors described herein are driving increased cloud adoption, including for PLM solutions, by companies of all sizes, in all industries.

Respondents have strong feelings about the desirable characteristics of their cloud offerings, as shown in the chart. Not all of these characteristics can generally be found in any single offering.

Cloud Deployment and SaaS Delivery

Windchill can be delivered as SaaS. In this case, PTC runs and manages Windchill in the PTC cloud. PTC takes care of the software and the hardware including security, performance, scalability, etc. SaaS customers receive a URL and are ready to go with the software/hosting/managed service wrapped together. All upgrades and updates are included, as well as dedicated production and non-production environments, storage allotment, and 2D and 3D CAD publishing. From an IT perspective, cloud deployment means not having to manage multiple partners in the cloud with lots of points of failure. SaaS represents less overhead and faster time to market. PTC is making significant investments in the future of SaaS and aligning the entire portfolio including CAD, PLM, IoT, and AR for even more value.

Windchill is also certified and optimized for both Microsoft Azure and AWS enabling manufacturers to deploy in the cloud themselves or with the help of a system integrator.

Platforms for Digital Transformation

Successful product company transformations require strong PLM capabilities

Manufacturers are adopting new approaches to product development and manufacturing, including model-based enterprise, systems engineering, generative design, and hybrid manufacturing (the combination of additive and subtractive manufacturing). These new paradigms rely on digital data and models, require increased interaction among functional activities and domains, necessitating more comprehensive and effective collaboration throughout the value network. This also includes increasing use of digital tools and processes that automate data creation and movement of that data among users and applications–reducing non-value-added activities, errors, and inconsistencies.

To implement these new working paradigms, companies need a flexible, sustainable infrastructure to support their extended value network that can quickly adapt to business evolution. As product lifecycle management (PLM) has evolved, so have the solutions used to support PLM strategies and processes. The platformization trend in other industries has spread to the PLM industry. To help the PLM industry understand this shift, CIMdata worked with other leading analyst firms to develop a hierarchical description of platforms used to support industrial activity. *

Business platforms offer a comprehensive set of functional capabilities that can be packaged and configured to enable standardized end-to-end business processes that help companies more easily evolve their technology, information, and supporting applications and environments. Nested within the business platform concept are product innovation platforms—product-centric platforms that focus on enabling product and process innovation, leveraging functional capabilities configured to support those processes.

Whether delivered on-premises or via the cloud, platforms are architected to provide the flexibility needed to help manufacturers quickly deploy solutions that better support their business domains. Ideally, platforms support full PLM capabilities, incorporate industry best practices, expose data in context, and automatically bring that information to the point of work. Platforms should be easy to tailor and support personalized applications in a sustainable way. For example, low/no-code development capabilities are used to fulfill new requirements for accessibility and mobility. Developers can quickly create business-unique applications, often “mashups” of enterprise and external data, that can be delivered on any device. Cloud-based platforms, combined with SaaS, enable these business-unique applications to be quickly deployed and used across the value network.

Enterprise product innovation platforms enable a digital thread of integrated information that spans the product lifecycle which is key to digital transformation. Manufacturing companies need to have a platform-based PLM strategy and deploy enabling solutions to achieve their transformation objectives.

PTC has a comprehensive end-to-end vision for a digital thread that's hyperconnected throughout the product lifecycle including to the physical device and all available via SaaS delivery.

Windchill’s openness, computer vision, machine learning, and AI capabilities are purpose-built for highly configured products with sophisticated dependencies (mechanical, electronics, and software), analysis led design and simulation, model-based systems engineering, manufacturing execution, connected products, distributed supply chains, and workforce performance.

* “Business Strategy and Platformization.” CIMdata Position Paper. March 12, 2015. https://www.cimdata.com/en/resources/complimentary-reports-research/position-papers/item/3664-business-strategy-and-platformization-position-paper

Powering Global Collaboration

Enabling different roles and stakeholders to cooperate to create business value

Manufacturing companies need to enable effective value network collaboration across all functional domains, including development, production, marketing, sales, and service. Developing, producing, and servicing innovative complex, smart, connected products requires seamless, transparent collaboration across technical and operational organizations and functions. Successful companies must enable efficient collaboration for both technical and non-technical users involved in the product lifecycle from idea through life to create successful products and services and drive business value. Intuitive user experiences and enhanced visualization capabilities, e.g., augmented reality, can enable users to become more productive and drive faster time to value.

