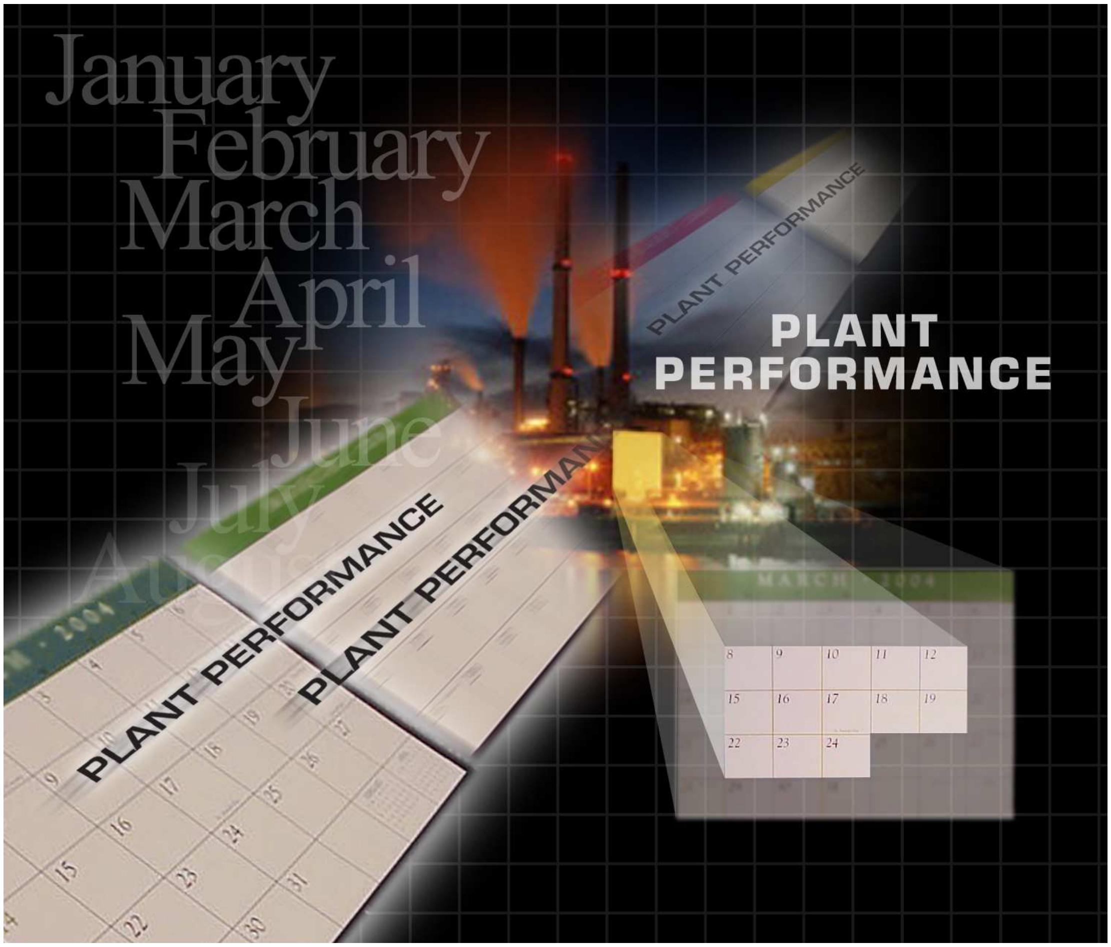

Advanced Fieldbus Diagnostics, Without Fieldbus

Tom Kinney
ExperTune, Inc.

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Summary

Digital field buses are often justified on the basis of the benefits of advanced diagnostics. This paper investigates and shows alternative technologies available to capture diagnostics. This alternative technology is available even with traditional analog systems. The alternative method is field-proven and costs a fraction of the cost of field bus, yet has many diagnostic capabilities simply not available with field bus devices.

