WHITE PAPER

Digital Thread for Connected Products:
A New Paradigm for Product Lifecycle Management

Abstract

Today, connected products and services provide manufacturing firms an opportunity to disrupt their business models and functions. This disruption is made possible through a framework such as digital thread along with technologies like big data and internet of things. These technologies help manufacturers by harnessing the abundance of data generated, consumed, and referenced throughout the product lifecycle in their organizations.

Despite the benefits of digital thread, implementing it at full scale requires high upfront investment. While organizations may opt for integration in lieu of digital thread, this process merely connects traditionally siloed enterprise systems and does not always yield the desired returns. Complex product ecosystems, inflexible technology stack, rigid business processes and practices, and organizational dynamics make it difficult to build an effective digital thread and to realize the intended business benefits. It is thus paramount for manufacturers to understand what digital thread means in the context of their organizations.

This paper examines the key building blocks to build a successful digital thread, the right model to derive maximum business value, and the maturity level of an organization to successfully implement digital thread.

Key Constituents of Digital Thread

Digital thread is a communication framework that connects the data flow of an asset and offers an integrated view of that asset's data—that is, its digital twin—throughout the product lifecycle[1]. Digital thread allows seamless data continuity and data interoperability across the product lifecycle ensuring that the right business use cases can be configured, thereby providing business insights. Further, used in conjunction with big data and IoT, digital thread can help manufacturers develop intelligent insights from the abundant data available with them. Industry estimates indicate that digital thread can reduce operation cycle times by 75% and save manufacturers $30 billion annually[2]. Further, it is especially critical during situations like COVID-19, where data-driven decisions and working in shared virtual environments will surge. The four key constituents of digital thread are described below (see Figure 1):

