PLC to DeltaV™ Systems Migration

This document describes PLC to DeltaV™ system integration and methods for migrating PLC functions to a DeltaV system.

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Introduction

Programmable Logic Controller (PLC) service in process industries began as an alternative to hardwired relay systems for sequencing controls and safety systems. PLC usage increased with the addition of analog control capability. As Original Equipment Manufacturers (OEM's) adapted skid based equipment to include pre-engineered PLC's, this convenient equipment and controls combination propagated rapidly.

Sites implementing skids from different OEM suppliers may have an array of PLC models with various control, Human Machine Interface (HMI), alarm, and historian packages. Upgrading such PLC's tends to be cost prohibitive, as OEM PLC's typically have minimum control and data capabilities to meet a price point.

Thousands of PLC's are approaching 100,000 hours in service, over 11 years of continuous operation. Beyond this age, higher failure rates are likely and replacement parts availability is declining. PLC replacement in kind will likely add a second control platform, which includes separate controller and HMI databases. Whereas, modernizing with a new automation system, such as the DeltaV™ system consolidates configuration of the HMI and controllers in a single database. Other advantages include data integration, asset management, advanced controls, and improved diagnostics.

This paper examines techniques for PLC to DeltaV system modernization through integration or migration. Integration refers to a physical connection and software application for passing data between your older PLC and a new DeltaV system. Migration implies removing functionality from your PLC based system and implementing it in a new DeltaV system. Solutions may combine integration and migration. For example, one may migrate critical PLC shutdown logic into a new DeltaV SIS application, and for non-critical plant areas, integrate PLC I/O with DeltaV controllers.

We first will examine integration methodologies and supporting technologies, followed by migration options and transition services.

Integration Options

Integration between two control systems requires communication protocols and hardware devices compatible with each end control device. For DeltaV system integration, three widely used protocols are Serial, Industrial Ethernet and Object Linking and Embedding for Process Control (OPC). Here we present typical architectures and applications supported by each of these protocols, specifically for data exchange with PLC based systems.

Serial

Since the 1970s, serial interfaces have connected PLC's and other devices to control systems. Serial integration is a proven communication method with countless industrial applications. Serial, by far, is the most widely applied system integration communications protocol.

Physically, the serial interface connects a DeltaV serial card to a PLC serial communication module, for a single or multiple PLC network nodes, as shown in Figures 1 and 2.