Product development, production, and service technologies are rapidly evolving, bringing new digital capabilities directly into the development process and across the product's lifecycle, enabling enterprise-level digital transformation and driving enterprise-level product and process innovation. For example, a virtual model can be animated with simulation and/or field data to predict product behavior and offer performance insights. Applications and user interfaces can incorporate AI to increase efficiency in product lifecycle processes. Leveraging these new capabilities requires having new and better levels of interaction and collaboration among users and systems throughout the extended value network.

Increasing product and system complexity is requiring more productive interaction and collaboration among all departments and roles that contribute to the development, production, and operation of smart, connected products that incorporate semiconductors, electronics, electrical, mechanical, and software components. Companies must implement an environment that provides users and stakeholders with accurate, up-to-date status of products and services regardless of time and location. To accomplish this, companies need to leverage technology that will help dissolve the boundaries between technically oriented domains (e.g., product and process conceptualization, design, development, production, support) and other business domains (e.g., administration, manufacturing and support operations, digital services, sales, and marketing) and enable information sharing and global collaboration.

Courtesy of PTC

Extending the digital foundation can drive cross-functional transformation by sharing data and enabling closed-loop feedback

Enabling the Digital Thread

Tracing and managing products from idea through life

A diverse, distributed set of data and sources must be seamlessly integrated for access and use by personnel and processes across the product lifecycle. This distributed information needs to be linked to product definition data to help users make effective decisions. The data should be presented as needed, wherever users are located, whenever requested, in the appropriate context, often transparently to the user. Users should be provided access to required data via a multi-platform user experience (desktop, smartphone, tablet, laptop).

While the goal is to provide consistent, centralized access to all necessary information, there generally is no “single” physical data repository of all product lifecycle information within a company or its value network. A business platform does not need to manage all information, only that information critical for performance and integrity.

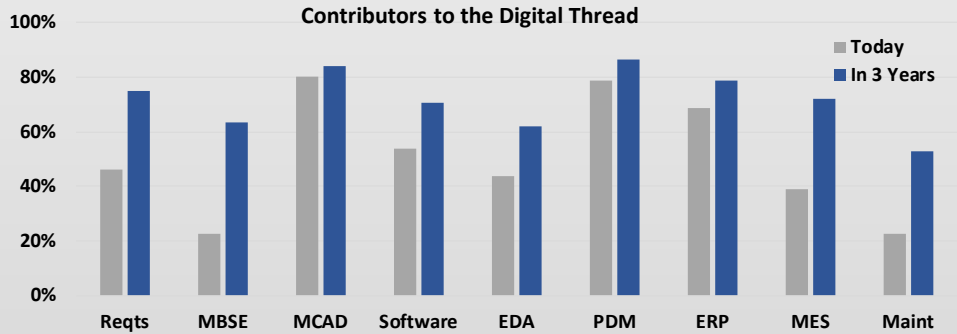
Digital Thread:

CIMdata defines a digital thread as a communication framework that connects data flows; one which can be used to produce an integrated, holistic view of an asset’s data from physical and virtual systems (i.e., its digital twin) throughout its lifecycle across traditionally siloed functional perspectives

For information it does not manage, it needs to know where to find things when they are needed and be able to present them to the user as required. Thus, a user (or application) is able to communicate with and access different information repositories, using each for what it is best at managing to achieve an end goal. For example, large volumes of IoT or social media data are best stored differently from structured enterprise data. However, certain "real-time" collaboration and decision-making elements should be on the same platform, to overcome latency and eliminate sync errors.

