Emerson Digital Twin: A Key Technology for Digital Transformation

Introduction

As decision-makers in the process industry embrace Digital Transformation to improve visibility over their businesses, to increase their asset reliability and to optimize their operations, it is imperative to consider a Digital Twin as the first step of this transformation. The Emerson Digital Twin is a key technology of our Plantweb Digital Ecosystem which leads to top quartile operation performance for our customers.

A Digital Twin must be a practical investment for any operations manager to make, regardless of the size of the plant or the industry. It must allow plant operations to reduce the cost and risk of improving the operation and control of the plant and support upskilling of the work force. It must be proven to provide value to the execution of capital projects and control system modernization as well as the lifecycle operation performance of the plant.

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Defining the Digital Twin

The Digital Twin is a representation of the physical plant assets (i.e. process equipment, instrumentation and controls) and the processes that take place within them (i.e. chemical reactions, separation processes, heat transfer). The Emerson Digital Twin does that with some unique features that support the value and use for plant operations.

1. **Automation System Vendor Independence** - The automation platform, DeltaV or other, is represented with an exact, complete replica of the control system configuration without changes. This direct connect approach, using DeltaV Simulate and other control system simulators, provides the customers with an exact replica of the control system, functionality, and interfaces.

2. **Selective Fidelity** - A selective approach to model fidelity means that everything is simulated in a best cost basis supporting the goals of the project and the process. Selective fidelity also supports fast, flexible deployment of solutions to meet tight project schedules.

3. **Open Architecture** - The interaction between control data, historical data, and design data is integrated in an easy-to-use structure that can evolve and change with the needs of the operation, delivering a low total cost of ownership. Custom thermodynamics and custom unit operations are integrated into the solution using a high performance DLL integration library. Connectivity with other automation systems or simulator technologies is possible through OPC UA and OPC DA protocols.

4. **Cloud Ready** - The Emerson Digital Twin is built on a 64-bit architecture, multi-threaded architecture built for virtual environments (VMWare, Hyper-V or Citrix) or Emerson Cloud Hosted Solutions. Multi-user support makes it an ideal solution for distributed teams, learning management systems and automation program deployments.

Emerson's Digital Twin supports the needs of control system engineering, allowing distributed teams access to system experts, regardless of location. It supports the proven value of using dynamic simulation for designing, implementing, and testing automation solutions.

It enables virtual training of process operators and supports the continual need for process optimization and experimentation without risk to the process or the operations of the plant.

The Emerson Digital Twin solution is designed for the broad range of industries and operations that we serve. Delivering business results across the process industry from chemical, food & beverage, life sciences, pulp and paper to mining, upstream oil & gas, refining and petrochemical, a flexible and complete Digital Twin solution covers this wide range of industry needs.

Building the Digital Twin

The Digital Twin is built on proven technology, providing a digital representation of the automation system, IO systems, and process.
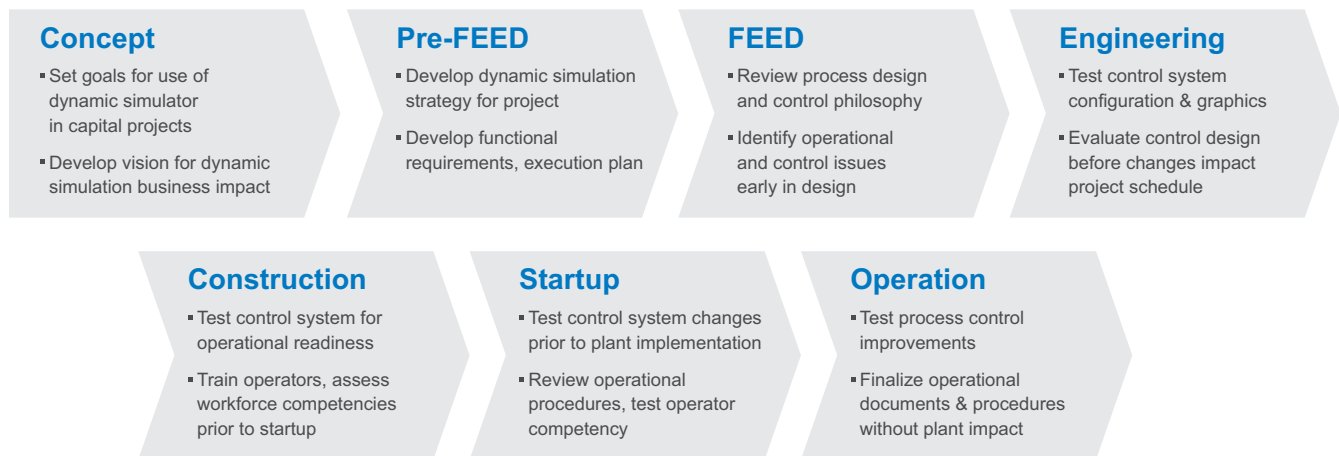
■ The automation system is represented by the control system simulator. The Emerson plant can use DeltaV Simulate to provide a direct replica of the control strategies, operator displays, and alarms. Simulators for other Distributed Control Systems, Programable Logic Controllers, and Safety Instrumented Systems are included to provide the direct representation of the other automation platforms in the plant.

