Overcoming Automation Challenges

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While Typically a Very Small Percentage of Project Costs, Automation Has Big Impact on Operations

Successful Automation Project Management Requires Successful Management of People, Processes, and Technologies
Basic process automation technologies and approaches to automation projects have changed very little in the past 20 or more years. However, new project engineering practices combined with new technologies such as configurable and characterizable I/O, cloud computing, and virtualization can help owner-operators significantly reduce project costs, hardware footprint, and completion times. This new model for managing automation projects is a key part of ARC’s Collaborative Process Automation System vision.

Executive Overview

ARC Advisory Group’s Collaborative Process Automation Systems (CPAS) vision goes beyond applying new technologies to include best practices for managing the lifecycles of process automation systems. The CPAS lifecycle management perspective starts with the early stages of the automation project through supplier selection, front end engineering and design (FEED), installation, commissioning, startup, through the operational phase of the plant or facility.

Our newest edition of CPAS (version 3.0) includes new approaches to automation projects, for which we’ve included some details in this report. New technologies such as configurable and characterizable I/O can greatly reduce installed project cost and better accommodate late changes to the project, as well as providing a smaller footprint. Technologies such as fieldbus can provide similar advantages. Other new technologies such as virtualization and the cloud can reduce engineering times and provide a true path to concurrent engineering.

Technology benefits, however, must also be considered in the context of the people and work processes that make use of those technologies. Workforce demographics are changing and new work processes must be developed to accommodate new technologies. The new breed of automation systems, for example, allows users to divorce the automation system hardware from the software, providing the means to pair the software aspects of the system to the hardware at a very late stage in the project. This has the potential to eliminate traditional factory acceptance testing (FAT) approaches.

ARC has always believed that automation should be viewed with an eye toward business value, and this is certainly the case with today’s automation project challenges. By applying the concepts outlined here, end users can shave months off traditional automation project times and reduce the control system hardware investment significantly. More importantly, these approaches provide a great path toward eliminating the huge cost of customization historically carried by the process industries.
The Problem with Automation Projects

When looking at the total cost of a project, the automation portion of that project tends to be quite small. For an average refinery, for example, automation can represent 1 percent or less of total project spending. Other aspects of the project, such as piping, fittings, and vessels account for much more. For this reason, the value that automation brings to a project is often overlooked. However, automation provides the “brains” behind the plant, and the process cannot run without a well thought out and executed automation strategy.

Typical 18-24 Month Project Timeline

Despite the relatively small size of the automation portion of a project, automation is frequently on a critical path and can adversely affect project start up times. End users are increasingly challenged when it comes to managing ever-increasing project costs. Last minute changes and additions frequently extend project cycle times, projects are often behind schedule, and most project go over budget. At the same time, many end users, particularly in high-growth industries such as upstream oil & gas, are under mounting pressure to execute an increasing number of projects that must be executed flawlessly, on time and on budget, with a path to operational readiness. This means the plant is 100 percent ready for full operation right out of the gate.

New Model Needed for Executing Automation Projects

With so much pressure on the project side, it is clear that the traditional method of executing automation projects must change. This requires both a change in the work processes associated with projects and the technologies that make them possible. Let us take a look at the changes required and how they can be executed.
The Trend from Customized to Modular Construction

Traditional automation systems were designed and installed with a high degree of expensive and time-consuming engineering and customization. In a refinery, for example, the automation system would be applied to the specific refinery design and built around the refinery. Today, however, there is a movement towards more modular and standard construction, where standard components of a plant are put together along with standard automation components that are built into each modular piece of the plant. Clearly, this is far more efficient in both time and cost than the old “stick building” approach. It’s also particularly appropriate for those industry sectors that are seeing the most growth, including upstream and midstream oil & gas, water & wastewater, and life sciences.

Early Involvement Is Key to Success

One of the first steps to realizing better project success is early involvement by the automation supplier in the overall project cycle to identify all relevant instrument and control activities and develop an overall plan for the flawless execution of the project. For the end user, the project is never really over. Decisions that are made in the early stages of the project have an impact throughout the plant lifecycle, and data captured during plant construction must be seamlessly transferred through the operational phase.

Changes made in later phases of the project cost the end user far more than those made in the earlier phases. Early involvement means that fewer changes are made during project execution. This is due to a smoother transition between the project’s specification and configuration phases.

