

TECHNICAL ARTICLE

Automated Mass-Conversion of Code when Migrating Industrial Controller Platforms

By James Redmond, Schneider Electric

Replacing an aging control system which has reached end-of-life can be a daunting undertaking. There are many aspects to consider. These can include: I/O wiring, controller hardware, control panels, control system networks, servers, storage hardware and operator workstations. Furthermore, there is the software – also known as control system code – that ties the entire system together. In even a medium-sized control system it is not uncommon, for the existing code to represent several person-years of programming investment. Fortunately, there are now several automated tools available to help with the effort to translate control system code as part of a system migration project.

Introduction: Nothing lasts forever

There are many challenges in maintaining an aging distributed control system (DCS), PLC or RTU install base. Older sites, in many cases, include solutions dating back to the 1980s or 1990s and were developed using software tools that may no longer be available or able to run on modern computers. Documentation, describing the design and/or implementation of a specific application, can often be lost in the intervening decades. In addition, the skills and experience necessary to employ these legacy development tools may not have been maintained. It is not uncommon to find situations in which the software developer, who originally wrote, tested and installed the solution, has left the organization, and because the site kept performing as expected for many years, no further effort was made to build the capacity to maintain it. A final set of problems can occur due to these applications residing on hardware that has become obsolete. As the stock of spares is diminished over time, the ability to maintain operations at that site becomes increasingly difficult and risky.

Aside from aging equipment and loss of skills, and even where the systems are operating as designed, increasing demands and regulations may mandate a new methodology to evolve away from an older platform.

Consider, for example, the focus of the 2019 WEFTEC conference on cybersecurity at a hardware and software level¹ or a recent example of an NSA report which highlighted the vulnerabilities of several commonly used PLCs². These problems are not unique to the water/wastewater field. Older PLCs and RTUs will need to be replaced someday.

Control System Software Development Environments

Despite the evolution of industrial automation in recent years, the development of PLC and RTU applications is often performed in isolation, by users employing manual procedures and a range of tools. This is further complicated by the fact most industrial control system software tools are propriety in nature and often specific to each individual control system platform and hardware type.

This wide variation of software development tools in the marketplace is, in large part, been a product of the platform-specific implementations of IEC 61131-3, produced by PLC and RTU manufacturers. Fortunately, this is starting to improve as the automation market continues to develop. However, while many newer PLC and RTU platforms have taken efforts to ease development and to facilitate more sophisticated development practices, this does not address the aging install base used to control and monitor water wastewater sites.

An example of an industrial automation code development environment can be found in Figure 1:

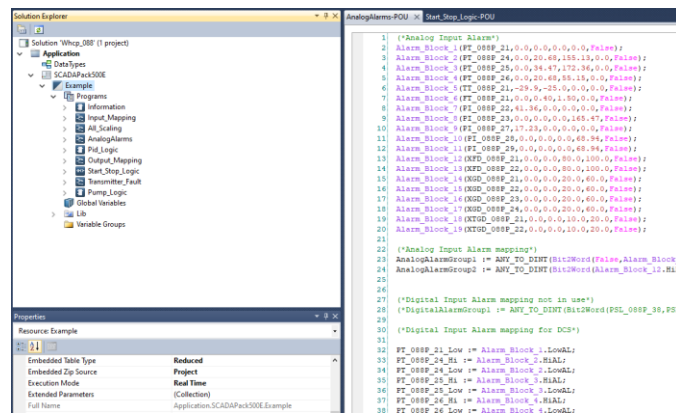


Figure 1 – Example of SCADApack Workbench Structure Text Application

Why automated conversion

Due to the many different types of controllers out there and code development environments, the use of code conversion tools can be a helpful tool when undertaking a control system upgrade.

The availability of code conversion tools can be especially helpful when confronted with an installed system that includes these features:

1. Large number of obsolete/end-of-life RTUs and PLCs
2. Large numbers of RTUs and PLCs
3. A mix of different RTUs and/or PLCs
4. A variety of unique applications

Figure 2 shows some of the various PLC and RTU models that are available from just one Automation Supplier.



