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Stitching the digital thread

How engineering service providers can help manufacturers with digitizing their value chains and staying ahead of the competition

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Data is the new oil. Data can help manufacturers in improving quality, reducing cost, increasing productivity, reducing time-to-market, improving traceability, extending collaboration, augmenting visibility, enabling predictive maintenance, increasing revenue and changing the business model. For capturing these benefits, manufacturers need operational, qualified data from design, production, and products in use, with context. To continue the oil analogy, data needs to be refined and piped to stakeholders as and when they need it.

All the above potential benefits of data can be enabled by the "digital thread" and the "digital twin":

» **The digital thread** is the digital representation of the value chain from product design and engineering to manufacturing, after-market, and product-in-use. The digital thread is not limited to internal entities only; it also connects design suppliers, manufacturing suppliers, and services partners.

» **The digital twin** is a digital representation of a physical asset, with all the necessary specifications and information.

The ability to replicate the behavior of product and plants is critical (e.g. considering wear & tear, vehicle part-replacement, etc.) and this is made possible by the digital thread and the digital twin, the value of which are summarized in Exhibit 1, below.

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Exhibit 1: **The value of the digital thread and the digital twin**
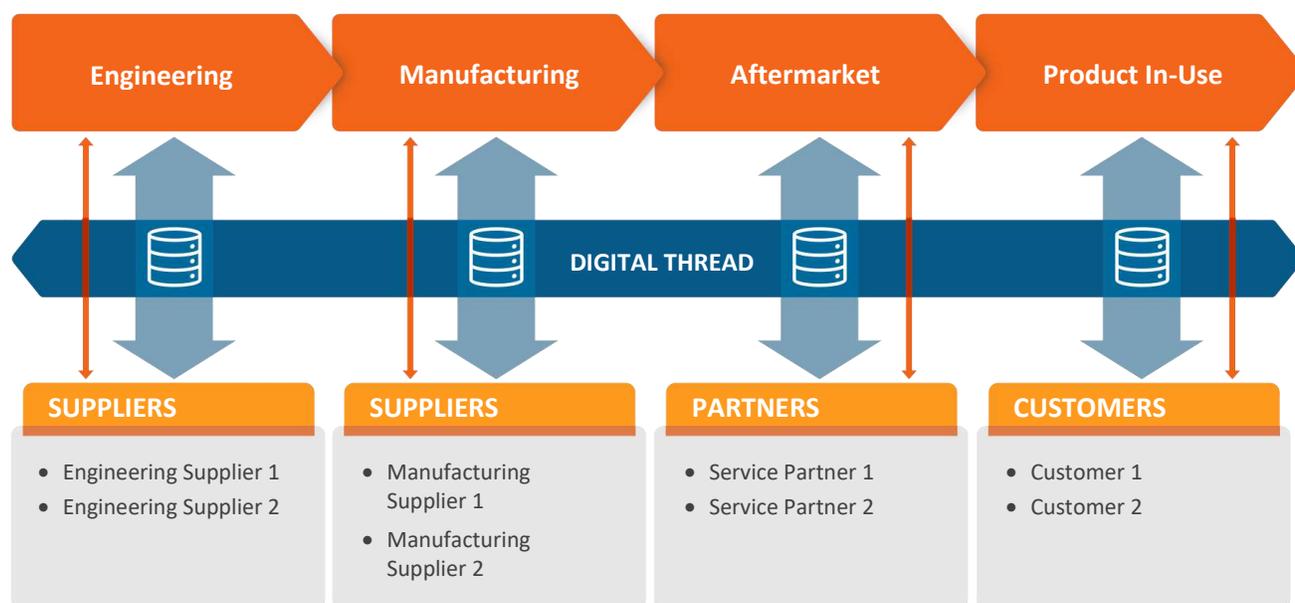
Value Lever	Details
Business Model	Product-As-a-Service by selling outcomes. If it's a jet engine, it could be price by flying hours, a tire can be priced by journey kilometers, and an elevator can be priced on the number of trips, all by analyzing data.
Quality	Improve quality by detecting and predicting quality issues earlier with data.
Traceability	Traceability, with the help of data, is important at the time of crisis of any component failure, and for recalls. For example, a large smartphone manufacturer had a swollen battery problem last year, and quick traceability to components and suppliers would prove very helpful. Traceability can be of people, material, suppliers, customers to requirements. Traceability is also important for certification, finding product information and resources details.
Productivity	Operational improvement by increasing production throughput, improved program timing and streamlining performance issues.
Cost	Reworks are reduced and costly mistakes are identified before plant commissioning or mass production, with the help of data. In design phase cost optimization is achieved by designing product components to a target cost. In services phase, warranty and services cost can be reduced by analytics.
Growth	Growth can be increased by identifying services and product upgrade opportunities early.
Visibility	Visibility of targets, past learnings, supply chain issues early with the help of data can help customers plan for contingencies better. For example, the delay of aero engines from a tier-1 aero engine manufacturer due to a few component performance issues and fixes delayed the delivery of a large number of aircrafts.
Time-to-market	Time-to-market is reduced because visualization of both product and production facility provides clarity, reduces delays, and identifies bottlenecks early.
Predictive Maintenance	Actionable insights from data generated throughout the product lifecycle can help in predictive maintenance and reduce unscheduled downtime.

