

AN ADVERTISING SUPPLEMENT TO

JANUARY/2002

# CONTROL

F O R T H E P R O C E S S I N D U S T R I E S

Leveraging Distributed Intelligence  
Over Plant Networks Brings Power  
and Transparency to Process,  
Advanced, and Batch Control

## CREATING THE DIGITAL PLANT



# FIELD-BASED ARCHITECTURE DRIVES INNOVATION

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**T**oday, there is an automation architecture that enables unprecedented value for manufacturers. This architecture makes full use of the substantial intelligence found in a wide array of field devices and communicates it via digital bus technology. The result is a digital automation architecture that lets manufacturers wring the most out of their capital equipment investments. They can now operate more reliably and stay within process constraints better than ever before. We call this technology the PlantWeb architecture. The DeltaV digital automation system and Asset Management Solutions (AMS) are key components of that architecture.



The DeltaV system's capabilities directly challenge some traditionally held automation beliefs. Advanced control is no longer difficult to implement and maintain. Efficient automation no longer requires proprietary operating systems and hardware. Fieldbus technology is running mission-critical applications around the globe. Batch software configuration and data tracking are no longer burdensome tasks. Today, users of PlantWeb technologies are proving that yesterday's approaches have been superseded with a new and easy approach to achieving better results from the plant.

This digital automation architecture is also now fully field-proven in well over a thousand installations worldwide. Several of these successes are reported here. These installations have all reported resounding successes. Rapid customer adoption of this technology has allowed our business to grow steadily—even throughout the recent global business downturn. Today, as the business results of using the PlantWeb architecture are realized in installation after installation, we expect the adoption of these technologies to accelerate.

Customers have reported three-to-one benefit-to-cost ratios for their PlantWeb architecture investments. We're so confident in the benefits of this technology that we guarantee installed cost savings. Find out the details at <http://www.EmersonProcess.com/PlantWeb/guarantee>.

TOM SNEAD, PRESIDENT  
FISHER-ROSEMOUNT SYSTEMS

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TODAY'S DIGITAL AUTOMATION SYSTEMS  
AND PLANT NETWORKS MAKE OPERATIONS  
TRANSPARENT DOWN TO THE SENSORS

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XML AND OPC OPEN DIGITAL CONTROL TO  
MULTIPLE PLATFORMS, LEGACY SYSTEMS,  
AND THIRD-PARTY APPLICATIONS

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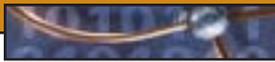
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# PROCESS CONTROL REDEFINED

## TODAY'S DIGITAL AUTOMATION SYSTEMS AND PLANT NETWORKS MAKE OPERATIONS TRANSPARENT DOWN TO THE SENSORS

In traditional DCS and PLC-based control systems, sensors provide signals to controllers, which in turn send signals to actuators. With communication limited to those process signals, operators, engineers, and plant control systems have to assume that everything is working properly. They have no easy way to determine if a valve stem seal is wearing out, process piping is getting clogged, motors are running hot, or similar problems are happening.

Today, however, the combination of smart instrumentation and digital bus architectures, like Emerson Process Management's PlantWeb architecture ([www.PlantWeb.com](http://www.PlantWeb.com)), allows operators and engineers to keep much better tabs on field devices. Instrumentation is available that will inform operators when it is having problems and requires attention from maintenance people. In some cases, the device even tells the operator exactly what the problem is, and what should be done about it.

But the digital plant goes far beyond just simplifying maintenance and installation. With data being collected from smart sensors, instrumentation, and controllers, and with digital networks to gather it all up, a modern plant has access to vast amounts of useful and informative data that it can use for asset management, plant optimization, and predictive maintenance.

### The Wired Plant

Over the years, dozens of different buses have emerged on the market. Originally, process control, PLC, and instrument companies invented proprietary buses to link their own equipment. In recent times, the trend has been toward development of more universal, non-proprietary buses, but users are still faced with a bewildering array of open and standard buses.

For fieldbus applications alone, eight different buses were accepted by the IEC. None of these fieldbuses can talk to each other, so it is very difficult for an end user to mix and match systems. The end user has to select one of the eight fieldbuses and stick with it.

As always happens in such situations, end users deter-

mine which systems work best, and the market rules. For process control—not discrete factory automation, which is a totally different environment—the users have spoken (Figure 1). A comprehensive system may use sensor, device, and fieldbuses in a hierarchical configuration (Figure 2).

### Sensor Buses Do Discrete

The lowest level sensor bus involves discrete or on-off field instruments, and the buses involved tend to be very simple. The Actuator Sensor Interface (AS-i) bus, for example, collects only four bits of information from devices on the bus. Each bit corresponds to a channel in the device and indicates if it is on or off. Some AS-i devices also report the status of the values. Other sensor buses often used in process applications include LonWorks and Seriplex.

Devices that are usually connected to a sensor bus include proximity switches, level switches, on-off valves, solenoids, and other devices that are either on or off, or working or not working. While the amount of information being supplied is minimal, the benefits are substantial.

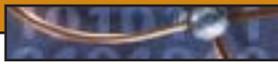
The first benefit is that the information is actually available. Before, if a discrete device (such as a level switch) failed, the results either were immediately apparent because a tank overflowed, or went unnoticed. Today, when a device fails, you know about it immediately because a status indication changes.

Second, a sensor bus simplifies field wiring. Jim Mitchell, principal process engineer for Cognis Corp., Hoboken, N.J., recently completed the installation of a batch and continuous digital automation system. "We are running four AS-i bus segments, with a total of 31 devices," says Mitchell. "We chose AS-i because just about every on-off valve or motor we needed was available in an AS-i version, which made it easy to find devices."

Mitchell points out that a major advantage of AS-i bus is the decreased wiring. "The system we replaced had hard-wired valves," he reports. "Every valve had three pairs of wires that ran from the controller to the field. We replaced all that with a single wire pair that connected all the devices on each segment."

