

AI Adoption in Process Control Won't be Instantaneous But Prepare Anyway

AI buzz is everywhere. Take a look at how you can begin to prepare for the future of process-control AI with eight key steps.

No one is suggesting that familiar physical interfaces or screens and keyboards in process industries are obsolete. However, the rapid evolution in [voice processing](#), [virtual reality](#), and artificial intelligence suggest that systems designers should keep an eye on the not-too-distant future when moving toward full automation. In particular, agentic control is likely to be the rule rather than the exception.

In the meantime, engineers can begin to prepare process-control systems and equipment to be more easily adaptable for further automation and AI adoption.

Generally, designers must architect systems with adaptability, visibility, and intelligence in mind. It involves upgrading legacy infrastructure where possible and embedding data-driven capabilities that can leverage historical and real-time data to optimize processes, enhance decision-making, and improve overall efficiency.

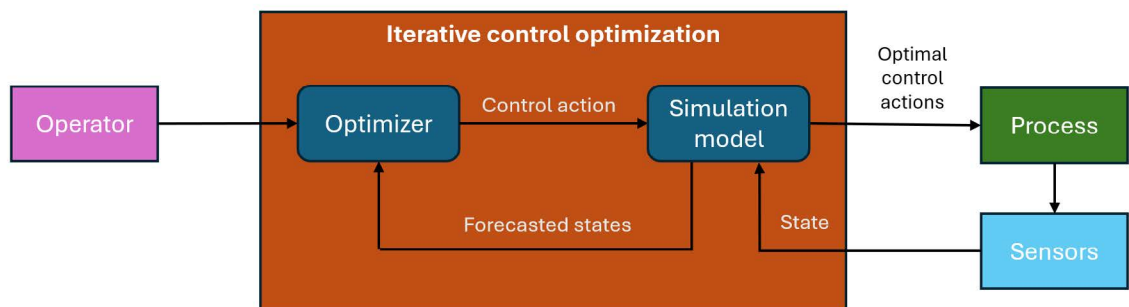
This perspective involves using data analysis and machine

learning to understand process behavior, predict outcomes, and identify areas for improvement, ultimately leading to better control strategies and reduced variability. Designers can also aim to incorporate control layers that both responds to and informs AI-driven optimization, often using [digital twins](#).

Key Strategies and Actionable Steps to Prep for AI *Enable Scalable Data Infrastructure*

1 While likely outside of the immediate purview of electronic design, having a scalable data infrastructure is important for enabling the adoption of, and transition to, greater AI control. For instance, if not already available, implementing a data historian or edge database to store time-series sensor and control data is one way to prepare for machine learning, diagnostics, and optimization.

2 Another step can involve adoption of edge gateways with buffering and preprocessing capabilities to filter and



This block diagram of an MPC controller illustrates the key distinction between MPC and PI or PID controllers, namely the continual iteration between an optimizer and a simulation model in the former. (Electronic Design)

tag incoming data, helping to ensure that the right data is available at the right time. Also, establish secure data pipelines to on-prem or cloud-based AI/ML and IoT platforms (AWS IoT, Azure IoT Edge, etc.).

Digitize and Instrument the Physical Process

1In essence, digitization and instrumentation is about making the physical world machine-readable. In other words, provide more — and better — data.

This can be accomplished by adding sensors and edge devices to capture key process variables (temperature, pressure, flow, etc.) and ensuring that you're able to deliver high-resolution, real-time data acquisition — with millisecond granularity where necessary. Adopting “smart” instruments with built-in diagnostics and communication capabilities such as HART, IO-Link, and Ethernet/IP can also contribute to positive results.

How Can Architectural and Design Choices Pave the Way for AI?

Modernize Control Architecture

2Are you still working with an older control architecture? Maybe it's time to move toward the ability to support modularity, data flow, and intelligent coordination.

3You can take big steps forward by adopting a **distributed control system (DCS)** or **modular programmable automation controller (PAC)-based design** that can better isolate and localize control tasks.

4It's also prudent to use **open standards** (e.g., OPC UA, MQTT, Modbus TCP) to facilitate interoperability and cloud readiness, as well as adopt **real-time capable networks** (e.g., EtherCAT, PROFINET IRT) for real deterministic control.

Design Control Logic with AI in Mind

5Control logic is central to much of the designer's task. Here, the challenge is to ensure that future AI agents can work with and around traditional control loops. This takes a disciplined approach and invites the use of model-based control or digital twins to simulate and validate AI inputs.

Proportional-integral (PI) and proportional-integral-derivative (PID) controllers are the workhorses of industrial automation. They adjust control outputs based on present (proportional), past (integral), and — if used — predicted (derivative) error between a process variable and a setpoint. These controllers are simple, fast, and effective for single-variable, steady-state systems, but they struggle when processes involve time delays, interactions between variables, or constraints.

Model predictive control (MPC), in contrast, uses a dynamic model of the process to predict future behavior over a time horizon (*see figure*). It optimizes control actions at each step by solving a constrained optimization problem that anticipates system responses and minimizes a cost function. MPC naturally handles multivariable systems, constraints on inputs and outputs, and time delays. Such capabilities are extremely limited or absent in PID-based control.

MPC's model-driven architecture is well-suited for integration with AI. It can absorb machine-learning forecasts, update optimization goals in real-time, and act as a bridge between traditional control systems and data-driven intelligence. In AI-enabled environments where adaptability, foresight, and coordination are crucial, MPC offers the flexibility and structure to embed predictive insights directly into control strategies, making it a better pathway to truly smart process control.

In pursuing this work, be sure to maintain separation between core safety logic and optimization layers to avoid compromising integrity. To be effective with AI, aim to design tunable control parameters (e.g., setpoints, gain limits) that AI can safely adjust.

Diagnostic and Self-Learning Capabilities

Useful now and in future of AI adoption are diagnostic and self-learning capabilities. Design investments here can provide visibility, prediction, and adaptability.

For instance, building self-diagnostic routines into PLC/PAC code can make it possible to quickly detect sensor faults, actuator drift, and communication issues. Condition-monitoring algorithms (e.g., vibration, current signature analysis) could provide the basis for predictive maintenance in the near term. Later, it can be comparatively trivial to integrate ML-ready feature extraction into the control environment (e.g., rolling averages, FFTs, anomaly scores).

Visualize and Interpret AI Insights

AI may be “taking over,” but people are still in charge. Keep this in mind and plan to make AI explainable and actionable for operators and engineers as it's adopted.

Use of modern HMI/SCADA systems with AI plugins can help to show forecasts, anomalies, and optimization suggestions.

Humans will appreciate “co-pilot” interfaces that potentially let users verify or override AI decisions. On the same theme, designers can also plan to include feedback loops where operators label or validate outcomes to retrain ML models.

Design for Cybersecurity and Governance

Cybersecurity and governance are already priority issues, but they will only become more critical with AI-enabled systems and data assets.

Start by applying the IEC 62443 security framework for industrial automation. Be sure to adopt secure boot, Transport Layer Security (TLS), role-based access control, and network segmentation. And as you move forward, build audit trails and traceability into AI decisions and control overrides.

References

[How to Build Production-Ready AI Models for Manufacturing](#) (video)

[How AI is transforming manufacturing and why AI-readiness matters](#)