Figure 2 – Example of a Mix of PLCs and RTUs from one Supplier

Challenges of manual conversion

To address these site maintenance barriers, system operators should take an approach to proactively migrate applications from aging platforms to newer platforms that can be sustainably maintained. A major challenge to this approach is the diversity of platforms that can require replacement. This creates a practical barrier in that programmers, looking to migrate a system from an older RTU or PLC to a newer RTU or PLC, must learn each individual platform.

Consider the steps required now for a user to convert an application from one platform to another are as follows:

1. Study the platform from which the solution is being ported (the source platform) including its tools.
2. Create a development environment for the source platform.
3. Manually convert the code from the source platform to the target platform.
4. Verify that the target platform application performs as expected when compared to the source platform application.
5. Document the updated application.

An example of the extensive requirements can be viewed online³. One consideration specific to the conversion of IEC 61131-3 code from the source to the target platform is that the time involved with the code conversion can vary significantly based on the language being used. For instance, the conversion of structured text (ST) code can easily be performed manually using a cut and paste method. It has been observed, however, that the copy/paste/modify approach can often prove to be error prone as the process is dull and repetitive and thus leaves developers less focused.

Consider the following example showing two code fragments from SCADAPack™ Workbench and its direct equivalent in RemoteConnect™ Logic Editor:

SCADAPack Workbench – Code Example

```
TON_NoTorque(
    Well[0].Control.iMode =
    eMODE_TORQUE AND
    Well[0].Status.Drive.iMotorTorque <= 0 AND
    (Well[0].Status.iMode = eSTATE_AUTO OR
    Well[0].Status.iMode = eSTATE_STARTUP),
    T#30s);
iTemp := F_DEL(i_sFileName + '.bak');
```

RemoteConnect Logic Editor – Code Example

```
TON_NoTorque(
    Well.Control.iMode = 3 AND
    Well.Status.Drive.iMotorTorque <= 0 AND
    (Well.Status.iMode = 300 OR
    Well.Status.iMode = 30),
    T#30s);
F_DEL_0(CONCAT_STR(i_sFileName, '.bak'), iTemp);
```

Observe that although each platform uses very similar code, even in these simple cases, differences can occur, including: defined words being supported in one environment and not the

other, the need to replace a function with a function block (FB) and the syntax of a FB call being different.

These challenges are only increased when working with the graphical IEC 61131-3 languages, ladder diagrams (LD) and function block diagrams (FBD), where the challenges of differing syntax, custom functions, and platform-based timing are coupled with the need to graphically recreate the implementation. Also, the interpretation of the graphical languages IEC 61131-3 may vary between development environments.

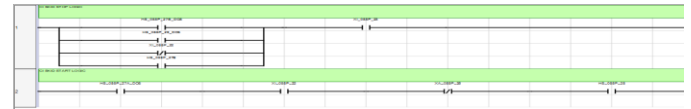


Figure 3 – Ladder Diagram (LD) Code Example

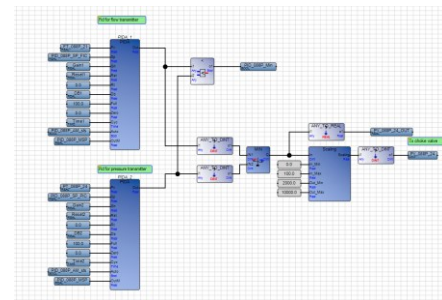


Figure 4 – Function Block Diagram (FBD) Code Example

Considering the need to repeat this process for each application, the time and effort required to migrate to a new platform can increase significantly.

Automated Code Conversion Tools

A powerful approach that can mitigate the significant costs involved in PLC and RTU modernization projects for system operators, consultants and developers, with this manual, platform-by-platform, and labor-intensive approach, - while avoiding the trap of attempting to indefinitely support aging platforms - is the use of automated conversion tools. The primary benefits of an automated conversion approach are reduced costs, time and risk. In some situations, migration costs can be reduced by up to 40% using an automated approach.

