Control System
MIGRATIONS

A PRACTICAL PROJECT MANAGEMENT HANDBOOK

DANIEL ROESSLER

The #1 Book on DCS System Migrations

Control System Migrations: A Practical Project Management Handbook

Control System Migrations: A Practical Project Management Handbook

DANIEL ROESSLER

To my Mom and Dad who established the strong foundation of values on which I rely every day. You have given me the gifts of independent thinking, perseverance, and a strong work ethic. Thank you for your support, love, and encouragement throughout my life.

Contents

List of Tables and Figures

Acknowledgments

A Special Message from Yokogawa

There is no one "right way" for distributed control system (DCS) migration—every plant is unique in its operational priorities, budget constraints, legacy systems, and so on. In a time where new technologies are developed rapidly, standing still with aging assets could mean your plant is not as productive as possible. The way forward must be planned carefully and flexibly.

The object of a control system migration is not to replicate your existing system and just keep things going the way they are, but to bring in new technologies, functions, and features that will make it possible for you to operate your plant more efficiently and profitably. It's an opportunity to benefit from the latest process control system technology combined with practical engineering experience.

About 40 years ago, in 1975, Yokogawa released CENTUM, the world's first distributed process control system, helping empower an entire generation of plant operations. Today, tens of thousands of plants entrust Yokogawa's DCS to deliver their production goals. Inevitably, it took a lot of DCS migration projects to get there; it helped us to better understand the complex scope and drivers behind these ventures.

With our field proven control platform and collaborative approach, we want to continue to play an indispensable role by providing value-added technology and solutions that help industries grow and thrive. It is our goal to help make our customers' dreams come true and do everything we can to contribute to society. This is our unchanging identity, and it is who we are. This shapes the actions of all Yokogawa Group employees and ensures outstanding teamwork across all regions and business fields.

By providing you with this copy of Dan Roessler's *Control System Migrations* book, we hope to portray our unprejudiced intention to help your company in getting future DCS projects executed as smoothly and efficiently as possible.

No matter where you go, Yokogawa will be there to add value to your business. We hope that this book will help you better understand the complex nature of DCS migration projects and ways to help ensure their success.

Yours sincerely,
Yokogawa Corporation of America

Preface

In 1992, I had just earned my degree in electrical engineering and was beginning full-time employment at a chemical (polymer) plant that I had interned at the previous two summers. The plant was in the midst of a control system migration and I was given an opportunity to help configure the new system under the watchful guidance of a senior controls engineer. It was my first migration project and a great learning experience. That project taught me a lot about the process of converting points, graphics, and control logic from an older system to a newer system including some of the unique challenges that migration projects present.

The world of process automation has changed significantly in the 20 years since my first migration project. The most visible changes are in technology. We have shifted from proprietary, largely independent control systems, somewhat isolated from other plant systems to PC-based solutions using standard operating systems. Today's control systems now have more open connectivity and are commonly integrated with numerous third-party systems and applications. They are also much easier to configure with extensive standard features and functions, minimizing the need for customization.

The way that control systems are used has also evolved. As a result, end users now expect much more from their control systems than they once did in most areas, such as reliability, flexibility, speed, and functionality. And, importantly, the process of making control systems purchasing decisions has changed. Now that the differences in control systems offered by various vendors are more subtle, the system selection process requires end-users to more clearly understand and prioritize their unique control system needs and decision criteria.

As legacy control systems move toward the end of their lifecycles and in some cases reach obsolescence, migrations to newer technologies are

becoming more prevalent. Even those companies which might prefer to continue extending the life of their existing control system are often compelled to migrate because of system limitations related to critical issues like cyber security. As a result, companies across process industries are currently making large financial investments to replace older control system infrastructure. This trend is expected to continue for the foreseeable future. The pace of technology advancements means that even some newer control systems will reach the end of their lifecycle faster and require replacement or upgrade sooner.

There are many variations on the definition of control system migrations largely driven by the motivation of the individual tasked with defining it. For the purposes of this book, I have included what some refer to as modernizations because I believe the same considerations and project management challenges apply whether you are converting an older control system to a different vendor's system or upgrading to your existing vendor's latest solution. Control system migrations update older systems to newer technology by substantially changing both the hardware and software of a control system. Minor software version upgrades are not considered migrations.

Note that the term control system generally refers to the combination of hardware and software technology that provides the ability to operate and control field devices from a centralized location. This includes Distributed Control Systems (DCSs) as well as Programmable Logic Controllers (PLCs), and Human Machine Interface (HMI) systems. There are also other commonly used control systems such as Safety Instrumented Systems (SISs) and Supervisory Control and Data Acquisition (SCADA) systems. For the purposes of this book, I group all of these systems and refer to them using the common term of control systems. While there are some differences in the detailed functionality, purposes, applications, and architectures of these systems, the process of migrating them to newer technologies requires the same basic process which is the focus of this book.

Control system migration projects have many obstacles that are not always obvious. This handbook discusses some of these unique challenges and recommends various tools and approaches for handling them. Control system migrations require you to understand and document all aspects of the configuration within the old system as well as develop a transition plan to the new system, often times in phases, while minimizing impact to manufacturing production. The success of your migration project will be greatly influenced by the choices that you make about when and how you move from the planning phase to the execution phase and finally to the operational phase of your project.

