SCADA system integrity

Peter Bauer, ABB Automation, USA, and Billy Mann, West African Gas Pipeline Company Ltd, discuss the importance of SCADA system integrity to the West African Gas Pipeline.

Gas operators are finding the need for more and more advanced technology to keep up with their data collection and processing requirements. This includes data from smart field devices, increasingly sophisticated control systems, open safety and fire & gas networks, remote terminal units (RTUs) and electrical systems. In a single pipeline network these systems and products could be supplied by multiple vendors – all with different communication protocols.

In order to keep up with these needs, gas pipeline operators need the latest technology a Supervisory Control and Data Acquisition (SCADA) system can provide. It is not enough in today's marketplace to simply have access to this data. An operator needs a system to sort through the massive stream of data originating from their various systems and a comprehensive display scheme to reduce time to decision and action.

Many other challenges that complicate standard SCADA solutions exist on gas pipelines. With custody transfer scenarios, issues such as security and data integrity become the foremost priority. Once collected, this data needs to integrate with a volumetric accounting system or other enterprise business systems. Since these systems and software packages are located many kilometres apart, complex telecommunication networks are often required. Due to the potential inaccessibility of the remote polling stations, maintenance and asset management must be automated as much as possible.

The West African Gas Pipeline (WAGP)

This project provides an example of how leading edge SCADA technology helps remote location pipelines operate more efficiently and securely.

Pipeline profile

The West African Gas Pipeline is a gas transmission system that will transport natural gas from Nigeria to power plants in Ghana, Togo and Benin. Both public and private sector companies from these four countries are collaborating in a joint venture company known as the West African Gas Pipeline Company (WAPCo) to construct and operate this pipeline.

The 671 km, US$ 635 million pipeline will extend from the existing Escravos-Lagos pipeline at the Alagbado 'Tee' in Nigeria and proceed to a compressor station west of Lagos. From there, the gas will flow offshore to Takoradi (Ghana), with gas delivery laterals from the main line extending to Cotonou (Benin), Lome (Togo) and Tema (Ghana).

Project benefits and environmental impact

The power provided by the supply gas has the potential to generate numerous primary and secondary sector jobs. Based on World Bank estimates and recent crude prices, Ghana, Benin and Togo may save up to US$ 300 million per year. These savings will be achieved by switching from more expensive petroleum, coal and charcoal products to natural gas.

The main environmental impact of this pipeline is the reduction of 'gas flaring', or burning off natural gas as waste, as associated with oil production in Nigeria, thereby contributing to the reduction of 'greenhouse' effects. Additionally, the pipeline will enhance the regional environment by substituting clean burning natural gas for less desirable fuels.

WAGP SCADA solution

The West African Gas Pipeline Company faced many challenges when developing their control and data collection solutions. The requirements included various hardware and software packages, complex telecommunications, security concerns and electrical asset management packages.

Willbros West Africa, Inc.. (WWAI), system integrator for this project, chose ABB's SCADAvantage™ solution to address their requirements. SCADAvantage™ is a powerful but simple package that offers a scalable and open solution.

Engineering requirements

Gas pipeline engineering contractors perform interface management; working closely with multiple suppliers from the front-end design through the engineering and implementation phases to ensure system integrity from concept to operation.

For the SCADA applications, the contractor will be responsible for all data flow between the vendors, EPCs and other engineering companies. The SCADA provider can design the hardware infrastructure, which becomes more complicated with remote scenarios. The designer must consider the priority of the data, how often it needs to be polled and what means to employ to transmit this data. Data may be transmitted via radio, fibre optics, cellular or satellite to name a few communications protocols. The importance, or priority, of the data will often dictate this transport mechanism. For example, transferring data indicating a pressure surge from an upstream location to a downstream location is very critical, as it may potentially protect the equipment of the downstream facility by warning the safety system of an unsafe upstream condition. With this scenario, polling the data once every 24 hours is clearly not enough and a more robust data stream might also be recommended. The addition, therefore, of redundant SCADA systems and telecommunication networks will ensure a more secure and safe solution.

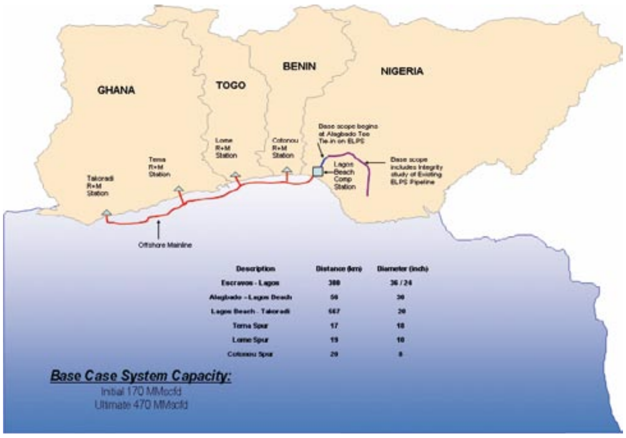

Figure 1. Map of the West African Gas pipeline and Escravos to Lagos pipeline.

