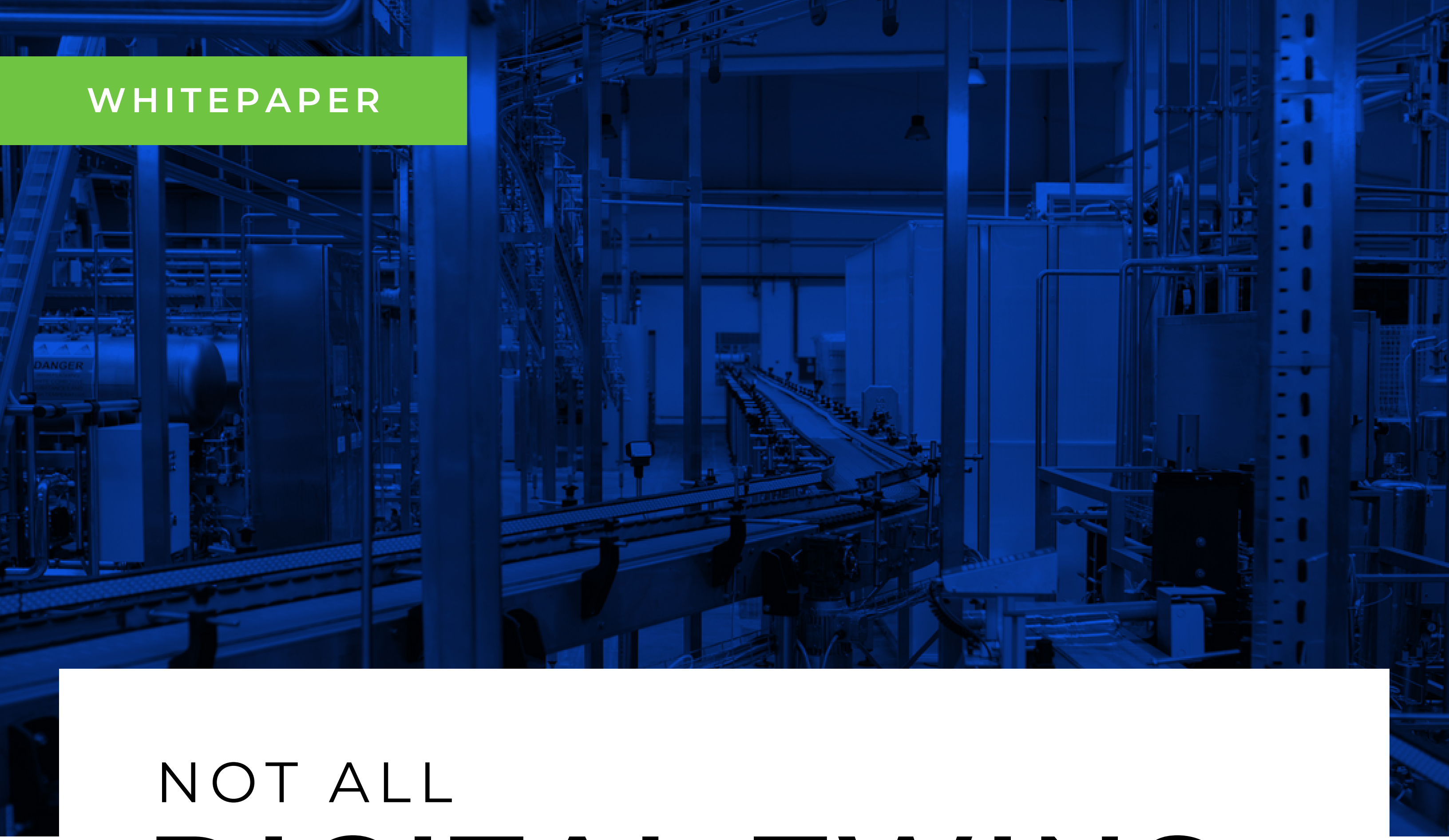
WHITEPAPER



NOT ALL DIGITAL TWINS ARE CREATED EQUAL

by Dave Westrom

The industrial digital twin software market is evolving and growing rapidly. Businesses undertaking digital transformation initiatives have much to consider when evaluating automation and optimization strategies, the most critical of which is their choice of digital twin infrastructure. There are multiple different approaches available, such as software tools, individual components, complete platforms, and packaged applications and solutions.

