The Integration of DCS I/O to an Existing PLC

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CPS, DCS, PLC, I/O

ABSTRACT

At the NASA Glenn Research Center (GRC), Existing Programmable Logic Controller (PLC) I/O was replaced with Distributed Control System (DCS) I/O, while keeping the existing PLC sequence Logic. The reason for integration of the PLC logic and DCS I/O, along with the evaluation of the resulting system is the subject of this paper. The pros and cons of the old system and new upgrade are described, including operator workstation screen update times. Detail of the physical layout and the communication between the PLC, the DCS I/O and the operator workstations are illustrated. The complex characteristics of a central process control system and the plan to remove the PLC processors in future upgrades is also discussed.

INTRODUCTION

Until about 2000, PLC I/O was used in the NASA Glenn Research Center's Central Process System Distributed Control System to provide remote control and monitoring of process equipment. For many years, these devices were the core of process I/O at the facility. As new industrial control and communication technologies emerged, the benefits of improving traditional I/O schemes for newer approaches became attractive. For this reason, NASA recently replaced several PLC I/O with DCS I/O hardware while keeping the PLC processor in order to evaluate the interoperability of this new technology.

The new technology provides improved throughput speed from the I/O to the operator screens. There are many attributes to a data point now including diagnostic capability and calibration.

Plant Description

The Central Process System (CPS) at NASA Glenn provides combustion air (to 1250 Psig), altitude exhaust (to 90,000 ft), atmospheric exhaust, refrigerated air (to -90 Deg F), cooling tower water, and

service air to for the major wind tunnels and propulsion test facilities at Glenn. The CPS consists of 20 miles of process piping and 600 valves to interface the above systems to the various test facilities. A DCS/PLC/Pressure and Surge Controller system consisting of nearly 100 PID Control loops and over 12,000 I/O points provides monitoring and control for the vast amount of equipment across the facility. Over 12 miles of dual redundant data highway cable is installed to interface the control/data system for these essential services.

Original System Operation

Historically, the equipment for control and monitoring of the process consisted of a PLC processor and its associated I/O distributed near process equipment. The PLC communicated to the DCS controller via Modbus RTU Protocol. The DCS controller then communicated to the operator console via a proprietary data highway.

Reasons for Conversion to DCS I/O

Although the existing I/O was adequate at one time, reasons for its replacement became more apparent as the technology changed. While the existing I/O was readily available in the 1990's, more recently parts for repair and replacement were difficult to find. Although an upgrade to the new replacement PLC I/O was available, it provided none of the benefits of the DCS I/O.   The DCS I/O provided much faster speed and a "Quality Status" which was not available on a Modbus RTU serial link with a transmission rate of 19200 baud.

The choice was to either replace the entire PLC System with DCS System at one time which required massive logic conversion and testing or perform a two phase implementation approach. The first phase would replace the PLC I/O with DCS I/O. Then the second phase would involve converting the PLC logic to DCS logic.

The split approach was chosen to minimize downtime and prevent a complicated check-out process.

Hardware Installation

The components for this application include new DCS controller, DCS I/O and new 24 V dual redundant power supplies for the I/O. The PLC processor remained and communicated strictly to the old DCS controller, which in turn communicated to the new DCS controller that talked to the new DCS I/O. Like with the old system, the primary function of the new system is to provide process control of the equipment via the DCS, which is made available to operators at a remote location. The basic system architecture is shown in Figure 1, page 5.

In all cases, existing wiring could be reused as part of the new scheme. The new I/O was mounted in the existing I/O space. The old field wires were terminated on the new I/O.

The 24 V I/O power supplies were installed in an existing cabinet. A new DCS Controller, connected to the new DCS I/O via Fiber, was installed in the same cabinet as the old DCS controller. The new DCS controller communicates to the old DCS Controller via a backplane that provided a local control highway within the cabinet.

Software Installation

The software for this application included DCS controller software that allowed communication between the old DCS controller and the new DCS controller. The PLC receives the necessary data for sequence logic from the new DCS controller. No field I/O connects to the PLC. All PID algorithms are processed in the new DCS controller and Pressure and Surge Controllers, which communicated to the old DCS Controller via Modbus.

