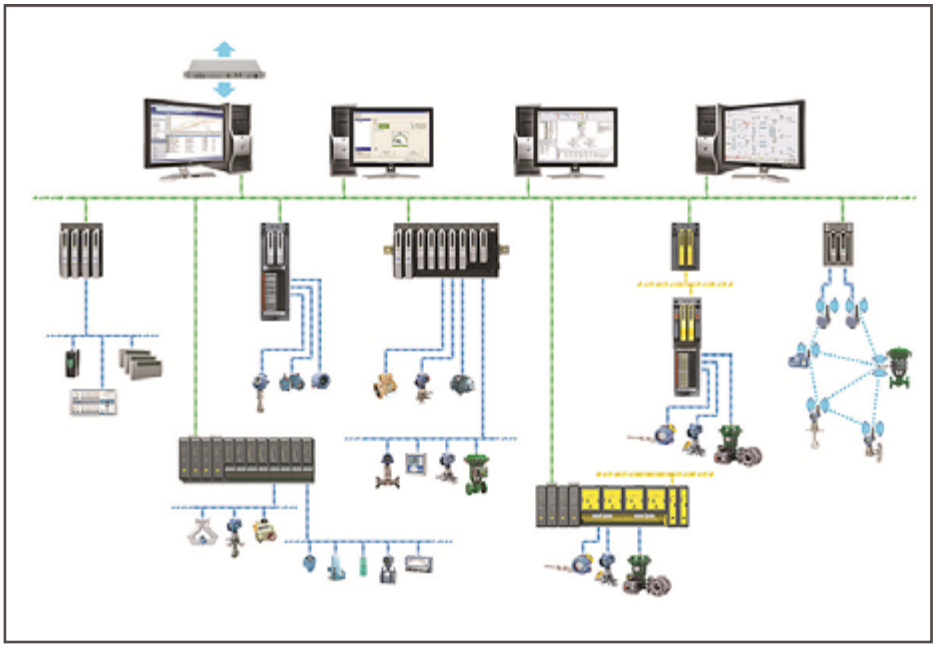
Realizing the Capital and Operational Benefits of an ICSS System

Integrated control and safety systems (ICSS) can provide unprecedented benefits if users balance the work process with the technology.



Introduction

Your company is committed to installing (or replacing or upgrading) the control and safety systems at one of your plants. You've seen the very aggressive project schedule and recognize that speed of implementation is critical. You've heard and read about modern highly-integrated, all digital system solutions. You recall hearing that these "smart" systems are a lot easier to implement than their predecessors, but you've heard things like that before. Besides, even if these modern systems are easier to implement, isn't it likely that all that sophistication will end up costing more to operate and maintain?

Twenty-first century economics dictate that "speed of implementation" stands as a hallmark to project success, but projects still have budgets and now, more than ever, shareholders additionally measure success based on their return on Capital Expenditures (CapEx). Alongside the CapEx performance metric, and possibly more important, stands Operational Expenditures (OpEx) performance. Improving OpEx performance in today's market requires extreme diligence beginning with the purchase of raw materials and extending all the way to how finished goods are shipped to the buyer. Simply stated, opportunities to reduce OpEx are everywhere.

When combined with the correct culture and organizational structure, modern technologies can make significant contributions to improving shareholder value by improving both capital and operational expenditures. Digital technologies have proven to be one of the keys to achieving CapEx and OpEx improvements. A number of studies indicate that significant CapEx and OpEx improvements can be contributed to control and safety systems using "Purpose Designed Integration"; meaning a system that's original design philosophy was to streamline every aspect of the systems use commencing at implementation, extending through commissioning and into day-to-day use.

This paper explores the following topics; Digital Revolution, Integrated Architecture, Intelligent Field, Smart Safety Instrumented System (SIS), the Entire Safety Loop, Integrating the BPCS & SIS, Reducing CapEx, Reducing OpEx, and Culture, Organization & Competency.

Digital Revolution

The digital revolution is evident from cameras to computers, telephones to television, music to video. Digital systems are replacing their analog counterparts. The reason is increased plant availability and better performance – plus a wealth of information previously unavailable. Distributed control systems were a major breakthrough in the mid-1970's, but these systems are based on 4-20mA signals and proprietary communications.

The industry's move into the digital revolution began with the introduction of the HART protocol more than 20 years ago. HART is a hybrid communication protocol that enables a digital signal, primarily for increased information, to coexist with a 4-20mA control signal. This digital bi-directional communication transforms field devices from single functional instruments to multi-functional devices that deliver multiple measured variables with single process intrusions, such as device health, process health, and end of life predictions.

Today there are more than tens of millions of HART devices installed in process control and safety applications. These devices are found in plants worldwide. Foundation fieldbus is an all digital communications network that's roots are the HART technologies. The introduction of all digital communications ushered in the term "SMART" plant. Smart plants are constructed using all digital devices (i.e. transmitters, controllers, final control, etc). In a SMART plant, intelligent devices work together to control, diagnose and predict.

