EBSA Controls and Monitors Power Distribution with Wireless Ethernet

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EBSA (Power Company Boyacá), an electrical power distributor in Colombia, has deployed a communications system to control and monitor the status of their service while enhancing the quality and additionally complying with the standards required by the Colombian Regulatory Commission for Energy and Gas (CREG). EBSA provides energy for the entire state of Boyacá, supplying approximately 1,500,000 people with power in 123 municipalities across an area of over 23,000 square kilometers (8,880 square miles).

Figure 1. EBSA Primary Substation No. 1

Boyacá spans the Cordillera Oriental mountain range in the Andean Region of central Colombia covering a total area of 23,189 km² (14,409 square miles). It borders to the north with the states of Santander and Norte de Santander. The Cordillera Oriental mountain range, including the Sierra Nevada del Cocuy with 25 snow covered peaks, has an average height of 5,380 meters (17,650 feet) above sea level. Access to some sites is extremely difficult due to road conditions and seasonal rains. In the event of communication failure, access to a site for repair may take a while. For EBSA these types of problems cause failure in customer services representing economic losses and hefty penalties. The ability to reliably monitor the status of their distribution network from a centralized control room saves money and ensures quality service for EBSA customers.

Figure 2. EBSA Repeater No. 2

The goal of this project was to control and monitor nearly 15,000 substations signals received from 18 primary and 44 secondary substations throughout the state. Providing a reliable and cost efficient communication network over this difficult terrain was the primary challenge to meeting this goal. EBSA investigated the use of commercial communication systems such as General Packet Radio Service (GPRS) and satellite. The bandwidth provided by either of these two methods was insufficient for the total signals required from the control room and EBSA would have had to contract with companies providing these services. When making a medium term economic analysis of both GPRS and satellite, the cost of operation of these two services over five years would be far more expensive than to invest in the private infrastructure and equipment necessary to install their own wireless Ethernet network.

Designing a wireless network over this large area was very challenging. EBSA has 12 administration office buildings located throughout the department where customers can gather information on rates, services and quality. Using these administration buildings as repeater sites along with some new repeater locations now available throughout the state provided enough wireless coverage to centralize the corporate information of the company.

EBSA required a product rugged enough to withstand the various climates throughout the state while providing years of reliable operation with minimal maintenance. 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 expansions. Additionally, the wireless network would require enough power to cover long distances over rugged terrain while remaining cost effective for this large scale project. After careful consideration, EBSA and ANDESwireless selected ESTeem Wireless Modems' Model 195Eg for their wireless Ethernet solution.

The ESTeem 195Eg is housed in a NEMA 4, watertight enclosure rugged enough to withstand wind, rain and temperatures from -30 to 60 degrees Centigrade while being directly pole mounted (Figure 3).

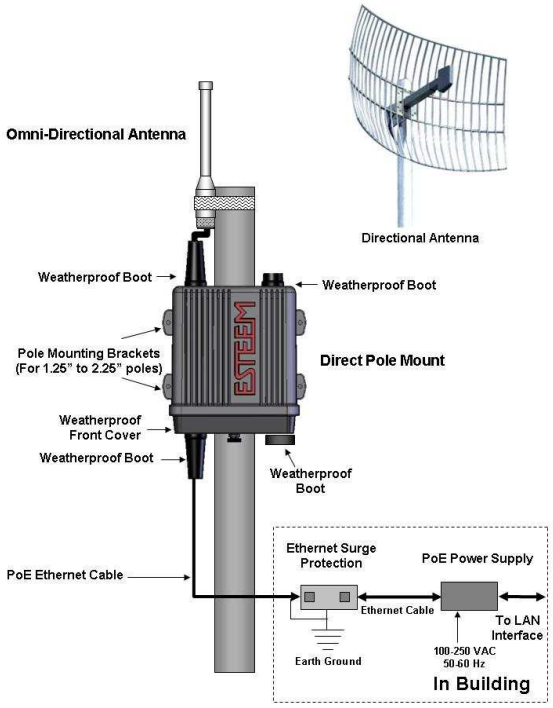

Figure 3. 195Eg Hardware Diagram

Figure 4. 195Eg Repeater Site

The ESTeem 195Eg eliminates the need to purchase enclosures or install expensive coax cable saving EBSA between $900 to $1300 dollars per site. In order to meet the challenge of 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 52km (32.3 miles) required between the hill top repeater sites (Figure 4).

One of the most powerful features of the ESTeem 195Eg is the ability to input multiple communication routes and designate the priority for each of these routes to create a wireless Mesh Network. The 195Eg will automatically change communication routes in the network if a route has failed. The new route will be based upon the priority level set during configuration. This wireless Meshing technology allows the RF network to "self-heal" if any of the communication paths fail. The ESTeem Mesh Network takes out the guessing game by allowing the user to select and prioritize all communication routes in the system

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 to maintain a minimal amount of spares. This unique feature affords customers like EBSA tremendous network

flexibility in addition to saving money. All ESTeem 195Eg radios in the network can be configured as self-healing Mesh repeaters, further extending the overall coverage area adding network redundancy at no additional cost (Figure 5).