■ Mimic Simulation Software provides IO and process modeling and a real-time execution and integration solution for these automation platforms. Mimic's process and IO modeling library supports low to high fidelity process modeling and accurate device simulation, customizable with specific process equipment data and operating conditions.

■ Users of Aspen HYSYS can integrate HYSYS Dynamics process models, using the Mimic HYSYS Link, a joint product development between Emerson and AspenTech creating a seamless integration between these platforms.

■ Mimic Operator Training Manager supports effective operator training by adding training scenarios and instructor station controls.

■ Mimic Test Bench supports the automation and documentation of control system testing, factory acceptance tests, and regression testing.

■ A VR immersive simulator provides a 3D plant environment integrated to the dynamic process model for training field operations on remote or dangerous plant operations.

■ The solution is hosted in a virtualized software architecture environment either within the user's server structure (on premise) or in Emerson's cloud hosting environment.
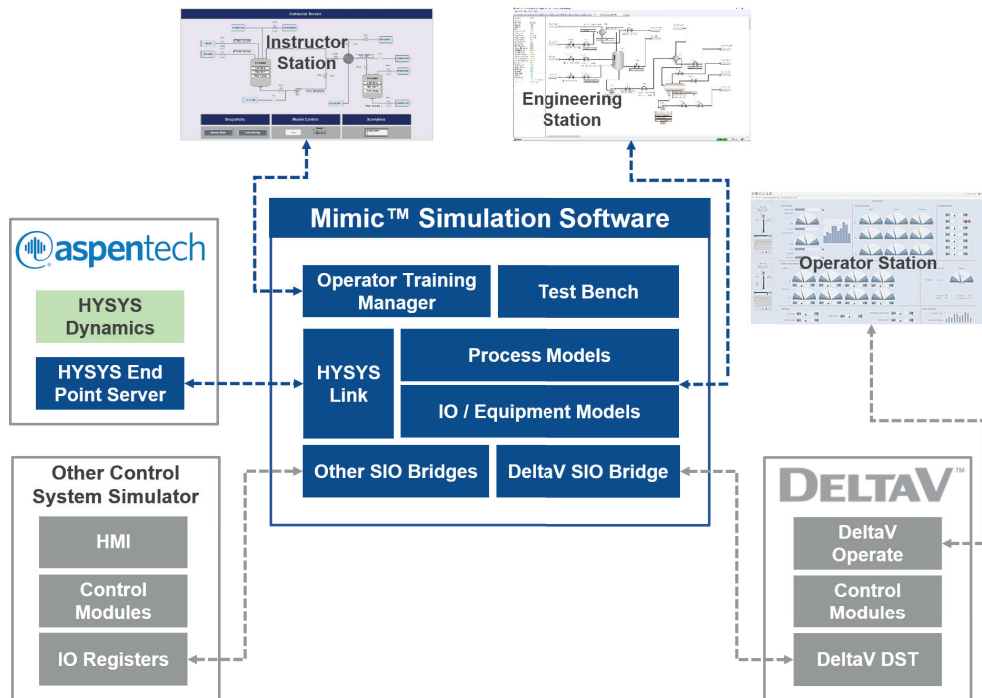
Digital Twin for the Lifecycle of the Plant