This whitepaper is designed to shed some light on the multiple options available to you, as well as help you determine the approach that's best for you and your organization.

TWINTHREAD

INTRODUCTION & OVERVIEW

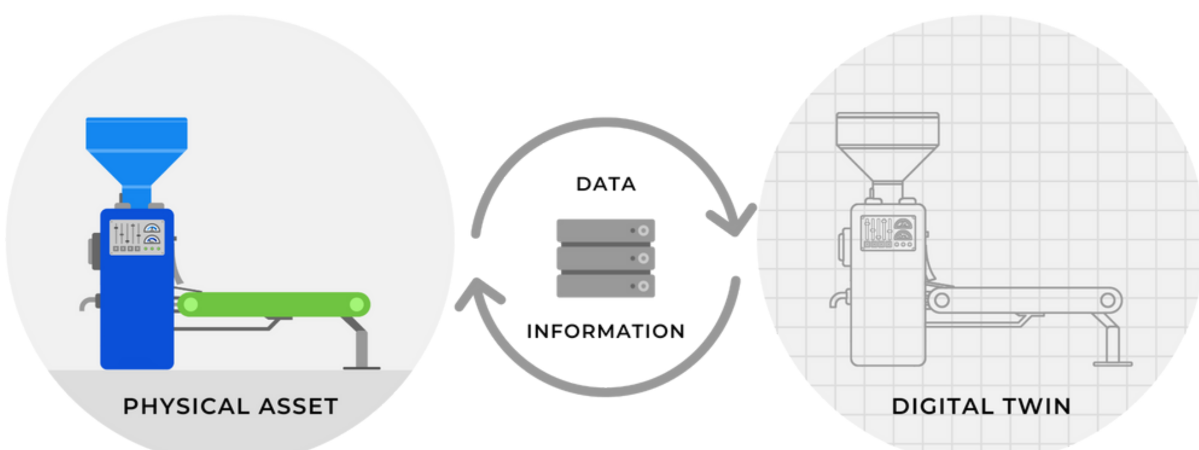
Any impactful digital twin infrastructure will start with automated capture and contextualization of data. The data contextualization and analytics infrastructure must include a range of functionality and packaged process steps to address multiple use cases and variables. Digital twin infrastructures can be designed for asset-centric implementations, process-centric, or both. Understanding the differences and requirements is essential when evaluating options.

Operationalization, or the enablement of business process generation driven by digital twin insights, adds another dimension and level of complexity that often is not considered. And finally, scaling or rolling out a digital twin solution requires underlying capabilities in the twin infrastructure that, if not designed into the architecture, could result in solutions having to be rebuilt from scratch for each implementation.

Each option has its merits, but the key to success is selecting the approach that works best for your specific operational and budgetary needs. Not all digital twins are created equal, and this paper will examine the range of options and factors that must be considered in any evaluation.

INTRODUCING: THE DIGITAL TWIN

A digital twin is a virtual, real-time representation of a physical asset, system, or process. The representation of the twin is based on historical and real-time data captured from physical assets and processes impacting those assets. This data serves as a virtual model, which in turn serves as the foundation for generating insights and actions that drive performance improvements.



THE DIGITAL TWIN SOFTWARE MARKET OPPORTUNITY

The market for digital twin software is growing rapidly. According to Grand View Research, the digital twin market was estimated at USD 7.48 Billion in 2021 with an expected compound annual growth rate of 39% from 2022 to 2030.

The anticipated growth in the market is predicated on the need to improve performance and optimize asset and human resource productivity across a wide range of industries. The scarcity of skilled workers and the increased complexity of manufacturing processes, enabling technology, and supply chains are primary drivers of a rapidly evolving market.

