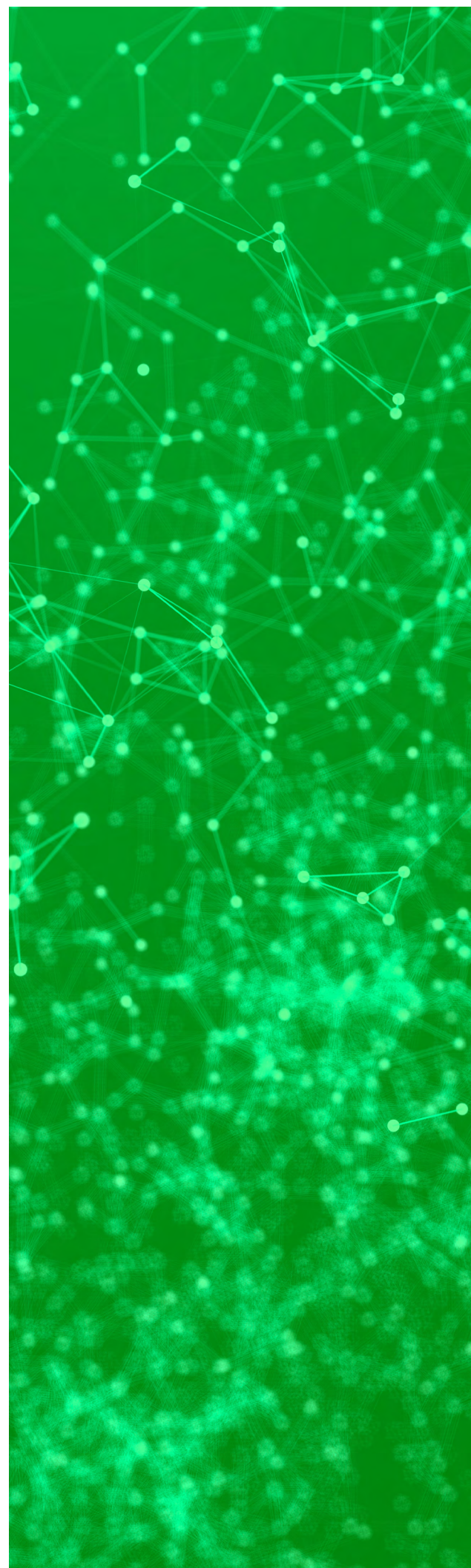![ptc]

Digital Thread

Building Continuity Across Products, Processes, and People

By Mark Taber, James Zhang, Terrence Strom, David Immerman, and Dave Duncan

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The Information or Digital Age is issuing greater change unparalleled by any previous technological breakthrough in the last century. This creation of new information through mass digitization and sensorization unlocks enormous opportunity and invites digital disruption. The results are an increased pace of innovation and accelerated consequences for those not prepared for it.

Digital Disruption Accelerates Need for Digital Transformation

· At the current churn rate, about half of today's S&P 500 firms will be replaced over the next 10 years.

· Nearly 90% of executives surveyed by Forbes cite a medium or high risk to their organizations of technology-driven disruption by startups and incumbents over the next five years.

· Yet almost 60% of executives recognize the top path to circumvent this risk is to achieve digital disruption in their own markets by leveraging their own data and digital technologies for new operational efficiencies and differentiated products or services.

Achieving this digital disruption requires enterprise-wide transformation, impacting the way products and services are developed, manufactured, sold, operated, and maintained. Global enterprises with large-scale projects increasingly require real-time collaborative work across functions, geographies, divisions, departments, and external partners.

Yet, global companies are challenged with inadequate data management practices (departmental silos, governance, etc.) across products, processes, and people. This inhibits the capitalization on the troves of data already existing within a company's walls and the sourcing of novel external data sources. These hurdles are significantly impeding collaboration and correlating worker productivity. Employees waste significant time searching for information instead of analyzing it. Companies cannot afford these inefficiencies when competing in today's data-driven world that is estimated to reach 175 Zettabytes of annually generated data by 2025.

Many organizations' solution is to capture these volumes of unstructured information in a data lake and attempt to develop an enterprise-wide digital thread all at once. For many, these lakes become inefficient and unusable data swamps; Gartner claims 80% of data lakes do not include effective management capabilities.

