Keeping the Plant On-Line during an Automation Hot Cutover

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SYNOPSIS

As existing plant lifetimes continue to be increased within the process industries, it is not uncommon for a process plant to require major control system refits in order to maintain its operating efficiency and to help increase the asset performance. This may result in having one or two control and monitoring system refits during the life of the plant. Deciding on the best course of action to achieve this refit, requires decisions on the actual choice of equipment and more importantly, how and when, to make the change.

In the past, a plant shutdown would have been seen as the best solution to achieve the required automation refit, but this activity in itself may delay the change and may not provide the best route to ensuring the plant meets all its operational and process safety targets. A plant shutdown is always a time limited activity, usually driven by regulatory mechanical inspections, and the new control system will always be the on the critical path for successful re-start where this in itself can lead to increased risk regarding fundamental change to plant equipment, operator workstations and human factors. Also the loss of revenue caused by extending the shutdown period and possible spurious trips at restart, usually dwarfs the actual cost of the replacement control system itself.

This paper will outline an alternative method to the shutdown transfer option for keeping the plant on line during the necessary automation cut over. The use of the method described and an attention to detail at the appropriate points in a project such as this allows a ‘right first time’ implementation with no rework and minimal business and safety risk. Clearly this will present a series of challenges, but careful planning and the use of the proven methodology can make this solution a desirable business option.

Introduction

This presentation will outline an alternative method for keeping the plant on line during the necessary automation cut over. The use of the method described and an attention to detail at the appropriate points in the project allows a ‘right first time’ implementation with no rework and minimal risk. Clearly this will present a series of challenges, but careful planning and the use of the proven methodology can make this solution a desirable business option.

At the outset of implementing this methodology, a set of technical procedures are required to be followed to enable this work to be carried out safely and efficiently. This starts with careful assessment of the type and complexity of each control loop. Filtering the loops into type and complexity allows the project to concentrate on the key systems and their detailed procedures needed for the cut over.

An objective analysis of these procedures is carried out by running a Failure Mode Effect Analysis session with key stakeholders and once agreed; a detailed automation cut over plan is developed which completes the foundations for a safe control transfer without losing unnecessary production whilst maintaining operational process safety requirements.

ABB engineering solutions has developed a road map and proven methodology to safely and successfully cutover a control system whilst the plant remains on-line and with minimum disturbance.

ABB (www.abb.com) is a leader in power and automation technologies that enable utility and industry customers to improve performance while lowering environmental impact. The ABB Group of companies operates in around 100 countries and employs about 120,000 people.

ABB Engineering Services as part of ABB Global Consulting provides technical services to improve performance in the areas of compliance, operations and engineering to customers in the chemical, petrochemical, oil & gas, power, life sciences, metals and consumer industries worldwide.

Past, Present and the Future

The holy grail of all forms of systems is to be able to mix and match and have simplicity when connecting and adding extra equipment (plug & play). We are at a point in the development of automation technology when some of these wishes are becoming a reality but it is still a long way from the full inter-changeability that users want. Obviously commercial interests of automation vendors play a part in this but it is better to be competing on operational and technical benefits rather than a restrictive band that holds operators to a particular automation vendor because change is far too much trouble.

The automation industry has moved a long way from the early control systems and perhaps we are at key point in time when inter changeability will be a key selling point. However in the mean time users are faced with a dilemma of their need to move to a modern automation system under the constraints of minimising both downtime and the associated costs of the migration.

Process control systems have significantly evolved since the Watt governor that controlled the early steam engines; from the first panel based control, through to the early bespoke Distributed Control Systems (DCS) and then finally to the commercial off the shelf platforms that exist today.

Established manufacturing capaility faces the challenge of managing ageing plant and therefore asset extension in order to compete. As long as the operating plant and equipment continues to be structurally and mechanically sound, then the associated control system will at some time require to be upgraded.