The Emerson Digital Twin functions as a Lifecycle Dynamic Simulator or Multi-Purpose Dynamic Simulator. In the best practice approach, it is applied to both Capital Project Execution (CapEx) and Operational Excellence Initiatives (OpEx).
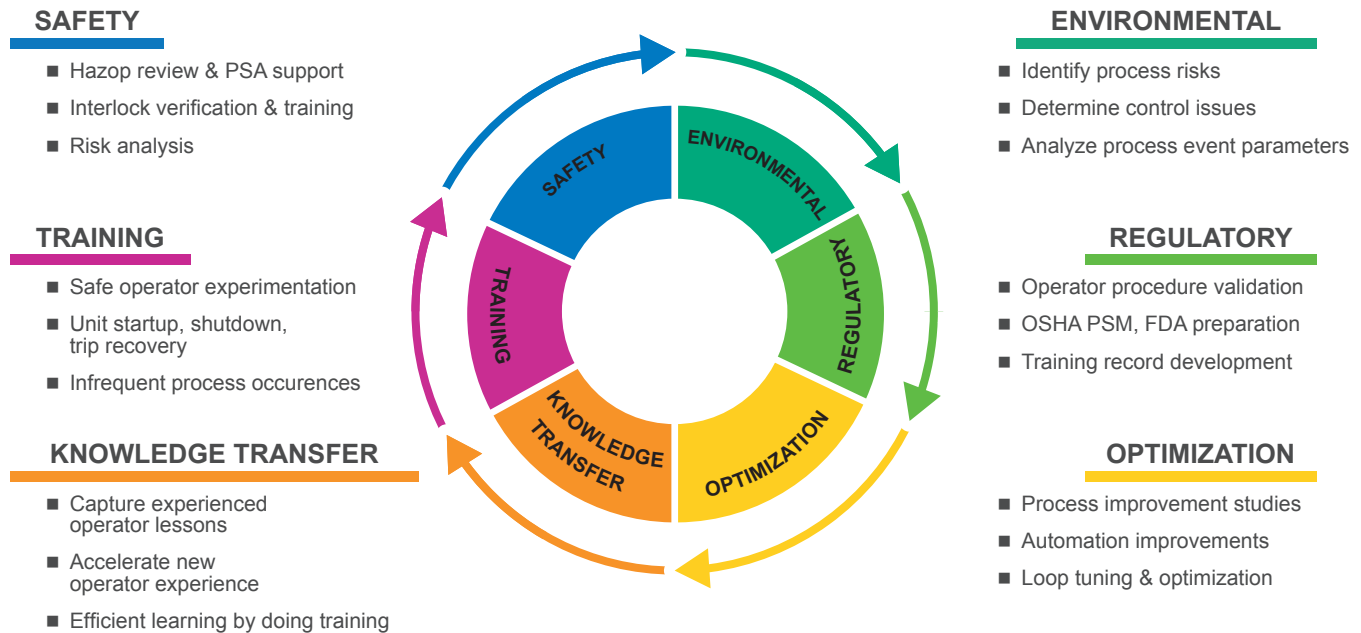
Applying the Digital Twin to Capital Project Execution (CapEx)

Concept
- Set goals for use of dynamic simulator in capital projects
- Develop vision for dynamic simulation business impact

Pre-FEED
- Develop dynamic simulation strategy for project
- Develop functional requirements, execution plan

FEED
- Review process design and control philosophy
- Identify operational and control issues early in design

Engineering
- Test control system configuration & graphics
- Evaluate control design before changes impact project schedule

Construction
- Test control system for operational readiness
- Train operators, assess workforce competencies prior to startup

Startup
- Test control system changes prior to plant implementation
- Review operational procedures, test operator competency

Operation
- Test process control improvements
- Finalize operational documents & procedures without plant impact

The Emerson Digital Twin is a valuable tool for both new process investments and process control modernization. Following best practices, the dynamic process model is developed early in the project and refined and tuned through project execution, into process unit and automation system commissioning. Using this same model for process and control system engineering, control system validation, operator training, and operations support provides the best results and reduces the cost of development and maintenance of the simulator.