Deloitte estimates 4 million new manufacturing jobs will be needed by 2030 and the impact on the global economy will be over USD 1 trillion. The recent COVID crisis both accelerated and amplified the skills gap that has been impacting the industrial sector for decades. . Leveraging digital twin technologies to optimize all aspects of operations, including extending the capabilities of limited in-house teams, will be key to growth as we move through this decade.

WHY THE TWIN?

Digital twin technology provides the foundation for driving innovation through continuous and autonomous improvement, addressing the operational performance and skilled resource challenges facing industrial organizations. Maximizing operational productivity with minimal human intervention is the primary goal. Digital twins enable businesses to establish and maintain a Virtual Center of Excellence (VCoE) that facilitates continuous innovation and process improvement.

The VCoE is composed of subject matter experts with deep domain expertise in the assets, processes, products, technologies, and services that make up the business. Powered by the digital twin infrastructure, the VCoE drives best practices and autonomous improvement across the enterprise through data capture, insight generation, advanced analytics, and new business process generation. It also eliminates physical location constraints, empowering a team of skilled personnel to drive operational improvement, maximize efficiency, and positively impact any asset or process - regardless of their location - at any time.

THE DIGITAL TWIN LANDSCAPE

When examining the industrial digital twin landscape, businesses will soon discover there are many different approaches and options, including:

- Off-the-shelf software tools, platforms, and complete, packaged solutions.
- Building your own from scratch.
- Building components from scratch in combination with tools or platform components from various suppliers.
- Stitched together components from a range of suppliers.

In addition to implementation methodologies, there's also a diverse range of architectures, including:

- An 'asset-centric' structure
- A 'process-centric' structure
- Product design, 3D modeling, and simulation-based
- Hybrids, which draw upon elements from all of the above

It's also critical to look at your options through the lens of tomorrow's needs as well as your needs of today. Some digital twins are designed to easily enable innovation and new business processes. Some include advanced analytics. Some are designed to scale while others require more extensive effort to expand functionality beyond its original configuration.

The considerations and variables can be complex and confusing. This paper examines options in the context of key requirements and issues that will impact results and save time and money for businesses developing a digital twin strategy and embarking on a digital transformation journey.

DIGITAL TWIN BASICS

There are several foundational components and processes that are required for a digital twin software hierarchy, including:

- Data connectivity and collection
- Data contextualization
- Analytics
- Operationalization

Organizations are leveraging digital twin technologies to target a range of different opportunities. Some are focused on improving productivity within manufacturing facilities while others optimize field-deployed equipment service and support processes. Businesses also find themselves at different stages of a journey to optimize and automate their operations based on a highly competitive and evolving landscape.

The journey to a more autonomous operating environment may start with simple automation of data collection and evolve over time to predictive applications which anticipate and correct problems before they occur. The selection of digital twin tools, platforms, and solutions must account for all facets of the journey and the fact that requirements will change and evolve over time. A selection based on the present stage of the journey may turn out to be suboptimal further down the road.

CONNECTING & COLLECTING DATA

The first phase of any digital twin initiative or journey includes automating the collection of data from data sources on a specific asset or across a manufacturing production line or plant. Manual data collection is often fraught with errors and highly inaccurate. It is an unstable foundation for any digital transformation initiative. Automated data capture requires a software data agent that can rapidly connect to a data source, capture all required data, and automatically push the data into a digital twin architecture.

Often, there will be multiple data sources related to an asset, manufacturing production line, and manufacturing plant facility. Some businesses choose to custom develop their own data agents. The process is costly and time consuming and often does not factor in the cost of sustaining the software over time. It also drives limited incremental value as there are many software companies that offer these agents individually or as part of an integrated digital twin platform.

KEY QUESTIONS DURING THIS PHASE

- Are you presently collecting data manually from your assets?
- How many data sources do you have across your enterprise?
- Do you develop your own data agents?
- How does your data agent technology align with your digital twins architecture?