System Architecture

The new DCS I/O is installed in the current PLC I/O location. Wires from the field were removed from the PLC I/O and re-terminated on the new DCS I/O. The new DCS I/O connects to the new DCS Controller via a Fiber Optics Network. The old DCS Controller utilizes a custom Foreign Device Interface "C" program and Modbus RTU protocol to communicate to the PLC. The old and new DCS controller communicate to the Operator Console via a Proprietary Data Highway.

One of the powerful features of the new I/O is the troubleshooting capability via DCS diagnostic and it also provides Bad Quality Status on the operator console in the case of signal failure. With the old PLC I/O system analog data was converted to digital counts (0-4095). The problem with this conversion is there is no "under" or "over" range. The live zero of a 4-20 ma signal was lost. This is a very important feature. Before DCS and HMI interfaces, when pushbuttons and meters were the interface to the operators, "zero based" meters whether voltage or current were common. The problem with "zero based" measurement readouts is the inability to distinguish a true zero reading from a failed transducer. With the PLC there also was no way to identify a zero reading (4 ma = 0 counts) from a failed transducer (0 ma = 0 counts).

High speed PID loops (100 msec sampling time) and analog data used for measurement and alarming is processed through the new DCS I/O. Only sequence data is processed through the PLC processor.

Testing of New I/O

Some problems were encountered while commissioning the new I/O installation. One of these involved minor wiring errors on the drawings which made it hard to find the field devices in order to perform HMI screen to field device point testing. This was a relatively easy fix. Verification of the drawings before demolition, although time consuming, would have lessened downtime and would have resulted in a net saving of time.

Having the same PLC logic lessoned troubleshooting, by isolating errors to the I/O cabinet.

General Evaluation

Although the PLC I/O was sufficient by prior standards, it was believed that the newer industrial technologies were at the very least worthy of trial in the CPS application. No historical data is presented here to detail the performance of the traditional PLC I/O system vs. the new DCS I/O system, but years of experience with them does give one an overall appreciation for the strengths and shortcomings of the vintage technology in general terms. All said, this type of I/O has, except perhaps in less demanding roles, outlived its usefulness in modern control and data acquisition systems.

Thus far, the new I/O has proved to be very accurate. There is no indication of failing or drifting from the original calibrations. However, one drawback to the system is that for the present the signal update time in the PLC is 4 to 5 seconds compared to 2 to 3 seconds with the old I/O. However, the signals that are not needed in the PLC are scanned at the field device and available to the operator console in 2 sec. The 4 to 5 second delay is due to the transfer rate from the new I/O to the old DCS controller in addition to the FDI interface of 2 to 3 sec. This update rate is tolerable, however, for these non-critical process sequence points. With the new I/O, the FDI interface is gone therefore eliminating the overhead of the C program and the 19200 baud serial transmission rate. The time required for the new DCS controller to scan all its associated I/O is 250 milliseconds.

Future Applications

There is a future plan to convert the PLC program to DCS controller program thereby reducing 2 controllers (PLC and old DCS controller) to one controller and reducing the 4 to 5 second response time for sequence points to 2 seconds.