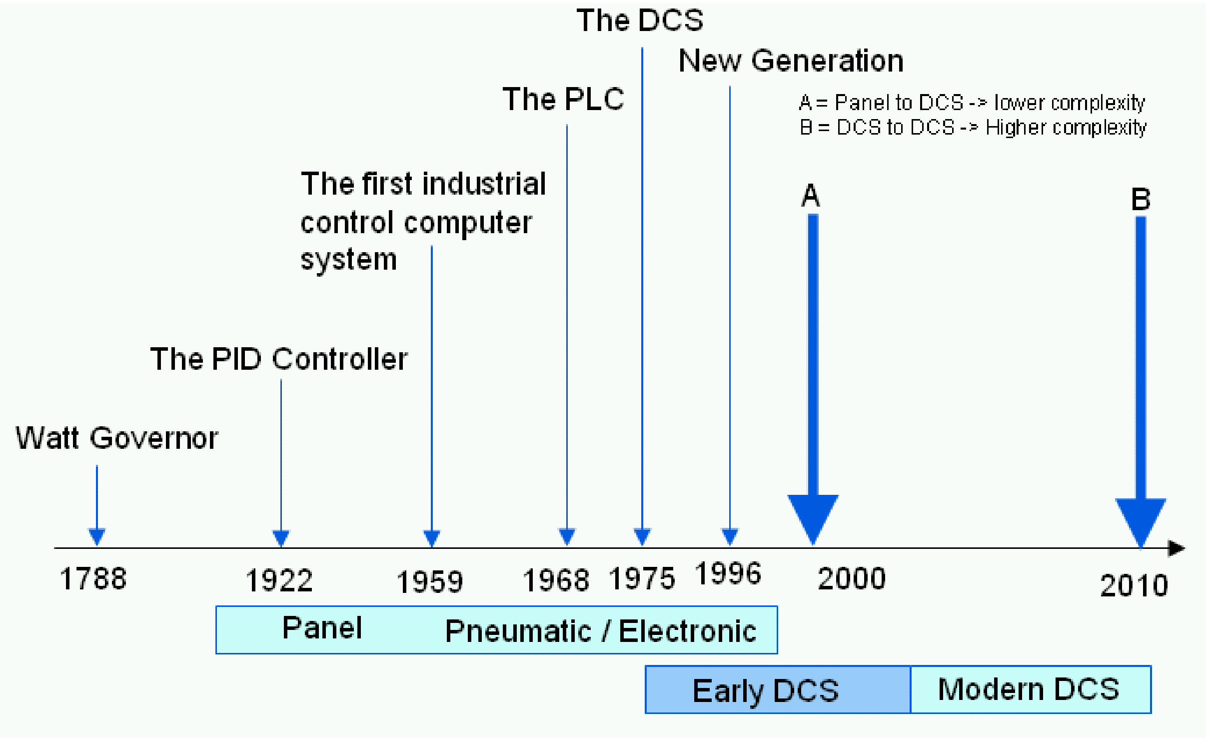

Fig 1 – Automation system time-line

Most process units are now highly dependent on automated control systems. Operators rely on the process control systems and its operator interface for process information during normal operation, for alarms during process excursions, and for troubleshooting process control problems. The process control system is now so specialised that typically only a few site personnel are truly knowledgeable in the automation control system design details and are responsible for implementing solutions to optimize the control system in order to garner improvements in quality, production, and cost.

Early migration of process control systems was from panel based control to that of the early DCS systems. Documentation, a key aspect for successful migration, tended to be comprehensive and understanding the legacy system could easily be confirmed by investigating the individual controllers and associated back of panel wiring.

Migrating the early control philosophy to new automation platforms can add extra complications. Adequate documentation is still a key aspect and confirming actual control schemes embedded in the old DCS systems relies on being able to accurately download the schemes and ensure any conversion truly reflects what is going on in the DCS. Maintaining accurate documentation assists this exercise but as history shows, this is generally not the case.

Why Change

According to the ARC Advisory Group, Inc., approximately $65 billion of legacy process control systems have reached the end of their reasonable life cycle. The process industries have undergone massive consolidation of both end users and suppliers, and have seen significant changes in the lifespan for Distributed Control Systems (DCS) components spurred by rapidly changing technology. While the expected life span for input/output (I/O) and wiring is 25 years or more, the life span of Human Machine Interfaces (HMIs) and workstations is now in the region of 5 years. Thus, migration to newer technology presents many challenges to the user and to the supplier.