Figure 2. Onshore pipeline construction in Ghana.

Figure 3. Alagbado Tee building wired for integration testing.

System integration

The automation and electrical systems were integrated at ABB's facilities in Houston, Texas. The equipment was installed in 40 ft reinforced steel buildings.

All major components were installed, integrated and tested before leaving the factory floor. This concept of 'modularisation' can dramatically reduce risk at start up when compared to traditional methodologies.

Modularisation is a recent trend that has several proven benefits. It can minimise the overall project cost, reduce commissioning time and allow for full integration testing before components leave the factory floor.

There are several reasons to use modularisation. These may include extreme environmental conditions remote locations with inadequate facilities and resources, schedule risk, lack of skilled local labour or expensive labour, security concerns, space or time constraints, or simply the increased procurement costs of utilising multiple vendors.

For WAGP, modularisation was selected primarily to reduce the schedule risk. By integrating ABB's modularisation solutions at the project design phase, WAPCo has the potential to show significant savings in commissioning, maintenance and operational costs while ensuring system integrity throughout the life cycle of the project.

Testing methodologies

All buildings were physically located just a few feet apart on the ABB factory floor to ensure that the project team was able to test the interconnectivity of all the components and solutions. Integrated factory testing greatly improves efficiency versus testing onsite when the buildings are located hundreds of kilometres apart.

As with most pipeline projects, safety is an integral part of operation. One safety test involved tripping a safety device at one location and observing (from a remote control centre) that corrective action was successfully taken. This test requires quite a few elements to be fully integrated and tested beforehand: ABB's safety system must be properly wired to detect the field fault and the software logic must be configured correctly. Also, the SCADAvantage™ system requires accurate

Figure 4. Electrician wiring UPS fault signals to integrated SCADA system.

point mapping to the safety system. To get the data to the remote control centre, the local SCADA station must have exact telecommunications configuration to replicate the data across the network.

The individual systems were first tested in isolation and gradually introduced to more and more integrated scenarios. For example, ABB's 800xA process control system (PCS) was first tested for each site. The logic was downloaded to a simulation soft controller and the testers verified the local logic, based upon detailed design specifications, P&IDs and other logic diagrams. Once the local PCS was deemed acceptable, other systems were gradually introduced.

Similar tests were conducted for all other sub-systems such as custody transfer, fire & gas, low voltage electrical equipment, LAN-WAN and telephone networks, safety shutdown and flow computers.

SCADA architecture and telecommunications network

The base tier of the SCADA system consists of local polling stations that are fully self-sufficient. The second tier consists of two control centres – a main control centre at the WAPCo headquarters in Accra, Ghana, and a backup control centre at the Lagos Beach compressor station.

Each of these tiers has a different security structure. The local station operators have full authorisation to access and control local data only, with the exception of custody transfer data. The operators at headquarters have access to all data across the pipeline, and can take general control actions.

Locally, each station has a redundant set of SCADA servers, as well as client workstations for the operators to access the site. Local servers eliminate the risk associated with a telecommunications network failure. The servers are designed to store all historical data for 60 days. They automatically backfill the main control centres should there be a signal interruption.

These SCADA servers and clients reside on a local control network. This network allows the SCADA system to poll data from all ethernet-based systems onsite. Communication is fed through a redundant telecommunications structure (satellite system VSAT) to the other locations.

There is an office network, with a full array of VOIP phones using the same VSAT. Therefore, prioritising data is very important. Any real-time data transferred through the network has highest priority, followed by SCADA historical data, telephone calls and finally internet access.

All engineering modifications can be done locally, but most are carried out at the headquarters locations. The SCADA network is setup to allow remote configuration (given the proper security profiles). The system is also accessible to ABB service centres, via remote access. A SCADA Certified Engineer can remotely access the SCADA system through a dedicated network tunnel and perform remote diagnostics or configuration changes. This represents a significant reduction in time and expense when compared to contracting a worker to visit onsite.

