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Multi-Purpose Dynamic Simulators and Lifecycle Modelling: One Model, Many Uses

Using the investment in an Operator Training Simulator (OTS) to improve & de-risk project execution in the energy industry and ensure operational excellence from Day 1 of operation.

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Introduction

The Multi-Purpose Dynamic Simulator (MPDS) is a groundbreaking concept that leverages dynamic process simulation by extending the application of dynamic process modelling across process design, commissioning, and operational phases.
Traditionally, dynamic process models have been used independently during engineering phases and later on for operator training prior to commissioning – as part of an Operator Training Simulator (OTS). Often, in engineering projects, the dynamic process models are siloed for specific uses. However, the MPDS methodology integrates and reuses these models throughout the project lifecycle, the models are used for a variety of extra applications, delivering additional benefits from the investment in the OTS.
In Inprocess' MPDS methodology, dynamic process models serve as the backbone of the engineering project, supporting various stages and evolving alongside the process lifecycle. Acting as a living repository of process knowledge, these models provide continuity and insight across design, commissioning, and operational phases. Such a methodology ensures that the process model is not just a tool but a central asset to support the engineering and operation of the process.
The main, basic ideas of the MPDS approach are:

- **Dynamic Model Development and Reuse.** Dynamic equipment process models are developed during the engineering stages and re-used in subsequent phases, ensuring continuity and enhanced return on investment.

- **Virtual Plant Creation and Control Strategy Validation.** These models are connected and extended to represent the entire process (the Pirtual plant), enabling a detailed analysis of control strategies and operating instructions before real plant startup.

- **Virtual Commissioning.** By linking the dynamic process model to the control and safety systems still under development by their vendors, the MPDS approach facilitates the extensive system testing against the virtual plant before its physical implementation.

- **Early and Enhanced Operator Training.** Operators can be trained using the direct connect OTS – or even before the control and safety systems are ready with Inprocess' early OTS accelerating operators' readiness and competency.

- **Continuous Operational Insights with Real-Time Simulation.** Post-startup, the virtual plant integrates with live plant data, evolving into a Real-Time Simulator (RTS) that provides continuous operational insights, enhancing decision-making and process optimization.

By using the MPDS approach, the process models extend beyond their conventional usage, becoming indispensable assets that accompany the process evolution. They facilitate a complete integration of engineering knowledge across all stages, delivering tangible benefits such as reduced risks, optimized operations, and accelerated project timelines. This methodology ensures that process models are not only tools for simulation but enablers of process engineering and operation support

During Project Development Phase / Prior to start-up:

- Ensure main equipment capacity and protection in the early phase of engineering project.

- Ensure safe-by-design processes through realistic engineering studies.

- Reduce capital costs (CAPEX) by accurate design of the equipment.

- De-risking commissioning time by having virtually checked out the control and safety systems .

- Train Operators on time, before start-up.

During Production Phase / After start-up:

- Reach Operational Excellence through well-trained operators and utilizing optimized operating procedures.

- Identify potential process bottlenecks.

