Industrial IT System 800xA
Industrial IT Training Simulator

SimulateIT

Application Overview

Features and Benefits

- **Lifecycle Simulator:** Integral part of a cost-effective comprehensive program for all phases of plant lifecycle. All-in-one simulator for operator and maintenance training, control logic development and testing, control logic and operator certification, maximizes value of simulator system.
- **Tightly Integrated with Running Plant System 800xA:** The simulator system is based completely on the same platform as the actual plant system; seamlessly extending System 800xA functionality.
- **Realistic Training and Test Environment:** Simulator uses a replica of the System 800xA plant configuration. Operator faceplates, dialogs, displays and control logic are reused without modifications.
- **Runtime Simulation Functions:** System includes a wide range of selectable runtime simulator functions such as freeze / resume.
- **Easy Configuration and Maintenance:** Transformation Tool is used for defining the parts of the plant that shall be simulated. Automated transfer of control definitions from plant controllers makes the simulator system easy to maintain. Re-transformation after plant modifications supports reuse of configurations in earlier project phases.
- **Interfaces for Process Model and Instructor Station:** Process models ranging from high fidelity third party models to low-end models stimulated through control logic work closely with simulator to provide desired level of process response.

Industrial IT enabled

Improving Safety and Productivity through Simulator Based Training and Testing

Continuous pressures to reduce costs are balanced by a company's social responsibility to protect its people, property, environment, and the surrounding community from harm. While control systems automate large sections of most plants, human error remains a critical contributor to most accidents. These risks, along with the number of unplanned shutdowns and start-ups after outages can be reduced with a well-trained staff. Trained operators, therefore, result in higher returns, as both product quality and productivity are improved.

By using an Industrial IT Training Simulator (ITS) solution, operators can learn to master the process in a safe and realistic environment. Additionally, engineers can fully test control modifications before transferring them to the actual plant environment.

Built on the Industrial IT Aspect Object™ technology platform, ITS solutions provide a natural extension to System 800xA functionality through runtime simulation functions and configuration tools. By using the same operator displays, control logic, and execution environment, skills are 100% transferable. The Industrial IT Training Simulator supports emulation for System 800xA controllers in a Windows computer environment.

In total, the Industrial IT Training Simulator offers a cost effective solution, throughout the entire lifecycle of the plant, by guaranteeing consistency between plant system and simulator system environments.

ABB

Overview

ABB's Industrial IT Training Simulator (ITS) creates a simulator system with the identical view and logic as the plant control system.

Available as an extension to the 800xA control system offering, ITS allows transparent copying of the plant configuration used in the running 800xA system to the training simulator environment. This allows ITS solutions to be an integral part of a cost-effective, comprehensive program for operator and maintenance training, control logic development and testing, and control logic and operator certification. By combining these capabilities into one system, companies can maximize the value of their simulator system. This also means as the plant system evolves, so does the simulator; assuring longer simulator life and lower lifecycle costs.

The simulator control room can be designed to be partly or completely identical to the actual plant control to suit business needs. Aside from the degree of physical similarities between the training and actual plant control rooms, the operator interactions with the control system are equal to that of the running plant. Specifically, operator environment factors can include:

- Physical look (room layout, furniture, keyboards, screens etc.)
- Panels with indicators and switches
- Operator faceplates, displays and dialogues

Typically, only specific parts of the plant are included in the scope of a training simulator. ITS includes tools that select the relevant parts of the control logic, and reorganize it into the simulator configuration. Using soft controllers for simulation, ITS offers emulation of AC 800M, AC 800M HI, AC 870P, and Melody controllers.

The actual plant's physical process I/O is replaced by software signals that are stimulated by a dynamic process model. These process models can range from high-fidelity third party models to low-end models stimulated through control logic. A model vendor interfaces and activates simulation implemented functions through the ITS Link interface, and stimulates I/O through 800xA's OPC Data Access interface. To date, ITS has interfaced with many application specific process models from a large number of vendors.