### Device Buses Link Components

Mid-level or device buses include systems such as CAN, ControlNet, DeviceNet, and Profibus-DP. In many cases,



this bus is determined first. This is because these buses control activities of motor control centers (MCCs), starters, and drives. Therefore, when a control system is being considered, the device bus looms large in process planning. Once this decision is made, the MCC/drive bus becomes the standard for the plant, because most end users do not want to support multiple device buses.

Device buses provide much more intelligence than sensor buses. They also provide information that formerly was not available to an operator or a control system. For the first time, an operator can access information such as current draw, how hot motors are running, motor speed, and other data. The device bus provides a richer set of diagnostics to the digital automation system.

In addition to motors and drives, several other systems and components can be attached. These include local operator panels, overload relays, pushbutton and switch stations, classic I/O bricks, and analog transmitters. In discrete automation applications, a device bus is often used to link many of the PLC-related subsystems together, but in a process plant running a sensor bus and fieldbus, almost all of the plant I/O is handled by the digital automation system, not the PLC.

In some plants, in fact, the PLC shares I/O with the existing DCS via gateways to the process I/O or fieldbus system.

Controllers on a device bus—such as MCCs or PLCs—can communicate with on-off devices on the sensor bus via gateways. For DCSs and PLCs, communicating with the sensor bus through a gateway on the device bus loses direct contact with the sensor I/O. Digital automation systems communicate directly with both the device bus and the sensor bus with native interfaces.

If the automation system uses the device bus gateway to get to the I/O, it must have internal maps that identify where the sensors are located. This can be very difficult, especially if assignments change in the future. It is far better to connect directly to the sensor bus.

### Fieldbuses Raise Functionality

The third and highest level is the most complex, and offers the most benefits for a digital automation system. Although there are eight approved fieldbuses, only three are being widely used for process control, with Foundation fieldbus topping the list. A fieldbus connects smart instruments in the field to each other and to a digital automation system.

The huge advantage of a fieldbus architecture is that it easily connects an array of plant instrumentation from

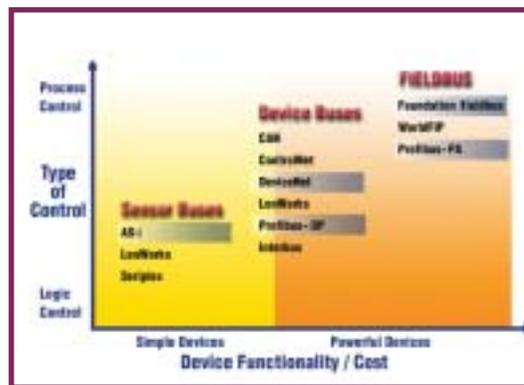
multiple vendors. They simply plug together.

Jim Mitchell also uses the DeltaV digital automation system with Foundation fieldbus at his Hoboken plant, so he has been through a startup. “One of the best features of Foundation fieldbus is that you can ask vendors to tag the devices you order,” he explains. “For example, I can order a valve, and ask the vendor to set the ID to, say, SV08901. When the valve gets here, we install it in the field, plug the actuator into the fieldbus, and the fieldbus immediately recognizes it as SV08901.”

When Cognis installed the automation system, it took about a month to do all the mechanical work, such as installing valves, transmitters, and other instrumentation on four fieldbus segments and four AS-i segments. Once everything was ready, Mitchell reports that commissioning took about four hours.

The reason that systems go together so easily is because they are tested and certified as being fieldbus-compatible. At the Fieldbus Foundation ([www.fieldbusfoundation.org](http://www.fieldbusfoundation.org)), for example, every device must pass a battery of

**FIGURE 1: END USERS HAVE SPOKEN**



There are several buses being used today in process control, with the most popular ones highlighted.

exhaustive tests to demonstrate that it does, indeed, meet the standard and that it interfaces properly. More than 100 different devices have passed the tests.

Of the eight buses, Foundation fieldbus appears to have gained the most support from the process industry, for three reasons:

- It was designed for process control from the beginning.
- It is a worldwide standard.
- It is vendor-neutral, favoring no particular company.

The standard is not controlled by a single vendor, but by the independent, nonprofit Fieldbus Foundation, which



has more than 100 members, including users and major process automation suppliers from around the world. Approximately 100,000 Foundation fieldbus devices are now in service, with more than 4,000 Foundation fieldbus-compliant systems on order or installed around the world.

Devices that conform to Foundation fieldbus standards are intelligent. Their built-in microprocessors make it possible to accomplish much more than just simple

## HART Helps

HART networks are another form of fieldbus that works quite well in the digital plant. Virtually every field instrument and control device built today for process control has a HART interface along with its 4-20 mA analog signal. In a HART device, digital data and status information are encoded into the analog signal, and can be extracted by handheld calibration devices or plug-in monitors.

Over the years, plants have discovered they can use HART-based systems to perform a limited amount of local control, obtain additional process data such as temperatures, and analyze problems such as hunting valves caused by poorly tuned loops.

With every instrument and system in the plant communicating from sensor buses, device buses, fieldbus, and HART, it is possible to acquire a huge amount of data concerning plant operations and system health, and use the data for asset management, predictive maintenance, and plant optimization.

## Using the Data

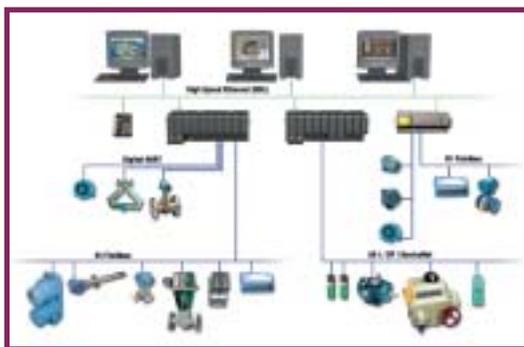
Access to information opens up many opportunities to run a plant more efficiently. For example, a continuous production plant may take several days to come back online after an unexpected shutdown, causing a significant financial impact. Today's intelligent instruments can report problems through the digital automation system directly to the technician and log them in the maintenance package. Problems can be fixed before a plant upset condition occurs.

The maintenance check also tells the technician what to look for. "We used to go to the field, hook up to the device, and look to see what was wrong," says Mike Chipowski, instrument engineer at Vopak, Galena Park, Texas. "Now, we can see immediately from our DeltaV system what is wrong with the instrument. What used to take 40 to 45 minutes now takes five to 10 minutes."

