

DeltaV™ InSight for Intelligent Process Control

DeltaV InSight improves plant performance with intelligent monitoring, diagnostics, and adaptive controller tuning.

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Introduction

Manufacturers lose millions of dollars each year due to process variability and poor control performance, often unaware they even have a problem. Control engineers are typically overworked and ill-equipped to monitor and maintain the hundreds of control loops and instruments for which they are responsible. And contributing to the problem, traditional control systems don't provide a systematic way to monitor, diagnose and improve process control performance.

DeltaV™ InSight provides a systematic approach to improving control by monitoring control performance; identifying and diagnosing problem loops; recommending tuning and maintenance improvements; and continuously adapting to changing conditions to optimize plant performance.

What makes DeltaV InSight special is its ability to automatically learn process characteristics by continuously evaluating plant conditions and calculating process models based on normal day-to-day operations. These process models may be applied in a wide range of applications to precisely benchmark control performance, diagnose problems, calculate tuning parameters, adjust tuning for adaptive control, test control configurations, and train operators.

DeltaV InSight has evolved from Emerson's research in the area of on-line adaptive control technology. The core Adapt Technology provides the ability to efficiently calculate dynamic response models based on normal day-to-day operations. The original intent for this technology was for closed loop adaptive control; however it became apparent through customer interviews and marketing surveys that the Adapt technology could be used in many other ways to monitor performance, identify and diagnose problems, and improve control performance across the entire control system. By incorporating the Adapt learning algorithms throughout the DeltaV control system, we are able to systematically identify opportunities, diagnose problems, and automatically improve performance through Intelligent Process Control.

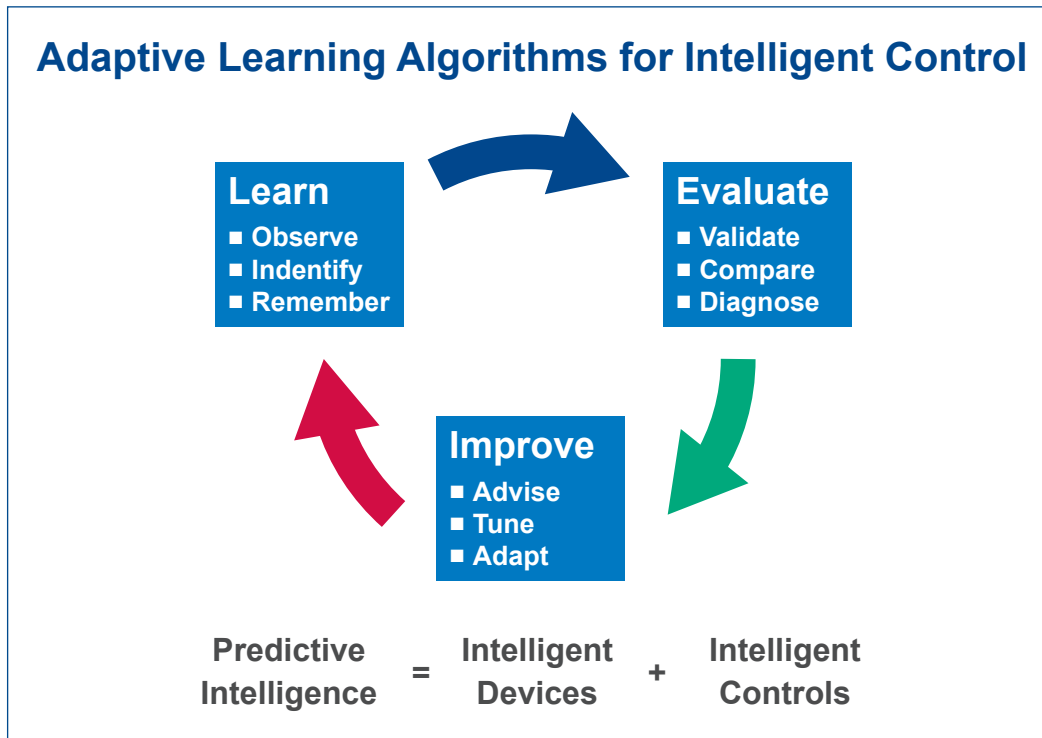
Improving Plant Operation with Intelligent Control