SUMMARY

The new DCS I/O provide simple installation, more accurate data and improved diagnostic capability than the old I/O systems at GRC. Therefore, in the long term we can foresee the utilization of DCS I/O as an enhancement to our facility DCS and a benefit to our customers.
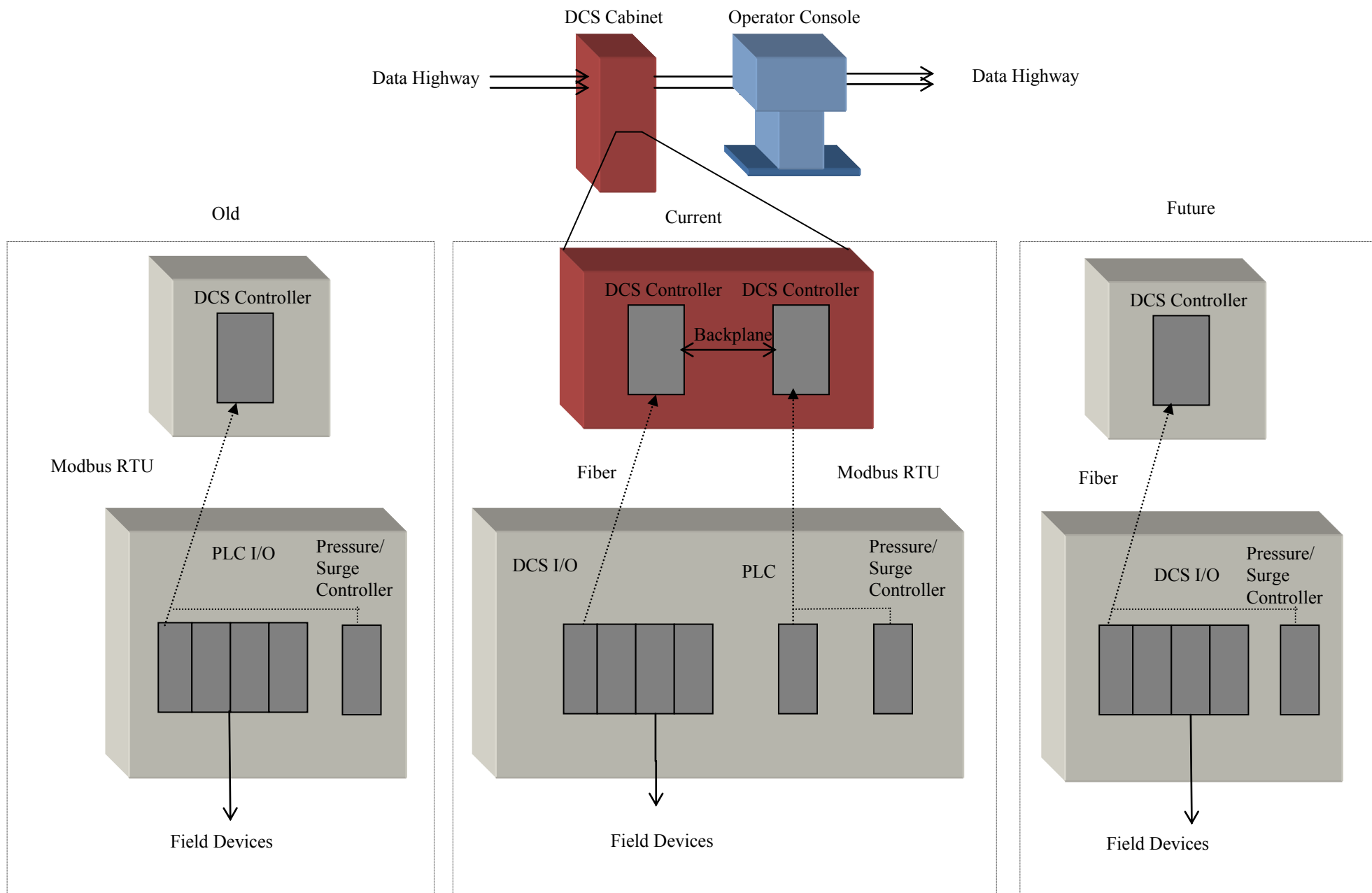
DCS Cabinet

Operator Console

Data Highway

Data Highway

Old

Current

Future

DCS Controller

DCS Controller   DCS Controller

DCS Controller

Backplane

Modbus RTU

Fiber

Modbus RTU

Fiber

PLC I/O   Pressure/ Surge Controller

DCS I/O   PLC   Pressure/ Surge Controller

DCS I/O   Pressure/ Surge Controller

Field Devices

Field Devices

Field Devices

Figure 1

The Integration of DCS I/O to an Existing PLC

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Presenter

- Debashis Sadhukhan – Process Controls System Manager an NASA Glenn Research Center (GRC). Employed at GRC since 1991. Experienced in integration of DCS and PLC systems.

- John Mihevic – DCS Control System Manager while employed at GRC. Retired in 2007.