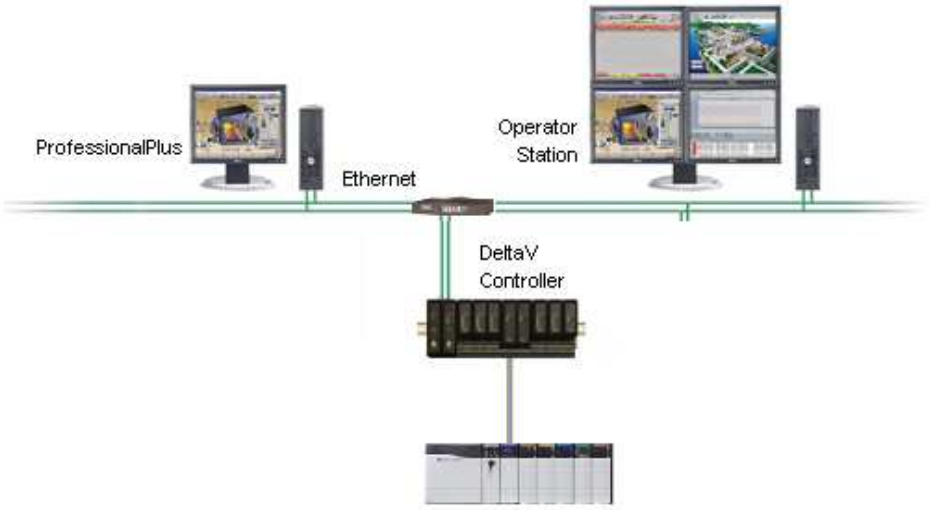

Figure 1— DeltaV™ serial connectivity to a PLC

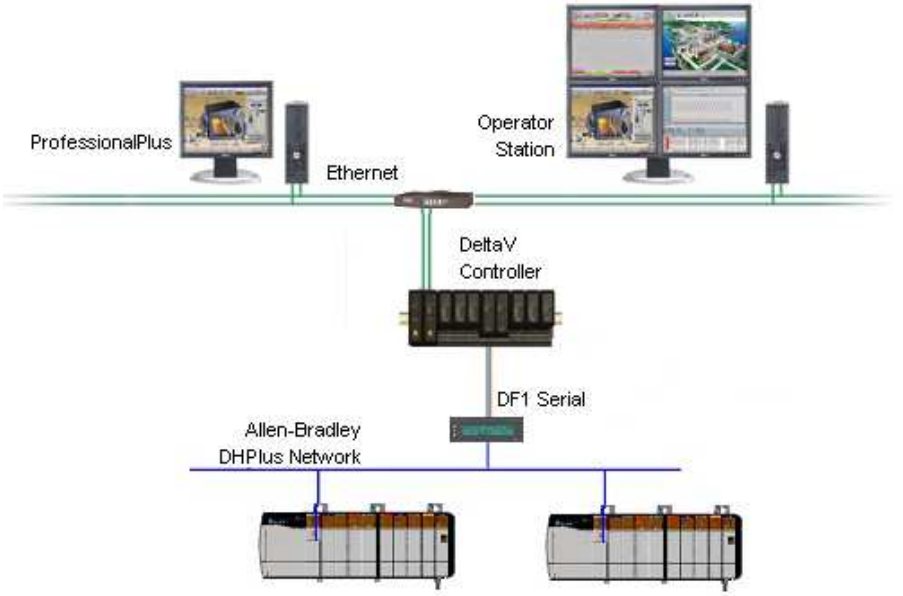

Figure 2— DeltaV™ serial connectivity to a PLC Network

Tight integration provided by a serial link enables you to implement a wide variety of functions in the DeltaV system. You can keep regulatory control in the PLC or change its programming so it becomes an I/O multiplexer.

Example applications for serial connectivity are shown in the following table:

DeltaV system role	DeltaV Device	PLC CPU Role
Advanced Control	Workstation or Controller	Continues regulatory control
Advanced Batch		
Supervisory Operations	Controller	
Regulatory Control		Changes to I/O multiplexer

You may combine these DeltaV applications. Another option is to expand DeltaV control functions and utilize any spare PLC I/O capacity.

DeltaV serial cards support 128 PLC datasets, with 100 registers per dataset and can be installed as simplex or redundant. Serial interface is an economical, stable, easy to use integration method for data rates of ~100 data values/second.

Industrial Ethernet

Industrial Ethernet offers a step up from serial communications, with greater speed, increased capacity, faster response, and peer-to-peer architecture. Unlike Information Technology (IT) Ethernet, *Industrial* Ethernet utilizes rugged Commercial Off The Shelf (COTS) equipment, often in redundant configuration, for higher reliability in harsh environments. Because it is a switched network with a high bandwidth, Industrial IP has few contention issues.

Higher speed, faster response time, and increased capacity of Industrial Ethernet introduce additional complexity, installation and configuration costs when compared to serial communications. Industrial Ethernet is less deterministic than serial buses originally designed for machine control.

Three open protocols widely used for Industrial Ethernet Local Area Networks (LANs) are Modbus/TCP, Ethernet/IP, and Profinet I/O. The first two are utilized in the lion's share of DeltaV system integrations with PLC based systems. Data rates for these protocols range from 10-100 Mbps.

- *Modbus/TCP* is an Ethernet version of Schneider Electric's Modbus® protocol. Modbus/TCP is used for non-PLC products, as well as PLC's.

- *Ethernet/IP* applies the Common Industrial Protocol (CIP) over TCP/IP, and is most often used to integrate Rockwell PLC's.

Other Industrial Ethernet protocols are available for specific applications, including FOUNDATION™ Fieldbus High Speed Ethernet (HSE) for process control.

Note: Industrial Ethernet is always installed physically and electrically separate from the DeltaV Ethernet based Area Control Network (ACN).

To bring Industrial Ethernet into the DeltaV system, a *Virtual I/O Module (VIM) Gateway* is installed in either simplex or redundant configuration. This technology is flexible, easy to implement, and allows high speed signaling between PLC controller(s) and a DeltaV controller backplane.