Emerson revolutionized the process control industry with the introduction of Predictive Intelligence through the use of Intelligent Field Devices. We now take Predictive Intelligence a step further with the introduction of Intelligent Control. By embedding learning algorithms directly into the control system, we can systematically apply the knowledge we acquire to:

- Locate hidden variability and underperforming control loops
- Monitor control performance against model based performance benchmarks
- Identify problems and diagnose causes such as faulty valves or process interactions
- Prevent downtime; increase availability
- Reduce variability, increase quality and throughput; and
- Sustain gains from performance improvements

Never before have intelligent learning algorithms been implemented across an entire control system to identify control performance problems and profit opportunities. The knowledge acquired by these learning algorithms provide an insight into the process previously only possible through weeks and months of testing by control experts. Now control engineers can quickly measure the performance of their plant and troubleshoot problems in a fraction of the time it takes with traditional control systems.

DeltaV InSight provides Intelligent Control using Emerson's Adapt Technology which enables DeltaV to automatically learn a process, evaluate its performance, and improve control through advisory or closed loop adaptive control.

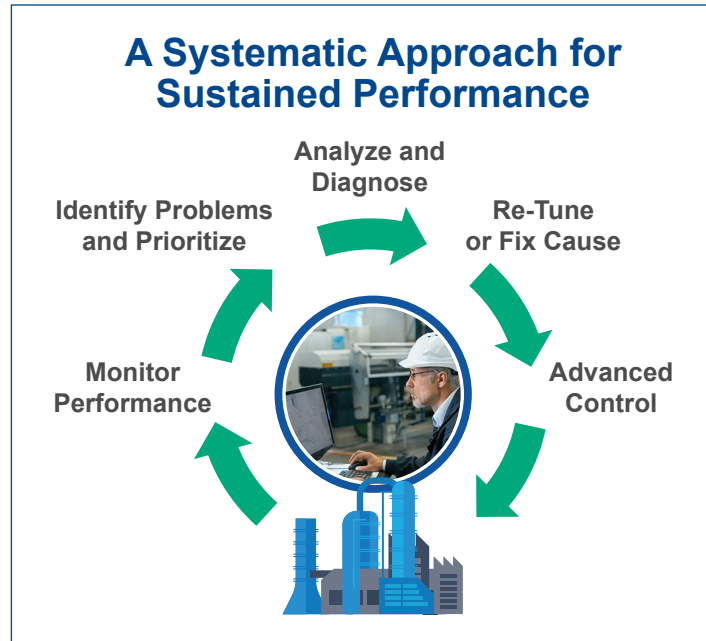


The embedded Adapt algorithms provide DeltaV the ability to learn or acquire knowledge about a process by constantly observing every control loop and identifying process models. As conditions change, the algorithms re-identify or re-learn the process automatically; and can remember the process behavior for different operating conditions. Therefore when conditions change, such as feed rate or product selection, DeltaV InSight can remember the process characteristics based on past experience.

We can then use this information to evaluate control loop performance, by continuously validating our process models and using them as benchmarks for comparing current performance vs. best performance. The models can also be used to diagnose problems when the process doesn't respond as expected; for example, with a sticking valve.

And third we take action to improve control performance by advising operations when control loops are underperforming, recommending tuning parameters or maintenance action, and ultimately provide automatic retuning of control loops with continuous adaptive control.

By learning the process, evaluating control performance, diagnosing problems, and improving plant performance, we are extending the power of Predictive Intelligence all the way from intelligent field devices through an Intelligent Control system.



DeltaV InSight – An Intelligent Control Performance Suite

DeltaV InSight provides an integrated control performance suite of applications to monitor, analyze, diagnose, and improve control performance. With DeltaV InSight the user can:

- Monitor performance of all control loops and process measurements to detect abnormal conditions such as high process variability, limited control outputs, or manual operation. Gain insight into process performance with embedded learning algorithms which identify process models and performance indices.
- Identify and prioritize problem loops based on control performance and operational importance.
- Analyze and diagnose process performance to pinpoint the cause of control problems such as poor tuning or limited control valves.
- Quickly tune loops with adaptive tuning which recommends tuning based on normal day-to-day operations; no invasive plant tests are required. Adaptive tuning is possible with our embedded learning algorithms which continuously calculate adaptive process models and diagnostics for every loop in DeltaV.
- Adapt to changing conditions with continuous closed loop adaptive control; ideal for non-linear processes or processes with significant changes that frequently need new tuning.
- Build a strong foundation for advanced control by keeping critical loops well tuned and operating properly.

