PUBLIC SAFETY PSWN PROGRAM WIRELESS NETWORK

Saving Lives and Property Through Improved Interoperability

Consolidated Radio Site— Red Lodge, Montana Volume I

A Solution for Public Safety Wireless Interoperability

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1. INTRODUCTION

The Public Safety Wireless Network (PSWN) Program works with public safety agencies nationwide to help achieve interoperability—seamless, coordinated, integrated public safety wireless communications that promote safe, efficient protection of life and property. The PSWN Program works with the public safety community to improve the interoperability of wireless communications by promoting coordination and partnerships, seeking funding alternatives, advocating adequate public safety spectrum allocations and efficient spectrum use, supporting technical standards development, and fostering secure communications.

The development and implementation, for proof-of-concept purposes, of technical solutions for interoperability among public safety networks is one of the PSWN Program's main areas of activity. These solutions, which are initiated as pilot projects in various regions throughout the country, are developed jointly by the PSWN Program Management Office (PMO) and public safety radio and operational personnel from the region. The individuals involved most directly in pilot development and operation constitute the pilot's Integrated Program Team, or IPT. IPT members focus the pilot effort and technical concept to be proven into a discrete, repeatable solution for an interoperability shortfall common among public safety agencies throughout the Nation. This approach allows the PSWN PMO to leverage the solution beyond the pilot region, and more broadly, to benefit the public safety community as a whole.

The PSWN Program supported a site consolidation project in the State of Montana. This effort stemmed from a statewide initiative to enhance and upgrade wireless communication systems integral to the safe and efficient completion of public safety missions. The PSWN Program sponsored the upgrade of this initial site to foster resource sharing and interoperability, and to assist the State of Montana in launching a repeatable site collocation effort. The goal of the upgrade was to assist multiple public safety agencies in consolidating their radio resources within a single, new shelter on Palisades Ridge near Red Lodge, Montana. Sharing of frequencies by multiple agencies was not part of the consolidation. After the various federal, state, and local public safety agencies have been fully integrated into the new shelter, two of the aging, adjacent electronic sites will be removed. This change will reduce the overall Palisades Ridge electronic site footprint while improving the overall quality and reliability of the radio communications service provided.

The PSWN Program assisted the Montana IPT with the technical details for the radio equipment (e.g., antenna subsystem design and intermodulation analysis) that will be installed in the consolidated shelter. Potential site users were surveyed to determine site requirements, including room capacity, layout, backup power, heating, ventilation, air conditioning, and future needs. This information was used to create a set of requirements that led to development of a statement of work and specifications for a site tower and shelter and their installation. Bids were

solicited and contracts awarded. The new tower and shelter were installed on Palisades Ridge in August 2001.

The remainder of this volume of the report is organized into the following sections –

- **Preparatory Actions**—Preparatory actions included selection of a site for the pilot project, data gathering from involved agencies, and achieving a consensus from those same agencies on the tower and shelter requirements and location.

- **Vendor Selection**—Vendor selection involved contracting for a geotechnical report (i.e., a core sample of the soil at the site), developing detailed specifications and a statement of work for the tower and shelter and their installation, soliciting and evaluating bids, and awarding a contract.

- **Implementation**—The installation phase consisted of reviewing and approving the vendor's detailed design drawings, intermodulation analysis, antenna subsystem design, and monitoring the work as it progressed.

- **Photographs**—Photographs included here, among others, are of the tower, shelter, and support equipment inside the shelter.

- **Conclusions and Observations**—The project conclusions include observations compiled throughout the course of the Pilot Project implementation effort.

2. PREPARATORY ACTIONS

The State of Montana provided the PSWN Program with an excellent opportunity to demonstrate how site consolidation could be implemented effectively. In particular, the IPT identified the radio frequency (RF) site along the Palisades Ridge at the Red Lodge Ski Area, which is 6 miles west of Red Lodge, Montana, as a strong candidate for consolidation because of the multiple local, state, and federal users currently operating radio equipment at the site. Multiple shelters, towers, and antennas were in use, and a cooperative environment existed among the agencies using the site.

The IPT collected the requirements of the six public safety agencies participating in the consolidation effort and used them as the basis of a new shelter and tower design. These six agencies included—

- Bureau of Land Management
- Carbon County
- Federal Bureau of Investigation
- Montana Department of Transportation
- Montana Highway Patrol
- U.S. Forest Service.

Based on the collective input from all of the participating public safety agencies, as well as from the PSWN Program, the IPT developed a statement-of-work (SOW) for purposes of soliciting quotations from vendors. The SOW called for a 52-foot tower and a 22-foot by 12-foot shelter. The tower specification included provision to allow future modification to extend its height to 100 feet. The shelter specification called for a robust structure capable of withstanding the harsh weather conditions present at the site as well as for efficient environmental control. The specification included battery backup, nominally sized for 72 hours.

3. VENDOR SELECTION

The IPT selected Rohn Industries to provide the shelter and tower. Rohn subcontracted the installation to Colton Towers. The purchase order issued covered an SSV Series hot dip galvanized, self supporting tower, a 12-foot by 22-foot by 9 foot concrete shelter, and installation. The selected tower is the bottom 52 feet of a 100-foot standard tower and is capable of being extended to 100 feet.

The structure was designed to accommodate the following loads:

- One PD220 antenna (or equivalent) step mounted at the tower top (100 feet) and fitted with one 7/8-inch transmission line.
- Three 6-foot diameter standard microwave dish antennas, with radomes, leg mounted at the following three elevations: 32 feet, 38 feet, and 48 feet. A single 1-5/8-inch transmission line feeds each of these antennas.
- The very high frequency (VHF) antenna and the three ultra high frequency (UHF) antennas are mounted on a 12-foot low-profile rotatable leg mounting frame assembly at the 25-foot and 45-foot elevations. A single 7/8" transmission line feeds each of these antennas.

