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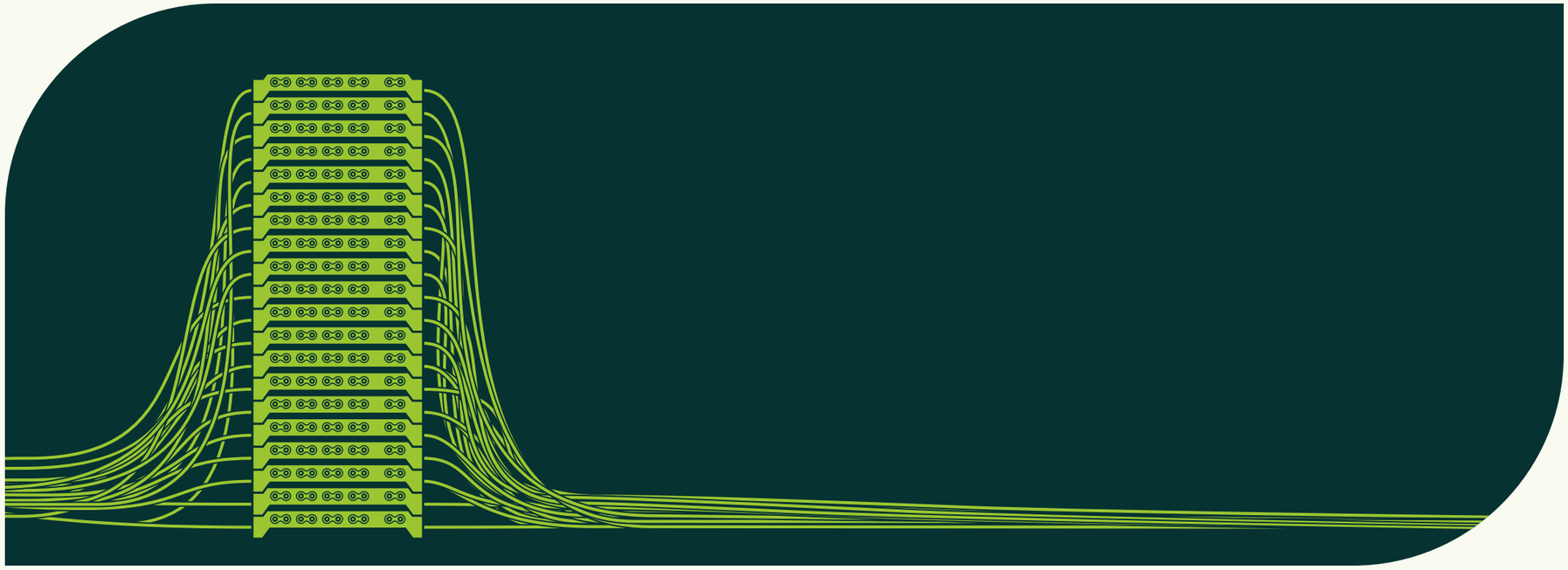
LIVE CONTROL SYSTEM MIGRATIONS
"REDEFINING HOT CUTOVERS"



