Automation and IT in a greenfield aluminium smelter project

Most greenfield projects focus on civil, concrete and mechanical engineering aspects but defining automation and IT needs at this stage and standardisation across networks ensures a more efficient plant start-up with associated cost savings. By Gaëtan Bolduc*

Implementation of automation and industrial IT components in a fully integrated greenfield aluminium smelter project presents many challenges. Schools of thought range from complete software development executed by the EPCM (Engineering, Procurement, Construction and Management) contractor or by a specialist company, to leaving the entirety of these activities to individual vendors. The approach presented in this article is based on experience acquired by Keops in greenfield aluminium smelter projects.

Project Strategy

This article emphasises standardisation and is based on the presence of a strong automation team embedded as part of the EPCM. From past experience, standardisation is a key element to the success of a project. It will lead to an efficient start-up as troubleshooting will be facilitated with ease of resource interchangeability during critical project phases. Plant maintenance personnel will also benefit from this standardisation which will facilitate the handover process. Elements to be standardised are:

- PLC brand and models including the associated suite of software;
- Motor Control Centres (MCCs);
- Computer brand;
- Database software;
- Specialised software; and
- Network components.

The project team should also define three things as early as possible:

- Standard documentation templates for the many documents to be developed for the project;
- Libraries of common PLC, HMI (Human Machine Interface) and SCADA (Supervisory Control and Data Acquisition) objects to be used project-wide (including by vendors); and
- Project guidelines for computer rooms and network deployment.

All the above should be addressed during the Front-End Engineering and Design (FEED) stage so they are available before supply contracts with automation content start being awarded.

The project strategy should also be defined during the FEED. There is no single answer as the strategy which will be influenced by local culture based on the project's geographical location and the client's autonomy and level of comfort with respect to responsibility aspects.

At one end of the spectrum, automation systems developed by a single team facilitate integration and standardisation. The drawback is those vendors that then try to pull back from their responsibilities with respect to system performance and warranties. At the other end of the spectrum, leaving all automation development with vendors will lead to inconsistent systems as automation standardisation is sometimes difficult to impose on them.

Major integration challenges will appear during start-up and commissioning. It may also arise that the contractual split of procurement packages is not aligned with the final system structure.

Automation & SCADA systems

The development of automation and SCADA systems should be left to reliable vendors when there is a direct relationship between the equipment being supplied and the operating system to be delivered. The vendor should also contractually commit to adhere to the project standards and project supplied libraries. The EPCM must have a strategy for later integration of the various automation and SCADA components.

MES and ERP systems

MES (Manufacturing Execution Systems) and ERP (Enterprise Resource Planning) systems should each be developed from a single source. As these systems are related to operation and require client involvement, an option could be to exclude them from the EPCM scope and have them managed directly by the client.

Should the client team not be mobilised at the time of functional specification, a standard basic implementation should be considered with a plan to upgrade functionalities for specific plant requirements after the start-up.

Networks

Network design and implementation is relatively complex as it involves interaction with many disciplines. This should be managed by the EPCM as a single unit. Limits with other disciplines, however, must be clearly defined. Aspects to be coordinated with other disciplines are:

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- Backbone distribution to be coordinated with civil engineering with respect to man-holes, trenches, conduits, building entries.
- Active equipment installation to be coordinated with building design with respect to building entries, computer room size, heating, ventilation and air-conditioning (HVAC), uninterruptible power supply (UPS), false floor, fire detection and protection.

There are three different network layers to be implemented:

- The process network will typically interconnect PLCs and instruments. It is often a proprietary network related to the PLC technology selected for the project. Although the EPCM may be required to provide some integration, most of the implementation will be the responsibility of the equipment supplier.
- The manufacturing network will typically interconnect PLCs to higher level systems such as SCADA, Historian and MES. It is an Ethernet network, specially designed and configured to handle manufacturing data on a real-time basis. With the evolution of Ethernet technologies, it is feasible to consider merging the manufacturing and process networks.
- The corporate network will support traditional back-office applications. It is also an Ethernet network but designed and configured to support traffic related to conventional applications such as web access, e-mails and file servers. It interfaces to the manufacturing network across a 'De-Militarized Zone' (DMZ).

Apart from these three layers, a separate fire detection network, cameras as well as a radio network will have to be implemented.

**Engineering**
The interaction with the project disciplines will vary throughout the phases of the project.

**Pre-Engineering**
Pre-Engineering is often referred to as the Front End Engineering and Design (FEED) stage. Apart from defining the overall project strategy, several aspects have to be addressed. To provide ease of integration and facilitate future system maintenance, some basic IT and automation components must be standardised. Elements to be considered are automation hardware and software, computer and network hardware, operating systems, databases and ERP.

Nomination agreements with the strategic equipment manufacturer should be put in place to guarantee standard prices worldwide and provide engineering support to vendors. There must be provisions in some of these agreements for the strategic vendor to have their engineers embedded within the EPCM team to ensure overall coordination and provide technical support during plant start-up.

**Automation and SCADA**
During the early stage of the Engineering phase, the EPCM must prepare standard documents and software libraries supplied to all vendors that have automation and SCADA components included as part of their scope of supply.

While it is desirable to have vendors work as responsible as possible for the automation and SCADA part of their equipment delivery, it is unrealistic to believe that a vendor delivery will be 100% integrated with the overall plant architecture. As such, based on the vendor’s reputation and the importance of the automation component to be delivered, a decision will have to be taken with respect to its scope of delivery.

