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Rationalizing Control Systems Upgrade and Migration

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Abstract*: As the Distributed control system (DCS) reaches the end of lifecycle and an upgrade to new automation is essential, there is much to be considered. Potential challenges for instance are differences in hardware that can affect the migration process, unexpected downtime of the plant and unanticipated costs. These can jeopardize the upgrade project which is vital to the productivity of the plant. Advanced awareness of these challenges and groundwork can enable a smoother migration. This paper highlights the planning and requirements for safe and manageable control system migration, providing guidance to upgrade the automation systems while making the most from the prevailing plant resources and intellectual property.*

Keywords— Distributed Control system (DCS); Input/Output; Process Controllers; Automation; Migration

1. INTRODUCTION

In case the DCS maintenance work is taking more time fixing and restoring system components rather than improving the process and if the reliability of the Control system starts to decline with unexpected outages resulting in production losses then it is time to upgrade your control system. Another big sign that your DCS needs upgrade is when the hardware spare parts become hard to find, when vendors have minimized technical support for the products, recurrent lost time due to the control system failures, if the new technologies are not compatible with your older systems, also when you cannot find control room operators supporting the older DCS. It ceases to be a benefit if your control system regular operations demand too many resources, it is imperative to understand the risks of waiting to upgrade so you can decide when the time is precise.

The plant's DCS performance can significantly influence a manufacturer's financial bottom line. Current competitive markets demand latest automation solutions that increase plant productivity, lower costs and improve regulatory compliance while responding to customer demands for improved product quality and faster delivery. Recognizing the benefits that an updated and latest integrated control architecture provides helps the migration path easier. As operators become more effective, the overall operational effectiveness advances to new levels.

2. SUPERSEDED HARDWARE AND SOFTWARE

One of the most primary reasons for a DCS upgrade is outdated Control systems hardware and that the current technologies are not compatible with old DCS systems. Superseded DCS hardware such as Controllers, Input/Output IO modules and Communication hardware needs to be upgraded for prevailing and efficient processors, workstations, and servers. This obsolete hardware may not get the maintenance and backing required from the vendors as they may have ended support for these products.

The latest features of the new DCS products comprise of basic and simplified procedures for bulk-building and editing of I/O points, Microsoft Excel or XML formats that allow users to build the control database more easily than with cumbersome text dumps and graphical function block configuration, which makes configuration easier than text-based forms and allows for easier control application maintenance and self-documentation[1]. The old DCS systems would not work with these new technologies with modern features as they were designed to handle the technologies of the past era. Depending on the age of the installed system, original equipment manufacturer (OEM) supplied parts may not be available. Then the only option for the facility is to resort to purchasing used components on a secondary market to keep the DCS operational, which will put the reliability of the facility in jeopardy and an immediate control system upgrade should strongly be considered.

2.1 Redundant Controllers

Redundant Controllers are critical in many industries such as mining, nuclear, gas control and often in manufacturing which cannot afford interruptions in operations and safety monitoring where 100% uptime of the control systems are needed to prevent deadly and costly incidents. Redundant Controllers are used to protect your process automatically when one of the controllers are failed. The delay in upgrading of old redundant Controllers can be a bigger issue if a single controller fails, it will have to be replaced with a modern controller while the other redundant controller is still old. Running the plant on sole controller until the next downtime or upgrading both the controllers at the same time will put the plant in risk.

2.2 IO Modules

When IO modules fail, they can cause risk to personnel, equipment or can result in a plant trip. Therefore, the IO modules are designed to fail in a safe position. Outdate IO modules need to be updated to critically reduce the risk of an entire module failure.

2.3 Communication Hardware

Outdated DCS communication systems cannot use updated new technologies. An old DCS using older networking protocols cannot interconnect effectively with many third-party systems. Upgrading to Ethernet-based networks and an OPC-compliant DCS opens the door to a wealth of productivity tools and advanced control applications able to deliver more return on your DCS [1]. Adding simple wireless field devices also becomes challenging with older DCS systems, eliminating the remote access capabilities which is vital for wireless technologies.

2.4 Resources

While the operators and engineers knowledgeable of the outdated DCS will be hard to find when most of the industry is using the new technology, the newer generation skilled technicians would prefer working with newer systems and technologies. Plus, the external deadline reduces your flexibility to adjust to unforeseen problems and since the product support ended long ago, upgrades are also more challenging.