Managing these unwieldy data lakes becomes more of a daily chore than a benefit to the organization – a growing cost center using up significant resources. Trying to build this holistic enterprise-wide digital thread from the outset instead of starting with high-value use cases sacrifices years of development and correlating time-to-value, and ability to adapt to market conditions.

The Digital Thread is the Solution to Overcoming Information Challenges

A digital thread is a single source of data truth creating consistency, collaboration, and alignment across functions by real-time data synchronization of related upstream and downstream derivative information. This scalable common set of democratized data enables enterprise-wide accessibility and continuity across products, processes, and people.

Starting a Digital Thread Strategy Today

A digital thread strategy provides a more promising path to effectively manage data, circumvent productivity bottlenecks, foster enterprise-wide collaboration, increase market agility, and drive business value in the digital age.

While every function in an organization stands to benefit from a digital thread, taking a more structured approach in implementation is more cost-effective and efficient than a traditional enterprise-wide initiative. A digital thread strategy sets an organization up for long-term success; however, the first challenge is identifying a starting point.

Below are a few necessary steps to contemplate in your digital thread strategy:

1. Define all potential digital thread use cases across the enterprise: Forming a list of potential digital thread use cases is needed to understand the universe of opportunities. This provides a critical qualifier for evaluating technology solutions and negating vendor lock-in to any offerings that cannot handle the current and future breadth of digital thread possibilities.

2. Prioritize the digital thread use cases that will drive the most business value: For any major digital transformation initiative, the roadmap to success must start with well thought-out business goals that consider the needs of the company, its value to customers, and the aligning use case. These will be unique for every organization, but typically digital thread use cases linking data across different departments and domains drive the greatest, quickest, and most cost-effective value.

3. Conduct an internal digital audit to identify relevant data: A digital audit of internal systems is critical to identify what data is available, useable, interoperable, and impactful to the prioritized use cases. With the prioritized use cases, organizations have a defined scope for the digital audit; many organizations have succumbed to 'death by data', attempting to source all enterprise data at once to only have it reside in an unstructured and unwieldy data lake. This data hoarding mindset must shift to one that prioritizes sourcing relevant data for the selected use cases.

> Gartner claims 80% of data lakes do not include effective management capabilities.

4. Demonstrate quick digital thread wins and scale to drive enterprise-wide transformation: After linking the identified data to generate the digital thread use case, internal advocates must demonstrate short-term wins with measurable value and ROI. Validation of the digital thread use cases will be critical to establishing credibility for executive level buy-in, to build on these existing use cases, and implement new ones.

Expanding these use cases will require integrating both new touchpoints for personnel and data sources. Adding new functions, departments, and roles to form a more comprehensive digital thread can capitalize on hidden pockets of internal information and source external supply chain data. Momentum with the thread will only continue as an increasing number of stakeholders across functions are impacted and culture change occurs organically to capitalize in today's digital marketplace.

Benefits of the Digital Thread

Creating a digital thread strategy opens limitless opportunities for cross-functional coordination and subjugate previous collaborative inhibitors.

When data resides in multiple operational domains, concerns arise about multiple sources of truth, duplicated efforts, access control and security, interoperability, and inaccessibility. The digital thread knocks down these barriers and equips industrial enterprises with the flexibility and agility required to drive business outcomes across the value chain.

Enterprises connecting technologies, domain systems, and data with a digital thread can react quickly to shifting market conditions and impact key financial and operational metrics. These include:

Engineering Excellence:

- Improve quality and first-time yield rates
- Reduce rework, scrap, failures in the field, and warranty costs
- Expedite new product development and time-to-market

Manufacturing Efficiency:

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

Product and Service Innovation:

- Increase customer engagement and satisfaction
- Product-as-a-Service and outcome-based business models impact top-line revenue

Service Optimization:

- Improve technician effectiveness and first-time-fix rates
- Reduce asset downtime, truck rolls, and time-to-resolution

Sales & Marketing Experience:

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

Digital Thread Value Recognized Today

Real-time global flexibility and agility is required in today's data-driven world and industrial companies are taking the digital path to achieve this. For example, Flowserve, a manufacturer of flow management systems faced substantial challenges for global collaboration and data management. With 63 manufacturing facilities and 170 service centers, Flowserve needed to globally scale its engineering knowledge and interrelate domain systems to improve collaboration and productivity.