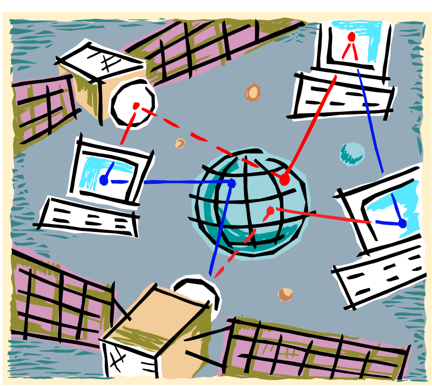
Diagnostics of field bus will be compared to the diagnostics of this new alternative including these diagnostics:

- Field equipment diagnostics for valve performance
- On-line oscillation detection
- Controller output noise band
- Output standard deviation
- How long the output is at a limit
- Percent of time is the loop in a normal mode
- Percent of time the loop is oscillating
- Percent of time the loop is oscillating because of valve stiction

There are 2 key technologies critical to the field bus alternative:

1. OPC connectivity
2. Performance Supervision software

Since the alternative looks at data collected via OPC, any DCS or PLC is supported without any additional wiring or field hardware .This includes ones that use 4-20mA signals, field bus, Profibus, or HART. Another advantage of the field bus alternative is that all diagnostics are done non-obtrusively: diagnostics are done from normal plant operating data. The performance supervision software does not require specific tests or hand-held probes and all loops stay in automatic mode.



Background

There have been many approaches to create standards-based field bus technologies over the past 10-15 years. The design objectives of these systems have addressed interoperability, power requirements in hazardous locations, and wiring requirements to name a few. From a customer standpoint the potential benefits include the possibility for control in the field, reduced wiring costs and enhanced diagnostics of the field equipment as some of the primary benefits.

The cost justification of a field bus system for a new grass root facility should be more compelling for the new facility versus a migration of an existing facility. This paper will consider the features and benefits of field bus diagnostics for an existing facility versus those offered by the new performance supervision software approach described in this paper.

The new approach looks at field diagnostics by considering the whole control loop including the controller, the valve and the sensor. The new approach uses existing infrastructure including 4-20 analog instrumentation to enable the diagnostic capabilities. The new approach is based on a class of manufacturing intelligence software which has been emerging over the past several years which includes novel algorithms to detect valve, sensor and controller problems. This software is referred to as a software based performance supervisor. The performance supervision software utilizes OPC and OPCHDA, a standard communication system, allowing the performance supervision system to acquire real time data from a variety of sources used in diagnostic calculations.

Requirements to Install a Digital Field Bus

To realize a functioning field bus-based instrumentation or control system a user must address the following major tasks:

- Transmitter Replacement
- Positioner Upgrade
- Wiring
- A/D Conversion Upgrade
- Process Downtime
- Software Installation
- Training

Each of these issues is addressed below.

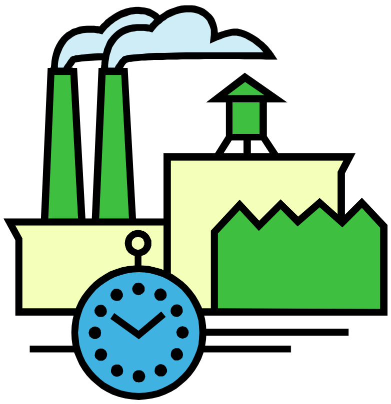
<u>Transmitter Replacement for Digital Field Bus</u>
With a digital field bus, for each control loop, the user must install a new transmitter or at least a new top works for the field sensor. Instrument costs range from $500 to over $3000 each.

<u>Positioner Upgrade for Digital Field Bus</u>
For field bus on valves, the control valve positioner must also be replaced with a digital valve positioner. Costs may range from $300 to $1500 per positioner.

<u>Wiring for Digital Field Bus</u>
New wiring for the digital field bus must be installed back to the control room. The wiring will include both the valve and transmitter on the same wiring since a digital protocol is employed. It may be possible to re-use existing cable trays and wireways if engineering calculations show that they can handle the load.