In designing the BDO plant we want to avoid older analog communications or proprietary digital buses and instruments. These would reduce our design flexibility, inflate life-cycle costs, and complicate upgrades.

- John Rezabeck, BP Chemicals

Digital technology taps the intelligence of today's microprocessor-based instruments speeding data between process, plant, and business applications. It enables systems and software to transform 1's and 0's into useful information for better process control, better asset management, and better decision-making. Using digital technology, plants benefit in many areas including:

- Reduced capital and engineering costs
- Reduced operations and maintenance costs
- Increased plant availability
- Reduced process variability
- Enhanced safety and environmental compliance.

Integrated Architecture

Based upon its unique architecture, the primary litmus test for an Integrated Control and Safety System (ICSS) is that it has been designed, from the ground-up, as one system. Typical subsystems of a modern ICSS include:

- Redundant control networks
- Distributed and scalable process controllers
- Distributed and scalable safety controllers
- Human machine interface (HMI)
- Engineering workstations
- Application servers.

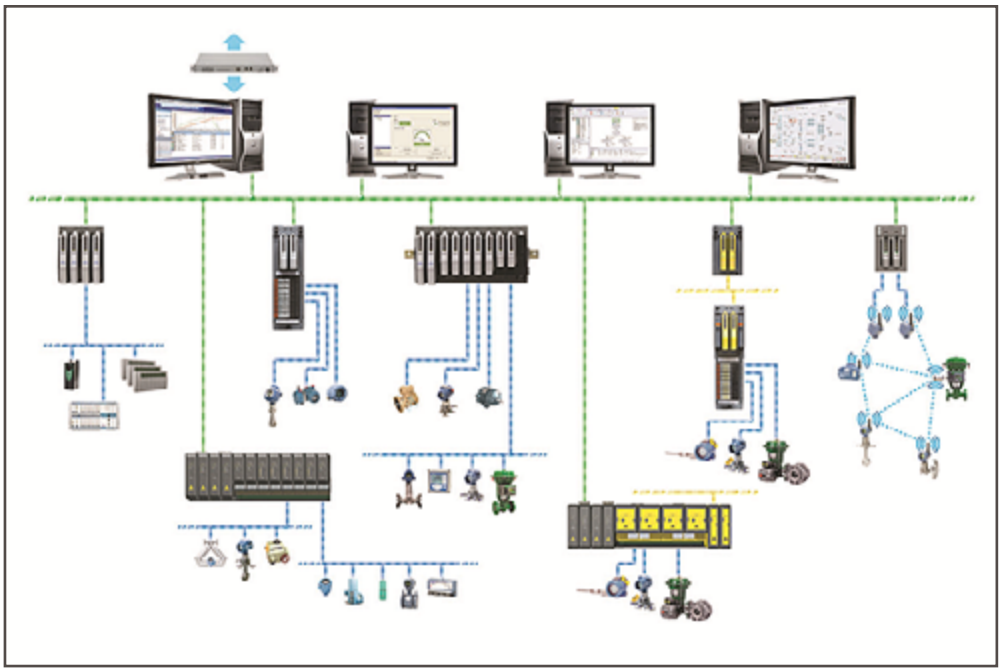


Figure 1: Typical ICSS Architecture

The first commercially available ICSS solution appeared in 1996. To some people this may mean that a particular system is becoming obsolete and is due to be replaced. However, one of the amazing things about digital technologies is that they allow the system manufacturer to incorporate digital technology advances with minimal impact to the rest of the devices or to the system - resulting in the only thing that remains of the 1996 ICCS is the name and the packaging. Theoretically, a manufacturer of an ICSS could keep the system current indefinitely.

Because every implementation begins with plant design, ICSS generated CapEx savings should begin with an engineering environment that is tightly integrated with third-party plant design tools such as Intergraph's SmartPlant Instrumentation software. Today's project "speed of implementation" often results in having project teams distributed around the globe using secure communication technologies to support 24/7/365 project activities - equating to CapEx savings. It also means the ICSS architecture must include a secure common database and engineering environment uniquely designed and sufficiently robust to facilitate parallel and geographically distributed engineering activities. In such a diverse and fast moving, often changing engineering environment, the ICSS engineering database must include excellent management-of-change and audit trail features. Without these two features in place, resources can be wasted in re-engineering and re-testing. Though it may not seem very important during the early engineering phases, having these two features in place helps ensure that the ICSS solution that is delivered on-site is what was "Approved for Construction."

