Canadian Consulting Engineering Awards 2017

Online Control System Migration of Industrial Centrifuge

Project Description

Category: Natural Resources, Mining, Industry & Energy

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Partners in excellence

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1. Project Description

During a critical component of the oil sands recovery process, centrifuges are used to separate impurities from the bitumen stream. This is one of the final steps prior to “forwarding” it for upgrading. Suncor Energy Inc.’s (Suncor) secondary extraction plant 4, in Fort McMurray, consists of multiple centrifuges in a variety of manufacturers and sizes. Due to the criticality of the final separation process, individual centrifuges had been migrated to a new, common Distributed Control System platform over several plant outage opportunities. This was completed using traditional migration techniques that require the process to be offline. To support the complicated and delicate migration process, CIMA+, as prime consultant, developed the TEMPUS tool to facilitate the migration of any industrial control system to a new platform, without the need to shut down the plant’s production. TEMPUS was field piloted and tested to complete the online migration for a Suncor 500HP ODB centrifuge to the new control system.

1.1 CIMA+ Scope of Work

To accomplish the migration of the 56 signals associated with the ODB centrifuge, the following tasks were reflected in construction work packages, and subsequently completed:

+ Assemble all drawings, datasheets, and documentation related to the centrifuges;
+ As-build all drawings, datasheets, existing logic, and update control narrative;
+ Assign points to an existing new controller cabinet and update/design existing drawings to reflect the new Input/Output (I/O) alignment, then migrate the associated logic and graphics/operator interface to the new control system platform;
+ Factory Acceptance Testing (FAT) of graphics and logic;
+ Develop strategy for swingover and execution of the resulting commissioning activities from the existing control system to the new control platform, completely online.

CIMA+ worked closely with Suncor to integrate this unique engineered solution with no disruption to routine operations, and no impact on the production process itself.

1.2 New or Advanced Approach

Considering the magnitude, variety of hardware, and unique control system configurations, over time, the industry has developed a variety of traditional approaches to executing migration projects. The most commonly applied migration solutions available today 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.

During a traditional control system migration, wires must be moved from the old system to the new. Moving these signal wires is one of the fundamental problems which all migrations face, as it inherently means that the signal will be lost during the swingover. With the TEMPUS hardware and procedures, wiring can now be completed without disrupting the I/O signals for an online comprehensive control system upgrade. This new process is an innovative, and proven method for migrating one system to another, while remaining completely online, thus improving cost effectiveness and reducing loss of production.

A critical component of the new online migration process, is the TEMPUS tool, an electrically certified, specialized temporary hardware installation, providing a new and advanced solution to traditional control system migrations. 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 online 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.

When considered in its entirety, the TEMPUS solution radically changes the way control system migrations can be completed, making them safer, quicker, and at lower cost than has been previously possible using existing techniques and tools.

1.3 Project Schedule

The project was completed in approximately five months as per the original plan from January to May 2014. The plan included all normal project phases including conceptual design to construction packages, testing, and programming, all of which were completed in a typical progression. The project execution including construction, commissioning, and turnover occurred within a three week period, while the swingover to the new control system was carried out in less than four hours, from start to finish. Overall, the project was completed on time, and did not deviate from the original schedule agreed to by Suncor.

1.4 Original Cost Compared to Final Cost

1.4.1 Total Installed Cost

The final cost was closely tracked to the original estimate, with minor scope changes to include more signals to the original tag list. The Total Installed Cost (TIC) of the project was $400,000. As a result of the design activities and associated data collection of the installed equipment, we were able to make optimal use of existing control system equipment, with the corresponding benefit of no additional capital investment in equipment of infrastructure being required.

1.4.2 Engineering Services Cost

The original cost for the intended scope of work was $130, 916, and with the additional scope change mentioned, CIMA+ engineering services, programming, and commissioning was completed for a final cost of $157,099.