A VIM Gateway provides tight integration, keeps the PLC in operation and makes available new operational capabilities such as the following:

DeltaV system role	DeltaV Device	PLC CPU Role
Advanced Control	Workstation or Controller	Continues regulatory control
Advanced Batch		
Supervisory Operations	Controller	
Regulatory Control		Changes to I/O multiplexer

You may combine these DeltaV applications. Another option is to expand DeltaV control functions and utilize any spare PLC I/O capacity. Over 300 VIM implementations are installed and performing well.

The VIM supports 128 datasets, 100 registers per dataset. Scan rate is 100 ms for 16 datasets and 32 IP user-configurable addresses. An Ethernet interface card fits into the DeltaV rack as does a DeltaV serial interface card, and emulates up to four serial cards. VIM architecture is shown in Figures 3 and 4.

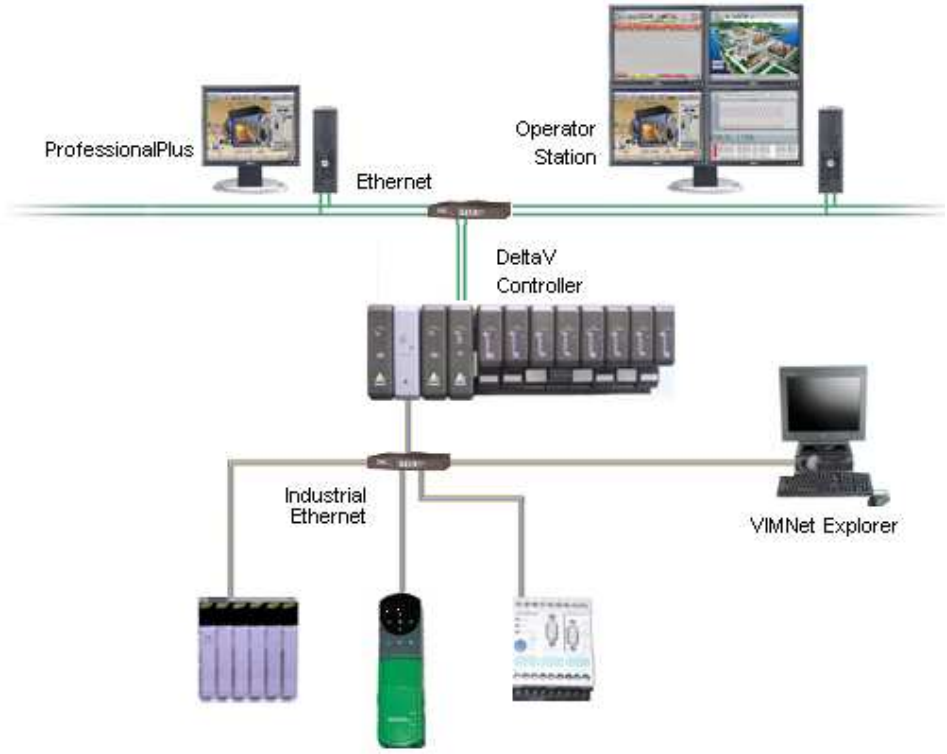

Figure 3— DeltaV™ Industrial Ethernet connectivity to third-party devices

Figure 4— DeltaV™ controller with Virtual I/O Module Gateway

OLE for Process Control (OPC)

OPC provides open connectivity in industrial automation as well as enterprise wide applications, allowing otherwise incompatible equipment to communicate via a common data format. OPC has become an accepted standard for process automation. As such, OPC servers are readily available for many PLC's.

To implement an OPC interface between a PLC and DeltaV system, you need a PLC OPC server, residing in a PC node on the PLC network (Ethernet LAN), plus a DeltaV OPC Server and DeltaV OPC Mirror. DeltaV OPC Mirror enables data read/write between OPC servers.

DeltaV OPC software runs in a DeltaV Application Station or other workstation with OPC server capability. DeltaV OPC architecture is shown in Figure 5.

