Automation systems today have become remarkable warehouses of knowledge and information. Beyond just system configuration, many years of effort is inevitably invested in these systems, not only by control engineers, but operations, process, maintenance, business, and management personnel as well. In fact, over the life of an automation system the value of the total intellectual investment will come to exceed the initial hardware and software cost many times over.

This paper will discuss some of the factors contributing to the impending process industry automation knowledge crisis, present real-life industry examples, and provide an optimal solution to mitigate the problems.

**Essential Facts about Automation Systems**
What is unique about automation system knowledge? Why is it so critical that it be captured? Consider the following facts about automation systems:

1. **Automation systems are critical to operations.** They are the heart (or more accurately the brain) of the plant. You cannot run a plant without them. They are also platforms for continuous improvement and change, evolving continually to embody much of what we learn about our process on a daily basis. Since they evolve continually, there is ample opportunity for the introduction of errors that can result in compromised unit operations, plant shutdowns, or possibly even an accident.

2. **Automation systems are highly interdependent.** They are a collection of components from a number of suppliers integrated together to provide desired functionality. Typically these systems integrate a variety of disparate subsystems, each with unique data structures, and employing multiple interface techniques. In modern plant automation systems, a tremendous amount of data is exchanged, and interoperability between and among the subsystems increases daily. These different components need to work together seamlessly for the automation system to function properly.

3. **Automation systems contain vast amounts of information.** They have embodied within them knowledge from a variety of sources that have been added and refined over the years. This knowledge represents the collective intelligence of an accomplished group of individuals, many of whom have most likely spent a significant part of their career optimizing the functionality of that particular system and process.

4. **Automation systems documentation capabilities are limited.** Although there is a large amount of critical information contained in them, the self-documentation functionality of even the latest versions from the leading suppliers lacks the capability to capture their inherent complexity. Furthermore, each automation supplier provides tools that manage only their specific system, providing no understanding of the relationships and levels of interoperability between it and the various systems it is connected to. Thus, users are left with an incomplete understanding of their installed automation, forcing them to rely upon outdated, manually generated documentation, or individual recall to understand the system.
The Knowledge Crisis
Safe, reliable, and profitable plant operation requires strict protection and careful management of the knowledge that resides in automation systems. Two critical, converging factors threaten the integrity of automation systems and the ability to effectively manage them. These factors are: loss of critical automation knowledge and the escalating complexity of installed systems. Throw in the ever-increasing regulatory requirements and you have a “perfect storm” on the horizon.

Loss of Critical Automation Knowledge
The United States Census Bureau considers a baby boomer to be someone born during the demographic birth boom between 1946 and 1961. In the United States alone, some project that at least three million engineering jobs have been vacated between 2004 and 2010 with no expectation of the trend slowing down. A recent study revealed that a major refining company in the United States lost 2500 man-years of knowledge in just one year when 100 operators retired. This loss of plant knowledge will take many years to regain, if it is even able to be fully recovered at all. This situation is not unique to the United States or the process industries; it is occurring regularly around the world. While the current economic crisis may have delayed this exodus temporarily, the clock is still ticking and the departures will be even more dramatic once the economy fully turns around.

Figure 1 shows an example of how dramatically group demographics can change over a decade. This is real data from a group of automation professionals at a major global petrochemical company. The age distribution data from January of 2005 showed that the group was definitely skewed to the older end of the age spectrum. Management recognized the need to attract younger engineers into the group to maintain its viability as the baby boomers retired.