The characteristics of modern ICSS' share a lot of similarities, including open communications between subsystems. Facilitating this communication openness requires a strong, yet flexible common engineering platform and the use of an advanced global database designed to eliminate the need for managing and synchronizing multiple data resources. The ideal ICSS will also be both flexible (right type of device for the application) and scalable (ability to add controllers and logic solvers with no impact on system performance). Additional characteristics of a modern ICSS include:

- Advanced alarm management
- Security management
- Access control
- Multiple fieldbus support – AS-i, Profibus, DeviceNet, FOUNDATION, etc.
- Management of change tracking
- Audit trail / Version control
- Data historian
- Sequence of events recording
- Asset management capabilities
- Process simulation
- Training systems.

Intelligent Field

A strong ICSS foundation begins with intelligent field devices – devices that can anticipate problems, report current device health, control variability, and perform multiple measurements to reduce the number of devices required – even take local control when necessary to maintain plant availability. Intelligent devices contain a wealth of diagnostic information, available remotely to allow you to streamline your maintenance efforts. No longer is a transmitter or valve a one-way communication device. However, gaining access to all this data can become a challenge in the traditional DCS architecture. Without open communications architectures found in today's ICSS systems, mapping all of the available data becomes a cost barrier and results in valuable information being stranded at the field device. Because leading instrument manufacturers build intelligent devices to global industry standards, ICSS systems are designed to allow the freedom to choose the best devices from the best suppliers, without being limited by proprietary technologies. Examples of the diagnostic data and predictive maintenance alerts that are now available to ICSS system are:

Plugged impulse line	Sensor probe suspect	RTD drift
Reverse Flow	Travel pressure high	Signal Saturation
Calibration error	Travel accumulation	PV out of range
Empty pipe	Cycle counter	Drive signal
Device health	Valve signature	Stem position

The ICSS solution lets you put control anywhere – where it best suits the application and level of performance you require.

Smart SIS

An equal but physically separate entity of the ICSS, the smart SIS uses a modern approach to safety to help reduce risks and uses the intelligence embedded in the total SIS loop: sensors, logic solvers, and final control elements to increase overall system availability.

> Today's safety systems need an integrated safety approach where transmitters are part of the safety system and perform auto-calibration, diagnostics, validation and remote monitoring, connecting with an intelligent fieldbus such as HART or Foundation fieldbus.
>
> **– Wayne Labs, CONTROL Magazine, May, 2005**

Based on an interpretation from the Offshore Reliability Database (OREDA), 50% of SIS malfunctions – failure to perform on demand – result from valve malfunctions; 42% from sensor malfunctions; and only 8% from logic solver malfunctions. The smart SIS uses a holistic approach by diagnosing the sensors, logic solvers, and final elements ability to perform on demand – a smart SIS solution approach. A smart SIS can address the following areas of improvement:

- Risk reduction
- Easier regulatory compliance
- Increased availability.

Risk Reduction

The smart SIS begins and ends with field devices. Smart field devices:

- Monitor the entire SIS loop from sensor through the final control elements
- Provide non-disruptive actuator partial-stroke testing and spurious trip prevention
- Imbedded HART multiplexers proactively communicate device alerts from intelligent sensors and actuators
- Support advanced diagnostic capabilities for sensors, logic solvers and final control elements for both self-test and detection of abnormal situations in the surrounding process.

Easier regulatory compliance

The smart SIS, including sensor, logic solver, and final element, is designed in accordance with IEC61508 and is certified by a third-party certification body such as TÜV. To help you address the IEC61511 standard more easily, a smart SIS should have:

- Safety logic signature authorization
- Change management of safety logic and field device configuration/calibration
- Security authorization of online trip point or bypass changes.

Increased availability

A smart SIS increases the availability of an operating process by:

- Increasing system availability through redundancy as required

- Minimizing risky manual final element testing through automatic periodic testing
- Reducing operator response time with advanced alarm management
- Managing bypasses during startup sequences.

A high-functioning SIS requires a high-functioning programming environment. Expect the smart SIS to include:

- A full palette of TÜV-certified smart function blocks designed specifically for SIS functions. Special blocks like MooN voter blocks with bypass management reduce what used to be pages and pages of ladder diagrams to engineer, test, and commission into a simple drag-and-drop specification activity.
- Voter blocks which simplify device upset and diagnostic condition handling to avoid spurious trips while automating bypass management.
- Cause and Effect Matrix (CEM) block which greatly simplifies the logic solver configuration.
- Step sequencer which saves hours of engineering over conventional ladder logic approaches.
- State Transition Diagram which provides simple fill-in of state, transition inputs, and desired outputs saving hours of engineering.

Other capabilities making the smart SIS software intuitive include:

- Built-in sequence of events handler with automatic first-out trapping.
- Built-in bypass handling
- Built-in override bundling
- Tools to aid in compliance to the IEC 61511 standard
- Built-in alarm state engine per EEMUA 191 standard
- Optional operator interface.