Control systems

Several control systems were utilised for the automated operation of the pipeline. Each of the Regulation & Metering (R&M) locations, as well as the Lagos Compressor Station utilised ABB's System 800xA as the common engineering interface for both the Process Control System (PCS) and the Safety System

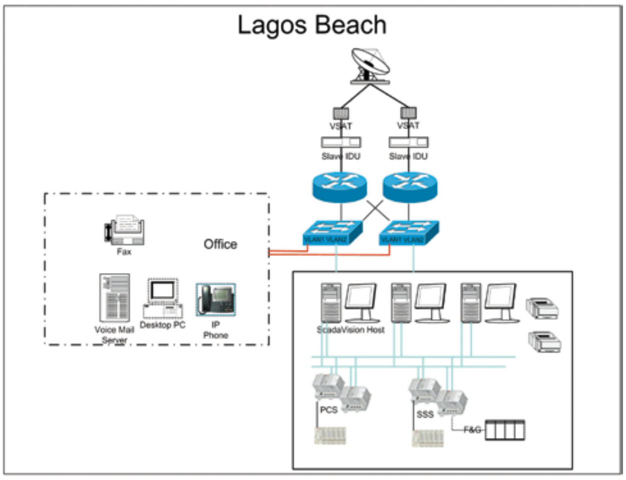

Figure 5. Local network example.

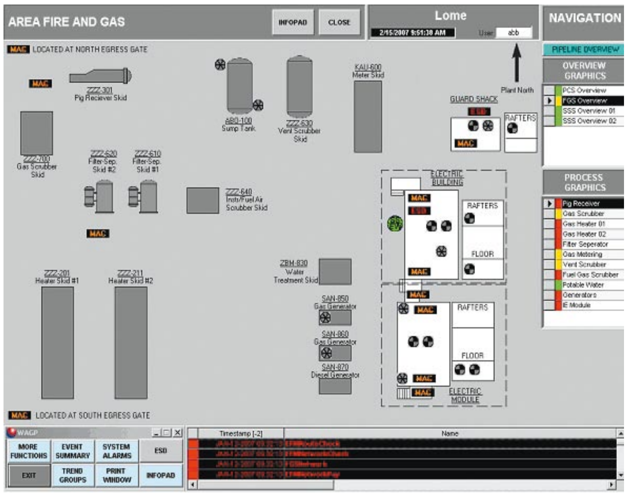

Figure 6. Fire & gas display.

Figure 7. Construction of offshore pipeline.

(SIS). The advantage of utilising the common system platform is that the SCADA system can poll one standard database to collect and control all data.

The Fire & Gas System (FGS) is based on addressable loops that provide advanced diagnostics and reduce cabling. A separate gas detection system was provided as an early warning system for the local communities. The SCADAvantage™ station functions as a fire & gas mimic panel wherein the operator can get immediate information on the status of all fire & gas detectors and manual call stations. Maintenance personnel can use the SCADA station graphic displays to assess the status and health of each field device.

The compressor station has surge control, compressors and turbines. These have independent PLCs with hundreds of I/O points. ABB designed the system to be capable of polling critical points to the local SCADA server for observation and control.

Other systems utilised include a High Integrity Pressure Protection System (HIPPS), Low Voltage Switchgear, Low Voltage Motor Control Centers, UPS, HVAC and Breaker Panels.

The accessibility of data from the various PLCs, Fire & Gas and electrical systems is crucial for maintaining safe operation of the equipment. SCADA provides an easy mechanism to provide all required information, in context, so that the appropriate actions can be performed. This reduces the time needed to assess the issue and limits time spent travelling to each control panel or subsystem.

Custody transfer solution

Every gas pipeline has a unique challenge when it comes to custody transfer. For WAGP, it is especially complex due to multiple suppliers and multiple end-users. This requires a thorough analytical package, secure data transfer and interfaces to accounting software.

The supplier of the gas transferred in the WAGP has seven sites on the Escravos-Lagos Pipeline. Each site has a gas analytical shelter provided by ABB. These shelters include a gas chromatograph and moisture analyser. Data from these devices is available on the WAGPCo network via the SCADA system. This communication link is important to enable assessment of gas quality in the pipeline and of each supplier's contribution.

Once in the WAGP distribution network, each of the R&M stations has its own custody transfer system. These consist of metering skids with redundant meters. These meters feed into ABB's TotalFlow Pay & Check RTUs, along with data from the local gas chromatograph. The RTU then sends data to the local SCADA server to display to the operator, sends the custody transfer data to the historian and sends the compensated flow data to the PCS for controlling the metering skids.

The data transferred to the historian is extremely important. This data, along with standard flows, BTUs etc., also contains an audit trail of any changes to the system or data. This data is transferred to an historian server at one of the control centres, but is also stored locally in the RTU for up to 60 days. Once the data is in the SCADA historian, it interfaces to the volumetric accounting system. Minimal configuration in the accounting package is required.

What's next?

WAPCo is currently looking at the various features offered by SCADAvantage™ to ensure that their system evolves along with SCADA technology. Trends show the future requirements will be complex, and companies need to account for this in their plans now.

In today's SCADA market, it is not uncommon to replace systems once every seven to ten years due to obsolete technology. However, with WAPCo's strong partnership with ABB's technology centres, and local/remote support centres, the goal of an extended life cycle (with an evolution strategy) is achievable.