Such data can also be automatically collected in asset management software (AMS) to keep better track of all plant assets, maintenance requirements, analysis, and troubleshooting. (Go to [www.AssetWeb.com](http://www.AssetWeb.com) for more details.)

"Without AMS, maintenance would have to shut down the process for four or five hours to replace a valve that was in perfectly good working condition," says an engineer at Goldschmidt Chemical Corp. "The cost would have been more than just for the replacement valve and the crew's time; it would have included several thousand dollars per hour of lost production time. Having the asset management capability enabled us to avoid those costs." ❏

**FIGURE 2: LAYERED ARCHITECTURE**

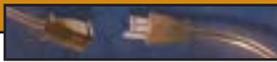


The emerging communications scheme is a three-tier network with a sensor bus (such as AS-i) on the bottom, a device network (e.g. DeviceNet) in the middle, and a control network (Foundation fieldbus) on the top.

instrumentation and loop control. The devices can talk to each other, so they can be configured using Foundation fieldbus techniques to perform complex control tasks.

For example, Foundation fieldbus temperature, flow, and pressure transmitters can be configured to perform a complex cascade control function with no intervention from the host automation system. This puts control out in the field, where some engineers prefer it to be, and adds a level of security and safety to the plant—if something were to happen to the host system or plant communications, a fieldbus system can continue to operate safely.

With the large number of standardized products available, it would seem easy to assemble such a system and run it with a PC or PLC. "We discovered we could certainly run the plant from a PLC, but interfacing to the plant buses would be very hard," Mitchell reports. "With a PLC, we would have to acquire, learn, and configure at least four different software interface packages to connect to the buses we use. Instead of trying to splice all these systems together, we used a DeltaV system, which comes with native interfaces to all the popular buses such as Foundation fieldbus, Profibus-DP, AS-i, DeviceNet, and HART."



# COTS WHERE IT COUNTS

Commercial off-the-shelf (COTS) technologies are the way of the present and future for control systems. Today's digital automation systems make extensive use of COTS in many areas including operating systems, workstation platforms, and data exchange standards. Using COTS technologies enables cost-effective systems that are truly open to other computing and control systems.

This article focuses on two COTS data exchange standards: Extensible Markup Language (XML) and Object Linking and Embedding for Process Control (OPC). OPC and XML allow control and monitoring software products to communicate with other hardware and software products in a seamless manner. These standards can be easily implemented because they are widely used and supported by large numbers of vendors, software developers, and end users.

Many users perceive the major automation vendors as hostile to open systems. Although this may be the case with some vendors, others leverage COTS technologies wherever possible. Emerson Process Management was an early adopter of COTS products and is a leading proponent of COTS technologies. "In 1995, the DeltaV digital automation system adopted Ethernet for its control network, enabling customers to use standard network cards, switches, and hubs," says Ram Ramachandran, director of product marketing at Emerson. "More recently, we have embraced XML technology to integrate with enterprise-wide resource planning and execution systems."

Use of COTS hardware and software allows Emerson to leverage general technological advances to provide price and performance benefits to its customers. "We focus our technology resources on providing value-added benefits to our customers rather than reinventing the wheel," adds Ramachandran.

## XML Eases Data Exchange

XML is a data definition standard used as the primary medium for business data interchange in virtually every industry. It was created so richly structured documents could be sent and received via the web. Documents created with XML can be served to users via the web and accessed through standard browsers.

Many of the large enterprise resource planning systems

## XML AND OPC OPEN DIGITAL CONTROL TO MULTIPLE PLATFORMS, LEGACY SYSTEMS, AND THIRD-PARTY APPLICATIONS

have embraced XML as an open communication interface. Using XML technology, automation users can easily exchange production information from the DeltaV system with business applications like SAP R/3, Oracle 8i, and PeopleSoft 8.

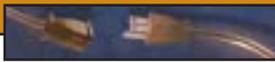
Each industry defines its own set of XML schemas, which are basically different dialects of the XML language. For example, the petrochemical industry uses PetroXML as a standard schema for transmitting information among industry participants. A schema simplifies data exchange in an industry by constraining the content of XML documents to the types of information normally exchanged in that industry.

"DeltaV EasyIT products leverage XML as the primary mechanism for disseminating transactional information from the process automation environment to external applications," explains Dave Deitz, Emerson DeltaV Batch and EasyIT product manager.

A wide variety of DeltaV EasyIT applications and enterprise-level computing systems make use of XML (Figure 1). These applications can be linked to each other via an XML transaction server such as Microsoft BizTalk Server 2000. BizTalk can accommodate many different data types including XML, SQL, and binary files, and can provide communications over both company intranets and the Internet.

One of the primary advantages of using XML in EasyIT products is the wide variety of XML tools. "In addition to Microsoft's BizTalk product, there are a number of other companies, for example Data Junction, that have tools for translating XML data for different applications and for coordinating the flow of that information to various parts of the enterprise," Deitz says. "These tools provide users with a great deal of flexibility in developing solutions that meet their business requirements."

"XML is a very well promoted and supported platform for data integration and analysis," says Rafael de la Torre, head of process control and information systems, Atlas Paper Mills, Hialeah, Fla. "It is an excellent way to store and



describe data. The different dialects (schemas) being created by manufacturers' associations will simplify XML use."

### COTS Simplifies Device Maintenance

Maintenance is performed on a preventive and/or a reactive basis in many process plants. Scheduled maintenance programs are wasteful because some devices are checked too often and others not often enough. Reactive maintenance means device problems are not addressed until device failure, often causing lost production.

**FIGURE 1: EXTRACT VIA XML**



DeltaV EasyIT and other applications can be linked via an XML transaction server such as BizTalk to handle different data types (XML, SQL, binary, etc.) and communicate over intranets and the Internet.

Predictive maintenance eliminates the time and expense of scheduled maintenance and ensures that reactive maintenance is minimized. "Foundation fieldbus devices from Emerson, part of the PlantWeb architecture, are very intelligent and can perform a variety of diagnostics, which in some cases extend beyond the device and into the process," explains Ramachandran.