Entire SIF Loop

Safe operations include many aspects—material handling procedures, process operations and safety instrumented systems (SIS). Yesterday's SIS solutions considered only the logic solver and left it to maintenance organizations to manually test the entire safety loop.

Measurement

Sensors for pressure, temperature, flow and level play an important role in any risk reduction strategy. It is important to consider improvements in measurement technology as well as installation and maintenance practices. The health of any safety loop is only as reliable as the weakest component so in an ICCS solution, the entire safety loop – sensor, logic solver, and final element.—consists of smart devices.

The use of smart devices throughout the safety loop:

- **Delivers predictive diagnostics –** By replacing switches with transmitters, the first step towards reducing undetected failures is taken. Smart transmitters have far fewer dangerous undetected failures than switches. In addition, the latest generation of smart measurement devices extends the embedded diagnostics beyond the device and into the process.
- Extends health diagnostics – Today's leading smart transmitters go beyond detecting component failures. They evaluate the performance of the complete measurement system, extending diagnostics to detect formerly undetectable dangerous failures outside the physical bounds of the transmitter—providing both transmitter and process diagnostics.

The end result is greater credit for failure on demand calculations, easier compliance with IEC 61511, higher safe failure fractions, less redundancy, and less proof testing, less often.

Process Measurement Devices

IEC 61511 defines two approaches for selecting the right device for your safety measurements. Both methods have merit and are used extensively.

- **Certified –** These sensors have been designed and analyzed to meet the guidelines that are set in IEC 61508 by a third-party certifier, such as TÜV or exida. This takes the burden of proof from the user to get the product certified.
- **Prior use –** The user must prove the device is safe for use in a specific application and environment. This method requires sufficient failure data to be able to investigate and calculate the probability of failure on demand and the safe failure fraction. Device manufacturers can provide the reliability date needed for these calculations.

Final Elements

Because final elements have been shown to have the highest rate of failure-on-demand, the next step is to equip the final elements with digital valve controllers that provide the diagnostics to extend the proof test interval, while delivering higher reliability and safety.

Final Element Testing

Process manufacturers have gone to great lengths, adding bypass valves, manual jamming devices, and expensive pneumatic panels to facilitate proof testing of final control elements. Beyond the increased capital expense, safety valve testing often involves the installation and subsequent removal of mechanical valve interlocks. This can expose maintenance personnel and operators to hazardous locations in the process. If the interlocks are not removed after the testing, the performance of the safety instrumented system may be severely compromised. The majority of plant incidents are caused by personnel and procedural error, so removing the need for manual proof tests while maintaining the overall SIS integrity is critical in SIS applications.

Digital Valve Controller

Digital valve controller instruments provide automated performance monitoring and testing by enabling remote partial stroke testing while the safety valve is online - keeping personnel safely away from the valves' locations. In addition, these instruments have extensive diagnostics to monitor travel deviation, pressure deviation, valve packing friction and more. Information is communicated back to the ICSS asset manager software.

Logic Solvers

Monolithic PLC and multiplexer technologies can now be replaced with modern logic solvers that support digital communications for continuous health monitoring of every complete Safety Instrumented Function (SIF). Ideally, the ICSS solution should consider the entire safety loop. When the entire safety loop is considered – sensor to final element diagnostics and testing – the process benefits from a significant decrease in spurious trips, thereby increasing reliability from sensor to final element.

Key capabilities of the ideal ICSS safety logic solver will include:

- Certified for applications up to SIL 3
- 24V DC redundant power
- Configurable I/O supporting many types of field devices
- Line fault detection on all I/O
- Single-channel isolation for all I/O
- Failsafe and Fault Tolerant CPU Configurations Available
- Consistent 50msec application execution time base
- Modifications, Downloads and addition of new modules on-line
- Geographically Flexible architecture
- -40 to 70C temperature rating
- ISA G3 (corrosive environment rating

- NAMUR NE21 electromagnetic compatibility rating
- Common Database and HMI Communications Network.

Additionally, the flexibility of the ISCC system provides for increasing the availability of the process with a fault tolerant configuration of SLS logic solvers. The two modules should work in an "Active Redundancy" configuration with no conditions of master/slave or hot backup functionality. This ensures bumpless transfers, allows automatic online proof testing, updating and replacement of the logic solvers thus avoiding process downtime.

Integrating BPCS & SIS

Historically, design of the DCS included the engineering of communication subsystems in order to integrate subcomponents from different manufacturers. These subsystems were limited by the ability of the communication interface to transfer the information back to the operator and maintenance personnel. Several options were available; however, this bottleneck often stranded much of the data potentially available for safe and efficient operations of the facility.

Disparate Systems

With the advent of open standards, integration of Basic Process Control System (BPCS) with an SIS from a different manufacturer became easier. Introduced in 1996, the OPC standard provided a mechanism for high data transfer rates in real-time from an SIS to a BPCS. However, these interface options carried a significant cost for engineering and testing. In addition to the mapping of data points between the two systems, the standalone concept brought with it a need to manage and synchronizing as many as three separate databases. Finally, the fiscal requirements for long-term support of the system communication subsystem had to become part of the system maintenance plan.

