Whitepaper

The Simio Solution Platform

for

Manufacturing, Warehousing, and Supply Chains

Simio
Forward Thinking

2025

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1. Introduction

Amid today's dynamic environment, companies must demonstrate exceptional agility to navigate an ever-changing and increasingly uncertain business landscape, all while adapting to rapid shifts in products, services, materials, technologies, machinery, and workforce skills. A successful manufacturing supply chain requires the orchestration, coordination, and synchronization of these elements, operating both independently and cohesively together. As Industry 4.0 progresses, with interconnected systems exchanging data and autonomously managing operations, companies face substantial challenges in navigating complex, multifaceted digital transformation initiatives. Outlined below are key challenges stakeholders encounter in their pursuit of a highly agile, smart, and low-touch/no-touch manufacturing-centric supply chain:

Understanding the current processes and constraints

Despite teams of workers having years of experience operating factories, warehouses, and supply chains, achieving a comprehensive understanding of all processes involved is often difficult due to the compartmentalization of information across different departments within the company. To achieve this, you must start by identifying all the physical constraints in the process of sourcing materials, followed by the processes involved in the production, warehousing, and distribution of the final products to customers. There are also many different documents describing the business rules that management wants to apply to govern the process, often conflicting with the realities of current operations. In most organizations, much of the execution know-how and detailed decision logic remains tribal knowledge, residing in the minds of those making day-to-day decisions on the shop floor. This knowledge is lost as the workforce ages and key workers retire.

Identifying the best data sources and aggregating accurate and relevant data

Understanding the quality and correlation of data across various enterprise systems is a tremendous challenge, as the values for the same fields often differ between systems, making it difficult to determine which is correct. The varying levels of detail between systems further complicate data correlation and aggregation. Synchronizing different data sources to maintain a consistent, time-relevant state presents a challenge too, as some systems operate in near real-time, while others depend on periodic batch processes that run as infrequently as once a day or week. Identifying the sources and flow of data to establish a relevant data pipeline for process modeling, control, dashboarding, and analysis is crucial to the transformation process.

Identifying and exploring areas for transformation and modernization

It is difficult to accurately identify and determine the impact that proposed process changes and optimizations will have on factory, warehouse, or supply chain performance. Large capital investments are often made without a full understanding of the requirements or potential impact on the business. The same applies to automation and digitalization initiatives aimed at enhancing efficiency and performance, as these projects are often developed in isolation, ultimately failing to drive the business's digital transformation goals.

Predicting and prescribing future behavior and performance

Transformation often involves many concurrent aspects, such as people, processes, equipment, automation, new products, sales, global reach, warehousing, and distribution. Making changes to any of these areas without understanding the interactions and end-to-end impact on business operations can result in failure to meet expectations. It is critical to evaluate alternatives to understand the ROI of all options and to visualize and present realistic future results to all stakeholders for buy-in and decision-making.

The most effective way to enable and facilitate business and digital transformation, as well as address the challenges discussed above, is by creating and using a detailed simulation-based virtual model or offline Process Digital Twin of the process (factory, warehouse, and/or supply chain). This model allows for step-by-step design and analysis of current and future processes (predictive solution) and can be connected to real data from enterprise systems to become an online Adaptive Process Digital Twin for operational deployment (prescriptive solution) and near-real-time decision-making.

This whitepaper outlines the key components of the Simio platform that empower organizations to address critical design, analysis, and execution challenges—essential for advancing comprehensive business and digital transformation initiatives.

2. Key Solution Components

The Simio platform includes key components that enable organizations to develop detailed virtual process models for the design and analysis of manufacturing, warehousing, and supply chain operations. These models are structured to later transform into fully integrated Intelligent Adaptive Process Digital Twins by connecting to enterprise data systems or centralized data storage. The following sections will describe key components and capabilities provided by the Simio platform.

2.1 Process Digital Twin

In recent years, the term "Digital Twin" has become popular for describing the use of a simulation model connected to real-time data and employed in an operational setting. While many applications are positioned as Process Digital Twins, significant challenges exist in implementation, and legacy simulation applications are not designed to address these challenges. With the capabilities included in the Simio platform, users can create powerful Intelligent Adaptive Process Digital Twin models to support their transformation journey from process design through to low/no-touch operational execution.

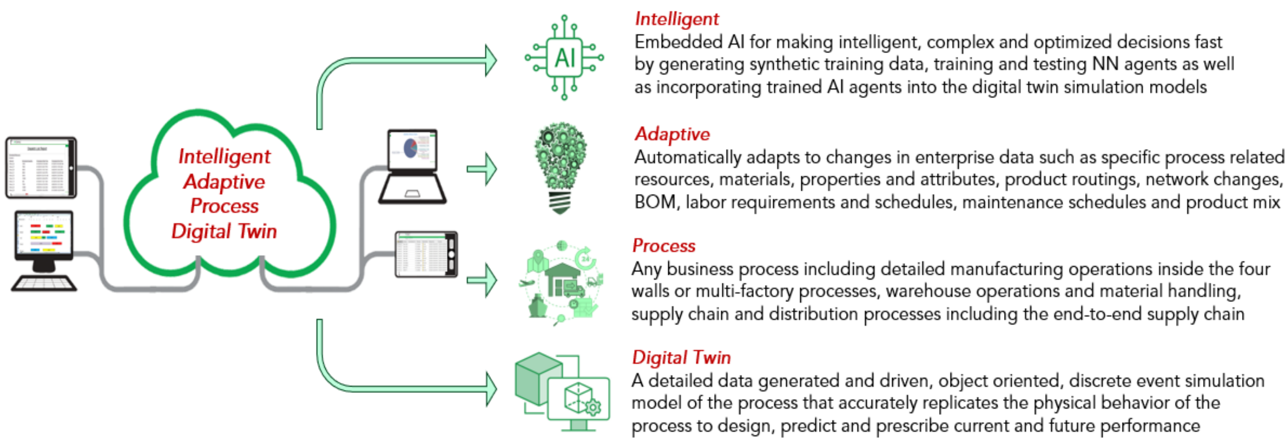

Figure 1: The Simio Intelligent Adaptive Process Digital Twin

The following figure summarizes the distinction between a Digital Shadow, a Virtual Model, and a Digital Twin. In the case of a Digital Shadow, there is no simulation model of the system, but automated data collection is in place. Analytics, such as statistical regression or AI, can be applied to identify patterns and predict events like machine breakdowns, allowing problems to be addressed before they occur. This approach only works when there are no fundamental changes to the system, as historical data is used to predict the future.

In the case of a Virtual Model, a simulation model of the system is built and can be manually fed with representative data and executed offline. This facilitates the analysis of design decisions, such as the purchase of new equipment or the introduction of a new product. Unlike the Digital Shadow, the Virtual Model is forward-looking and allows for the analysis of the impact of changes on the system. This has been the traditional use of simulation modeling over the decades.