A Rosemount pressure transmitter can detect a plugged impulse line and report the condition to the DeltaV system. A Fisher Controls digital valve controller can detect failure conditions such as loss of air supply or failure of the I/P drive. It can also detect possible maintenance conditions such as excessive valve travel or when temperature exceeds a specified limit. The valve controller can report all of these conditions to the DeltaV system.

The DeltaV system can display these types of alerts in the operator interface software along with instructions on how to fix the problem. Ramachandran adds, "More importantly, the DeltaV system can send the device alert

information, called PlantWeb alerts, to a maintenance management system using our EasyIT products. The maintenance system can proactively generate a work order with the details of the device and the nature of the problem. This alleviates the need to periodically check the status of the devices and the costly troubleshooting needed to identify the problem."

The digital automation system can also send out a device alert as an XML message to an XML transaction server. "The transaction server can be used to map and route the device alerts to a pager, cell phone, or a PDA. With Windows XP, these XML transactions can be routed to Windows Messenger for integration with your passport," says Ramachandran. "This data exchange can be easily created through simple drag-and-drop graphical-configuration routines."

### Accessing ERP

Many companies are implementing just-in-time manufacturing strategies to reduce inventories and improve the use of capital in their production facilities. These firms have made significant investments in ERP systems.

One function of the ERP system is the ability to schedule production at one or more facilities based on incoming orders. To make efficient use of these capabilities, the digital automation system used in the production facility must allow the ERP system to automatically schedule production runs or campaigns.

The DeltaV Campaign Manager addresses that need via XML technologies. "Campaign Manager provides the ability to programmatically schedule campaigns for execution by the DeltaV system," says Ramachandran. "The ERP system delivers an XML document containing the campaign definition to the DeltaV system. The Campaign Manager then schedules the campaign within the DeltaV Batch software." The system also provides the status of the various campaigns in an XML format that can be viewed through an Internet browser or PDA.

### OPC Enables Interfaces

OPC is a standard data exchange mechanism for communication among process control components (Figure 2). Emerson Process Management is one of the founders and creators of the OPC specification. "OPC has been a part of the DeltaV system since the first OPC specification was released back in 1996," says Chris Felts, Emerson product manager, DeltaV OPC and historian products. He says DeltaV was the first automation system to incorporate the OPC Data Access specification as a stan-



dard product offering. “As the master editor of the OPC Data Access specification, Emerson Process Management knows OPC.”

There are now more than 250 members of the OPC Foundation ([www.opcfoundation.org](http://www.opcfoundation.org)). More than 450 products are available in the OPC Foundation catalog including servers, clients, and server/client development tools. OPC-compliant products are clients, servers, or both. Servers typically originate and provide data to clients, for example, an OPC-compliant loop controller.

OPC clients receive data from OPC servers; and OPC clients can also send commands, setpoints, and other information to OPC servers. The DeltaV system has both OPC client and OPC server capabilities.

Emerson Process Management also provides OPC Mirror to enable OPC server-to-OPC server communications. “The OPC Mirror application is a unique OPC Data Access client application that allows two or more OPC Data Access servers to communicate with each other,” explains Felts. A “lite” version of the OPC Mirror is freely downloadable from [www.EasyDeltaV.com/OPCMirror](http://www.EasyDeltaV.com/OPCMirror).

There are several OPC standards that address different aspects of real-time data communication for the process industry. “The specifications are fairly self-explanatory: OPC Data Access for process data, OPC Alarms and Events for alarm and event data, OPC Historical Data Access for historical data, and OPC Batch for batch data,” adds Felts. “However, when people talk about OPC in a general sense, they are usually referring to OPC Data Access, as this was the first OPC specification published.”

### OPC Integrates Alarms and Events

Emerson Process Management makes extensive use of the client and server functionality incorporated in the OPC Data Access and Alarms and Events standards. One type of application uses an OPC Alarms and Events client called Plantwide Event Historian (PEH). PEH provides a common data repository for all plant alarm and event data by providing an OPC Alarms and Events client interface to OPC Alarms and Events servers.

A typical process plant might have a DeltaV system controlling the main plant, a safety system controlling the burner management system, a legacy control system controlling an older section of the plant, and several PLCs controlling an off-site material handling system. With PEH, Emerson can integrate the alarms and events from all of these systems (as long as each has an OPC Alarms and Events server) into one common Microsoft SQL database for viewing and archiving.

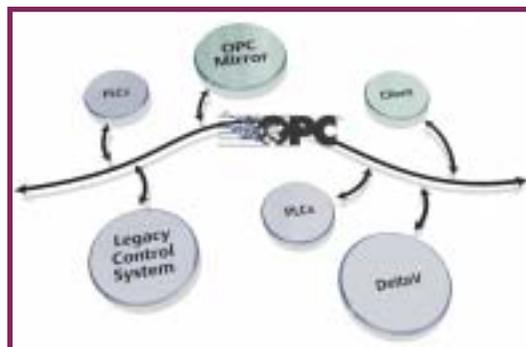
With this system, the operator does not have to monitor multiple alarm screens on multiple systems. Operators do not have to analyze the sequence of events and to determine what caused the plant shutdown by filtering through alarm summaries from each system. PEH has all of this data organized and integrated, and has all the tools needed for viewing, filtering, and managing this data.

Process plants have been implementing custom data integration strategies for decades, but OPC offers vast improvement over custom solutions. Instead of having to develop and maintain individual drivers for each system or device, OPC allows all the systems to talk together using one common protocol.

Custom software is not needed. Hardware suppliers provide an OPC server or OPC client with their devices, the end user connects all the OPC-compatible devices together, and the OPC standard ensures interoperability.

OPC is now the standard for real-time plant communication. All the major process equipment vendors provide OPC-compliant devices and many software houses develop and sell OPC-compliant software for some of the more obscure or legacy control systems.

**FIGURE 2: OPEN WITH OPC**



OPC lets DeltaV digital automation systems, legacy DCSs, PLCs, RTUs, and single-loop controllers talk among themselves and with enterprise-level systems.