1.5 Level of Success

Not only was the original pilot project successful, proving all elements of the migration tool on a range of different signal types without affecting operations, the client subsequently executed a second, larger and more process critical project using the TEMPUS technology. The second project scope included the migration from three different control systems to a new platform for six critical heat exchangers, 12 pumps and associated equipment that could not be removed from service as it would affect the entire facility. As the utilities provided by the heat exchanger systems are in constant demand to support parts of the plant operation including during normal plant outages, the systems had been operating continuously for over 25 years by the time this migration was executed. This second project was also completed without any process disruption.

1.6 Application

TEMPUS has been designed to be used on any type of migration project regardless of whether that project is for a replacement system, phased migration, or mixed system implementation. TEMPUS also works with any type of control platform including:

+ **Programmable Logic Controller (PLC)** - Typically used for systems with smaller signal counts or modular installations;
+ **Distributed Control System (DCS)** - Normally found in large complexes such as refineries, chemical plants, pulp mills, or other processing facilities;
+ **Supervisory Control and Data Acquisition (SCADA)** - Deployed in the water and wastewater, oil and gas gathering, renewables, utilities, pipeline, and other geographically distributed systems;
+ Or, as is often the case in integrated organizations, any combination of these systems.

As the TEMPUS system is modular, one signal per hardware element, it can be used for any size system regardless of how the system is architected, installed or distributed by simply using the number of elements required for the number of signals being migrated.

The above appears to be all things for all systems which may be difficult to believe. However, the following more fully describes the functionalities of the tool to illustrate how it can be applied in this wide range of applications.

Each migration tool is used individually for a single loop, but multiple tools are used at concurrently, for many loops comprising an operating system. When all signals for a system are connected through the migration tool, both control systems see the exact same real-time information. With the same inputs, the outputs for both control systems will match and follow the programmed logic of the system being used for control. This allows for real function testing and commissioning of the new control system, while the old control system is actively controlling the required outputs. Once the commissioning of the logic is complete, the swingover of the existing system being replaced (actually controlling the outputs), can begin one loop at a time until all loops have completed the swingover. As each loop is migrated, the new control system wires can be terminated, and the migration tool removed, leaving a clean and organized wiring scheme for that operational system. All of this can be accomplished without any loss of signal and without shutting down any equipment.

TEMPUS has been designed for use in the migration of any control system incorporating support for a range of input and output signals as per the table below:

Table 1 – TEMPUS Input/ Output Configuration Options

Signal Type	Input		Output	
	24 VDC	120/ 240 VAC	24 VDC	120/ 240 VAC
Analog 2 wire (4-20 mA)	+		+	
Analog 4 wire (4-20 mA)	+		+	
Analog Field Power (4-20 mA)	+		+	
Analog Control Power (4-20 mA)	+		+	
Isolated Analog	+		+	
Discrete Input	+	+	+	+
Discrete Input High Side	+	+	+	+
Discrete Input Low Side	+	+	+	+
Discrete Input Isolated	+	+	+	+
Discrete Output	+	+	+	+
Discrete Output High Side	+	+	+	+
Discrete Output Low Side	+	+	+	+
Discrete Output Isolated	+	+	+	+

To set up each module to match the type of signal, the modes need to be selected via the pushbuttons on the unit, before it is used. To prevent accidental changes from the tool operator or by anyone else in the area, a dual pushbutton action is required to change a mode. The selected mode is indicated back to the operator via a positive feedback LED light in the pushbutton.

2. Technical Excellence

As part of the online migration for the 500HP ODB centrifuge, an average of 10 loops per hour were migrated without any disruption, while allowing for complete visibility and control of all I/O on both systems during the migration. The main advantages derived from online migration tools can be summarized as:

+ Migration without loss in productivity;
+ Decrease in risk of losing control over the system;
+ Full online commissioning;

TEMPUS achieves these advantages by providing the following capabilities:

+ No simulation system is required for development;
+ No disruption to the I/O signals;
+ Utilizes the physical signals rather than a communication protocol;
+ Marshaling cabinet wiring is bypassed to allow new control system wiring to the existing marshaling terminals;
+ Designed to be failsafe;
+ No limit to the quantity of I/O to be migrated;
+ Non-vendor specific and can work on any platform from a remote SCADA system to a DCS/PLC or SIS system;
+ Multiple different platforms can be migrated simultaneously ;
+ All conventional control system I/O)types are supported;
+ Any combination of isolated, non-isolated, high side, low side, 4 wire, 2 wire; device powered and control system powered loops are supported;
+ Significant reduction in project lifecycle and Total Installed Costs.