ICSS Solution

> As data-driven systems become larger, making more extensive use of data, the identification and management of data integrity becomes a significant factor in the demonstration that the required system integrity has been achieved.
>
> **– Alastair Faulker, CSE International Ltd**

In the ideal ICSS solution, the BPCS and SIS communicate over a common data network and configured from a common engineering environment: BPCS and SIS data and alarms are displayed on the same operator interface while the power supplies, communication channels, hardware, and real-time operating systems remain completely independent of the BPCS and any of its components and subsystems; thereby, maintaining the separation promoted by mainstream safety philosophies. All operations, engineering, and maintenance functions for the two systems are integrated including:

- Alarm handling
- Configuration
- Time synchronization
- User security
- Device health monitoring.

The integrated configuration environment simplifies and streamlines the engineering effort. This integrated approach eliminates the need for expensive data mapping, and handshaking logic that is common in existing solutions. The result of the ICSS integrated-yet separate architecture allows operators to more effectively manage the process from a single operating environment.

Reducing CapEx

Keep in mind that ICSS solutions are not simply a product or a specific control and safety system brand name. ICSS has become a proven strategy for building an all digital architecture, a blueprint for building solutions that optimize plant performance by:

- **Leveraging digital intelligence –** The intelligence (smarts) available in today's field devices represents a new source of previously unavailable information, including diagnostics that enable predicting and preventing problems before they impact process availability.
- **Connecting the plant -** Open communication standards link devices, systems, and applications in a secure, robust plant-wide network designed to ensure that process and equipment information is available wherever it's needed.
- **Controlling your process -** The more you know about your process and its operating equipment, the easier it is to improve production and achieve high-integrity process availability.
- **Optimizing your assets -** Digital technologies permit tapping into the architecture's information flow in order to increase uptime, optimize performance, and reduce maintenance costs.

After having converted several hundred DCS-centric architectures to ICSS solutions, overall plant efficiencies typically improve by at least 2%. Some of these efficiencies actually begin before the system arrives on site.

Historically, "Experiential Preference" has been the best measurement for reducing the capital cost of an automation project; however, in an ICSS project fiscal savings can come from a variety of sources spread along the entire project execution timeline. Additional CAPEX improvement opportunities may include the following:

Project related savings resulting from the selection of an ICSS solution from a single supplier can include:

- Project management:
  - Minimal number of people to contact
  - Efficient coordination meetings
  - Coordinated procurement and expediting
  - Coordinated cabinet designs, wiring, etc.
- Integrated FAT/SAT
- Consolidated packing and shipping
- Coordinated construction support.

In addition, advanced ICSS solutions include the following characteristics and features designed to assist with CapEx savings during implementation, configuration management, regulatory compliance, and commissioning.

Implementation

- Flexible, modular, and scalable design for applications of any size, anywhere – and for easier system change orders
- Security Access used to audit user privileges and system access
- Common database and engineering environment
- Intelligent point configuration, for example, each time a point is initially configured, that point contains all the appropriate attributes (i.e., process variable, setpoint, output, alarms, data historian, etc.)
- Complete palette of pre-engineered function blocks
- Integrated/intelligent alarm management
- Integrated Event Historian
- Integrated Audit Trail for Management of Change.

Configuration Management

Your team's engineering efforts are automatically chronicled and saved as part of the ICSS configuration audit trail. This audit trail should provide you with a complete version-to-version comparison – not just who, when, where and why the changes were made, but most importantly, what was actually changed. The audit trail should automatically record changes to device's configuration and include the following information for each event:

- Date and time of the event
- User who made the change
- Exactly what was changed.

Some of the time reductions reported by ICSS users include:

- 90% in configuration
- 75% in loop-checkout
- 85% in commissioning
- 28% in transmitter count when multivariable transmitters are installed.

Further reported reductions realized by the use of the ICSS's all digital fieldbus network include:

- 93% in I/O cards
- 74% in wiring
- 84% in terminations.

Regulatory compliance

Nearly every process plant is subject to some form of regulatory compliance. In the United States, these regulations include FDA's 21 CFR Part 11, OSHA's 29 CFR 1910.119. Additionally, most plants have committed to complying with ISO 9000. Where safety system conformance is required, the governing safety standards include ANSI/ISA 84 and IEC 61511. The ideal ICSS solution should provide considerable assistance in complying with mandated and voluntary regulations by completely integrating change management and generating, on demand, detailed documentation from its:

- Device audit trail
- Device calibration history
- Control and/or safety configuration audit trail
- Process history
- Event history.