Using this diverse distributed information, companies need to establish complete (end-to-end) digital threads across the extended value network and enable comprehensive collaboration and closed-loop feedback among functional domains. This connected data should readily support the traceability needed to troubleshoot issues from the field back to the original idea, which is particularly important in regulated industries. The digital thread connects a physical asset with the digital assets that define it over the course of the asset’s complete lifecycle and requires connecting the entire value network.

CIMdata asked respondents what solutions contribute to their digital thread today and will contribute in three years. As might be expected, MCAD, ERP, and PDM are well represented. The percentages of requirements and software are a pleasant surprise as many of CIMdata's industrial clients are often less mature.



Managing Structures Throughout the Lifecycle

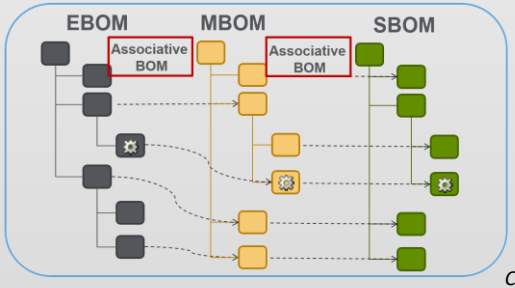
Cloud delivery provides an efficient bridge between development, production, and service

A fundamental capability for developing, producing, operating, and servicing today's complex products and systems is having accurate, complete configuration management of product and product-related structures, at all phases of the lifecycle available to personnel in multiple organizations that may be globally dispersed. Each user should be presented the "view" of the structure in the context pertinent to them and their role.

Maintaining consistency and integrity among structures populated using a diverse set of data and content authoring tools and how they are "viewed" and used by personnel in different functional domains is critical. Having bi-directional transfer of product definition, structure (e.g., a Bill of Material or BOM), and process information among development, production, and service is a key capability of the digital thread. Creating and maintaining a comprehensive digital twin requires a multi-domain structure capability that incorporates a combination of mechanical, electrical, and software information and views. Examples of these different structures and views are the engineering BOM (EBOM), manufacturing BOM (MBOM), and service BOM (SBOM). Many use the shorthand "XBOM" to refer to this suite of BOMs.

The ability to accurately and consistently manage multiple views of the product structure as needed by different functional domains is key to improving overall product/service productivity and quality. Each domain views and uses structure information differently. Manufacturers need to implement seamless connectivity to mechanical, electrical, software, formulation, associated documentation, and other product data regardless of where that information is located to ensure complete structure definition.

Leading solution providers have developed enterprise BOM solutions (logical BOM/structure views) that help automate the transfer and transformation of structures from one domain to another. The digital thread supports the flow of this structure data throughout the lifecycle. One of the key capabilities of cloud delivery is that it can make this XBOM information more accessible—across departments, organizations, and geographies.



Courtesy of PTC

Transform your bill of materials for organizational improvements

By utilizing BOM management software, you reduce the risk of errors and rework by eliminating the reuse of obsolete data. Not only does this save time in development and industrialization, it also ensures that suppliers, factories, sales, and service are always aware of changes with automated synchronization among the respective bills of materials. The result is faster time to market, higher operational efficiency, greater component availability, and lower costs of quality.

With PTC's BOM management and transformation solution, product designers create and manage a part-centric digital product that can be leveraged at every step of the product lifecycle. Now mechanical, software, electronic parts, and related artifacts can be integrated into the engineering bills of materials. This provides organizations a single interface for collaboration among domain systems such as CAD, PLM, and ERP. The PLM system ensures that everyone from the shop floor worker to the service technician to the seller configuring a customer order are using the correct product information.