THE DATA CONTEXTUALIZATION FOUNDATION

The foundation of any digital twin strategy starts with data contextualization. Contextualized data are the datasets that can be visualized, monitored, analyzed, and acted upon. These datasets, pulled from disparate data sources tied to physical assets and processes, often with different measurement units and time slices, also feed analytics engines and artificial intelligence (AI) models for advanced and predictive analytics applications.

Data contextualization consists of the following steps:

Translation | **Alignment** | **Transformation**

Segmentation | **Filtering**

STEP ONE: TRANSLATION

Translation consists of converting data tags into a digital twin hierarchy. Tags are mapped to digital twin properties to clearly understand data that is specific to each asset and process. For example, as illustrated below, if we have several pumps configured as digital twins, we need to ensure that all tag names are translated into the twin hierarchy to capture the same measurement for pump flow.

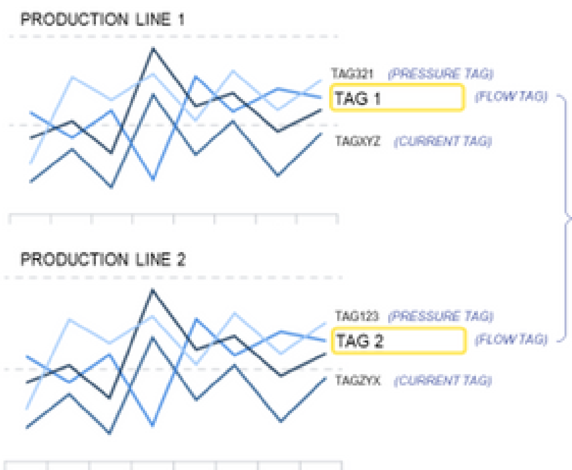
The digital twin structure must have the intelligence built in to pull tag data from different pumps and present the data under the same property, in this case pump flow. Tag 1 is the raw time series data from a sensor that measures the flow rate for production line number 1. Tag 2 is the data from the sensor that measure flow rate for line number 2. Tag 1 and Tag 2 both represent a measure of flow rate but without translation, are not related to a specific asset, process, or production line. Without this level of translation, a business would struggle to leverage insights around performance.

Translation Equates the Time Series Tags

Pump efficiency: flow, pressure, current

Translation Equates the Time Series Tags

Pump efficiency: flow, pressure, current



- Both tags equate to same water flow rate for a pump
- One is from Production Line 1 and the other is from Production Line 2

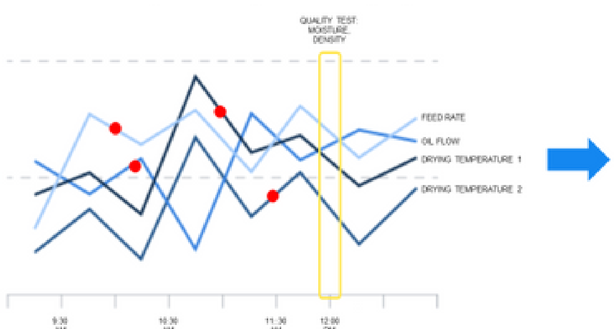
STEP TWO: ALIGNMENT

For manufacturing facilities, most processes have many different time series properties that capture measurements at different times in production. If a product quality measurement is taken at noon, the measurements for the properties that explain the quality occur at different time periods in the past. This is because production includes a product's "transport" through the process.

In the example below, let's assume Product A starts the process at 9 am with the first measurement in the process capturing the rate at which the product moves through the process (ex. feed rate) at 10 am. The next measurement captures the oil flow rate at 10:15, followed by drying temperature measurements at 11 am and 11:30 am. Solving for time displacement requires the alignment of these measurements with the quality outcomes for moisture and density at noon.

Alignment Addresses the Data Transport Challenge

Processes are dynamic
What was the temp and pressure for a quality test at noon?