DeltaV InSight provides many capabilities to help you improve control performance in your plant, including:

- A user interface provides seamless navigation between monitoring, diagnostics, and advanced tuning functions. Historical trend charts provide historical benchmarking for control performance indices.
- Process model analysis provides additional insight into process characteristics. Embedded learning algorithms continuously calculate new process models for monitoring, tuning, and analysis.
- Tuning recommendations are available for every control loop in the system with no additional plant testing.
- Model based performance monitoring accurately identifies control loops that are underperforming with a Tuning Index.
- Control performance reports are easily scheduled or generated on-demand to provide operations, maintenance and control personnel with reports that track key performance indicators.
- Closed loop adaptive control continuously updates tuning parameters and remembers optimal tuning for up to five operating regions.

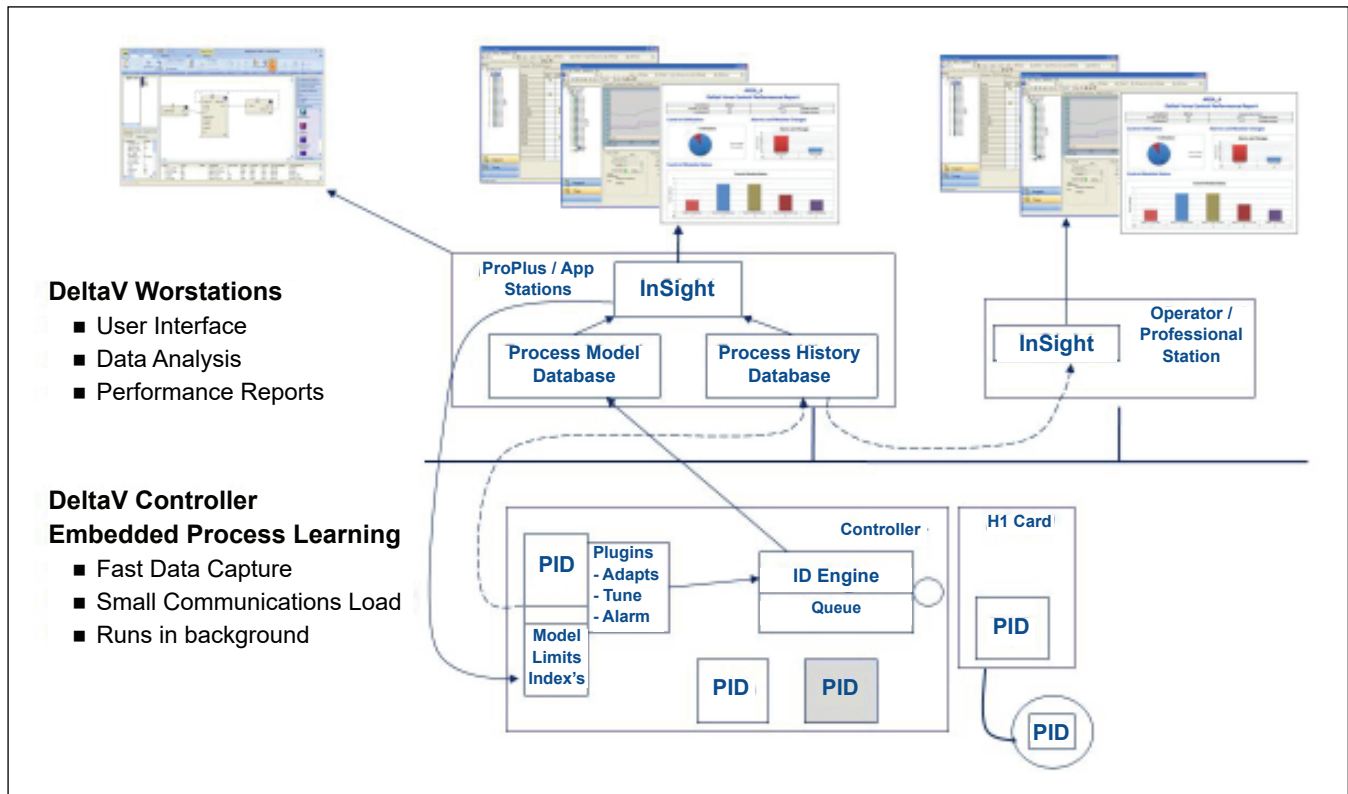
And best of all, this technology is completely embedded into DeltaV and does not require any additional configuration. As an embedded application in the DeltaV system, InSight requires no software installation, integration, or configuration. Using DeltaV software's common configuration database, InSight automatically recognizes input, output and control blocks as they are added to or deleted from the system. This means faster startups and less maintenance.