Fundamental project management principles apply to control system migration projects just as they apply to other disciplines, such as civil or

mechanical projects. In addition, good project management requires understanding subtleties like:

- When a scope is the right granularity?
- When a schedule is realistic and accounts for hidden "gotchas"?
- How to smoothly transition through the various phases of a project?

The project team is another key component of any project's success. Team members must understand the overall project and be clear on their specific responsibilities. This handbook is intended to educate all parties on key areas of migration projects and provide insight into how to best plan and execute the project. I hope that you will refer back to this handbook often as your preferred resource in guiding you to the successful completion of your control system migration project.

Effectively managing control system migration projects is about a process and successful projects are a result of many factors. There are many ways to approach a control system migration project and no two control system migration projects are identical. The chances of success are directly related to good planning and the approaches used to manage and execute the project. This is true of most projects and certainly applies to control system migration projects. The project manager must be familiar enough with the project to know what is reasonable and be able to proactively identify and manage high risk areas.

If you are new to control system migrations, this book should advance your understanding of the migration projects steps, help you identify key areas on which to focus time and effort, and provide you with tools to better plan and execute your project. If you are a control system migration veteran hopefully you will find many familiar concepts and approaches along with a few unique perspectives and valuable suggestions. It is my hope that this book delivers insight into control system migration projects to a broad audience of end users, system integrators, EPC companies, vendors, and control system engineering students.

Whether you are an operator helping design graphics as part of the control system migration team or the instrument and electrical (I&E) manager responsible for the field installation, this book will provide an overview of the steps and stages of the migration process, tips and suggestions for success, and a better appreciation of your role in the project. Managers in operations, maintenance, and engineering departments should also find this book helpful in better understanding the value and benefits of a control system migration. Improving the understanding of all parties involved in a control system migration project will help each understand how they influence the project's success. When the project is successful, the entire team wins.

My goal with this handbook is to capture migration best practices and ensure successful transitions from one control system to the next. The book is organized in a logical project workflow and begins by examining how to build an effective justification that will help initiate your control system migration project. We then cover the details of performing a comprehensive Front End Loading (FEL) study which forms the critical foundation of a successful control system migration project. Our next focus is on how to build complete and effective scope, schedule, and budget documents that are consistent relative to one another, enhancing your chances for a successful migration. There is also valuable information included to help guide users through a logical vendor selection process that reduces the emotional component of decision-making which is commonly a source of frustration on migration projects.

The book includes a chapter on how to plan and execute training which is often an overlooked aspect of migration projects essential to success. We review common migration project challenges related to graphics, third-party application integration, and numerous other high risk areas detailing specific issues and discussing ways to avoid them. We also examine the nuances of successfully planning, managing, and executing a system cutover which is generally the area of highest risk on a migration project.

Many processes are outlined, templates provided, and topics discussed specific to project management activities in this handbook. We cover key elements of project staffing and how to build an effective team. We also examine how to handle project monitoring, change order management, and project reporting throughout the project detailing how to make these project management responsibilities an extension of normal project activities reducing the amount of time and effort required. Finally, we address the project closeout process and how to transition from the project to an effective lifecycle management program for your new control system.

The content of this book includes methods, approaches, and tools that have worked for me on specific migration projects throughout my career. You will want to selectively use and adapt this information so that it works best for your particular project. It is my hope that by identifying and outlining key considerations of a control system migration project and giving context to these elements, you will be better prepared for migration success.

This handbook should help you, whether or not you are familiar with control systems, to approach the migration project in a methodical manner. This book contains boxed item features of some of my experiences in anecdotes and examples. I also outline some ways to establish common expectations among all parties early in the project process so that everyone is aligned and working toward the same goals.

Many of the tables in this book can be used as checklist by your project team. Project team members cannot know or remember everything so this is

written as a handbook that will enable you to quickly reference specific areas when needed. Each chapter of the book begins with an overview of the topics and ends with a summary of key takeaways, similar to the following takeaways from this Preface:

Three Key Takeaways

- This handbook is intended for a broad audience of people with diverse roles either directly or indirectly involved in control system migration projects.
- Topics covered in this book are comprehensive and include everything from the migration project justifications to vendor selection processes to project management reporting best practices.
- The processes, tools, and tips shared in this book are a result of my experiences with migration projects for more than 20 years as an end user, system integrator, and control system vendor.

KEY WORDS

Control System Migration, DCS Migration, Control Room Modernization, SCADA Upgrade, Cutover, Front End Loading, DCS System, Control System Projects, Project Management Methodologies, Project Management Tools and Techniques, Project Management Process, Project Management Books, Project Management Best Practices, Project Management Resources, Control System, Control System Design, Control Systems Engineering, Distributed Control System, Process Control Systems, Control System Upgrades

About the Author

My early career was as a controls engineer and project manager for a chemical company. I worked in two plant locations over roughly nine years. Our control systems included a combination of DCS and PLC systems that were operated from multiple control rooms. During my time at the plants, I managed several migration related projects including DCS controller upgrades, a control room consolidation, and operator workstation migrations. Our team also had responsibilities for the configuration and maintenance of these control systems as well as third-party systems and applications interfaced with the DCS, such as the process historian and advanced process control solutions.