Reputable vendors delivering sizable equipment should be accountable for the implementation of the associated automation and SCADA components. They must also be contractually obliged to provide all necessary support to the team assigned to the overall integration at plant start-up. They should be subject to auditing during the development phase where they will have to provide documentation and software components for validation and confirmation that project standards are being adhered to.

Vendors that do not demonstrate a strong track record with implementation of automation and SCADA applications, or vendors awarded the supply of equipment that does not constitute a full system on its own, should have software development excluded from their scope of supply. However, they should still be required to supply a Functional Specification that will provide enough information to the EPCM automation team to carry on with software development. They should also have personnel available during plant start-up to assist with pre-operational verification and commissioning activities.

As a consequence of the above, the EPCM team will inherit the responsibility for the development of a number of orphan systems and will have to prepare functional specifications, develop the software and perform factory acceptance tests.

The Automation and SCADA team must be involved during the Request for Proposal (RFP) and tender evaluation and must provide recommendations as to the extent of the scope of supply to be expected from the vendor. The same team must also participate in the factory acceptance tests.

**Network & IT Equipment**
Being distributed across the entire plant, network distribution will need to be closely coordinated with the engineering team responsible for the various plant services such as water, power and gas distribution.

As the network may not be fully designed at the time the infrastructure contracts are awarded, it is suggested to initially focus on designing a ducting network that will provide as much flexibility as possible for the anticipated cable routing. It rooms must be located with connectivity to distribution points located in most buildings.

Many building contractors will be awarded contracts for the 100-plus buildings present in a modern smelter. Standard specification documents must be prepared to define building requirements, cable routing and structured cabling requirements. Specifications must also be prepared to address HVAC, UPS, power distribution, and fire detection and protection.

**Manufacturing Execution System**
Being a plant-wide implementation, the realisation of a Manufacturing Execution System (MES) must be handled by a single party. It will follow the standard cycle of software development, starting with the definition of user requirements, followed by functional specifications, development, configuration and factory acceptance tests.
Although many software companies will claim to have MES software packages, the effort that will be needed to implement a fully functional MES for an aluminium smelter must not be underestimated. Most software packages will address standard MES functionalities such as Overall Equipment Efficiency (OEE), Key Performance Indicators (KPI) and others, however this is only a fraction of what is needed in an aluminium smelter. Keops is currently developing a standard MES package specifically designed for aluminium smelters.

**Procurement**

The involvement of the EPCM automation team with procurement is twofold. There are packages that should be managed directly by the automation team and there are also packages with automation content (mostly mechanical or electrical) that are managed by various EPCM Area Managers. For these, the automation team only needs to provide support for the automation portion of the packages.

Packages that must be handled directly by the automation team are related to:

- Automation or IT equipment such as PLCs, computers and network switches not included with the equipment supplied by vendors.
- Control room furniture. This also needs to be coordinated with other packages with respect to HVAC, UPS, power distribution and fire detection and protection.
- Fibre optic cables should be standardised and procured as a single package to be later freely issued to the various contractors.
- Radios should be procured early so they can be used by construction personnel during the project. All radio frequency licenses must be obtained from the local authorities before the radios can be used.

Equipment suppliers that provide automation components as part of their supply should be subject to a strict procurement policy to ensure efficient delivery of this part of their supply. Although the automation component of a package may be small financially, the impact of non-performance can be dramatic during plant start-up.

The procurement strategy for this type of package should include payment milestones for key deliverables such as functional specifications, key software components and successful factory acceptance tests completion.

Standardisation must be enforced whether it is on selection of standard components or adherence to project standard specifications.

**Site Activities**

Most equipment to be installed contains sensitive electronic components. It is imperative that locations where such equipment is to be installed have reached a level of completion that will comply with the standard warranty provided by the equipment manufacturer. HVAC and UPS must be operational, ideally with permanent power and the environment must have minimal dust content. Control rooms should be furnished and workstations installed on an as needed basis to avoid damage by ongoing construction activities.

The network will be gradually deployed in a sequence that provides network availability along with plant start-up operations. As various network segments become available, they should be thoroughly tested before they are made available to the pre-operational verification team.

**Pre-Operational Verifications**

Pre-operational verification consists of all tests that can be conducted prior to using the equipment in an operational environment. For PLCs, it consists of I/O connection tests and validation of basic sequences. For HMI and SCADA, each tag present on every screen must be validated to confirm proper mapping with the physical I/O. Alarms and faults must also be validated. On the MES, screens and reports will be reviewed to confirm that information presented is based on the correct tag mapping. Connectivity between the various systems must also be thoroughly tested.

Successful pre-operational verification is typically the end of the EPCM mandate. It is formalised by a handover demonstration, providing the client with handover documentation that will include a list of non-critical deficiencies with a commitment for their resolution.

**Commissioning**

During commissioning, the operations team will start all the items of equipment so as to eventually take the plant to its nominal capacity. Ownership at this point is transferred to the client operational team. However, it is customary to have the EPCM and vendors provide assistance to address any issues not discovered until the equipment has been started in a real production environment. It is also not unusual for commissioning personnel adjust their operating procedures. This can have an impact on some of the systems’ components and may require changes to a PLC programme or other software applications.

In conclusion, a rigorous approach on automation and IT aspects during the project will lead to a much more efficient plant start-up. Associated cost savings will be significant, not even taking into account the increased productivity obtained from an efficient increase in production capacity. Automation and IT activities are long lead time activities if they are addressed properly and as such, they should also have the proper level of attention during the early days of the project.

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