Consider a scenario using a number of COTS technologies to provide seamless data integration. “A control system could expose data from Foundation fieldbus field devices via OPC,” says de la Torre. “An application would then send this data over XML to a maintenance application that would schedule maintenance based on production schedules. The maintenance application would be linked to customer and supplier information via XML through BizTalk.”

# ADVANCED CONTROL BECOMES EASY

THE DIGITAL AUTOMATION SYSTEM HELPS

ELIMINATE PROBLEMS THAT PLAGUE

CONVENTIONAL IMPLEMENTATIONS

Users have long been aware that advanced control algorithms and techniques can improve throughput, increase quality, and decrease energy costs. However, the cost and complexity of these applications have tended to impede their widespread use.

Emerson Process Management can now help users easily deploy advanced control solutions through its DeltaV digital automation system and the PlantWeb architecture built on Foundation fieldbus. Emerson and DeltaV

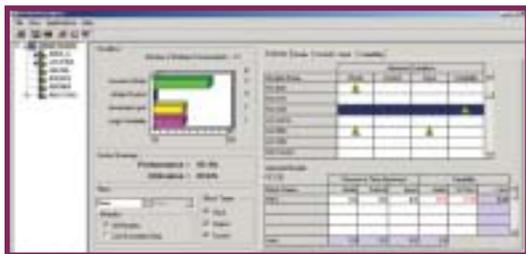
performing control loops (Figure 1). "With Inspect, plant personnel can walk up to a workstation and know exactly where to start fixing their control problems," says Darrin Kuchle, advanced controls product manager, Emerson Process Management.

Users without Inspect typically rely on manual searching or custom-built performance calculations to identify control loop problems. "Inspect extends the capabilities of an operator by watching all control loops at the same time for offending conditions," explains Kuchle. "Without Inspect, only the control loops that cause process alarms draw the attention of the operator." With the proper tools, those problems can be detected much earlier, minimizing their impact.

Inspect can monitor any control loop for improper mode, limited control, uncertain process variable, and/or excess variability. Excess variability compares actual performance to best possible performance by automatically calculating a variability index. Inspect by default monitors every loop in the system and continually looks for new ones as they are added.

"Inspect basically tells the user where to spend time in order to make the most improvement possible. Rather than wait for control problems to manifest themselves as alarms or shutdowns, users can proactively solve problems using data provided by Inspect," says Kuchle. "Inspect is the executive overview for the status of a process plant and an automation system." The package identifies automation system problems, and other DeltaV applications correct these problems.

**FIGURE 1: INTERNAL VIGILANCE**



DeltaV Inspect continually and automatically identifies poorly performing control loops, preventing problems and saving a lot of searching for causes.

embedded advanced control products support this deployment and include Inspect, Tune, Fuzzy, Predict, Neural, DeltaV Simulate Suite, e-fficiency.com, and RTO+ Real Time Optimization.

This article focuses on DeltaV applications Inspect, Tune, Fuzzy, and Predict, which deliver tremendous process benefits along with simple implementation and automatic integration through the DeltaV system.

## Where's the Problem?

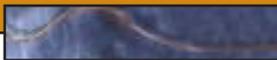
The first step to implementing advanced control solutions is problem identification. Some control loops have obvious problems, but many others have subtle problems that often go undetected. Inspect running on a DeltaV workstation continually and automatically identifies poorly

## Anything You Can Tune I Can Tune Better

A typical process plant has many improperly tuned control loops. Many of these loops have been taken out of automatic mode by operators and are run in manual. These improperly tuned and manual loops cost process plants untold sums in reduced throughput, poor quality, and excess downtime.

A user of DeltaV Inspect typically identifies a loop that needs tuning. DeltaV diagnostics along with fieldbus components can be used to analyze loop components prior to loop tuning. A loop cannot be properly tuned if it includes a sticky valve or a malfunctioning transmitter (Figure 2).

After loop components are analyzed, DeltaV Tune



addresses and corrects loop-tuning problems by testing the process and determining proper tuning parameters. These parameters can be either automatically applied to the loop or manually applied by an operator after additional verification. Tune can be used to tune loops controlled by PID or by DeltaV fuzzy algorithms.

“Tune is typically used where proper tuning will reduce variability and/or minimize overshoot and integrated absolute error in the event of a setpoint change or disturbance,” says Kuchle. “Since some loops with complex dynamics are difficult to tune by hand, many users find it much quicker to use Tune rather than play ‘what if’ by manually tweaking gain, rate, and reset parameters.”

One of the most powerful applications of Tune is for users commissioning DeltaV fuzzy logic control blocks as a replacement for PID. “Learning the principles of fuzzy math can be a daunting task for most of us—myself included, so Emerson has actually built in the ability for Tune to set up fuzzy rules, apply weightings, and manage scaling factors,” continues Kuchle.

DeltaV Tune can optimize the performance of PID and fuzzy control algorithms, but many process control loops cannot be successfully controlled with these techniques. In cases with complex dynamics or process interactions, engineers can turn to another DeltaV advanced control product: DeltaV Predict.

### Bring Us Your Toughest Loops

DeltaV Predict is a multivariable model-predictive control (MPC) module. Unlike PID or fuzzy logic, MPC can simultaneously control multiple process variables through multiple outputs (Figure 3). Predict takes into account the interaction of several controlled and manipulated variables.

There are clear cases where MPC will outperform standard PID or fuzzy logic:

- Processes with a long dead time, a characteristic of many temperature loops.
- Processes with one or more measured disturbances.
- Processes with multiple loop interactions. Control of one loop may inadvertently affect one or more other loops. Multivariable MPC was developed mainly to address these applications.

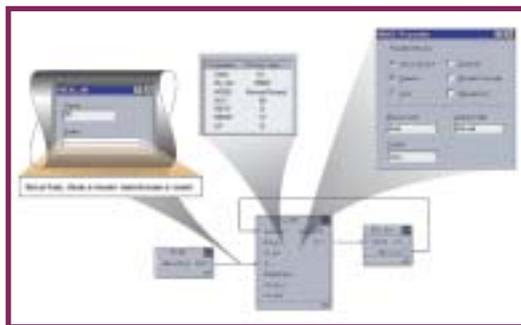
Some common applications for MPC are distillation columns, heat exchangers, evaporators, dryers, boiler drum levels, reformers, and kilns.