12:00 PM QUALITY TEST	11:30 AM DRYING TEMP 1	11:00 AM DRYING TEMP 2	10:15 AM OIL FLOW RATE	10:00 AM FEED RATE
Q_1	$DT1_1$	$DT2_1$	OF_1	FR_1

- Dynamic time adjustments

Although this may seem like a simple step at first, automating this process for multiple products across many lines is not trivial. The first challenge with process data is that new data points are ingested and dealt with in real-time, and any digital twin solution must automatically handle this data stream.

Many production processes run at different speeds at different times - one run may be slower than the other. The twin structure must be designed to account for different speeds and solve for dynamic time adjustments to fully align data automatically for analysis.

STEP THREE: TRANSFORMATION

Data transformation is the creation of new properties that are derived from the root property to generate additional insight or inputs into analytic tools and AI models. For example, a property for Agitator Speed can be used to derive additional properties that include the average, standard deviation, and slope. These supplemental properties can be incorporated into the digital twin if the twin hierarchy is designed to accommodate transformed data. The digital twin structure should provide the ability to automatically create these transformations and update the calculations.

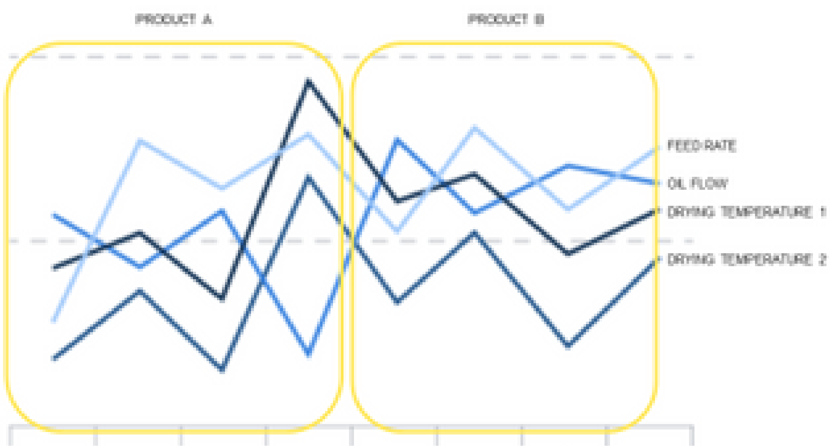
STEP FOUR: SEGMENTATION

Segmentation is a means of analyzing and evaluating data across multiple operating conditions, or modes, of assets and processes. Segmentation incorporates events such as product changes that require grouping data by individual stock keeping units (SKUs). Segmentation is dependent on the specific query and use case.

In the example below, a moisture prediction for a particular product incorporates the transport lag alignment but predicting energy does not because we only care about how much energy is consumed by the process at a given time. Incorporating an automated and scalable way to segment data is critical for solving multiple use cases simultaneously under different operating modes.

Without this capability, business enterprises become mired in an endless data preparation cycle.

Segmentation Separates Data by SKUs



- Digital twin structure automates data segmentation
- Segmentation is done in the contest of specific use case

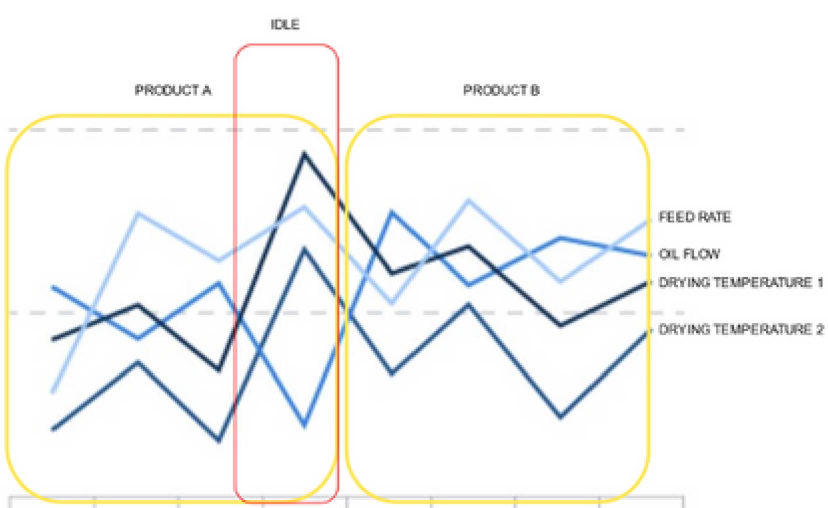
Example:

