Repeated S88 Success Yields Cost Reductions at Large Consumer Products Company

Mark P. Givens
Project Engineer
Rockwell Automation
1 Allen-Bradley Dr
Mayfield Heights, Ohio
USA
440.646.4714
440.646.3138
mpgivens@ra.rockwell.com

Andrew McDonald
Control Engineer
Unilever Research
Quarry Road East, Bebington
Wirral, CH63 3JW
UK
+44 151 641 1917
+44 151 641 1844
andrew.mcdonald@unilever.com

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ABSTRACT

A large consumer products company was faced with implementing multiple new product lines to meet product demands. Using S88 models for batch process control across the multiple process and product lines this company was able to achieve a high degree of engineering re-use. Key elements in this success were teaming with the automation provider to achieve requirement definition and applying object-oriented design techniques. The state transition documentation allowed for ease of understanding and repeated application.

The S88 models, applied to the process resulted in improved product quality and consistency, recipe flexibility and increased productivity. Engineering re-use allowed a significant reduction in the time to production for repeated application. Project Design and Implementation time also showed a significant reduction. Additional business benefit has been realized, through the application of S88 principles. This has come from capital cost and project risk reduction through reuse of tried-and-trusted components and improved manufacturing flexibility and faster introduction of new products.
INTRODUCTION

This large, global consumer products company has a challenge to bring together product lines, brands, marketing, engineering and manufacturing from numerous, varied production facilities. Many of these production facilities have been added to the company through merger and acquisition. Consequently, many different engineering and manufacturing styles are represented in the global company.

As part of a wider corporate program on the development of reusable standards in engineering, the company’s corporate engineering group has reviewed the process control requirements for batch processes across all the products which are manufactured. This review has shown that there are significant similarities in the control functions required within these different product categories (Ice cream, culinary, home and personal care etc). By working in close collaboration with its alliance partner control systems vendors it has been possible to exploit these similarities and develop standard modules of process control software which can be reused many times across multiple projects. Cost savings are realized all the way through the lifecycle of the plant. This is delivered through reduced project risk, reduced engineering costs and reduced maintenance costs all because process control projects can be built from tried-and-trusted components of known quality and pedigree which, in turn, have been developed according to an international standard (S88).

This case study focuses on the application of S88 batch process control systems to multiple locations within the global company, each producing a different type of product. To be explored in the case study are the goals of the global consumer products company and how the following key elements were brought together to meet these goals:

- Relationships between central engineering and plant-based engineers
- Relationship with a global automation supplier
- Application of S88 models for batch process control
- Application of object-oriented design techniques
- Re-use of phases and equipment modules, regardless of product type.

The goals of the consumer products company were:

- Reduce production cycle time, via process automation and process design
- Repeatable Manufacturing, via S88 control and recipes
- Product Traceability, via electronic batch record
- Improve Batch Product History, via process variable trending
- Improved product time to market using S88 for rapid deployment of recipes
- Reduce Waste, via process automation
- Reduce cost for automation, using engineering re-use for rapid specification, design and implementation of projects.
RELATIONSHIP APPROACH

As a global company there are many relationships to be managed during the course of any capital project. The various internal company organizations include:

- Capital Authorization/Review
- Product Brand organizations
- Geographic corporate organizations
- Central Technology and Engineering Organizations
- Central Supply Chain Management
- Global Procurement
- Geographic procurement
- MES strategists
- MES implementation
- Plant Management
- Plant-level Engineering
- Plant-level Operations
- Plant-level Quality
- Plant-level Maintenance

Each of these organizations may have influence and/or direct responsibility for a given capital automation and information project. These influences can extend throughout the corporation, having either direct or indirect effect on capital projects elsewhere in company, anywhere in the world.

To manage and gain benefit from these many influences, this global company established a corporate technology group for manufacturing and supply chain management. The function of this group is to create synergies between the operating companies with the goal of cost-reduction, both initial purchase and total cost of ownership, with respect to automation and information technologies. This organization’s involvement is to coach technology specification, selection, design and implementation across many of the operating companies.

