

SCADA AND TELEMETRY IN GAS TRANSMISSION SYSTEMS

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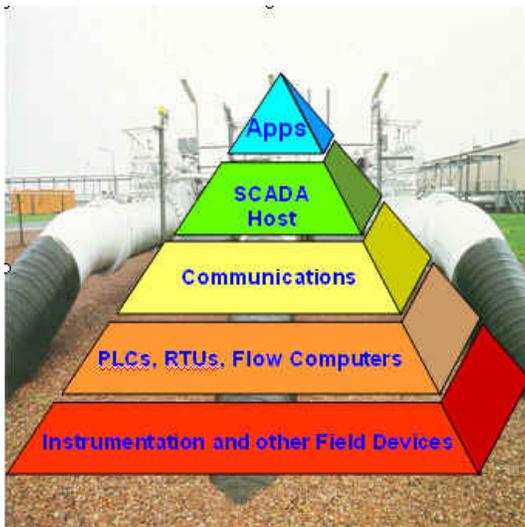
Introduction

SCADA systems provide for safe, reliable, semi-efficient operation of gas transmission systems. Advanced applications and interfaces to business systems provide the keys for highly profitable operation.

This paper introduces the basic building blocks of the SCADA system, including field devices. The SCADA host and advanced applications are discussed in detail. The paper concludes with a discussion of SCADA trends.

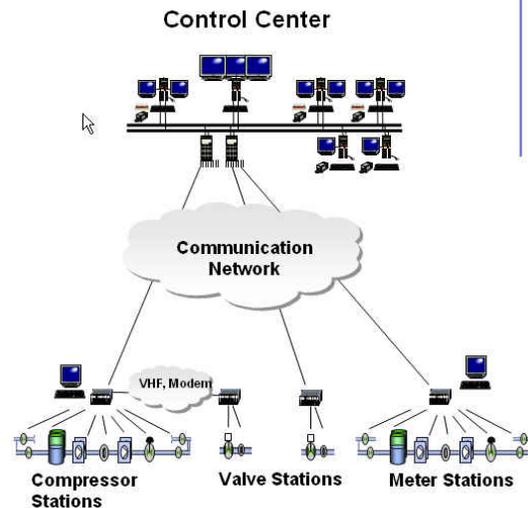
Gas Pipeline System Overview

The following drawing shows the five logical levels that make up the SCADA system.



The physical connection to the pipeline is through the end devices or instrumentation. This instrumentation is connected to Programmable Logic Controllers (PLCs), Remote Terminal Units (RTUs) and/or flow computers, depending on the type of remote station. Data then flows from these remote devices through the communications network to the SCADA host (also referred to as the SCADA Master or Master Station). Examples of applications at the top of the pyramid would be advanced control and optimization applications used by the gas controllers as well as business applications used by other departments within the pipeline company's organization.

Another way to depict the SCADA system is the following physical view.



Compressor Stations

Each compressor typically has its own "Unit PLC" supplied by the compressor manufacturer. These Unit PLCs are interfaced to the "Station PLC" which aggregates all of the unit data for transmission to the host. The Station PLC also picks up data from other station equipment such as liquid handling facilities, fire and gas systems, analyzers, etc. Most compressor stations have a local Human Machine Interface (HMI) so a local operator can view station information. Note that although there is often a meter station at or near the compressor station, the meter station is usually handled separately (see next section).

It is not uncommon for a large compressor station to have dozens of PLCs and multiple HMIs. These stations may also serve as communications hubs to pick up data from nearby valve and meter stations. In total, millions of dollars of automation and communications equipment might be installed at a major compressor station.

Meter Stations

Meter stations can range from small, single run stations to large multiple run stations. Common primary measurement elements are orifice meters and ultrasonic meters, with some turbine meters. A flow computer or RTU is used for measurement to AGA and API standards. Logic and controls for tube switching, pressure

regulation, heaters, valves, odorant control are provided by the RTU or flow computer. Some stations have HMIs although it is more common for the operator to interface to the RTU via laptop.

Block Valve Stations

This is the simplest station on the pipeline. A small RTU is installed to monitor pressure (oftentimes flow and temperature as well) and to accept remote control commands to open and close.

Communications Networks

Whose life hasn't been changed by the communication revolution? High speed digital communication is available almost everywhere. For SCADA, moving data from the field to the host has become almost a "no-brainer". Most major gas transmission companies have extended their corporate WANs out to at least their major compressor stations. Smaller stations, or more out-of-the-way sites, are easily picked up by inexpensive spread spectrum radios and mesh networks, for example. Even satellite costs, both hardware and time, have decreased drastically.

SCADA Host

The primary purpose is the real-time operation of the pipeline. To meet this requirement, three main functions are performed.

- Communicate with the field devices
- Process and store the data into the real-time and historical databases on the SCADA servers
- Visualize data to the gas controllers

A secondary purpose is sourcing data to other applications and departments for safe and profitable operation of the pipeline.

Host Communications

The SCADA host must be capable of interfacing to the various communications circuits employed. This hardware interface is the easy part. More difficult is the software interface between the host and the field devices. It is not uncommon for a major gas transmission company to have 10, 15 or more different types of PLCs, RTUs and flow computers installed on the pipeline, each communicating using a different protocol. There have been attempts to establish gas industry protocol standards such as Enron Modbus, but for the most part, it is still a requirement that the SCADA host have a library of protocol drivers to handle the wide variety of devices. The software must be able to support backup communications paths to key stations.

Real-Time Database

The core of a SCADA system is the real-time database. This is where all the data from the field must be processed and stored. For a large pipeline, it must be capable of handling hundreds of thousands of data points, quickly and robustly. The real-time database is memory-resident, meaning all of the data is stored in the memory of the server, not on the disk. Alarm processing, control sequences and other functions are performed by the real-time database.