A/D Conversion Upgrade for Digital Field Bus

Once the new wiring is in place, a new electronic module must replace the old A/D converter which will make the digital field signals available to the network of the control system. In some cases this device may not be required if the same digital protocol is utilized throughout the system.



Process Downtime for Digital Field Bus

To install the above digital field bus equipment it may be necessary to shut the process down while key sensors and vales are cut over to the new system.

Software Installation for Digital Field Bus

Next, it will be necessary to install new software to manage the new digital field devices and to solicit diagnostics from the field devices.

Training for Digital Field Bus

Lastly, it will be necessary to retrain plant personnel on the new procedures for servicing the new devices and on usage of the new software.

The cost for new field devices is conservatively estimated to be $2000-$3000 per loop.

The manpower and cost to achieve the above scenario are not completely quantified in this paper since many variables will affect the final cost but it can be assumed that this must be viewed as a major undertaking in man power, cost, and potential lost production. After the field based system is installed what kind of diagnostics are available to justify the effort to install such a system?

Available Diagnostics from Sample Field bus Devices

We surveyed several sample field bus devices to determine the field diagnostics available from them and how they compare to the alternative performance supervision approach. Diagnostics that exist purely to report the status of the field bus electronics were not included, since traditional 4-20 mA instruments have no need for these. The major operational diagnostics which are useful for the dynamic performance of the process were considered.