Canfor Corp., an integrated forest products company based in Vancouver, British Columbia, recently implemented Predict on a lime mud kiln at its Northwood Pulp mill in Prince George, British Columbia. The lime kiln

converts lime mud (composed primarily of calcium carbonate and water) into calcium oxide (lime) that can be used in the recausticizing process to produce white liquor.

Relatively large amounts of energy are required in the calcination process to fully recover the spent lime, so the

**FIGURE 2: INTELLIGENT TRIAGE**



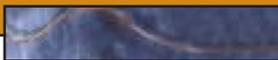
**A loop cannot be properly tuned if it includes a sticky valve or a malfunctioning transmitter. DeltaV diagnostics and fieldbus devices can be used to analyze components before tuning.**

lime kiln is a prime target for control optimization. The fact that the controlled parameters are highly coupled with very difficult dynamics (long process dead times and time constants) makes the kiln a good candidate for MPC.

Multiple Predict MPC blocks were implemented. “The application at Northwood included control for front-end temperature, back-end temperature, excess O<sub>2</sub>, and lime mud flow as an optimized variable,” says Terrance Chmelyk, control engineer, Norpac Controls, Prince George, British Columbia. Norpac is the sole sales and service representative for Emerson Process Management in British Columbia. “The strategy includes a 2x1 MPC Predict block cascaded onto a 5x3 MPC Predict block along with constraints and disturbance inputs.”

Implementation was straightforward. “There has been substantial reduction in variability of the controlled parameters—specifically, front-end temperature, back-end temperature, and excess O<sub>2</sub>. This reduction in process variability yields more uniform lime quality,” explains Chmelyk. “Overall efficiency of the lime kiln has improved since the start of the project and, as a result, there has been a reduction in energy usage.”

DeltaV, Predict, and other Emerson products brought benefits in addition to process improvements. “As is often the case when one undertakes a project to improve a control system and optimize a process, the performance of the field equipment became a real focus,” observes Dave



Sordi, P.Eng., a process control engineer with Canfor in Prince George. “Instrumentation and mechanical equipment received some necessary upgrades. In addition, the extra information the complete control package presents to the operators, such as real-time energy efficiency, allows them to truly optimize the process.

“We are indeed very pleased with the outcome thus far. The robustness of the control exceeds all expectation. The

## Clear Up Problems With Fuzzy

DeltaV Fuzzy is another control method that can be successful in many situations where PID control is difficult. Fuzzy logic control with the DeltaV system is implemented with a simple function block. DeltaV Fuzzy modules can be combined with DeltaV Tune to automatically generate the correct fuzzy logic tuning parameters. This removes much of the effort normally required to implement fuzzy logic control.

The Dixie Group uses DeltaV Fuzzy on a carpet drying oven. Carpet travels through the oven and temperatures have to be adjusted to evenly dry the product. “Due to the nature of the changes and their frequency, we needed to adjust temperatures and control them as fast as possible with minimal or no overshoot,” explains Francisco Campa, a process development engineer with Dixie in Calhoun, Ga.

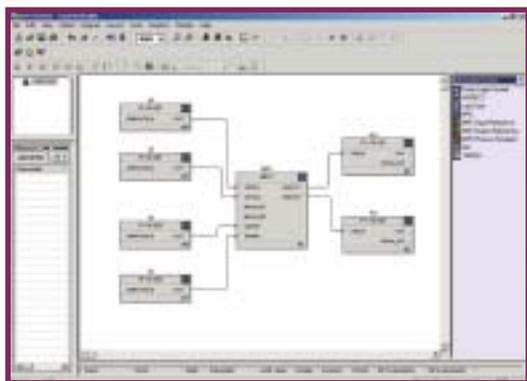
Replacing PID control with Fuzzy improved oven operation. “We are now able to process different products sequentially because we know the dryer will respond fast enough to the new settings,” adds Campa. “We have increased throughput, eliminated off-quality and damaged products, and reduced reprocessing.”

DeltaV Fuzzy is also applied in paper machine applications that traditionally use “big valve/little valve” control methodology. The little valve provides final trim control and the big valve provides coarse control. Two specific applications on a recent project were the dryer section header pressure control and the high-density stock chest consistency control.

In both cases, the primary goal of the big valve control was to remain at an operating point where the little valve could operate in its sweet spot. “This control is usually performed by either a gap controller or by an integral-only controller,” says Stewart. “The gap controller only makes an adjustment when the small valve is outside of the desired range. The integral-only controller adjusts continually but sluggishly because of the lack of proportional or derivative action.”

Using a properly tuned Fuzzy controller in place of the gap or integral controller allows continual adjustment of the valve position control with quicker response and minimum overshoot. “Basis-weight variability decreased immediately after installing the DeltaV Fuzzy controller,” Stewart adds. “Reducing the variability of consistency at the high-density chest decreased propagation of variation from the high-density stock chest to the reel. Pressure variations in the dryer sections also decreased.”

**FIGURE 3: COOL CALCULATION**

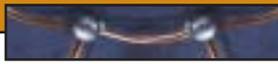


**DeltaV Predict multivariable predictive control (MPC) can simultaneously control multiple process variables through multiple outputs, taking into account interaction of several controlled and manipulated variables.**

system even seems to perform optimally when burning four different fuels concurrently,” adds Sordi. “To date, we are achieving near 100% control program uptime.”

DeltaV Predict often can succeed in areas where PID control alone may not be optimal, such as this paper machine application. “pH was being controlled on a blend chest in a paper machine by controlling acid flow to the top of the chest, where it was mixed with the stock. The pH measurement was taken at the pump discharge. The process had a four-minute dead time and a 25-minute first-order time constant,” says Wade Stewart, PE, product manager for paper machine automation for Orion CEM, a division of Emerson Process Management in Alpharetta, Ga.