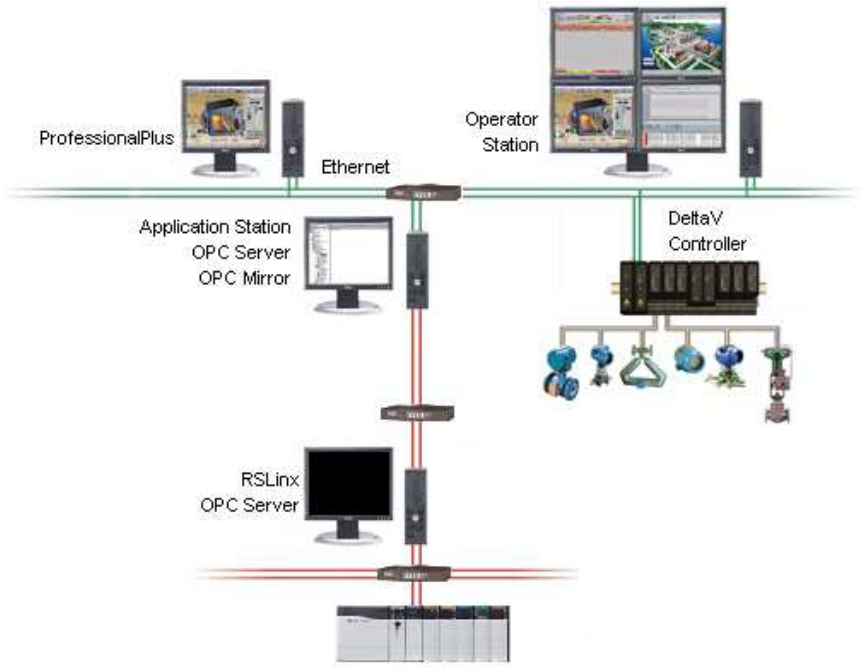

Figure 5— DeltaV™ OPC connectivity to a PLC

OPC connectivity offers speed, seamless integration with Microsoft and other OLE compliant applications, reduced integration costs because proprietary drivers need not be created, and the ability to talk to a wide range of equipment and devices for which OPC servers have been written.

OPC integration keeps your PLC in operation and supports operations including the following:

DeltaV system role	DeltaV Device	PLC CPU Role
Advanced Control	Workstation or Controller	Continues regulatory control
Advanced Batch		
Supervisory Operations	Workstation	

Comparison of Serial, Industrial Ethernet and OPC

The following table summarizes specifications for serial, Industrial Ethernet and OPC communication protocols.

	Serial	Industrial Ethernet	OPC
Network Protocol	Modbus, DF1	Modbus/TCP, Ethernet/IP	Varies
Capacity per Unit	3200 registers 100 registers/dataset	12,800 registers 100 registers/dataset	30,000 parameters
Network Speed	19.2 kbaud typical, 115 kbaud max	10 Mbaud	Varies, based on network architecture
Data Throughput	1000 ms per dataset	100 ms for 16 datasets	5000 parameters/s
Stability	High	Medium – High	Medium – Low
Redundancy	Yes	Yes	Possible
Ease-of-Use	High	High	Low
Cost	1X	2 – 3X	4X Plus

Next is a discussion of how these protocols enable you to keep some PLC based system components in service, while modernizing others as you move automation functions into a DeltaV system.

Migration Options

Visualize a migration continuum, beginning with a standalone PLC based system, with no ties to another process automation platform. The end point has no PLC; functions formerly performed by the PLC are implemented in a DeltaV system. The DeltaV system shares process and equipment data with business and maintenance systems for predictive diagnostics, quality assurance, and resource management.

In determining the best route for your system migration, consider these intermediate phases, shown in Figure 6, which allow you to extend useful service of some PLC components during modernization.

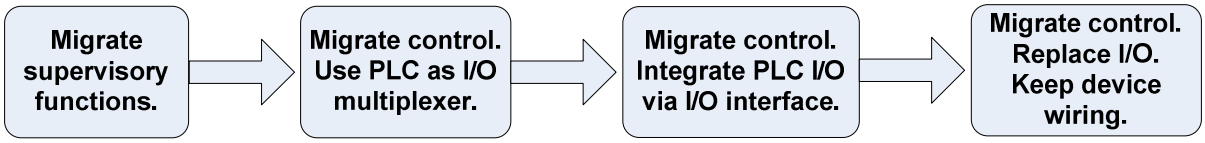

Figure 6— Migration Phases

Migrate Supervisory Functions

In the DeltaV system, you can implement supervisory functions to work in concert with (continued) regulatory control executing in the PLC. Example *supervisory applications* include *operator actions, advanced control, batch/recipe control and history collection*. These DeltaV applications utilize serial, Industrial Ethernet or OPC protocols and require minimal or no changes to PLC application code. Some PLC's require additional blocks to support specific communication protocols. These are indicated as "Application Code Changes" in the following table.

