Foxboro A2 Whitepaper
Case Study: System Cost and Engineering Advantages over PLC's

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Introduction

This whitepaper sets out to show the relative merits of using a Foxboro A^2 system in favor of a PLC based system and will describe the system components and discuss the advantages of the Foxboro A^2 system including the development software. A real-life project, in which the customer was initially considering both an AB PLC-based system and the Foxboro A^2, has been taken as an example of the cost differences between a Foxboro A^2 solution and a PLC solution.

The Foxboro A^2 system is a scaleable system starting at a single loop controller and increasing to a several hundred loop distributed system. It can exist with or without a SCADA front end and has been designed from the ground up to reduce engineering effort during the development, installation and commissioning phases of a project.

In this whitepaper the engineered cost to develop the process control system showed a savings of 23% over the PLC engineered solution. Savings were generated in virtually every facet of the project: hardware, HMI configuration, process configuration, and start-up.

What factors need to be assessed when considering a new control system

Upfront cost, project cashflow, product risk, % uptime, product support and control accuracy are all-important factors when deciding upon which control system to purchase.

Upfront cost: The initial project cost of a system using Foxboro A^2 is, in most cases, significantly lower than an equivalent PLC system. When all costs are taken into account, typical savings of 25% are often achieved.

Project cashflow is significantly eased with Foxboro A^2 since the entire remote I/O installation can be performed with the purchase of only 20% (in terms of cost) of the I/O system. Customers are able to postpone purchasing the rest of the modules until shortly before installation is completed. This is because the I/O system is made up of a rack, inexpensive termination assemblies and I/O modules. The system is wired completely with just the rack and termination assemblies, something PLC's don't accommodate.

Risk: There are several types of risk involved. There is the risk that the system will not perform as required, the risk that operators will object to the change and not utilize the system to its maximum performance and the risk that future requirement changes will not be able to be implemented (flexibility of the system). The Foxboro A^2 is an evolution from a previous family of Invensys products and as such there are thousands of systems installed across multiple industries around the world. One of the biggest areas of concern in trying a new system is the concern over configuration time and in particular communications. This concern can be removed with the use of Control Modules and transparent communications. Control modules are pre-built, pre-tested macros that represent pumps, motors valves etc. Since they are already proven, no

design and no test need to go into their development. ProfiBus or Modbus is used to communicate with the remote I/O and with either, the control program simply addresses the rack, slot and channel numbers of the I/O and the system takes care of the rest. The savings here, in engineering time alone, are enormous.

Owing to the incredible ease of use of the system there has been virtually no resistance to change from operations personnel and the emphasis from Foxboro on ease of use, especially the use of standardized templates has reduced training requirements as well as the possibility of incorrect operation. The ability to move sections of code between networked controllers and rebuild in a couple of minutes gives Engineers unprecedented flexibility for future requirements. The typical PLC and associated third party HMI package require the creation of templates and scripting features. This takes engineering effort and increases the chance of not meeting the original intent of the feature. The standardized templates in the Foxboro A^2 system remove this problem completely.

% uptime: Hot swap capability on I/O without the requirement to hook up laptop means mean time to replace a bad module is measured in minutes. Full use of the comprehensive Foxboro A^2 diagnostics in conjunction with the Operations server alarm filtering allows for the prediction of a problem either with comms or hardware. The mean time between failures for the T640F controller is close to 100 years.

Support: The configuration package has context sensitive help such that the user can press F1 at any time and the help screen appropriate to the cursor position will appear. The user can jump straight from this help screen to the section in the manual dealing with the topic in more detail. More extensive help is achieved through the Foxboro technical support center, which is staffed with Engineers having a deep understanding of the system.

Accuracy: The analog inputs are available in up to 18 bit, there is an A to D on every analog channel and with available auto-tuning, adaptive gain and full isolation Foxboro provides a level of control accuracy and repeatability that is without competition at this price level. On a recent project, temperature control of +/- 0.05 deg C was achieved and maintained over a period of several days by running a system model in the remote I/O.

The Foxboro A^2 system takes a single large database and allows the developer to literally break it apart and run different sections in different controllers. The communications are virtually invisible and unlike other systems they require absolutely no configuration. The Foxboro A^2 uses a system of Function Block 'caching' whereby a mirror image of any block may be run in one or more multiple controllers.

Project cost comparison

A recently completed project allowed us to contrast and compare products from two different suppliers. A short description of the customer's requirement is followed by cost comparison of the two solutions. The customer has three fermenters and three addition tank skids and each of the six skids has a control panel in which the customer would like its I/O to be housed. The customer had existing Allen Bradley equipment and initially wanted to upgrade it but was keen to look at other alternatives before making that decision.