Previous efforts to control the pH used a cascade arrangement with two single-loop controllers (pH cascading to acid flow control). It was not possible to tune the loop satisfactorily. Operators adjusted the acid flow periodically if the pH was too high or too low. After commissioning the loop using DeltaV Predict, at a setpoint of 8.0 the controller was able to maintain the pH between 7.95 and 8.05.



# BATCH CAN BE SEAMLESS

## BUILT-FOR-BATCH ARCHITECTURE

## PROVIDES AN INTEGRATED ENGINEERING

## ENVIRONMENT TO MAKE BATCH EASY

Continuing evolution in software, standards, and practices has brought the process control world to the era of the seamless batch, and today's digital automation systems make implementation much more straightforward than the patchwork solutions of the past.

Emerson Process Management's DeltaV system provides an integrated batch-control environment built on current industry standards. Control Activity models, as well as terminology used throughout the system, are based on the ISA S88.01 batch manufacturing standard. The suite of applications provides recipe management (configuration), batch execution, production planning and scheduling (campaign management), and process information management (batch history analysis and reporting) capabilities (Figure 1).

### Recipe Management

The software is integrated so that every recipe, phase, procedure and batch execution is linked. This makes it possible to create a recipe, schedule it, track it through the process, and produce all necessary compliance reports.

Following the S88 Control Activity Model for Process Control and Unit Supervision, DeltaV Batch software allows easy configuration of control modules, unit modules, and unit phases. Phase logic is constructed graphically using IEC 61131-3-compliant Sequential Function Charts (SFCs).

Phase logic can be designed using aliases for equipment names, variables, and so on, to create generic control logic that can be used repeatedly on similar equipment. Mark Rouch, process control engineer at Coors Brewing, Golden, Colo., has made great use of this function. "We have nine brewing lines, and each line goes through seven separate units," he explains. "With aliases, we can define recipes only one time, and then use them on any of the units."

Following the S88 Control Activity Model for Recipe Management, DeltaV Recipe Studio allows users to define recipe configurations (procedures, unit procedures, and operations) in an offline environment. Procedural elements are configured with similar tools and techniques used to construct basic level process control strategies. Drag-and-drop, point-and-click, and simple browsing tools help users maneuver in the recipe application. Hierarchical and object attribute views offer additional information to the user and bring more power to the engineer.

"We were pleased that it is so easy to program," says Jose Rentas, project engineer at IPR Pharmaceuticals, Guayama, Puerto Rico. IPR installed a DeltaV system last year to replace an aging legacy control system. "We have 20 operators here, and only 10 were trained on the system. The other 10 picked it up by themselves, just by watching and learning."

Procedural control models are based on the ISA S88.01 batch manufacturing standard. Procedures, unit procedures, and operations are constructed graphically using IEC 61131-3-compliant Procedural Function Charts (PFCs). A single, object-oriented database eliminates the need for managing and synchronizing configuration data across multiple configuration databases.

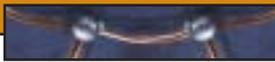
Whenever any element of the configuration database is modified, the DeltaV Configuration Audit Trail and Version Management software tracks it. Information captured by the audit trail includes who made the change, the date and time the change was made, the exact scope of the change, and any comments entered by the engineer making the change. This functionality has been provided to support the requirements of the FDA's 21 CFR Part 11, OSHA, and ISO 9000.

"It maintains an accurate paper trail," says Rentas. "With the embedded history and audit trail, we can track down any problems or difficulties in a batch."

### Batch Execution

Control modules and phases that perform basic control actions are executed in the DeltaV controller. Procedures, unit procedures, and operations coordinate the execution of the phase logic and are executed by the Batch Executive, which passes recipe data to phases running in the DeltaV controllers and reads back report data from the phases. These events, along with all other recipe execution activities, are automatically generated and collected by the Batch Executive to provide detailed batch historical records.

At Coors, the coordination problem is magnified because each of its nine brewing lines has three DeltaV



controllers. "We have to make 27 DeltaV processors cooperate with each other and hand recipes over from one unit to the next," says Rouch. "The DeltaV Batch Executive software and database work together to accomplish this."

Recipes, formulas, and parameters developed in Recipe Studio are downloaded to the Batch Executive after recipe configuration. During execution, the Batch Executive coordinates the execution of individual unit phases, coordinates resource arbitration, and automatically captures recipe execution data. All events and runtime data are stored in files that can be read by the Batch Historian or accessed from the Batch Operator Interface.

An operator can monitor recipe execution online from a PC or workstation, enter data, or respond to prompts. Operator actions are often needed during a batch to confirm that certain actions have taken place, verify that manual phases have been completed (manually adding an ingredient, for example), or re-allocate equipment. When operator intervention is required, the system may be configured to require a user-name/password-based electronic signature. The electronic signature mechanism provided in DeltaV has been implemented to support the requirements defined in 21 CFR Part 11. DeltaV's embedded security system ensures that only authorized individuals are allowed to interact with the control system.

An electronic operator log replaces the old paper log-book. The operator can make comments about the batch, which are added to the batch history.

### **Production Planning and Scheduling**

A campaign is a series of batches that might define the production for a shift, a day, or a week. With the DeltaV Campaign Manager software, setting up a campaign is a fairly simple matter that could take just a few minutes at the workstation.

For production planning and scheduling, the DeltaV Campaign Manager can be used to schedule multiple batches. The tight integration of Campaign Manager with the DeltaV Batch configuration tools and DeltaV Batch Executive allows the user to define and create campaigns with minimal effort.

The Campaign Manager also includes a comprehensive application programming interface (API) that allows users to develop applications to interact with the Campaign Manager Executive. For example, an enterprise resource planning (ERP) system, such as SAP, running in the corporate headquarters, could create a production schedule for execution in one of its production facilities. The ERP system then transmits the production schedule to the

Campaign Manager API, which in turn adds the new production schedule to its campaign list.

In addition to the API, the Campaign Manager also has an extensible markup language (XML) interface that is defined by an XML schema. In this case, if the ERP system also has an XML interface, the ERP system could use the Campaign Manager's XML schema to structure the production schedule data for input into the Campaign Manager.

