Photograph courtesy De Beers Finsch Mine

Abbreviations

I/O	- Input/Output
FAT	- Factory Acceptance Testing
FMEA	- Failure Mode and Effect Analysis
MCC	- Motor Control Centre
PLC	- Programmable Logic Controller
SCADA	- Supervisory Control and Data Acquisition

Avoiding the heat in swapping over PLC systems during plant upgrades

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Pretty much all of industry relies on PLCs for effective and reliable control. But many legacy systems are old, and newer PLCs have more punch and indeed offer better cost of ownership. It sounds simple to replace old PLCs, and it may be so. But consider that you are running a critical process and simply don't have the time to waste while 'experts' play with possible solutions. This article makes the case for seamless upgrading of PLC systems, and hence the complete control system, and is based around experience gained with the Siemens Simatic S5 to S7 upgrades taking place on many plants.

The company SAM recently completed four successful Siemens S5 to S7 upgrades. All the plants required complete PLC swap outs from S5 to S7 as well as the upgrading of the SCADA and network systems. Previously, standalone PLCs were integrated into the new system. The significant thing about these upgrades is that they were completed while the plants were running and changeover took place during regular maintenance shutdown periods.

Of the four systems, three were complete I/O to I/O swaps from S5 to S7 with the integration of standalone systems, while the one at the De Beers Finsch mine was a complete re-engineering of the system with distributed I/Os in the field, undertaken with Siemens.

The concept of seamless integration

The key to any project where PLC upgrading is required is to recognise that the new PLCs must be correctly programmed and integrated to ensure that the same (or better, when necessary) control and management is ensured, this requires significant engineering input. The method employed is to complete the PLC and SCADA programming and in-office testing, then wire up the new system in parallel with the old.

The wiring up takes place during normal plant maintenance days, and therefore has no impact on production. During normal maintenance periods (typically 8 to 12 hours), the old system is taken offline and the new system plugged in, and then tested. Once it has been established that the plant is running correctly on the new system, it can be left in place, online, and production can continue directly after the maintenance shutdown.

This approach is completely seamless, and has a number of key considerations:

- The change management processes are critical to the success of the project, they ensure that the correct software version is loaded onto the PLCs and SCADA systems [1].
- Versionworks provides the following advantages:
  - archiving of program and data files on a server with secure user, access and copy management
  - version control and archiving
  - change history and audit trail
  - scheduled automated backup of PLC controllers and device programs including change detection
  - automatic change notification via e-mail
  - efficient and speedy 'disaster recovery'
  - documented change process inline with ISO 900x and FDA 21 CFR 11
- The integration must be seamless, which means that the engineers and technicians working on the project must have an absolute understanding of the process and of the control strategy.
- The various states of the process must be understood, and hence so must each possible state of the software in the PLCs. This again implies an absolute understanding of the task by the engineering team.
- The system, once swapped out, must work correctly, first time.

The secrets to successfully completing these projects are:

- full FMEA
- full client participation in all stages of the project
- updating of PLC and SCADA software to new client standards
- intensive FAT of both the hardware and software with the client
- onsite preparation prior to access to the plant
- running the old and new systems in parallel until such time that all issues have been resolved
- step by step change over of selective plant sections during the maintenance periods
- detailed preparation of a 'fall back strategy' for worst case scenarios
- operator and technical training for client personnel
- updating of existing plant documentation to 'as built' status

Take Note

- many legacy PLC systems are in need of replacement with newer devices
- complete PLC upgrades at any plant can be achieved seemlessly
- the change management process is a critical success factor
- pre-site preparation, and the selection of the right system integrators are crucial

The view of a coal mine

Goedehoop Colliery is an Anglo Coal colliery situated 35 km outside of Witbank in Mpumalanga producing 6,2 Mt annually for the export market. The plant has been in operation since

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1983 and originally operated with three Siemens S5-155U PLCs utilising S5-150A distributed I/O.

Due to various expansions and modifications over the past years the plant had become interdependent on the three S5-155 PLCs and could only run if all three were in operation. A decision was made to combine all three PLCs into one S7-400 with distributed ET 200 I/O situated in MCCs and various instrument rooms alleviating the need for inter PLC communication and reducing the amount of hardware required.

A requirement of the project was that the changes could only be done during maintenance periods in the week (3 x 8 hours), public holidays and Sundays. It was unacceptable to run sections of the plant on the new system alongside the old PLCs due to the complexity of the interlocking, and having to utilise two SCADA systems to run the plant.