Embedded Process Learning

DeltaV InSight uses learning algorithms embedded in the controller to calculate process models and diagnostics for every control loop in the system. These models and diagnostics are used for intelligent performance monitoring and adaptive tuning to accurately identify problems and recommend tuning improvements. Process learning is easily enabled from DeltaV Explorer or DeltaV InSight for individual control modules or entire controller nodes.

DeltaV InSight calculates process models based on process changes made by the operator or automated procedures such as batch control sequences. Whenever there is a change in the setpoint (or output when controller is in manual), InSight captures the process input and output data and performs an efficient calculation to identify process dynamics. These process models are stored in a database for users to evaluate performance over time and to identify potential process non-linearities and degradations, such as the fouling of catalysts, heat transfer surfaces, and sensors.

A unique aspect of DeltaV InSight is that it is an embedded part of every DeltaV system. Calculations for control performance, diagnostics, adaptive tuning, and adaptive control are performed directly in the controller. Historical data analysis and reporting are performed on a PC workstation with user access from any DeltaV PC on the system network. DeltaV InSight's architecture is shown below.



DeltaV InSight Architecture.

Embedding DeltaV InSight into the automation system improves both ease of use and calculation performance. InSight is easy to use because there is no additional configuration required. InSight configuration is automatic: every time a control loop is added, deleted, or modified in the control system, InSight configuration is automatically updated with the latest configuration. DeltaV InSight also performs better because the control calculations are embedded directly in the controller. Calculations for control performance, diagnostics, and tuning require a lot of information, which can significantly add to system communications loading. Embedded calculations greatly reduce the system communications as compared with traditional OPC data access. Furthermore, for fast loops, it's virtually impossible to scan the control loop via OPC fast enough for accurate calculations.

Intelligent Control Performance Monitoring

The ability to quickly inspect control and measurement loops is of primary importance to industrial applications. Poorly tuned loops and malfunctioning field devices can jeopardize product quality and, quite often, production or yield. DeltaV InSight provides advanced process monitoring that allows under-performing loops to be identified instantly.

DeltaV InSight provides control performance monitoring for you to quickly assess control conditions across your entire system. Overview displays provide a summary of the abnormal control conditions for the selected system, area and module level. Once an abnormal condition is detected, you may easily drill down to get detailed performance metrics and historical information on specific control blocks.

The Control Conditions monitored for every control loop and reported in the Overview and Summary displays include:

- **Uncertain Input.** A block's process variable is bad, uncertain, or limited.
- **Limited Control.** A downstream condition is limiting the control block action; for example, the output is at a maximum limit.
- **Incorrect Mode.** The actual mode of a block does not match the normal mode configured for the block.
- **Large Variability.** A block's standard deviation and variability index are exceeding their maximum limits.
- **Process Oscillation.** A block's process variable has oscillatory behavior.
- **Recommended Tuning.** A tuning recommendation has been calculated that significantly improves control.
- **Device Alerts.** Indicates when a control module has one or more devices that have had active device alerts.

DeltaV InSight calculates the percent time that these control conditions exist and reports them as an abnormal condition if the percent time exceeds a defined global limit. Abnormal control conditions are indicated in overview graphs and summary tables from which the user may drill down on specific blocks for more detailed control performance indices and historical trends.