System History
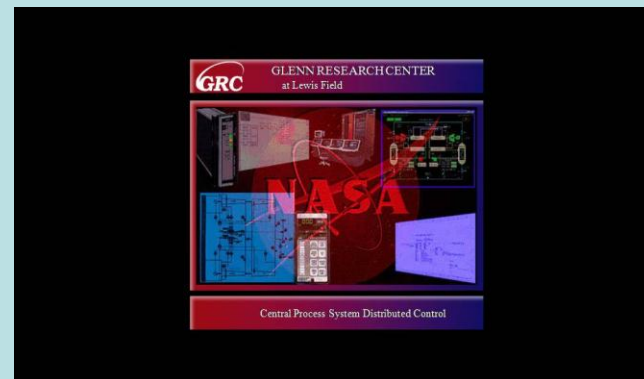
- 1983 SCADA System Installed
  - Host computer communicating serially to:
  - Remote Terminal Units (RTU) & PLC's
  - RTU manufacturer went out of business & CRT response times were degrading as I/O increased (3800 to 9000)
- 1992 Infi-90 System Installed
  - All RTU's were replaced with PCU's and Foreign Device Interface (FDI) was used to interface to Modicon PLC's
- 1999 PI Archive System Installed
- 2001 Upgrade
  - Alpha DX10's
  - Dell PC Clients with LCD's
  - Faster DCS Controllers Installed
- 2006 Upgrade to S800 I/O for Equipment Shutdowns
- 2013-2014 Upgrade Alpha DX1's with Windows 7 with new Process Screens

Introduction

- Original I/O System
- Reasons for Converting to the new System I/O
- New I/O System
- Advantages of the new I/O System
- Future Plans

Plant

- The Central Process System (CPS) at NASA Glenn provides combustion air (to 1250 Psig), altitude exhaust (to 90,000 ft), refrigerated air (to -90 Deg F), cooling tower water, and service air to for the major wind tunnels and propulsion test facilities at Glenn.

- The CPS consists of 20 miles of process piping and 600 valves to interface the above systems to the various test facilities.

- A DCS/PLC/Pressure and Surge Controller system consisting of nearly 100 PID Control loops and over 12,000 I/O points provides monitoring and control for the vast amount of equipment across the facility.

- Over 12 miles of dual redundant data highway cable is installed to interface the control/data system for these essential services.

Central Process System Air Flow
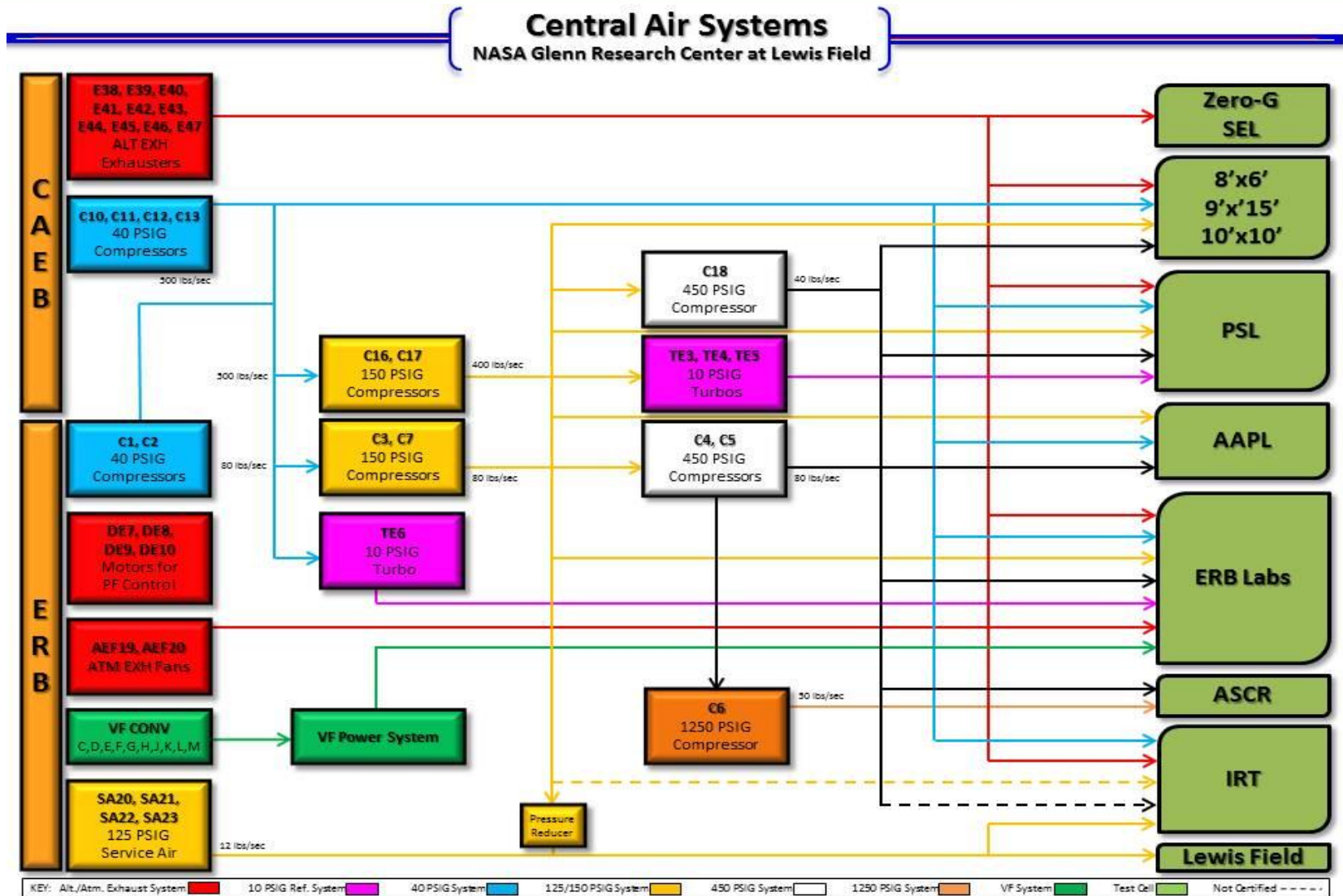
Original I/O System