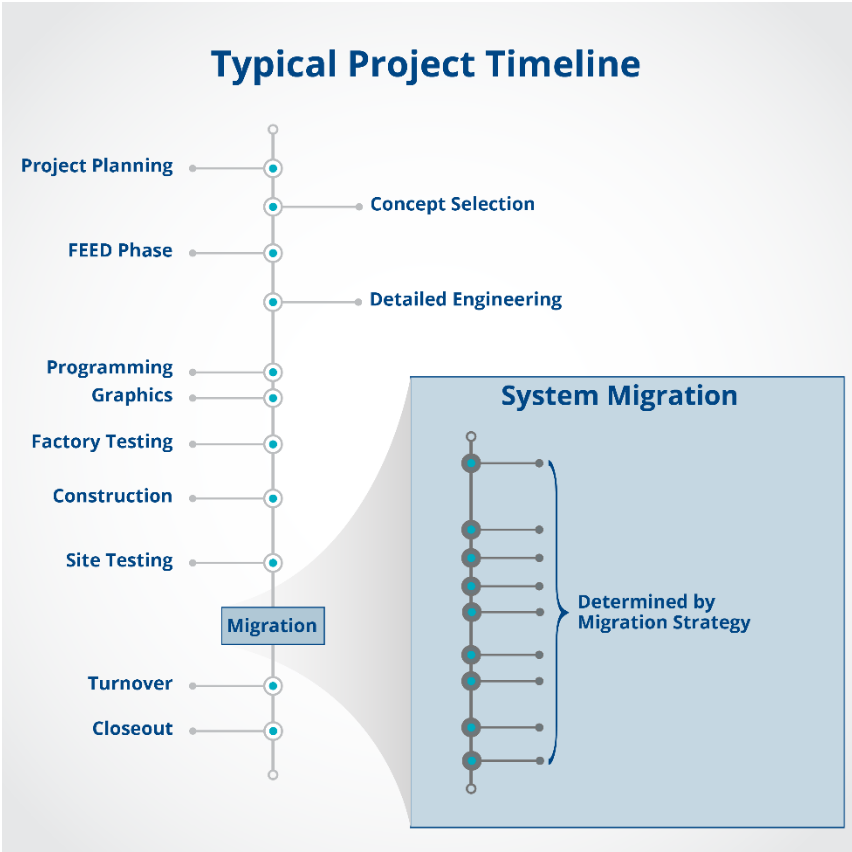
3. Degree of Difficulty

Control system migrations are typically a challenging project requiring balancing many conflicting demands. These projects often have very unique aspects starting with the requirement of needing to cleanup decades of undocumented changes. Unless the present installation details are 100% accurate, it is not possible to migrate to a new system without creating a process upset. Since TEMPUS provides an “extra” level of protection should a signal have been missed or erroneously documented, this would not have been an issue on this project.

The analysis of new control system’s requirements provided a value add opportunity to this project. CIMA+ was able to fit in space in the existing marshalling cabinet, thus saving real estate and freeing up space for other uses.

As a pilot project, it was necessary to develop new processes and procedures for the commissioning, swing over, and execution strategy of the actual migration process. The figure below shows it was in the critical ‘system migration’ stage when the plant is actually being moved from the old to the new system, that these processes are needed most.

Figure 1 - Migration Project Timeline



Another complicating factor for this project is that it was necessary to migrate from one legacy control platform to a completely new system from a different manufacturer. As a result, it was necessary that all logic and graphics required in depth checking as 'automated' migration tools normally used to convert these elements, are not reliable in this scenario. Again, the project team was able to complete this work using the procedures developed for this purpose.