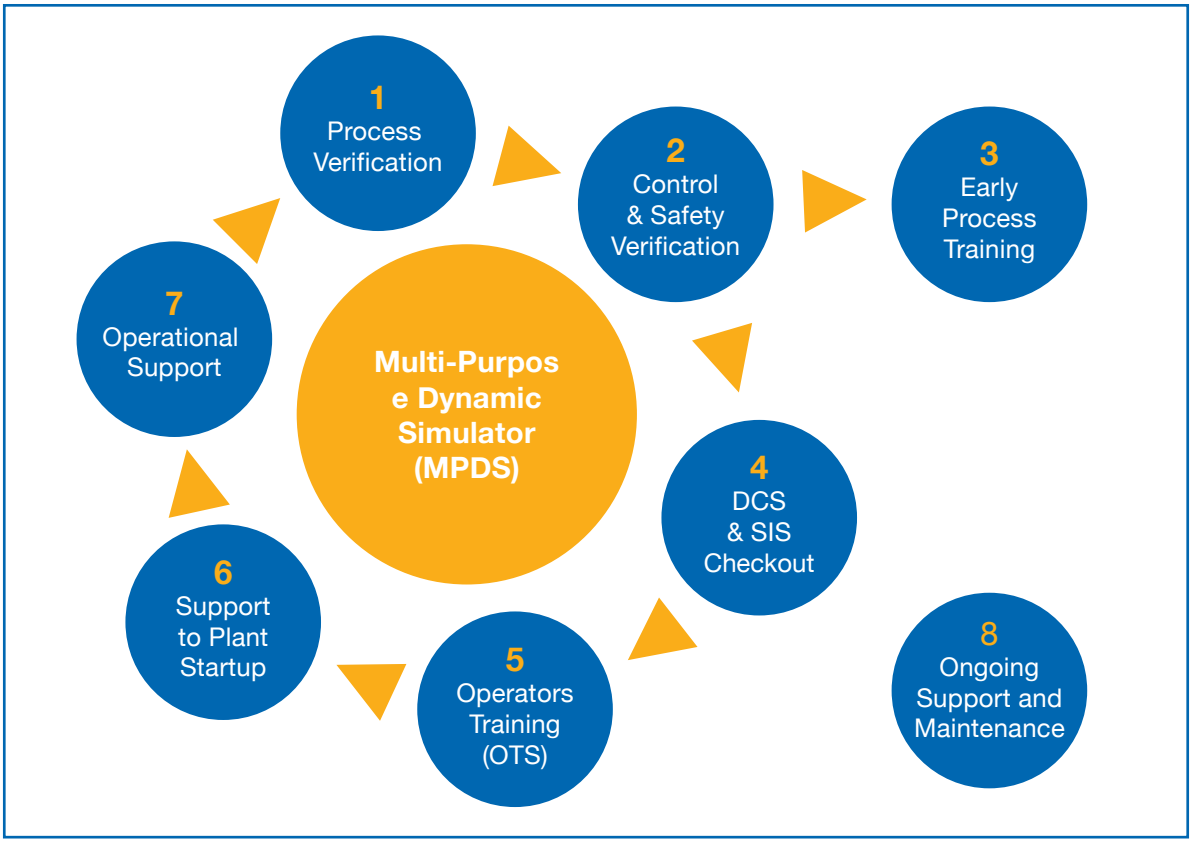
- Infer process values by simulation for non-instrumented variables.

- Detect deviations of equipment performance.

- Decision support with real time information obtained from process simulation.

The MPDS Lifecycle: A Phased Approach

Inprocess employs a phased approach to MPDS development, ensuring that models grow and adapt to meet evolving project needs. Each phase represents a distinct stage in the lifecycle:



Phase 1: Process Verification

The foundation of MPDS begins with the creation of rigorous dynamic process simulation models. Using first principles-based simulation tools and engineering data, this phase focuses on verifying design feasibility and enhancing control philosophies. Typical activities include:

- Validating design alternatives.
- Verifying equipment protection and capacity considering the potential transient peaks.
- Optimizing equipment such as compressors, pumps, and buffer vessels.
- Enhancing safety systems and transient response mechanisms.

This phase establishes a number of reliable equipment process models that evolve in subsequent stages.

Phase 2: Control and Safety Verification

Building upon Phase 1 and combining the different equipment models into a single process unit model, this stage incorporates control narratives, safety interlocks, and cause-and-effect matrices (C&EM). Known as the Safety Test Simulator (STS), this phase is crucial for:

- Testing regulatory contro
ls and safety systems.
- Validating operating procedures, alarms, and interlocks.
- Refining startup, shutdown, and emergency protocols.

Dynamic modeling in this phase enables engineers to identify gaps early, reducing risks during future plant commissioning.