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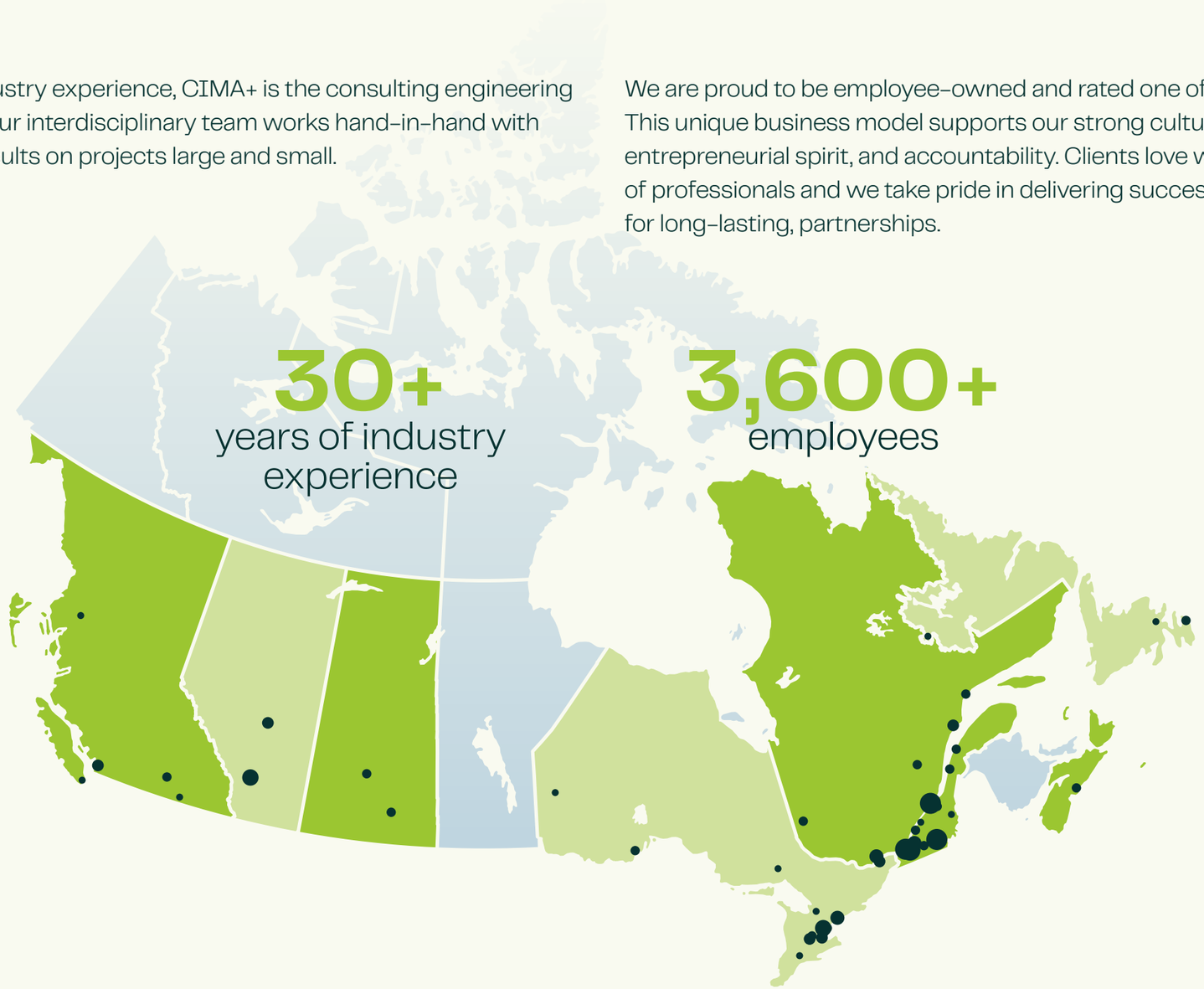

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>
> **Denis Thivierge,** P. Eng.
> President and Chief Executive Officer

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EXECUTIVE SUMMARY

One of the challenges the automation sector is currently facing, is the replacement of aging control system infrastructure. And with more than 80% of the systems now being in excess of 20 years of service, the problem is expected to continue to grow.

Control systems have, and continue to be upgraded using a variety of different methods. All existing migration system currently require some degree of taking the system offline, which means disrupting plant control. Every facility faces unique challenges with control system upgrades, which can be a risky proposition or simply not possible – until now.

Imagine being able to wire, test and commission your control system while the plant is running, then complete the swingover with the press of a button.

CIMA+ has developed TEMPUS, a unique product that facilitates the live migration from one control system to another, without downtime. During a traditional control system migration, wires must be moved from the old system to the new. With the TEMPUS hardware and procedures, wiring can now be completed without disrupting the I/O signals for an online comprehensive control system upgrade setting **“a new control system migration standard.”**

“80% of control systems are obsolete.”

CIMA+

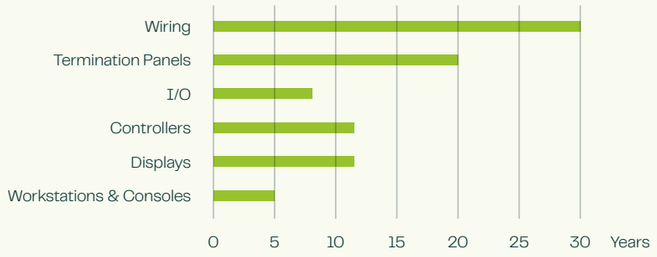
WHY MIGRATE?

> **“Hardware, technical and functional obsolescence are key factors in justifying a migration.”**

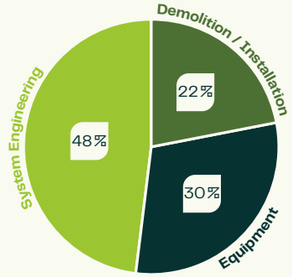
A market analysis by Automation Research Corporation estimates that globally, in excess of USD $65 billion in control systems have reached their end of life, with more than 80% of those systems having been in service for over 20 years. DCS systems are only the tip of the iceberg, with PLC, SCADA, and safety systems adding to this obsolescence challenge.