Industrial IT Training Simulator solutions provide a range of runtime simulator functionalities, including:

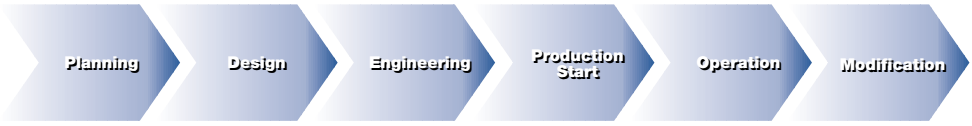
- Transfer I/O between controllers and simulator model
- Simulation of HW-module and I/O channel failures
- Bumpless Freeze and Resume of simulation
- Speed to run the process faster or slower
- Save and Load of Initial Conditions (ICs)
- Save and Load of Snapshots (cyclic save as well as manually)
- Reload alarm/event and trends when loading IC/Snapshots
- Time synchronization of simulated system time.
- Configurable switch check function

The Industrial IT Training Simulator features, as described within this Overview Document, can be classified in the following categories:

- Lifecycle Simulator
- Integration with System 800xA
- Realistic training environment
- Simulation functions
- Configuration and maintenance
- Interfaces to process model and instructor station

Lifecycle Simulator

The ITS system can be easily modified to follow the plant lifecycle changes as shown in the diagram below.



Project Key Milestones	Usage	Benefits
Planning and Design	Design and Engineering Simulator	Improve and verify design through dynamic simulator model.
Engineering	Control System Test Simulator	Integrate the model with DCS. Verification of process control and operator dialogs.
Production Start	Operator Training Simulator	Prepare operators with training before plant startup.
Operation	Training of new operators, hazard training	Well-trained operators that can handle upsets in the process
Modifications	Process optimization and modification studies	Optimize control. Verify control changes and train operators before implementation on real plant.

Figure 1. Simulator for the entire plant lifecycle

Specifically, ITS solutions can support each phase of the plant system lifecycle, including:

- Design and engineering: A dynamic simulator model is developed in parallel with process design and used for verification. Benefits include: quality verification of design, major rework avoidance during the construction period, and test of control and safety philosophy.
- Control system test: Using the simulator for realistic testing reduces commissioning time and increases safety during commissioning phase.
- Operator training: Realistic operator training in safe environment and before plant start-up increases safety and reduces the number of unplanned shutdowns.
- Training of new operators and hazard training: Training of new operators and operators on new process areas. Hazard and critical training can be repeatedly performed in a safe environment. Without the simulator option, this type of training is very expensive or is not possible.
- Process optimization and modifications: Verify changes to new or changed process areas, and train operators accordingly. Also, one can perform optimization studies through running scenarios, and then apply good results to the running plant.