The next six years of my career were at a system integration company. It was during this time that I was exposed to migration projects that involved multiple industries, numerous control systems, and diverse scopes. My responsibilities included leading migration Front End Loading (FEL) studies and managing migration projects. There are noticeable differences among industries and systems, but I also learned that there are many more commonalities which contribute to control system migration project success. I was also responsible for proposal development and as a result understand the details of the bid process. This experience has helped me understand how to position bid documentation to get the most complete and comparable proposals from control system vendors and services providers.

Finally, I have spent a number of years working for process automation vendors. This includes several years at a major control system vendor as well as time with software vendors providing applications that integrate with control systems. I learned a tremendous amount about challenges that control system migration projects present to the vendors themselves. I also gained insight into the strategies and approaches that vendor's use in responding to bids. As a result, I can offer tips on avoiding common misunderstandings during the bid process and streamlining control system vendor selection.

I have learned through my diverse work experiences that all parties, whether the control system vendor, a system integrator, or the end user, want a successful control system migration. Unfortunately, not everyone has the same definition of success, hence the need for a handbook to help establish alignment among all team members. My experiences are unique to me and my perspectives are a direct result. After over 20 years involved in some way with control system migration related projects, I am confident that the strategies, approaches, and processes that I provide in the following pages are a roadmap to successfully managing your migration project.

1

Migration Project Justification

It is a testament to the automation vendors of the 1970s, 1980s, and 1990s that so many legacy control systems from these periods continue to operate industrial facilities today. However, many process control engineers will tell you this is both a blessing and a curse. Because these control systems continue to operate reasonably well, one of the biggest challenges controls engineers face is getting support for control system migrations. Short of failures by the control system that lead to significant downtime, the need for migration projects is often scrutinized and questioned.

When compared with capital expenditures on more tangible and easily understood return-on-investment (ROI) projects, control system migrations are frequently considered lower priorities, which often results in repeated delays to funding them. Understanding the ROI of a project like an equipment debottleneck is straightforward because additional throughput capacity is easily converted to dollars. The ROI on control system migration projects tends to be much less tangible and more difficult to convert to financial benefits that are easily agreed on by key decision-makers.

It is important that someone take ownership of building the case for justifying a control system migration while also establishing realistic expectations within the organization regarding the benefits of replacing the control system with newer technology. This person is often the controls engineer who may or may not be the project manager on the eventual control system migration project. For example, some organizations have a separate project group to manage all capital projects. The project manager, if someone other than the controls engineer, should be identified and involved in the justification process if at all possible. This is the individual who will ultimately be responsible for ensuring

that the project delivers on the economics defined in the Authorization for Expenditure (AFE) process.

In this chapter, we examine how to build an effective justification so that your control system migration project will be appealing. We begin by discussing different funding request strategies as well as how to identify and involve key stakeholders that can help support justification efforts. Determining the appropriate timing for your control system migration is also examined. We review how to capture your control system migration project's ROI and develop supporting business cases and examples. Finally, detailed sections are included, which highlight common areas to consider in your justification process such as parts availability issues and limitations in integrating with third-party systems and applications.

DETERMINING YOUR APPROACH

One of the first steps in the justification process is determining what funding to initially request. There are two options, either request funding for the full project or request funding for a Front End Loading (FEL) study, to better define the scope, schedule, budget, and other project details. Requesting FEL funding is generally a better approach. It requires substantially less initial funds so is often easier to gain approval. Also, a good FEL study details the scope, identifies areas of risk and uncertainty, and generates a tighter estimate with reduced variability. When the subsequent full migration project funding is requested, there is typically much greater certainty in the estimated project cost increasing the confidence of decision-makers and approvers. Even if the migration project is not immediately approved, the FEL documentation is usually largely applicable when the project does move forward requiring minor revisions to account for any updates.

When requesting full funding without having completed a thorough FEL, the budget is much more at risk and typically not more detailed than ±25%. For some organizations, this is an acceptable approach. If this approach is used, be sure to include money for upfront FEL work as part of the overall scope and build this upfront engineering effort into the schedule. This step is crucial to help identify and resolve potential problem areas before project execution begins.

It is essential to include as many key stakeholders as possible in developing the business case for a control system migration project. Identifying parties with a vested interest early in the process and understanding their control system needs not only helps you build a compelling business case but also strengthens support for the project. For instance, visit with the maintenance

manager, instrument and electrical (I&E) supervisor, and I&E technicians to understand what challenges they have in maintaining the system. Maybe the team is having trouble with common parts availability on input/output (I/O) cards, controllers, termination panels, or operator consoles? Maybe they have been purchasing updated field instrumentation with expanded diagnostic capability and can't take full advantage of these newer diagnostics in the older control system? The team will appreciate you seeking their input and will be more supportive of the project if they believe it will help alleviate some of their specific work challenges.