There are three main states - off, fermentation, sterilization - for each of the fermenters. Each of the addition tanks is similar but heat control is substituted for fermentation. Sterilization consists

of about 8 steps and at each step customer has defined status of valves, PID loop SP's and pumps. Abort can be performed at any time.

There needs to be an operator interface (hardened) in the production area that gives details on all PID loops (about 25 total), allows all valves and pumps to be operated manually, shows P and ID type pictures of air, water and steam loops plus another for ancillary, about 50 mimics total. The customer needs to see alarms in the production area.

A SCADA system needs to provide details of all PID loops (with ability to change SP's) plus trends and historical archiving for all analog variables. No automated reports are required and neither are mimics.

The customer wanted to undertake the installation using his own resource so this did not form part of the original proposal.

The total I/O count on the project is 43 AI, 32 AO, 9 DI, 155 DO.

Several systems were considered for this project but the two main contenders came down to Allen Bradley or Foxboro. The AB offering is based on six enclosures, each with a FlexLogix processor and I/O rack(s), two Panelview 1000 local operator interfaces and a single HMI PC with RSView license. The Foxboro offering is based on six enclosures, each with 2500 remote I/O, two T800F controllers and a single HMI PC with Wonderware license. The corresponding costs for each of these systems are shown below.

	AB FlexLogix	**Foxboro A^2**
Control hardware and enclosures	$74,000	$58,300
Local operator interface configuration	$7,600	$7,400
Control and sequencing configuration	$41,600	$26,000
HMI configuration	$7,400	$2,800
Project management	$6,800	$11,200
Start –up	$16,000	$12,000
Total	**$153,400**	**$117,700**

The Customer is a very experienced Biochemist but knows little about Engineering or how to utilize current technology. Even specifying the requirement in engineering terms proved to be extremely difficult. The Foxboro A^2 system was chosen over the other systems because it offered the customer the ability to define the requirements as the project progressed, reduced his training requirements and gave him the most ongoing flexibility.

Although the customer was unable to fully define the project, it was possible to start programming on day 1. The structure of the plant was defined i.e. three fermenters and three addition skids. It was also known that two T800F units were being used. This allowed the Plant model utility to be used to set up plant areas and then allocate plant units to these. Alarm and security areas could also be set up to correspond to the plant areas.

The next requirement was to define the I/O count, which was relatively straightforward. The customer provided us with an I/O listing in Excel format detailing each point including its tag, descriptions, ranges, alarm and security areas and whether or not it needed trending. This spreadsheet was imported directly into the tag browser and in less than five minutes the entire tag database had been generated. Any changes after this point simply required a re-import. The Tag allocation utility not only allowed us to allocate each I/O point to a plant unit but also the documenter allowed us to generate an html document that was used to order the correct number of racks, processors and I/O termination assemblies. The customer was on a tight budget and their cashflow was significantly helped at this point in the project since they did not have to order any of the I/O modules (80% of the cost of the entire I/O) since they were not required to complete installation. Unlike with a PLC, the I/O modules were not installed until the start of the commissioning phase.

Once the enclosures were mounted and the field wiring completed, we installed the I/O modules and were able to test each of the remote I/O racks by connecting a laptop locally via the configuration port on the front of the processor module. This meant that before the control system or SCADA was even present on site, every I/O point was correctly wired and scaled. We found that the ability to put this aspect of the commissioning to bed before looking at control code was an enormous time saver as any problems found from that point on where guaranteed not to be with the remote I/O or the physical wiring.

Programming commenced and the ability to mix and match IEC61131-3 languages at will was immensely powerful. Whilst Function Block (FB), Structured text (ST) and Sequential flowcharting were appropriate for this application and used extensively, the ability to add ladder logic for some of the interlocking meant that at every point in the software development the easiest language could be used.

To aid in the fast deployment of code, more than one Engineer worked on the code and by using the layering feature of Foxboro A^2, it allowed us to build a base, referencing the I/O, and then as each loop was defined it was implemented in isolation and tested on a PC simulator, which is provided as part of the development package. At the point when all the layers were complete, a project build is done. The build function takes all of the tags and layers and assembles them into a series of coherent files that can be downloaded to the controller. Shortly after the initial download the customer decided to change which controller some of the skids were run from. A quick change in directory location of some of the layer files and two minutes of drag and drop in the Project directory followed by a rebuild and the new control strategy was done.