The major driver from the user's perspective to replace their automation system is usually driven by obsolescence. However there may also be other drivers, and so the key issues are typically:-

- Obsolescence

  This is usually the main driver for most users. Even though the user may have kept up to date with hardware and software upgrades, eventually the system will no longer be supported by the automation vendor and the system will be withdrawn from support. Once this happens and depending on the actual age of the equipment the user then find themselves himself continually fighting to keep the system alive

- Maintenance / Reliability issues

  Usually as a consequence of obsolescence, the user finds that parts of the system requires a high amount off attention to keep them going. An example of this is proprietary workstations, which the plant cannot afford to lose, and therefore, users spend a lot of time maintaining them just to keep them going until the next failure

- Productivity / Quality

  As can be seen in Fig 2, the automation system may have been 'tuned' for process control in a conservative manner to ensure that the plant is not pushed up against equipment constraints. This conservative approach usually impacts on productivity, efficiency and quality which are usually sacrificed at the expense of really understanding the safe limits of your manufacturing base. When a modern DCS system is installed, the resolution of the data that can be gathered is much improved and therefore the tuning of the plant can be tightened to allow the process to operate closer to the plant constraints, and hence increasing parameters such as productivity, efficiency and quality whilst maintaining the correct operating safety envelope.

- Functionality

  There may be a requirement to use fieldbus devices for a plant expansion or possibly the use of Multi-Variable Control (MVC) for a part of the plant. As such these technologies may not be available in the current platform. It can be shown that the use of advanced control techniques can yield an extra 2-3% profit from the existing asset.

- System capacity limits

  The expansion capacity of the current system may have been reached, and if a plant expansion/extension is required then this will not be feasible using the current technology deployed, and therefore it will need to be upgraded/replaced before the new plant can be built.

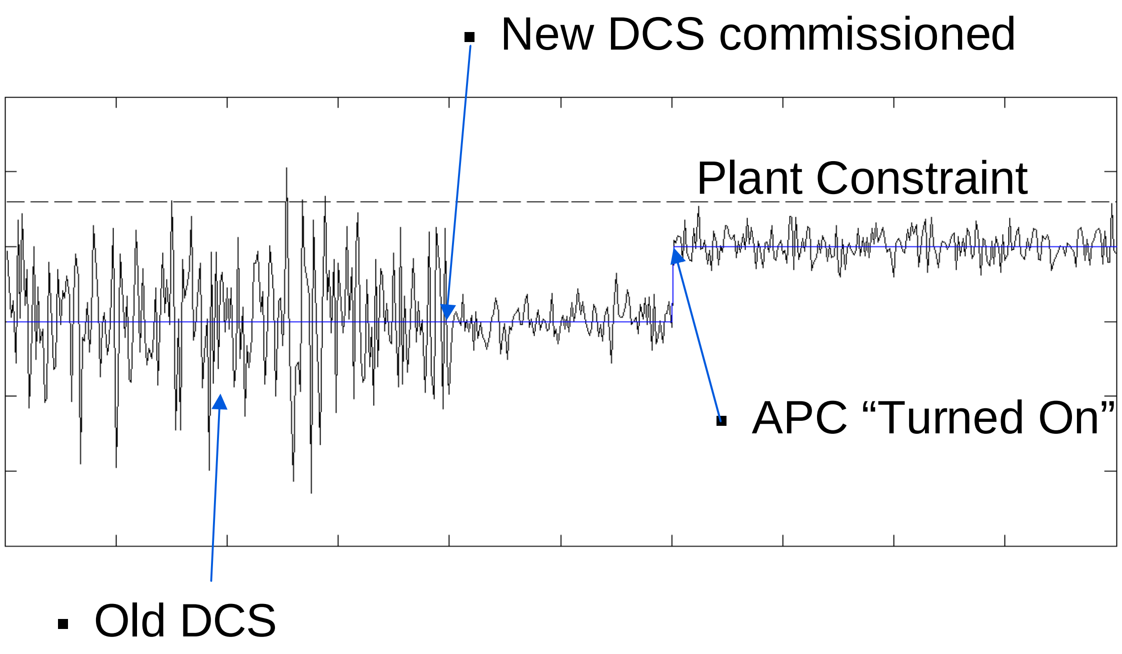

Fig 2– Benefits of a modern Automation system

What are the options for change?

ABB have developed a road map (Fig. 3) to help the user answer this question, and to guide the user along the chosen path.