- Predicting moisture content for Product A includes transport lag & translation
- Predicting energy consumption while making Product B only considers the
- amount of energy consumed at that time

STEP FIVE: FILTERING

SThe final step in the data contextualization process is filtering. This step removes abnormal operating conditions to enable accurate data analysis through the digital twin. As shown in the example below, we want to exclude analyzing data during planned downtime events. Like Segmentation, Filtering is use case specific, and any viable digital twin platform must be structured to enable multiple different use cases.

Filtering Removes Abnormal Running Conditions



- Automatically define the different operational states of an asset of process to filter out idle conditions from analysis
- Filtering is done in the context of the specific use case

ASSESSMENT QUESTIONS

- Does your digital twin architecture incorporate all 5 of the data contextualization steps?
- Does your company custom build data contextualization for each project and initiative?
- Does your digital twin platform fully automate the data contextualization process?
- How much time is required to contextualize data for each project or initiative? What is the cost of sustaining?

THE ASSET-CENTRIC TWIN

Many digital twin offerings available on the market today are designed to model, or virtually represent, a single physical asset. This is in contrast to digital twins designed for more complex process-centric initiatives found in manufacturing production environments. The asset-centric twin structure is designed to primarily address use cases focused on optimizing asset performance for field equipment or devices. Use case examples include Asset Reliability and Asset Health. The digital twin is generated for a specific asset to automate the processes that will turn asset data into insights and actions.

Once again, the key processes are data collection, contextualization, analytics, and operationalization. Each process is case specific so if we are addressing both Asset Reliability and Asset Health, each process is run individually to create unique outcomes.

Configuring a Digital Twin for a single asset is straightforward. Properties are mapped to the Twin for the two types of data sources (time series and events). Time-series data is aligned to events, operating conditions are defined, irrelevant data is filtered out, and contextualized data is defined. Contextualized data is leveraged to power analytics and train AI models to improve asset performance.

Digital twin platforms must accommodate both first principle models and machine learning models. First principle models are based on a known set of conditions and an understanding of the processes related to those conditions. These models typically incorporate complex logic and mathematical analytics to drive manual or automated work processes. Machine learning models are based on more complex algorithms focused on anomaly detection and predictions.

ASSESSMENT QUESTIONS

- Is your architecture limited to single asset use cases?
- Does your digital twin platform enable both first principle and machine learning models?
- Is your digital twin architecture designed to incorporate advanced analytics such as anomaly detection and predictive models?

OPERATIONALIZATION & DIGITAL TRENDS

Once an insight is discovered or an anomaly or predictive model is generated, it must be operationalized to ensure optimal performance and full value attainment. Operationalization is the enablement of a business process that will be created, changed, or enhanced due to the insight or generated analytics.

This also includes the level of automation of the processes. The processes could be entirely manual, fully automated, or somewhere in between. Operationalization of data insights and AI model outputs requires:

- A fully integrated digital threat, or workflow, engine.
- A digital twin architecture designed to enable and capture operationalized.
- An intelligent digital twin architecture designed to learn and iterate, continuously updating and optimizing AI models and the associated operationalized workflows based on changing data.

The output of operationalized workflows can take the form of alerts, notifications, control system automations, or other system integrations. The digital thread engine is also required to automate several of the data contextualization steps. For example, digital threads automate the segmentation of data based on multiple products produced by an asset or process. Digital threads determine which product is produced based on the property values that represent a specific SKU. Digital threads automatically define the different operational states of an asset or process to filter out idle conditions from the analysis.