Source: HfS Research, 2018

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For capturing above business value, manufacturers need to invest in the digital thread implementation. Exhibit 2 shows the conceptual representation of the digital thread connecting different internal and external entities.

Exhibit 2: **Digital thread representation**

Engineering	Manufacturing	Aftermarket	Product In-Use

DIGITAL THREAD

SUPPLIERS	SUPPLIERS	PARTNERS	CUSTOMERS
• Engineering Supplier 1 • Engineering Supplier 2	• Manufacturing Supplier 1 • Manufacturing Supplier 2	• Service Partner 1 • Service Partner 2	• Customer 1 • Customer 2

Source: HfS Research, 2018

Challenges in digital thread implementation

While there is a growing interest among manufacturers in the business value of digital thread, manufacturers are facing a number of challenges in digital thread implementation, as shown in Exhibit 3.

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Exhibit 3: **The challenges faced in digital thread implementation**
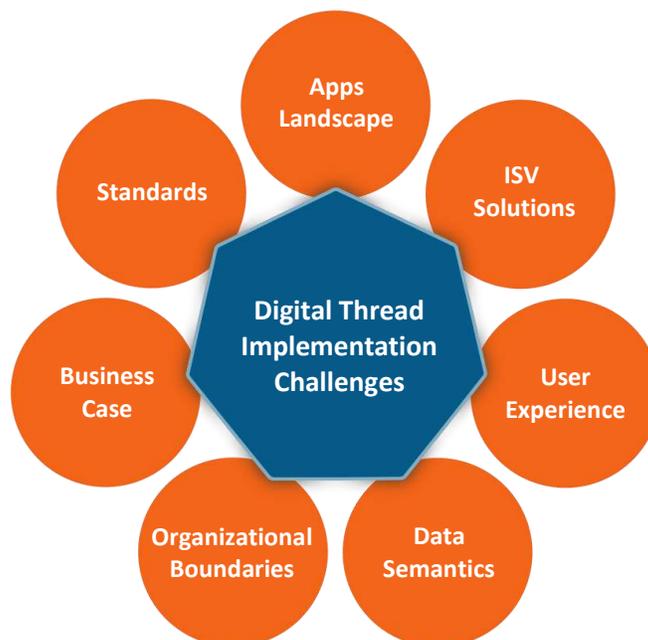
Source: HfS Research, 2018

» **A heterogenous application landscape**: The traditional deployment methodologies of IT applications by the function are not capable of addressing digital thread requirements. There are different applications across the four towers of engineering, manufacturing, after-market, and product-in-use, as shown in Exhibit 4. Inside these towers also, there is a functionality division visible in application landscape. The interoperability between these silos is a big challenge. Some of these are legacy applications which further increases this challenge.

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Exhibit 4: **Heterogenous application landscape in a manufacturing enterprise**
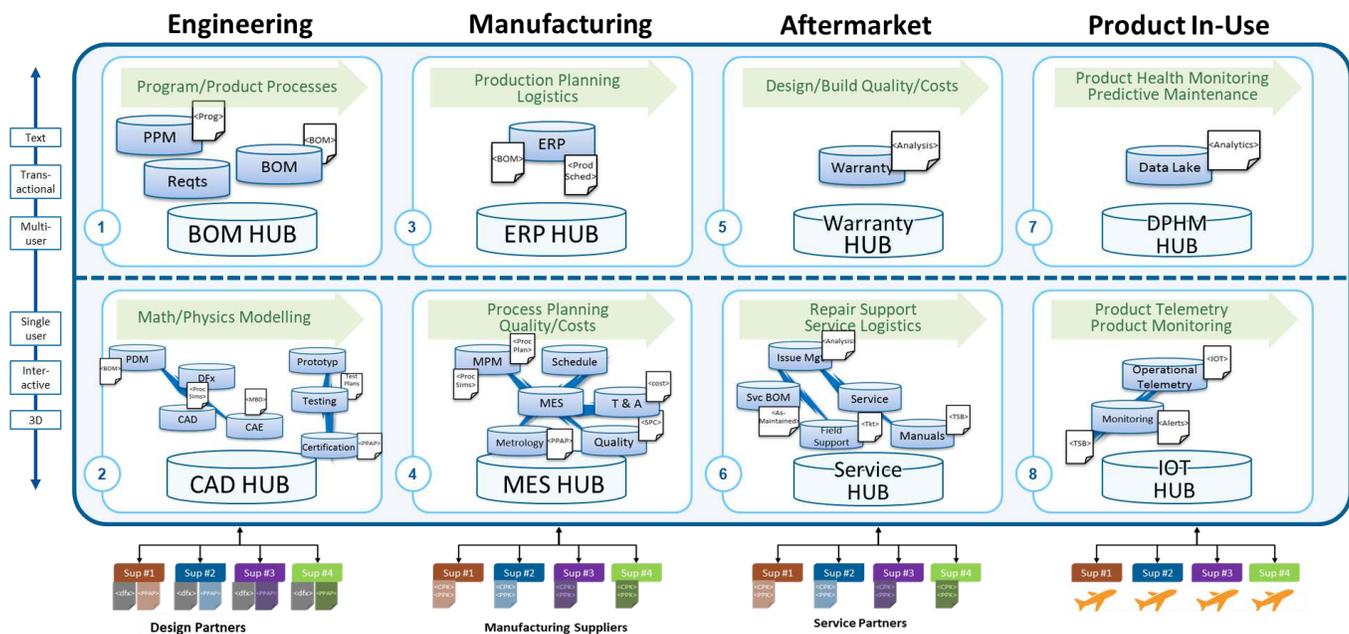
Source: HfS Research, HCL 2018

» **Challenges of organizational boundaries**: Manufacturers need to connect to their design suppliers, manufacturing suppliers, and services partners for constant data exchange, as shown in Exhibit 4, above. In the B2B space, manufacturers need to connect with their customers also. The more external entities comprise the ecosystem, the more complexity is added to the implementation of the digital thread -- each organization has its own data semantics, applications, and so on, which may or may not talk to each other. On top of this complexity, there are security and legal concerns, which need to be addressed when exchanging information with external entities.

» **Lack of end-to-end ISV solutions**: The software solutions from independent software vendors (ISVs) are limited to one or two of the four towers (that is: engineering; manufacturing). Many ISVs tried to extend their solutions to other towers, but their efforts have met with mixed results. The situation today is that no ISV can offer end-to-end solutions across all four towers. To overcome the problem of ISVs being either unable or unwilling to provide robust data and process interoperability solutions (both within a given hub and across hubs), manufacturers have invested heavily in creating and maintaining multiple point-to-point integrations. This raises further interoperability issues, forcing major OEMs to freeze application stacks with obsolete applications, operating systems, databases, and hardware, to support compliance mandates. As an example of this, some aerospace manufacturers have application stacks, per aircraft

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program, from design through to end-of-life (50-75 years), where stacks are frozen but still needs to be supported.

» **Difference in data semantics**: There are differences in data semantics across different functions, applications, and enterprises. Even if data is available, the context and latency are often missing. This makes the implementation of the digital thread more difficult. Another issue is that data should be dynamic and fresh for organizations to get the benefit of the digital thread, but often data becomes static and stale.

» **Personalized user experience expectations**: User expectations are very high for technology in the digital world. In the digital thread, ability to serve personalized and actionable content by the role of the user is important. Often in enterprise applications, the focus is on functionality, and personalized user experience becomes an afterthought. One of the reasons PLM solutions have a relatively low adoption is the lack of good user experience. To be successful, digital thread implementation needs to give priority to good and personalized user experience with actionable content.

» **Lack of clear business case and sponsors**: In the enterprise, many earlier investments in enterprise applications in the manufacturing domain (such as PLM, MES, ERP consolidation, and so on) did not yield expected benefits, for a variety of reasons. As enterprises have continued to invest in multiple generations of authoring applications, they have seen their digital asset investments fail to realize the full value of synthesizing data to information, and then to knowledge. That makes enterprises skeptical about adopting another large-scale implementation program. Based on our conversations with customers, they are not sure about the business impact of the digital thread. Many organizations look at this as a "technology" initiative, and they are not sure about the outcomes they should look for from a "business" perspective.

So, a clear business case should be defined along with business outcomes. Another challenge is having a single sponsor for a complete digital thread initiative, as the digital thread cuts across the complete product development lifecycle. Business impact cannot be limited to one single department as it is coming from a network of effects. This initiative should be championed at C-level, which can help navigate organizational silos.

» **Proliferation of standards**: Digital thread implementation is in its early stages, and there is a proliferation of standards. Standards will converge over time, and global manufacturers are driving a few initiatives around these. Until then, digital thread implementation should comply to a few existing standards, such as PLCS, AP242, ISA-95, ISO 15926, and have enough flexibility to adapt to new standards.

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These challenges mean that manufacturers are not well equipped to deploy and operate the digital thread on their own. Manufacturers will need an engineering service provider to help them to develop and implement a digital thread strategy.

Solutions and roadmaps to the digital thread

Manufacturers need a digital platform solution, which can be customized and implemented in a step-by-step way with a clear ROI. This kind of digital platform can help manufacturers navigate digital thread implementation challenges, as shown in Exhibit 5.

Exhibit 5: **How a digital thread platform can help enterprises to navigate the challenges of digital thread implementation**.
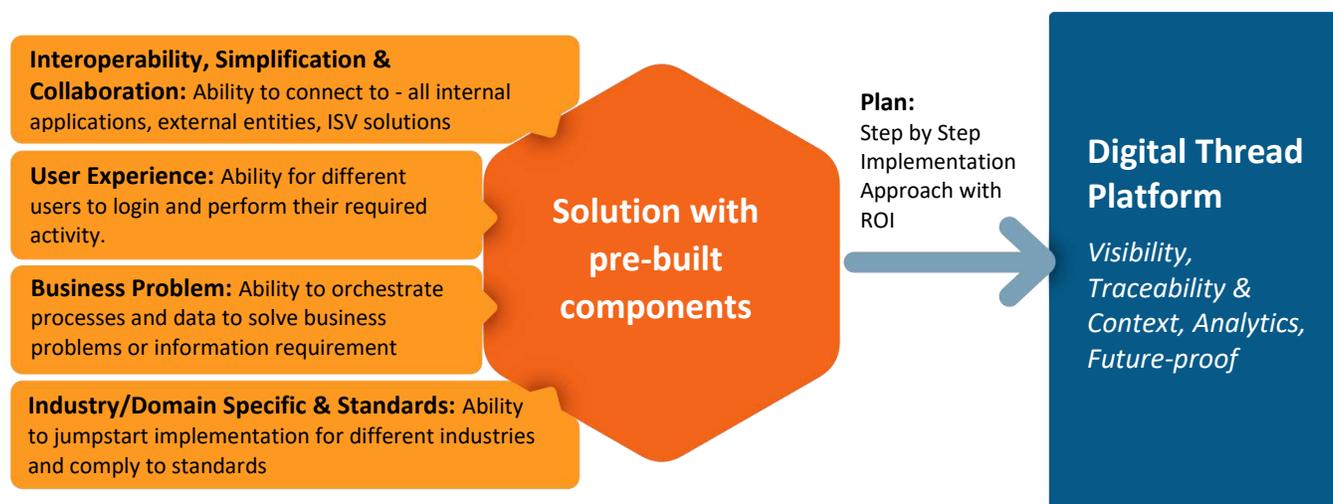
Challenges	Solution Requirements	Digital Thread Platform Dimension
Application Landscape	Should be able to connect disparate enterprise applications. It should have seamless data and process interoperability between applications.	Interoperability, Standards and Architecture Simplification
ISV Solutions	Should have scalable interoperability for ISVs across different functions. Also, able to work with ISVs and incorporate the changes in their product roadmap.	Interoperability and Standards
User Experience	Users should be able to log in and ask queries. The platform should serve personalized and actionable content by the role of the user.	User Experience
Business Case & Sponsors	The step-by-step methodology which provides business case and quick ROI. Ability to solve business problems and orchestrate processes.	Prebuilt Components, Step by Step Methodology, Business Problem Orchestration
Organizational Boundaries	Should be able to connect to external entities. There should be no walls between business domains, supply chain, service partners, and products.	Interoperability, Collaboration
Data Semantics	Should have mechanisms to take care of different data semantics for different industries and enterprises.	Domain Specific Ontologies and Semantics
Proliferation of Standards	Should be able to support evolving standards across the industry.	Industry/Domain Specific Standards and Mapping

Source: HfS Research, 2018

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A digital thread platform should have pre-built components and should take care of interoperability, simplification, collaboration, user experience, business problem solving, standards and industry-specific challenges, as outlined in Exhibit 5. The characteristics and functionalities of an ideal digital thread solution, which can help enterprises in overcoming implementation challenges and capturing business value, is depicted in Exhibit 6, below.

Exhibit 6: **Requirements of digital thread platform solutions**

Interoperability, Simplification & Collaboration: Ability to connect to - all internal applications, external entities, ISV solutions

User Experience: Ability for different users to login and perform their required activity.

Business Problem: Ability to orchestrate processes and data to solve business problems or information requirement

Industry/Domain Specific & Standards: Ability to jumpstart implementation for different industries and comply to standards

Solution with pre-built components

Plan: Step by Step Implementation Approach with ROI

Digital Thread Platform

Visibility, Traceability & Context, Analytics, Future-proof

Source: HfS Research, 2018

With the above characteristics, a digital thread platform should perform its functionalities, as outlined in Exhibit 7, below.

Exhibit 7: **The functionalities of digital thread platforms**

Functionality	Examples
Enable visibility, traceability & context	» Program/product NPI maturity » Manufacturing supply chain schedule and quality integrity » Root cause analysis (RCA) of product issues, failures.
Enable analytics-based validations	» Design intent (requirements to customer usage models) » Build/monitor predictive maintenance models to support after-market.
Enable a future-proofed application stack	» Existing authoring applications "plug-in" to the digital thread platform » Applications provide data content based on platform ontologies » Applications can be exchanged without disruption to processes & users.

Source: HfS Research, HCL, 2018

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An example of a digital thread platform implementation

Digital thread platform implementation is no longer just a theory. Implementation is already taking place in the industry. Exhibit 8, below, shows an example of an early-stage digital thread platform implementation, as described to us by an enterprise we interviewed.

Exhibit 8: **A digital thread platform implementation case study**:

Leading Aerospace Manufacturer
Digital Thread Challenges
The client wanted to create a digital continuity from design to shop floor execution and enable new simulation and automation capabilities to enable production ramp-up. It had the following challenges: » **Data Semantics:** Different data semantics in design and manufacturing functions » **Heterogenous Applications:** The application landscape is different across the design and manufacturing function, creating interoperability challenges. » **Lack of ISV solutions:** There are no ready-to-implement software solutions from ISVs for this situation. » **User Experience:** Designing the application which should be used by shop floor people.
Digital Thread Solutions Offered by the Engineering Service Provider (HCL)
HCL leveraged its pre-built solutions and approached this in incremental steps. Its solution in the first phase includes: » A limited scope ontology to cover the engineering and manufacturing domains » PoC application providing a unified view aggregating the information from enterprise systems, best practices in manufacturing, tool and material locations, connectivity to actual fastening tool, and feedback confirming operations to specifications In next phase, HCL will develop solutions including: » Discovering semantic-based architecture and PoCs to create semantic bus-based system as the digital thread » Using the latest W3C recommendation for shape graph to define business process and rules as ontologies and create a distributed system with industrially-relevant inferences » Application on distributed IoT infrastructure with "edge" inferences on ontologies.

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Outcomes Achieved

» Removed paper-based processes in manufacturing

» Automation through digital infrastructure and single front end for decision making

» Connect simulation capabilities to shop floor execution and improve optimization of line balancing, prediction of shortfalls, and recovery decisions.

Source: HfS Research, HCL, 2018

The above example highlights the role that an engineering service provider can play in delivering value to manufacturers by digital thread implementation in an incremental way.

Advice for manufacturers as they implement digital thread

1. **Develop a digital thread strategy**: The digital thread should be considered as a business initiative and manufacturers should develop a comprehensive digital thread strategy, covering both internal functions and external entities. Often, manufacturers think that they need point technology solutions -- actually, they need a comprehensive strategy. Think of the digital thread as an enabler for business model transformation for product as-a-service.

2. **Build the business case and identify sponsors**: A clear business case should be defined along with business outcomes. As the digital thread cuts across the complete product development lifecycle, the business impact cannot be limited to one single department (because it is coming from a network of effects). It is important to identify sponsors for a complete digital thread initiative who can help to navigate organizational silos.

3. **Adopt an incremental approach to digital thread implementation**: Digital thread is a journey with different starting points. Manufacturers need to progressively build the digital thread. They will have to identify their most critical business problems and start by addressing them. An organization cannot build its digital thread all in one go. For example, if manufacturing ramp-up is the priority, they need to adopt MBD-MBPP, which will contribute to the overall digital thread.

4. **Take help from external partners**: It is difficult to have all the expertise, experience, and knowledge in-house to implement digital thread. Enterprises should take help from experts who have implemented the digital thread in multiple customers and industries.

5. **Select your digital thread implementation partner diligently**: It is a good idea to select service providers that have:

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» Expertise in product engineering, PLM, manufacturing, and IoT. This will eliminate the need for additional service providers later.

» Pre-built components, which can reduce cost and deployment time.

» A dedicated digital thread practice of some scale (and they should continuously invest in developing and updating their capabilities).

» Partnerships with ISVs for understanding software products and reducing implementation time.

» Knowledge of digital thread standards across different domains and regions.

» A global footprint and can provide digital thread implementation for different countries and regions.

6. **Monitor digital thread projects and results proactively**: Selecting a service provider is a big challenge, but the biggest challenge is that of ensuring that the outsourcing partner operates in the manufacturers' long-term interest. Value is generated when the whole organization benefits from the availability of the right data at the right time. Constant monitoring and evaluation of ROI of digital thread implementation is done to ensure problems are predicted, proactively solved, and business value generated. Even if the manufacturer decides not to outsource, proactive monitoring of digital thread business outcome is the key to long-term value generation.

7. **Continuously evolve the process**: Enterprises need to be flexible enough to adopt and implement new technologies, software products, and standards as and when they emerge. Given the pace of technology development, manufacturers cannot afford to be left with legacy service providers that cannot embrace new technologies, software products, and standards fast enough.

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The bottom line:

Engineering services providers can help manufacturers implement and capture business value from the digital thread

The digital thread is important for manufacturers changing their business model to product as-a-service as well as for streamlining operations, but its implementation is challenging.

Right now, the digital thread is in its initial stages. It might seem to be optional, a 'nice-to-have' solution, especially for manufacturers who have not realized the business value of their past enterprise application investments.

But here's the thing: in the connected world, manufacturers who don't plan and implement the digital thread will be left behind by those that do. In fact, now is an opportunity to take an early lead and build competitiveness, instead of playing catch-up later. Some engineering services providers, with their pre-built digital thread solutions, can help to make manufacturers ready for the connected world.

HfS would like to extend a special thank you to HCL for its support of this study.

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Pareekh Jain is a Senior Vice President at HfS Research. He established the global engineering services practice at HfS Research which covers mechanical engineering services, embedded engineering services, software product engineering services, PLM services, and Industry 4.0. He also tracks telecom and manufacturing vertical along with outsourcing deals and runs India operations for HfS Research. He is regularly quoted in media on engineering services and outsourcing trends (view bio and contact details).

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About HfS Research: Defining Future Business Operations

The HfS mission is to provide visionary insight into the major innovations impacting business operations: Automation, Artificial Intelligence, Blockchain, Internet of Things, Digital Business Models and Smart Analytics.

HfS defines and visualizes the future of business operations across key industries with its OneOffice™ Framework.

HfS influences the strategies of enterprise customers, to help them develop OneOffice backbones to be competitive and to partner with capable services providers, technology suppliers, and third-party advisors. The "As-a-Service Economy" and "OneOffice" are revolutionizing the industry.

Read more about HfS and our initiatives on www.hfsresearch.com or follow @HfSResearch.

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About HCL

HCL is a leading IT services company with expertise in IT, business processes, and engineering services. For the last four decades, HCL has been creating world-class products that delight customers. Today, HCL's Engineering and R&D Services (ERS) partners with more than half of the world's top 100 R&D companies, helping them create the world's leading products. HCL has partnered on products that have created multi-billion-dollar businesses, doubled end user satisfaction, extended product lives that have generated additional millions of dollars in revenues, and delivered innovations that have won industry awards.

HCL has developed a clear strategy and roadmap for Digital Thread implementation in a typical discrete manufacturing landscape. It's experience across product realization lifecycle and portfolio of technology innovations is helping them offer a broad spectrum of services and solutions to enable digital thread.

HCL's approach is to capitalize on the investments made in digital assets by organizations and augment the gaps with interoperability solutions to knit the digital thread

The services portfolio includes right from consulting to assess the readiness and develop the vision aligned to the business needs, to implementation and integration services. HCL's portfolio of technology solutions span across engineering, manufacturing and service domains. HCL is building a framework to enable digital thread across the enterprise. HCL's existing solutions like IoT WoRKS to connect to devices, PANGEA a big data technology that brings the power of machine learning and predictive analytics, GeometricEDGE to provide collaboration can help enterprises achieve their digital vision faster.

Learn more about HCL and its Digital Thread implementation expertise at www.hcltech.com.

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