- PLC I/O
  - PLC Processor communicating to analog and discrete I/O that was near the field equipment

- PLC communicated to DCS via Modbus RTU Protocol

- DCS controller then communicated to the operator console via a proprietary data highway

Reasons for Conversion to the New System

- Parts to repair old PLC I/O and direct replacements are difficult to find

- New replacement of PLC I/O is available, but it does not provide some the benefits of the DCS I/O

- The DCS I/O provided much faster speed and Quality Status which was lost using a Modbus RTU serial link with a transmission rate of 19,200 baud

Reasons for Conversion to the New System cont.

- Replacing the entire PLC System with DCS System at one time which required massive logic conversion and testing
- Two Phase approach:
  - The first phase would replace the PLC I/O with DCS I/O
  - The second phase would actually convert the PLC logic to DCS logic
- The split approach was chosen to minimize downtime and prevent a complicated check-out process

The new I/O System

- New DCS controller
- New DCS I/O
- New 24 V dual redundant power supplies for the I/O
- The PLC processor remained to communicate sequence logic to the old DCS controller
- PLC communicated to the new DCS controller that talked to the new DCS I/O
- The primary function of the new system is to provide process control of the equipment via the DCS, which is made available to operators at a remote location. The basic system architecture is shown in Figure I
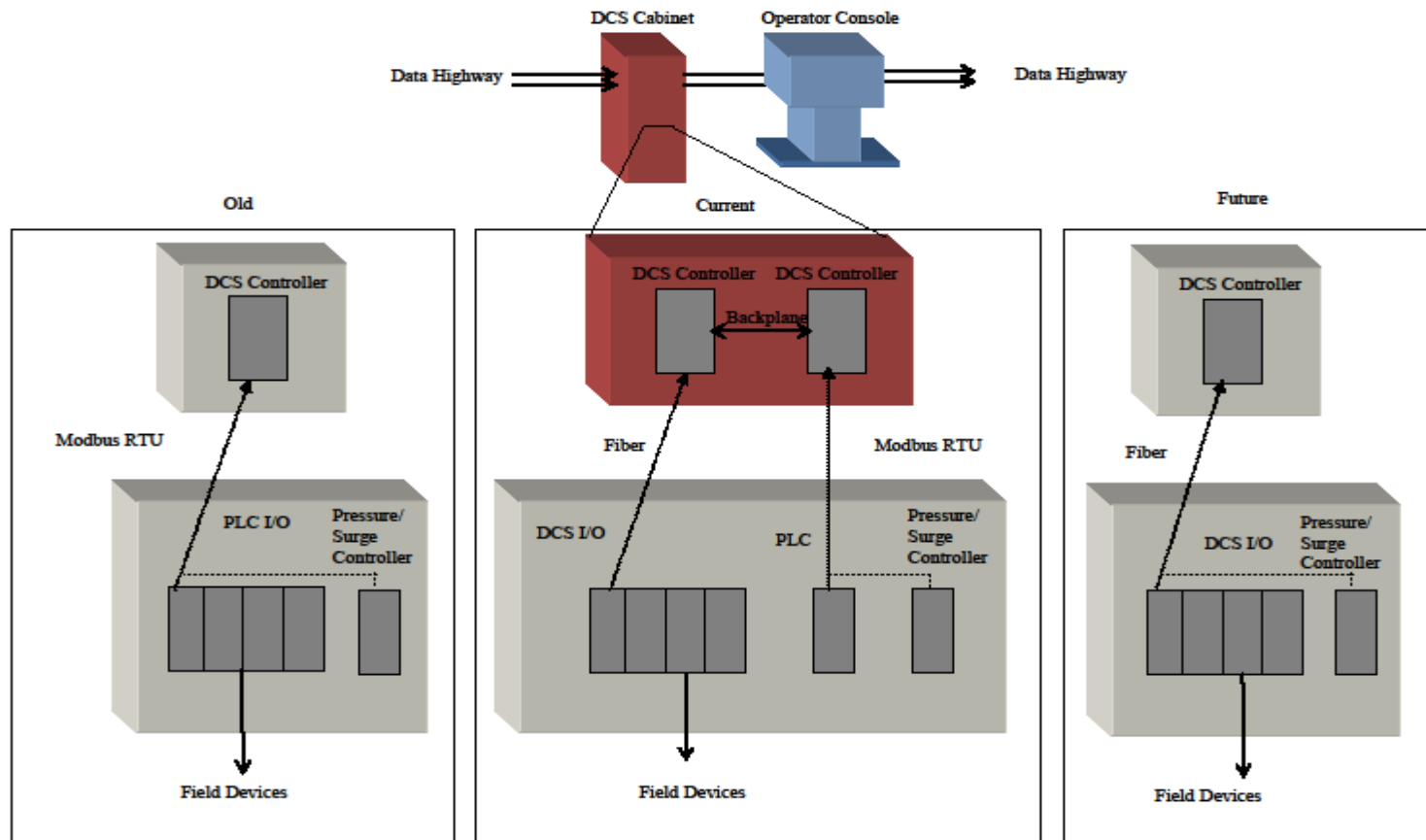
The new I/O System cont.

Figure 1

The new I/O System cont.

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- The 24 V I/O power supplies were installed in an existing cabinet
- A new DCS Controller, connected to the new DCS I/O via Fiber, was installed in the same cabinet as the old DCS controller
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The new I/O System cont.

- The software for this application included DCS controller software that allowed communication between the old DCS controller and the new DCS controller