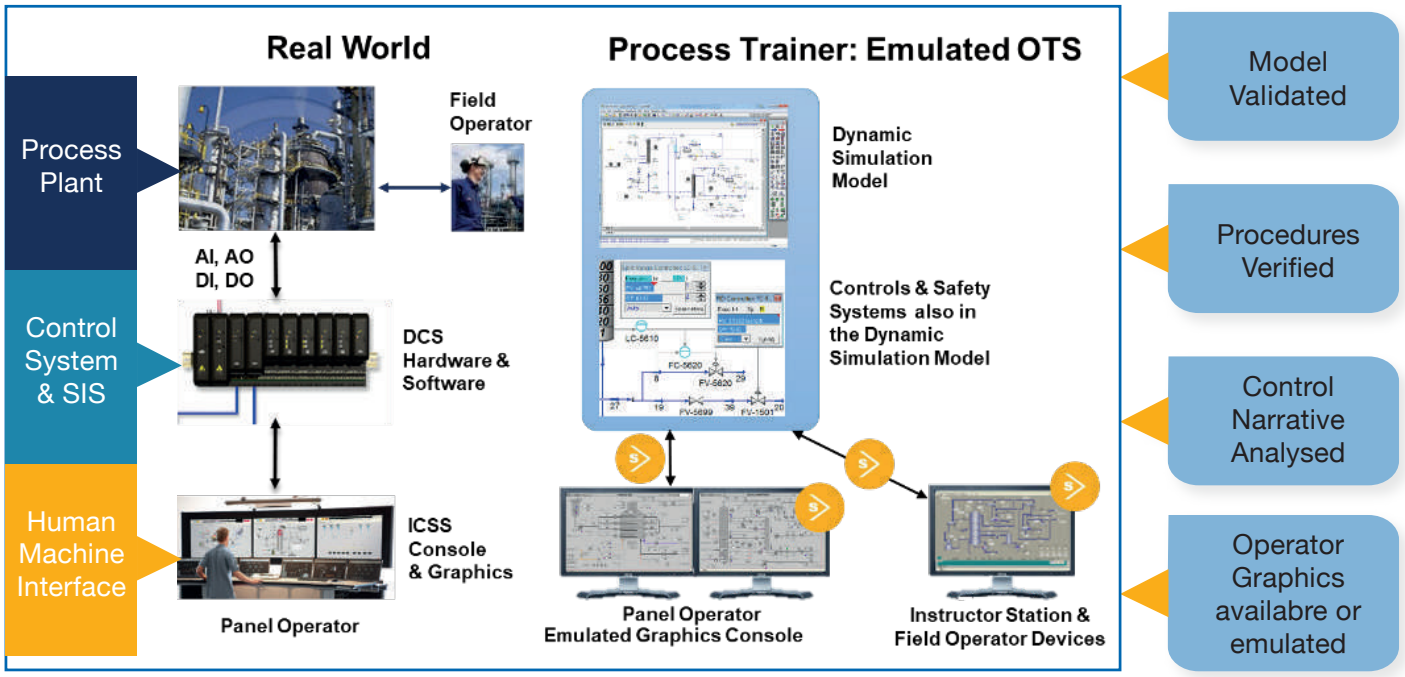
Phase 3: Early Process Trainer

With the integration of Human-Machine Interfaces (HMI) and instructor tools to the current dynamic process unit model, the MPDS is transformed into an Early/Emulated Operator Training Simulator (OTS). This tool allows operators to:

- Gain process familiarity.
- Practice scenarios such as start-up, shutdown, and emergency responses.
- Enhance understanding of process behaviors and limits.

Training at this stage accelerates the learning curve for operators, ensuring that operators begin to be prepared well before the plant startup.

Optionally, our customers can utilize for this early training the expertise of the Inprocess staff who have been involved in the MPDS development from the beginning. By this point, these experts possess a deep understanding of the plant's intricacies, operating procedures, and control and safety philosophies. Their knowledge ensures that training is highly relevant and effective.



Phase 4: DCS and SIS Checkout

Once the Distributed Control System (DCS) and Safety Integrated System (SIS) databases are available from their vendors, Virtual Commissioning is conducted. This activity is usually an iterative process where Inprocess tests and validates more than one version of the databases, while the vendors keep updating them until approved. Known as the Automation Test Simulator (ATS), this phase:

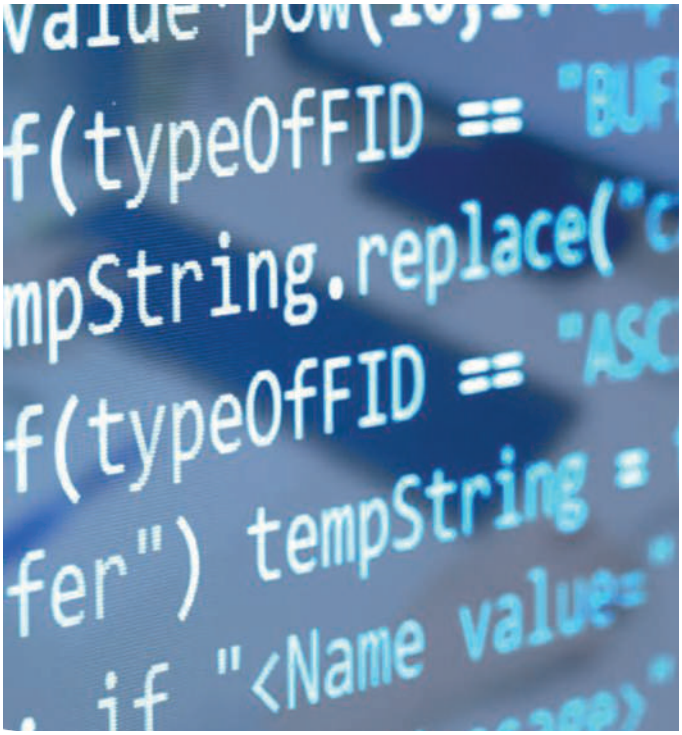
- Risk Mitigation and Safety Assurance: Virtual commissioning enables operators and engineers to test and validate control strategies and process responses within a simulated environment before real-world implementation. This approach significantly reduces the the risk of of accidents, hazardous events, and operational disruptions. Given the complexity and inherent risks of many industrial process operations, this feature is highly relevant for safeguarding personnel and protecting the environment.
- Enhanced Control Logic and Strategy Optimization: By using an integrated DCS and process simulator model, operators can refine control logic and strategies by evaluating their performance under different scenarios and conditions. This iterative testing and adjustment process ensures that control systems are optimized for the process' dynamics, resulting in enhanced operational efficiency.
- Realistic Scenario Testing: Virtual commissioning facilitates the testing of the control system's

response to a wide range of realistic scenarios, which may be difficult to replicate in a physical environment. These scenarios include emergencies, process disturbances, variable load conditions, and equipment malfunctions. Training operators with such scenarios in a controlled environment, the process operation team can develop effective strategies for handling such situations in real-world operations

- Minimized Downtime and Production Interruptions: Unlike traditional commissioning, which often requires extended downtime for equipment testing and calibration, virtual commissioning minimizes this downtime by allowing parallel testing of the control system while the physical components are being prepared for deployment. This is essential for many industrial processes, where production downtime can lead to substantial financial losses.

- Control System Performance Validation: Connecting the DCS to a high-fidelity process simulator model allows operators to validate control system performance under varied conditions. This ensures that control algorithms, tuning parameters, and feedback mechanisms operate as intended, supporting smoother process operations, particularly during the initial startup phase.

Virtual Commissioning with MPDS can eliminate most of the DCS and SIS programming errors prior to real-plant commissioning, significantly reducing the risk of commissioning.



Phase 5: Operator Training Simulator (OTS)

A fully integrated OTS is developed by incorporating in this phase the finalized DCS and SIS versions. This Direct-Connect OTS (DC-OTS) mirrors the real control and safety environments, enabling operators to be trained in:

- Performing unfamiliar tasks safely.

- Responding to abnormal scenarios and emergencies.

- Developing proficiency in complex automated systems.

Continuous training with OTS increases the confidence of the operators, minimizes human errors and delivers operational excellence.

Phase 6: Supporting Plant/Unit Startup

During the initial plant startup, MPDS serves as a critical troubleshooting tool. By replicating expected plant conditions, it helps to:

- Address issues promptly.

- Reduce ICSS vendor reliance during commissioning.

- Ensure smoother, faster startup processes.

Inprocess teams can provide on-site support, leveraging their deep knowledge of the plant acquired during MPDS development.

Phase 7a: Operational Support (offline)

Once the processing plant is operational, the MPDS evolves into a Process Digital Twin by incorporating final "as-built" data. Now the process model(s) can be used for ongoing support for operations and maintenance activities. These include:

- dynamic analysis for any new equipment design and sizing,
- flare system revalidation,
- process debottlenecking,
- and control studies to refine loop configurations or validate inferred process values.

It also aids operational studies e.g., to analyze alternative feedstocks, mitigate plant issues, or explore more profitable and sustainable operating strategies.

A distinctive feature of this phase is its ability to support advanced safety and hazard management practices. The MPDS facilitates tools like HAZOP studies and alarm rationalization by validating event trees and reducing time spent in risk assessments. This capability enhances plant safety and operational efficiency, providing engineers with a reliable simulation environment to address complex challenges.