Integrated with System 800xA

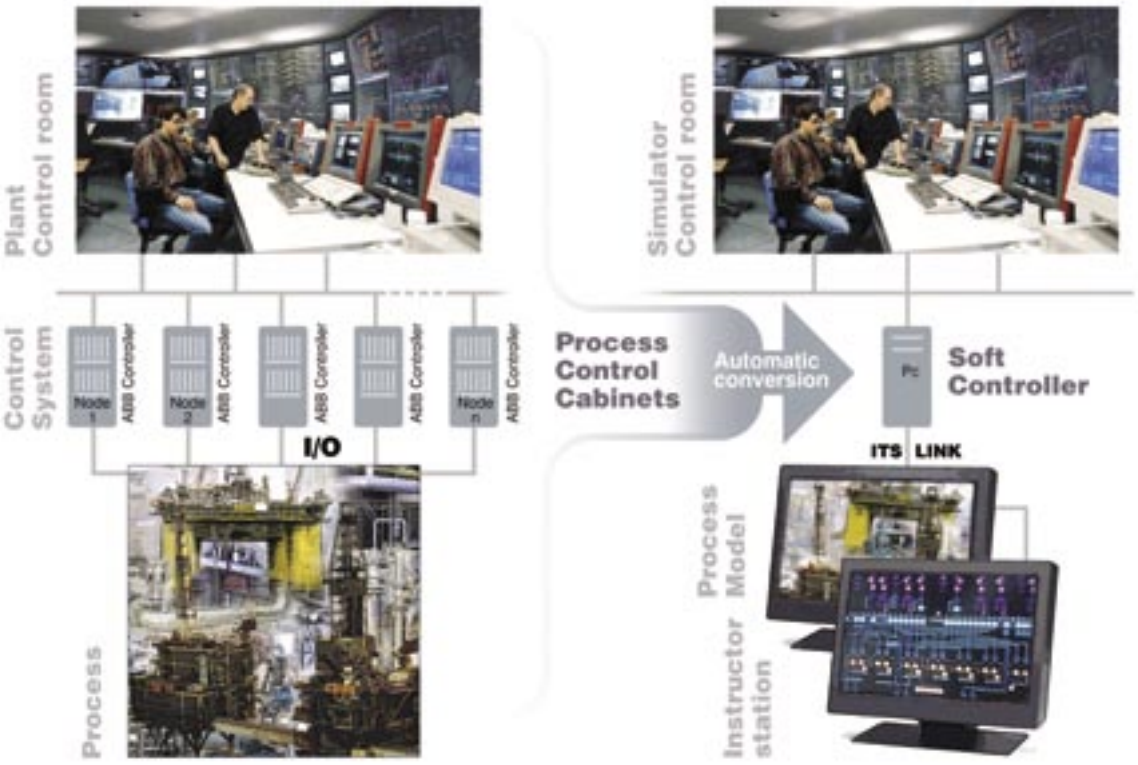


Figure 2. ITS architecture

Industrial IT Training Simulator features are integrated within System 800xA components, thereby making them *"ITS aware." ITS awareness* includes adding simulator functionality to the Alarm & Event and System Messaging system, the History Server, and Time Server. In addition, the 800xA controllers are supported with *"ITS aware"* soft controllers and connectivity options.

In this way, the simulator system is based completely on the same platform as the running plant system, and thereby offers all the advantages of the 800xA system architecture. As the same personnel can easily maintain both the plant and the simulator systems, simulation maintenance costs are greatly reduced.

The *ITS aware* emulators allow the actual plant control applications, residing in numerous process controllers, to be transferred directly to a Windows computer environment for execution. These emulators execute control logic identical to hardware controllers, thus yielding the identical behaviors to the running plant. The usage of emulators results in a minimized control hardware architecture.

The AC 800 Soft Controller is used for execution of the AC 800M control applications, while the Soft Controller HI is used for AC 800M HI safety applications. AC 870P and Melody applications are executed in their respective emulators.

The running plant's hardware controllers and their Windows based emulators are compiled from the same source code. Hence, the emulators offer identical task scheduling and execution environment as found in the running plant controllers. All function block libraries and control application code are equal at the binary level when downloaded.

With more memory space and higher CPU capacity than a hardware controller, ITS offers an option to execute multiple hardware controllers applications within one computer. The emulators are also capable of utilizing multiple CPUs and Hyper Threading in a computer, so that the whole CPU capacity can be utilized.

With ITS functionality included throughout the 800xA system platform, consistent handling of all simulator specific functions, such as simulated time and save/load of snapshot data, is ensured.

Realistic Training and Test Environment

With ITS, it is possible to create a simulator system with the identical view and logic as the running plant control system. The running plant's 800xA system configuration can be copied to an identical operator training simulator environment for both testing and training.

Figure 3. Example of training simulator with identical control room as plant

To meet business needs, the simulator control room can be made partly or completely identical to the plant control room. Independent from that, the operator interactions with the control system are equal to the running plant. The typical operator environment factors include:

Operator Environment Factors	ITS Options
Physical look (room layout, furniture, colors, lightning, etc.)	Customer need
Operator hands on (panels with indicators and switches, keyboards, screens)	ITS supports physical I/O between controllers and control room and Switch Check. Can use the same computer hardware for operator workplaces.
Operator faceplates, process displays and dialogs	Copied directly from plant automation system
Event/Alarm lists, history/trend configuration	Copied directly from plant automation system

Operator Environment

Due to the complete integration of ITS, 800xA plant specific configuration is transferred directly to the simulator system. This means that operator displays are reused without modifications, offering the trainee operator with an environment identical to that in the running plant control room. Since the simulator uses the same operator graphics and configuration, support of the training workplaces is simple and cost effective.