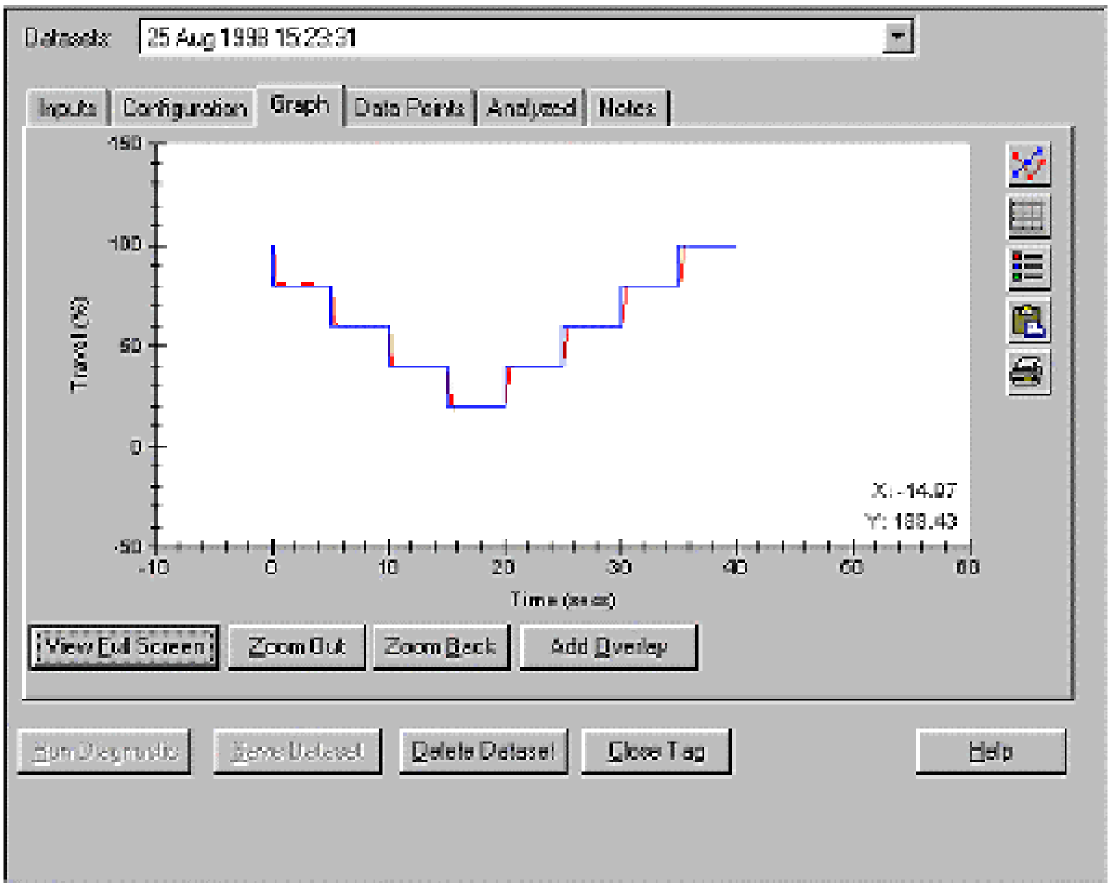
Fieldbus Device 1

Several diagnostics relate to the hardware failure of the electronics, memory errors or mechanical failure of the device and power failure to the device. Under extended diagnostics such things as board to board communication failure and communication timeout are listed. One has to ask the question: Are many of the diagnostics present to detect problems with the digital electronics themselves rather than diagnostics which directly relate to the operation and reliability of the process?

Two meaningful diagnostics in the extended category are total valve travel and valve reversals. These diagnostics relate directly to the required service of the device. These diagnostics can be used to identify and predict other issues with control loop performance, such as tuning and interactions with other control loops in the plant.

Two additional diagnostics were of note. They are a friction alert and a travel deviation alert. The friction alert could be very useful as valve friction is a leading cause of poor control loop performance which can in some cases affect the profitability of an entire process unit.

Fieldbus Device 2



Step Tests to Track Valve Response

According to the published literature we obtained the following information with the above set of step tests.

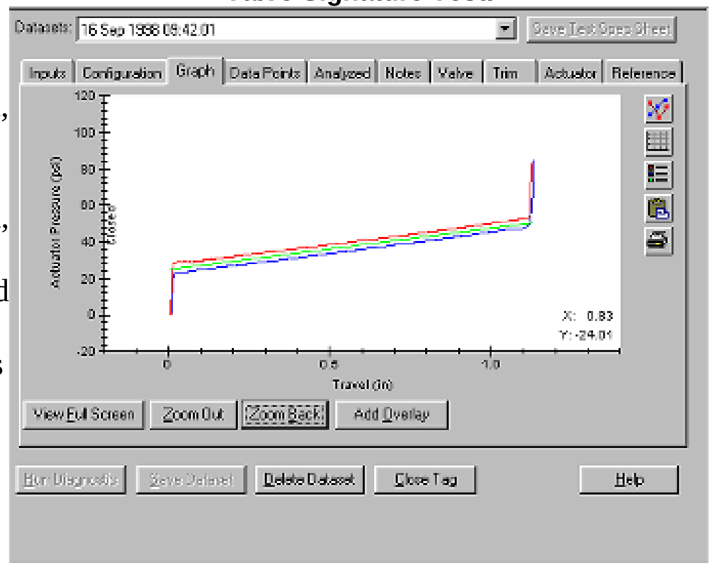
- With the Step Response test you can:
- Validate your current tuning parameters
- Obtain a numerical analysis for overshoot, hysteresis, dead time, t63, and t86
- Define up to 30 steps

In addition to the above diagnostic test the following test with stroking the valve and observing the stem position can be performed and observed as follows.

Using the Valve Signature test, you can determine:

- Valve friction, dead band, and shutoff capability
- Actuator spring rate and bench set
- Potential packing problems

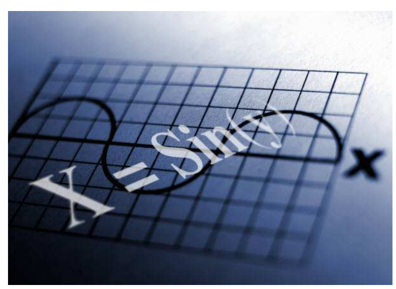
Valve Signature Test.



The text accompanying these plots mentions that it is not necessary to take the valve out of service and that by utilizing available software that diagnostics and reports can be scheduled on a periodic basis.