In the case of a Digital Twin, the simulation model is extended to daily operations by directly connecting it to the real-time system status. This allows the simulation to look forward in time to visualize and mitigate operational issues in the real system, such as delayed or late orders, before they occur.

With Simio, the focus is on using a Discrete Event Simulation model as a Virtual Model for system design and extending that model to provide a Process Digital Twin. Many organizations are driving a digital transformation agenda that includes both traditional design applications using a Virtual Model and the operational use of the model in planning and scheduling. Depending on the digital maturity of the organization, users may be at different points along the digital transformation journey, as depicted in Figure 2 below.

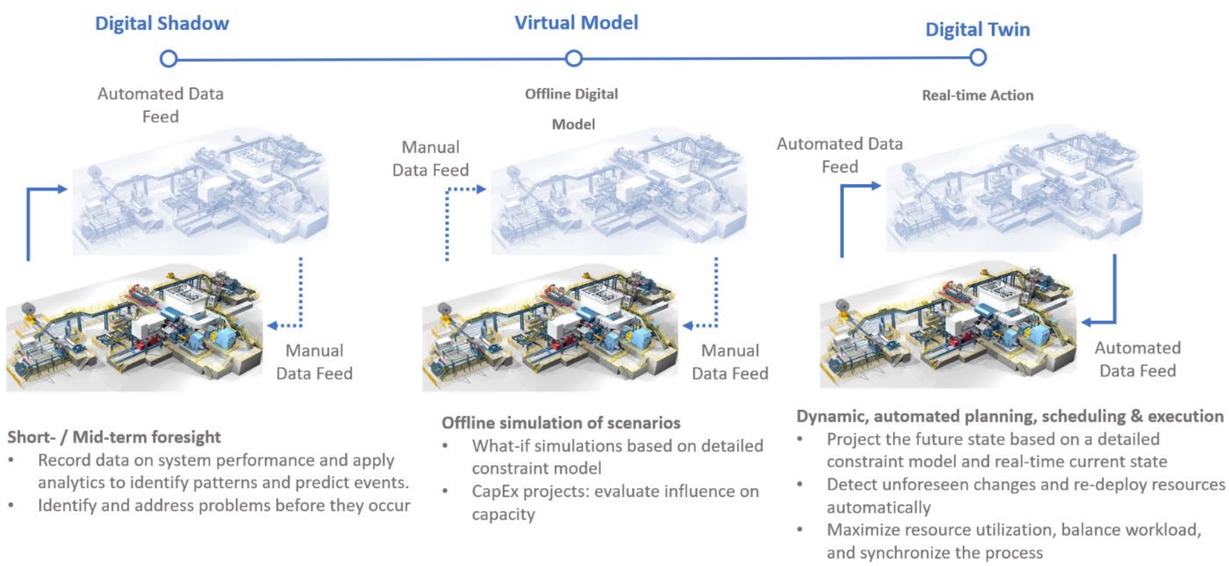

Figure 2: Digital Transformation Scenarios

Many organizations are effectively using a Virtual Model for predicting performance and optimizing system design; however, few have fully mastered the transition to an operational Digital Twin that automatically optimizes daily operations. Even if the intermediate focus is on using a Virtual Model for traditional design simulation applications, Simio provides a rich platform for building and experimenting with design models while positioning users for future expansion into a fully connected Digital Twin. The Simio platform is designed to support the full design-to-operate continuum, as shown in Figure 3 below.

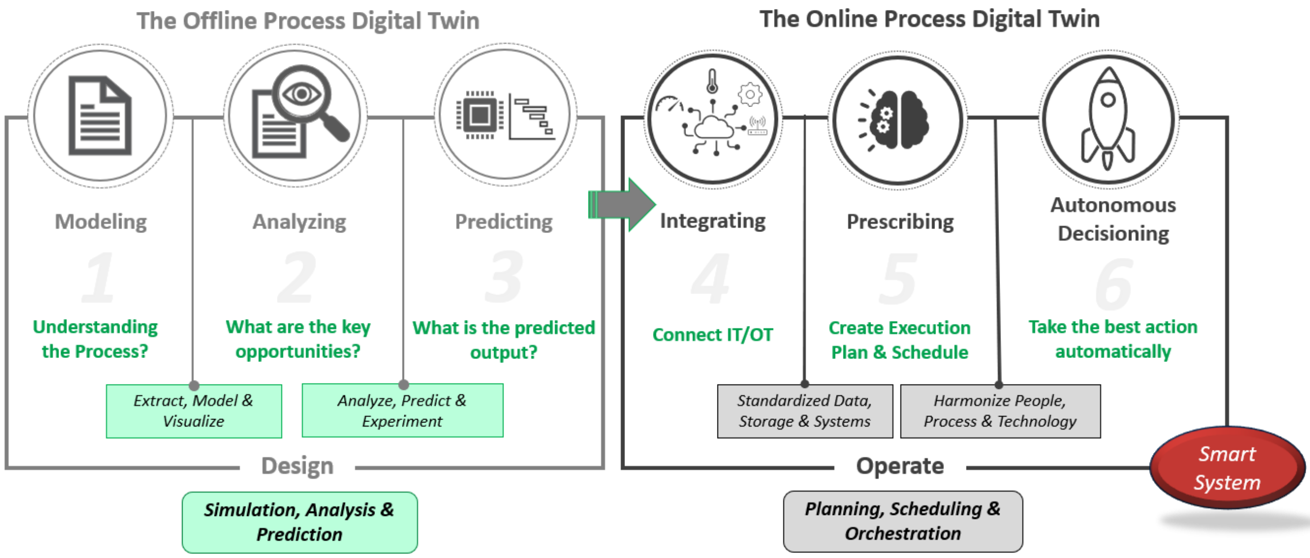

Figure 3: The Digital Continuum

2.2 Simulation

With Simio, the focus is on using a detailed Discrete Event Simulation model as a Virtual Model for system design, as well as extending that model to provide a comprehensive Intelligent Adaptive Process Digital Twin. Below are key components of Simio's simulation capabilities that enable this process.

2.2.1 Object Framework for Complex Modeling

Simio is a simulation modeling framework based on libraries of intelligent objects. A beginning modeler may prefer to use pre-built objects from Simio libraries; however, the system is designed to make it easy for even novice modelers to build their own intelligent objects for use in creating hierarchical models. Custom intelligent objects can be built by modelers and then reused in multiple modeling projects. These objects can be stored in libraries and easily shared. The flexibility and ease of building custom objects are critical for developing Digital Twin models that can be quickly adapted to complex applications and represent a key advantage of Simio over legacy simulation products. In contrast to other object-oriented simulation systems, building an object in Simio uses an intuitive graphical interface that allows the user to focus on object logic rather than on writing complex code.

A Simio object can represent a machine, robot, crane, customer, tank, fork truck, ship, part, or any other item encountered in a system. A model is built by combining objects that represent the physical components of the system. Each object is animated in 3D to reflect its changing state; for example, a forklift raises and lowers its lift, a worker walks to a location or carries items between locations, and a robot opens and closes its gripper. The animated 3D model provides a dynamic view of the system in operation. Simio's detailed 3D, GIS, and VR features (using the Oculus headset) offer powerful visualization capabilities to validate model behavior and showcase functionality.