A digital thread was required to standardize, manage, and automate process changes for product and engineering data across Flowserve. **Ultimately, this strategy created a significant benefit for end customers by saving them millions by reducing downtime.** This is a real-world example of an industrial incumbent disrupting the markets it serves and its own business models through the digital thread.

As with the Flowserve example, the core of every digital thread is cross-functional connections across the industrial enterprise. Equipping different roles with contextualized, up-to-date, and accurate information across the value chain – ranging from engineering to service – is enabling flexibility and agility, which are now competitive requirements for organizations.

The breadth of digital thread opportunities is driving industry-wide excitement supported by analyst firms including Gartner, 451 Research, and Forrester. Industrial companies are channeling this excitement to drive value through differentiating their products, optimizing their processes, and empowering their people.

The next section will share more examples of how forward-thinking companies are leveraging the digital thread, unlocking value across products, processes, and people, and realizing significant benefits across the enterprise.

Digital Threads for Products, Processes, and People

At a high-level, executives have three levers to improve their companies' position in the marketplace:

- Advance **products** for differentiation
- Optimize **processes** for efficiencies
- Empower **people** for productivity

To date, the scope of a digital thread has commonly been limited to product data; however, those strategies ignore a greater opportunity to also create continuity across processes and people. For example, people play a major role in every factory and their seamless interactions with digital threads across product lifecycles and industrial processes is critical to their jobs and generating operational efficiencies.

In the following sections, we've outlined the digital thread opportunity across products, processes, and people, with examples of lighthouse adopters innovating in these domains. While there is value and benefits in each of these components, a digital thread strategy will increasingly have continuity across all three areas and the functions within them.

Digital Thread for Product Differentiation

For product manufacturers, the digital thread begins in the engineering department. There, organizations have a lucrative data source in the digital product definition and its traceability as its derivative information scales departments and functions, forming digital continuity across the value chain. Democratizing this common product data model can increase product volume, top-line revenues, and operating margins.

Contextualized digital product information can be leveraged bi-directionally to-and-from service, manufacturing, quality, sales and marketing, among others. With real-time data synchronization of the product, engineering teams dynamically inform derivative departments of crucial information. Consider these use cases:

- Quality assurance functions access timely product regulatory and compliance data.
- Manufacturing departments leverage up-to-date product assembly, bill of materials (BOM), and inspections information.
- Maintenance and service teams create more accurate closed feedback loops to engineering with real-world product usage data to enable enterprise-wide configuration lifecycle management.

These are a few among countless examples where engineering excellence is achieved and top challenges, including product complexity, shorter product lifecycles, and global flexibility, can be resolved through the product digital thread.

Case Study: *Vestas*

The global wind energy provider Vestas is digitizing its production process for its industry-leading wind turbine products. Managing the complex build process for these sophisticated turbines requires global collaboration and seamless orchestration of thousands of supplier materials, CAD designs timely reaching the factory floor, and accurate derivative process and work instructions delivered to production machinery and Vestas' workers.

A digital thread enables real-time data synchronicity for Vestas between these previously siloed systems and information sources, which improves time-to-market, flexibility in adding new product features, and worker productivity. Digitizing paper-based CAD files and work instructions through the digital thread also benefits the renewable energy provider's own ecological footprint.

Value
- **Engineering Excellence**: Managing and scaling engineering information to manufacturing functions improves time-to-market and quality.
- **Manufacturing Efficiency**: Optimizing factory floor production equipment and workers with accurate, real-time workflow instructions drives efficiencies and productivity.

Case Study: B

Global boat manufacturer Beneteau has rejuvenated and streamlined its engineering value chain and the functions within it. Challenged with managing change dependencies from mass customization customer demands, Beneteau created a digital thread to seamlessly democratize common product data models across its 10 brands, 200 boat design models, and several more variants to downstream manufacturing processes. Beneteau can more quickly create customized products and constantly improve customer satisfaction through IoT-enabled factories. These efforts have improved agility and throughput and made it possible for augmented reality to be used in its sales and marketing process.