From the information available on this digital fieldbus it is not clear how to generate the first graph without taking the control loop out of auto while the test is being run. If it is necessary to take the control loop out of automatic mode then it may be necessary to coordinate with plant operations while the test(s) are being carried out.

Depending on the DCS or PLC system, field bus diagnostics may not be readily viewed. Special engineering workstations may be required to access the performance data from the field bus instrumentation.



Lastly, the literature refers to making diagnosis of oscillation, and valve friction. It is not clear how much of these diagnostics are carried out by the software or by the person interpreting the data based on best practice.

The Alternative Approach – Performance Supervision

Several suppliers have released software packages over the past 4-5 years which are aimed at performing control loop analysis based on normal operating data. Rather than being device-centric, these packages reside in a server class PC. They read normal operating data to perform diagnostics about the health and performance of the control system.

Performance Supervision Software provides:

- Controller Health and Diagnostics
- Actuator and Sensor Health Diagnostics
- Process Health and Diagnostics

.This paper will focus on final actuators rather than measurement devices, but there are as many examples in measurement analysis not covered in this paper.

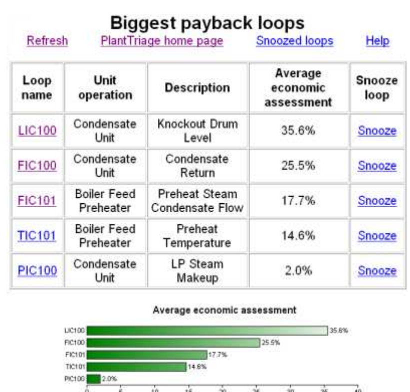
OPC Opens a Window into the Process

One of the leading suppliers of PC based control loop monitoring software is ExperTune with their Performance Supervision product. The package resides in a PC server class machine and connects to a variety of DCS and PLC systems via OPC. OPCHDA, a relatively new standard, is supported as well. It allows connectivity to historians such as PI, IP21, and others. OPC is a good choice since it is supported by a wide variety of suppliers.

Once connected, the performance supervision system reads data from the underlying control system and performs a variety of performance and diagnostic assessments. Several of these assessments can be compared with those found in the digital field devices mentioned above. Many other performance indices are calculated, but the focus of this paper is to compare and contrast the diagnostics from some of the leading field bus based devices with those possible with the monitoring software.

Performance Supervision Identifies Problems

The performance supervision software monitors the process 24 hours a day, and uses normal operating data to develop control loop diagnostics. No special step tests or stroking of control valves is necessary to develop diagnostics.