By providing a fully realistic training environment, all kinds of losses due to human error can be significantly reduced. It also facilitates the certification of operators according to industry standards, for example those in the nuclear power industry, and reduces the risk associated with any specific type of plant.

Because some industries require that the training simulator have 100% realistic and correct behavior, including the mimicking of hardwired operator room panels and switches, the simulator system accommodates physical I/O connections.

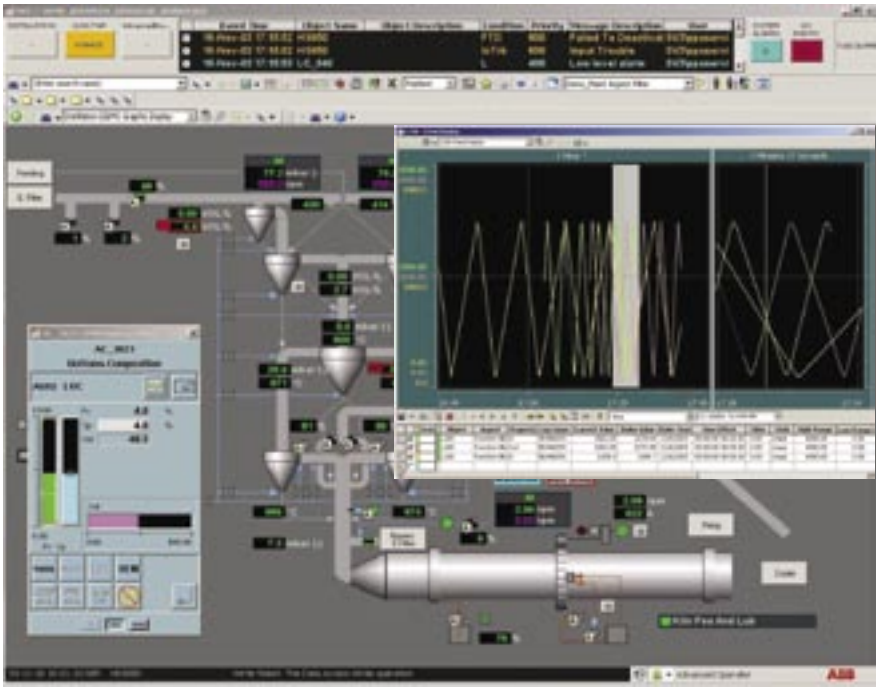


Figure 4. Operator process displays, faceplates, and dialogs are copied directly from the running plant.

Control Logic

The application code is easily transferable between the running plant and the simulator system. As well as supporting training activities, this provides plant engineers a realistic environment for:

- Design and Engineering Simulation for DCS checkout
- Verification of logic changes before implementation in the plant
- Process optimization and modification studies

All of which add up to getting the best performance from plant technology throughout its lifetime.

System 800xA controller applications can be debugged using ITS in Run mode and the controller engineering tool. During debugging applications signals can be changed.

This direct reuse of plant control configuration makes it easy to upgrade a simulator to reflect changes in the running plant. This simplifies engineering and maintenance, and extends the simulator's useful life, thereby reducing overall lifecycle costs.

Simulator Functions

Set-up and operation of the simulator is performed via the Instructor's station. Through this workstation, a wide variety of specific runtime simulator functions are available. These are described below.