- **Pre-FEED** - the strategy for the Digital Twin is defined and the functional requirements are developed.

- **FEED** - the dynamic simulation is used to review process design and control philosophy and to identify control and operational issues early in plant design.

- **Automation System Design / Implement / Test** - during control system engineering, the dynamic simulation is integrated to the control system simulator. This begins the use of the integrated Digital Twin. The Digital Twin is used to test control system configuration and graphics. Control design can be evaluated early in the project when rework and changes will have the least project impact.

- **Factory Acceptance Testing** - including system integrity and operational tests are done with the Digital Twin. Operating procedures are tested and refined. Problems and issues that could delay unit startup or disrupt production are caught before they impact the project. Loops are initially tuned to support smooth startups.

- **Operator Training** – begins early, at the completion or concurrent with FAT. Operators begin developing competency well before the startup of the plant or the commissioning of the process automation system using the Digital Twin. Structured training and open exploration of process dynamics and control system performance are both valuable in preparing the operator for actual plant operations.

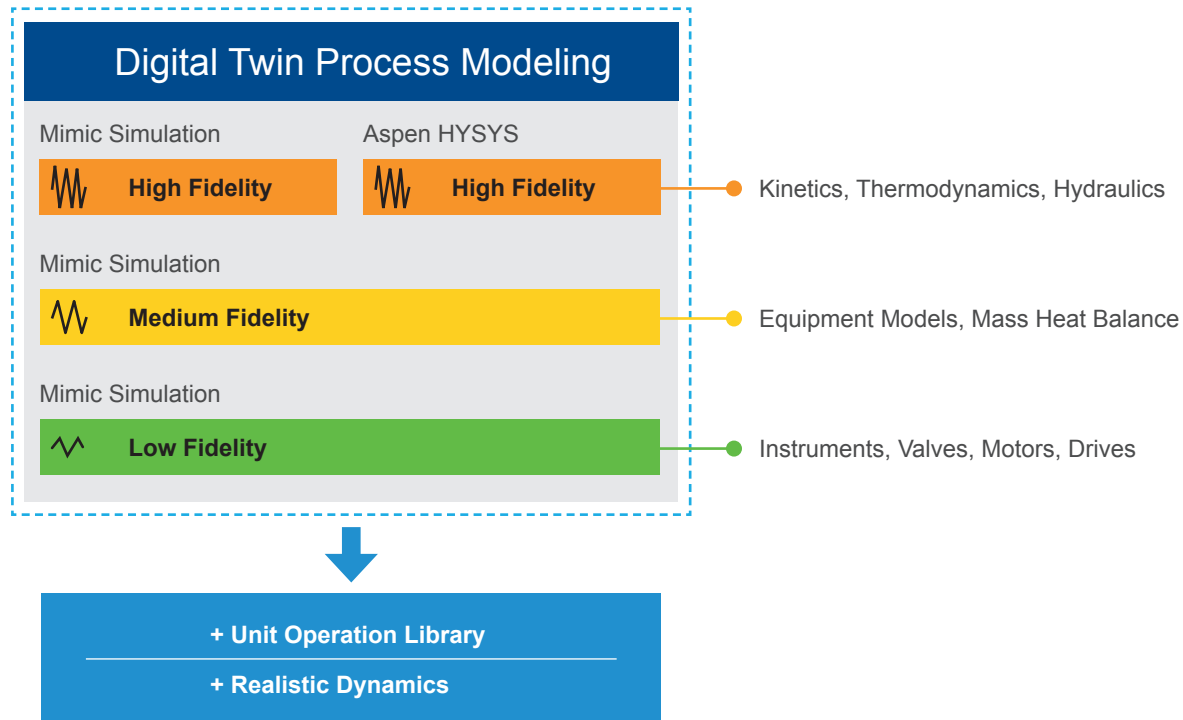## Applying the Digital Twin to Operational Excellence Initiatives (OpEx)