Campaign Manager is integrated into the DeltaV software suite, so it works with data generated by the recipe and configuration tools and the Batch Executive. To create a campaign, the user simply provides the necessary security information, specifies the number of batches to be executed, and selects the recipe, formula, and equipment to be used to execute the campaign.

If requirements change, Campaign Manager permits extensive modifications by adding or removing batches or by changing recipe, formula, or equipment specifications.

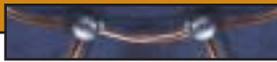
### **Production Information Management**

DeltaV Batch Historian is a configuration-free, batch-based data collection tool. It provides non-intrusive, automated collection of recipe execution data from the DeltaV Batch Executive and process event data from the DeltaV Event Chronicle, the data repository for DeltaV system events.

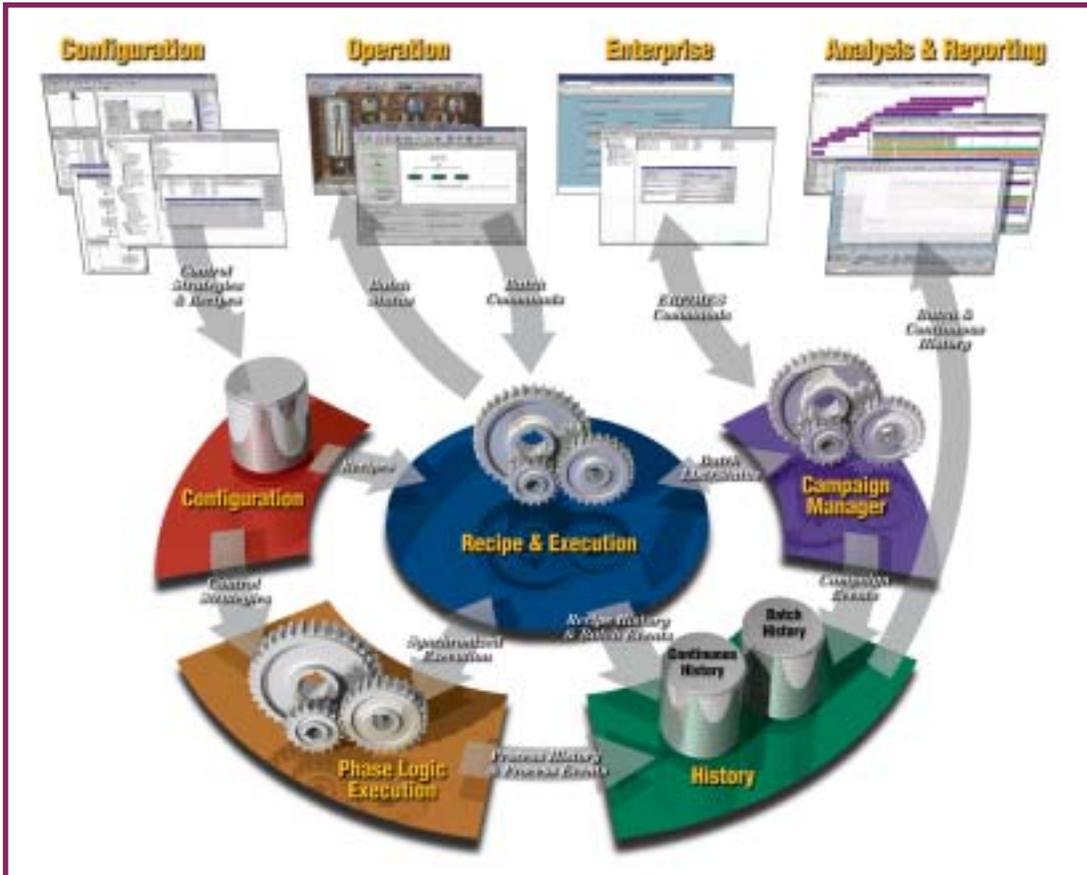
Historical data is viewed graphically using the Batch History View application or one of the other Batch Historian client tools provided with the software. These tools include out-of-the-box batch reports that are generated in the form of MS Word documents, predefined database queries, and a database management interface for manually or automatically archiving data to local or remote mass storage. Batch History View provides graphical views of batch history based on the S88.01 procedural model. It allows the user to generate batch-based process trends from a single, integrated interface as well as perform batch-to-batch comparisons.

While all this sounds simple, it is a complex task that is often beyond the ability of conventional control systems. "We were looking for a new batch system because our PLC-based systems simply could not keep with the data requirements any more," relates Rouch. "As databases get bigger and reporting requirements increase, control gets more difficult to accomplish with local devices. We wanted a homogenous solution that handled everything from control to historians."

Once configured, the entire data collection and archiving process is completely automatic. Data collection includes recipe execution data, such as phase start and end



**FIGURE 1: BEARING THE STANDARD**



The DeltaV S88.01-compliant engineering and operation environment integrates recipe, batch execution, campaign management, and historical applications with each other and with information systems.

times, formula values, and operator inputs; batch data, such as batch ID and operator comments; and event data, such as process alarms, system events, and operator actions.

The Batch Historian also works with the DeltaV Continuous Historian to display continuous process data in the Batch History View. As a batch executes, the Batch Historian captures the batch start and stop times and uses these times to query the Continuous Historian for any continuous process data that occurred during this time period. Through the Batch History View, the batch operator is able to view and analyze all batch and related continuous data. For example, the temperature in a reactor can be analyzed during the execution of a batch to determine if the quality of the product will be acceptable. The Continuous Historian uses PI Server from OSIsoft, the leading continuous data collection application in the process industry.

### Built for Batch

The DeltaV system is widely used by leading pharmaceutical and chemical companies. For example, the top 24 pharmaceutical companies have DeltaV systems, and 17 have multiple systems. Eighteen of the top 24 specialty chemical companies have DeltaV systems, and 16 have more than one.

IPR Pharmaceuticals is so pleased with their system, they are planning to convert their remaining legacy systems.

DeltaV batch is scalable and can handle virtually any size of batch control process. It is currently being used in facilities that vary in size from a couple hundred I/O to more than 14,000 I/O.

The reason the DeltaV System has become so popular is because it was built for batch, so it makes batch control as simple and seamless as possible for the end user. ❏