Modeling the Future

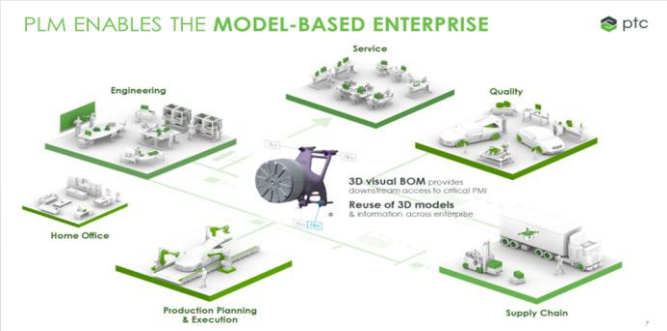
Model-based approaches and digital twins are crucial to success

Companies use a range of modeling approaches to support different functionality across the product lifecycle. Model-Based Definition (MBD) is the practice of using 3D models to specify individual components and assemblies. The Model-Based Enterprise (MBE) essentially applies MBD and its data across the enterprise. Model-Based Systems Engineering (MBSE) is the integrated use of models to define the system technical baseline across the full lifecycle and across all disciplines and program members. CIMdata and others refer to this group of modeling approaches by the shorthand "Model-Based X." Using these model-based approaches requires a company to establish a complete digital thread to support digital twins that can reflect all phases of the product lifecycle, including use cases for product design, production, performance (operation), service, etc.

CIMdata defines the digital twin as a virtual representation (i.e., digital surrogate) of a physical asset or collection of physical assets (i.e., physical twin) that exploits data flow to/from the associated physical asset(s). It has the required accuracy and fidelity to predict and even optimize the actual performance of the "as-built" and "as-used" physical object. It parallels its real-world companion throughout its lifecycle, changing in tandem with the physical version. Multiple digital twins can be defined and used, including:

- Product twins—a physics-based virtual representation of the physical product being created
- Production twins—a virtual representation of the manufacturing environment and processes as well as the product as it is being created
- Performance twins—a virtual representation of the in-service environment and the performance of the product in use

Gathering data about a product during production and in-use operation (performance) requires using IoT/IIoT connectivity for twin validation and creating closed-loop feedback between lifecycle domains. Maintaining a consistent link between the physical product and its virtual representation (even when used by personnel and applications scattered across the value network) maintains consistency and context between the physical and virtual instances. This facilitates the use of model-based development paradigms (such as simulation and design space exploration) enabling product designs to be improved and optimized for cloud- and IoT-driven connectivity.



Courtesy of PTC

Model-Based Enterprise

MBSE captures and communicates architecture through SysML models of components, products, product lines, and ecosystems for improved ideation. The model, which can have role-based views, becomes the glue between the engineering and business domains. Multi-user MBSE (system requirements., functions, structures with visual system and IIoT co-simulation) combine with requirements and test management for improved design communication (with standard OSLC links for transition and trace directly to BOMs). 3D annotations (Model-Based Design) are created and delivered downstream, with workflow that constrains/ensures standards conformance.

As products evolve from standalone one-offs to complex product families for mass customization, Windchill's ability to control and understand the exact configuration of a product based on effectivity and version control is critical in delivering a Digital Twin. Augmented Reality visualizes the Digital Twin in the context of the physical world.

IIoT Provides Many New Business Opportunities

Intelligent connectivity between assets and systems is growing

In today's connected world of smart products, ever-growing volumes of data are being generated and managed using a combination of edge computing and cloud technology. Companies must determine how much of this data to analyze and keep, define where to keep it, and provide easy access for the appropriate people or systems when needed.

Fortunately, technologies such as AI and ML offer major new capabilities and automation functionality for assembling and analyzing this avalanche of data that had previously required human interaction. The use of smart, connected devices, and the data they collect, is creating new capabilities for developing, producing, and servicing these new products and systems. Applying more advanced analytics to the growing volume of data from smart devices is enabling generative product design, new manufacturing techniques (e.g., 3D printing), more proactive, predictive service, and in-use performance optimization.

Driving this connectivity is the IoT and the IIoT, which provide new ways to manage assets, e.g., products and systems, more efficiently. The IoT and IIoT use the cloud or other appropriate networks to gather and make the needed data available to users and systems that may be widely geographically dispersed.

This use of network-delivered data and application access using IoT and IIoT connectivity is an important part of any effective digital transformation.

ThingWorx provides factory and field connected IIoT data through every step of the lifecycle.