2.5 Software

Outdated software from the DCS vendor is not the only issue, windows operating system software can also be a major problem. When Microsoft discontinues support for the Windows operating system, DCS packages which are operating on those Windows OS and are approaching end of life will not be able to remain any longer. Control systems that rely on this platform are exposed to increased security risks and availability issues.

3. BENEFITS OF UPGRADE

The new DCS systems have many features to enhance security, performance, safety, controllability and reliability of the industrial facilities. They have enhanced graphic display capabilities to provide technicians with the ability to address issues and keep the unit running when problems arise. Built-in alarm reporting capabilities and remote access allows management to monitor the stations remotely, access reference information through the control system, the alarm tools allow operators to respond to events quickly and plan for outage activities. Automated patch management and user profile maintenance provides protection against security intrusions and reduces workload for Cybersecurity team. With the DCS software upgraded, all the software systems can be regularly updated with the newest security features such as encryption, authentication, auditing, and more so the DCS systems are no longer vulnerable to the daily Cybersecurity threats.

Upgrading the communication hardware will keep the yearly software costs low. With the legacy systems, vendors would often charge more for maintenance and support of the older software due to obsolete components and availability of specialists. In many cases that money that you spend on maintenance costs could be used to purchase and deliver an entirely new system to not only have potential lower maintenance costs, but to give you newer technologies which have enhanced features and capabilities.

If the facility expansion is soon coming, it is best to introduce a new DCS into your plant so that the operators and engineers can be trained on the new technology, which will make future upgrades for your facility easier. The DCS upgrade provides maximum return to the facility with reduced downtime, improved safety, productivity, increased security and operational integrity to the facility.

4. RISKS

The risks associated with your current DCS system needs to be evaluated along with the new upgrade enhancements, a review of each control area should be performed to analyze the existing conditions and the effects of a control system upgrade. A detailed control system assessment assesses the risks and also evaluates the potential benefits.

The downtime of the DCS directly results to the loss of revenue, so an analysis needs to be done accounting for the downtime required due to Control system upgrades, including the multiple years of outages by the present DCS systems [5]. Downtime of the Plant and the interruption to certain systems is a major risk and could be planned to minimize or circumvent. Testing the migration of Control system can be risky if the programming is deployed to the entire plan instead should be implemented per system or area. By comparing the before and after risks, it becomes clear which risks will be mitigated and which will remain an issue, allowing for long-term planning.

The risks and technical capabilities of the existing systems to support the business processes should be evaluated [4]

- hardware condition (history of failure or mean time between failure, age of equipment, availability of spare parts)
- software condition (support from vendors, availability of documentation, availability of competences)
- system restore capability (redundancy, mean time to repair)
- business impact assessment (disclosure of information, data errors, non-availability)
- indicative scoring (system reliability, system criticality, and life-cycle management)

Use a standardized reference model (based on the ANSI/ISA-95 series of standards) to explore business processes [3]. It comprises 19 high-level business processes that are broken down to the relevant level of details to understand weaknesses and the need for changes from a business point of view. Figure 1 is ISA-95 Typical Control Hierarchy Levels.

Figure 1. DCS Hierarchy as per ISA 95

5. COSTS

Control system upgrades are most often considered to be a disgrace as an unnecessary cost due to the difficulty of analyzing the risks associated with the legacy systems as well as incorrect valuation of the benefits from upgraded DCS systems. Estimate the budgetary costs and log every assumption made.

If calculated, the costs of managing the old DCS systems ultimately will surpass the costs of an upgrade or full migration. Also, the maintenance of older systems becomes expensive as system support declines and as spare parts become harder to find. By gauging and comparing the cost of past outages and downtime with future occurrences, it can be determined if a control system upgrade is cost effective.

The total cost of the DCS upgrade needs to be assessed and budgeted accurately for the justification and successful completion of the project. The cost of control systems hardware, software procurement and also the construction, engineering and internal owner costs need to be considered. The principal cost areas for execution of a DCS upgrade are engineering, procurement, construction, commissioning/startup and internal owner costs.