Biggest payback loops

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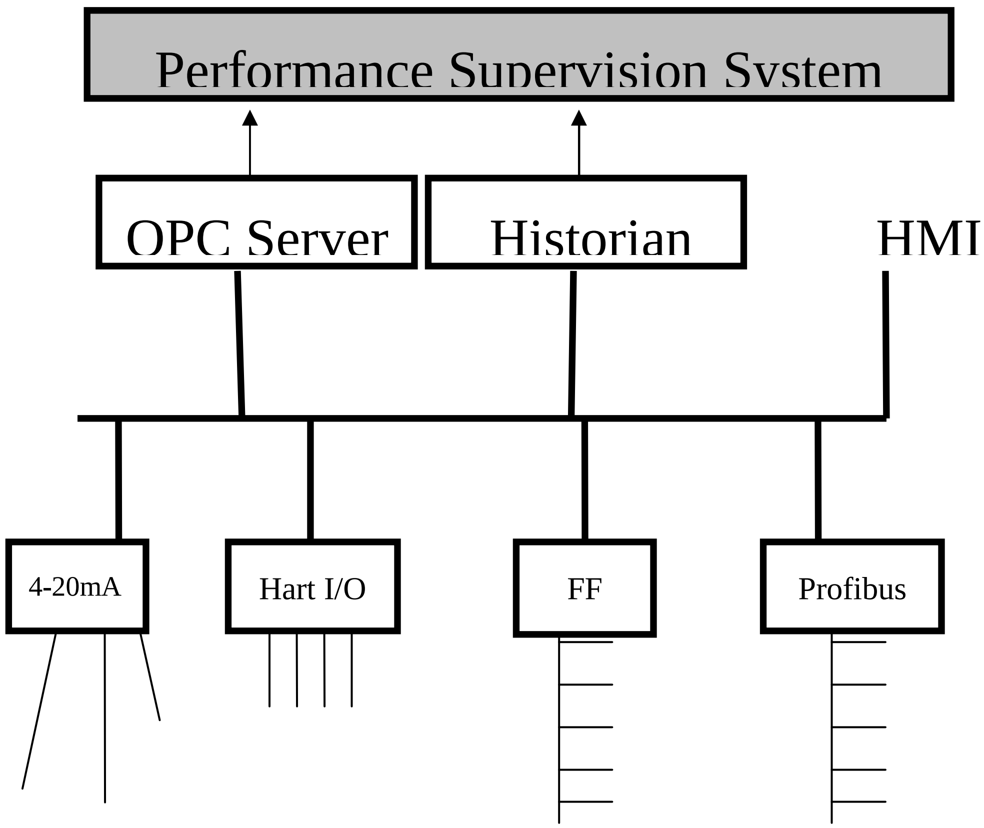
Loop name	Unit operation	Description	Average economic assessment	Snooze loop
LIC100	Condensate Unit	Knockout Drum Level	35.6%	Snooze
FIC100	Condensate Unit	Condensate Return	25.5%	Snooze
FIC101	Boiler Feed Preheater	Preheat Steam Condensate Flow	17.7%	Snooze
TIC101	Boiler Feed Preheater	Preheat Temperature	14.6%	Snooze
PIC100	Condensate Unit	LP Steam Makeup	2.0%	Snooze

With this use of OPC technology and performance supervision software, any actuator can be monitored including traditional 4-20 ma devices. While there is a slow migration to field bus technology, the installed base of the traditional 4-20 ma technology is enormous. It will take many years to make a complete migration to digital based field devices. Many may never migrate and for diagnostics do not need to. As long as the underlying system has OPC connectivity the data can be obtained and the diagnostic calculations can be performed. For advanced diagnostics it is not necessary to migrate.

The diagram below shows the generic connection structure from the DCS or PLC system to the performance supervision system.



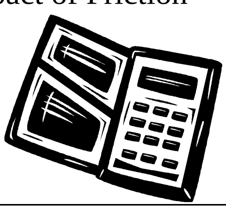
Signals from Field Instruments to Performance Supervision System

A Comparison of Available Diagnostics

The table below compares available diagnostics, Operational faults for a valve and other faults which affect the operation of the process and its continual push toward higher profitability are compared. If either of the field bus devices mentioned above have a listed feature then a yes is given in the column for digital field bus.

(We did not include diagnostics for memory or a power supply fault. These are important for a digital device but they are only relevant when a digital device is present.)

Parameter	**Performance Supervision System**	**Digital Field bus**	**Notes**
Diagnostics without trip to field	Yes	Yes	Performance Supervisor presents results in a browser display.

Parameter	Performance Supervision System	Digital Field bus	Notes
Diagnostics without trip to plant	Yes	No	Performance Supervision Browser displays can be viewed anywhere on the corporate intranet
Valve Signature	Yes	Yes	
Hysteresis check done automatically without interrupting the process	Yes	No	Fieldvue requires this to be done on a per-valve basis. Performance Supervisor does it automatically for the entire process, without interruption.
Slewing error, spring rate, seat load	No	Yes	.
Friction	Yes	Yes	Performance Supervisor calculates stiction from online data at various operating points.
Impact of Friction 	Yes	No	Performance Supervisor calculates the process impact of friction.
Can perform all diagnostics using 4-20 ma	Yes	No	Performance Supervisor requires no costly and manpower intensive digital protocols.
Can perform diagnostics from normal plant data	Yes	No	Much of the analysis and **all** 60 of the Performance Supervisor assessments require no special tests. All controls and valves stay in automatic.
Impact on other parts of process determined	Yes	No	Spectral analysis of valve movement can be correlated to other parts of the process.