Value
- **Product and Service Innovation**: Accelerating new product introductions (NPIs) cycle times and attaining mass customization by democratizing product data models.
- **Manufacturing Efficiency**: Engineering data quickly informs manufacturing process plans and instructions enabling flexibility and agility, while reducing scrap and rework.
- **Engineering Excellence**: Expanding the digital product definition and its continuity across the value chain to create a closed-feedback loop that improves design collaboration and quality.

Case Study: VOLVO
VOLVO GROUP

The Volvo Group is implementing product-centric digital transformation to achieve flexibility and agility. To accommodate for custom configurations and shifting customer requirements while upholding the highest product quality, the Volvo Group has implemented a digital thread to streamline its engine quality control and assurance process. This rigorous and complex task includes 8-minute quality assurance stations, where a technician must complete 40 checks with 200 possible variants. Once a paper-based process, the Volvo Group added augmented reality to ease QA operators' cognitive burden and enable real-time data synchronicity to its digital thread, which connects an IIoT platform integrating information across multiple software systems including PLM and CAD. Democratizing engineering data and delivering it through contextualized work information to downstream personnel enables Volvo to improve process efficiency, quality control, and workforce productivity.

Value

- **Manufacturing Efficiency**: Manufacturing processes infused with upstream digital engine definition data empowers downstream QA operators and drives operational efficiencies.
- **Engineering Excellence**: Democratizing engineering data enforces intensive engine quality standards and drives Volvo closer to its '0 Part Per Million' quality goal.

Digital Thread for Process Efficiency

Manufacturers and asset-intensive companies have extremely complex industrial processes operating over myriad systems – some dated and some newer. A digital thread for process efficiency can cover a range of information sources; linking machine performance data to subsequent production line machines to increase overall throughput, informing off-site broader ERP systems to advise higher-level strategic planning, and/or empower operators and technicians to maintain asset uptime.

Across these examples, the advantages are similar: Real-time production line IIoT data empowers cross-functional collaboration in and out of the factory. Dynamically providing this information benefits a variety of roles, including material handlers or operators who use the information for daily work insights. Further down the supply chain, logistics firms are given more accurate and timely delivery information.

Using technologies to access, integrate, and scale digitization across these interrelated processes drives an array of operational KPIs, including overall equipment effectiveness and changeover times. To preemptively adjust to changing marketplaces, organizations need this real-time data synchronicity for their workers operating across assets, facilities, and end customers.

Case Study: PACTIV

Pactiv, a food packing producer, is driving digital transformation across its 11,000 employees by rolling out its Factory Asset Intelligence (FAI) program in more than 50 manufacturing plants.

Pactiv's production lines were challenged with micro-stoppages of downtime, unnecessary process adjustment, sub-optimal process capacity, and lack of real-time performance visibility.

FAI brings real-time performance monitoring and a production 'single source of truth' through its end-of-line display boards, which eliminates concerns for inaccurate or inaccessible information. This HMI and other IIoT-enabled role-based applications are leveraging the digital thread to deliver contextualized information to manufacturing functions, including floating line operators, material handlers, maintenance, shift supervisors, and plant leadership. Pactiv's implementation of a digital thread for its processes generates greater line efficiencies, improved profits, product quality, and throughput, while reducing the need for additional capital expenditures. The manufacturer will continue to scale FAI as it transitions its facilities to fully-enabled smart factories and links in innovative technologies, including machine learning, which will further predict asset health and reduce downtime.

Value

- **Manufacturing Efficiency**: Optimizing production lines and current capacity to improve product quality, overall throughput, and reduce downtime.

Case Study: Carlsberg Group

The global brewer is optimizing its manufacturing processes through implementing a digital thread across its production sites, floors, and machinery. Carlsberg needed to tap into information residing within its critical manufacturing execution systems. These systems are unique and widely dispersed across its 100 sites, which annually produce 12 billion liters of beer. The process manufacturer integrated IIoT into its legacy systems to drill down to the factory floor and connect with interrelated factories. Carlsberg can access digital twins and performance KPIs at the global, factory, and even production-line levels, for greater operational transparency and end-to-end visibility. With increased flexibility and agility, the brewer improved its service to its 150 geographical markets.

Value

- **Manufacturing Efficiency**: Gaining operational intelligence of production facilities and processes drives efficiencies and visibility across the supply chain.