The ramifications of not having an optimized digital twin design with an embedded digital thread engine are substantial. The time to develop analytic solutions increases dramatically as complexity is increased. The level of customization required for operationalization also increases. These solutions also must be sustained once developed, which becomes exceedingly difficult without a platform designed to account for operationalization. Lastly, the ability to scale such a solution becomes impossible. We will discuss scalability later in this paper.

ASSESSMENT QUESTIONS

- Does your business have a plan for analytics solution operationalization?
- Does your Digital Twin Platform have an embedded workflow or digital thread engine?
- Is your digital twin architecture designed for operationalization?
- Is your digital twin platform designed to automatically learn, iterate, and adjust based on changing conditions.

THE PROCESS-CENTRIC TWIN

In manufacturing production operations, assets are connected through processes which create relationships with downstream and upstream assets to create a production line. Material continuously flows through these assets under a wide range of conditions with multiple variables. This highly dynamic, process centric, multi-asset requirement creates a level of complexity not found with single asset initiatives. To add to the complexity, innovation around these manufacturing operations is driven by many use cases.

Examples of such use cases include:

- Quality
- Throughput
- Uptime
- Energy Efficiency

Process-centric use cases are also challenging due to the need to solve for time lags (alignment) across the process. These more complex process-centric use cases require additional digital twins for all the assets that make up a single line. To address process complexity effectively and efficiently, the digital twin architecture must be designed to nest asset twins in a larger, production line digital twin. The production line twin will require additional variables to create production line-specific, use-case specific contextualized data sets.

Complexity increases exponentially when we transition from a single asset to a single production line that makes up a manufacturing process. Complexity also increases when we add additional use cases because each use case requires a specific contextualized data set and operationalized workflows. Complexity not accounted for in design results in significantly longer time to value and higher costs for developing and sustaining solutions.

Digital Twin platforms can accelerate time to value by packaging use cases into applications. This requires deep domain knowledge of the assets, manufacturing processes, and use cases, along with a platform designed to address complexity and facilitate the packaging of applications.

ASSESSMENT QUESTIONS

- Is your digital twin platform designed for the dynamic, process-centric, multi-asset requirements of a manufacturing facility?
- Is your digital twin platform designed to simultaneously address multiple use cases?
- Does your digital twin platform accelerate time to value by including packaged applications?

SCALABILITY OF DIGITAL TWIN SOLUTIONS

Let's assume we manage to create a digital twin solution that includes predictive models for a specific asset or manufacturing production line. Let's also assume that the solution is operationalized and is proven to deliver value for targeted use case(s) related to the asset or manufacturing production line. We are then presented with a new challenge that many businesses do not factor into their process for evaluating digital twin tools: rolling out, or scaling, the solution.

If the solution drives value around a singular asset or production line, it will logically generate far greater value if cloned and rolled out across all similar assets or production lines.

In the case of the asset-centric digital twin, we may have hundreds of thousands of assets geographically deployed across the globe. In the case of the process-centric digital twin, we may have hundreds of production lines across multiple plants in multiple geographic locations. Each of those production lines will have variations in the specific assets that make up those lines, materials being fed through the process, the products being made, operating conditions, sensors, control systems, etc.

If these variables are not designed into the architecture of the twin platform, each implementation in a rollout may require a complete restart of the solution development process. Off the shelf data science tools that are available today are not designed to account for this level of complexity associated with scaling digital twin solutions. Because of this, you can almost be guaranteed that each implementation using these tools will require starting from scratch. A digital twin platform, and any associated solution, must incorporate scale in its design.

Incorporating scale in the design of a digital twin requires abstracting the complexity associated with each individual asset, process, and use case. Properly designing and incorporating a digital twin 'class' structure captures interrelationships between separate assets that are similar. A class structure allows for the automated inheritance of all properties, logic, models, and workflows related to the asset or production line digital twin. A digital twin class will then automatically propagate unique twins with unique properties, logic, models, and workflows as the solution is scaled across the enterprise.