Product Design: Product design assumptions are replaced with data from an existing product, prototype, or system for analysis. Collected data from assets or fleets of products in the field and from enterprise systems improves future product designs, based on functionality that customers are/are not using and functions that are/are not performing. Analyzing data on how customers are using products or want to use products helps engineers better meet current or future product design goals.

Manufacturing: Machine data is fed back into the manufacturing process planning for improved routing, asset utilization, and work instructions (design for manufacturing). This optimizes manufacturing and improves production quality.

Closed-Loop Quality/Risk Management: Connected data can be used to develop a risk log over time. This combines pre-production, post-production, and real-world failure data to build fault tree analysis using the data stream more easily. For products in the field, ThingWorx analyzes data to predict when future maintenance will need to take place.

Making the Move

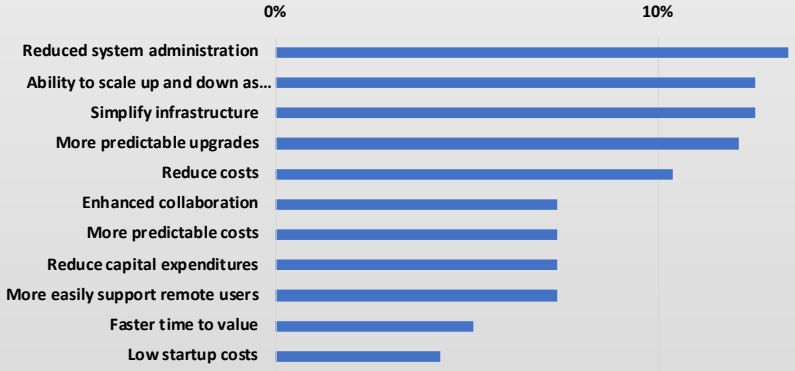
Deployment options provide business flexibility and investment protection

PLM capabilities such as collaboration and data access are being delivered using the cloud in many ways: "lift and shift," managed service, virtualization—all fulfill different use cases. Every company has made different application and infrastructure investments, and therefore needs different deployment options. Each needs a unique combination of capabilities and delivery—on-premises, edge, cloud, hybrid—and the ability to migrate and scale functionality and data across their environment (and ecosystem) as appropriate. Each will receive their own combination of benefits such as performance, on-boarding, accessibility, scalability, to achieve maximum investment value and evolution.

While security was an early concern with using cloud delivery, the cloud infrastructure providers have invested, and continue to invest, significant resources to develop and maintain secure environments. Companies such as Amazon, Microsoft, Alibaba, IBM, and others can invest many more resources (financial and human) than any individual company to ensure security of these environments. As a result, security on the leading cloud platforms is considered to be better than any company can achieve themselves. Despite ~~of~~ that reality, some companies still want to keep their intellectual property on-premises. However, this too is changing. Even the United States Department of Defense is moving to some cloud delivery for secure environments. Respondents to our survey are already seeing the benefits listed in the chart below.

As discussed throughout this eBook, a company's business platforms need to support a broad, distributed, heterogenous set of digital thread contributors. This includes all their internal organizations as well as touching and working with their ecosystem of suppliers, partners, and customers. The flexibility of cloud infrastructure environments enables each company to create the value network environment that best supports their specific business strategy and enables the effective collaboration needed across that network. Regardless of cloud deployment type, companies can ensure they maintain the ability to create and tailor business-unique applications as required to maintain their competitive edge.

Cloud Benefits Cited by Survey Respondents



PTC Windchill

Kickstart digital transformation with PTC Windchill's open, flexible, scalable and secure SaaS PLM architecture

With even greater benefit as a SaaS deployment, Windchill is PTC's industry-leading, enterprise PLM software with over 1.5 million seats deployed. Windchill is a trusted, web-based and scalable platform for global collaboration and innovation with comprehensive out-of-the-box functionality, role-based apps, and industry configurations. With Windchill you'll enable your entire organization with a digital thread of information to speed time to market, improve product quality, decrease costs, and so much more.

Learn more about Windchill's secure, SaaS-based open architecture and deployment options today!

Get Started (https://www.ptc.com/en/products/windchill/architecture-and-deployment)

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