The following figure shows the expected life span for the various elements of control systems installed since 1995. Prior to this date, most systems were ‘closed,’ meaning that almost all elements were developed internally. Since 1995, suppliers have incorporated ‘open’ or Commercial Off the Shelf equipment and software such as servers and web based HMI’s. These have reduced the expected life of many components inside the control and interface room, to be closer to that of similar equipment in the IT space. Regardless, if we consider the data below, many of these newer systems are now approaching their end of life.

Hardware Lifecycles



System Migration Costs



I/O assemblies and Controllers are the most important interface between the process and the control system. Despite their importance, one of the results of moving to open systems is that the lifecycle for a post-1995 element is approximately half of that of a pre-1995 I/O card or Controller.

Control systems continue to evolve. They are now moving from proprietary technology developed by the individual suppliers, to more open systems based on Commercial Off the Shelf equipment using Ethernet networks, web based operator interfaces, and servers running advanced control and historization applications. The benefit of open systems is that the equipment is lower cost and widely supported, however the life cycle for this equipment is significantly shorter than the equipment it replaces. Evolution continues with virtual machines and cloud based schemes being used for system development, and in some cases, incorporated into the higher level elements of the control systems.

Another reason to upgrade is that legacy systems were not designed with cyber-vulnerabilities in mind, and in some cases are more prone to failure if attacked than the newer systems that incorporate basic cybersecurity features.

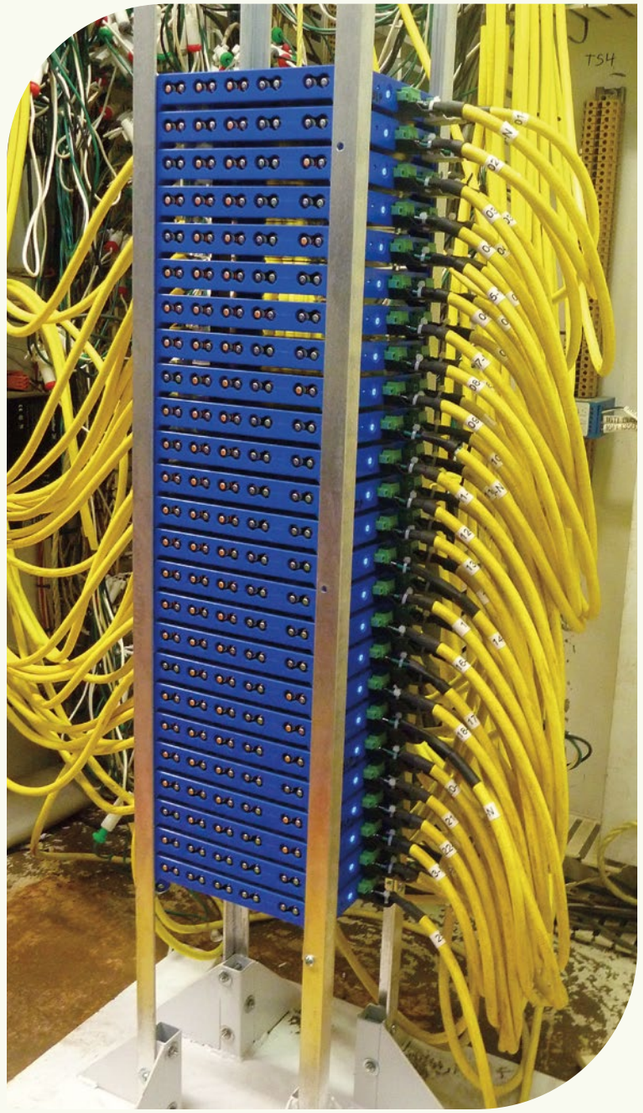
In addition to the issue of hardware obsolescence, control systems can suffer from technical and functional obsolescence as well. The most commonly used reasons for upgrading is if there is an increasing risk of control equipment failure shutting down a critical process and affecting continued operations. Lost production and associated recovery costs from an unplanned outage can quickly surpass the cost of a migration project.

