ARTICLE

A digital twin spanning design, operation, and optimization

A digital twin is best defined by the practical ways it can operate on data to provide insights supporting the design, operation, and optimization of an industrial process throughout its entire lifecycle.

Authored by:

Simon Bennett
Head of Research and Innovation, AVEVA

With so much discussion and countless published interpretations about industrial automation digital twins, it can still be unclear what exactly makes a digital twin. In fact, one could be excused for wondering “what isn’t a digital twin”? However, engineering, operations, and management teams are interested in more than digital twin definitions; they want a practical approach to apply this technology usefully to the large quantities of available data, in a way that spans the entire lifecycle of their operation.

AVEVA

In basic terms, a digital twin will be composed of a combination of data, models and analytics, and a visualization experience (Figure 1). The constitution of these three elements will vary depending on the problems that the digital twin is designed to solve:

- Data sources: Raw data–both real-time and historical – gathered from process equipment, utility systems, and other external sources.
- Models and analytics: Tools to convert raw data into useful information and key performance indicators (KPIs), as needed for the different types of workers and problem solving.
- Multi-experience visualization: Software and hardware options to access, visualize and handle data, data analyses and KPIs.

An ineffective digital twin is costly and complex to develop, use, and support, and it will fail to deliver value due to these issues. Conversely, a successful digital twin provides constructive industrial intelligence throughout the design, operation, and optimization phases of a manufacturing or processing operation.

The latter type of digital twin is built on a heritage of industrial information technologies common throughout industry, but it incorporates innovations that enable users to connect the future of their operations with their history of accumulated knowledge.

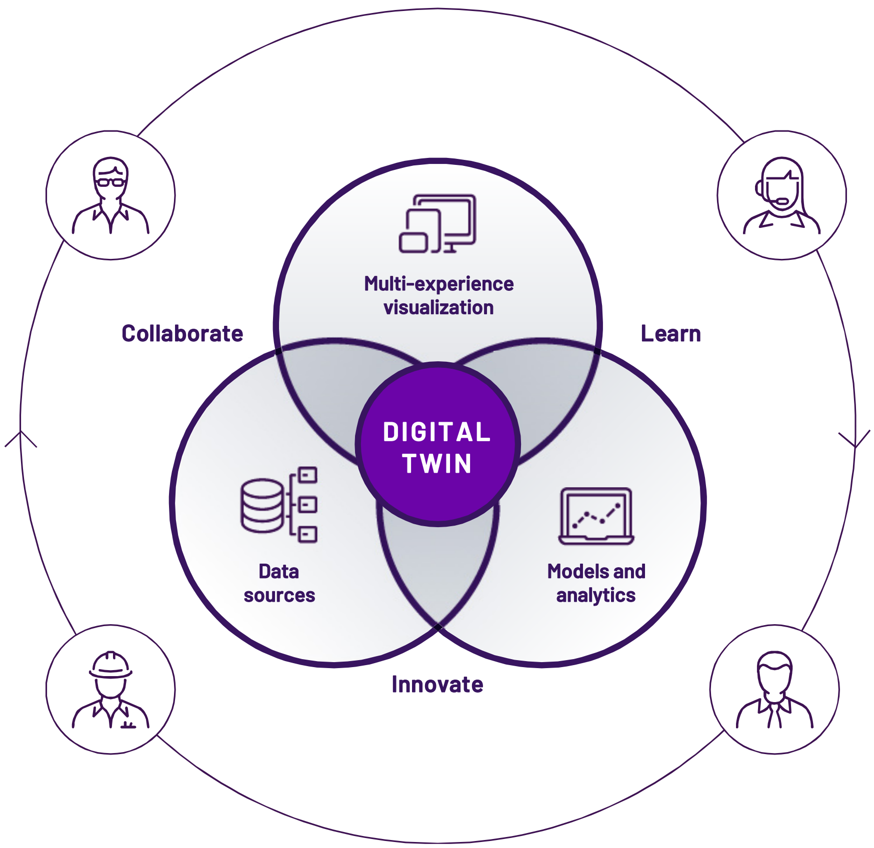

Figure 1: An effective digital twin combines data, models/analytics, and multi-experience visualization to provide industrial intelligence to users throughout all phases of design, operation, and optimization.