Operations, maintenance, and engineering are the common organizations represented in the utilization and care of most control systems. While not as obvious, there are other groups to include as well. Information Technology (IT) is often involved in getting data out of the control system for other applications. Increasingly, the separation of company IT and control system networks are blurred. While most controls engineers will argue that the process control network (PCN) is a separate entity, at the very least, critical information is transferred across networks daily to support business applications. Talking with the owners and users of various business applications that utilize control system data is also important. They may have difficulty getting the information they need from the control system, may need different formatting or granularity, or have other challenges that can also contribute to the business justification for migrating the control system.

Another factor in the justification process is identifying the proper timing to propose the migration. The timing of when a control system migration should occur is not an exact science. Control system viability is based on balancing a combination of factors such as reliability, total cost of ownership, and system performance to meet defined business objectives. Whenever a given element is out of balance, it can signal that it is time to evaluate whether a migration might be necessary.

Obviously, there are numerous factors in the migration timing consideration process. Each company must make the decision based on the available capital and relative prioritization with other projects. Some companies will take a pro-active approach and continually evaluate the long-term viability of their control systems. Other companies hold on to their existing control systems well past the optimal point and are hesitant to migrate until a specific issue, such as security vulnerability, system failures, etc. forces them to take action. It is important that the decision to migrate your control system is an educated one that is based on a full understanding of not only the financial ROI of a migration project but also those benefits that may be difficult to quantify. Every company should have a control system lifecycle plan that is

reviewed and updated at a regular frequency, which will help them evaluate the lifecycle status of their system.

DEFINING ROI

So how do you calculate ROI for a migration project? There is no universally agreed upon answer. Companies use a variety of ways to calculate ROI, rate-of-return analysis, and other financial metrics to determine whether a proposed project meets defined payback thresholds. I won't tackle ROI calculation methodology details other than to note that it is seldom a single factor that should be used to justify a control system migration project. Instead a combination of additive factors is generally used to build a strong ROI case. There are of course projects that are approved based on factors other than ROI, such as safety and maintenance reliability projects. In these situations, many of the justification cases outlined below will still apply.

For many industrial facilities today, control system migrations are part of a larger vision. For instance, facility siting frequently identifies problematic control room locations. As a result, companies are building new control rooms in alternate locations within the facility and using this opportunity to upgrade their control system. Many companies have also reduced staffing and subsequently consolidate control rooms as part of streamlined operations. In these cases, control rooms are often re-designed and control systems are updated as part of the consolidation process as well.

When there are larger projects, such as these driving control system replacements or modernizations, it can reduce the challenges of the justification process but comes with other pitfalls. In these situations, the control system migration is not the focal point of the project and the scope as well as the budget can get minimized to balance other parts of the project. If scope or budget reductions to the control system migration occur and are substantial they can impact the long-term benefits of the migration. It is also not uncommon to see critical control related design strategies or control system selections being made for financial rather than technical reasons with prioritization given to how it impacts the overall project rather than what is ideal for long-term operations.

What are some effective justifications for standalone control system migration projects? The answer is complex because it is largely dependent on a given facilities specific situation. Some common considerations that contribute to control system migration project justifications are identified in Table 1.1 below.

Table 1.1.   Common control system migration project ROI considerations

Issue	Result	ROI Considerations
• System failures	• Decreased reliability • Increased downtime	• Lost production • Unplanned outages • Product schedule and shipment disruptions
• Parts availability or obsolescence issues	• Extended outages (often unplanned) • Lost system functionality • Increased maintenance requirements	• Increased maintenance costs • Lost production • Impact to production quality
• Difficulty integrating with newer applications and systems	• Can't realize full potential of new applications • Key data not easily available to decision-makers	• Less optimized operational performance • Slower business decisions • Higher costs associated with project implementations and ongoing support
• Reduced availability of support services	• Difficulty troubleshooting maintenance issues • Extended schedules for projects requiring engineering	• Increased maintenance costs • Increased engineering costs • Delays in realizing benefits of projects involving control system configuration
• Operational inefficiency	• Inability to take advantage of current best practices • Operator mistakes contributing to product quality issues and downtime	• Reduced product quality • Increased downtime • Operator stress

As you begin to put together your justification, consider how many of the considerations in Table 1.1 are applicable to your control system migration project. The ROI for your specific project will be unique and may include numerous other issues related to your particular migration. We examine these common issues that drive control system migration projects in more detail throughout the remaining sections of this chapter.