Phase 7b: Operational Support (online)

When connected online to the plant's instrumentation and historian database, the MPDS transforms into an Online Digital Twin/Real-Time Simulator, significantly expanding its utility. It enables real-time performance monitoring of critical equipment, predictive maintenance, and faster what-if scenario evaluations to preempt potential issues.

Operators and engineers can use the Online Digital Twin for informed decision-making, offering real-time advice and insights into process adjustments without disrupting actual plant operations. This integration also supports post-incident analysis, allowing engineers to restore past plant conditions for detailed examination and improved incident management protocols.

With its real-time capabilities and versatility, this phase ensures that the MPDS remains an invaluable resource for maintaining operational excellence throughout the plant's lifecycle. It provides a robust foundation for continuous improvement, enabling plants to adapt to evolving operational demands while maintaining safety and profitability.

Phase 8: Sustainment = Ongoing Support and Maintenance

A key strength of the MPDS lies in its ability to remain relevant and functional throughout the plant's lifecycle, provided it is maintained as a living tool. Ongoing support and regular updates are crucial to ensure that the MPDS reflects real plant conditions, incorporating changes in equipment, control configurations, and process variables. This alignment ensures the simulator retains its value as an accurate representation of the operational plant, enabling operators to trust its outputs for training and decision-making.

Inprocess emphasizes a proactive approach to maintenance, offering tailored support contracts to ensure MPDS systems stay up to date. These contracts include regular audits, updates to match plant modifications, and performance checks to address any technical issues promptly. This commitment minimizes downtime and ensures that the MPDS continues to serve as a reliable resource for operational studies, process optimization, and safety assessments.

Furthermore, Inprocess facilitates ongoing operator engagement with the MPDS through structured training programs. These programs, designed for both new and experienced operators, enhance skills retention and reinforce best practices. By addressing the tendency for skills degradation over time, these programs ensure that operators remain proficient in managing both routine and abnormal scenarios, reducing the risk of incidents.

The combination of robust maintenance and continuous training underscores the MPDS as not just a tool for initial project phases but as a long-term asset. This approach enables plants to achieve sustainable operational improvements, ensuring safety, efficiency, and profitability in an ever-changing industrial landscape.

How can Inprocess develop MPDS?

Inprocess is a Process Simulation powerhouse with >100 process simulation experts. In addition, Inprocess developed Technology Provider independent MPDS connectivity tool: Inprocess Infrastructure Suite (IIS). This SW provides the required connectivity between the different process simulation tools and all the available control and safety systems technologies.

In addition, IIS is the Early OTS HMI development environment and it is also used for Instructor Station and Field Operator station.

So, by utilizing IIS, Inprocess is able to develop OTS and MPDS projects for most of the ICSS makes and version deployed and using any of the available commercial simulators. Any OTS/MPDS project has a different mix of Process Simulator and control and safety systems simulators – and with IIS we are able to deliver all combinations.

This is why Inprocess is the best choice for MPDS projects – despite not being the automation provider.

Conclusions

The Multi-Purpose Dynamic Simulator (MPDS) represents a transformative leap in process plant lifecycle, redefining how dynamic simulation can be utilized beyond traditional boundaries. By extending the application of a single, evolving dynamic model across all phases of a plant's lifecycle, MPDS delivers unparalleled benefits in design validation, operational excellence, and risk mitigation.

The integration of diverse technologies within the MPDS framework, facilitated by the Inprocess Infrastructure Suite (IIS), addresses the complexities of combining tools from different vendors. This technology-agnostic approach ensures seamless communication and interoperability. Furthermore, the proactive maintenance and support services offered by Inprocess safeguard the MPDS as a living tool, ensuring it remains aligned with real plant conditions.

Inprocess, as a technology-independent leader in MPDS development, ensures that every implementation maximizes value for its clients. By addressing technical and operational challenges with innovative solutions and dedicated support, Inprocess reaffirms its commitment to enabling safer, more efficient, and profitable process plant operations.

In an era where operational excellence, safety, and sustainability are paramount, the MPDS stands out as a vital tool for achieving these corporate goals. By facilitating continuous improvement and adaptation, MPDS empowers the processing industries to remain competitive, resilient, and forward-looking.