We found that, by far and away one of the most significant time saving tools used on this project were Generic sequences. The three fermenters were almost identical in operation and so once the sequence for the first fermenter had been developed, installed and passed FAT, it was possible for a technician with little knowledge of the process, to develop the other two sequences.

A generic sequence is produced from a standard sequence and uses the idea of indirect mapping. For example the air inlet steam supply valve for the first Fermenter has a tag name of NV535 and for the other two Fermenters is NV335 and NV435. NV535 is allocated a generic name, in this case air_inlet_stm_sup_Vlv and from there any text editor can be used to map the generic name to a specific tag. This is done for all tags and once complete, a build utility turns each of the generic sequences into specific sequences.

There were six sterilization sequences on the project, all of which were almost identical. The most complex sequence was built first and then taken to site and tested. Once the customer was

happy with the operation, a generic sequence was created and from the generic sequence, the other five sequences were built in about two hours.

Once the controller code was tested, the Wonderware front end needed configuring. We quickly realized that this stage of the project is where an incredible amount of Engineering is saved by the automatic generation of the Tagname.x file. It took us just 40 minutes to get all 30 of the PID loop faceplates on the screen with live data in them. This was possible because there are several Active-X objects, PID being one, that when dropped onto the screen need only a single tag allocated to them in order to bring in the following parameters – SP, PV, OP, high and low absolute and deviation alarms, SP and OP limits, P, I and D tuning constants and loop mode. What made the process even more simple is that the tag required is NOT a Wonderware tag, its actually the controller tag i.e. there was no Wonderware tag database to configure.

Since the requirement to trend a point is an attribute for that point, it can be allocated in Excel and imported into the tag editor. Once the tag editor has the attribute checked and a build is performed, that point will automatically become part of the historical database and become available for trending. Monitoring points can be added or removed dynamically by the user and, if needed, the trend saved for later recall. Reports can be performed by the operator into csv format using any of the logged data.

At this stage, all that was left was to produce the graphics themselves and on this project, like the installation, the customer elected to do this in-house. Use was made of the many thousands of InTouch symbols in the symbol library and of course many more are available from other vendors. This was done over a period of months with no pressure since all the critical plant data was already displayed with the Active-X objects.

A major feature on smaller systems that need to be supported by generally short staffed maintenance departments is the ability on the T800F to diagnose problems and modify software from the front panel without the need for a PC of any sort. Often this means that small issues can be dealt with immediately with telephone assistance without waiting for engineering support on site.

The T800F's touchscreen interface results in significantly reduced operator training. In many cases this training is as short as one hour. The reason this is possible is that the entire application can be made context sensitive, that is, whenever a field device needs to be manipulated, the operator touches on that device (no menus to memorize) and a pop-up screen will appear showing all possible options.

Description of possible applications for Foxboro A^2

The T800F is an ideal controller for industrial boiler systems and small batch reactors. In a boiler application a single controller can perform cross-limited air and fuel control, drum pressure. In a batch reactor the T800F can control speed, temperature, pressure and level plus all of the sequencing requirements. The T800F is a perfect fit for any application that requires a custom touch-screen operator interface with up-to 40 PID loops and 200 I/O. Larger batching applications such as Fermentation and many continuous control functions as used in the Metal, Water, Food and Petrochemical industries are handled by the T800F. The T940F is the high-end controller capable of handling 50 or more PID loops with redundant CPU's and power supplies and communicating to multiple other devices concurrently on up to four separate networks. It is ideal for the power industry, chemical plants, wastewater treatment sites and any large distributed control applications.

Description of Foxboro A^2 system components

The Foxboro A^2 system is made up of a number of hardware components and a single software package. The hardware consists of a three hardware platforms. The T800F, a 21CFR11 ready, 10" touchscreen device capable of running 30 PID loops with a recipe manager, batch manager, graphic recorder, custom HMI screens, security and alarming package; the T940F, a redundant processor capable of running 50 or more PID loops and handling 1000+ I/O; the 2500F, a remote I/O system capable of running its own autotune capable PID loops as well as PLC type code; Operations server, which is Wonderware V8 but with additional Active-X's, much more sophisticated alarm filtering, an automatically generated tagname.x file, built in 21CFR11 tools and a highly flexible security manager.

High speed, intelligent, peer-to-peer communications are standard on the process control platforms. These communications form the backbone of any system and function in such a way that owing to the uniqueness of each tag, there is no communications set up required. Whenever a parameter needs to be accessed remotely, the entire block is mirrored in the remote controller.