Lastly, since the desired outcome of this new process was to not disrupt operations in any way, the project had to overcome the challenge of how to connect to field wires without affecting the existing I/O signal terminations. Traditional methods would have required inserting a new wire or plug into the terminal block and hope that holding the wire in place while doing so, would not affect the signal – an endeavor high risk and low probability of success. To overcome this project, the project team developed the two part pierce probes to slip over the wire with subsequent connection of patch cables. (Further described in Section 5). This project was the first implementation of TEMPUS in a running plant environment. The project was completed without interrupting the process, and would not have been possible without development of the TEMPUS work processes, tools and technology.

Many learnings were identified throughout this project and have since then been implemented into the next revision of the product's design.

4. Management of Risk

Minimizing risk associated with a migration project is a key element of success, and is why most projects are executed while the facility is out of service. TEMPUS reduces and distributes these risks in a way that is controllable and manageable on any scale.

Another critical tool to managing risk is the Project Execution Plan, which incorporates the procedures to be used in association with the migration tool itself. In addition, full as-built documentation is required to fully understand the process and the current wiring.

5. Innovation

TEMPUS is the only product on the market that encompasses the full migration process into one tool. TEMPUS also allows for full online commissioning which has never before been possible.

Development of this product required two critical innovations. First, a way to connect to the individual signal pairs with minimal risk of disrupting the process, and second, the design and manufacture of a tool that replicates the most commonly used input and output signal types to and from two control systems.

The first challenge is addressed by the pierce probe assembly. As illustrated in **Figure 2** below, the slotted wire assembly was sized to fit so that it is centered over the cable which contains a probe, so that when the two parts are screwed together, the probe can pierce through the cable insulation to the conductor.

Figure 2 – Pierce Probe Assembly

Probes are placed on the wires being migrated, typically on either side of a terminal block, thus eliminating the need to disrupt or disturb the signal terminations. Three connections are required for each loop, one for the field side wires, one for the old control system wires, and one for the new control system wires. When the migration begins, a temporary patch cable is threaded to the other open end of the probe to the temporary cables, and then connected to the main innovation, the TEMPUS migration module.

The migration module incorporates a significant number of features beyond support for the range of signals listed above, including:

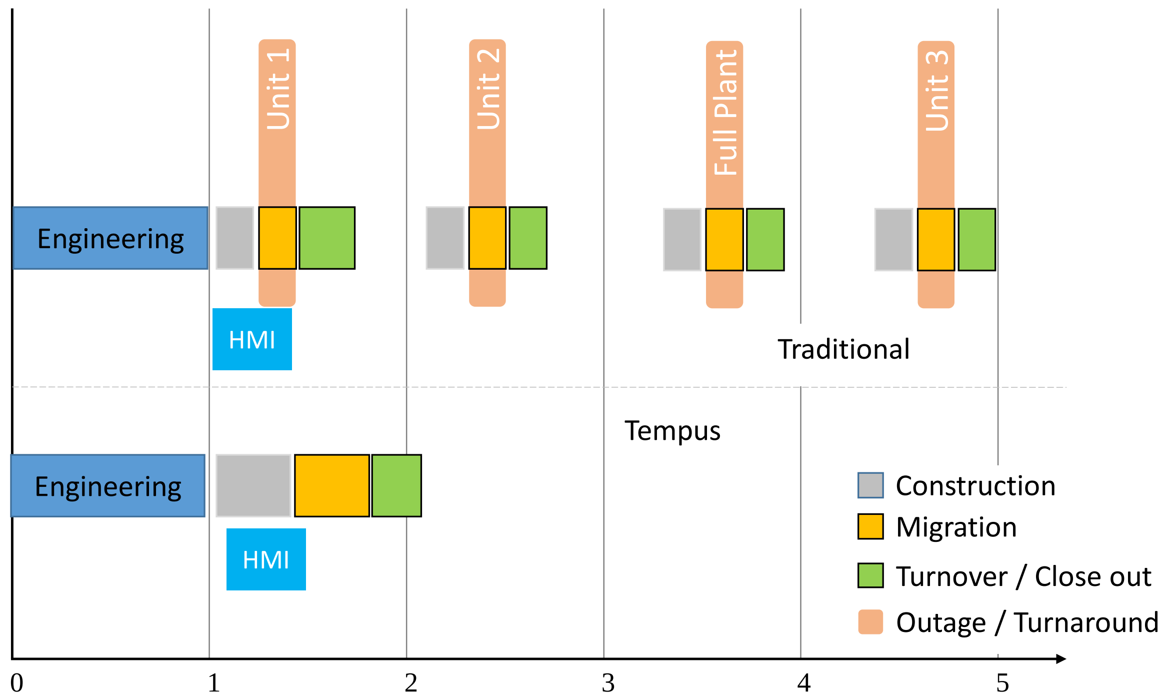
- Designed to operate of 24VDC power, the same power source used for analog field signals and thus available at any control system installation, or if necessary, via battery;
- Linked power connectors between modules;
- Mode selection does not change on loss of power;
- "Pass through" primary signal so active control loop is not affected by the module;
- Isolation between primary and secondary signal;
- Tool mimics an end device on secondary output to prevent an open loop detection alarm;
- Reverse polarity protected to not only prevent damage to equipment, but to also allow the signal to flow in the correct direction and polarity;
- HART signals maintained on the primary signal and intentionally blocked on the secondary signal to allow proper communication between the field device and the control system that is in control at any time.