Another reason to migrate, and an example of missed opportunities, is the increased integration that new systems enable between business and control systems, which provide multiple benefits including:

- Advanced process control;
- Minimizing waste;
- Optimizing products based on market conditions;
- Seamless connection with laboratory information systems resulting in process applications;
- Maintenance planning and understanding equipment status in real time.

Put simply, migrating your control system while it is still supported is an exercise in risk management that once complete, can provide an increase in your facility’s capabilities. The challenge is to execute a migration at a reasonable cost and schedule, while most importantly minimizing impact to production.

Considering the magnitude, variety of hardware, and unique control system configurations, it should come as no surprise that there are a variety of traditional approaches to executing migration projects.



WHY MIGRATE?

The most commonly considered migration solutions are:

System Replacement: Replacement of all hardware from I/O racks and cards, to processors/controllers and displays;

Phased Migration: Staged replacement of different system elements;

Mixed Systems: Combining new control system elements with the existing system as necessary.

System Replacement involves replacing the full control system hardware, and is typically categorized as hot (live) or cold (plant outage) cutover. This decision of hot or cold cutover defines every aspect of your Project Execution Plan (PEP). Whether to migrate hot or cold, drives the PEP and is a decision that should be made early on in the project. However, the unknowns at this early stage often drives the decision to err on the side of caution, resulting in choosing to execute the project during a plant outage. This decision often has unintended consequences.

Phased Migration allows system modernization in gradual steps, typically replacing one part of the control system at a time. Often, the HMI is the first to be replaced, followed by the controllers and I/O for individual process units over several years, as opportunities such as planned unit outages present themselves.

Mixed Systems use parts of the existing control system in parallel with the new systems' hardware. This situation often results from new controllers being added with a plant expansion, or because a facility has decided to upgrade critical system components independent of a full system migration. Mixed systems are difficult to maintain, and do not fully address the problem of obsolescence.

Each option has merits as well as limitations and risks. A challenge, especially for the Phased Migration and Mixed Systems approaches, is how to migrate "common equipment," that is, parts of the process that are shared across multiple process units.

	Reversible	Online Swingover	No additional footprint	No legacy equipment	No temporary program changes	Conventional signal support	Online commissioning	Realtime operator training	No intercontroller communication	Online loop tuning
TEMPUS Migration Tool	✓	✓	✗	✓	✓	✓*	✓	✓	✓	✓
System Replacements – Cold	✗	✗	✓	✓	✓	✓	✗	✗	✓	✗
System Replacements – Hot	✗	✓	✗	✗	✗	✓	✗	✗	✓	✗
Phased Migration	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗
Mixed Systems	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗

* RTD Support in development

In all cases, the ideal execution strategy is to fully, and quickly replace the obsolete control system at a reasonable cost, with no impact to production. For large projects, scheduled unit outages drive a multi-year migration plan, adding both cost and complexity.

For comparison, the table below summarizes the advantages and disadvantages of the above mentioned traditional migration solutions, as well as the TEMPUS migration tools' characteristics.

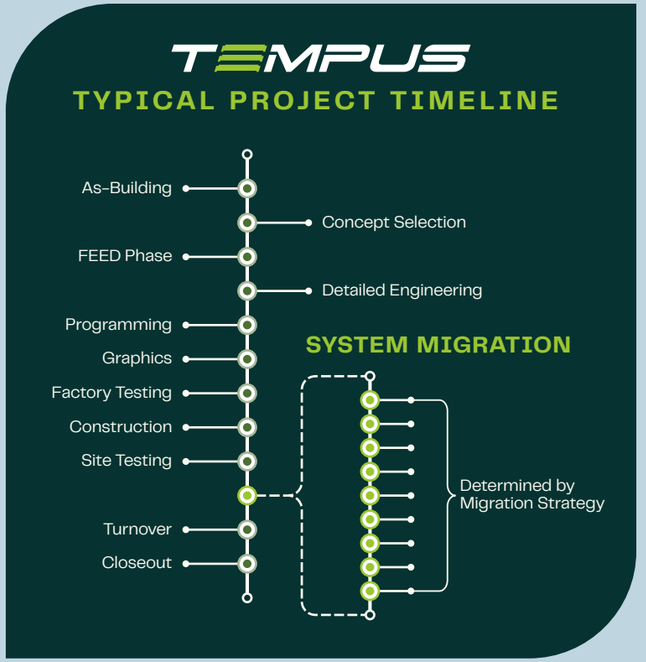
Risk, is the driving factor in justifying and determining which of the above approaches is used for the migration project.

Indubitably, the objective is to minimize risk during all phases of the project life cycle including planning, design, and execution. Ultimately, the projects' cost and schedule are significantly affected by the selected execution approach.

Costs of a migration project can be broken down into five categories: equipment costs, demolition and installation costs, engineering costs, commissioning costs, and the cost of lost production due to downtime to perform the work.

Engineering projects typically begin by evaluating all options, not only from the method of execution, but also the most suitable technology for the present and future growth of the facility. Therefore, the first step is usually the development of an automation roadmap for the organization, identifying the existing and future control requirements. This roadmap includes integration with other elements of the business; technology trends; and what additional functionality, if incorporated, would maximize the return on your automation investment. With a clear vision of the goal, it will be possible to select the type of control platform that is most suitable, which will then begin the decision making process for the balance of the migration decisions.

A migration project then follows a "typical' timeline, as shown in the figure above, with engineering progressing through



"Proper analysis of the facts is required to determine the migration roadmap."

FEED to Detail Engineering which includes converting the programming/ code and graphics, then factory testing, construction, site testing, and finally, the actual migration process itself, followed by turnover and closeout.

The migration itself can be the step which carries the highest risk, which is the reason for the extensive engineering and design planning in advance. Since the creation of electronic control systems, there have been three major generations of hardware. These systems have not typically been designed for ease of upgrade due to obsolescence. Until now, there has been no standard cross platform method for full system hot cutover.

NEW PARADIGM

Solving the challenges with traditional migrations required a new way of thinking; a new paradigm for control system migrations. One of the main problems all migrations face is that signal wires need to be moved from the old control system to the new control system. This inherently means that the signal will be lost during the swingover.

An innovative, and proven method for migrating one system to another, while remaining completely live, has been developed by CIMA+.

TEMPUS is a control system migration solution that utilizes an electrically certified, specialized temporary hardware installation that facilitates all the wiring from one control system to another, without disrupting the signals. Once the new control system is operating the plant, the tool is removed, leaving a new and well-organized control system.

This temporary hardware solution solves the traditional challenges of migrations allowing for a complete online migration, with the following benefits:

- No disruption to the signals;
- No loss of signal to both old and new systems during the migration;
- Full live commissioning of the new program/logic;
- Eliminates the requirement for plant shutdowns;
- Uses the physical signals rather than a communication protocol;
- No limit to the quantity of I/O that can be migrated;
- Non-vendor specific working with any platform, from any supplier.

Commissioning is the process of assuring that all systems and components are designed, installed, tested, operated, and maintained according to the owner's specific and unique requirements. The ability to perform commissioning tasks on the new control system while the existing system operates the plant, provides unparalleled flexibility and confidence. All aspects of the programs, logic, operator interface, and communications with other systems, will be fully verified prior to removing the existing system. With the capability for live execution of the commissioning and swingover, TEMPUS represents a new standard for control system modernization projects.

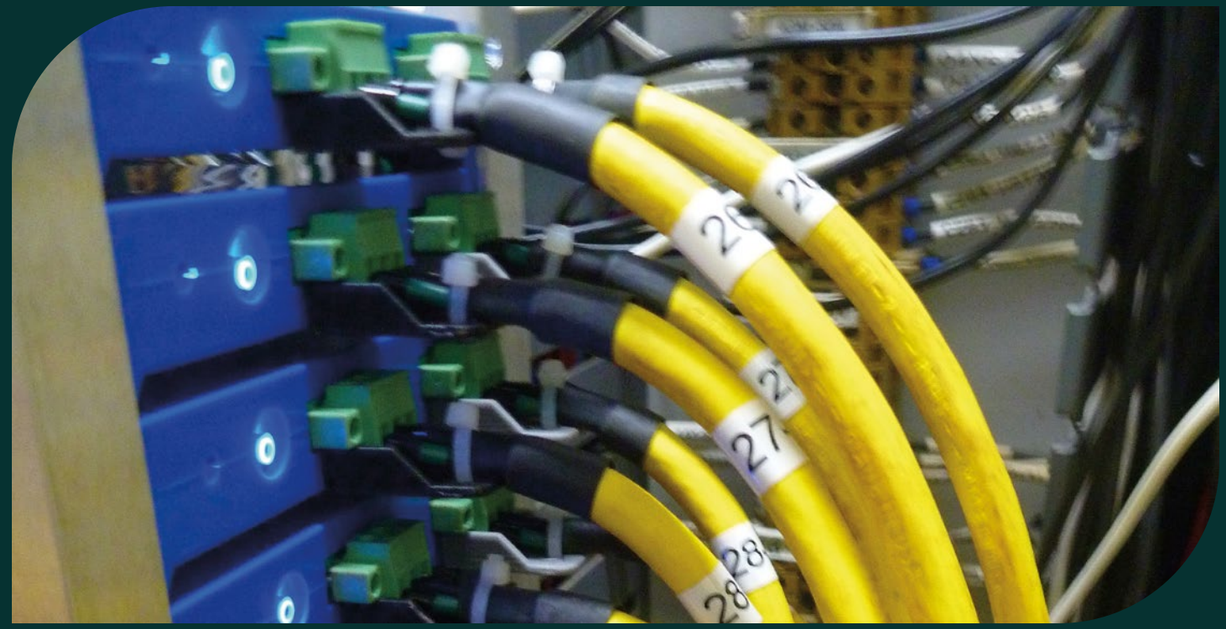
"Modular systems are completely flexible and scalable."

The PEP establishes the means to execute, monitor, and control projects by clearly defining responsibilities as well as methods to be used to implement and deliver the agreed project outputs. Since control systems are an integration of many components and subsystems, keeping track of all the systems and their interactions with the plant, requires development of a rigorous PEP. A key element of any migration execution plan is the system interconnection diagram, because it helps us understand how the systems communicate and connect with each other. Knowing how all the different elements interact, ensures that the impact of making a change in one place will not adversely affect another part of the process and circumvent the preparations made to prevent system disturbances.

Plants can be separated into common equipment that works across all systems or units, and the individual units themselves. Units can often then be separated into sub systems. This separation allows for the plant to be migrated in manageable sections one at a time. For the common equipment, TEMPUS is active throughout the migration of each system to allow both the old and new control system to see the exact same values.

The seamless connection of TEMPUS is accomplished by using specially designed interconnection cables with pierce probes that don't affect the integrity of the wires. The signals are routed through TEMPUS and replicated to both the old and new control system in parallel, with no interruption. The primary signal is passive while the secondary signal is replicated and isolated from the primary signal. This passive design of the primary signal allows for fail safe operation of TEMPUS.

This process for connecting one TEMPUS tool is repeated for each wire pair, thus maintaining the independent signal integrity. Using a modular approach provides the flexibility of being able to expand to as many signals as required, per the PEP system breakdown. The following figures illustrate the wiring sequence for a single analog input. The same process would be followed for all I/O to be migrated for the specific sub system.

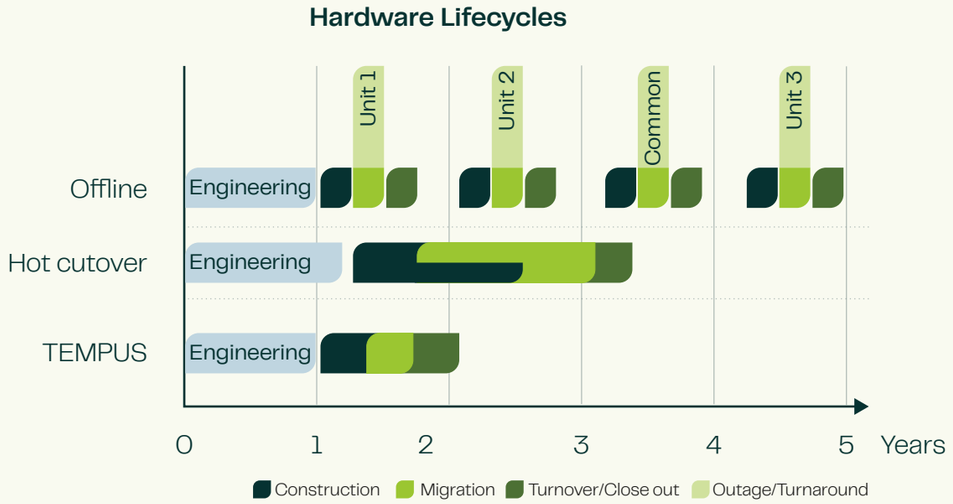


SCHEDULE ADVANTAGES

A traditional migration where implementation of the new control system is carried out during scheduled plant outages often takes many years to complete as the individual unit outages are staggered.

This becomes logistically complicated for the project and operations as they need to maintain and operate from two independent systems over an extended period of time. With TEMPUS, the construction, migration and turnover all occur consecutively back to back. This result of being project driven rather than outage driven, offers a significant reduction in the project schedule with a corresponding reduction in project costs such as maintaining the project team, cost of capital, and efficiency in project execution.

“Manage the migration process, not equipment availability.”



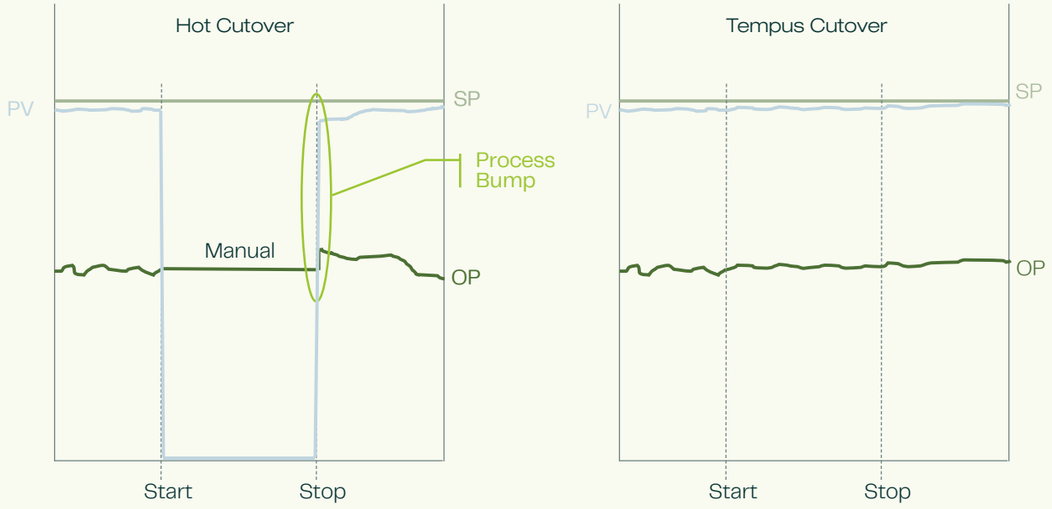
BUMPLESS TRANSFER

A commonly used approach for loops that cannot be removed from service is known as a 'hot cutover.' The hot cutover process consists of operating the affected loops in manual or bypass mode which normally means either freezing the input at last value (hoping the process does not change), and/or putting the output signal in manual to hold the output constant. If the process has changed during the migration process, there will be a corresponding disturbance or "bump" as the loop returns to automatic. This procedure is time sensitive and becomes impractical for anything but the simplest of control loops.

The trend graph on the left shows what actually happens during a traditional hot cutover on the corresponding analog I/O cards during this time. Conversely, as can be seen on the right, because there is no disruption of signal with the TEMPUS system, the process remains under control the entire time.

"Stay in control of your process at all times."

Process trend on cutover



Step 1: The new control system is installed and wires are pre-pulled to the marshalling terminal strip.

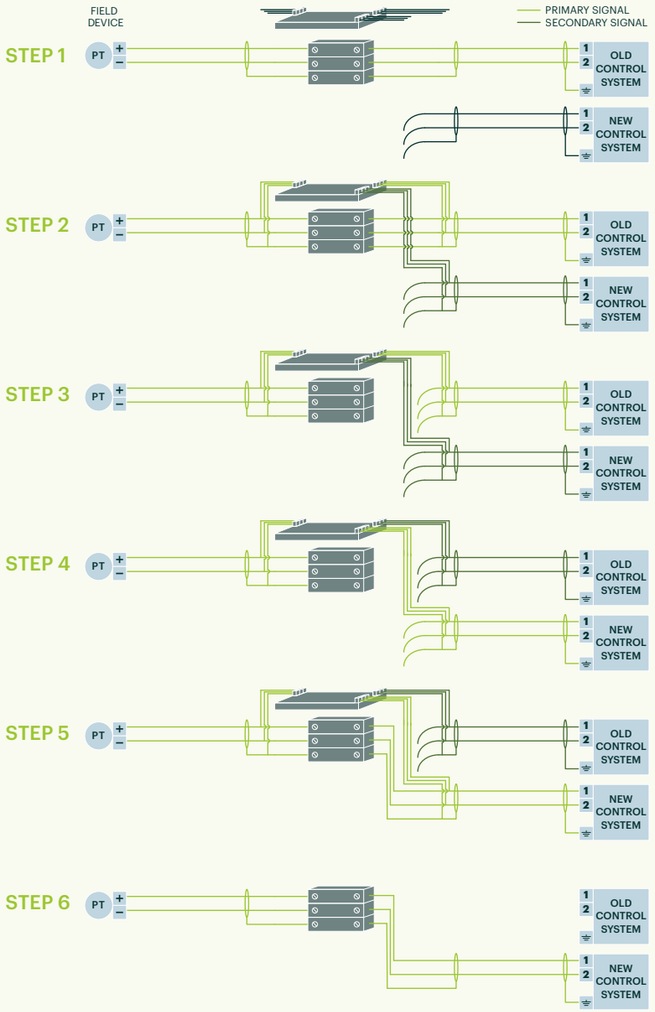
Step 2: Without lifting or affecting the termination of the existing control signal wires, custom interconnection cables are temporarily connected via the TEMPUS pierce probes to the field side of the marshalling terminal strip, as well as the old and new control system.