Redundant processors can be complemented by redundant I/O and redundant communications, both at the I/O and the system backbone level.

The remote I/O has fuses and test disconnects built into the modules and field wiring is landed directly onto the termination assemblies reducing both installation time and enclosure size. The I/O modules including the processor can be pulled and replaced whilst under power.

OPC servers enable simple integration of third party clients.

Description of Project developer

Project development starts with the Plant model utility which is used to define the look of the project based on the S88 standard i.e. it breaks the application down into Plant areas and units and allows the designer to allocate security and alarm areas independently of the plant areas. This is all done with drag and drop functionality using the tags generated in the tag editor.

The Tag editor is a utility that allows tags to be imported electronically or generated internally. All the properties associated with a tag are allocated here e.g. ranges, descriptions, alarms, whether it is to be trended, security and alarm areas and descriptions.

The I/O allocation editor is where each of the tags gets dragged into an I/O module and assigned a channel. The documentation facility from this editor allows a complete I/O listing to be produced and is often used to generate the functional specification saving valuable time later in the project.

Code generation is done based on a layered approach and this overcomes one area that is often a problem when medium to large applications are developed which is the ability for multiple designers to work on the project simultaneously. Foxboro has introduced this layering concept in which different sections of software can be developed independently of one another. The base layer references all the I/O and then additional layers can be added, each one referencing the base layer as well as other layers when necessary. A project build takes all of the layers and combines them into a single file for download to the instrument.

Screen Navigation is a simple tool that enables the designer to define how the user navigates around the different screens. Four function keys are automatically enabled for moving up, down and side to side which allows the screens to be developed with a hierarchical structure. Each screen then has four other screens allocated from a drop down menu that can be accessed from each of these pre-defined function keys.

Foxboro has developed an integrated security manager that works on a user and group approach and allows different groups to have access rights to differing functions. The time saving approach here is that security for the entire system can be configured on a single PC and then deployed across a multi-node system.

For the Pharmaceutical industry, 21CFR11 is an important regulatory requirement and the Operations Server comes with all the features needed to make the system compliance.

Advantages of Project Developer

The number of supplied Function Blocks is significant and in addition to all the standard logic, timer, PID etc., Foxboro have added blocks such as 2 of 3 voting, cross-limited combustion, duty-standby pump set, 2 and three way valves and many others. These blocks handle the entire functionality of the plant hardware, drastically reducing the Engineering overhead involved with developing the control strategies. In the event that there is a requirement for a block that does not exist, Foxboro allows the user to develop their own function block based on a standard template.

The Operations Server comes with a number of Active-X faceplates, which allow PID loop interaction to be generated in seconds. The Active-X display is associated with just a single tag and this automatically picks up every field associated with the loop. An added advantage here is that this only counts as one block against your license.

Why is it that with most systems the same tag has to be entered twice and in some cases, where remote I/O is used, even three times. Surely an I/O point has the same range wherever it is entered? Foxboro has resolved this problem by requiring the tag to be entered only once (never if an import is done). This on its own is good news but it goes further. If we think of an I/O point as an object then why not enter all of the objects properties at the same time. Taking an analog input as an example, the Foxboro A^2 system allows the developer to assign the range, absolute alarms, deviation alarms and alarm time delays all to a single tag name.

Final documentation, including I/O listing, block layout and field entries are all done within an included utility.

Summary

The Foxboro A^2 system brings some very innovative features to the market and certainly reduces the time to Engineer many types of Process Control projects. The ability to build the project in manageable chunks, a lot of which can be done by junior technicians, the ease with which repetitive sequencing can be generated for multiple pieces of equipment and the reduced Engineering at the SCADA end all combine to make this product very rewarding to work with.

Code can be fully simulated on a laptop prior, even, to building the project. Each project has the same look and feel regardless of who worked on it and the customer does not have to pay for all the hardware at the start of the project. Changes to the FDS can be implemented very quickly at commissioning time with the talk through feature allowing remote I/O to be reconfigured from the control room. Finally, training is achieved in significantly less time than other systems and the DCS style diagnostic capabilities make systems maintenance straightforward.

It all adds up to a more flexible system that can be implemented faster and has lower lifetime running costs.

About the author: Stephen Arnold is an engineer with Neal Systems in Philadelphia, PA and has been working in the automation industry for 15 years as a system programmer and application development engineer. Stephen has developed projects in a varied number of industries such as Food, Water, Pharmaceutical, Boiler, tobacco and more. Stephen has a master's degree and is a member of MIEE.