SAFETY

- Hazop review & PSA support
- Interlock verification & training
- Risk analysis

TRAINING

- Safe operator experimentation
- Unit startup, shutdown, trip recovery
- Infrequent process occurences

KNOWLEDGE TRANSFER

- Capture experienced operator lessons
- Accelerate new operator experience
- Efficient learning by doing training

ENVIRONMENTAL

- Identify process risks
- Determine control issues
- Analyze process event parameters

REGULATORY

- Operator procedure validation
- OSHA PSM, FDA preparation
- Training record development

OPTIMIZATION

- Process improvement studies
- Automation improvements
- Loop tuning & optimization

The investment in the Digital Twin provides excellent returns for the lifecycle operation of the process plant. The investment can be easily justified based upon the following OpEx benefits. In addition, by using the same simulation technology and dynamic model applied to the CapEx initiative, a cost-effective, integrated, consistent approach can be realized.

- **Process Control Improvements** are developed, tested, and demonstrated to operations management without affecting the operation or production of the actual plant. The control system configuration developed in the Digital Twin is exported directly to the process automation system minimizing operational risk.

- **Training New Operators** on process operations, startup and shutdown procedures, and hazardous or infrequent process occurrences, is accomplished without affecting the running process.

- **Evaluating New and Experienced Plant Operations** is done on pre-developed training scenarios. Plant operations competency requirements are established and reinforced with repeatable, measurable, documented training sessions.

- **Process Optimization Studies** are done on the Digital Twin providing the process engineers with a tool that accurately models the process dynamics not seen in steady-state design models. Process changes with control improvements are thoroughly tested before construction begins, reducing rework and startup times.

- **Process Safety Design** is tested on the Digital Twin without impacting the process. Levels of Protection (LOP) in the BPCS, SIS, and Operating procedures are verified before implementation. Capital investment decisions are validated and optimized using the Digital Twin.

- **Process and Regulatory Documentation** is developed and tested on the Digital Twin without impacting the operation of the process.

Dynamic Models for the Application

Through the course of a project or the lifecycle of a plant, different complexity or fidelity of process models support different uses. Accurate models of motors, drives, valves, and instruments are essential for interlock verification and testing regulatory controls. Mass and heat balance models are required for validating sequences and phases of a batch. Reaction kinetics, advanced thermodynamics, plant piping and hydraulics models are necessary to develop in-depth operator knowledge and make significant operational improvements.

Digital Twin Process Modeling

Mimic Simulation	Aspen HYSYS	
High Fidelity	**High Fidelity**	Kinetics, Thermodynamics, Hydraulics

Mimic Simulation	
Medium Fidelity	Equipment Models, Mass Heat Balance

Mimic Simulation	
Low Fidelity	Instruments, Valves, Motors, Drives

+ Unit Operation Library

+ Realistic Dynamics

The Emerson Digital Twin uses Mimic and HYSYS models to provide the right models with the real-time, dynamic performance required to support our users drive to top quartile operational performance.

Selecting Model Fidelity

A rigid approach to high fidelity modelling only will leave out some equipment and operations due to the investment required and the lack of accurate device models. The Emerson Digital Twin uses a selective approach to model fidelity, low, medium and high, providing a more complete picture of the operation of the plant. This selective modeling approach supports more uses cases for the Digital Twin.

