ECOPETROL Maximizes Monitoring Efficiency through Wireless Ethernet

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ECOPETROL S.A is the state oil producer in Colombia, one of the top four producers of petroleum in Latin America. Their nationwide operation includes multiple oil and gas fields, refineries, shipping ports on both coasts and a network of pipelines throughout the country that interconnect the production system with the consumption centers and marine terminals.

ECOPETROL has also been a pioneer in the adoption of wireless technology in oil and gas operations. From the beginning, ECOPETROL has recognized that wireless networking provides the most cost efficient and effective means of monitoring their expansive operations. By using wireless communication to interface well sites, operation centers and distribution centers across long distances, ECOPETROL saves hundreds of man hours and millions of dollars over the life of the system because they are not faced with the high cost of cable installations and maintenance.

When their installed network of legacy, serial, 900MHz radios using Modbus protocol began to run out of bandwidth, ECOPETROL turned to the engineers at ANDESwireless Ltda. for assistance. Together they developed a plan to upgrade their existing wireless network to wireless Ethernet. A major technical challenge was that the current system used multiple protocols such as Modbus, DNP 3.0 and others in a serial format on multiple hardware platforms of Modicon and Allen-Bradley at the Remote Terminal Units (RTU). All these remote RTU's would then need to be brought into the new Ethernet network though upgrades or serial to Ethernet converters. The wireless Ethernet network would not translate protocols; it would be the communication medium that allows the devices to communicate. This open wireless Ethernet network would allow connection of any Ethernet compatible device such as new RTU, video cameras or Voice over IP (VoIP) phones.

This very large scale project called for integrating over 160 control points (oil wells, clusters, stations, etc.) from two different production fields into their main Emerson Delta-V DTS computer system. There is a fiber-optic ring between the control rooms and substations in the system that handles most of the high-speed Ethernet traffic. The wireless Ethernet supervisory control and data acquisition (SCADA) network connects the control rooms to the remote RTU's at the well sites over distances that span 47 kilometers. The control system gathers the information such as

temperature, pressure and flow at each of the 125 well sites in order to control the submersible pumps that extract crude oil.

ECOPETROL required a product that would be rugged enough to withstand the harsh, Amazonian climate where the oil fields are located. This new wireless network would not only carry the control data for the supervisory control and data acquisition (SCADA) system, but would also require enough bandwidth for any future site additions. The wireless Ethernet network had to comply with an open IEEE network and security standards for both providing a common interface and any future growth. The selection of an open protocol would not tie the network to a single vendor for future upgrades. Additionally, the wireless network would have to be powerful enough to cover long distances over rugged terrain and had to be cost effective due to the large scale of the project. After careful consideration, ECOPETROL SA and ANDESwireless selected ESTeem Wireless Modems' Model 195Eg for their wireless Ethernet solution.

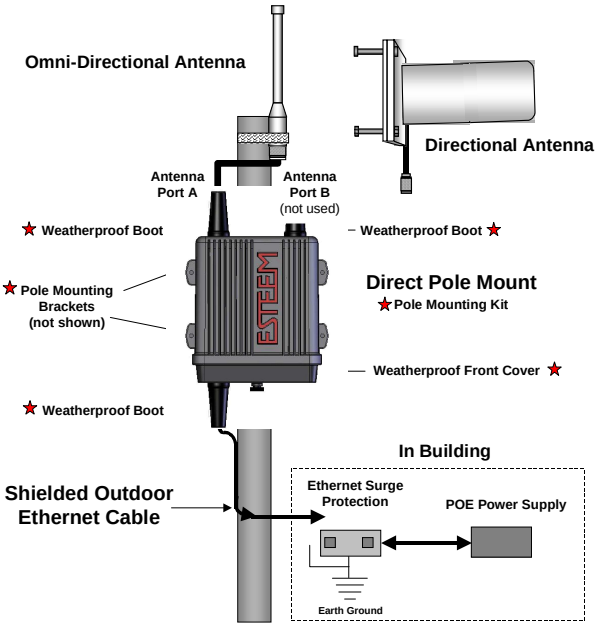

Figure 1:Pole Mounting Diagram

The ESTeem 195Eg is housed in a NEMA 4, watertight enclosure and rugged enough to withstand wind, rain, and temperatures from -30 to 60 degrees Centigrade and can be directly pole mounted (Figure 1). Not having to purchase enclosures or having to install expensive coax cable saved the ECOPETROL anywhere from $900 to $1300 dollars per installed site. In order to meet the challenge of providing sought after bandwidth, the 195Eg has up to 54 Mbps of radio frequency (RF) data rate and multiple RF channels in the 2.4 GHz frequency band. With a peak power of one (1) Watt, the ESTeem 195Eg is one of the most powerful radios on the market. Used in conjunction with high gain directional antennas on point to point connections, the ESTeem communicates the 47km that ECOPETROL needed for their upgrade project.