Front-end engineering and design (FEED) is one early involvement example that can have a big impact and add value. The FEED stage is where much of the value is built into the project. Many suppliers view the FEED process, in conjunction with consulting, to be a critical factor in determining
project success and derived benefits for the customer. Technologies such as fieldbus, dynamic optimization, and real-time performance management rely on a good engineering and design effort, as well as a seamless transition from engineering and design to implementation, operations, maintenance, and the rest of the plant lifecycle. Suppliers can leverage the knowledge gained in their own FEED work with their service capabilities in the rest of the plant lifecycle to create more effective automation strategies.

Managing People, Processes, and Technologies

Automation is not just a technology issue. People and processes are becoming increasingly important as end users struggle to maintain safe and efficient operations with a shrinking pool of qualified personnel. The workforce is continuously shrinking and there are not enough people to fill all the vacancies that will exist. The overall approach to automation projects and lifecycle management must take this into consideration. It is difficult to deploy a highly custom-engineered solution if there are no engineers around to do the customizing. With necessity being the mother of invention, end users are taking new approaches to managing their people and work processes just as much as their technology management and selection.

Users must carefully select and contract the best resources available to them, and that means knowing who your human resources are as well as their areas of expertise. Project activities must be assigned to the people that can execute those most effectively to help ensure on-time completion. The work processes that people follow must also be carefully managed. Many leading edge end users have created and are continuously improving a standard set of best practices used globally within their companies for both project management and the operational phase of their plants or facilities.

Technology remains a major part of project success, however. More consideration must be given to technology selection. This requires a better understanding of how technology can provide specific business benefits. Technologies must fit their purpose and be proven in use. Instead of evaluating individual technologies on their own, users should also consider any unnecessary or artificial barriers that a specific technology may create and its impact on the overall success of the project and the operating lifecycle. This includes barriers like having to configure (and maintain) interfaces to third-party software applications and an inability to accommodate late changes in the project.
The impact of hardware and software version changes must also be taken into account. Many end users find themselves filling the role of an IT professional, and are spending an inordinate amount of time managing version changes, patches, and other “housekeeping” chores related to today’s technology. Documentation is also an issue. Care must be taken both to eliminate generating unnecessary documentation, and to automate the generation of required documentation as much as possible.

The Technology Challenge

Automation suppliers are listening to the demands of their end user customers and responding with a new range of automation technologies and practices that can help reduce project cost and time to completion. New technologies include new I/O and control devices that are more efficient, flexible, and have smaller footprints. For the project lifecycle, automation suppliers are leveraging new technologies like the Cloud and virtualization to make engineering more efficient and eliminate some of the traditional steps of factory acceptance testing (FAT).

From Traditional Fixed I/O to Characterizable and Configurable I/O

Traditional I/O, wiring, and marshalling schemes can be problematic for an automation project. Conventional I/O modules are rigid, with dedicated connection points for analog or digital input or output, as well as other signals. This fixed structure can make it difficult to adapt to late changes in the project. Many end users try to get around this issue by pre-planning additional spare I/O capacity and through other measures. However, late changes must almost always be accommodated and, in many cases, new I/O modules need to be added along with all the associated point-to-point wiring and associated labor.
For many end users this is more than just a nuisance. Significant I/O increases, forced post-FAT rework, and field modifications can mire down a project and have a major impact on cost. Almost every facet of a project can be affected by these late changes, from delays in release of construction drawings to delayed delivery of automation systems, delayed construction and commissioning, and late startup dates.

Leading automation suppliers have “stepped up to the plate” with new I/O that is either characterizable, configurable, or a combination of the two. Characterizable I/O includes hardware nodules that plug into a rack and can represent analog input, analog output, digital input, digital output, etc. The type of module plugged into the rack determines the type of signal. Modules can be plugged anywhere in the rack and are location independent.

Configurable I/O solutions take a similar approach in terms of point independence and flexibility, but the points are configured through software rather than hardware modules. Some vendor solutions offer a combination of characterizable and configurable I/O points, depending on the type of signal.