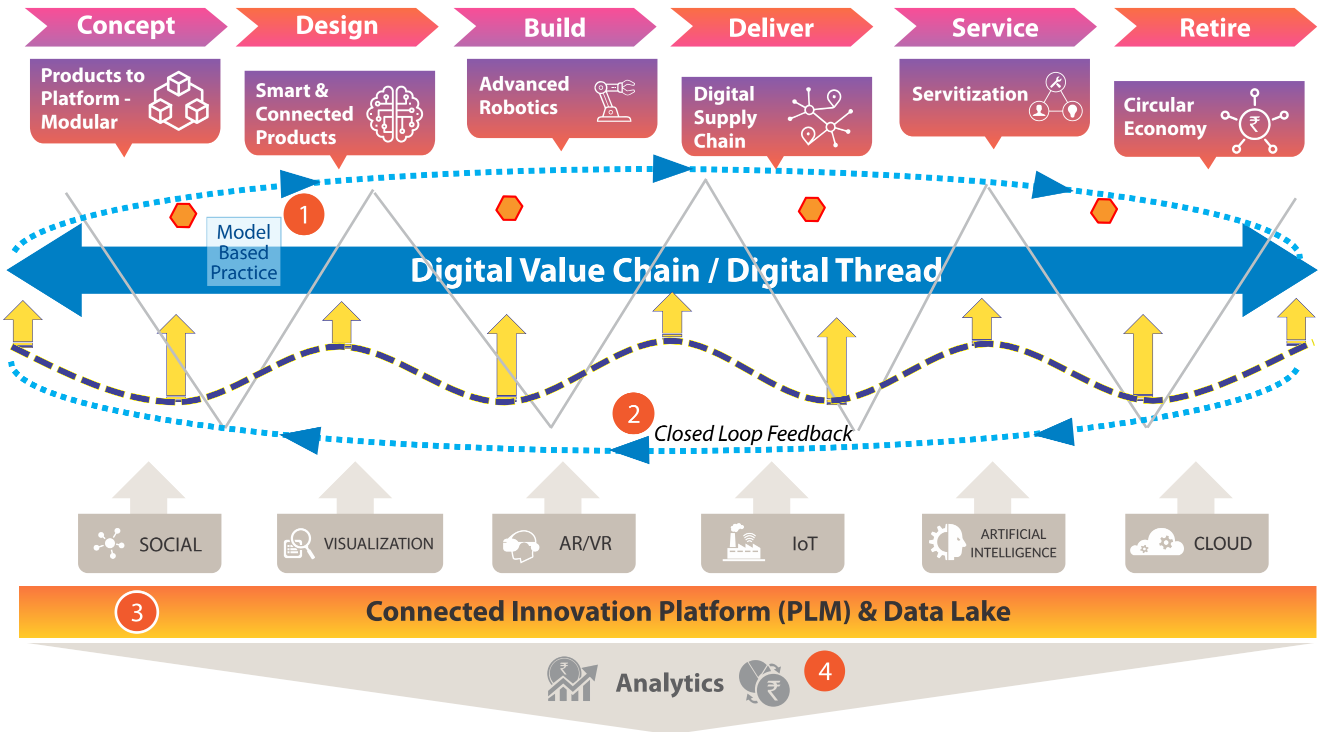

Figure 1: The key constituents of digital thread

[1] CIMdata; Managing the Digital Thread in Global Value Chains (Commentary); February 18, 2020; https://www.cimdata.com/en/resources/complimentary-reports-research/commentaries/item/13431-managing-the-digital-thread-in-global-value-chains-commentary#:~:text=CIMdata%20defines%20the%20digital%20thread,used%20but%20definitions%20vary%20widely

[2] National Institute of Standards and Technology; System Lifecycle Handler - Spinning a Digital Thread for Manufacturing; July 12, 2018; https://www.nist.gov/publications/system-lifecycle-handler-spinning-digital-thread-manufacturing

1. **Imbibing model-based practices across the value chain:** Implementing digital thread will fundamentally change the way information is captured and exchanged across different functions in a manufacturing entity. However, most organizations still use documents as a medium of information exchange. This makes it difficult for them to reuse and track their information or data. Transforming into a model-based enterprise that is data driven will help firms draw insights from their own data. A model-based practice with systems engineering is critical to enabling traceability across the multi-disciplinary and complex product lifecycle environment.

2. **Enabling forward connect and closed loop feedback:** Digital thread fails to work if it is not configured with the right business use cases based on end-to-end data communication with forward connect and closed loop feedback. Forward connect enables left to right traceability by connecting processes and data, right from concept to design, manufacturing planning, and production and service. For example, design can have a long-term impact on manufacturing, warranty, and service lifecycle phases. A closed loop feedback framework will ensure right to left connectivity, where information from downstream value chains can provide feedback to an upstream value chain. For example, feedback from a product in the field can be fed back in the new product development cycle, thereby allowing organizations to innovate and improve their products and services.

3. **Deploying a smart connected innovation platform:** Typically, organizations have multiple tools and applications to manage their product data and business information across the value chain. Therefore, it is not easy to build a digital thread architecture from scratch. Business architecture should be designed based on the organization's existing heterogeneous ecosystems that can be integrated into the platform to maintain data continuity across the value chain and drive data interoperability. For instance, product lifecycle management (PLM) can act as an innovation and integration platform to harness digital thread that can run across multiple systems and platforms.

4. **Delivering contextual business insights through analytics:** As digital thread connects functions and enables information flows across the value chain, its real benefit lies in deriving insights from information captured across various processes and functions. For instance, warranty information captured through service functions can be mined by the design engineer for meaningful insights.

While organizations can adopt key constituents of digital thread, they also need to consider foundational elements such as data governance, data quality, core business processes, and enterprise systems capabilities.

Unlocking Business Value with Digital Thread

Digital thread can be deployed at a different scale and model while keeping the key constituents intact. However, it is not necessary to harness the digital thread in the initial stages for the entire value chain as it incurs huge upfront investment. Having a business value framework (see figure 2) will help manufacturers devise the right strategy to implement digital thread with optimal disruption and at appropriate scale for maximum business value.