The real-time database serves data to the operator workstations and other users, as well as to other applications.

The real-time database often runs on two servers in redundant fashion to provide 99.999% availability.

HMI

The HMI or client software is the graphical display environment used by the gas controllers to view and control the pipeline. Example displays would be overview maps, station displays, control pop-ups, etc.

Beyond SCADA – some common gas pipeline applications

Line pack and draft calculations are used to monitor the inventory in the pipeline. A major pipeline can have well over 1 Bcf of storage available to meet deliveries. The line pack application requires that the user input the pipeline segment data (length and diameter). The application acquires real-time pressure measurements (and temperature and gas composition, if available) from the SCADA system. The calculated information on line pack is returned to the SCADA system for display to the gas controllers.

Another common application is Gas Schedule Tracking. This application takes the gas plan from the nominations system and compares it to the real-time flow values to help the controller meet the receipt or delivery requirements.

Real-time transient models

Many gas transmission companies have built numerical models for both offline and online uses. One of the primary online uses is leak detection. The actual pressure and flow readings from the SCADA system are compared with the modeled pressure and flow readings. Discrepancies could indicate a leak. Other model-based applications include the following:

- Look-ahead simulation
- Survivability analysis
- What-if analysis
- SCADA data validation
- Flow studies for smart pigging

Models are also used to build training simulators. With a training simulator, an offline copy of the SCADA system is connected to a model that simulates the pipeline. An instructor, through his training console, introduces an upset in the model which propagates through to the SCADA system. The trainee operates the SCADA console as if he was operating the pipeline.

Measurement Systems

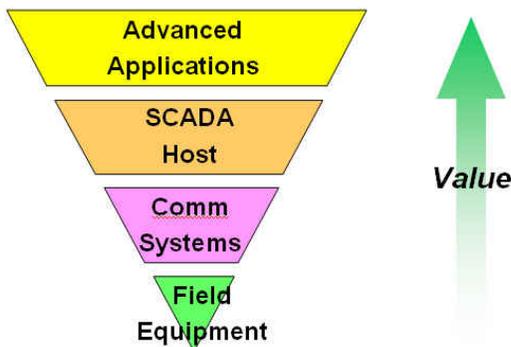
Measurement systems are used by pipeline companies to manage the custody transfer data from the metering stations. This is often referred to as the “cash register” aspect of operating a pipeline. The flow computers and/or RTUs at the metering stations provide both real-time flows and volumes for operational purposes and historical records for measurement. The host measurement system is almost always separate from the SCADA system. However, the communications front end of most modern SCADA systems can poll for both real-time operational data and custody transfer data.

Other high-value-add applications

Gas pipeline companies are finding that their SCADA systems are a virtual goldmine of information which can be used to optimize the return from their pipeline assets. Some examples of applications which have been developed include:

- Expert systems and neural networks for load forecasting
- Long-term and short-term capacity planning applications
- Variable cost estimators
- Station optimizers and system optimizers

Many of these applications provide a huge payback in relational to the costs to implement them. For that reason, some people in our industry invert the SCADA pyramid as shown below.

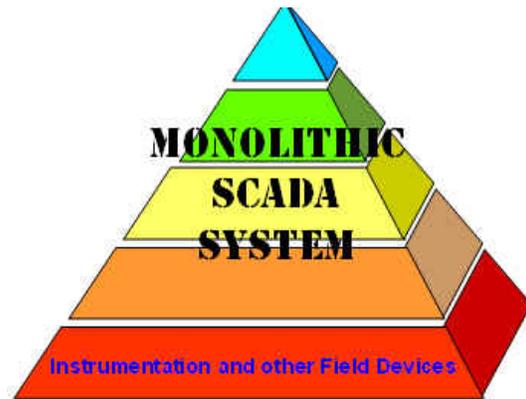


Most of the cost in a SCADA system is in the lower layers. These costs are necessary to safely operate the pipeline. The advanced applications aren't entirely

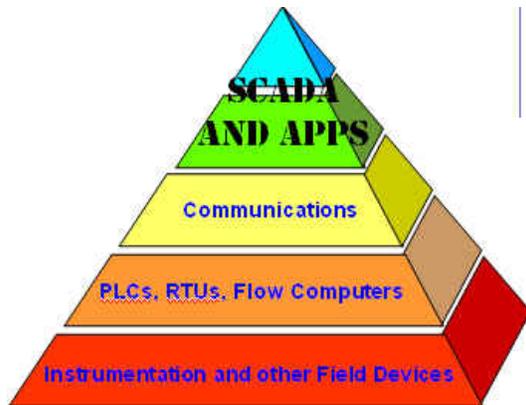
necessary to operate the pipeline. Yet spending a relatively small amount of money (in comparison to the large amount spent of field devices, for example) on an capacity planning application, for example, could dramatically increase the profitability of the pipeline.

SCADA System Integration, Then and Now

SCADA systems used to be complete solutions from a single vendor. The vendor packaged his RTUs with his communications equipment with his SCADA software into a monolithic SCADA system. The only items that the customer was free to choose were the instruments. Fewer choices meant less competition, higher prices, and more reliance



In the 80's and 90's, systems became less monolithic with more choices for RTUs, PLCs and flow computers. The SCADA vendor still bundled the SCADA system with the applications.



Today, gas transmission companies have many choices at every level. This has brought many benefits:

- Prices have fallen, in some cases, dramatically
- More vendors = more investment = better products
- More functionality = more bottom-line benefit to the pipeline company

However, resources are required to put it all together. Many pipeline companies hire consultants and contractors that are specialists in system integration.