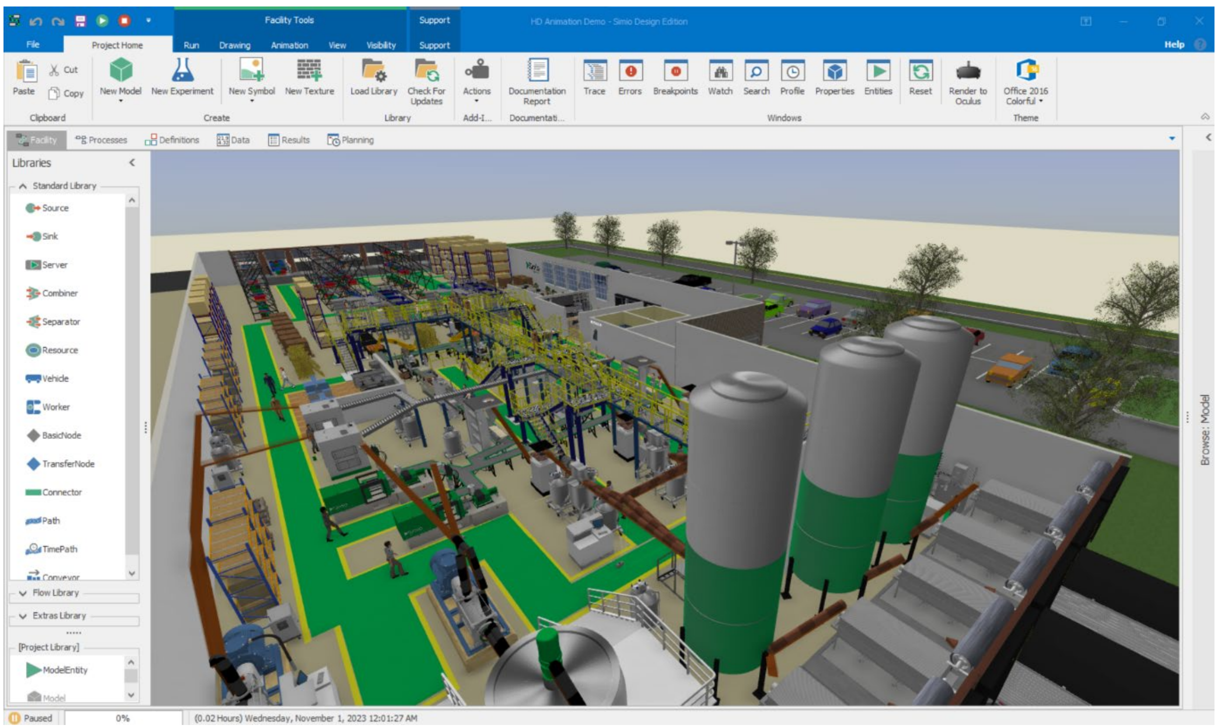

Figure 4: Simio Digital Twin Animation View

Simio's object-oriented modeling framework makes it easy to create application templates that jump-start model creation. A template is a library of custom-built objects, data schemas, and custom reports focused on a specific application area. Simio provides templates for modeling common discrete and batch manufacturing processes and warehouses, and users can expand on those objects or create their own objects and templates for use within their enterprise.

Simio's core set of modeling features for defining object behavior, combined with the graphical object-oriented design, is key to making it easy to create custom-made objects targeted at specific applications. Simio offers advanced modeling features for capturing complex resources, as well as material and business logic constraints in typical production, warehousing, and distribution systems. For example, any processing delay can be modeled directly as an action network of parallel and/or sequential tasks, each requiring its own set of materials and resources. Each task in the action network can have a sequence-dependent processing time based on multiple attributes such as color and size, and task times can be adjusted based on learning curves for the workers assigned to the task. Likewise, vehicle movements within a warehouse can use Simio's fleet management features to automatically plan travel and avoid deadlocks on bidirectional paths across the transportation network.

One important modeling capability within Simio includes features for implementing Demand Driven Material Requirements Planning (DDMRP) for inventory replenishment in manufacturing-centric supply chains, as well as Demand Driven Distribution Requirements Planning (DDDRP) for distribution-centric supply chains. Using principles established by the Demand Driven Institute to optimize production and distribution, this methodology is crucial for modeling the optimal placement of inventory both within the factory and across the supply chain. Simio has been certified by the Demand Driven Institute (DDI) for all three levels of software compliance to be used for Demand Driven Material Requirements Planning (DDMRP), Demand Driven Operating Model (DDOM) and Demand Driven Sales & Operations Planning (DDS&OP).

2.2.2 Data Centric Design

In the past, simulation models were built by dragging and dropping objects into a model and then directly populating the objects with data. For example, a simple model in Simio can be created by graphically placing a Source, Server, and Sink in the Facility view, and entering the interarrival time for the Source and the processing time for the Server. In just a few mouse clicks and keystrokes, a running model of a simple server system is built. A similar approach is used by many simulation products.

Although this approach to modeling is sufficient for simple models, Simio's data-centric framework offers a superior option for large models. For more extensive models, it is best practice to use data tables to define the objects in the model. Simio can then automatically generate the model based on the provided data description. The data tables specify the objects to be included in the model, along with their associated property values. This approach is particularly useful in applications where multiple similar facilities are being modeled, allowing each model to be defined and managed through data tables. This transforms the problem from a model-building activity to a model-configuration activity. For example, a new machine can be added to a model simply by adding a new row of data to the appropriate data table.

The term data-generated refers to models that are automatically created from a data set. The term data-driven refers to models that supply their property values to the modeling objects using a data set. A model can be data-driven but manually built using drag and drop, or it can be both data-generated and data-driven.

In many cases, the data that drives a model is relational, where a row in one table maps to multiple rows in other tables. For example, a table of sales orders might map to multiple rows defining the products that make up the sales order. Simio fully supports relational data tables with key columns and foreign key references. Data sets in Simio have a flexible schema and can be fully configured by the modeler. Users can add, delete, or edit columns, keys, and foreign key references. The columns in the table are defined with specific data types, allowing them to store both numeric and non-numeric values.

The data-generated and data-driven modeling approach is particularly effective when combined with a custom application library, which includes pre-defined data tables and objects focused on the specific application, along with data mappings to connect to the appropriate table columns that supply the relevant data for the objects. A skilled modeler can create an application-specific template that others can then use to auto-create and maintain their models via data. This is one of the reasons why Simio's graphical approach for object definitions is crucial for the successful implementation of data-generated and data-driven models.