If for various reasons (i.e. a shutdown window is not available, or it's too far in the future, etc) a cutover during a shutdown window is not possible then the question "How" would be answered, as the "When" would need to be on-line using hot cutover techniques. Similarly if the process was deemed too complex (i.e. unstable process conditions, batch operation) to cutover on-line then the question, "When" would be answered, and the "How" would mean a cutover would need to take place during a shutdown window.

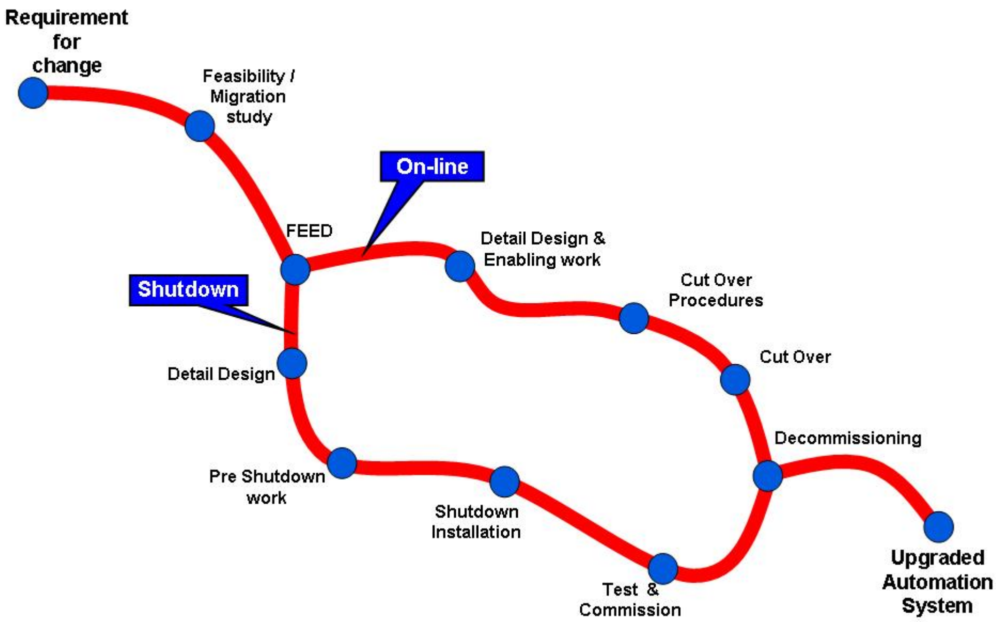

Fig 3. Automation Upgrade Road map

Shutdown Window Approach

Many users will think the only option available to replace their current automation system is that of using a shutdown window, or the "Big Bang" approach. This is where the old system is 'ripped-out' and the new system installed, connected and tested, all within a shutdown window. Clearly there are both advantages and disadvantages to this approach.

Using a shutdown window approach is seen by many as a potential reduction in time for the upgrade. It is also perceived as the 'Easy Option', with it being sold to the business as a reduced risk and cost solution. And for this reason the plant will usually 'Buy-in" to this option if offered.

However this approach comes with some major disadvantages. The first is that the plant will be shutdown using the old automation system, and then started up using the new automation system. Starting up of plants are seen as abnormal situations and inherently more dangerous than when the plant is running stable. To therefore add to this intense and often stressful situation by giving the plant operators the extra burden of using a new automation system that they are unfamiliar with presents further problems. Within the old automation system, there will be sequences that are possibly only run on start up. These sequences must be interpreted and implemented correctly so that they work fully when required, otherwise this will put further pressure on the cutover team when trying to start the plant up.

Shutdowns and turnarounds are primarily used for maintenance, overhaul and statutory inspections and are heavily focused on mechanical activities with a planned critical overhaul path utilising all available pant staff and contractors, and so the importance of the intended automation changeover can be neglected by the plant operations, maintenance and management teams due to the numerous distractions that occur in a busy period such as this. Ultimately our experience reveals that this leads to the changeover becoming the critical path for the shutdown halfway through the event and so increases the pressure on the cutover project delivery team.

When the automation system is cutover, if a major technical issue is discovered that prohibits the plant from starting up, then owing to the 'Big-Bang' approach that has been adopted there is no fallback position available. This ultimately puts unwarranted pressure on both the change over and plant operation teams and it is in these instances that short-cuts can be made leading to plant incidents and accidents in order to get the plant started up.