Solution: Migrate Supervisory Control		
PLC	**Networks**	**Application Code Changes**
PLC-5® PLC-3®	Ethernet/IP or Data Highway Plus™ (DH+™)	None
SLC™505		None[1]
RSLogix™		None
Modicon® Quantum™	Modbus/TCP, Modbus Serial, or Modbus Plus	None
Modicon® 984		None
Series 90™-30	Modbus/TCP IC693CMM321 rev FH or later	None
S5, TI500, TI505	TIWAY NITP[2] Serial Driver to UNILINK Host Adapter	None
S7	Modbus/TCP CP 343-1/443-1	Add Modbus blocks

1- If previous MMI used a different network, such as RSLinx™, code changes may be required
2-Non–Intelligent Terminal Protocol (NITP)

Migrate Control – Use PLC as I/O Multiplexer

When you are ready to migrate controller logic and regulatory control, as well as supervisory functions, you may want to continue using the PLC as a multiplexer, to keep I/O in service. Serial and Industrial Ethernet protocols support this option. I/O addresses are assigned to internal PLC memory registers, which get mapped to DeltaV I/O. The following table lists networks and mapping details for specific PLC's.

Solution: Migrate Control – Use PLC as I/O Multiplexer		
PLC	**Networks**	**Application Code Changes**
PLC-5® PLC-3®	Ethernet/IP or DH+	Map I/O to I, O, and N-tables
SLC™505		
RSLogix™	Modbus/TCP, Serial, or Modbus Plus	Map I/O to I, O, and N-tables or ENBT slots
Modicon® Quantum™	Modbus/TCP, Modbus Serial, or Modbus Plus	Map I/O to registers
Modicon® 984		
Series 90™-30	Modbus/TCP, IC693CMM321 rev FH or later	
S7	Modbus/TCP, CP 343-1/443-1	Map I/O to Modbus blocks

Migrate Control – Integrate PLC I/O via I/O Interface

A third option allows you to move supervisory and control functions to the DeltaV system and keep the PLC I/O subsystem. You bypass, and can remove the PLC CPU. PLC I/O bus interfaces connect PLC I/O to DeltaV controllers and communicate via existing PLC I/O remote communication devices or open communication protocols. Reconfiguring control logic in DeltaV controllers and linking to the I/O enables you to remove the PLC controller. I/O bus interfaces include industry standards, such as PROFIBUS DP and DeviceNet™ communication networks, as well as specific DeltaV I/O interfaces for three families of PLC I/O, Allen-Bradley 1771, Modicon S908 and GE Genius (also known as TRIO).

This table summarizes the PLC's which have I/O interface capability with DeltaV systems.

Solution: Migrate Control – Integrate PLC I/O via I/O Interface	
PLC	**PLC IO Interface**
PLC-5® PLC-3®	PLC IO Interface for 1771 Remote I/O_1
RSLogix™	FlexIO with Ethernet/IP or DeviceNet™
Modicon® Quantum™	PLC IO Interface for S908 Remote I/O_1 or Modbus/TCP
Modicon® 984	PLC IO Interface for S908 Remote IO_1 (for 800 Series I/O only)
Series 90™-30	PLC IO Interface for Genius I/O_2
Series 90-70	
S5, TI500, TI505	PROFIBUS DP to SIMATIC® 505 PROFIBUS-DP Remote Base Controller (RBC)
S7	PROFIBUS DP

1-Rebuild I/O configuration 2-Rebuild I/O configuration using auto-configure utility

PROFIBUS DP and DeviceNet™ I/O

PLC I/O modules can directly integrate into a DeltaV controller, using native DeltaV PROFIBUS DP or DeviceNet I/O cards. PROFIBUS hardware and configuration software are available for TI 500 and TI 505 I/O, ABB S800 I/O and Siemens ET200 I/O. Similarly, a DeviceNet interface is available for Rockwell FlexIO.

Emerson Process Management offers "Proof of Solution" services to reduce risks associated with standard digital bus device integration. This service includes analysis of all communication parameters and signal diagnostics.