HIGH FIDELITY MODEL	SELECTIVE FIDELITY MODEL
A high fidelity only model **leaves out many operations** due to the investment needed to develop the model.	Selecting the fidelity based on simulation needs provides an economical path to a **more complete picture** of the operation.
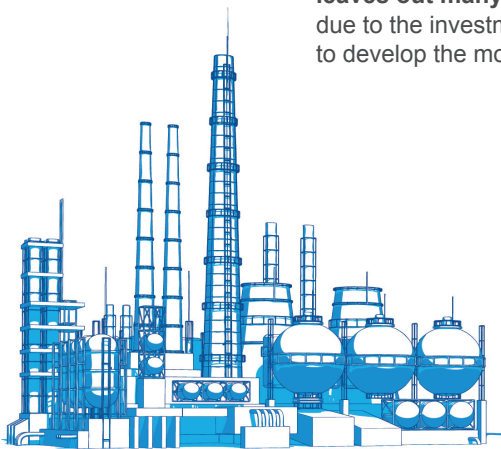
By simulating all unit operations and equipment the operator develops a more complete, accurate "mental model" of the plant, understanding the cause and effect of actions and the complex interactions of the automation platform with the process.

Plant Design to Plant Operations

The integration of Aspen HYSYS, into the Digital Twin with the Mimic HYSYS Link, allows our customers to leverage the investment in initial model build for design purposes and carry that process design and intellectual property data forward through the continuous improvement of their operation. This way, for example, in a new capital project development, the same baseline can be used by different engineering groups (i.e. HAZOP, process, controls), more data can be added into the models as it becomes available (i.e. preliminary, FEED, detailed engineering, as constructed), and an audit trail remains for each phase of the project.

REAL-TIME MODEL

+ Mimic Dynamic Modeling
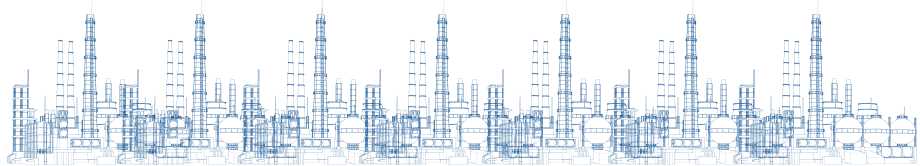
Continuous Update

DYNAMIC MODEL

+ Aspen HYSYS Dynamics

Periodic Update

Steady State Model
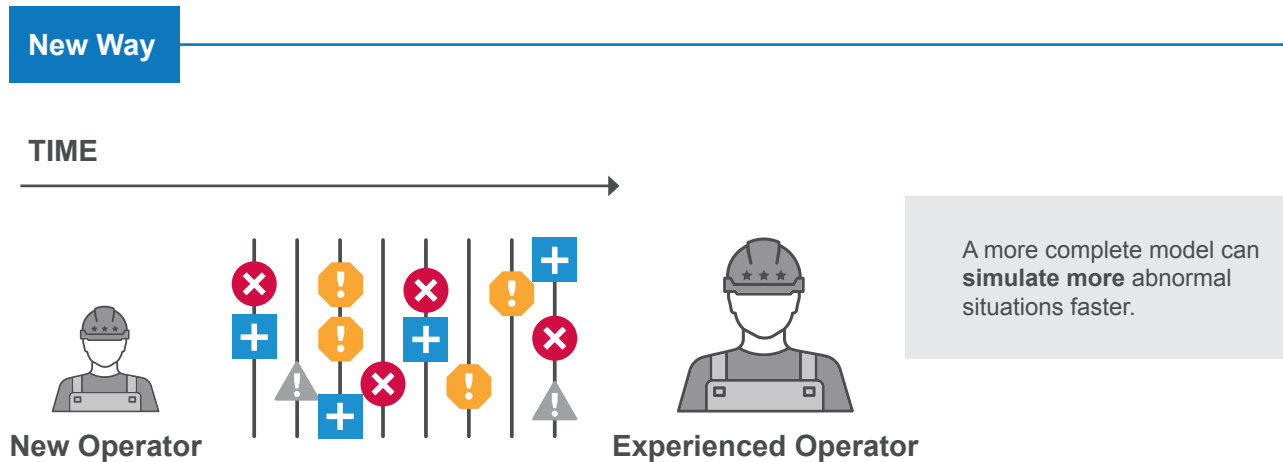
Aspen HYSYS®

Start Here

Built at Construction

Steady-state, design models built with Aspen HYSYS can be converted into dynamic process models in HYSYS Dynamics, and then integrated with the real-time, dynamic simulation capabilities of Mimic.

