Standardising control systems for the water industry

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In addition there is often a requirement for data gathering to enable plant optimisation and satisfy the regulatory and management reporting requirements.

Industrial computer-based processors, such as programmable logic controllers (PLCs), have been developed to perform control functions and provide the operator with visual information to allow him to operate and control the plant. The PLCs are configurable, via specifically written software code, to perform a variety of control actions, and have the mathematical functionality required to control and monitor modern day processes. Indeed some of the interdependent processes would be difficult if not impossible to control by hand.

The PLCs first used by United Utilities had limited functionality and display capability. Nowadays the equipment used typically comprises several networked PLCs and colour human machine interfaces (HMIs) offering both graphical and tabular displays. In many cases the graphical displays, traditionally provided by SCADA systems for plant operation and monitoring, are now provided by the PLC HMI.

Most of the facilities are unmanned, automatic operations that are monitored continuously by telemetry. Connection of the telemetry outstation to the plant control and monitoring system is commonly via the PLC network. The outstation accesses data tables within the PLC memory to avoid the need for costly telemetry I/O and its associated wiring.

System integration

The system integrator is required to ensure that the process equipment is operated safely in the correct sequence and that the outputs are controlled within set limits. Where abnormal conditions occur the system is required to shut down faulty equipment and start any available alternative plant, generating alarm information for the operator.

Originally instrumentation and automation engineers employed by the manufacturers of motor control centres or automation panels performed the system integration. Skills are now needed in designing control system architecture considering the variety of legacy systems in the plant and the new system, and software writing which brings its own issues regarding control of modifications, records and the associated version control.

This is controlled in our projects through the following:
- Asset standards; and
- Technical specifications.

Custom and practice within the industry also forms the basis of some of the standards employed. Within previous asset management period (AMP) programmes there were often multiple software vendors - often second, third, and fourth tier subcontractors - consequently control of the detail was difficult. The solutions provided were often what others thought the company needed rather than what was wanted. This situation led to an inconsistent approach to system design and coding, a lack of good documentation and concerns regarding maintenance after project ‘in use’.

Historically, engineering service providers and contractors have attempted to write some software ‘in house’ and made an attempt to use standard building blocks. The aim was to provide repeatable solutions that could be copied for similar functions on other sites.

This was difficult to achieve for the following reasons:
- The hardware was often from multiple vendors;
- There were multiple suppliers often within one project; and
- There was poor or non-existent version control.

Modifications were often made during commissioning or subsequent operation and poorly recorded, and errors were fixed as they appeared. The process of system integration lacked upfront thinking and the planning needed for successful software development and implementation.

United Utilities appointed Tata Consultancy Services (TCS) to help it meet these requirements. In July 2002 it commenced work on a three year systems integration (SI) programme, becoming the company’s single PLC system integrator, supporting their operation through effective design strategy and good documentation. It was also agreed that TCS would use the onsite offshore business model, which is a proven process for many of its international clients.

Issues with control systems

The test of good design and implementation of a control system is realised during plant operation and maintenance or when there is a requirement to upgrade. Though rarely effectively measured, the tangible benefits can be measured by the
true cost incurred for these activities. Hence, while planning for a system, the focus should be the life cycle cost of operation rather than the initial capital invested.

The following are the key issues typical of a major capital investment programme:

The quality of software can be measured by:
- Documentation of the code;
- Version control/back up availability;
- Diagnostic and testing facilities; and
- Security in the supply chain.

Mobilisation of adequate technical resources is a continuing challenge for most organisations especially close to the end of a programme of work or as is the case in the water industry as we approach the agreed dates for delivery of regulatory outputs.

Securing engineers with the right skill set and knowledge is a further challenge. This area is also further challenged where documentation and manufacturers’ support may not be available for many of the legacy systems. The long term ability of the vendor to support the above is also an important consideration, historically there have often been dependencies on individual capabilities or availability of specific personnel.

As previously mentioned, instrumentation, control and automation (ICA) is at the centre of any plant operation and systems integration for any given project is absolutely critical. ICA is one of the most dynamic areas in any industry, and this is certainly the case within the water industry today. The scope for innovation, change, and preferential engineering and therefore non-standard engineering is significant.