Parameter	Performance Supervision System	Digital Field bus	Notes
Total valve travel calculated, benchmarked, and tracked	Yes	Yes	Performance Supervisor tracks valve travel for predictive and proactive maintenance.
Total valve reversal calculated, benchmarked and tracked	Yes	No	Performance Supervisor tracks valve reversals in conjunction with valve travel for predictive proactive maintenance.
Oscillation diagnosis	Yes, automatic	No	Performance Supervisor automatically diagnoses the cause of oscillation: the valve, PID tuning or a load upset.

A Cost Comparison

The cost to install a digital field bus for a new installation is known to be less than that of an existing plant retrofit. The cost of a new install is considered for comparison basis. The cost of a digital field bus device can run as much as $1000 more than a traditional analog device. To be conservative a $500 premium per device is used. If a typical control loop has one transmitter and one valve then a low estimate for the cost is $1000 per loop. The cost premium for the interface device, field bus wiring and software to interface with the device is not considered.

The cost for the Performance Supervision software is approximately $100/loop inclusive of all costs. The cost for OPC server software is estimated to be $15,000 per server which can easily accommodate up to 2000 control loops. The per loop cost of the OPC software is estimated to be in the range of $7.50 per loop.

For a plant with 1000 control loops the cost of the field bus installation would be approximately $1,000,000 and the cost of the Performance Supervision solution would be $115,000. The Performance Supervision solution is about 1/10 the cost of the fieldbus.

A plant shutdown, which would be required for a field bus conversion, could add several hundred thousand dollars in lost production opportunities to the field bus installation. Costs are summarized the table below.

	Field bus Conversion	Performance Supervision
Instrumentation Costs	$1,000,000	$0
Supervision Software	$20,000	$100,000
OPC Server	$0	$15,000
Wiring, Shutdown, etc.	$50,000 - $500,000	$0
TOTAL	**$1,070,000 or more**	**$115,000**

Comparison of Costs for 1000 Loop System

Conclusions

The capabilities of the Performance Supervision solution for online diagnostics exceed those offered by some of the leading field bus solutions, and delivers these benefits faster and at a far lower cost.

Other key advantages of the Performance Supervision System are:

- Ability to perform a superior level of diagnostics on traditional analog systems
- Ability to perform all diagnostics without interrupting the process.
- Ability to perform process diagnostics, such as modeling

Lastly, by making very conservative assumptions, the cost per loop of the Performance Monitor solution is easily an order of magnitude less than a comparable Field bus solution. This basis of comparison focused on the diagnostic capabilities and not the ability to perform control in the field or potential wiring cost savings.

PlantTriage™

For more information about Performance Supervision, or to discuss any of the content of this white paper, please contact Tom Kinney at ExperTune, Inc. at (262)369-7711 or email sales@expertune.com .

About the Author

Tom Kinney is the holder of 4 patents in the process control field. Formerly with Invensys, Tom has over 20 years of practical field experience in Oil & Gas, Chemicals, and other industries. Tom holds a B.S. in Chemical Engineering from the University of Maine at Orono.

Glossary

Term	Definition
DCS	Distributed Control System. A centralized process control system that typically provides data collection, operator interface, and control functions.
HMI	Human-Machine Interface. Typically, a PC-based interface that allows the operator to control the process.
OLE	Object Linking and Embedding. The Microsoft standard that is at the base of the OPC communications protocol.
OPC	OLE for Process Control. An industry standard communications protocol, allowing
OPCHDA	OPC Historical Data Access. An enhancement to the OPC protocol that allows data to be pulled directly from standard data historians.
PLC	Programmable Logic Controller. A simple controller that provides data collection and control. Often paired with an HMI or SCADA system.
SCADA	Supervisory Control And Data Acquisition.