The Control Performance Indices provided on a block basis include:

- Standard Deviation is calculated for each AI, AO and control block.
- Variability Index (or modified Harris Index) is calculated for each control block and indicates the control performance as compared to minimum variance control.
- Tuning Index is a model-based performance index that provides an easy-to-understand benchmark comparing current tuning with the desired tuning based on calculated process dynamics. The Tuning Index is the predicted % change in control variability for the new tuning recommendation.
- % Time Limited provides an indication of how often any of the control conditions listed above are active.

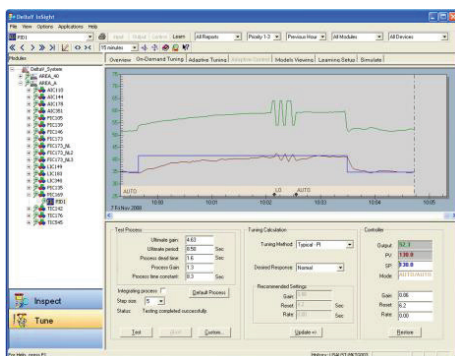
DeltaV InSight performance monitoring is easy to use because it automatically configures itself as control strategies are added to or deleted from the system. No communications interface or mapping of tags is required. Default performance limits for control conditions and performance indices are provided and may be easily changed based on your specific knowledge of your process.

Asset Alert Monitoring: DeltaV InSight also provides overview displays with summary status information for smart devices (Fieldbus and HART). Four asset alert levels are reported including: Asset Failed, Maintenance Soon, Advisory, and Communications Failed. Detailed asset information is also easily available by launching AMS Device Manager from DeltaV InSight for any device in question.

Advanced Controller Tuning

DeltaV InSight provides two basic approaches to loop tuning:

- On-demand tuning – Uses on-demand testing of the process to automatically provide tuning recommendations.
- Adaptive tuning – Uses past operator changes in setpoint or output to automatically provide tuning recommendations. No additional plant tests are required.



DeltaV InSight's On-Demand Tuning is available for PID and Fuzzy Logic control blocks in the DeltaV controller. Tuning recommendations are available on demand by initiating automatic testing of the process. During the tests, the loop remains under control to prevent large disturbances to the process. The on-demand tuning method is based on the Aström-Hägglund algorithm referred to as the relay-oscillation method. Users may easily adjust the desired speed of response for the control loop to speed up or slow down the closed loop response. Advanced users may also specify optional tuning rules for modified Ziegler-Nichols, Lambda, or Internal Model Control.

DeltaV InSight's Adaptive Tuning is available for all PID blocks that have embedded process learning enabled. Adaptive tuning is based on process models that are continuously calculated based on changes the operator makes during normal day-to-day operation. The process models used for tuning are validated using quality parameters for model identification and model variability. Tuning recommendations are automatically provided for validated models based on Lambda or IMC tuning rules.

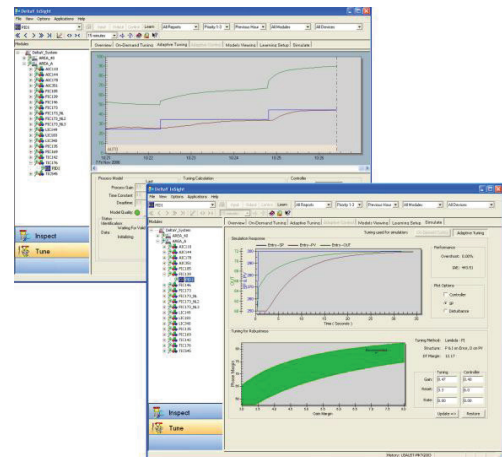
The unique value of DeltaV InSight's adaptive tuning comes not only from providing optimal tuning recommendations, but from proactively identifying loops that need to be re-tuned. For each PID block, a tuning index provides a quantitative metric for the predicted percent change in variability for the new tuning recommendation. With a tuning index it is possible to identify and rank control loops that need tuning, before operational or variability problems are reported.

For the advanced user, DeltaV InSight also provides sophisticated but easy-to-use loop simulation and model analysis tools. The simulation allows control loop performance to be predicted before the new tuning is used. The user can view a simulated loop response based on the recommended tuning parameters and compare the response with the current tuning parameters. You can also assess loop stability for different tuning parameters with a robustness plot. The model analysis tool provides insight into process characteristics and can be used to validate model consistency, identify non-linearities, or process changes over time.