When the plant is eventually re-started, all of the automation system along with the associated instrumentation will be on-line. Therefore, if a an error has been made in the configuration of a level loop, this might not reveal itself immediately when starting up, as the focus is on the start up of the plant to meet expected operational norms and not in the detail of a particular loop. If this error is detected in time (so that it doesn't result in a major plant problem) then the configuration error may need to be corrected in the other 100 level loops whilst the plant is trying to start up, again adding further pressure to all involved in the process.

Finally, shutdowns are typically used to add and commission new parts of plant and equipment. Therefore not only has the new automation system to be engineered to replace the old system, but it also has to be engineered for the new installed projects at the same time. This in itself adds additional risk in correct configuration and control being in place and effective on re-start.

Hot Cut Over Approach – The ABB Approach

The Hot Cutover approach offers many advantages to that of the 'Big Bang' approach. The most important to highlight is that the plant is not being started up on a different automation system to that which was used to shut it down.

The business can also benefit from the new automation system and the extra functionality that it brings with it, by cutting over the system on-line ahead of any possible shutdown window.
By cutting over the system on-line it greatly reduces the overall risk of upgrading the automation system, as when you are cutting over from the old to the new system, you are concentrating on a loop-by-loop basis and as a result of the cutover procedures the cutover team will have fallback positions available to them if anything should go wrong.

As a result of cutting over the automation system whilst the plant is on-line, there is limited, or no impact on the plants production or safety envelope. Therefore revenue is not lost owing to a control system failure that may occur during a shutdown window.

The cutover will be planned by cutting over plant units in a specific order. This lends itself to a phased implementation over a period of time in line with business requirements if so required.

To decide which path is the optimum for the user, the road map shown in figure 3 is followed and the first crucial step to action is the **migration and feasibility study.**

The remit of this activity is to clearly understand the scope of the existing automation system and then investigate what viable options are available to migrate to a new automation system. From understanding the options available an implementation plan is proposed along with a project budget and plan. Any risks that may be encountered are also identified. To achieve this, a survey is conducted of the existing automation system. Detailed information is gathered relating to the existing automation system. A picture is built up of the architecture of the automation system, including the various hardware and software versions of the equipment, and also it's interaction with other propriety systems, such as historians and safety related systems, etc.

An outline URS is then produced and an enquiry package is issued for the new automation system to automation vendors. The URS itself documents the functions that are required from the new system.

The replies from the enquiry package are then reviewed with regards to the technical and commercial offering. Once it is clear what options are available from the vendors, a migration implementation strategy is produced. This is reviewed with regard to the technical implications of migrating from the old to the new automation system.

Once the migration implementation strategy is finalised an overall project budget estimate and plan is produced. This is based on ABB's project experience/norms and also any relevant information from the client.

The next stage is a Front End Engineering Definition **(FEED)**. This is an important stage in the journey to upgrade the automation system as it is used to validate the earlier work. Our experience suggests that the final solution from the migration study may well have been a culmination of various parts of a number of possible options. The FEED allows the assumptions made and the options chosen to be "rubber stamped" and approved by all stakeholders.

The FEED stage will identify/review:

- Documentation quality
- Critical loops identification - criteria
- Any enabling work if required
- Cutover points are confirmed
- "How it will be done" with regards the location of the new DCS equipment
- System rationalisation addressed - graphics, redundant areas
- Safety - voltages, process
- Any technical issues resolved with the chosen automation vendor
- Project estimate refined to a value required for full project sanction

Hot Cut Over

This paper will now describe a process that can be followed to ensure a successful migration of the old automation system to a new one with the plant continuing to be on-line during this process.

The key to delivering a successful automation cut over lays very firmly with a robust and detailed plan that allows all parties to consider the key implications.

The first phase of this is to ensure the documentation, drawings and knowledge of the current plant automation system is up to date and validated.

If during the migration study it becomes clear that plant records do not accurately reflect the installed base, a detailed survey is carried out to document the installed system and provide the following deliverables:

- Documentation of the current I/O, associated termination details and automation system architecture
- Investigation and documentation of possible hot cutover points
- Identification of pre-work to enable a hot cutover

Critical Loop Review

As the automation system will be migrated using a Hot Cutover methodology, it is vital that all the control loops are assessed to rank their criticality in the overall plant control scheme. As a result, the high ranking critical loops are then reviewed to understand what could be modified during a minor shutdown/plant outage (enabling work) to enable them to be cut over on line.

Work covered at this stage includes:

- Working with the user to determine the most critical control loops
- Surveying the most critical loops and I/O
- Gathering supporting documentation for the loops and I/O

- Discuss and review with plant personnel possible options for the enabling work.
- Production of detailed work packs to allow the enabling work for the critical I/O to be implemented

Enabling Works

As a result of the critical I/O review process, the requirement for any enabling work packs will be identified. These are produced for loops which are deemed to be critical for the operation of the plant, and as such, need to be modified to allow them to be cutover in a minimum amount of time with no interruption to the actual operation of the loop. An example of this is a control loop that the plant cannot afford to lose operation of at all. In this instance, an enabling work pack will be produced that may add a 3 way valve to the instrument air to the valve in the field. Then when it is time to cutover this loop, a local air set will be connected to the 3 way valve and the valve switched to allow a local operator to control the valve on instructions from the control room. Once the loop has then been cutover and commissioned to the new automation system, the 3 way valve will be switched back, the air set removed and the loop connected to the new automation system.

The contents of any enabling work packs normally consist of:

- Installation scope of work
- Hook-ups (before & after)
- Loop diagrams (before & after)

Measurement Function and Control Complexity

When a user finds themselves migrating from an early automation system, a potential problem area may be the documenting of the actual system configuration and control strategies. Unfortunately depending on the ownership of the system and the ability to record this information this may prove a very large and complex exercise as everything will need to be reverse-engineered to allow them to be implemented in the new automation system. Application code and control strategies rarely port over directly. However this can also be seen as an opportunity to “clean-out” any legacy code and to revisit the control strategies and understand their objective and see if their performance can be improved with the new technology and tools available from the new automation system.

Detailed attention needs to be given to this stage as what is finally produced as this will be used to define the control strategies in the new automation system. It has been found in older automation systems, that there is a large amount of application code that is not directly part of the control strategies, but is required as part of the “eccentricities” of the old automation system. An example of this is the addition of code to allow peer-to-peer communication to happen between system controllers of some old automation systems. Depending on the age of the automation system, the documenting of the configuration may prove to be a very slow and difficult task. With older systems it is not always possible to visualise the control strategies, and therefore it may require plant operating personnel to help read and interpret the control strategy.

Production of Generic Cutover Procedures

A set of procedures are required to enable an automation Hot Cutover to be carried out safely and this starts with careful assessment of the type and complexity of each control loop. Filtering the loops into type and complexity allows the project to concentrate on the key systems and their detailed procedures needed for the cut over. Procedures are then produced for the various loop types

This is supplemented by Failure Mode Effect Analysis (FMEA) reviews of the generic cut over procedures so that an objective risk assessment is carried out. An FMEA is a systematic procedure looking into what can go wrong, what causes it and what are the potential effects. Recommended actions are then made to reduce the likelihood of the problem occurring, and mitigate the risk, if in fact, it does occur. ABB ES use their own in-house methodology to efficiently produce these procedures.

The FMEA is used as a tool to:

- Ensure that each step in the procedure was the correct step to be made and in the correct order
- Ensure that there is a fallback position available for every step

- To guarantee that if all the steps are followed in the correct order then the result would be a successful cutover of the loop
- Highlight any design or construction/commissioning problems that may occur
- Highlight any tools or specialist equipment that may be required during the cutover

It is important that key plant personnel who will be involved with the hot cutover are actively involved in this process. They are needed to discuss any issues with the cutover procedures so that the operation staff has full “buy-in” to how the work will be carried out.

Bespoke Cut Over Procedures

Bespoke cutover procedures are produced to allow the transfer of larger complex control schemes onto the new automation system. The bespoke procedures methodically break the control schemes into smaller simpler control loops for which standard cutover procedures can then be used. The bespoke procedures can only be developed and finalised with plant input. Once the complex control schemes have been broken down into the simpler elements, the procedure is produced for all the loops to be cutover and then re-commissioned in a particular order.

Once these bespoke procedures have been developed, as for the Generic Procedures, a FMEA review is applied to ensure the procedure does not compromise safe plant operation.

Efficient working for each measurement function

On a typical migration project there could be more than 1000 cutover procedures required. To allow these to be produced efficiently as possible, a mail merge technique is used. During the life of the project, data is gathered regarding the actual loop i.e. tag name, title, type, range etc, and is saved into a database. Once this data is complete and the generic procedures have been reviewed and approved, a mail merge technique is used to populate the generic templates with actual data to produce the final cutover procedures.

Work Pack Production

A hot cutover requires the production of two types of Work Pack procedures:

- Pre-Cutover procedures
- Hot Cutover procedures

Pre-Cutover Procedure

The pre-cutover procedure is applied when the new automation system has been installed, commissioned and SAT tested. These procedures are a key stage gate with a series of risk assessments to confirm the following:

- The new system functionality will mimic the old system
- The physical point of cut over
- New automation system is operational prior to cutover
- Graphic and alarm details are correct
- Loop configuration details are correct
- Existing plant equipment associated with the cut over is in full working order. For example: Do manual bypass valves or manual hand jacks work

Hot Cutover Procedure

As mentioned previously, these procedures are crucial to the success of the hot cutover. However, they also need to be supplemented with further information so that at the time of the cutover, the cutover team has all the required information at hand. Therefore the work packs contain the following information needed to physically complete the cutover:

- Completed pre-cut over procedure check sheets for each loop to be cut over
- Procedure to safely complete the cut over of the loop
- Existing and new loop diagrams
- Termination schedule

Detailed Plan / Cutover Schedule

The hot cutover plan monitors progress of the cutover and indicates to plant personnel up to date information about which loops have been cutover. The cutover plan would list the various documents that would be needed on a daily basis to facilitate the smooth running of the hot cutover workflow. This helps with the daily handover of loops to and from operations and helps record any faults that are found during the cutover with regards the loops. The cutover plan would be organised into plant areas and then prioritised by loops. As it is updated on a daily basis, the plant would be able to track progress of the hot cutover and keep all staff and management informed.

An assessment on Human Factor and control room ergonomics is reviewed at this stage to ensure any improvements made do not affect the ability of the operations team to follow standard operating and safety procedures and the ability to effectively communicate plant operational data to colleagues and management alike.

Carrying out the Hot Cutover

A Commissioning Manager manages the Hot Cutover team. This role manages a team that comprises of the following personnel, to ensure a safe and successful cutover:

- DCS / System Engineer/Instrumentation Engineer
- Process Operator / FLM
- Technicians / Electrician
- Project Designer

A series of documents are used to aid and record the workflow during the cutover process. Before a loop is cutover to the new system, the pre-cutover procedure must be complete and signed off. When the plant is ready for the loop to be cutover, it is signed over to the cutover team. The loop is then cutover and tested, and signed back to operations, with any necessary remedial actions highlighted and documented.

Other activities that need to happen on a daily basis prior to work starting:

- Plant is operating normally
- Resources are all in place
- Confirm all documentation is in place
- Relevant operator training has been completed
- Control/Safety system platform is fully operational
- Check feedback from overnight shifts
- Impact of any other work in area
- Permit to work situation
- Toolbox talks
- Reservations / punch listing
- Human Factor checklists are completed and available for review
- Update end of day report

These activities are managed/performed by the cutover over team in the control room and relayed to key stakeholders.

At the end of the cutover day, it is essential to have a de-brief for the team so as to capture any learning activities, and to prepare for the next day's planned cutover activities.

Conclusion

As plant lifetimes are pushed out it is not uncommon for a plant or process to have one or two major control and monitoring system upgrades during its life. This is needed to ensure that the plant can benefit from improved functionality and reliability. This paper has presented a process and road map to allow an automation system to be migrated to a modern automation system using hot cutover procedures whilst the plant is on-line, with no disturbance to the plant.

The natural tendency for people presented with a challenge of upgrading/migrating their old automation system to a modern system is to default to a shutdown window to achieve the migration. The reasoning behind this is that it is seen as the "easiest, safest and lowest risk" option.

However it has been shown that this is not always the case and that by applying a defined and agreed methodology in the majority of cases, the control system can be migrated to the new system whilst the plant remains on-line.

This methodology aims to deliver new automation systems and all their associated benefits with:

- No additional plant outage.
- No lost production.
- No increase in business risk.
- Safety built into every step of the process.

This methodology and road map has been applied successfully to many projects ranging from 200 I/O to 8000 I/O systems.