SYSTEM FAILURES

The most straightforward justification for a control system migration is when the system is failing. When your plant shuts down multiple times in a year due to control system failures, the justification process becomes immediately easier. However, no controls engineer wants the frustrations or visibility that comes with these system failures. If this is the situation at your company, then it is possible that you are well past the best time to migrate your control system. Ideally, your migration project takes place prior to reaching a stage in the lifecycle where an unacceptable failure rate is occurring. As indicated in Figure 1.1 below, failure rates increase as control systems move toward the end of their lifecycle.
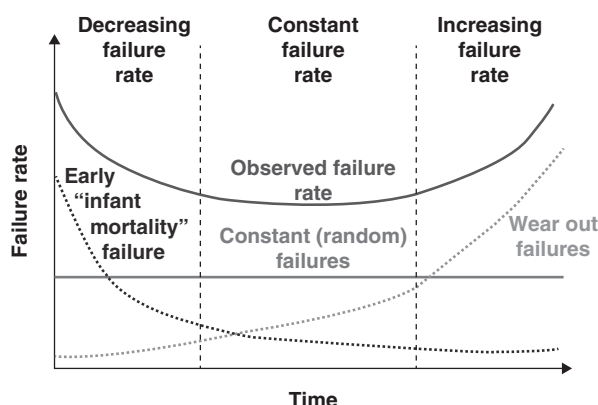
Figure 1.1.   Typical control system lifecycle reliability curve.

Control system migration projects take a substantial amount of definition and planning. If reliability has already become a significant issue, the project schedule is likely to be compressed. This often causes deviations from methodical and proven approaches for selecting the right vendor, performing thorough upfront planning, taking full advantage of features and benefits of the new system and developing a comprehensive operational transition strategy.

If control system failures create an urgent project need, project costs also tend to increase. The higher costs are associated with compressed schedules, paying a premium for engineering or vendor resources, and poor project planning. Without proper planning another area that is impacted is the ability to take advantage of improved functionality within the new control system. For instance, alarms in the control system are configured like for like with alarms in the old control system with no thought given to their applicability and effectiveness. This can often reduce the effectiveness of the new control

system and translate into a higher ongoing cost of ownership for the system. If your facility is in this situation and there is a push to get the control system migration done quickly to eliminate shutdowns, take time to understand and communicate the potential negative impact on the project.

If reliability issues exist but are not to the point of forcing schedule compression, then you are in a strong position to get approval for the migration project while also following best practices to execute the project. The economics associated with control system failures are more tangible and clear to management when they are experiencing lost production. It moves the argument for the need to migrate a control system from the theoretical to the real. The example below outlines the significant financial impact control system failures can have on a company's operations.

Example

A polymers plant with a continuous process has the control system fail three times in the course of a year. Each failure costs at least one day or 24 hours of production at a normal production rate of 40,000 pounds per hour (PPH). The average price per pound of product is 70 cents. Three days of downtime result in a financial impact due to lost production alone of $2 million.

This does not account for any cost associated with getting the unit back up and running, such as maintenance and operations personnel overtime. This is also unscheduled downtime, which means that the plant is often not able to take advantage of these outages for other maintenance activities that could prevent or delay a scheduled outage at a later time.

The impact of the example above is not isolated to lost production. In today's environment of on-demand scheduling, the entire product wheel can be thrown off when events like the example above occur. If this lost production occurs at a critical point in the schedule when you are making a specialty polymer that is only produced on that specific production line it may result in a missed shipment. This damages your brand. If it causes your customer to miss production targets and shipments to their customers, it may even result in your company losing the customer account.

What is the financial impact of these additional areas? That is difficult to answer and I do not suggest that you try to define any quantitative financial impact for this in your ROI calculation unless it has actually occurred and you have real numbers. However, I would suggest that you build this what-if scenario into your supporting justification documentation to raise awareness that when you start having system failures, there is a domino effect on your business. This message will resonate with management teams who are very customer focused.

PARTS AVAILABILITY OR OBSOLESCENCE ISSUES

As legacy systems get older, vendors reduce and eventually eliminate the availability of certain components whether I/O cards, controllers, consoles, or any variety of subcomponents. Most vendors use a staged approach, but the system cost of ownership immediately begins escalating as parts phase-outs begin. There are a few different approaches that companies typically use to address potential issues with parts availability:

1. Pre-stock additional spares in-house
2. Coordinate with a distributor or third-party vendor to stock additional spares
3. Find a refurbished parts dealer as an alternate supplier.

Unfortunately, parts cost a premium with any of these options. Maintaining excess in-house inventory is inefficient, has tax implications, and is generally not desirable for most companies. Most distributors will charge stocking fees in addition to the elevated parts costs from the vendor. And while there are many reputable refurbished parts dealers the reliability of re-built parts is always a concern.

In addition to the higher system costs, a second issue when parts become obsolete is the potential elimination of expansion capability. Control system capacity limitations can create significant challenges to a company's ability to execute projects needing integration with the control system as highlighted in the example below.

Example

Your plant site is going to build a new unit, which will add 500 points to your existing control system. A last-time buy offering on controllers for your version of the control system was two years ago. Your current controller is near recommended maximum load and will not handle the additional unit. What are your options? There are creative ways to use serial communications from programmable logic controllers and only bring absolutely required points into the controller. There is also an option to eliminate nonessential points in the existing system, but there are likely not many that will be identified. Both of these options are workarounds that just avoid the inevitable conclusion that you need to replace the control system. Maybe the appropriate choice is to use the new unit as a compelling reason to migrate?