Commissioning

Commissioning costs are dramatically reduced as the ICSS auto-recognizes intelligent field devices and control hardware. The ICSS automatically sets up the fieldbus, making deployment of the devices fast and trouble free. Additional commissioning areas realizing cost savings from an ICSS solution include:

- Proof testing
- Training costs
- Documentation costs
- Automated performance monitoring, testing, and documentation.

Specific to the safety system, the ideal ICSS solution will include:

- Third-party certified function blocks

- Secure bypass handling, with configurable time expiration
- Automated partial-stroke testing
- Sequence of event handler with first-out trapping
- Executable cause & effect matrices - eliminate design to configuration interpretation errors
- Graphical indications of bypasses, overrides, and degraded modes of operation.

Certainly an ICSS solution lowers upfront costs of engineering, installation and commissioning, but it will also reduce ongoing maintenance and management costs to satisfy your safety and regulatory requirements.

Reducing OpEx

After commissioning the process, plant efficiency comes from making more with less – more product on-spec – with less staff, less variability, and more process availability (less unscheduled downtime). The ICSS is designed to deliver results in operations and maintenance to improve plant efficiency and profitability. Part of those 2% improvement mentioned earlier, is the result of having access to the advanced digital diagnostics embedded in field-based measurement devices, such as analyzers and transmitters.

Predictive maintenance is key, whether in the control room or the maintenance shop, use of asset management software's advanced diagnostic information allows keying in on the field devices that really need attention. Beyond the advanced warning of faltering equipment, asset management software suggests corrective action and streamlines every faucet of maintenance work, including troubleshooting, diagnosing and calibration. With predictive maintenance, unnecessary trips to the field can be reduced by as much as 63%. Surveys conducted by different sources at different times reveal that more than 80% of maintenance is reactive (too late) or preventive (unnecessary)[1]. In fact, typical maintenance practices for reactive, preventive, and predictive maintenance have not changed in over 15 years[2]. This is primarily the result of an insufficient tool-set capable of improving maintenance practices – a situation that a modern ICSS can change.

Not only has digital technology improved the accuracy, repeatability, and stability of primary measurement sensors, embedded digital technologies also enable intelligent predictive diagnostics – a critical first step to achieving high-integrity process availability. Frequently, under-performing assets often go unnoticed until quality and/or rate became affected. When analyzers and transmitters are fitted with intelligent predictive diagnostics under-performing assets and potential problems that may eventually result in off-spec product and/or an unscheduled shutdown are monitored and assessed by asset management software. If a problem is detected, such as a plugged impulse-line, an alert is automatically generated.

Similarly, using embedded sensors and advanced diagnostic algorithms, control valve-signature diagnostics can determine which control valves do and don't need attention during the next scheduled shutdown. Being able to embed digital technologies in field analyzers and transmitters is analogous to how digital technologies have changed how we live, work, and stay connected. For example, the digital technologies that allow the service technician at an automobile dealer to pinpoint that a car's fuel injectors need cleaning is similar to the digital technologies that can detect that an in-line pH sensor needs cleaning.

It is hard to imagine but even as recently as 2002, independent surveys revealed that over half of today's maintenance activities are unnecessary. This includes routine equipment checks as well as preventive maintenance on equipment that does not need it. For example, one analysis showed that over 60% of all instrument work orders did not result in corrective action because there was nothing wrong with the instrument. Or consider that a diagnostic evaluation of 230 valves that were already scheduled to be rebuilt during an upcoming shutdown revealed that only 69 of those valves actually needed to be rebuilt.

1 *Reliability Magazine, 2002 (No longer in existence.)*

2 *"The Business Case for Reliability," available at www.mrginc.net*

The use of robust ICSS solutions can go a long way toward ensuring that instrument technicians are spending their time where they are needed and when that is happening, process availability will also improve. However, survey results aren't enough. In order to appreciate the benefits of investing in an ICSS solution to management hard numbers are needed. Maintenance cost as a percentage of Replacement Asset Value (RAV) is a frequent benchmark of maintenance productivity. For example, a plant spending $5,000,000 annually to maintain assets that could be replaced for $100,000,000 has a 5% RAV. The graph "Benchmarking Maintenance Costs" shows typical as well as worst- and best-in-class %RAV.