Digital Thread for People Productivity

The financial footprint of industrial organizations workforces presents a major opportunity to identify inefficiencies and streamline processes. However, to date technological advancements have not been focused on these 2.5 billion global frontline workers who are critical to the success of an organization, whether it's field service teams or operators in manufacturing plants.

Service KPIs, such as mean-time-to-repair, or overall labor effectiveness on factory floors, drive daily strategic decisions and influence critical operating margins for industrial companies. Using augmented reality and other connected worker technologies as inputs to the digital thread, companies can capture real-world worker procedures and optimize future service instructions to improve these metrics.

> With augmented reality in their digital thread use cases, GlobalFoundries reduced employee onboarding time by 50% and created standard operating procedures 10x faster than traditional methods.

With the fluidity of the digital thread, this captured information can be made relevant to multiple roles, such as informing product designers with captured service process data, quality teams with compliance information, or training departments to improve knowledge retention.

On the opposite end, out-in-the-field frontline workers can access and consume a variety of cross-functional information relevant to their job or task – such as work instructions or service-level agreements. The digital thread can even extend outward to end customers for self-service use cases. Organizations seeking to drive workforce productivity and alleviate retention concerns need to include people in their digital thread.

Case Study: GLOBALFOUNDRIES®

GlobalFoundries, a major semiconductor manufacturer, is scaling and capturing worker data and applying it to a variety of functions across the value chain.

With augmented reality as the enabler to their digital thread use cases, it's reducing onboarding time of new employees by 50% and creating standard operating procedures 10 times faster than traditional documentation methods.

GlobalFoundries is at the forefront of innovation and empowering its employees and is now looking to scale these successes across eight factories to further drive worker productivity.

Value

- **Manufacturing Efficiency**: Junior and experienced workers are more productive through digitized and in-context training and procedural information.

Case Study: WOODWARD

Woodward is linking its legacy systems and technologies and delivering the relevant data to its workers. The fixed wing and rotorcraft systems provider has constructed a digital thread it calls a manufacturing information system (MIS), which integrates previously siloed data sources into one seamless manufacturing workflow. By linking product-centric software (CAD, PLM), manufacturing systems (MES, MOM), and floor devices (pressers, torque wrenches), it has equipped its factory workers through real-time contextualized information, such as digital work instructions. As a result of these efforts, Woodward has improved operational efficiencies, worker productivity, and other production KPIs.

Value

- **Manufacturing Efficiency**: Democratizing manufacturing data to various factory roles improves worker productivity and operational efficiencies.
- **Engineering Excellence**: Bringing the digital product definition downstream through manufacturing processes streamlines workflows and the product lifecycle.

Case Study: Mercedes-Benz

The luxury automotive OEM is rejuvenating its end user's digital experience with its products. By extending outside of its traditional four walls, Mercedes-Benz is applying the digital thread to a novel yet critical function: the customer. An augmented reality mobile application (known as Ask Mercedes) provides a self-service immersive interaction with the vehicle dashboard that digitally overlays engineering information for product education and increases the driver's learning retention for the vehicle's features. Mercedes-Benz can also capture data from these AR interactions to understand feature usage and potentially inform future product iterations.

Value

- **Sales & Marketing Experience**: Creating a more immersive and intuitive experience for customers to learn product features drive brand value, and a provide feedback loop to engineering.

With a digital thread vision, these organizations are democratizing critical data across products, processes, and people and eliminating the departmental silos inhibiting growth, efficiency, and innovation. The digital thread opportunity is immense to capture value across these three 'P's' today and drive transformative change in the near future.

About the Authors:

Mark Taber is the Vice President of Go-to-Market and Marketing for PTC's Product Lifecycle Management organization.

James Zhang is the Vice President of Market Development for the Smart Connected Operations team.

Terrence Strom is the Vice President of PTC's Augmented Reality Market Strategy team.

David Immerman is a Senior Research Analyst on PTC's Corporate Brand team.

Dave Duncan is the Vice President of Product Development on PTC's Product Lifecycle Management organization.

Contact an expert to learn more about how PTC's unique technology portfolio and partner ecosystem can help you unlock the value created at the convergence of the physical and digital worlds through digital threads.

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