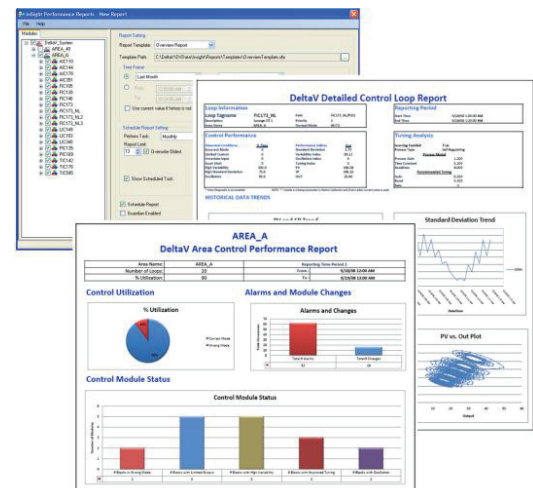
Control Performance Reports

DeltaV InSight Performance Reports help operations, maintenance and control personnel track control performance and identify opportunities for improvement. Standard "out of box" reports are provided for system overview, area control performance, and detailed loop analysis. DeltaV InSight automatically accounts for all control configuration changes, making it easy to generate and maintain performance reports. These reports may be created on-demand or scheduled for automatic generation, such as for monthly or weekly reports.

Furthermore, DeltaV InSight reports are easily customized to include additional key performance indicators such as critical alarms, energy consumption, or production rates. Based on Microsoft Excel templates, reports are easy to enhance using DeltaV Reporter, an Excel Add-in provided free with DeltaV, which lets you add process, alarm and event information to your InSight reports.



InSight Adaptive Tuning and Simulation.



InSight Control Performance Reports.

Adaptive Control

With DeltaV InSight's Adaptive Control (Adapt), you may never have to re-tune that problem loop again. Adaptive controllers continuously adjust their tuning parameters to account for changing conditions and non-linear process dynamics. Adapt not only calculates optimal tuning when process conditions change, but also remembers the best tuning from the last time it was controlling in the same operating region. Adapt learns and adjusts to new environments, AND remembers the last time it experienced similar conditions. This is truly "Intelligent Control".

DeltaV InSight's Adaptive Control includes the following features:

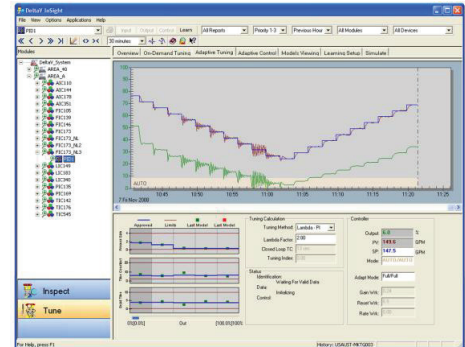
- Fully adaptive control for any DeltaV PID control block
- Coordinates model identification and adaptive tuning calculations for closed-loop, automatic mode.
- User defined state variables to account for known non-linearities
- Up to five operating regions for automatic switching to previously calculated tuning
- Expert users may specify performance criteria for adaptive tuning

For maximum flexibility, DeltaV Adapt enables PID blocks to operate in one of three adaptive control modes:

- Full Adaptive Mode – Continuously adjusts tuning parameters based on the last good model calculated for each operating region.
- Partial Adaptive Mode – Adjusts tuning parameters only when operating regions change, and only using process models that have been approved for each region.
- Learn Only Mode – Process learning and adaptive tuning recommendations are calculated for each operating region but no tuning parameter changes are written to the on-line PID block.

Control Performance Services

Emerson's Control Performance Services provide a cost effective way to increase asset performance and minimize unplanned maintenance, freeing customer engineers from the day-to-day maintenance of hundreds of discrete and analog control loops. And with efficient tools like DeltaV InSight, DeltaV Analyze, and Emerson's EnTech Toolkit, we can quickly uncover additional control improvement opportunities for our customers.



InSight Adaptive Tuning and Simulation.

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