Execution Modes

Start and Stop simulation functions will enable and disable simulation mode in the control system. Upon entering simulation mode, all licenses are verified, all components are checked for availability, and the simulated time is synchronized. When in simulation mode, the following functions can be split into two execution modes; 1) Run mode, and 2) Freeze mode:

Run mode features:

- Transfer I/O between controllers and simulator model
- Freeze simulation without bumps
- Save Snapshots in background, SnapshotOnTheFly (cyclic as well as ordered by instructor)
- Time synchronization between simulator model and control system
- Running in Real Time, as well as slower or faster than Real Time

Freeze mode features:

- Save and Load Initial Conditions (ICs)
- Save and Load Snapshots
- Save Snapshots as Initial Conditions
- Resume simulation without bumps

Simulated Time

The Industrial IT Training Simulator uses Actual Time and Simulated Time. All operating system related time stamps are always in Actual Time, for example file system and Windows monitoring, while all control system related time stamps are in Simulated Time, for example event-/alarm-lists and trend logging.

The simulated time stops through Freeze, and is set back/forward through Load Snapshot/IC. Resume will continue the clock with frozen or loaded time.

Inputs to trends and alarm/event lists, together with simulated time, are stopped through the Freeze command. Historical data in Snapshot/IC can be restored through load. When the system Resumes, due to manipulation of simulated time, new process data from the controllers will seamlessly follow the timed data in trends and alarm/event displays.

Simulated functionality also applies for timers in control logic. This means that a timer stops propagating during freeze mode.

After a training or testing session, the simulator can easily be set back to actual time.

Freeze

Freeze is convenient for pausing a training or test session, or is used for any of the Freeze mode features listed above.

When the simulator freezes, both the simulated process and the control logic must stop execution. ITS Link provides a Freeze command that:

- Stops the Control Program execution
- Stops logging historic data
- Stops the Simulated Time
- Stops updating trend displays
- Prevents the operator from changing data
- Synchronizes data flow to ensure system consistency
- Allows the instructor to save and load IC's and Snapshots

An engineer can configure operator views and control logic through the standard engineering tools in System 800xA while the system is in freeze mode.

In addition, the operator can navigate freely to inspect the system and process status. The values of all variables are safely preserved, thus ensuring bumpless Resume of process and control logic.

Resume

After the simulator system has been in freeze mode, the Resume function is used to continue operation. ITS Link ensures bumpless resumption of control system execution with the variables preserved at the freeze point or with those loaded at a restore of a Snapshot/IC. The control system then continues the execution of the process application with either the old or new set of data.

In most cases, one will continue from the simulated time of the freeze. However, in other cases such as resuming after start-up, the instructor can synchronize the control system simulated time with the model by setting the simulation start time.

An additional command argument, SpeedFactor, allows the instructor to set the simulator to run faster or slower than normal real time. This is described in more detail later.

Initial Conditions

Initial Conditions (ICs) are convenient for starting a training or test session at a certain process state, for example 100% production, cold plant or shutdown.

To save or load an Initial Condition (IC), the control system must be in freeze mode. When saving an IC, ITS obtains data consistency by ensuring that each component in the control system stores all dynamic data to file. ITS will use a descriptive file name, as an ID, provided by the Instructor Station for storage and retrieval.

An Initial Condition contains:

- All dynamic data in the controllers
- Event and Alarm Lists, with time stamp and correct Acknowledge state
- Historical data with time stamp

An IC is stored in a format that makes it possible to reuse it after making changes to control logic (see following section - IC Upgrade Tool). ITS can store as many IC's as the system disc space allows.

Snapshots

ITS supports manual instructor initiated snapshots, as well as background snapshots initiated in regular intervals by the Instructor Station. Snapshots are convenient for backtracking to a specific time or state during the training or test session, for instance if the process tripped.

When performing a background snapshot, ITS will briefly, perform an internal freeze, synchronize data flow to ensure data consistency in snapshots, copy the process data, and then resume the system. Note, these actions are performed in the background, and are not noticeable to the operator.

A previously saved snapshot can be restored during Freeze. When saving a Snapshot, ITS ensures that each component in the control system stores all dynamic data to file. The Instructor provides an ID for storage and retrieval. An ID can be reused, in which case, ITS will overwrite the existing Snapshot, and hence offer ring buffer functionality.