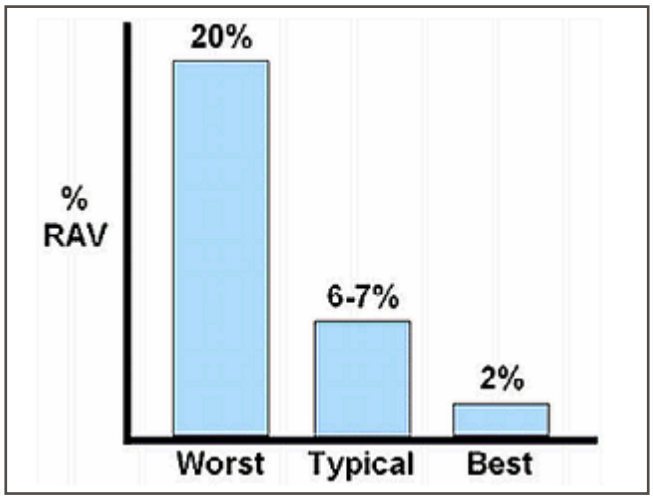


Figure 2: Benchmarking Maintenance Costs

For a plant with $250,000,000 in maintainable assets, moving from typical to best-in-class could mean more than $10,000,000 in annual savings. The goal is to use the maintenance-budget and -personnel more efficiently in order to reduce overall OpEx while advancing toward high-integrity process availability and minimizing process variability.

The key to minimizing process variability in order to produce on-spec product is the health and precision of the field devices and equipment.

Performance of control is best measured as close to the process as possible. With ICSS intelligent field devices its performance can be calculated in the device. Using all digital fieldbus communications, the system collects the variability data to provide process engineers with a snapshot of the sources of variability in your plant – by current measurement, by shift or by month. And it does this instantaneously with no configuration.

With this precise data available those problems that have the greatest economic impact can be tackled.

The ideal ICSS solution permits assigning alarms on variability index trip values for the loops that can influence variability most. For the plant manager, this should all be automatically rolled up into a summary display that includes key performance metrics.

> Operations have achieved a reduction in process variability due to tighter controls on the process. This has resulted in a more consistent product with respect to quality, yields, and cycle-times.
>
> **– Dean Hale, DSM Catalytica Pharmaceuticals**

Identifying and predicting problems in the entire safety loop – sensors, logic solvers, final elements, and surrounding process – is also critical.

The ICSS helps monitor the health of the entire safety loop by:

1. **Detection -** Continuously monitoring the health of each safety loop device and the associated process.

2. **Notification –** When a problem is detected, the ICSS generates an alert. Within the system alert types are pre-configured to be sent via narrowcasting to the appropriate personnel. Some alerts may be sent directly to "on-duty" plant personnel. Other alerts may be sent to an expanded list such as the on-duty plant personnel plus the unit and maintenance managers. Each alert includes information identifying the root cause of the detected problem along with context sensitive guidelines on possible actions and corrective measures.

3. **Correction –** Once the correct personnel arrive, additional information from the intelligent devices will be stored in the ICSS' asset management software database thereby facilitating quick access to detailed device diagnostics and problem correction.

The bottom-line is the ICSS architecture provides a platform for more reliable safety loop operations, from early detection through notification and correction.

> It's not only possible to check valves, but we can also do so more safely, at less cost, and with greater efficiency.
>
> **– Patrick Flanders, Saudi Aramco**

Because it's been shown that more than 50% of SIS malfunctions can be contributed to valve malfunctions, the use of partial-stroke testing has become a valuable means of detecting related malfunctions. During an automated partial-stroke-test, expect the ICSS to verify that the valve physically moves by measuring pneumatic supply, actuator pressure, and valve position. Benefits of automated partial-stroke-testing include:

- Less human error
- Better maintenance practices
- Better documentation
- Less risk
- Extend the period required between partial stroke tests.

Automation removes the guess work associated with when a safety valve needs to be maintained. The ICSS provides the ways and means to better understand the overall electro-mechanical condition of valves. Valve signatures generated during each partial-stroke-test provides maintenance personnel with insight into:

- Valve friction
- Air-path leakage
- Valve sticking
- Actuator spring-rate
- Inherent diaphragm pressure range.

This information provides maintenance personnel the ability to obtain the correct repair parts and schedule repairs. Because of the actual measurements and actions taken during partial-stroke testing the ICSS can automatically develop detailed documentation thereby making regulatory compliance much easier.

Interlock Testing

Checking process and safety interlocks is one of the most resource-intensive tasks of commissioning and in some cases represents a recurring requirement. Typically, technicians in the I/O room and/or in the field connect signal generators to simulate an interlock condition. In the control room additional technicians man the operator interface and verify that each interlock performs its pre-defined actions. Given the hectic environment of commissioning, efficiency is often degraded by additional communication traffic, misunderstood tag identifications, etc. The asset manager portion of the ICSS and the "wonders" of intelligent digital technology permit quickly and efficiently facilitate interlock testing and verification from a single location.

Ron Harlow, Principal Automation Engineer at Syngenta in St. Gabriel, Louisiana shares that before they can change-over to a new herbicide they must re-validate 20 sets of safety instrumented functions involving approximately 60 inputs. He says that the use of the ICSS's asset manager to verify interlocks has reduced the time to verify these safety interlocks from two to three days to one day.