The first phase of the project was to verify all instrumentation control loops, drive drawings, and redraw a majority of the drawings:

- installation of the new PLC marshalling cubicles
- paralleling of all field instrumentation and drives
- testing of all field instrumentation, drive I/O signal
- PLC programming and SCADA development utilising existing PLC standards and structures
- extensive FAT
- onsite testing of individual modules
- decommissioning of old PLCs and I/Os

In total 21 modules in the plant were tested during a 10 week period comprising of 370 drives, with each module being disconnected from the existing PLC during testing and reconnected after the completion of testing. Once the testing phase had been completed only then was the complete PLC and SCADA changed over during a planned shutdown.

The key factors that ensured the success of the project were:

- selection of the right system integrators for the project
- commitment and co-operation between the system integrators and the mine
- system integrators understanding the process needs of the mine and being prepared to be flexible
- setting and adhering to standards
- extensive FAT testing offsite of the PLC and SCADA before implementation
- planning and preparation before testing modules
- committing mine personnel full time for the project duration

The view of a diamond mine

De Beers' Finsch mine plant control system was outdated, didn't have any expansion capability and couldn't incorporate modern communications and integration systems. The plant was on the verge of expansion and an upgrade became necessary.

The requirements for the Finsch surface PLC replacement project were:

- change from centralised I/O reporting to distributed I/O stations (ETs)
- introduce centralised CPU placement
- provide reliable ET to ET and ET to CPU communications
- establish a PLC programming standard for the mine

Centralised I/O to distributed I/O

Critical to the upgrading process was the preparation of the project to determine where the ETs would be situated in the plant, taking into consideration the planned upgrades. These ETs would have to be situated to ensure that field cables are kept to a minimum and they must be in a safe environment.

The remote I/O provided the freedom to add and change to the control system as requirements and control philosophies change.

Communications

The Profibus ring network was also critical to ensure that fibre routes are different to ensure maximum use of the ring typology. Only fibre was used for communications between ETs at different locations and CPUs due to long lengths and high lightning risk to copper communications.

Communications between ETs and CPUs were done on Profibus via a ring setup. Past experience showed that most PLC

related downtime was due to a break in communication, which is why the Profibus ring configuration was selected.

Centralised CPU placement

The standardisation on the same type of CPUs ensure simple spares holding. CPUs were divided into different plant areas, and the only inter PLC communications that was established was the process and safety interlocks between different plant sections.

CPUs are centralised and housed in a controlled environment away from the plant – this will ensure maximum uptime of the CPUs.

PLC programming standard

A critical part of the project was to establish a PLC programming standard for the mine. In this process typical function blocks, data blocks, program blocks etc were developed to cater for all the mine's requirements. This was done to enable all future programming to be on the same standard which also simplified the training of mine technicians.

Project execution

The only time available for the actual upgrade was during normal weekly maintenance periods (8 to 10 hours) as the plant ran on a continuous operation program. In order to achieve the output for this time, the project had to be planned thoroughly and all resources had to be available for this period. All planned work was tested and a factory acceptance test was done and signed off to ensure that all areas were covered. Commissioning time was at the end of the maintenance periods and all the I/O of the affected sections of the plant were tested.

The changeover was done in two phases. First the I/O was changed from centralised I/O to distributed I/O. This meant the re-routing of all field I/O to the newly established ETs. These ETs were commissioned and the existing S5 program was altered to accommodate the S7 ETs. This in itself offered many challenges and a lot of preparation work needed to be done to ensure that all I/O were re-addressed in an orderly manner. A lot of inter PLC communications was also required as the existing S5 CPU allocation wasn't done according to the different plant sections. All I/O was first changed from S5 to S7, running from S5 CPUs. This was the high risk part of the project as there was no chance of swapping back to the old S5 I/O after commencing the task!

The second phase was to replace the S5 CPUs with the new S7 CPUs. All new programming was tested from simulated I/O to the SCADA system. When the required functionality was reached, the change over could start. For this phase a long startup time was negotiated for the plant after planned maintenance shutdowns. This proved to work and commissioning was done. This was also the low risk part of the upgrade, as we could switch back to the S5 CPU if we ran into problems.

The change over was done successfully with a lot of effort and commitment of all the project members and contractors.

The critical factors that ensured the success of the PLC replacement at Finsch mine were:

- proper planning of the whole project
- all preparation work was done beforehand
- constant supervision
- PLC programming standards for the mine
- thorough testing of the whole system
- proper revision control and backups
- use of trained and highly skilled people
- commitment of all stakeholders
- understanding and commitment of the client (plant production)

One must never under estimate this type of change over. A lot was learned with little sleep, hard work and most of all, the commitment to make it work!

Conclusion

PLC systems can be seamlessly swapped out – but only by professionals who have a full grasp of the consequences of getting it wrong. Successful swap out must be quick, efficient and accurate.

References

[1] Brown G. "Data management – not on the version of chaos", Electricity+Control, July 2004.

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