Critical in the relationships within this organization is the management of standards, developed by the corporate technology group and the application of these standards at an individual plant level, by plant- or brand-level engineering and manufacturing. The expressed desire for re-use and adherence to standards at the corporate level is likely to generate some amount of requirement conflict with the plant level. The plant may have process configurations that do not match well with the standards. Also, the plant clearly has the goal to get into production as quickly as possible.

To assist in the management of these relationships and the implementation of automation projects, this company has identified a set of global automation suppliers. These suppliers have the responsibility to understand the complete automation requirements, considering the corporate standards, plant specifics and other influences to achieve:

- The technical success of getting a working production and automation system
- The commercial success of completion within budgetary limits
- The schedule success of completion within schedule
- Continuous improvement through reduced costs and, possibly, increased scope on subsequent projects

For this particular case study, one global automation supplier was chosen and performed these roles, over a set of projects, over the course of two years and two different plants.
SCOPE OF PROJECTS

All of the projects have been implemented and are in production. All control system architectures applied PLC controllers. The S88 engine and HMI products were recognizable brand names, also available from the automation supplier, as standard product. Table 1 shows the overall characteristics of the projects, for comparison purposes.

<table>
<thead>
<tr>
<th>Description</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td># Units</td>
<td>22 (4 fixed compounding tank, 18 portable storage tanks)</td>
<td>4 (Fixed compounding tank)</td>
<td>5 (Fixed mix tank)</td>
</tr>
<tr>
<td># Equipment Modules</td>
<td>144</td>
<td>56</td>
<td>27</td>
</tr>
<tr>
<td># Control Modules</td>
<td>428</td>
<td>157</td>
<td>132</td>
</tr>
<tr>
<td># Phase Instances</td>
<td>456</td>
<td>72</td>
<td>66</td>
</tr>
<tr>
<td># Trains</td>
<td>4 flexible unit trains, in a network configuration</td>
<td>4-single unit trains</td>
<td>1, multiple path structure</td>
</tr>
<tr>
<td>Procedure Complexity</td>
<td>Highly flexible, header allocation, moderately complex.</td>
<td>Relatively simple</td>
<td>Relatively simple</td>
</tr>
<tr>
<td>Product Type</td>
<td>Creams and Lotions</td>
<td>Deodorant</td>
<td>Liquid Body Wash, Shampoo</td>
</tr>
<tr>
<td># Controllers</td>
<td>6 PLCs</td>
<td>1 PLC (interface to 3 other PLCs)</td>
<td>1 PLC (interface to 2 other PLCs)</td>
</tr>
<tr>
<td># HMI Display Stations</td>
<td>5</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td># HMI Apps</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td># HMI Tags and/or displays</td>
<td>Approx. 170 displays, approximately 15-20 overviews</td>
<td>Approx. 100 displays, 5-10 overviews</td>
<td>Approx. 100 displays</td>
</tr>
<tr>
<td>Networks</td>
<td>ControlNet, DeviceNet, Ethernet, Proprietary I/O</td>
<td>DeviceNet, Ethernet, Proprietary networks</td>
<td>Ethernet, DeviceNet, Proprietary networks</td>
</tr>
<tr>
<td>#Discrete Inputs</td>
<td>410</td>
<td>275</td>
<td>135</td>
</tr>
<tr>
<td>#Discrete Outputs</td>
<td>180</td>
<td>86</td>
<td>55</td>
</tr>
<tr>
<td>#Analog Inputs (includes pulsed input)</td>
<td>80</td>
<td>80</td>
<td>13</td>
</tr>
<tr>
<td>#Analog Outputs</td>
<td>26</td>
<td>10</td>
<td>55</td>
</tr>
<tr>
<td>Database &amp; Reporting</td>
<td>ODBC compliant (Oracle)</td>
<td>Relational (MSAccess)</td>
<td>Relational (MSAccess)</td>
</tr>
<tr>
<td>Other</td>
<td>45 DeviceNet Drive Interface</td>
<td>16 DeviceNet Drive Interfaces</td>
<td>8 DeviceNet Drive Interfaces to existing units</td>
</tr>
</tbody>
</table>