Characterizable and/or configurable I/O offer benefits that go beyond just making it easier to incorporate late changes and reduce time to project completion. These solutions have a much smaller footprint than traditional I/O, resulting in significant space savings on a new project, and better management of the small space that will probably be available in migration projects. Controller cabinets can also be smaller, and some vendor solutions offer field-mounted junction boxes for a more distributed environment. Entire marshalling cabinets can be eliminated. Users no longer have to customize cabinets and can choose from a smaller, more manageable catalog of standard cabinets. Other benefits stem from smaller footprints and standard design. These include reduced power consumption and heat generation.
**Additional Benefits of New I/O**

Characterized or configurable I/O not only reduces the footprint from all of the cabinets and junction boxes, but also significantly reduces weight. This can be a significant value for offshore facilities. Many end users are undergoing record-breaking construction projects for huge floating LNG platforms, FPSOs and offshore rigs. On topside modules, companies are compressing everything down to the smallest possible size and weight. These companies are incorporating this new I/O or, as an alternative, fieldbus-based solutions, to reduce footprint and weight, which can provide significant value for offshore facilities.

For many companies, the traditional approach also means large numbers of controller/I/O cabinets, marshalling cabinets, and field junction boxes to collect the I/O in the field. With the new I/O technologies, the total number of cabinets and junction boxes can be reduced by as much as 66 percent. The amount of terminations for all of this I/O can be reduced by about 66 percent as well. This is a significant reduction in construction work and removes many of the sources for errors.

**DICED: Or How to Automate Automation**

“DICED,” a technology concept that originated at ExxonMobil, takes smart I/O to the next step. DICED stands for auto-Detect, auto-Integrate, auto-Configure, auto-Enable, and auto-Document. Essentially, DICED will automate many of the key facets of an automation project. Initially, DICED will enable HART devices to be self-commissioning, but many automation suppliers are working to extend this capability to switches or digital devices. When commercialized, this technology could reduce commissioning times for automation systems by up to 80 percent.

DICED will also allow users to greatly simplify the documentation for a project and eliminate the causes for errors. Interconnect drawings created by an engineering contractor will no longer be required. A construction contractor will hook up an instrument, run the wiring to the closest smart junction box, terminate on any set of input terminals, and -- if the control system is powered up -- the loop will self-commission. When the contractor is finished, a few clicks will generate the needed “as-built” interconnect drawings. DICED will detect where the instrument is connected. Since smart I/O does not care about polarity, the construction contractor cannot make a mistake, so no human checking is necessary. This brings a new level of “bonehead simple” to automation systems.
Late Binding and Separating Hardware from Software

The impact of characterizable and configurable I/O goes beyond reduced hardware, footprint, and wiring. These new forms of I/O represent a fundamental shift in systems architecture. Specifically, they allow the hardware- and software-related aspects of the system to be separated. With fully adaptable and standard I/O and control hardware, the user can theoretically design and test all of the software aspects of the system before it is deployed into the physical system hardware. This allows the software to be deployed into the hardware infrastructure at the very late stages of the project. This is often referred to as “late binding.”

Late binding has some interesting implications for the project lifecycle and can eliminate the need for FAT and other project stages. It also allows for more flexibility in system design and facilitates concepts. These include concurrent engineering, in which multiple people can work on the system engineering project from different locations around the world, with the system software configuration residing in a cloud-based infrastructure. The implications for true collaboration are powerful. With the system design totally contained within the software, it can be validated virtually with no need for hardware FAT. The hardware can be virtualized for engineering purposes and the software design is proven using this virtualized hardware.

This new approach also means that certain elements of the project can be executed simultaneously with less interdependence, so system hardware and software can be configured at the same time. The hardware and software are brought together at the site, with all the necessary hardware available when it is required. This could reduce typical automation project execution times from 18 to 24 months to just 12 months.
The Field Device and Automation Asset Challenge

Fieldbus can provide many of the same benefits as characterizable and configurable I/O and should be considered when evaluating automation technologies. Purely digital fieldbuses such as FOUNDATION fieldbus and Profibus PA share the same physical layer under the IEC 61158 standard. Both can help reduce field wiring requirements because of the bus structure, with spurs that connect to a field junction box.

FOUNDATION fieldbus goes a step further by supporting function blocks and providing software-based connectivity, in which devices provide multiple signals over the same two terminals. Instead of relying on custom hardware configurations, FOUNDATION fieldbus accomplishes traditional marshalling tasks through a software-based structure. All signal linking (block-to-block) is done in software without hardwiring.