In the end EBSA installed 176 ESTeem Model 195Eg wireless Ethernet radio modems in 72 remote locations, including 32 hills and/or repeater sites, with the ability to cover the entire 23,189 km².
The ESTeem 195Eg radios were acquired and installed in three stages. The first stage installed 17 195Eg radios as backup to their existing fiber optic network. This network linked 6 substations, 3 administrative buildings and utilized 2 high, hilltop repeaters. Ranges of these links averaged 10 km (6.2 miles) and were established between the administration buildings and substations to their respective hilltop repeater. The two hilltop repeaters were linked through a back-haul connection at an approximate distance of 48 kilometers (30 miles). (Figure 6)

In the second phase, 145 radios were installed for the integration of 38 substations and 9 administrative buildings with wireless links ranging from 7 kilometers (4.3 miles) to 52 km (32.3 miles). The last and final stage included 14 radios for the integration of 6 substations with links ranging up to 10 km (6.2 miles).

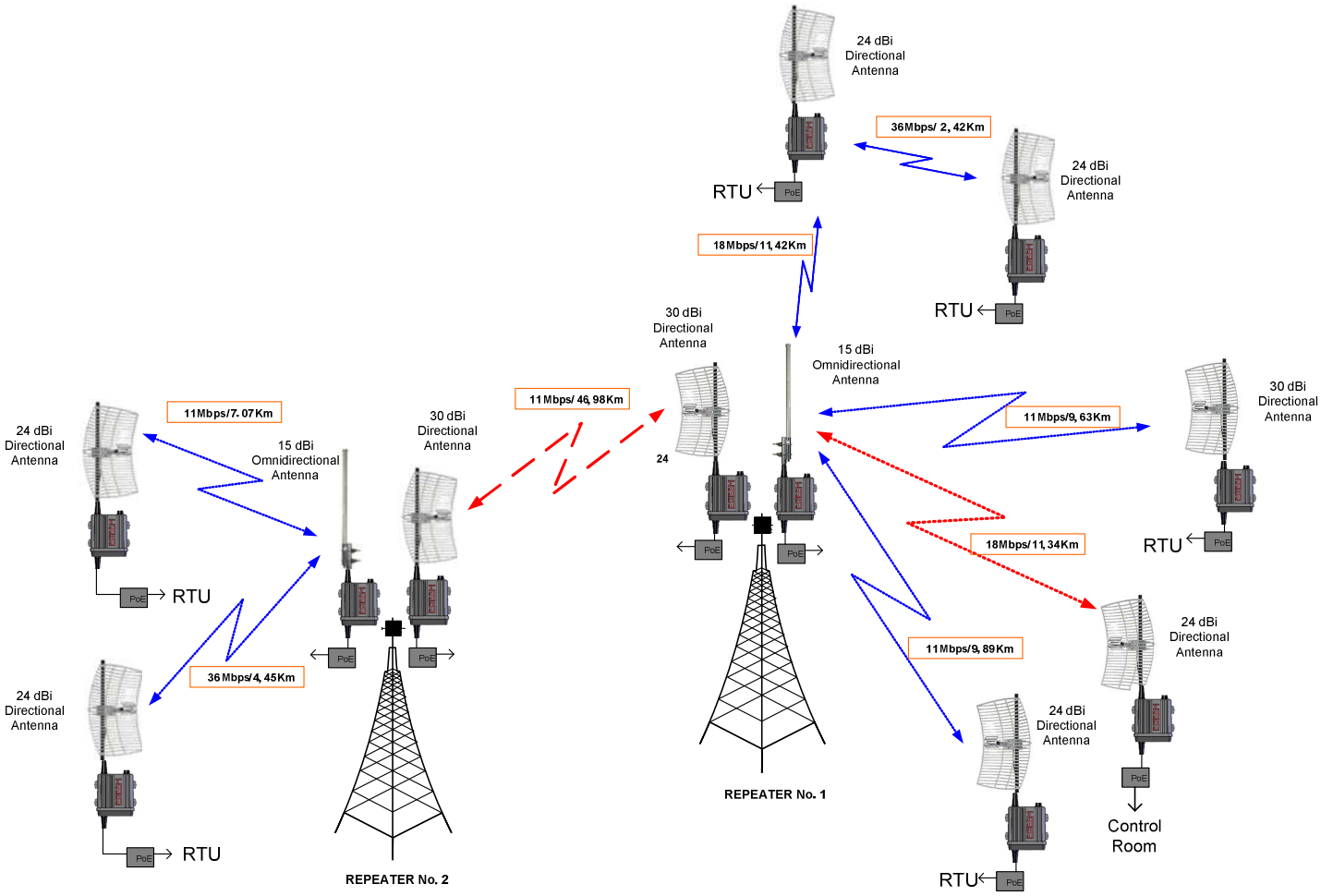

Figure 5. Wireless Network Layout

Each phase of 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 site'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.

Figure 6. EBSA Building No. 1

Phase 2. On-Site Radio Survey

After the design study was approved by the customer, an on-site radio site survey was conducted by physically testing all wireless links between networks. Site survey testing includes measuring received 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 to make any site adjustments if an on-site problem is identified.