Nothing is lost, and this integrated Digital Twin approach helps our customers improve decision making and data integrity during all steps of the project and the lifecycle of the plant.

Reducing Time to Operator Competency

Both new, greenfield investments and old assets optimizing and modernizing, have the need to improve operational performance. According to the 2010 SBC Oil and Gas HR Benchmark, it takes six to seven years to prepare a chemical plant operator to make good decisions. With the average tenure of five years or less, plant operators in the process industries, move on to other roles before they are competent in their current position. The industry needs a way to accelerate operator competency.

TIME

New Operator   **Experienced Operator**

New Way

TIME

A more complete model can **simulate more** abnormal situations faster.

New Operator   **Experienced Operator**

Using the Emerson Digital Twin, years of plant experiences can be compressed into months, by allowing the operator to experience process events, startups, and abnormal situations rarely seen in the plant.

Supporting Highly Automated Plants

Because the Digital Twin combines the dynamic and real-time simulation capability of Mimic, it is built for accurate representation of plant transitions and transient operations.

This is very important because that is where our customer plants are most dangerous and least profitable. The process industries are moving to highly automated plants, using procedure automation and advanced control to ensure safer and more profitable operations. The Digital Twin is an essential tool to support the Design / Implement / Test of these new automation strategies.

**Without a complete picture of the operation,
a plant is brought back online with manual process.**
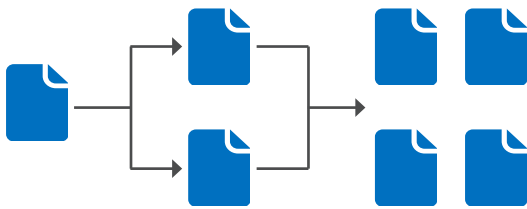
Many Manual Processes

Many Operations Personnel

New Way

Automated Processes

Highly Trained Operator

A more complete up-to-date model **enables digital workflows.**

As our processes become highly automated, we need highly trained, highly skilled operators to manage them. These operators need to be trained to know how to interact with the complex operational procedures, controls, and advanced controls, to ensure safe and most profitable operations. The same Digital Twin is the solution to train operators and support this move to more automated, safer operations.