The following highlight some of the problems associated with the extension of an existing facility:
- Legacy systems: A great deal of technological development has taken place in this area and the rate of obsolescence is high. Technical issues often prevent legacy systems being integrated with a new control system. In many cases, the budget and schedule do not permit wholesale replacement of legacy systems;
- Documentation: Availability of “as-built” documentation and software backups;
- Coding philosophies: Different system integrators have followed different coding philosophies;
- Multiple vendors: It is commonplace for different SIs to be working on the same system under different projects often driven by contract strategy; and

Avantages of single integrator

The advantages of a single integrator for PLC software are summarised as follows:
- Ability to have a standard solution;
- Versions control simplified as all work is done by one organisation;
- Simplified communication as one group of people responsible for control;
- Consistency in documentation standards;
- Simplified dialogue for the end client; and
- Availability of a core of ‘experts’ to assist with design.

To realise maximum benefit from these advantages the end client must accept responsibility for, and be more proactive in, the management of interfaces, information flow and support for the system integrator to deliver the benefits of standardisation.

Information is needed in a timely manner from several vendors in the project supply chain for integration to be successful. The requirement for this information to be provided in a timely manner cannot be underestimated. Sufficient time must be allowed in the project implementation phase to plan and write the necessary software with adequate verification and checking to ensure success.

Most of the projects within the current asset management programmes involve additions to existing facilities. During the initial phases design of an assessment is required of the existing PLC network, if any, together with the age and extensibility of the legacy equipment. The availability of the system integrator’s expertise to assist in this assessment helps eliminate risk when determining estimates.

Although low in value compared with the civil engineering elements of projects, the impact and likelihood of failure of the process is high. Historically it is an area that has been grossly underestimated, often leading to compromise during implementation. Standardisation of plant design and control systems integration is key, as these are a means of bringing all components together into one coherent system.

In a regular model, the civil and/or process contractor engages the motor control centre manufacturer. The motor control centre manufacturer in turn engages a control systems integrator. Hence, the system integration vendor has very limited visibility of the end-client’s overall objectives to derive the benefits out of many projects.

A single systems integrator has the advantage of knowing the detail design requirements on all projects within the investment programme. They are able to capture the design philosophies for different projects and map them to demonstrate how the same design requirement is often implemented in various ways on different projects. It is here where they need support from the end client. The end client must support the joint goal of standardisation, in order to reduce any pressure from contractors or individuals to follow preferential engineering.
Standardisation can be achieved through the following:
- Modular software code;
- Standard SCADA and HMI mimic design; and
- Optioneering services before the plant design gets frozen.

A single system integrator can contribute by:
- Supporting the development and testing of standards for software coding, SCADA and HMI graphics;
- Maintaining legacy system information;
- Supporting the end-client in determining the replacement/maintenance strategy of legacy systems; and
- Supporting the end client in delivery and maintenance of as-built documentation.

Modular software

Historically within the company each project was treated as 'atomic' and its design and implementation as an independent non-repetitive task. This led to long development times and high costs. There are many repetitive tasks in the design, development and operational philosophies. United Utilities and TCS jointly undertook to follow a defined approach in the AMP3 programme to reduce project execution time and implementation costs.

This approach promoted the development of modular software components around standard functions or facilities and reusing these wherever possible.

Using pre-fabricated modules greatly reduces the development times. Substantial cost savings can be realised by using the inventory of reusable standard modules. These small sets of modules can be assembled to develop large configurations in a short space of time. Combining this small set of modules in different ways permits many different topologies to be developed. For example, pump unit logic can be standardised as a library function. It can be combined with another pump unit logic to develop duty/standby pump logic along with minor added logic for automatic changeover.

The software modules are split utilising a layered approach as shown in Fig 1. The smallest individual modules, which act as the basic building blocks are grouped in the 'Basic level'.

In the basic level there are four subgroups of the modules, called layers. The physical layer constitutes the software modules for interfacing with the physical signal coming from field or control panel. The device-specific modules (motors, valves, etc.) are covered in the device layer. The process interlocks constitute the process layer. The modules related to a HMI are assigned to the supervisory level.