Because the data used to generate or drive a model is typically from third-party systems such as ERP, MES, IoT, Excel, CSV, or Web Services, Simio provides direct connectors for importing and exporting data to these common sources. Additionally, Simio offers a framework for developing new data connectors. These connectors are used to pull data from various sources into Simio's in-memory relational data sets for quick access by the model. The use of Simio's in-memory relational data sets is critical for supporting fast execution and maintenance of the Digital Twin model.

2.3 Planning and Scheduling

In today's world, companies compete not only on price and quality but also on their ability to reliably deliver products on time. A good operational production schedule, therefore, directly influences a company's throughput, sales, and customer satisfaction. Although companies have invested millions in information technology for Enterprise Resource Planning (ERP) and Manufacturing Execution Systems (MES), these investments have typically fallen short in detailed production scheduling, causing most companies to rely on manual methods involving Excel and planning boards. Meanwhile, industry trends toward reduced inventory, shorter lead times, increased product customization, SKU proliferation, and flexible manufacturing are making the production scheduling task more complicated. Creating a feasible plan requires the simultaneous consideration of time, materials, labor, equipment, and demand. This bar is simply too high for any manual planning method, yet companies all over the world create schedules manually every day. They often do so in non-optimal ways, leaving significant room for improvement. The challenge of creating a reliable plan requires a digital transformation that can support automated and dependable scheduling.

Central to effective factory scheduling is the concept of an actionable schedule. An actionable schedule fully accounts for the detailed constraints and operating rules in the system and is synchronized to the event timeline, allowing it to be executed in the factory by production staff without additional human intervention. A common issue with many scheduling solutions is that they ignore one or more detailed constraints, plan in set time buckets (daily or weekly), and therefore cannot be executed as specified on the factory floor. A non-actionable schedule requires operators to step in and override the planned schedule to accommodate the actual constraints of the system. At this point, the schedule is no longer being followed, and local decisions are made that impact the system's KPIs in ways that are not visible to the operators.

A second key element of effective scheduling is properly accounting for variability and unplanned events in the factory, as well as their detrimental impact on throughput and on-time delivery. Most scheduling approaches completely ignore this critical aspect of the system, resulting in optimistic schedules that cannot be met in practice. What begins as a feasible schedule degrades over time as machines break down, workers call off sick, materials arrive late, rework is required, etc. The optimistic promises made cannot be kept.

A third consideration is the effect of an infeasible schedule on the supply chain plan. Factory scheduling is the final step in the production planning process, which begins with supply chain planning based on actual and/or forecast demand. The master planning process generates production orders and typically establishes material requirements for each planning period across the entire production network. These production orders are based on a rough-cut model of the production capacity, with the master planning process having very limited visibility into the true constraints of the factory. As a result, the production requirements often overestimate the factory's capacity. Factory schedulers must then develop a detailed plan to meet these requirements within the actual constraints of the equipment, workforce, etc. However, the factory adjustments needed to make the plan actionable are not transparent to supply chain planners, creating a disconnect in a core business planning function despite significant investments in resources and systems. Including factory digital twins in a network model can support the network or master planning process, ensuring feasibility at all levels and time horizons. The same digital twin can be used for short-, medium-, and even long-term planning, fully automated on the cloud for distribution to all stakeholders.

We will now further summarize the key advantages of the Simio Factory Digital Twin in creating a detailed factory operational scheduling solution that generates feasible schedules in terms of material, capacity, demand, and timeline.

2.3.1 Dual Use: Factory Design and Operation

Although the focus here is on enhancing throughput and on-time delivery by improving scheduling with the existing factory design, the Simio Factory Digital Twin can also be used to optimize the factory layout and design, unlike traditional scheduling tools. The same Simio model used for factory scheduling can be employed to test changes to the facility, such as adding new equipment, adjusting staffing levels, consolidating production steps, adding buffer inventory using the DDMRP replenishment methodology, or introducing new product SKUs.

2.3.2 Actionable Schedules

A basic requirement of any scheduling solution is that it provides actionable schedules that can be implemented in the real factory. If a non-actionable production schedule is sent to the factory floor, the production staff have no choice but to make adjustments and decisions based on local information. Since the foundation of the Simio Factory Digital Twin is an object-oriented modeling tool, the factory model can capture all these constraints in as much detail as necessary. This includes complex constraints such as material handling devices, sophisticated equipment, workers with varying skill sets, and intricate sequencing requirements.

The Simio modeling framework features flexible rule-based decision logic for implementing these operating rules. As the simulation model runs, these rules and constraints are evaluated at each point on the event calendar to ensure that all material and resource tasks are fully synchronized with the actual production execution timeline. The result is an actionable schedule that respects both the physical constraints of the system and the standard operating rules and execution timeline.

2.3.3 Fast Execution

In most organizations, the useful life of a schedule is short because unplanned events and variations occur, rendering the current schedule invalid. When this happens, a new schedule must be regenerated and distributed as quickly as possible to keep production running smoothly. A manual or optimization-based approach to schedule regeneration that takes hours to complete is not practical; in such cases, shop floor operators typically take over and implement their own local scheduling decisions, which may not align with system-wide KPIs. When random events occur, the Simio Factory Digital Twin can quickly respond by generating and distributing a new actionable schedule. Schedule regeneration can be triggered manually by the scheduler or automatically by events in the system, such as those initiated by MES or IoT devices.

2.3.4 3D Animated Model and Schedule

In other scheduling systems, the only graphical view of the model and schedule is the resource Gantt chart. In contrast, the Simio Factory Digital Twin provides a powerful means of communicating and visualizing both the model structure and the resulting schedule. Ideally, anyone in the organization—from the shop floor to the top floor—should be able to view and understand the model well enough to validate its structure. A good solution not only enhances the ability to generate an actionable schedule but also improves the capability to visualize and explain it across all levels of the organization.

The Simio Gantt chart has a direct link to the 3D animated view of the factory. By right-clicking on a resource along the time scale in the Gantt view, Simio instantly displays an animated view of that resource in the factory, showing the machines, workers, and work in process at that point in the schedule. From there, the scheduler can simulate forward in time and observe how the schedule will unfold in the real system. The benefits of the Simio Factory Digital Twin start with its accurate and fast generation of an actionable schedule. They culminate in the Factory Digital Twin's ability to communicate its factory structure, model logic, and resulting schedules to anyone in the business who wants to understand the trade-offs.

2.3.5 Risk Analysis

One of the key shortcomings of legacy scheduling applications is their inability to handle unplanned events and variations. In contrast, the Simio Factory Digital Twin accurately models these unplanned events and variations, providing not only a detailed schedule but also analyzing the associated risks. When generating the schedule, random events and processing variability are initially disabled to produce a deterministic schedule. Like other deterministic schedules, it is optimistic regarding on-time completions. However, once this schedule is generated, the same model is executed multiple times with events and variations enabled to produce a random sample of schedules based on system uncertainty. This set of randomly generated schedules is then used to derive risk measures, such as the likelihood that each order will ship on time. These risk measures are displayed directly on the Gantt chart and in related reports, informing the scheduler in advance of which orders are at risk of being late, so actions can be taken to ensure important orders have a high likelihood of shipping on time.