Because of the large coverage area required on the site survey, several groups of engineers traveled to the remote sites and repeater nodes within a single area of coverage to install and configure the ESTeem 195Eg radios temporarily while testing the connectivity between the sites themselves. After the entire test passed, proving the connectivity between sites was successful, the engineers moved to the next area of coverage. After the viability of communication was confirmed in two areas of coverage, the communication between repeaters in each area of coverage was tested to ensure interconnectivity between them. Due to the complexity of the terrain and mountains that blocked the line of sight, additional test were required between some repeaters so that the farthest remote sites could be linked.

When all testing was completed and wireless routes established, ANDESwireless presented a formal site survey report with all testing information and installation plans to EBSA.

Phase 3. Installation/Commissioning

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

The purpose for all this extensive testing is to provide a reliable wireless network that will be the "backbone" for all communications in the power distribution network. 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.

With all communication testing complete and a plan for installation secure for each link, EBSA bought the radios through ANDESwireless – Colombia. ANDESwireless installed, configured and put into operation the network that allows EBSA to control, monitor and transmit information to 72 remote nodes from a centralized control room. The EBSA 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.

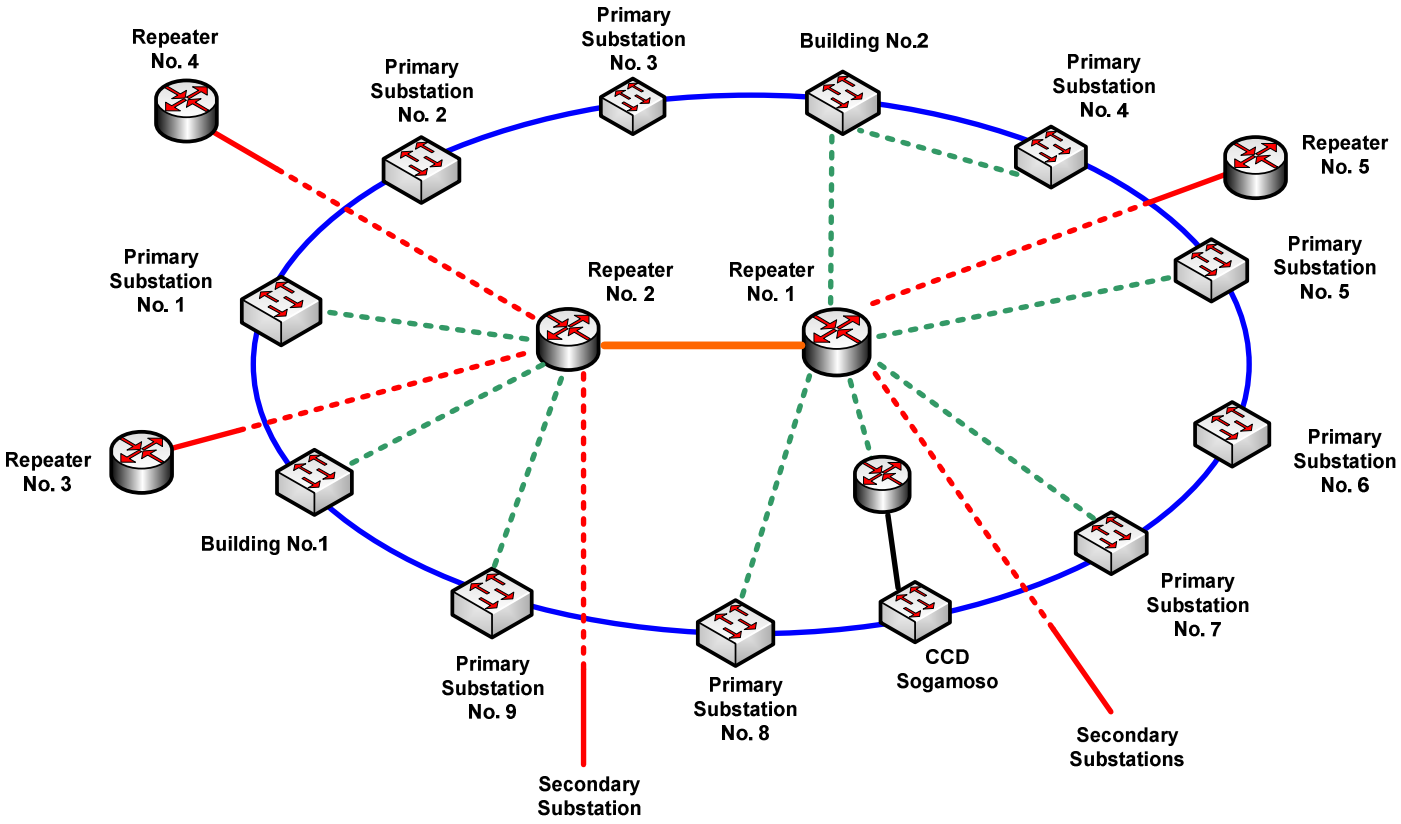

Figure 7. EBSA Network Topology