These basic modules are used throughout the system integration software code. The next level of the modules is the unit level module. There are some process units which are common in many plants. A unit level module is developed for each of such identified process units by using the basic level modules.

Reuse strategy

The basic concept of systematic reuse is simple. Develop systems of modules and reuse them, then extend the idea of 'modular systems' beyond to requirements, design, and testing. Substantial reuse requires that reusable assets be identified in terms of the plant architecture. The reuse approach shortens the development time and the implementation cost only when the developed modules are effectively re-used. The desired ROI of the modules developed through this modular approach can be achieved with the reuse concept of 80% - 20% (that is, for any project 80% re-use, 20% customisation).

The reuse strategy we adopted started with focused pilot projects expanding incrementally, increasing reuse coverage and penetration. Fig. 2 shows that the benefits due to reuse such as improved project delivery, higher quality systems, and lower overall development costs, increases as the level of reuse increases.

Modular approach

Modules were designed by systematically linking objects, together based on operational principles. Objects are small devices like switches, signal converters, relays, and so on. These devices can be used in a variety of different settings depending on the targeted concepts of a particular module.

For example, a motor with a direct on line starter will have a motor as a device with a starter, two or three sensors for feedback signals, and one or two command inputs. It also has various equipment sensors like over-current and temperature. The combination of all these will result in a motor module (Fig. 3).

A module implements logically coherent functionality. Each module has an interface by which it is linked to the systems. Also, modules have dependencies on other modules on which its functionality is dependent.

The standard modules developed continue to be re-used in projects. To date there have been more than 5000 instances in over 100 projects where the standard modules have been re-used, thus validating the standardisation philosophy.

Offshore – onshore model

Using an onshore-offshore business model, the company has been able to drive down costs and improve the efficiency in the production of PLC software.

The offshore team is co-located with the alliance design and construction contractors, supported by a separate onshore technical team. The responsibility for passing the work to offshore is with TCS offshore, with the incentive of reducing the costs and providing maximum benefit from the offshore approach to United Utilities. All contact with the UK-based supply chain is via the onshore team.

Different parts of the system integration process were broken down into clearly identifiable activities. They are requirement study, site study, design and development, factory acceptance test (FAT) and site acceptance test (SAT) and commissioning, user training and programme and project management.
The efforts required for different activities are shown in Fig. 4.

Design and development and programme and project management, which constitutes 81% of the process, is the area which can be sent offshore, providing adequate communication links are provided. For any new project, the offshore/onsite ratio tends to be low and increases as the design develops and moves to implementation. All code developed offshore is fully tested in replica hardware prior to dispatch to the UK factory and site acceptance testing is carried out onshore by TCS in conjunction with designers and control panel vendors.

The benefits of a single SI

The use of a single systems integrator enabled the company, in its AMP 3 programme, to make significant progress towards standardisation. The following areas are under constant development and review:

- Consistency in design interpretation;
- Standardisation of control techniques;
- Standard software modules;
- Consistent and complete documentation; and
- Further development of United Utilities standard specifications.

Little historical data exists from previous delivery models, and little benchmarking data is available in the public domain to compare the performance of the current system integrator with the past vendors. Over 97% of factory acceptance tests have been successful with minimal rework in the factory or at subsequent stages.

The effort required at each stage of project execution is clearly understood and the process mapped. Process improvements are agreed jointly across the delivery chain and implemented in a controlled manner.

Working with a single systems integrator has enabled the company to realise benefits in the following areas:

- Improved operator flexibility; where all sites have the same 'look and feel'. This helps operators and maintenance personnel when they move between facilities;
- Improved maintenance, as the maintenance personnel are familiar with the equipment and configuration;
- A reduction in legacy interfaces and development of decision trees to support replacement or retention of legacy systems;
- Improved efficiency in engineering design, the company having a suite of agreed standard modules, applications and architectures; and
- A more reliable control system that has resulted in improved performance at factory acceptance tests and likewise for site acceptance tests resulting in fewer commissioning problems.

To achieve these benefits, it is essential to be proactive in continuously providing strategic guidance to the systems integrator and to drive programme-wide initiatives in a partnering relationship with the SI and the other framework and alliance contractors engaged in the delivery of the AMP3 capital programme.

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