Figure 1: Age Distribution by Year at a Major Global Petrochemical Company

Despite their best efforts, as of January 2009, the percentage of employees age 40 and younger actually dropped by more than half. Their projection five years into the future (January 2014) shows the trend only getting worse. By 2014, only 6% of the group will be age 40 and younger and nearly half will be eligible for retirement. This puts great

Industry Case 1:
A North American petrochemical plant was performing a migration of a very old Westinghouse DCS to a new DCS. The native documentation capability of the Westinghouse system was very limited and extracting configuration information required a high degree of system knowledge combined with sophisticated database manipulation skills. This plant had only one engineer with the ability to understand and extract the needed information and put it into a usable format for import into the new DCS. Unfortunately, he went in for surgery and passed away suddenly over a weekend, leaving the plant without that critical skill set. The project team turned to the new DCS vendor, who, surprisingly, could not supply that skill set. This caused significant delays and added cost to the project.
risk in the company’s ability to effectively manage its knowledge-intensive automation assets. Every company should perform this automation knowledge worker demographic analysis to assess their vulnerability. The results can be eye-opening.

Increasing Complexity of Installed Systems

Studies have shown that modern plants have as much as twenty-five times more points of measurement than they did before the advent of the DCS. Each time that a price or technology breakthrough occurs with measurement technologies, more points get added to the plant. Adding points of measurement is most often justified because they feed an integrated application that somehow improves production.

Furthermore, improved human interface capabilities, the addition of multi-functional controller platforms, and the general age of the installed systems are driving upgrades to newer DCS platforms (see Figure 2). The new DCS’ tend to be larger and are more likely to be integrated with other sub-systems than their predecessors.

This trend is likely to intensify as wireless instrumentation, lower-cost sensors, field device networks, and service oriented architectures gain acceptance in the process industries. These technologies taken together will drive down the cost of making and integrating measurements, as well as the cost of integrating the applications that use them. Therefore, this facilitates the integration of real-time systems, such as DCSs, with non-real-time systems, such as planning and scheduling. Mapping and managing all of these interdependencies becomes untenable without assistance (see Figure 3).

Figure 2 shows a medium-sized automation system (~4000 hard-wired I/O) based upon a Honeywell Experion DCS that replaced an older TDC2000 system. This upgrade added over 30 workstations and servers together with a complex, multilevel network architecture and several third party device interfaces. While certainly more flexible and capable than the system it replaced, the complexity of this new system is dramatically greater as well.
Ever-Increasing Regulatory Requirements
In addition to the aging workforce and complexity issues described above, the bar is also being raised on regulatory performance. Allowable emission rates continue to be tightened and mandatory reporting requirements have skyrocketed. For example, Houston, Texas area petrochemical plants are required to reduce their NOx emission by 80% compared to the year 2000. In 1997, one local plant was governed by 28 published air toxicity rules. Today, that same plant has to comply with over 125 published rules, each with additional mandatory monitoring and reporting requirements.

The trend toward increased regulation is driving increased enforcement activity from regulatory agencies and the intensification of media scrutiny. The graph in Figure 4 below comes from the Texas Commission on Environmental Quality’s 2008 Enforcement Report. Despite the fact that overall emissions have dropped significantly over the past five years, the amount of enforcement activity is rising. Furthermore, the penalties associated with these violations have increased dramatically.

The Solution
With regard to automation systems, the solution to the above problems must take a number of factors into account. First, it must capture the knowledge embedded in all plant automation and related systems. This includes DCSs, SISs, PLCs, instrumentation databases, historians, and applications (both real-time and non-real-time). It must expose automation system knowledge in context, graphically display the signal genealogy, and document the relationships among all interoperating systems. This knowledge capture mechanism must automatically update with the latest configuration in near real-time, and track all changes. To be fully utilized, it must be easily accessible via a secure plant Intranet. A solution of this nature would also facilitate the migration of legacy systems by translating their inherent knowledge to a format that provides for a quick and easy transition to a new control system.

Conclusion
As seen in the industry cases presented, the loss of critical automation knowledge, the escalating complexity of installed systems, and ever-increasing regulatory compliance requirements are conspiring to create an automation knowledge crisis in the process industries. There are tremendous benefits to be gained by assessing one’s current automation-related risks, and developing a plan to manage and preserve the priceless knowledge within the automation systems.
About the Authors
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