For example, when using one such automated code conversion tool, the following workflow could be used:

1. Conduct source code analysis to transform the source code into a generic platform independent set of source files.
2. Replace references to source PLC or RTU to references to target PLC or RTU.
3. Generate the code for the target platform.
4. Manually adjust code on target platform (the automatic conversion tool will indicate where this is required).

A diagrammatic representation of the automated code migration workflow is shown in the following figure:

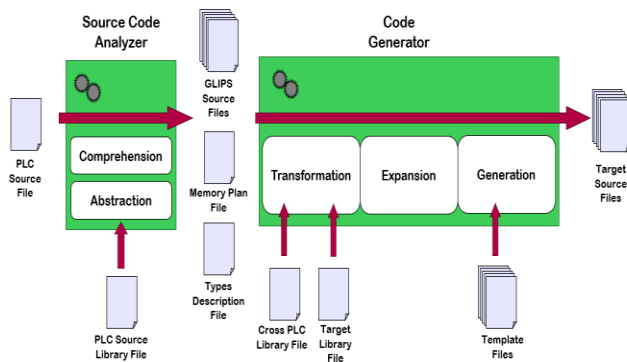


Figure 5 – Automated Code Conversion Process

An example of an automated code conversion tool is the EcoStruxure Control Engineering Converter, which is a tool used with Schneider Electric PLCs for the Modicon and SCADApack product lines. The EcoStruxure tool is able to import source code and convert it into a platform-independent GLIPS language. GLIPS is sufficiently abstract such that it can be transformed so as to produce target code for a variety of PLCs, RTUs, and other systems used for embedded applications (C code can be generated too). The flexibility of this platform-independent code is essential to an effective code translation system.

When looking at automated code conversion tools for doing code conversions using the IEC 61131-3 programming languages, here are some of the code conversion features that one should look for:

- Memory Organization: variables, points, registers, sizes, locations
- Data Types: simple types, structures, enumerations, functions, FB
- System Libraries
- System Information: status variables, timers
- Application Structure: tasks, program organization unit (POU)

In addition, the conversion process should support the translation and conversion between all five IEC 61131-3 languages (ST, LD, FBD, SFC, and IL) and advanced transformation mechanisms can even help customize the target code to specific needs such as going from one language to another for a given section. For example, having a tool to convert subroutines from Structured Text (ST) to Ladder Diagram (LD) would be a helpful feature for software code migration.

One thing to keep in mind is that no matter how advanced a code conversion tool is, there will be some parts of the conversion that will still need to be done manually by a skilled programmer familiar with both the old and new platforms.

Some tasks, due to the wide range of platforms and their unique implementations, typically require a programmer to manually update them. These tasks commonly include the assignment of I/O to PLCs, RTUs, and expansion modules, the configuration of communication port settings, security and credentials. This challenge can be expected for protocols more complex than Modbus™ such as DNP3 or IEC 60870-5-104.

Once the application has been converted by the tool, the development team, freed from the tedious task of code translation, is now positioned to focus on completing the migration to the new install base by allowing the developers to concentrate on finalizing, validating, and commissioning the new platform. This can help to leverage fully the capabilities of the new platform which is a hidden benefit of migrating beyond duplicating the functions of the obsolete system.

Summary

There are many challenges associated with maintaining aging systems currently in use by many water utilities. Personnel retirements, equipment-end-of life, changing regulations and the need for more sophisticated or efficient operations can force the need to move away from older platforms. The cost of a manual program-by-program change can be prohibitive due to the time required, by the developer performing the conversion, to learn the old system, and to then manually duplicate it on the new platform. The manual change approach also creates risk.

Water system operators should, when planning a large migration project, consider an approach that uses the automated conversion of PLC and/or RTU code from the old platform to the new. The benefits of using an automated approach increase as the mix of source platforms, source applications, and size of the install base increases. The automated conversion of PLC and RTU code has been used successfully in other industries and this experience can benefit the water and wastewater field⁵. The key benefits of this automated approach are reduced costs, time and risk.