PLC IO Interface

The PLC IO interface is based on the proprietary protocol of several common installed older PLC I/O systems. The solution leaves in place the PLC I/O and communicates via remote I/O communication protocol using the PLC IO interface. PLC I/O to DeltaV controller communications utilize Modbus/TCP and a VIM, which communicates with up to four PLC IO interfaces. VIM modules and PLC IO interfaces can be redundant. Simplex I/O interface architecture is shown in Figure 7.

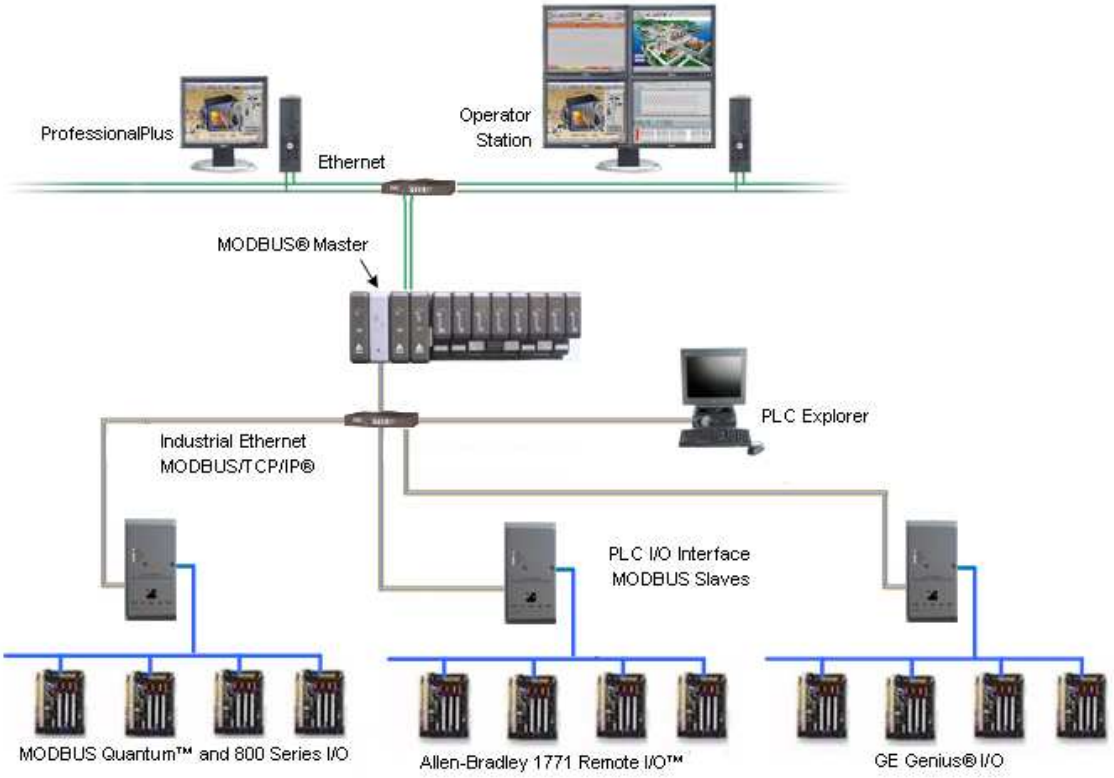

Figure 7— DeltaV™ PLC IO Interface connectivity to three families of I/O

PLC IO interface specifications:

- Allen-Bradley 1771 Remote IO Interface
    - Supports diagnostic functions for 1771 Remote I/O
    - Modules each support up to 32 remote I/O racks
    - Functions as a remote I/O master/scanner
    - Is applicable for Allen-Bradley PLC5 and PLC3
- Modicon S908 Remote IO Interface
    - Supports 800-Series and Quantum I/O
    - Supports device diagnostic information, housekeeping tasks of initialization and fault management
    - Modules each support up to 32 remote I/O drops
        - 800-Series I/O – Each drop has five 16-slot racks
        - Quantum I/O – Each drop has four 16-slot racks
    - Is applicable for Modicon PLC's and Novatech (formerly GSE) D3 systems

- GE Genius IO Bus
    - Functions as Genius I/O Bus Controller
    - Supports device diagnostic information, housekeeping tasks of initialization and fault management
    - Supports 31 nodes of I/O blocks and bus controllers including Genius blocks, Field Control I/O Stations, and Series 90-70 Remote I/O Scanner
    - Is applicable for GE PLC's and ABB MOD300 (TRIO I/O)

Migrate Control – Replace I/O – Keep Device Wiring

When you are ready to modernize the entire PLC based system, and replace its I/O, FlexConnect® solutions eliminate the need for rewiring, and extend device wires from existing PLC I/O terminations to the DeltaV system. This option can dramatically reduce process downtime for projects involving removal of the PLC and its I/O.