Step 3: The old control system wires can now be removed from the marshalling terminals and insulated. Since the primary signal path through TEMPUS acts like a passive jumper, the signal is unaffected by the removal of the wires from the terminal strip. At this stage, the new control system will receive the replicated signal and all inputs and outputs can be brought to this stage. The new logic can now be functionally tested with real site values, while the old control system continues to operate the plant. Commissioning of the new logic is validated with the real field values, eliminating the need for a simulation system. This also allows all applications and logic to be verified. Loop tuning can also be completed, and compared directly to the existing control system using trend screens.

Step 4: Once all the testing and commissioning checks are complete, at the press of a button the new control system takes over the primary signal (red signal path to the new control system). This switchover is completely bumpless with the signal buffer circuitry. The old control system will receive the secondary identical signal, allowing the logic in both the old and new control system to function correctly.

Step 5: The new control system wires are terminated to the marshalling terminal strip. Since the primary signal is on the new control system, this step has no impact on the signal.

Step 6: The TEMPUS interconnection cables and TEMPUS module are removed along with the old control system wires. At this point, the old control system can be demolished



CASE STUDY

Six heat exchangers supplying hot water for almost all processes in an upgrading facility had been in service for approximately 40 years. This system had never been modernized until now because it could not be taken from service without compromising the facility's hot water supply, which is still required during a total plant outage, or turnaround for freeze protection and line flushing.

For this reason, there were several generations of existing controllers and hardware that were obsolete and at risk of failure. The TEMPUS migration tool was used to complete the migration from three different platforms to a new control system by another supplier within a shorter timeframe, and at a lower cost, with no impact to plant production, loss of signal or any disruption to operations.

With zero impact on the process or production, the migration project was a success. TEMPUS also provided additional benefits to the client, as control over the system was maintained at all times, and any environmental side effects of the migration project were eliminated.

More case studies can be found at **www.cima.ca/tempus**

"TEMPUS is the preferred option when downtime is not an option."

This new approach has obvious cost saving advantages for the elimination of downtime and lost production. An additional cost saving is removing this work scope from the rigid turnaround and start-up critical path. Since any loop can be migrated at any time, the project schedule can be condensed from many years based on these outage opportunities, to one year, driven by the project as a continuous exercise.

"Any signal type. Any control platform. Any size. Any time."

Another important feature of TEMPUS is that the control system migration is non-vendor specific and able to work with any platform from any supplier, or combination of suppliers.

All conventional control system I/O types are supported, including any combination of analog, discrete, isolated, non-isolated, high side, low side, 4-wire loops, 2-wire loops, 24 volt, 120 volt, device powered, and control system powered. Since each loop is managed independently, there is no limit to the quantity or distribution of I/O that can be migrated, which also means that multiple platforms and locations can be migrated simultaneously.

The risks associated with hot cutovers or offline migrations cannot be entirely eliminated. For offline migrations, the main risk surrounds the unknowns during start-up.

These unknowns can cause significant delays or even equipment damage if not implemented properly. Traditional hot cutover migrations, where a single loop is forced and wired to the new system, pose many significant risks. These risks include temporary logic modifications, forces, lack of backwards compatibility, and the inability to commission your system before the loop swingover.

TEMPUS solves all of these traditional risks. And, although, it doesn't completely eliminate risk, the risks are reduced and distributed in different ways. The potential for risk with TEMPUS is related to the temporary wiring. However this wiring is a series of simple and repeatable steps that can be controlled and mitigated with well-defined procedures. During the migration, TEMPUS is fully backwards compatible which further reduces the total project risks.

Obsolescence is unavoidable, and control system migrations are a necessary part of a plant's lifecycle. Eliminating downtime revolutionizes how control systems are replaced. TEMPUS presents not only a new paradigm, but also a new standard for control system migrations.

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