Table 1: Summary of Projects

APPLICATION OF S88

In project A, automating the process, using S88, initially involved identification of units, equipment modules, control modules and phases. This facility included the following stationary equipment elements:
• Bulk Ingredients
• Staging Area Equipment
• Configurable Compounding Tanks
• Vacuum Utility Equipment
• ASRS Ingredient Dosing
• Liquid Ingredient Dosing

• Wax Melt Area Equipment
• CIP Equipment
• Unloading Area Equipment
• Heat Transfer Circuit
• Solid Ingredient Dosing

In addition, the following mobile equipment elements were present, providing a “pipeless” process environment:

• Mobile Process Tanks
• Mobile Storage Tanks
• Mobile Unload Pumps
• Mobile Homogenizers

From this list of equipment items, the tanks were identified as the primary units. Other equipment elements became recognized as equipment modules and control modules. A batch factory has an inherent structure which can be accounted for in the automation system. So, a typical S88 Batch application is decomposed through mapping the Process model to the Procedural Control Model and the Physical Model. The place where the Procedure Control Model is most commonly mapped to the Physical Model is at the Phase level. At this level a Procedural Phase is generally mapped directly to an Equipment Phase. Equipment Phases then utilize Equipment Modules, which direct Control Modules, to perform a process action.

![Figure 1: Procedural and Equipment Phase Mapping](image)
A Procedural Phase is typically implemented or defined using an S88 Batch Engine. Equipment Phases, Equipment Modules and Control Modules are typically defined or implemented in a controller, as shown in Figure 1, above. Through this mapping process, the following phases, equipment modules and control modules and phases were identified (the items listed in Table 2 below, represent a subset of the actual modules).

<table>
<thead>
<tr>
<th>Phases</th>
<th>Equipment Modules</th>
<th>Control Modules</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Add</td>
<td>• Disperser</td>
<td>• PID Control Loop(s)</td>
</tr>
<tr>
<td>• Feed (Dose)</td>
<td>• Scraper</td>
<td>• 2-state Devices (e.g. Valve, Motor)</td>
</tr>
<tr>
<td>• Agitate</td>
<td>• Flexible Compounder (Mixer)</td>
<td>• Variable Speed Motor</td>
</tr>
<tr>
<td>• Homogenize</td>
<td>• Dosing Equipment</td>
<td>• Flow Indicating Totalizer</td>
</tr>
<tr>
<td>• Transfer In</td>
<td>• Recirculating Equipment</td>
<td>• Weigh Scale</td>
</tr>
<tr>
<td>• Transfer Out</td>
<td>• Heat Transfer Circuit</td>
<td>• Transfer Panels</td>
</tr>
<tr>
<td>• Vacuum</td>
<td>• Vacuum System</td>
<td>• Discrete Temperature Controller</td>
</tr>
<tr>
<td>• Operator Prompt</td>
<td>• CIP Circuits</td>
<td></td>
</tr>
<tr>
<td>• Hand Add</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Null</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Timing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• General</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Recirculate</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Phases, Equipment Modules and Control Modules

As each of these identified elements were intended to be resident in a PLC controller and the corporate goal is to maximize re-use from project to project, the corporation and the automation supplier worked together to encapsulate and instantiate these using object oriented analysis and design techniques.

By applying the principles of object oriented design, each of these elements became an object class with its own design. This dynamic design of each class of object was represented using State Transition notation. A simplified class diagram represented the static design for each class of object where attributes and operations were noted.

The primary advantage of object oriented design techniques in this scenario is that they encourage definition of logic, internal data elements and data elements that are to be shared with other objects. These shared data elements typically consist of alarms, faults, events, production data, phase parameters and setpoints.

So, the effective identification of objects and the application of object-oriented design techniques allowed for a high degree of modularity. In addition, these design techniques facilitated ease of understanding with respect to the control system. Subsequent design of projects became simpler and more readily understood by the corporation and the automation supplier.