For instance, companies can harness digital thread by leveraging PLM as an integration platform over application lifecycle management (ALM), product data management (PDM), and enterprise resource planning (ERP) to bring about enterprise-wide change and for product configuration management. To illustrate, aircraft manufacturers can deploy digital thread by using PLM as an innovation platform that can plug all key design and engineering applications and interface bidirectionally with manufacturing operations management. Such a platform will enable parts information continuity from engineering to manufacturing seamlessly for all possible scenarios, including product structure synchronization, concurrent manufacturing process design, connected manufacturing operations with visual mock ups, and more. Industrial equipment manufacturing companies are integrating their PLMs with IoT to manage data and the configuration of as-installed bases. Such an integration will help these firms develop service-based business models.

Digital thread also makes organizations resilient, especially during and after disruptions such as that caused by COVID-19. The stakeholders involved in product development and sustaining the value chain can collaborate effectively using the information flow across the product lifecycle enabled by digital thread.

Successful implementation of digital thread using the model-based approach is essential for any organization to realize digital twin. Digital twins closely mimic the behavior of the physical product and opens the possibility for organizations to successfully adapt new business models.

Organizations can derive greater business value from digital thread by leveraging the larger ecosystem, beyond their business environments.

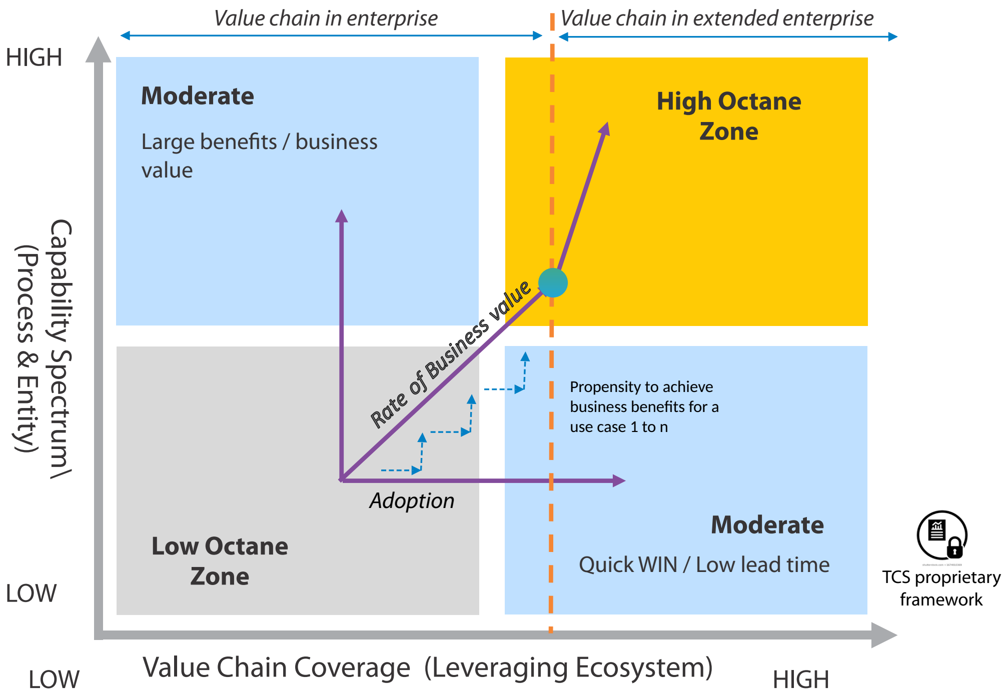

Figure 2: The business value framework of digital thread

Delivering business value via digital thread also depends on an organization's maturity. This can be assessed by defining the current and target state of digital thread in terms of scale and model according to envisioned business use cases and roadmap. It is also crucial to have key constituents and foundational elements such as people, process, technology, and data in place for the successful digital transformation of an organization (see figure 3)

An organization which has high maturity in terms of digital thread adoption has the capability to build an ecosystem with partners to generate exponential value for its end customers while also generating high business value for itself.