Design, operate, optimize

Conceptually, and in reality, any data which pertains to the business should be considered part of the digital twin. Certainly, the monitoring and control aspects of automation systems provide a voluminous real-time “living” data source, but other information such as equipment design, market prices, environmental conditions, business indicators, and others can be relevant. A digital twin must incorporate all these sources seamlessly, with tools and interfaces to encourage connected workers (Figure 2).

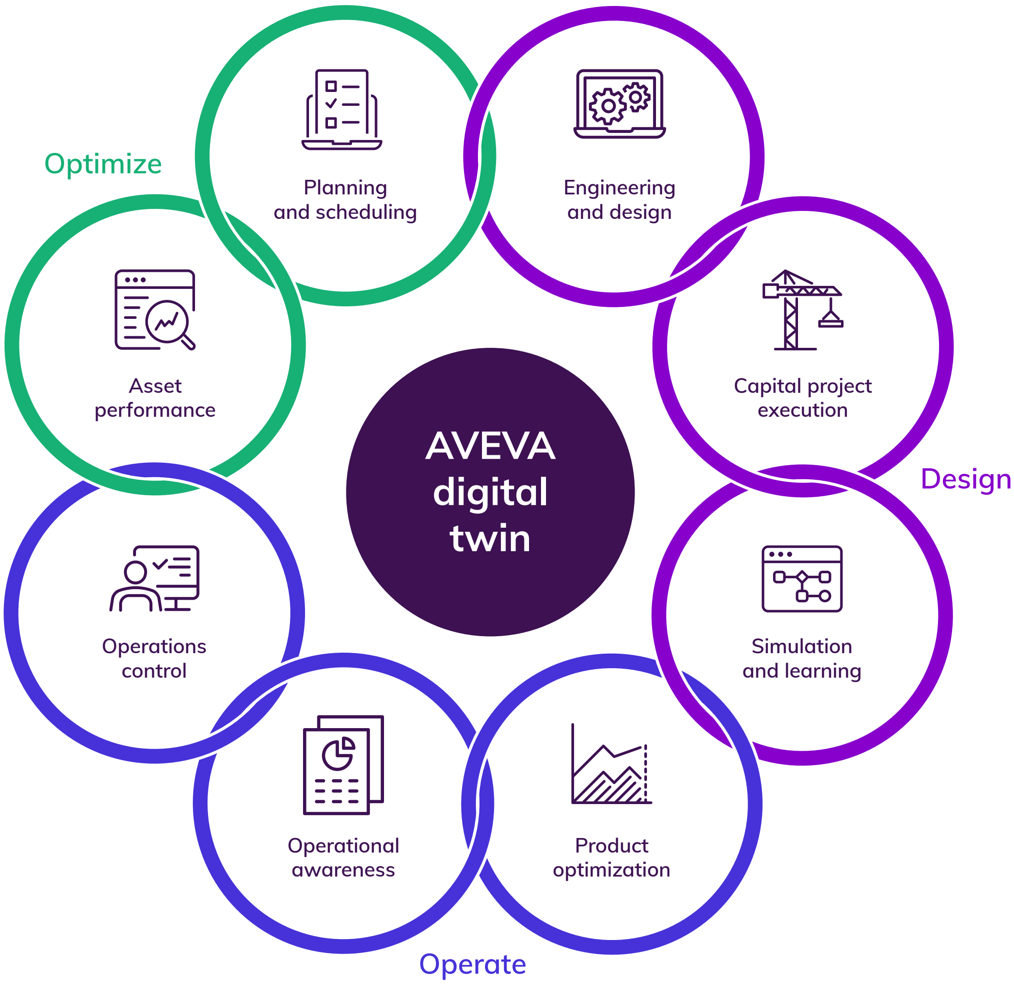

Figure 2: AVEVA offers a comprehensive digital twin, providing a unified way of connecting with all types of raw data and turning it into actionable information throughout the entire design, operation, and optimization phases of an industrial lifecycle.

Design

Many industry personnel consider a digital twin to be an operational and optimization tool, which is true. However, if we take a lifecycle perspective, a digital twin can begin its existence during the initial design phase when the boundary conditions are defined, and the process is functionally modelled.