While these object definitions were implemented in the controllers as defined sets of logic and data, phases and units were also represented in the batch engine. This definition, called an area model and phase configuration, facilitated the implementation of flexible procedures on the part of the customer.
PROGRAMMED APPROACH

The initial project dealt with a lotion product and a “pipe-less” approach to the process. The second and third projects involved a different style of product and a different process design. So, to meet the business goal of cost reduction, it was necessary to identify and develop the objects (phases, equipment modules, etc.), in a consistent manner using the S88 physical and procedural models. Once identified, the objects were developed using object-oriented techniques, including state transition diagrams and state processing logic.

The overall program involved a three-way partnership between the plant personnel, the corporate personnel and the automation supplier. This relationship allowed corporate goals to be stated and followed while still meeting the present production needs of the plant.

The corporate goals for engineering re-use and cost reductions through standardization, along with the specific plant requirements were both addressed through the application of modular objects.

While multiple projects were initially identified and the corporate goals for re-use and cost reduction well known, project A was completed before project B was started. Then, near the beginning of project B, the geographic corporate organization and automation supplier personnel worked to identify elements for re-use. Also at this time, three levels of re-use were identified i.e. total re-use, partial re-use and little or no re-use. Table 3 summarizes the elements in each category:

<table>
<thead>
<tr>
<th>Total Re-use</th>
<th>Partial Re-use</th>
<th>Limited or No Re-use</th>
</tr>
</thead>
<tbody>
<tr>
<td>• CM: 2-State Device</td>
<td>• CM: PID Loop</td>
<td>• Process Graphic displays</td>
</tr>
<tr>
<td>• CM: Variable Speed Motor</td>
<td>• CM: Heat Transfer Circuit</td>
<td>• Area Model</td>
</tr>
<tr>
<td>• CM: Flow Indicating Totalizer</td>
<td>• CM: Vacuum</td>
<td>• Interlocking</td>
</tr>
<tr>
<td>• EM: Configurable Compounder</td>
<td>• System Interlocking</td>
<td>• Safety Stop, E-stop</td>
</tr>
<tr>
<td>• EM: Scraper</td>
<td>• EP: GENERAL</td>
<td>• Communication Interfaces</td>
</tr>
<tr>
<td>• EM: Disperser</td>
<td>• EP: INIT</td>
<td></td>
</tr>
<tr>
<td>• Phase: Hand Add</td>
<td>• EP: ADD</td>
<td></td>
</tr>
<tr>
<td>• Phase: Null</td>
<td>• EP: FEED</td>
<td></td>
</tr>
<tr>
<td>• Phase: Timing</td>
<td>• EP: RECIRCULATE</td>
<td></td>
</tr>
<tr>
<td>• Phase: Operator Prompt</td>
<td>• EP: TEMPERATURE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• EP: VACUUM</td>
<td>LEGEND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CM: Control Module</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EM: Equipment Module</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP: Equipment Phase</td>
</tr>
</tbody>
</table>

Table 3: Summary of Reused Objects

By retaining the same solutions provider, keeping the consistent design and implementation methodology and pursuing the goal of re-use, the corporation was able to apply this same process between projects B and C. Again,

1. Project B was completed,
2. Project C requirements were defined
3. Project A and B elements were evaluated for re-use in project C.
It is clear through these projects that the elements that vary from plant to plant – the actual physical equipment, the process train and HMI implementations do not have as much opportunity for re-use as procedural phases, equipment phase logic and device-level control.

This programmed approach continues in the present as this corporation and automation supplier approach the next set of projects. As these next projects begin, evaluations for re-use will remain a constant approach. The expectation at this point is for projects of similar size (e.g. 4-10 units) to remain relatively constant in cost, while scope is incrementally increased – mostly in collection of information and interface with other systems.

**BENEFITS AND RESULTS**

With respect to achieving the stated goals, these benefits reflect some quantitative and qualitative assessments of this programmed approach.

Specifically regarding re-use of modules, the re-use of objects related to equipment can be significantly less than procedural or control elements, as shown in Table 4.