		Beginners	Laggards	Late Adopters	Early Adopters	Leaders
	Value Chain (Capability & Scale)	▪ Information capability not leveraged across functions ▪ Functions managed in silos	▪ Data continuity managed for one or two information capabilities ▪ Data interoperability managed between minimum two functions	▪ Data continuity and capability deployed ▪ Multiple functions connected through digital thread	▪ Major information capability deployed ▪ Digital thread managed substantially across functions	▪ Multiple information capabilities deployed ▪ Digital thread managed across the value chain
Key Constituents	Model-Based Practice	▪ Model based in engineering ▪ System-to-component level loosely connected ▪ Hardware, software, and electrical in silos	▪ Model-based practice extended to other functions ▪ System engineering concept adapted	▪ Model-based enterprise ▪ System engineering ▪ Model-based RFL model not adopted yet	▪ Model-based system engineering ▪ System-level definition (hardware, electrical, software) defined and managed	▪ Complete model-based system engineering – RFLP modeling ▪ Complex system of systems-level definition managed and planned through MBSE
Key Constituents	Integration Architecture / Platformization	▪ No enterprise architecture strategy defined ▪ No integration standards ▪ No common platform/strategy for integration	▪ No enterprise architecture strategy defined ▪ Integration standards/strategy within the group defined and put to use	▪ Enterprise architecture strategy defined ▪ Platform coexists with legacy integrations ▪ Integration standards/strategy defined for the enterprise	▪ Cloud adaptation at some level ▪ Integration platform to manage major part of information flows between multiple enterprise systems	▪ Cloud-based multi-tier information architecture (major) ▪ Platform to manage all information flows across enterprise systems
Key Constituents	Connected Enterprise (Feedback Loop)	▪ Systems in silos ▪ Feedback, data continuity managed manually	▪ Integration in some systems/ enterprises ▪ Synchronize/trigger-based data exchange	▪ Connected enterprise within functions (engineering, manufacturing, service, etc.) ▪ Enabled data exchanges run time	▪ Connected enterprise within functions (engineering – manufacturing, manufacturing – service) ▪ Enables bi-directional feedback loop	▪ Connected enterprise across functions (engineering, manufacturing, service, etc.) ▪ Enable backward and forward loop across the value chain
Key Constituents	Data Analytics & Insights	▪ Visualization and business Intelligent through reporting in a system	▪ Analytics adopted with description ▪ Some level of data ingestion	▪ Analytics extended to diagnostic ▪ Data ingestion in large pool, limited to few functions	▪ Predictive analytics and insights across functions ▪ Data lake to manage digital thread	▪ Prescriptive analytics and insights across functions, business ▪ Data lake to manage digital thread
Foundational	Data Management / Quality	▪ Data definition exists ▪ Data not standardized ▪ Data quality is compromised	▪ Data quality initiatives exercised ▪ Data definition and management adopted	▪ Master data deployment for key master data ▪ Data standardization and data governance initiatives exercised	▪ Master data introduced for critical master data ▪ Data standardization/governance for most functions	▪ Master data, data model standardized across functions and the value chain ▪ Fully mature data governance
Foundational	Enterprise System & Process	▪ Core enterprise systems available but not fully capable ▪ Processes are not harmonized	▪ Core enterprise system deployed ▪ Process defined to manage intent	▪ Core enterprise system available with extended capability ▪ Process definition initiated to leverage digital thread	▪ Core enterprise system interoperable with platform ▪ Process definition maturity and harmonization	▪ All core enterprise systems deployed with new-age capabilities ▪ Best-in-class process to deploy connected enterprise capabilities

Representative elements only

TCS proprietary framework

Figure 3: Organization-wide adoption of digital thread

Developing Future Business Models with Digital Thread

Digital thread can unlock extensive value for the enterprise when implemented with the right combination of strategic vision, current state knowledge, and target state definition. By adopting the right data communication framework, organizations can not only rapidly adopt digital thread but can also extend the integration with larger ecosystem partners and develop future business models.

Digital thread also shifts the perspective of ownership in the data communication framework, allowing system and technology integrators and service providers to play a role in data monetization and data governance.

Thus, when done right, digital thread presents manufacturing organizations with ample potential to disrupt business models across the value stream, from the manufacturer to the service providers, and finally, creates exponential value for firms and their customers.

About The Authors

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