This approach allows late addition of feedback and auxiliary measurement and control signals without the need for additional wiring. I/O-connected devices can also be changed without switching I/O cards and more devices can be added without having to install more cable. Design considerations for fieldbus networks are different than for analog networks. Factors such as trunk length and number of devices deployed on a fieldbus segment must be considered.

Today’s increasingly pervasive intelligent field devices promise to transform the way device and process information is utilized. Devices with impending maintenance problems, for example, can be identified earlier, and information provided directly to process automation systems, plant
asset management systems, or any other systems or software in a plant as required.

**The Electrical Challenge**

Electrical assets make up a huge portion of project costs. In many cases, the amount of electrical I/O equals the process I/O, and the electrical side is subject to the same challenges of rising project costs, constrained human resources, and the need for better visibility and actionable information for electrical assets.

Just as for the process automation side of a project, end users are increasingly looking at ways the electrical side of the business can benefit from a more streamlined project engineering and execution approach. New forms of characterizable and configurable I/O will emerge for electrical products, and we will see a more common approach to engineering for the electrical domain. This includes not only switchgear, but also drives and motor control centers; the largest consumers of power in today’s plants and industrial facilities.

Integration of Control and Electrification with IEC 61850

Automation and electrification, however, remain largely separate islands of functionality in today's plants, as are drives and motor control centers. Process operators, and even maintenance personnel, have limited visibility into what is happening in their electrical systems, or control over how much power their automation assets are consuming. Many suppliers offer solutions for improved visibility into the power side of the manufacturing process. ARC believes that taking a more proactive stance toward integrating the automation and power/energy domains of the
manufacturing process can yield significant energy cost savings as well as significantly reduced project costs.

**Benefits of Integration of Control and Electrification**

Integrated control and electrification offers significant benefits for the project side as well as the maintenance and operational sides. Integrating power and automation systems brings simplicity to various stages of implementation, through a common area of work. Reuse of engineering data can help reduce required engineering by as much as a 30 percent. Applying the same configurable/characterizable approaches to electrical I/O as we do to process I/O can reduce cost, footprint, and project completion times. Definition, design and engineering, as well as factory testing and commissioning times can also be reduced by up to 30 percent. Common tools can be used to engineer and integrate all devices.

By integrating electrical products under a common architecture, end users can optimize maintenance practices in asset management for instrumentation, motors, transformers, drives, communication networks, smart motor control centers, and more. A digitally integrated electrical system also enables the use of tools for remote maintenance. There are also safety and security benefits that can help reduce risks and contribute to flawless project execution.

**IEC 61850 Brings Digital Network Technology and Advanced Plant Asset Management Capabilities to Electrical Assets**

IEC 61850 is an Ethernet-based solution that can help provide tight integration between automation and electrical systems. IEC 61850, a global standard, defines the communication between intelligent electrical devices (IEDs) in switchgear and associated systems and considers all automation and engineering functions. IEC 61850 is the key enabler for integrating automation and electrical systems.

By providing a greater level of interoperability between electrical devices from different suppliers, the IEC 61850 standard does for electrical products what process fieldbus does for instrumentation and control valves. IEC 61850 also promises to enable the same level of enhanced diagnostics and plant asset management capabilities offered in process fieldbus devices.
Intelligent Motor Control Centers and Variable Speed Drives

Motors are a major source of energy consumption. Many industries can significantly reduce their energy costs just by addressing inefficiencies related to motor loads. Statistical research indicates that, in a single year, a motor can consume enough energy to account for ten times its initial cost.

Deploying variable speed drives and intelligent motor control centers integrated with the automation system can significantly reduce energy costs. In oil & gas industry applications, for example, it is common – if inefficient – practice to control the output of variable torque loads (such as in pumps, fans, and blowers) by throttling their input or output. In contrast, applying AC drives to large fans and pumps to control flow by modulating their speed, can produce significant energy savings. The higher the level of motor operating time and the larger the variation in load duty cycles, the greater the opportunity for savings. One pipeline operator expects to save $5 million annually in transportation expenses while reducing the frequency of pipeline shutdowns that can cost up to $750,000 per shutdown when the pipeline is running at full capacity.