<table>
<thead>
<tr>
<th>Element</th>
<th>% of Re-use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedural Phase</td>
<td>70-100%</td>
</tr>
<tr>
<td>Equipment Phase</td>
<td>70-100%</td>
</tr>
<tr>
<td>Equipment Module</td>
<td>20-100%</td>
</tr>
<tr>
<td>Control Module</td>
<td>90-100%</td>
</tr>
</tbody>
</table>

Table 4: Benefits Summary

The exceptions to findings shown in the above table can result from standardized equipment. For example, the “configurable compounder” was a primary unit in each of these projects. Application of this standardized unit significantly improved the amount of re-use. Credit is given to the corporate and geographic engineering organizations for development and propagation of this equipment. To measure the Cost Reductions due to re-use, the cost of the systems were normalized upon the re-used modules. The charts in Figure 2 show the normalized cost of re-used objects from project to project.

![Figure 2: Normalized Cost Comparisons](image-url)
In addition to the direct “per module” cost savings, there were additional areas that saved overall cost on the project. These additional savings included

- A 30-40% Reduction in time to complete automation from project A to Project B, resulting from re-use.
- A Reduced startup and commissioning time, by applying automation provider personnel to the effort for projects B and C
- Project C was executed to support a new product launch, which had to be achieved within very tight timescales. This could only have been achieved by using the same automation solution provider, their experienced project team and reuse of components of the engineering solutions from projects A and B
- Reduced “time to production”
- Reduced cost for repeated implementation.

To the credit of the entire S88 methodology, the corporation has also received significant additional benefits. These benefits are measured qualitatively:

- Increased flexibility in processing due to recipe application
- Ability to bring new products into production faster through the use of this process and automation
- Improved production capability and cycle time

The largest contributor to the qualitative benefits is improved capability and cycle time. This is a benefit, which has not been exhaustively assessed. However, such an assessment might support the assertion that the potential value creation could be millions of dollars. Being able to make a wider portfolio of products using existing manufacturing assets and the ability to more rapidly introduce new products to market creates significant business value.

Project A was originally intended to be the first of a number of projects for a new product launch. Subsequent projects were intended to add processing equipment and control as well as increased packaging line capacity. Based on the flexibility of the control contained in project A, the corporation has not found it necessary to invest in additional processing equipment – project A is able to fulfill demand for the product. The throughput of the processing area is greater than originally expected.

This has been achieved through the modularity and flexibility of the process equipment and automation. The way this flexibility is evidenced in the life of the production personnel is that due to a well designed, S88 aware system, extremely flexible recipes can be written, units become free and can be immediately applied to the production of the next batch. This allows high productivity, reduced cycle times and reduced requirements for additional investment in production facilities (higher return on net assets). It should be noted that additional packaging lines are planned, as the existing lines cannot keep up with the throughput of the process area.

The obtained business benefit, which has been realized through the application of S88 principles, has come from:

- Capital cost and project risk reduction through reuse of tried-and-trusted components
- Improved manufacturing flexibility and faster introduction of new products
CONCLUSIONS

• The consumer products corporation has recognized similarities in the control requirements for the manufacture of its wide portfolio of products. Exploiting these similarities, applying S88 models and concepts and working closely with its global automation solutions partners, it has developed engineering standards which can be reused many times across multiple projects.

• This approach has provided the opportunity to reduce capital project costs and risks and also deliver significant business benefit through improvements in manufacturing flexibility and faster introduction of new products to market.

• Benefits have been quantified across three projects executed in North America. Making cost reduction comparisons between Project A and Project C:
  • Equipment Phase from $2000/module to $660/module (Cost reduction 67%)
  • Control Module from $1780/module to $280/module (Cost reduction 84%)

• Project C could not have been successfully executed within the tight program timescales imposed upon it without using the same automation supplier for Projects A and B, in addition to its experienced project team and reuse of components of the engineering solution from the previous projects. The business benefit of this has not been quantified, but it allowed a new product to be brought to market on time. It can be concluded that the value of this is significant.

References: