The Network of Digital Twins
Executive Summary

We see companies in every industry challenged by unprecedented variability in customer requirements and product definition. In fact, product individualization is one of the primary drivers behind the rapid movement towards a more digitally oriented business.

Products or assets are now designed with their own unique footprint. Each one is defined by specific raw materials, assemblies, components, or ingredients and produced at a certain time, by certain operators, on certain machines in a plant, by a partner, or both. Typically, the product or asset is sold at a specific price, under defined terms and conditions, and with specific service agreements.

Unfortunately, most companies are not yet equipped to effectively manage this level of diversity. This challenge is where a digital-twin approach to product or asset management can help.

Essentially, a digital twin establishes a direct connection between the physical product or asset and its designed, manufactured, and deployed digital representation.

This relationship can be used to intelligently assess design integrity, operational characteristics, and maintenance projections for each uniquely defined product or asset. Visibility at this level can lead to improved and accelerated product design, more effective maintenance operations, and a newly introduced service and business model.

Our Intelligent Enterprise strategy is to deliver on the promise of a digital twin by extending it – creating a network of digital twins supported by real-time information embedded in business, product, procurement, manufacturing, logistics and asset intelligence systems.
The Evolution of the Digital Twin

Since the original definition of the digital twin was postulated by Dr. Michael Grieves in 2002, it has evolved and became more inclusive of new technologies and applied use cases. Dr. Grieves had a simple, but powerful, idea: there is an inextricable connection between the virtual design specifications of a product and its actual physical representation. He recognized that the as-designed, as-built, and as-maintained meaning of a product is often altered or impacted as the product is manufactured, installed, and maintained while in service.

This view was considered a product-centric definition oriented toward product lifecycle management (PLM) and later embraced by PLM solution providers as a design-centric digital twin. More recently these twins became an essential aspect of smart products and when addressing the expectations of consumer markets where products could be upgraded by automatically pushing changes into products already in use. In automotive, for example, performance and functional characteristics of a car could be changed to reflect design updates.

The definition of the digital twin was further expanded with the introduction of the Industrial Internet of Things (IIoT) concept and as new technologies emerged to help measure and track these changes. One of the most notable innovations is advanced IoT sensors embedded in the products or assets that monitor and transmit environmental, operational, and structural dynamic information in real time. They enabled the ability to analyze and report changes in key parameters and functional conditions.

In short order, new use models for the digital twin emerged in more asset-intensive industries and expanded the purview beyond smart products to include smart plants and production factories. Like smart products, assets in manufacturing facilities and production plants were fitted with sensors to provide performance, functional, and operational information. This approach led to advancements in predictive maintenance capabilities, created a foundation for the analysis of product and asset design improvements, and improved service-level agreement compliance.

Despite all of these advancements, more can be done to improve the value of the digital twin. Extending its reach into enterprise business information, cross-functional processes, and related networks outside the organization creates a relationship structure and collaboration environment between digital twins that go beyond the digital and physical product or asset to include commercialization aspects of the digital twin. This expansion of the digital twin into the ecosystem that supports and connects it to the product or asset throughout its lifespan creates a network of digital twins.
Drivers of The Network of Digital Twins

As markets shift toward mass customization and new service delivery models, manufacturers, operators, producers, and service companies must become more dynamic and agile to satisfy customer expectations while ensuring efficiency in their design, manufacturing, and service processes.

Customer centricity and individualized products have empowered customers to the point where variable configurations and product personalization are no longer the future. In fact, the market of one is happening in nearly every industry today. Managing and controlling extensive variability in products, the digital twin becomes the true single source of truth that bonds the unique digital design of every product or asset to its physical representation throughout the lifecycle.

Operations running with more predictive processes and smarter products and assets are changing work methods across the entire enterprise. Since everything is connected in real time and live, notifications of required actions must be provided in the context of synchronized workflows (which are integrated with end-to-end solutions) within and outside the business.

The digital twin becomes the centerpiece of a digital transformation strategy, and the network of digital twins paves the path to a complete digital transformation of the business. The network of digital twins is enabled by incorporating and connecting to processes across functional areas of the business to other networks such as projects, designs, sourcing, and assets. Plus, it established a seamless, collaborative communication channel between a product intelligence and asset intelligence system.
The Network of Digital Twins

The network of digital twins institutes a real-time single source of truth – everywhere. It creates real-time, secure communications and a collaborative environment within the business while encompassing relevant external networks. The network includes not only the digital representation of the physical product or asset, but also the commercialization aspects represented by the ERP business system of record.

This approach provides a holistic digital twin of one that reflects the intelligence built into products and assets through the reporting of their real-time digital and physical state combined with master, production, quality, consumption, usage, and service data. The digital twin can be tailored and graphically represented in relevant formats for design, monitoring, manufacturing, production, maintenance, and external collaboration purposes by leveraging 3D and 2D visualization technologies or operating in augmented reality applications.

Leveraging real-time information from both the product and asset intelligence systems enables dynamic, responsive, and predictive innovation of existing and new products and assets. In the meantime, the performance of products and assets already in use are optimized.

When used within a network of digital twins, the digital twin of one can serve as the basis for commercial transactions between stakeholders or as a collaborative system for project management, design review, and component and assembly sourcing. It can also provide opportunities for new business models such as alternative manufacturing, predictive maintenance, and services.

Take, for example, a digital twin combined with the master data of a bill of materials. As a collaborative design view for defining a 3D printing production order, the digital twin can be combined with supply chain information and used as the basis of a first article inspection. In addition, it can serve as the source for the development of manufacturing or maintenance and repair procedures.

These examples assume that more than one functional area of the business, multiple companies, and a variety of users need to access the digital twin representation of the product or asset. In other words, the digital twin must be securely transferred and viewed, as well as assigned uniquely to the digital twin of one with controlled access and modification rights.
The network of digital twins synchronizes the virtual, physical, conditional, and commercial definitions of assets in real time to optimize operating performance conditions, predict service or repair requirements, improve diagnostics, and enhance decision-making through combined technical and business information.

Because it manages and controls extensive variability in product and asset configurations, the digital twin of one becomes the true single source of truth. It bonds the unique digital design of every product or asset to its physical representation throughout the lifecycle.

Companies can then address product individualization; accelerate time to market; provide a mechanism for the delivery of new business models; and ensure effective, timely performance of asset maintenance and repair. Furthermore, the network of digital twins that monitors distributed assets enables collaboration with partners when managing assets as a service or engages suppliers when defining part and assembly requirements and enhancing change management. The approach combines digital twins with manufacturing solutions from SAP, cloud networks and SAP Leonardo capabilities, including machine learning, blockchain and Internet of Things (IoT), to optimize the product lifecycle with:

• **Digital representation:** SAP synchronizes digital twin business data, product information, asset master data and IoT-connected data from both on-premise and cloud solutions enabling companies to represent the world digitally. Solutions including SAP Predictive Engineering Insights, SAP Predictive Maintenance and Service and the SAP 3D Visual Enterprise applications provide access to rich data processing capabilities and live configuration, state, condition and control information.

• **Business process:** Rich enterprise-grade data processing capabilities allow customers to create, access and update digital twins to support business processes. SAP solutions provide an integrated data model from design, production and maintenance to service, including packaged integration to existing systems for computer-aided design, ERP, and product lifecycle management. Offerings providing end-to-end process support for manufacturers and operators include SAP S/4HANA, the SAP Engineering Control Center integration tool, SAP Hybris Service Cloud solutions, and the SAP Manufacturing Integration and Intelligence and SAP Manufacturing Execution applications.

• **Business networks:** With leading network offerings such as SAP Ariba solutions, SAP Asset Intelligence Network, and the SAP Distributed Manufacturing application, SAP is uniquely positioned to provide a virtual platform for collaboration on products and assets. The network of digital twins enables secure data access, sharing and governance on a global scale.

• **Networks of digital representation:** SAP enables twin-to-twin connections in systems within a specific asset and on an asset-to-asset level. SAP solutions such as SAP Asset Intelligence Network provide semantic and industry-standards support in an asset core modeling environment to enable live enrichment during the product or asset lifecycle.