5.1 Procurement Costs

The procurement cost estimates are developed by requesting budgetary estimates from potential DCS vendors. Many facilities prefer or even require bids from multiple bidders during this assessment phase to keep options open and pricing competitive. If a DCS vendor has been finalized, the specifications can be tailored to that vendor. A detailed specification to be developed with control system architecture, I/O count by controller, cabinet details, field service and administration expectations so the vendor can adequately price the materials required and the other cost. Another best practice is to reuse the existing field wiring to the greatest extent possible to minimize the material and labor costs.

5.2 Construction Costs

To develop precise construction costs, complete material take off and labor costs for all of the construction and commissioning activities should be accounted in the cost estimates. Construction costs may vary depending on the condition of the existing DCS and planned DCS modifications and upgrades. Some Control system migration projects require substantial field wiring changes, while other upgrades only comprise minor work in the cabinets. Labor cost for cable installation, terminations and demolition work can vary greatly, so a field verification needs to be done to get the closest cost estimate. For a DCS upgrade, I/O testing and commissioning is a significant work that the I/Os be tested from the field device back to the control system. Any assumptions made in the cost estimation, such as the contractor being required to workday and night shifts, should be clearly stated in the cost estimations and the project execution plan. The manpower should be accurately budgeted and considered for all these time-consuming activities for a successful upgrade completion.

6. RIGHT TIME TO UPGARDE

Planning the DCS upgrade project and mitigate the risks of an aging DCS requires good planning which may take years, so by initiating the planning process early you can complete the migration before the vendor support for the hardware and software completely ends. DCS upgrade should be immediate only during extreme situations when the DCS is triggering regular plant trips and when the replacement hardware is obsolete. In most cases, an in-depth analysis is necessary to identify the underlying issues and determine the best time to upgrade. Upgrading your DCS when the production is seriously threatened, and product support ended long ago is the worst time choice.

6.1 Planning

Define the high-level scope, activities list and project execution plan for the DCS migration or upgrade project. A project execution schedule is critical for planning the upgrade project to lay out the project and show constraints such as upcoming planned outages. An inclusive planning needs to be done to minimize downtime and the feasibility of interruption to certain systems. If a plant expansion is in plans, the DCS upgrade should be planned in advance of the expansion so that you will get all the resources from operations and technicians available. Estimate the additional PLC cabinets needed to accommodate the required I/O in the room depending on the capacity of the existing system, if the space

is limited then compact I/O for DCS may have to be used to accommodate the space.

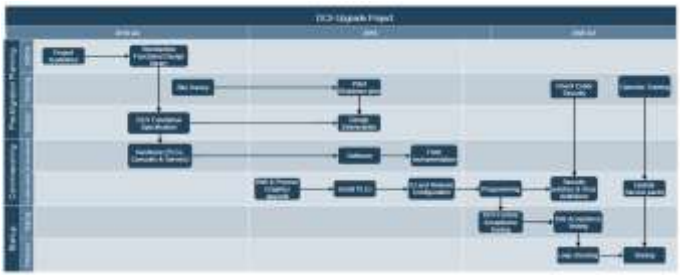

Figure 2. DCS Upgrade Project

Evaluate the CCR, central control room to determine additional consoles needed to improve the operations and any further lighting modifications necessary to comply with the ergonomics requirements. Validate and cleanup the Alarm lists before the upgrade, developing a whole new alarm management philosophy at this time may not be practical as that involves a substantial time commitment from operators, technicians and management. As part of the upgrade project, evaluate the Cyber security risks to check for any weaknesses and necessary technologies that need to be installed to protect the plant assets. Also, take this opportunity to upgrade all instrumentation switches to transmitters and outdated instrumentation to HART-smart to provide advanced control capability, calibration capabilities and secondary readings for improving operations. Estimate and account for all the resources needed to complete the upgrade on time, time needs to be allotted for support required from plant operations, technicians, engineering who will be providing supervision, direction and review while they have their other duties at the plant. Likewise, plan time required for individuals to review documents, attend meetings during the design phase, DCS factory acceptance tests, I/O checkout and startup which needs significant time commitment from engineers, technicians and operators. Budgeting the engineering time to match the level of resources involvement as described in the Project execution plan is vital for the resource planning. By properly accounting for the resources, time and all internal costs during the initial assessment, the project can be executed smoothly and successfully. Figure 2 see sample DCS migration project planning.