The analytics and AI layer of the architecture should also incorporate the concept of competing AI algorithms and models to address discrepancies among assets and manufacturing production lines across an enterprise. An anomaly detection model or predictive model that is optimized for a specific make and model asset or a production line with a specific set of assets, materials, operating conditions, etc. may not be optimized for assets or production lines in other locations that have variations.

The ability of a platform to automate competing models serves to abstract variability among assets and processes and optimize at the time of rollout.

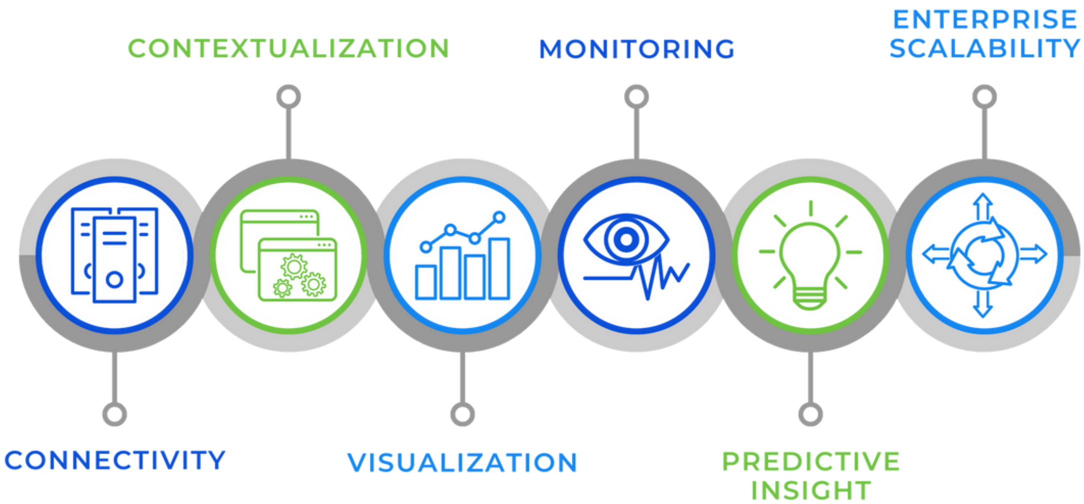
ASSESSMENT QUESTIONS

- Is your digital twin platform designed to enable a broad rollout or enterprise deployment of a solution?
- If you are using data science tools or are building your own digital twin infrastructure, how are you accounting for the enterprise scaling of solutions?
- Does your platform include a 'Class' structure to leverage asset similarities while accounting for digital twin variability?
- Is your platform designed to incorporate the concept of competing AI algorithms and models?

CONCLUSION

The digital twin infrastructure is a rapidly growing approach that addresses operational challenges faced by industrial businesses in a highly competitive and evolving landscape. There are many considerations when undertaking digital twin initiatives in industrial environments. These include business objectives and strategy, digital twin structure, specific use cases, how data is captured and contextualized in an automated manner, operationalization of solutions, and scaling, or rolling out, of solutions that drive value.

Not all digital twins are created equal. Some are designed, based on years of experience and deep domain expertise, to effectively enable a range of digital transformation initiatives. Others are not, leading to an ineffective, inefficient cycle of failed projects wasting valuable resources and resulting in competitive disadvantage.



ABOUT TWINTHREAD

TwinThread provides a unique software platform that leverages AI-enabled digital twin technology to drive a unique continuous innovation process, accelerating the journey to autonomous operations. TwinThread's platform enables operationalized solutions that scale across an enterprise, while simultaneously preserving the flexibility to choose software architecture components and maintain legacy investments. The TwinThread platform facilitates identification and prioritization of continuous improvement and innovation initiatives, and rapid enablement, through packaged applications, of use cases that are key to manufacturers such as quality, performance, and availability.

TWINTHREAD
twinthread.com
info@twinthread.com
+1 434-218-7856