A Snapshot contains:

- All dynamic data in the controllers
- Event- and Alarm Lists, with time stamp and correct Acknowledge state
- Historical data with time stamp

A Snapshot will not survive changes to the application. However, a snapshot can be stored as an IC by the instructor.

ITS can store as many Snapshots as the system disc space allows.

Variable Speed

By altering the Speed Factor, the instructor can set the simulator to run faster or slower than real time. This improves training by enabling a student to move quickly through any less interesting steady states, while using the slower than real-time to work through and learn from important process exception states. It is also helpful to execute the application in slower time-steps when a change is being tested.

A fixed maximum Speed Factor is not defined since it is limited by the computers CPU capacity, application size and execution cycles.

Simulated HW

Special features are available for controllers through the Industrial IT Training Simulator. This means that the plant system controllers' hardware definitions are available in the simulator.

The special features for simulated HW can include:

- Soft controllers can automatically re-route the running plant's peer-to-peer communication to the dedicated Soft Controller(s).
- ITS can simulate Sequence of Event (SOE) for I/O that are simulated through OPC DA write requests. Simulated SOE will use the timestamp when the simulated I/O changed its value through a write request, and generate the event/alarm with this timestamp.
- HW system statuses on I/O boards and I/O channels can be simulated through OPC DA write requests.
- A Soft Controller HI can simulate HW of several AC 800M HI controllers. The input signals to a safety module, SM810, can be simulated individually for each AC 800M HI controller that is merged into the Soft Controller HI. This will give identical behaviors of operator access and control logic as on plant.

Physical I/O and Switch Check for AC 800M Series

AC 800M and AC 800M HI physical I/O is supported in the ITS environment. These I/O signals can be used for mimicking control room indicators and switches. ITS also supports a configurable switch check function. This function helps the instructor set all inputs to the correct values when loading a Snapshot or Initial Condition.

Standard I/O modules are connected to AC 800M controllers for the I/O signals. This means that the same I/O modules, as used in the plant, can be used. Physical I/O and switch check are configured through the Transformation Tool, and

controller code to transfer I/O signals between Soft Controllers and real AC800M controllers is generated during the transformation. Switch check is invoked when loading a Snapshot or Initial Condition. It gives indications to the instructor through feedback on real output signals and input signals that need to be changed.

Configuration and Maintenance

Transformation Tool for AC 800M Series

Typically, only parts of the plant will be included in the scope of a training simulator. Industrial IT Training Simulator can select the relevant parts of the actual plant's control logic and controllers, and then reorganize it into the simulator's soft controller configuration. Repeatedly executed transformations are supported with user configurable setups. As the plant and simulator control systems usually have slightly different configurations, for example number of controllers and applications, the user will define a transfer function for moving the plant configuration into the simulator system. This transfer function is saved, and will be used repeatedly by the automated transfer program. Each time the simulator needs to be upgraded, for example after changes, this transfer function will be reused.

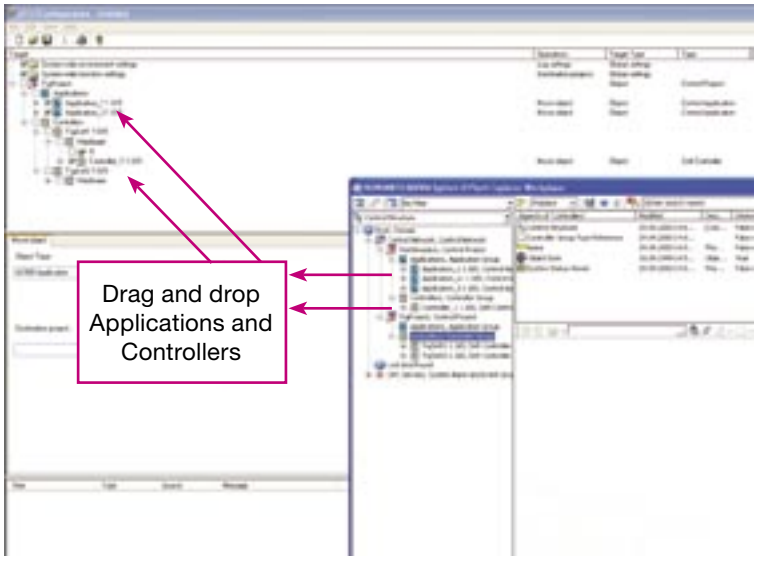


Figure 5. Transformation Tool for AC 800M controllers

ITS's Transformation Tool is used for configuring the parts that are identified in the training simulator's scope. The selected parts are simply dragged and dropped between the running plant's 800xA Control Structure and the Transformation Tool's Control Structure.