In addition to its electronic/ signal management capabilities, TEMPUS has been designed with a variety of physical features. The form factor is sized in a way that allows multiple tools to stack on top of each other. The height of each tool has been designed to align with typical field marshaling terminals (+, -, Shield) which reduces the length of the interconnection cables, and simplifies wiring. This allows each device to power each other individually. The plastic product housing protects the internal electronics from wear and external forces. With adequate external frame support installed to provide structural integrity, a stack of modules up to 100 units can be used at any time, with multiple stacks being used in different locations.

6. Technology Advancement

The ideal execution strategy is to fully, and quickly replace the obsolete control system at a reasonable cost, with no impact to production. For larger projects, scheduled unit outages drive a multi-year migration plan, adding both cost and complexity. 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. As shown in the figure below, the result of being project driven rather than outage driven, offers a significant reduction in the project schedule with a corresponding reduction in project costs including maintaining the project team, cost of capital, and efficiency in project execution. **Figure 3** below, represents a typical schedule for a migration project.

Figure 3 – Migration Project Schedule



7. Added Value

The main added value that TEMPUS brings to the table is the savings in shutdown costs associated with avoided plant outages. In addition, TEMPUS is a technology enabler that allows clients to upgrade a system on their schedule and without needing to wait for a full plant outage, at a lower risk than existing migration techniques.

Being completely 'reversible' at the push of a button until the TEMPUS modules are removed, also enables complete testing of all elements of the migration process on the new system before abandoning/ removing the existing equipment. This further reduces the risks associated with migration by enabling complete verification of everything from control algorithms and logic, through to the operator interface/ HMI in a controlled environment, rather than, for example, during a plant start-up.

8. Environmental Value

The direct environmental benefit for this project was minimal. However, when we consider how using TEMPUS on other projects will minimize the risk of an accidental loss of containment or disruption to the process, thus remaining not only within operational constraints but close to optimal operating conditions at all times, the life cycle environmental impact will be significant. In addition, residents in close proximity to the facility requiring an upgrade, will be sheltered from any corresponding impact to their environment, including the reduction of emissions or accidental releases.

9. Benefit to Society

By eliminating the need for plant outages, and as a result providing continuous monitoring and control of the facility, the facility workers will be safer by preventing an unplanned shutdown, which is not only high risk, but costly as well. For example, assuming a 10,000 Bbl/day oil sands facility with an industry average margin of $20/Bbl leads to a loss of $200,000/day exclusive of the additional labour costs associated with bringing the plant back to an operational state. Being able to maintain any process within its operating envelope will also contribute to the ‘bottom line’ of any company during a migration project through minimizing, and in most cases eliminating, a plant outage, or any disruption to the normal plant process operations. As a result, this will manage cash flow, and make the most effective use of the team tasked with executing the project.

15 Royal Vista Place NW, Suite 280
Calgary, AB T3R 0P3

T. 403-775-0100
F. 403-775-0102

www.cima.ca

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