Advantages include:

- HART® device management at the glass. By combining DeltaV I/O card HART® pass-through capability and Asset Management System (AMS) software, DeltaV operator workstations or dedicated maintenance workstations become the window to device parameters and diagnostics.
- Reduce wiring labor and material costs by 50% over the effort required to re-wire to the new system.
- Reduce process downtime by 75%, with faster checkout of I/O and minimal device out of service time.

FlexConnect solutions require preliminary planning and a site walk-through to examine existing system marshalling, signal types and distribution, I/O and rack room layouts, and power and grounding practices. Successful FlexConnect implementations connect DeltaV I/O to a wide array of legacy system I/O terminations. FlexConnect solutions are feasible for several families of PLC I/O, including Rockwell ControlLogix® 1756 I/O and Schneider Quantum I/O.

Transition Services

Database Conversion

Transferring PLC I/O and control configuration data to a DeltaV system requires careful oversight by engineers who understand both systems. Emerson Process Management migration teams:

- Are well versed in control database, logic, and special applications.
- Understand configuration and programming in DeltaV systems and PLC based systems.
- Provide design services.

Display Conversion

Recreating PLC displays to have a familiar look and feel on the new DeltaV system is one way to smooth the learning curve for operations personnel. However, developing new displays may be more advantageous, as this presents an opportunity to incorporate advanced graphic technologies with graphic standards and operating philosophies pertinent to this application, industry, and site. Whether using new designs or following the original display layout, PLC style faceplates may easily be implemented and can accelerate operator learning.

Managing Risk

Emerson Process Management and its alliance partners have an excellent track record of helping clients improve business results through modernization. Emerson engineers and project managers have implemented efficient system configuration, successful hot cutovers, site checkouts and system startups during tight turnaround periods. Through these experiences, Emerson has developed a suite of tools and services to ensure success in control system transitions. With these tools and services, Emerson project teams effectively address and contain risks associated with each stage of the project to meet budget and schedule requirements.

Method and scope of project will vary, based on factors such as: legacy PLC type, database size, modernization objectives and strategy, resource availability, budget and schedule constraints. Common milestones in successful modernization projects include:

- **Site Assessment and Modernization Study**. A modernization study delivers a report of business benefits, including Return On Investment (ROI) made possible through process optimization, or other technology enabled techniques for improved efficiencies or reduced variability.

- **Front End Engineering Design (FEED) study**. The FEED delivers essential plans that significantly reduce risks of downstream implementation delays and cost increases.

- **Design and Implementation**. As mentioned above, modernization is most efficiently accomplished by engineers who know the older system, as well as the newer. Emerson offers such expertise for PLC migration to the DeltaV system.

- **Factory Acceptance Test (FAT)**. The FAT confirms new system control and operate functions are aligned with documented requirements. MiMiC®, an I/O simulation application allows testers to manipulate I/O, accelerates testing and gives added confidence in the DeltaV configuration.

- **Effective Training** ensures rapid adoption of newer technologies. Once DeltaV database and graphics are built and tested, operator training tools are available on the new system. DeltaV Simulate Pro generates realistic field responses to operator actions without connecting to hardware I/O. In a safe and virtually risk-free environment, operators can practice running a familiar process from new DeltaV workstations. Also, Emerson customizes training solutions to meet site specific needs. Custom and standard coursers are available at your site or in an Emerson training center. For more information about these effective training options, please visit DeltaV Operator Training Solutions at http://www2.emersonprocess.com/en-US/brands/edservices/deltavots/Pages/DeltaVOTS.aspx.

Summary

Emerson personnel are at your service, to assist with evaluating, justifying, planning and implementing your PLC modernization. By applying field tested and proven interfaces, you can keep viable components of the legacy PLC system in place while expanding data integration capabilities and improving operational efficiencies. Teaming with Emerson lowers risks associated with project execution, personnel training, commissioning and startup. These principles are depicted in Figure 8.

Figure 8— Emerson provides a bridge for successful system modernization

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