The ESTeem Model 195E series modems can be software configured for multiple modes of operation such as base, repeater, remote or mobile client allowing a large scale network such as this to maintain a minimal amount of spares. This unique feature affords customers like ECOPETROL a tremendous amount of network flexibility in addition to saving money. All ESTeem 195Eg's in the network can be configured as self-healing Mesh repeaters, further extending overall coverage area and adding network redundancy at no additional cost (Figure 2).

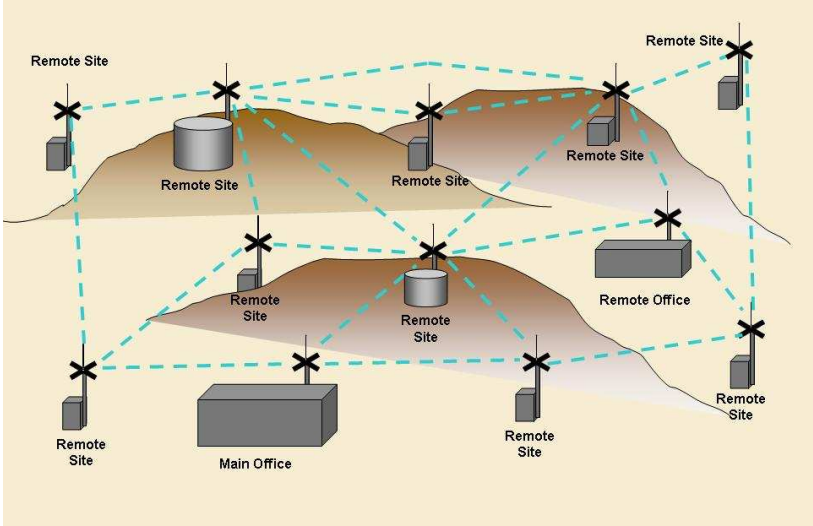

Figure 2:Mesh Repeating Diagram

The ESTeem wireless network was implemented in three phases with 61 sites being added on the first phase and 29 then 38 on additional phases. Each phase of the radio integration, completed by ANDESwireless, was an excellent example of how to design a reliable wireless network.

Phase 1 – Design and Inspection

ANDESwireless gathered data from the customer on each RTU's longitude, latitude and elevation to conduct a computer model analysis using the ESTeem RF Design program. This software program allowed ANDESwireless to make initial design decisions such as antenna height, antenna gain and location by analyzing the signal strength and fade margin calculated by the software. Most radio problems can be indentified and eliminated in this initial design phase. Changes to the radio network (height, antenna gain, location, repeater sites, etc.) that are extremely expensive on an installed system, can be changed by a press of a button. ANDESwireless also conducted a site inspection to find any problems that would not show up on a computer model. Problems such as blockage to the line of sight (LOS), overhead power lines or installation structures could be identified and adjusted in the final design.

Phase 2 – On-Site Radio Survey

Once Phase 1 design is complete, all sites in the network need to be physically tested with the hardware that will be installed at the site. Site survey testing will include measuring receive signal strength, RF background noise and data transmission efficiency. The purpose of this testing is to confirm the results found in the initial design phase and also to make any site adjustments if an on-site problem is identified. ANDESwireless presented a formal site survey report with all the testing information and installation plan to ECOPETROL.

Phase 3 – Installation/Commissioning

After the radio design plan was evaluated and accepted by ECOPETROL, ANDESwireless completed the installation of the wireless hardware and performed a site commissioning using the same testing techniques uses during the radio site survey. The testing was conducted on the installed hardware and the results should be equal or greater than the values tested during the site survey.

The purpose for all this extensive testing is that the wireless network is providing the "backbone" for all communications in the SCADA system. If any wireless link is unreliable then all devices connected to that link will also be unreliable. A properly designed, installed and tested wireless network can be as reliable as any cabled communication system.

Each remote RTU site could have a different wireless configuration depending on the communication requirements. Some remote sites would have very long communication paths that could only be bridged by using a pair of ESTeem 195Eg's and high-gain directional antennas pointing at each other. These point-to-point links could then be connected into the RTU's Ethernet interface. If multiple communication routes were required, this point-to-point connection could be interfaced with either a single ESTeem 195Eg and omni-directional antenna for local communication or other point-to-point links across the SCADA network. An example of this design is at the control room tower that has one 24dBi grid antenna to link with the second control room, two 24 dBi grid antennas pointing to the furthest locations and their corresponding radio clusters in the field and a 17 dBi panel antenna to gather the information from 7 local oil wells about 6 kilometers away. These multiple 195Eg's are connected by a local Ethernet Layer 2 and 3 switch/router.

The ECOPETROL network is an excellent example of how adoption of wireless technology, selection of the correct wireless hardware and correct RF design practices can provide a reliable, cost effective communication network in the harshest of conditions.