2.3.6 Constraint Analysis

It's not uncommon for the supply chain planning process, based on a rough-cut capacity model of the factory, to assign more work to a production facility than it can easily handle given the true capacity and operational constraints of the facility. When this happens, the resulting detailed schedule will show one or more late jobs and/or jobs with a high risk of being late. The key question then becomes what actions the scheduler can take to ensure that important jobs are delivered on schedule.

While other scheduling approaches generate a schedule, the Simio Factory Digital Twin goes a step further by providing a constraint analysis that details all non-value-added (NVA) time spent by each job in the system. This includes time spent waiting for a machine, an operator, material, a material handling device, or any other constraint impeding the production of the item. Thus, if the schedule indicates that an item is going to be late, the constraint analysis identifies potential actions to reduce the NVA time and help ship the product on time. For example, if an item spends significant time waiting for a setup operation, scheduling overtime for the associated operator or additional campaigning of products to reduce setup times may be warranted.

2.3.7 Multi-Industry

Although scheduling within the four walls of a discrete production facility is an important application area, there are many scheduling applications beyond discrete manufacturing. Many manufacturing applications involve fluid flows with storage/mixing tanks, batch processing, as well as discrete part production. In contrast to other scheduling tools limited to discrete manufacturing, the Simio Factory Digital Twin has been applied across various areas, including mixed-mode manufacturing, master planning, and capacity planning. These applications are made possible by the flexible Simio modeling framework.

2.3.8 Flexible Integration

A Factory Digital Twin is a detailed simulation model directly connected to real-time system data. Traditional simulation modeling tools have limited ability to connect to real-time data from ERP, MES, and other sources. In contrast, Simio is designed from the ground up with data integration as a primary requirement. Simio supports a Digital Twin implementation by providing a flexible relational in-memory data set that can map directly to both model components and external data sources. This approach allows for direct integration with a wide range of data sources while enabling fast execution of the Simio Factory Digital Twin model.

2.3.9 Data Generated Models

In global applications, there are typically multiple production facilities located around the world that produce the same products. Although each factory has its own unique layout, there is often a significant overlap in resources such as equipment and workers, as well as processing logic. In this case, Simio provides special features to automatically generate the Digital Twin for each facility from data tables that map to modeling components describing the resources and processes. This greatly simplifies the development and maintenance of multiple Factory Digital Twin implementations across the enterprise and supports reconfiguring each Factory Digital Twin via data table edits to accommodate ongoing changes.

2.4 AI/DNN Training, Testing and Implementation

Simio is the first and only Discrete Event Simulation software to provide comprehensive and embedded AI features, including full support for creating and auto-training regression neural networks within a model without requiring Python/Java programming or integration with external third-party AI tools. Simio enables the definition of one or more neural network models, which can then be referenced for inference within a Simio model through a neural network element. Some of the key AI features will be described in more detail below.

2.4.1 Synthetic Training Data for Neural Networks

One of the major challenges of AI is having the required labeled training data, and many AI applications fail due to the unavailability of this data. Labeled training data is often unavailable when evaluating a new system, and for existing facilities, recorded data becomes invalid when a new part or change in flow is introduced. This is why Simio's built-in auto-labeler for creating synthetic training data is critical to the success of an AI-based modeling application.

2.4.2 Embedding Third Party Machine Learning Algorithms

Simio's built-in AI features support defining, training, and using the classic feed-forward regression neural network. However, users are not limited to this machine learning algorithm. Any machine learning regression model from over 50 third parties, including Google and Microsoft, that support the ONNX model exchange format can be imported and used within Simio. Users can build and train models in third-party tools and then import them into Simio for complex decision-making within a model. Exporting to the ONNX file format is also supported. Additionally, Simio models can generate synthetic labeled training data for export to be used by third-party tools.

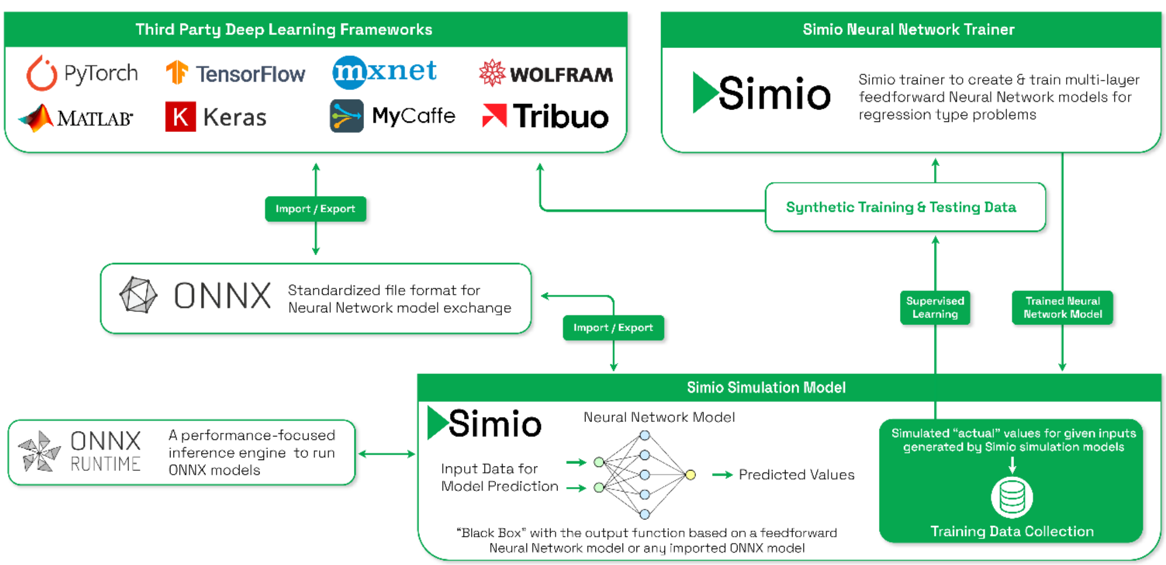

Figure 5: Using Third Party ONNX Models

2.4.3 Defining, Training, and Using Neural Networks in Simio

This Simio neural network framework employs a Neural Network Model and an associated Neural Network Element. A Neural Network Model represents a trained neural network regression model for inference. It can be a feedforward model created and trained directly in

Simio (no code or third-party framework required) or an imported ONNX model. The Neural Network Model definition is integrated into simulation logic using a Neural Network Element. This element defines the neural network model's inputs and "actual" output, along with simulation event-based triggers for recording the input and output values. It also provides a Predicted Value function that can be used in any simulation expression for inference purposes. The relationship between a Neural Network Model and a Neural Network Element is a one-to-many relationship, allowing a single Neural Network Model to apply to multiple use cases in the simulation. The relationship between the Neural Network Model and associated Neural Network Elements is illustrated in Figure 6 below.