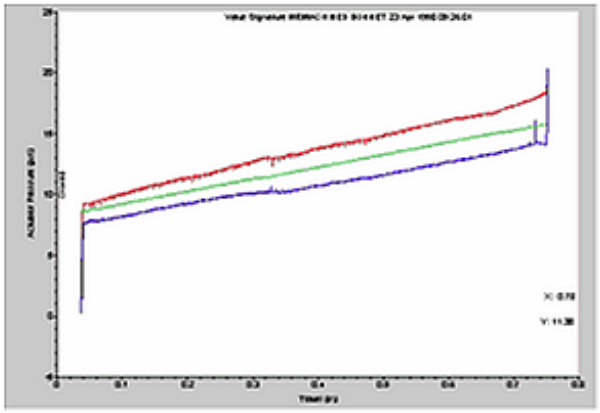
To make the most of an ever-dwindling staff and budget, or to trim operations and maintenance costs, a modern digital ICSS solution with built-in predictive intelligence can provide significant assistance.

Culture, Organization & Competency

This white paper has repeatedly stressed that an ICSS solution can reap significant plant efficiency improvements, but those benefits can only be achieved if the technology is harmonized with the correct culture, organization, and competencies.

Automobile mechanics used to work in the service bay of the local gas station or in a garage in back of their house. As cars became more sophisticated, independent mechanics were replaced by service departments at the automobile dealers, and mechanics began to receive special training for specific automotive systems. When cars became fitted with a variety of advanced technologies and associated sensors, service departments changed once again. Today, no service technician works on a car until the diagnostic technician has run a series of tests, analyzed the results, and printed out the details of why the "Check Engine" warning light on the instrument panel is 'ON'. With the detailed diagnostic results in hand, the service manager is able to assign the right service technician to the job. Modern automobile service departments provide a very good model for organizing plant maintenance departments desiring to take advantage of the digital ICSS solution.

As shown in the "Intelligent Field" section of this article, digital technologies enable intelligent predictive diagnostics of analyzers, transmitters, and control valves. For example, control valve stiction – a combination of sticking and friction – can be a major cause of process variability. Modern control valves, fitted with digital positioners are able to detect the presence of control valve stiction under actual operating conditions. Depending on the amount of stiction present, there are several things that can be done to improve the situation without shutting down the process. An operator would not be expected to recognize there's a control valve stiction problem, but the operator would be expected to recognize there's a problem maintaining process stability. That recognition alone would get them to the correct group of graphic displays where they would see a system generated warning indicator next to a particular control loop – the equivalent of the "Check Engine" light. The operator notifies the diagnostic technician, describes the process symptoms, and gives the technician the loop identifier. The diagnostics technician can login to the control valve, gather data, analyze the data and turn over the findings to the service manager. After a brief consult with the unit manager and the shift supervisor the service manager dispatches a service technician trained in re-tuning control loops. Because the service technician knows the cause of the misbehaving control loop, he knows just what to do to minimize the stiction problem. Follow up is needed, but this illustrates the importance of harmonizing the architecture of the organization using the technology with the architecture of the technology itself. Every analyzer, transmitter, control valve, controller, logic solver, fieldbus, etc. of the ICSS solution is conducting its own diagnostics and reporting the results to the database of an asset management application – the application where predictive intelligence begins to take place.



Valve signature diagnostics reveal conditions that if left undetected will increase process variability.

Asset management solutions are a collection (suite) of applications with each application targeted at specific asset types such as mechanical equipment, electrical systems, process equipment, instruments, and valves. Working with data automatically populated into the asset management database, each application runs appropriate performance checks. Any performance check that exceeds pre-defined limits is flagged in a report that is sent to the diagnostic technician, thus providing technicians a list of devices that require further diagnostics and analysis. Once the advanced diagnostics is complete, the technician forwards it to the service manager who determines the appropriate next course of action. For example, there may be a backup device available that could be placed into service; it may be necessary to expedite repair parts; or it may be necessary to schedule third-party services. What's important to recognize is that because the ICSS technology has been harmonized with both the using (operations) and supporting (maintenance) organizations high-integrity process availability is achieved. Simply stated, the features and capabilities of the ICSS technology can not be fully maximized unless the culture, the organization and the competencies of the entire organization – engineering, operations and maintenance – are thoroughly and completely developed.

Summary

Your company is committed to installing (or replacing or upgrading) the control and safety systems at one of your plants. You've seen the very aggressive project schedule and recognize that speed of implementation is critical. You've heard and read about modern highly-integrated, all digital system solutions. You recall hearing that these "smart" systems are a lot easier to implement than their predecessors, but you've heard things like that before. Besides, even if these modern systems are easier to implement, isn't it likely that all that sophistication will end up costing more to operate and maintain?

The fact of the matter is, choosing a modern ICSS architecture with its "smart" devices and embedded predictive diagnostics is more likely to meet an aggressive project schedule and end up costing less to purchase, engineer, install, commission, and maintain.

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