While live data is not yet available, other data such as process requirements and constraints can be developed to support energy and mass balance calculations, along with projected processing rates and throughput estimates. Digital transformation enables adoption of a full data-centric approach, estimated to reduce total installed cost (TIC) of projects by 5 to 10%, primarily through more efficient and effective project delivery and startup (Reference 1). A digital twin established and managed through conceptual, front-end engineering, detailed design, and subsequent construction and commissioning phases of a capital project improves the control, visibility, and trust over work products generated by engineering/procurement/construction (EPC) contractors. With the right platform and perspective, designers can hand over the digital twin to the production team so they can use it for operational improvements after the plant start-up.[1]

Operate

Many companies throughout the process industries are familiar with a digital twin implemented to monitor operations, providing near-real-time visibility into what is happening at the moment. This type of digital twin goes beyond basic human-machine interfaces (HMIs) and supervisory control and data acquisition (SCADA) systems, supporting efforts to improve agility, resilience, and sustainability.

HMI/SCADA provides solid visualization and helps users obtain some insights, but a true digital twin models the process functionality and enables deeper investigation. The full scope of operational efforts covers the entire planning process including resource allocation, supply chain considerations, and execution efforts.

As the digital twin evolves to more closely mirror the real-world production systems, users can increase their understanding of not just what is happening, but why, so they can take actions leading to better efficiency. This is because the digital twin provides the broadest context for the information, connecting to other streams of information – enabling decision making.

Optimize

Optimization helps users manage the gap between the operational plan and actual results. A digital twin models actual operations based on real-time, historized and calculated data. While real-time and historized data is provided by the operational data management system, the calculated data can be generated through different types of models according to the purpose of that digital twin. Common modeling approaches are artificial intelligence (AI)– including machine learning (ML) – and first principle models (or rigorous models).

The combination of measured data and calculated data enables deep understanding of current operations conditions. This supports faster troubleshooting, and also prediction of future abnormal behavior, so corrective action can be undertaken before upsets are experienced (Figure 3).

Users can prevent unplanned downtime and adjust various production parameters to prevent production losses and avoid quality issues and ineffective energy use, while evaluating how productivity and overall production efficiency and costs are impacted by each event.

1. Deloitte article, “Digital Capital Projects”

Figure 3: By incorporating artificial intelligence, machine learning, and other analytics based on comprehensive access to all data sources, users can visualize and understand current operating conditions and benefit from predictive maintenance recommendations.

By running various sensitivity analysis in this way, a production team can explore options for running their plant. Some results might be obvious, but in many cases non-intuitive ways of optimizing operations are revealed. And all these trials are performed virtually, without impacting actual operations, encouraging exploration and resulting innovations. This in turn creates greater business agility.

Framework of a digital twin

A digital twin is not a single software product, but instead consists of many elements forming an ecosystem. Key characteristics include:

- Comprehensive connectivity for collecting, consolidating, aggregating, contextualizing, enriching, and historizing all types of process and business data. Integration with third-party products, and both new and legacy systems, is essential for breaking down data silos.
- Availability of an asset framework and analytics solutions so users can start with supplied objects, and create their own, to build out the digital twin model and take advantage of AI-infused capabilities.
- Multi-experience visualization options for on-site and mobile, which include HMI/SCADA, but also other industrial-specific capabilities, such as combining 3D models with live data views or even immersive visualization.
- A flexible hybrid approach, where solutions can be on-premises, in the cloud, or both, ensuring that all data and objects can be securely shared and synchronized throughout an organization. Cloud-enabled architectures are a useful facilitator, but an agnostic approach is important to preserve any existing digital investments at a company.
- A modular architecture providing one digital experience so users can start a digital twin anywhere and then build it out and scale it up as needed, even to the degree where companies may develop their own applications on the platform in the future.

Whatever an organization's vision for the future, it should include adoption of digital twin strategies to ensure efficient and effective growth. A living digital twin will span all phases of design, operation, and optimization to unlock value from raw data, transforming it into industrial information useful for maximizing productivity and supporting continuous operational improvement.

About the author

Simon Bennett is head of research and innovation at AVEVA, helping to accelerate the commercialization of new technologies. He has over three decades of experience in the software industry, working with commercial off-the-shelf and enterprise software companies serving many business sectors. Simon has a background in civil engineering, and has helped AVEVA partner with some of the world's leading universities.