Most vendors provide upgrade paths that can help buy additional time operating an older system without requiring complete transitions to a newer system. These may be partial upgrade paths or designed interconnectivity of

older and newer control system components. This can be a viable option under certain circumstances. However, when considering these options keep in mind that the vendor is motivated to lock you in with a financial commitment so that when a complete upgrade does occur it will be more difficult to justify migrating to another vendor's system because of the additional investment you have made in the current vendor. If you have no desire to consider other vendors and are planning on moving to your existing vendor's latest platform in the future, then this is an excellent option. One further caution is that once you start mixing components of various generations of products, it generally increases your maintenance costs and makes overall system maintenance more difficult.

If limited parts availability or obsolescence is a part of the issue that motivates the need for a control system migration, there are a few quantitative values that can be included in the ROI. The first recommendation is to capture the differential cost between historical and anticipated escalated parts cost. If a part's price has increased by 25% in a year and the plant purchases roughly five annually, then capture that increase as additional cost associated with keeping the existing control system minus any normal annual escalation pricing.

A second financial indicator to track and capture is the increased cost of adding points to the control system. Cost per I/O is an average dollar amount that represents the cost of hardware, software configuration, and any other I&E and engineering services related to adding an I/O point to the control system. Most controls engineers have a good idea of what this number is for their system. Consider areas where pricing has increased and calculate a new cost per I/O as the system nears end of life. Use your historical cost per I/O for the system as a baseline to do a comparison and capture the differential. This cost per I/O will increase dramatically as parts availability and more importantly, parts obsolescence becomes an issue.

In some cases, the severity of the parts availability issue may be limited to delays in parts delivery. For instance, instead of a standard four-week delivery, a controller that is being phased out may require eight weeks to deliver. While this may seem like little more than an inconvenience, it can have a financial impact in certain situations. If the part is needed for a project longer lead times can usually be planned into the schedule, but for maintenance activities that is often not the case. The only ways around this issue are to pay expediting fees when available as an option or to stock extra components. Both of these approaches again increase the maintenance costs associated with the system. Isolated instances of parts availability issues can be overcome, but when numerous parts within a system become difficult to obtain in a timely manner the practical longevity of the system should be evaluated.

DIFFICULTY INTEGRATING WITH NEWER APPLICATIONS AND SYSTEMS

The early generations of control systems were largely intended to work in isolation as standalone entities. Over the years this philosophy has changed. To varying degrees, modern control systems are interfaced to and integrated with many third-party systems and applications such as those reflected in Figure 1.2.

Lab Information Management Systems (LIMS)	Manufacturing Execution Systems (MES) or data historians
Advanced Process Control (APC) applications	Real-time optimization solutions
Supply chain and scheduling software	Asset management and maintenance systems
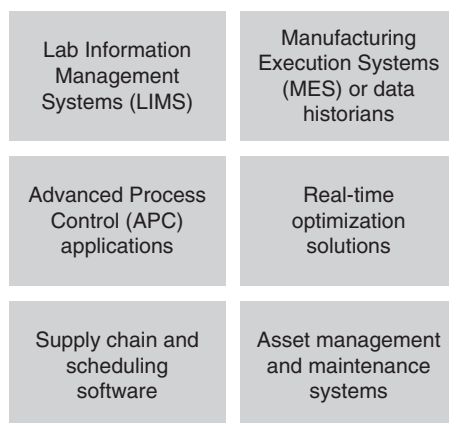
Figure 1.2.   Common third-party solutions requiring control system integration.

The architecture and proprietary nature of historical control systems often does not lend itself to seamless communication with these other products. With many older generation control systems the interfaces and/or integration to these other systems is difficult and in a few cases impossible. Brute force methods or customized solutions are often used to enable communications or transfer data. These solutions are both labor intensive and difficult to maintain. Even when data can be successfully passed from the control system, it is often in a less than ideal format. This can reduce the effectiveness of third-party applications and systems decreasing their business benefits.

Defining the ROI associated with interfacing and integration issues is not straightforward. First, document any customization that has been done to facilitate existing communications. If there are maintenance issues or challenges with these customizations, then apply a maintenance cost to them, especially if there is recurring work involved. Second, note any manual activities that take place as a result of system deficiencies, such as the case outlined in the example below.

Example

An inferential model was just developed, which resides on a third-party server. The model predicts several product quality parameters that will be used in an improved control algorithm within the distributed control system (DCS). The expected cost savings resulting from reduced off-quality production losses is $3 million annually. Unfortunately, the model cannot pass predicted value data directly to the DCS because there is no standard communications driver between the inferential model application and the older control system.

Two options are identified as viable solutions. One option is to build a custom driver, which introduces another maintenance point into the system and is expensive. A second option is to have the information sent to the data historian and require that the operator look up the value at some regular frequency. The operator would then have to manually enter that information on a graphic at the DCS console so that it can be used by the control algorithm.

Neither option is ideal, but to quickly get the improved control algorithm in place, you select the option of having the operator manually enter the data at regular intervals. This option requires operator time, distracts from other operator responsibilities, and runs the risk of a manual entry error that can affect plant performance.

In this example scenario above, you would want to capture the costs as well as the risk associated with this manual process in building your justification. If newer control systems offer standard drivers that can securely pass data from the inferential model to the control system, you would also be able to note that as an additional benefit to a migration.

It is equally important to identify any deficiencies in integrated third-party applications and systems that are related to the control system's inflexible architecture and limited communication capabilities. Validate that newer control systems can use standard drivers or other communication methods to exchange information with the third-party system to eliminate the deficiencies. In most cases you will find that they can. If in your situation they do, you have the option of adding these to the benefits of a migration either as supporting information or by including quantitative financial benefits in your ROI calculation. I would caution that unless you can determine a reasonable financial benefit value to claim, which will not be controversial, you may be better off just documenting this as an additional benefit and citing supporting examples.

REDUCED AVAILABILITY OF SUPPORT SERVICES

An often overlooked pitfall of older control systems is the challenge in finding resources to support the system. This is true of both engineering and

maintenance support including vendor, third-party system integrator, and in-house resources. The retirement of many of the original contributors to the design, installation, engineering, maintenance, and operation of these older systems results in the loss of significant knowledge, which is not easily recaptured. In the case of vendors and system integrators, they eventually reach a break-over point where it is no longer reasonable to support these systems because there is simply not enough need. Training or maintaining system experts much beyond the end of the product life may not be cost effective. When knowledgeable resources can be found to support aging systems, they are often expensive and demand a premium knowing you have few options. You will want to capture any service price increases related to your system in your ROI as a burden on the total cost of ownership. The example below illustrates this point.

Example

Last year your maintenance contract with the control system vendor was $50,000. The system has gone into the final years of support and the vendor has increased the annual support contract to $80,000 for the same scope of services citing fewer resources available to support the older system as a primary reason. It is not uncommon to see these kinds of increases for services at the end of a control system life.

   Let's assume your vendor normally includes a 5% annual escalation in the support contract. In this circumstance beyond that 5% there is an additional increase of $27,500 that is directly related to the late stage lifecycle of the control system. These support costs will continue to increase until the system support services are no longer available. As you build justification for a migration project, you capture the difference between the normal escalation and the current support contract pricing as added cost to continue operating with your existing control system.

   To be fair to vendors, their support costs increase as systems near the end of their lifecycle as explained in the example above. However, many vendors also use this as an opportunity to help motivate end user companies to move to their latest system.

   When using external resources such as vendor or system integrator engineers and technicians to support near end-of-life control systems, the availability of these resources usually becomes more challenging, meaning you may have to wait longer for their services. When your control system was in the middle of its lifecycle, you may have been able to call and schedule someone to work on your control system within a few days to a week. An older system with fewer resources to provide support may require scheduling a month or more in advance. When the services are needed for projects, you may be able to plan for this, but on maintenance activities you often cannot wait. For example, if

you have a workstation fail, you might need a quick response. In this situation, maintenance work will either be delayed or you may have the option of paying extra fees or a premium for an expedited service call.

To account for the increased cost of third-party services, review the pricing for previous projects or maintenance activities. Request a quotation for the same scope asking the service provider to update pricing with current rate. Be sure to explain the purpose so that the service provider does not think it is an active project. Use the differential cost minus any normal escalations to show any increased cost and include this in your ROI calculation. You might also want to ask for an estimate of a similar work scope on a newer control system and include it for comparison purposes.

While issues finding third-party service providers for your control system can be challenging late in the life of a control system, losing knowledgeable in-house resources over time can cause even more difficulties for end user companies. In many older systems, a tremendous amount of coding, graphics scripting, and other customizations were required to achieve the desired flexibility and functionality from the control system. In many companies, these customizations are not well-documented and in-depth knowledge of the control system is isolated to a few individuals. When the resources responsible for programming, maintaining, and operating these systems are no longer available due to retirement, job changes, etc., it reduces the efficiency and increases the cost of most control system related activities. For example, troubleshooting activities can take substantially longer, leading to maintenance inefficiency and longer periods of downtime. When system changes are required, engineering and configuration efforts can also be both time-consuming and costly.

A percent efficiency factor can be used to account for some of these effects in an ROI calculation. Assuming an efficiency factor of 1.0 for the expert resource, the efficiency factor for a less experienced resource may be 0.70, which means a 30% reduction in efficiency, which can be applied to both cost and schedule for control system-related activities. It is an estimated factor, but as long as you make logical assumptions and document them it is a reasonable approach. This efficiency factor can be applied to engineering and maintenance activities using in-house resources and included in the calculation of total cost of ownership.

OPERATIONAL INEFFICIENCY

Understanding the capabilities of newer control systems is essential for identifying operational improvement opportunities that modern technologies can provide. Justifications should not only be based on the costs associated with the weaknesses of the existing control system but also on capturing the

operational benefits of newer control systems. My thoughts on migration projects and operational inefficiency are captured very well in the following article excerpt:

> The objective should not be to simply replace and replicate, but rather to innovate. DCS migration is an opportunity to design, implement, and maintain a 21st-century control system that will enable the manufacturer to operate more efficiently and safely; position it for market growth; and firm up its stability for a quarter-century or more. Further, it is an occasion for process improvement and expansion, as well as a much needed opportunity to address the gap between how the plant is currently operated and controlled and how it should be.[1]

The new functions and features available in control systems today along with the emergence of standards and best practices can enable major improvements in operational efficiency compared to older control systems. For example, the automation industry has made tremendous progress in establishing best practices in situational awareness areas over the past twenty years. As our knowledge has grown on how to improve situational awareness, control systems have evolved to incorporate tools to align with those best practices in modern systems.

These new system capabilities combined with the best practices can significantly improve operational efficiency and performance. Better situational awareness helps operators to more quickly recognize and act on abnormal events, which can be safety, quality, or equipment related. Better designs reduce operator distractions so that the operator can focus more time on control of the product quality and throughput. Improved contextualization of information also results in faster and better informed decision-making. The specific impact on ROI includes incident avoidance, production quality and rate improvements, and reduced operational downtime.

Are your company's control room operators as efficient and effective as possible? In most cases, the answer is unequivocally no and it is well-known and generally accepted. Consider defining the costs of operator ineffectiveness where you can identify and claim a realistic portion in your ROI calculation as benefits for a modernized control system.

To capture operator ineffectiveness, first review the operational incidents including safety, quality, and lost production over the past five years. Capture those that were likely due to or contributed to by deficiencies in situational awareness. Quantify these incidents in terms of production losses, downtime, or off-quality product. It is unreasonable to expect that a new control system will avoid every operational issue, but you can claim a reasonable percentage

---

[1] Matt Sigmon, "DCS Migration: Failure is Not an Option And Doing Nothing is Not a Solution," *Control* XXV, no. 12 (December): 41–42.

from enhanced situational awareness tools such as improved graphics and better alarm handling and management. Be sure to state the basis of your assumption as part of your ROI calculation explanation. The example below illustrates how an operational incident can be used to capture inefficiencies and operator ineffectiveness with an older control system.

Example

An operator is responsible for running the distillation area within a chemical plant. The HMI graphics were designed 25 years ago when the control system was installed. They do not use current recommended best practices for color, layout, background, or alarming. During a thunderstorm, a flood of alarms occurs as temperature deviation alarms are activated. The operator acknowledges the alarms but in the process acknowledged an alarm that one of the column feed pumps has shutdown. Eventually the entire unit is shutdown. The enhanced alarm management capabilities and streamlined HMI graphics available in a modern control system built using current best practices would likely have avoided the alarm flood and made the pump feed alarm more easily identifiable.

Another aspect to consider regarding operational efficiency is reliability and percent uptime. Newer instruments have the capability to send a lot more diagnostic information to the control system helping to quickly identify the root cause of maintenance issues. This enables a preventative approach to maintenance often avoiding or minimizing the operational impact of instrument and equipment problems. Many of the older control systems do not fully support the diagnostic capabilities of newer instruments and equipment. In addition, the internal diagnostics built into modern control systems can help avoid and certainly minimizing troubleshooting time associated with control system issues. In older control systems identifying root cause issues can be difficult resulting in less efficient troubleshooting efforts.

In legacy control systems, the programming languages were often customized and vendor specific, while with newer systems they are standardized, common languages. This enables companies to bring much more consistency to how things are programmed and reduces customization. The result is a simplification of troubleshooting for both maintenance technicians and engineers, which can reduce downtime.

These last two aspects of operational efficiency are not something I would recommend trying to quantify. However, I think they are important points that should be included in the business case justification defining the benefits of control system migration. I would suggest including realistic case examples applicable to your operations as part of your supporting documentation.

SUMMARY

Each organization has unique decision processes when it comes to funding projects. There is no replacement for your understanding and knowledge of your individual organization. When key decision-makers must decide on the merits of a control system migration, they frequently overlook the beneficial aspects and focus on the main points. They consider that the migration may include potential operational downtime, create chaos in the control room during the transition, require re-training of personnel, and cost a significant amount of money.

Common misperceptions and biases regarding control system migrations require controls engineers and project managers do an extremely effective job defining the benefits and ROI of the project to gain support and approval. In this chapter, we have examined some of the common motivations for migrations. As stated earlier, it is seldom a single factor but an additive combination of several of these areas that ultimately builds the successful case for a control system migration. Many of the benefits of a modernization are intangible and difficult to quantify in an ROI calculation. It is important to document these benefits even if not numerically, to build understanding within the organization of your migration project's business value.

Many times, justification efforts are focused on reliability, obsolescence, and other problems with the existing control system. These are valid and are certainly key components of the case for migration. However, as you develop your justification case, also document how improvements in technology will give you an opportunity to improve operational performance. Outline ways to take advantage of new functionality and better tools within modern control systems as they relate to improving your process operations.

Gaining the support of others with a vested interest in seeing a migration occur is a critical starting point. Do not be afraid to incorporate multiple scenarios and justification points into your business case. Ultimately, the decision to approve a control system migration will largely be based on your ability to sell the value to your management team.

Three Key Takeaways

- Include as many key stakeholders as possible early in the process to help build the business case for your control system migration.
- Justification is likely a combination of multiple factors and the ROI is an additive result of these components.
- Do your homework and identify the operational performance improvements that you can take advantage of as a result of new tools and functionality within a modern control system.