- The PLC received the necessary data for sequence logic from the new DCS controller. No field I/O connects to the PLC

- All PID algorithms are processed in the new DCS controller and hardware specific pressure and surge controllers. The pressure and surge controllers communicate to the old DCS Controller via Modbus

Advantages of the new I/O System

- One of the powerful features of the new I/O is the troubleshooting capability via DCS diagnostics
- It also provides Bad Quality Status on the operator console in the case of signal failure
- With the old PLC I/O system analog data was converted to digital counts (0-4095)
  - The problem with this conversion is there is no "under" or "over" range.
  - The live zero of a 4-20 ma signal was lost
  - The problem with "zero based" measurement readouts is the inability to distinguish a true zero reading from a failed transducer
  - With the PLC there also was no way to identify a zero reading (4 ma = 0 counts) from a failed transducer (0 ma = 0 counts)

Disadvantages of the new I/O System

- One drawback to the system is that for the present the signal update time in the PLC is 4 to 5 seconds compared to 2 to 3 seconds with the old I/O
  - The 4 to 5 second delay is due to the transfer rate from the new I/O to the old DCS controller in addition to the FDI interface of 2 to 3 sec
  - This update rate is tolerable, however, for these non-critical process sequence points
- However, the signals that are not needed in the PLC are scanned at the field device and available to the operator console in 1 sec
  - With the new I/O, the FDI interface is gone therefore eliminating the overhead of the C program and the 19,200 baud serial transmission rate. The time required for the new DCS controller to scan all its associated I/O is 250 milliseconds

FUTURE APPLICATION

- There is a future plan to convert the PLC program to DCS controller program thereby reducing 2 controllers (PLC and old DCS controller) to one controller and reducing the 4 to 5 second response time for sequence points to 2 seconds

SUMMARY

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