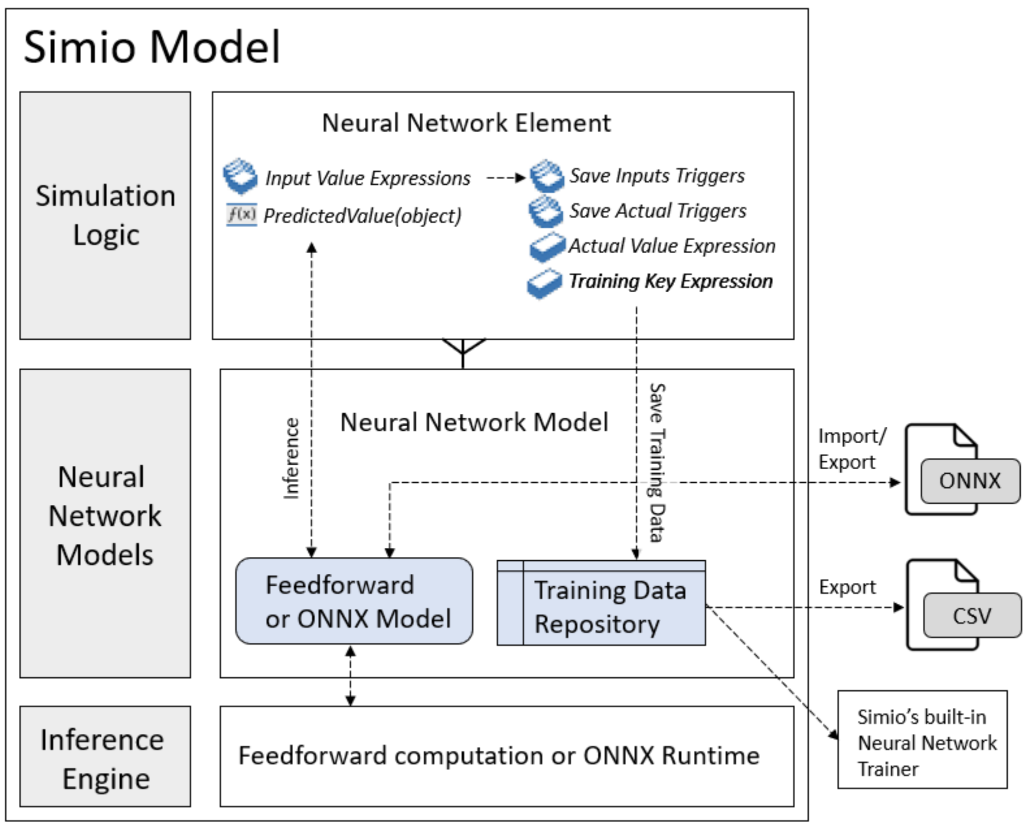

Figure 6: Neural Network Model and Elements

2.5 Optimization

Digital Twins are used to optimize both the design and operation of complex adaptive systems. For optimizing system design, a Digital Twin can be used to select the best option among competing designs, rank those designs from best to worst, or optimize parameter settings to maximize the design's system performance. Design optimization can be accomplished using Simio's built-in design optimization tools. Once the system design is finalized and design parameters are optimized, the Digital Twin can be used to make state-based intelligent decisions to optimize the daily operation of the system. In design optimization, the system is configured for operations by selecting equipment, processes, operating rules, staffing levels, and so on. In operations optimization, the specific tasks to be performed, resources to be used, and materials to be relocated are selected.

During the design phase, it is important that the Digital Twin captures variability within the system, such as variable processing times or random breakdowns. Variability has a significant impact on system performance and ignoring it will result in overly optimistic outcomes. Therefore, all experimentation and optimization during the design phase must include system variability. These unplanned events and variability are automatically disabled during planning and scheduling runs.

In Simio, we use the term "simulation run" to denote a run of the model with variability enabled. During design optimization, replications of a simulation run are conducted to capture the impact of variability on system performance. The term "plan run" is used to denote a single run with variability and unplanned events disabled. Since variability is disabled, there is no need to replicate plan runs when generating schedules. However, in operations optimization, we use simulation runs and replications to analyze the risk associated with the schedule due to random variation and unplanned events.

2.5.1 Optimizing System Operation

One of the key advantages of a Process Digital Twin is that the same model used to optimize the design can also optimize the daily operations of the system by creating intelligent, deterministic plans to be executed in the real system. Simio employs a state-based optimization approach to dynamically create an optimized plan that fully respects the resource, material, and logical constraints of the system as they evolve over time and are captured by the Digital Twin. Since the Digital Twin captures these true constraints of the system, the optimized plan is fully actionable in the real system. Each decision in the system is optimized based on the current state. In contrast, legacy systems do not capture detailed constraints and use a rough-cut measurement of capacity within fixed time buckets, such as weekly. They then employ a heuristic solver to search for a feasible solution to this simplified representation of the system. Although legacy systems present their solution as optimal, their rough-cut approximation of both capacity and time yields results that are not actionable in the real system and are misaligned with the actual production schedule. In contrast, Simio's state-based optimization approach captures all critical constraints along a true time horizon and produces a plan that is fully actionable without human intervention.

The key to the plan produced by the state-based optimization approach is the quality of the decision logic embedded in the Simio Digital Twin to determine decisions such as which job to work on next and which resources to assign to each job. In typical factories, these decisions are often made using dispatching rules like shortest processing time, earliest due date, smallest changeover, or Critical Ratio. Many finite-capacity scheduling tools use various dispatching rules to create a detailed schedule for the factory. While these dispatching rules can generate effective schedules, a more advanced strategy involves utilizing Simio's neural network capabilities to leverage the detailed state model of the Digital Twin. These features allow for training and supplying inputs to the neural networks, enhancing intelligent decision-making. With Simio, standard dispatching rules and complex model decision logic can be replaced with self-trained neural networks. The neural networks provide complex decision logic in the model, and in return, the model generates the synthetic data required to train the neural networks. This simplifies the model's decision logic, making models easier to build, understand, debug, and maintain. Simio also provides integrated training algorithms for training neural networks using synthetic data generated by the model. Hence, Simio provides a complete solution for embedding neural networks in Process Digital Twin models.

Simio's AI features are particularly useful in production planning Digital Twin applications, where the neural network can be trained to predict critical KPIs, such as the dynamically changing production lead time for a factory or production line within a factory. The neural network learns the impact of changeovers, secondary resources, business rules, and other production complexities that affect KPI predictions. The intelligent Digital Twin captures complex relationships that would otherwise be impossible to include in a model. The neural network KPI predictions can then be used to optimize decisions both within the factory and across the supply chain. Within the supply chain, the neural network can assist in critical supplier sourcing decisions by predicting the production lead time for each candidate supplier and selecting the lowest-cost producer that can complete the order on time. AI-based factory sourcing within the supply chain Digital Twin eliminates the need for Master Production Scheduling software.