About the Author



James Redmond, CD is the acting product line manager for the SCADAPack RTU product line at Schneider Electric. He has over six years of experience in the SCADA and telemetry industry. Prior to his time in industrial automation sector, he designed and implemented automated equipment for various industries. James also served for 14 years as an Engineer Officer with the Canadian Forces (Primary Reserve). James received his Bachelor of Engineering degree from the University of Western Ontario in 2004. He is based out of Ottawa, Ontario, Canada. Contact: james.redmond@se.com

References

1. http://isawaterwastewater.com/wp-content/uploads/2020/04/ISA-WWID_newsletter_2019fall-winter.pdf
2. <https://us-cert.cisa.gov/ncas/alerts/aa20-205a>
3. [https://wx.toronto.ca/inter/pmm/d/callawards.nsf/0/57C242CC31D7DA7F85257CDBD0072250F/\\$file/9117-14-7076%20Viewing%20Copy.pdf](https://wx.toronto.ca/inter/pmm/d/callawards.nsf/0/57C242CC31D7DA7F85257CDBD0072250F/$file/9117-14-7076%20Viewing%20Copy.pdf)
4. <https://www.itris-automation.com/plc-converter/>
5. <https://www.itris-automation.com/clients/>



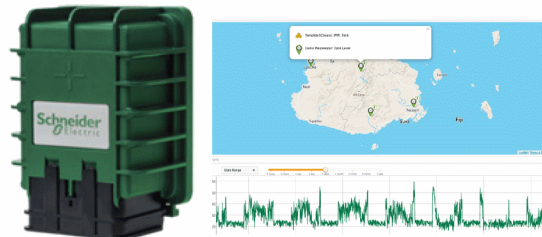
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STANDARDS UPDATE

ISA112 SCADA Systems Standard: The Document Begins to Take Shape

By Graham Nasby, ISA112 standards committee co-chair

Since its establishment in late-2016, the ISA112 SCADA Systems standards committee has been hard at work developing a new management lifecycle for the long-term management of SCADA systems and a standardized workflow for managing the SCADA aspects of capital upgrade projects.

Based on work to date, the committee released the draft ISA112 lifecycle and the ISA112 model architecture diagrams in mid-2020. PDF copies are available at www.isa.org/isa112/. See the Summer 2020 issue of the WWID newsletter for an introduction to these two reference diagrams. These diagrams will also be soon joined by several SCADA system maturity model diagrams that the committee is currently working on.

In parallel with diagram development, the committee has been working on the actual text for the upcoming ISA112 standards documents. This has included writing the Table of Contents and developing “point-form” content for each of the document’s various sections. Individual volunteer section authors have been using this outline to create the first draft of the documents’ written content.

As of January 2021, the ISA112 master working document has reached a staggering 393 pages with about 75% of the written content now at the first draft stage. It is expected that once the first rough draft is complete, the page count will reach approximately 500 pages. The committee will then begin the process of editing/refining the rough draft content, and then portioning the text into the core ISA112 standards documents and associated ISA112 technical reports.

It is expected the main ISA112 SCADA Systems standard will be published in 3 parts, namely: Part 1: SCADA Terminology and Diagrams, Part 2: Requirements for the ISA112 management lifecycle, and Part 3: Requirements for the ISA112 model architecture. The development of standardized SCADA terminology has been a major goal of the ISA112 committee. Part 1 will provide a standardized way for end users, vendors, consultants and contractors to communicate to each other when discussing SCADA systems. The Part 1 document will also include the already-developed ISA112 SCADA management lifecycle diagram and ISA112 model architecture diagram along with a brief introduction of each. The committees is aiming to publish Part 1 in 2022/2023.

At present the ISA112 committee comprises of over 210 volunteer SCADA experts from around the world and from a wide range of industries. To find out more about the ISA112 SCADA standards committee visit www.isa.org/isa112