The Transformation Tool will generate a file with all I/O that are defined as simulated in the soft controller(s). A model vendor can utilize this when setting up the I/O simulation through OPC Data Access.

In addition to transformation of plant configurations, the tool can transfer simulator configurations between simulator systems. By selecting source systems and target systems, it is possible to make transformations between simulator systems, for example a training system and a development system, or copying Initial Conditions (ICs) between similar simulator systems.

IC Upgrade Tool

Preparation of Initial Conditions (IC) is supported in the ITS tools. This includes upgrade of existing IC's upon control logic changes as well as reset of events and trends.

An engineer may use the offline IC upgrade tool feature to make an existing IC compatible with a changed application. As it may take weeks to arrive at some steady states, this function makes it possible to train on changed control logic in a much shorter time.

It is also possible for the engineer to set/change values of specific variables, such as set points, limits, boundary values etc. within an Initial Condition. Initial Conditions are further described in the preceding section – Simulation Functions.

Interfaces for Process Model and Instructor Station

The physical process I/O in the plant control system is replaced by software signals that are stimulated by a dynamic process model. The process model can be a third party process model from a model vendor, or for simple modelling it can be stimulated through control logic.

I/O flow and simulation commands must be synchronized with an external model. A model vendor can interface and activate simulation functions in System 800xA through an interface based on the Microsoft standard Component Object Model (COM). I/O is stimulated through the OPC Data Access (DA) interface in the 800xA OPC Server. Application specific process models from a large number of vendors have been interfaced to date.

I/O Interface for Model

Process signals are exchanged with a simulator model using the OPC DA standard. Signals can be grouped in different categories with different read and write rates. This is a widely accepted industry standard for communicating data with a control system. In this way, the process signal interface is independent of the model vendor, giving a choice of both ABB and 3rd party application specific solutions.

The 800xA OPC Data Access interface ensures that the Simulator model will relate to one data source only, no matter the complexity of the control system(s) connected to the platform. Un-modelled I/O data may also be written and read through the same OPC DA interface.

An Operator Workplace client can be used to force modelled and un-modelled process values, for example temperatures, flows, pump or valve statuses etc. Alternatively, such overrides can also be performed through the OPC DA interface.

In accordance with the OPC DA Specification, all calls return a status code in general, furthermore read or write operations return a status code per item (tag). Thus, the simulator model should detect this, and initiate a Freeze or stop simulation to prevent negative training.

Simulation Command Interface

The Industrial IT Training Simulator is supported with a simulation command interface through ITS Link. This is convenient for 800xA simulator systems that are integrated with a third party process model. In most of these cases, the system will be supplied with an Instructor Station, where the simulation commands are synchronized and distributed to both the model and the control system.

Simulation manipulations are supported through the ITS Link Interface. This interface is based on the Microsoft Windows standard Component Object Model (COM). Hence, the command interface is independent of the model vendor.

The command repertoire allows the user to synchronize the simulator model and the ITS system. Each command is automatically distributed to all the components of the control system. For example, commands are routed through an ITS aware Connectivity server to the soft controllers.

For every command given from the Instructor Station, there will be an asynchronous response, and the total result of the operation is returned to the caller (i.e. model supplier software), which can present this on the Instructor Station. This response indicates success or failure of the operation. For example, an error could be one component that could not perform the requested operation, or the request timed out. If the operation fails, detailed diagnostic information is written to an error log. ITS Link Interface will detect if the connection with the Instructor Station is lost and immediately distribute a Stop Simulation command to all ITS aware components.

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