2.6 Data Management and Integration

In contrast to traditional simulation modeling tools, Simio is designed from the ground up to function as a Process Digital Twin with a focus on data integration with existing ERP, APS, MES, IoT, and other data sources. This requirement has driven the design of both the data and modeling features of Simio. Simio connects to both the master data—such as bill of materials, routings, work centers, staffing levels—and the transactional data, including work orders, work-in-process, resource status, and inventory of raw and finished goods materials. The relationship of the Simio Factory Digital Twin to the enterprise systems is illustrated in an example in Figure 7 below.

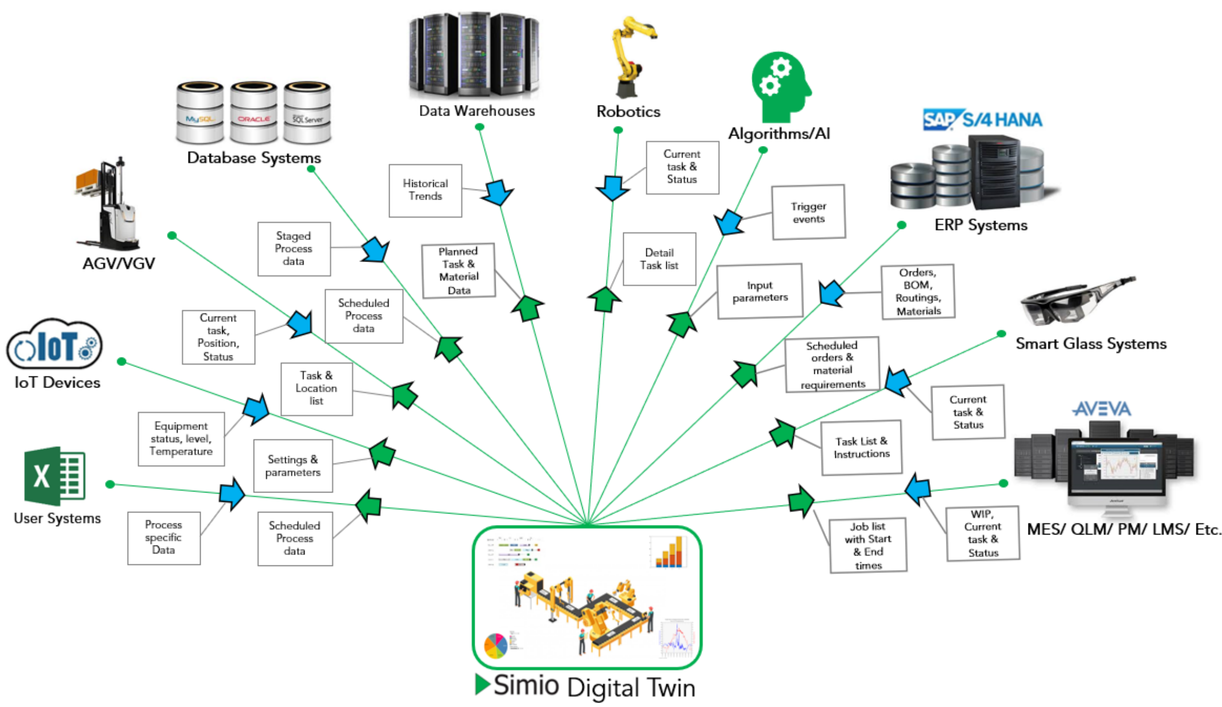

Figure 7: Simio as Factory Digital Twin connected to the Enterprise Systems

Although the transactional data for a Factory Digital Twin may come from various sources, most of the critical data comes from ERP, APS, and MES systems. These systems provide the primary data sources for managing production. They offer a master list of production orders—such as release dates, due dates, and order quantities—along with component products and end products required to meet customer demand. This list also includes secondary data such as job routings and bills of materials. Additionally, it provides a material purchasing schedule listing items required from outside suppliers, including their expected arrival times, with the goal of aligning these materials with the production schedule.

In some cases, transactional data may reside outside ERP, APS, and MES systems, such as in spreadsheets, databases, flat files, or other forms. Simio is designed to import transactional data from these varied sources.

Simio provides three key features for integrating the scheduling model with transactional and operational data. The first is an in-memory relational database that is fully configurable to match the schema of any external data source. The second is an open architecture for configuring data connectors to import transactional or operational data from external sources. The third is a set of modeling constructs that are fully configurable to map to in-memory relational data in the data tables.

These features combine to provide a modeling framework that can map to any external data, regardless of the source or data schema. Simio's in-memory configurable relational database serves as the key interface between the enterprise data and the model logic. The transactional and operational data is imported into this database and held in memory for fast execution of the digital twin model. The model logic can both read from and write to this in-memory database.

The database schema is fully configurable and can precisely match the existing schema of the external data sources, often eliminating the need to transform the data during import/export. Import/export actions are managed through Simio Data Connectors. Standard data connectors are provided for most popular databases, Excel, CSV files, and Web APIs.

Simio provides interoperability between systems as summarized in Figure 8 below.

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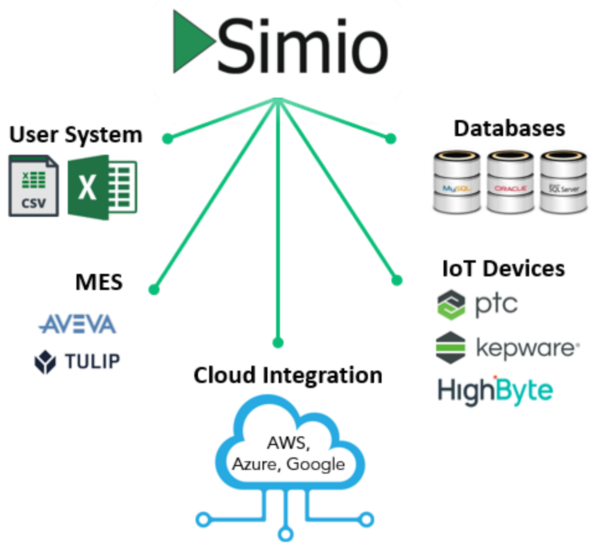

Figure 8: Simio Integration Capabilities and Data Connectors

The transactional data for the Digital Twin model is typically imported or downloaded from the ERP at the beginning of each planning period and remains static during that period. In contrast, MES operational data is constantly changing, so the MES data connector is often a dynamic connector. For example, a machine failure detected by the MES may automatically trigger Simio to generate a new schedule based on the expected downtime for the machine. The Simio integration framework supports both static and dynamic data connectors for transactional and operational data, as well as both indirect ("Push") and direct ("Pull") approaches to integration.

3. Business Value of the Simio Process Digital Twin Platform

The Simio platform provides value to all stakeholders throughout most phases of the digital transformation process, including the final operational deployment. It addresses questions in both the design and investment phases of the transformation and business reengineering process, as well as for the operational day-to-day management of ongoing processes.

The value proposition will vary for each customer depending on the project phase, current initiatives under review, or operations under management. Below, Figure 9 illustrates a graphical view of typical use cases and potential business benefits for key stakeholders and teams in manufacturing, warehouse, and supply chain organizations.