The People Challenge

According to the US Bureau of Labor and Statistics, over 10,000 workers from the "Baby Boomer" generation (people born between 1946 and 1962) are leaving the workforce daily. Most of this is due to a combination of these people reaching retirement age and employer workforce reductions. BLS statistics further show that this leaves the US with a shortfall of over 42 million people in the workforce, eight million of which are professional positions. Other developed regions are experiencing a similar crisis.
For some industries, this could not happen at a worse time. Even with the current drop in oil prices, the process automation business keeps, growing, and many end users cannot find enough experienced people to execute all the projects on their drawing boards. In many ways, the increased adoption of new approaches to automation project execution presented in this report are a direct response to the looming labor crisis and the shortage of experienced personnel. End users have no alternative but to look to alternative project approaches to complete projects on time and on budget. The resources required to support the large degree of customization that the industry has endured for decades are simply no longer available and the industry must adapt by deploying new forms of technology.

The Work Process Challenge

This does not mean, however, that technology will replace people. People must learn the new technology-enable work processes and procedures. Technology changes the way we work. Conducting a daily predictive maintenance routine with digital field devices, for example, is much different from doing preventive scheduled maintenance with conventional analog or pneumatic field devices. This includes work processes in the engineering phase of a project, from the FEED stage to commissioning and startup.

ERP systems and production management systems often come with a choice of embedded work processes, but these may not be the best for your requirements. In many cases, the work processes supported by the application providers represent a force fit for the end user (although, in some cases they could represent an improvement, so it’s important to keep an open mind). Fortunately, owner-operators and end users can obtain recommended work processes and best practices for their implementation from a number of sources, such as the ISA and IEC standards bodies. These include standards that offer advice on work processes for everything from project management to intelligent device management.
ISA95 includes models and terminology for the interface between business systems, manufacturing operations management systems, and production systems. These models and definitions for information flow and communications can also be used to guide work processes. The ISA106 standard defines work processes as they relate to procedures in process plants, and offers guidance on which procedures should be manual, guided, or automated. ISA108 provides work process templates that can be used with intelligent field devices to drastically reduce installation and commissioning costs, maintenance costs, and turnaround times.

Regardless of which resources are available, they key to success in driving new work processes in a process plant or other industrial facility is to obtain buy in from the people that will be using these new work processes. This often requires proper training and education. New work processes, especially if they are corporate standards, should also be a mandate from upper level management and include appropriate incentives.
Recommendations

Clearly, the era in which large global upstream and downstream companies with vast resources of capital and human talent could afford to spend whatever it took to bring a new project to completion is over. Today’s industrial organizations – large and small – face substantial pressures to reduce project costs and time-to-value and must accomplish this in a tight capital environment, with severely constrained human resources, and faced with a much broader array of more powerful, but also often more complex, automation solutions.

As we’ve seen in this report, which relates to ARC’s latest vision for the collaborative process automation system (CPAS), when embarking on major greenfield or brownfield expansion projects, owner-operators face significant challenges relative to automation technology and assets, electrical technology and assets, people, and work processes.

The good news for owner-operators, is that – just as for CPAS – the technologies and approaches presented here for streamlining, improving, and speeding automation project execution are all available today; providing the opportunity to significantly reduce project costs, hardware footprint, and time to project completion.

ARC strongly encourages owner-operators and end users to evaluate these new technologies, approaches, and work processes as they relate to their projects. ARC believes that, when applied properly, they offer the potential to reduce installed project costs by at least 30 percent and significantly reduce time-to-value, while yielding significant cost reductions in the much longer operate and maintain phase of the plant or facility.

The new CPAS 3.0 study from ARC details these new approaches to automation and also provides an overall framework for what the ideal process automation should look like, including supported applications, functionality, support of new technologies like the Cloud and virtualization and more. ARC will continue to research and report upon new technologies and approaches that offer the potential to make capital projects less challenging for owner-operators.
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CPAS Collaborative Process Automation System
EAM Enterprise Asset Management
ERP Enterprise Resource Planning
FAT Factory Acceptance Test
FEED Front End Engineering Design
FPSO Floating Production Storage and Offloading
IED Intelligent Electrical Device
IT Information Technology
LNG Liquefied Natural Gas
MCC Motor Control Center

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