DCS can be upgraded in several phases instead of a single turn-key project but taking this path may cost more in the long run however the advantage of going the phased upgrade is that costs can be spread out over a longer period of time. This method is also fundamentally less risky which allows for less downtime than upgrading the entire DCS at one time. Most common way to phased upgrade is to update HMIs first and then replace the Controllers in the next phase, leaving the existing I/O modules to be upgraded in future. Although replacing the processing units usually is done at the same time as I/O migration, it's not absolutely necessary [2]. HMIs upgrade can be done live while the plant is running with little impact to production during the alteration. Involving your operators in the process of upgrading the HMI from the beginning will improve operator effectiveness, safety and efficiency. By upgrading the HMI first, it is also the perfect time to replace your old graphics by developing a high-performance HMI strategy. Allowing the I/O and field wiring to be left in place and upgrade as needed in the future is particularly well suited to reconfiguration of the I/O to be done as shutdown schedules permit which reduces the labor costs for electrical and wiring work and the associated documentation updates.

6.2 Design

A DCS functional specification with control system architecture is required to provide a layout of the complete DCS system. Develop key documents needed for the DCS upgrade such as DCS procurement specification, logic enhancement diagrams, graphic markups, alarm management criteria, instrumentation data sheets, electrical schematics, cable schedule, I/O checkout plan and functional test plan. The I/O list, logics, graphics and alarm list will have to be extracted from the old DCS system and converted to the new system. HMI documentation needs to include redesign graphics and logic enhancements required by involving the operators in the design phase. This is also a perfect time to validate the alarm list and clean up the I/O list to improve operator effectiveness when the new DCS system is launched.

6.3 Construction

Detailed DCS specification is vital for the procurement of DCS for the upgrade project. The DCS specification should clearly define the functional and performance requirements, control system architecture, I/O counts by cabinet and any additional information required. A Good contract needs to be written with the DCS vendor to define the terms and conditions. The DCS vendors need to perform site investigation study during pre-bid to review the site details. Once the contract is awarded, a project construction kickoff meeting should be scheduled to review the scope and schedule. Throughout the project, design review meetings and regular conference calls with the DCS vendor should occur to monitor project status and programming testing should be performed after a phase completion to ensure the project is being executed as planned. The DCS factory acceptance test should involve engineers, technicians and operators to check the design and configuration for quality assurance.

A construction specification should also be developed to define the construction and commissioning scope. The main focus of the Construction during control system upgrade is to keep the plant outage duration as minimum as possible. Once I/O checkout is complete for a system, functional testing and tuning can begin. Tuning parameters can be transferred over from the previous DCS system but minor changes in control system execution most often require that a re-tune of the entire system be performed. Each system should be tested to make sure the logic was converted as intended and any logic enhancements performed are as expected.

7. CONCLUSION

This paper presents the best practices of Control systems upgrade and the planning methodologies required for minimizing downtime, risk mitigation to ensure safe and successful completion of a successful DCS migration. This article fills in those gaps that remain in planning and managing the Control systems upgrade that is critical to all industrial plants before the systems become obsolete and the issues the previously published articles did not cover such as the practical challenges encountered, the lessons learned, and the resolutions that need to be taken to streamline the migration of control systems without losing plant production time during the migration process which will be beneficial for the readers and many industries planning DCS upgrade. This article helps highlight the right time of the upgrade and emphasize the planning required in design and construction in terms of resources, cost, procurement, scope, the risks involved, and the strategic countermeasures needed. Migration of old DCS to new is inevitable but the key is to abide by the best practices and planning listed to minimize downtime, risk and ensure successful completion. Control system upgrade projects, although seem impossible or challenging, have the potential to deliver great value to industrial plants. The most critical consideration is planning, the further upfront detailed planning done, the lesser the risks in the execution phase of the migration. A well-planned and executed DCS migration guarantees the seamless integration of new technology and constant lifespan sustenance for legacy control systems. In the end you will have a robust control system that will improve the overall efficiency for your plants operations, and you can begin to gain the rewards that a new DCS is sure to provide.

8. REFERENCES

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