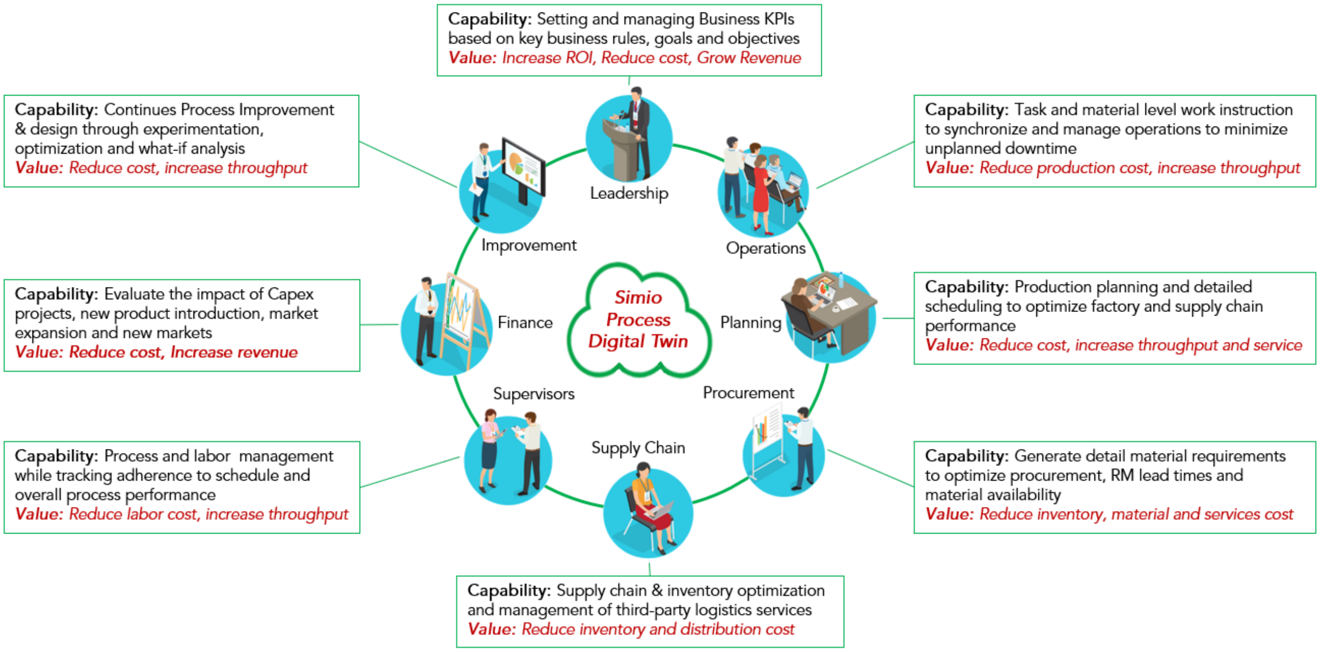

Figure 9: Typical Value to Stakeholders

4. Enterprise Deployment

During the design and analysis phase, when developing the virtual process model, it is often preferred to run Simio on a laptop or desktop. This supports offline work by project team members, as models are stored as XML files that are easy to transfer between computers. This desktop option is also practical for operational deployment of the scheduling system, provided the desktop or laptop has access to the customer's network to retrieve the operational data required to run the model and generate the schedule. This option is often preferred during the early deployment and testing phase of the solution while ongoing enhancements and model changes are needed to fine-tune the schedule before final enterprise deployment on a cloud-based platform.

Simio's cloud platform, Simio Portal, supports both public and private cloud hosting. A private cloud version can be hosted on-premises to comply with the most stringent corporate IT deployment and operating policies for production systems. Regardless of the hosting strategy, the Simio Portal cloud platform can be used for publishing results to all relevant stakeholders, running experiments to evaluate operational strategies by changing data sets and parameters, performing detailed planning and scheduling—both manual and fully automated—and providing access to third-party service providers to fully synchronize execution and maximize end-to-end supply chain performance. These use cases are depicted in Figure 10 below.

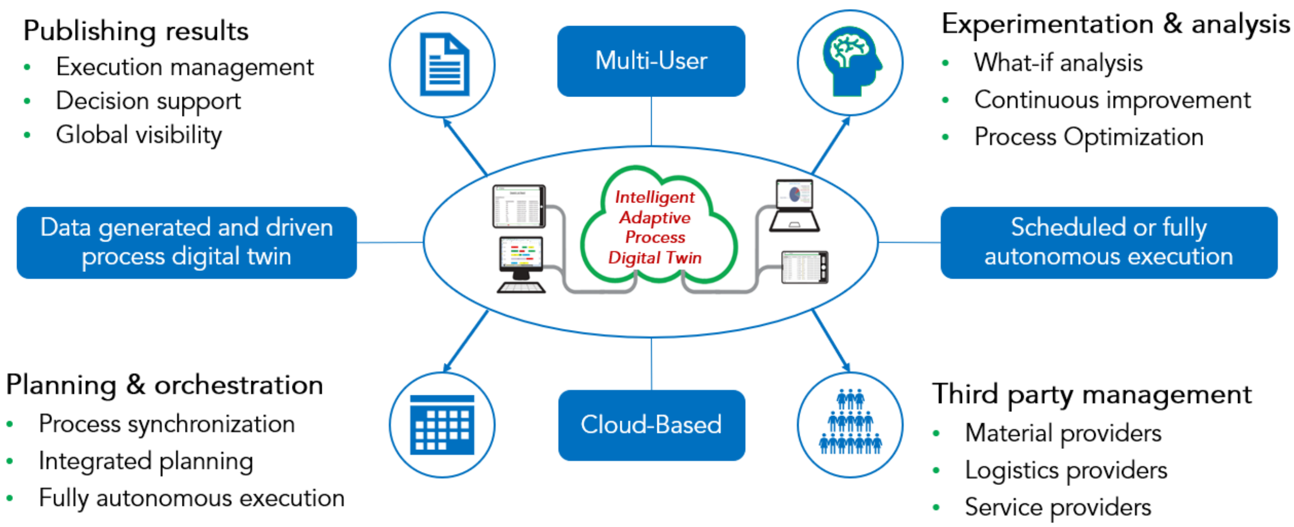

Figure 10: Simio Cloud Deployment

5. Summary

The Simio platform provides a simulation modeling framework based on intelligent objects to optimize both the design and operation of complex systems. Key features supporting the design-to-operate continuum include Simio's code-free object-oriented modeling architecture, a data-centric framework for both data-driven and data-generated models, simulation and scheduling experimentation and reporting features, neural networks for optimizing decisions, and enterprise deployment options for experimentation and scheduling on private and public clouds. Simio offers a comprehensive simulation-based solution platform to develop Intelligent Adaptive Process Digital Twins for both predictive and prescriptive applications, supporting all phases of a complete end-to-end digital and business transformation journey.