Unique Value of Digital Twin in the Validated Industries

In the Life Sciences industries, the use of the Digital Twin is proven and accepted for offline (without process equipment) testing of the automation system in Design/ Implement /Test, Software or Factory Integration Testing and the System Acceptance Testing phases of Installation Qualification (IQ) and Operational Qualification (OQ). In addition, the Digital Twin can be used to provide more effective operator training and operating procedure development.
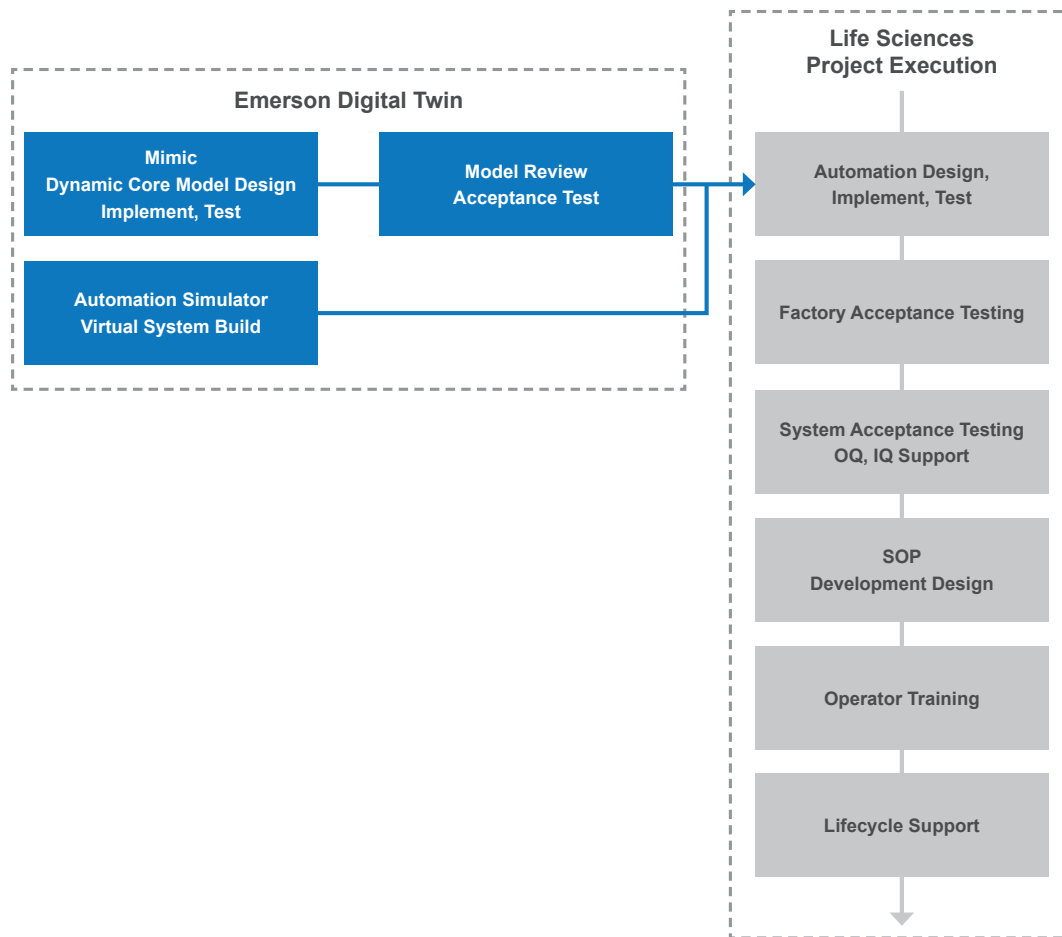
By including a Digital Twin solution in Life Sciences projects, users will be able to reduce project cost, schedule, and risk. In addition, leveraging dynamic simulation as part of a comprehensive validation strategy will allow users to:

- Reduce field qualification requirements and minimize field deviations

- Speed up isolation of issues to individual objects for Change Management

- Enforce consistent testing of the automation by using automated testing scripts to accelerate and reduce manual testing

- Catch configuration and code regression errors early in the project cycle when remediation is best cost and operation costs are minimized

- Perform a subset of software commissioning/shakedown activities prior to installing the code on the production equipment. This can reduce the time needed to perform testing on the production equipment, reducing the startup time for the plant

- Show equivalency where applicable to reduce OQ tasks reducing operation costs

Best Practices

To support the implementation of a Digital Twin and to maximize its value to operations and return on investment, there are some best practice requirements for implementing this technology. Those best practices are:

- Dynamic process models must be first-principles, following fluid dynamics, kinetics, and thermodynamics laws, but must also be dynamic and real-time. Real-time response must support good process dynamics for even fast processes without changes to process control system loop tuning.

- Applying the same Digital Twin solution to both CapEx and OpEx provides a cost-effective, consistent approach, that maximizes the return on investment in the model development. A multi-purpose approach will result in the greatest return on investment.

- The Digital Twin solution must allow incremental model development, enhancement, and tuning to support the evolving requirements of the lifecycle. The ability to start with a model with preliminary data and then to tune it with detailed engineering or actual data, is essential. The simulation must support a wide range of process model complexity from simple IO models to complex unit operations models.

- The control system simulator used with the dynamic simulator must run the exact application software without deletions or modifications from the plant system. In order to provide a solution that can cost effectively be kept current with the plant system, it is essential that the control system simulator reflect the control system configuration with no additions or deletions.

- All process automation system IO should be simulated even if their signals come from simplified models. This allows operator training or operational studies to extend beyond the boundaries of the rigorous process models.

Learn More

Implementing a Digital Twin is the first step to on the road to Digital Transformation and top quartile operator performance. The following resources will help you understand further how to use the Digital Twin to improve the performance of your plant:

- **Improve Process Performance by Validating Systems and Preparing Operations**

- **An Introduction to Mimic Simulation Software**

- **Understanding and Applying Simulation Fidelity to the Digital Twin**

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