The shelter includes power distribution panels, lighting, grounding, heating, air conditioning, ventilation, cable ladders, and a backup battery plant with associated chargers capable of providing 30 amps of power at 12 VDC for 72 hours. The shelter construction is 4-inch rebar reinforced concrete that is bulletproof from a distance of 15 feet and has a 2-hour fire rating. Rohn based its projected time frames for installation on standard soil conditions and good site accessibility for the trucks and cranes required to complete installation.

4. IMPLEMENTATION

A geotechnical survey of the site was commissioned, and the task was subcontracted to Maxim Technologies, Inc. of Missoula, Montana. Maxim determined the condition of the soil at the site in accordance with guidelines set forth by Rohn Industries. Maxim did a single test boring at the site and provided its report on July 26, 2000. Maxim reported that "the site consists of silty clay topsoil with some gravel to a depth of 1.5 feet. The topsoil is underlain by dry, silty, subangular gravel to a depth of 15 feet, the maximum depth of the boring. The relative density of the gravel is very dense from a depth of 4 to 15 feet." Maxim planned to bore to a depth of 25 feet, but encountered what was assumed to be bedrock at a depth of 15 feet and went no deeper. Rohn recommended the use of a mat-type foundation.

Rohn Industries developed a tower foundation design based on the geotechnical report and submitted it for approval. The proposed tower foundation consisted of a 19-foot by 10-foot by 4.5-foot concrete pad to be placed directly on the silty clay with gravel to support the tower's structural loads. The Forest Service indicated that material removed during excavation would have to the trucked off the mountain because of environmental concerns associated with spreading the dirt at the site. That, along with rising concerns about the potential for forest fires in the area (Class 4 restrictions were in place) led to a request for a different foundation design. Rohn Industries returned with a "pier and pad" design that required far less excavation and provided superior performance.

The Bureau of Land Management's (BLM) existing shelter and tower were located where the new shelter and tower were to be installed. The IPT temporarily relocated the BLM equipment while the old shelter was demolished and the new shelter was installed. The BLM equipment was temporarily housed in the Montana Department of Transportation facility, located approximately 100 yards away.

At this point, the IPT indefinitely postponed installation of the tower and shelter, scheduled for mid-August 2000, because of the breakout of a wildland fire in the Red Lodge area. Work at the site did not resume until October. At that time, Colton Tower installed the tower. Due to significant snowfall and to avoid interfering with the operations of the Red Lodge ski area, installation work then ceased for the winter. In June 2001, Colton Tower installed the foundation for the shelter and in July Rohn transported the shelter to Billings, Montana. Colton Tower's delivery of the shelter to the site proved to be difficult, requiring road modifications to accommodate the equipment and trailer needed for the installation.

The grounding system for the site was designed to minimize the risk of damage from lightning and to provide a sound single-point ground for the installed radio equipment. The contractor dug a trench around the tower and shelter to a depth of approximately 48 inches (frost line) and laid Number 2, tinned solid copper wire at the bottom of the trench. Solid copper, 8' x

5/8", grounding rods were buried into the ground and the tops were cadwelded to copper wire ring. Approximately 14 of these rods were installed. The contract backfilled the trench once all connections were made. Upon completion, the site ground was demonstrated to provide less than 5 ohms of resistivity. (Note that measurement of the resistivity in late summer should provide a worst-case measurement because it is the driest time of year.) Each of the tower legs was connected to the site ground using Number 2 tinned solid copper wire. All connections were cadwelded.

The shelter grounding system consists of two parts: halo and equipment. The halo ground was formed by installing a copper wire ring around the inside of the shelter, along the wall, just below the ceiling. To this ring, the heating, ventilation, and air conditioning (HVAC) equipment and all vertical metal components of the shelter (excluding those that are part of the power system), were connected. The halo was connected to the site ground by running wire from each of the four corners of the shelter to the floor, then through a conduit, and then welding the wire to the buried ring. Thus, the equipment ground design provided a single point at which all electrical grounds converged. A copper plate was used to accomplish this single-point grounding, and it was located inside and outside of the tower end of the shelter. The cable ladder and all power system components were then connected to this single point. A single tinned copper wire was then run from the exterior plate to the site ground and cadwelded into place.

Intermodulation analysis and antenna subsystem designs were completed based on the frequencies provided by the participating organizations. The objective of the intermodulation analysis was to determine whether the frequency of any intermodulation distortion products coincided with or was adjacent to a receive frequency. These distortion products occur when transmit signals impinge on nonlinear junctions. Proper antenna system design can mitigate or even eliminate the impact these distortions if their presence is known and if they are not generated outside the antenna system. Use of isolators on transmitter outputs and filters on receiver inputs can mitigate antenna system generation distortion products.

The antenna subsystem design's goal is to develop a design that accounts for intermodulation distortion products, if they are present, and prevents transmit sideband noise and transmit signals from desensitizing (desense) colocated receivers. Transmit sideband noise is reduced by bandpass cavity filters on transmitter outputs. Transmit signal desense of receivers is reduced by bandpass cavity filters on receiver inputs and by careful spacing of antennas on the tower. Physical separation is the key factor in spacing, so minimizing the number of antennas is also important. The Red Lodge site will have four UHF transmit and receive frequency pairs on separate directional antennas with duplexers for a total of four UHF antennas. The site has eight VHF transmit and six VHF receive frequencies. All the VHF transmit signals will be combined onto a single omnidirectional antenna as will the VHF receive signals. This arrangement gives a total of two VHF antennas. Cavity filters and isolators will comprise the transmit combiner. Cavity bandpass and possibly notch filters will comprise the receive signal distribution.

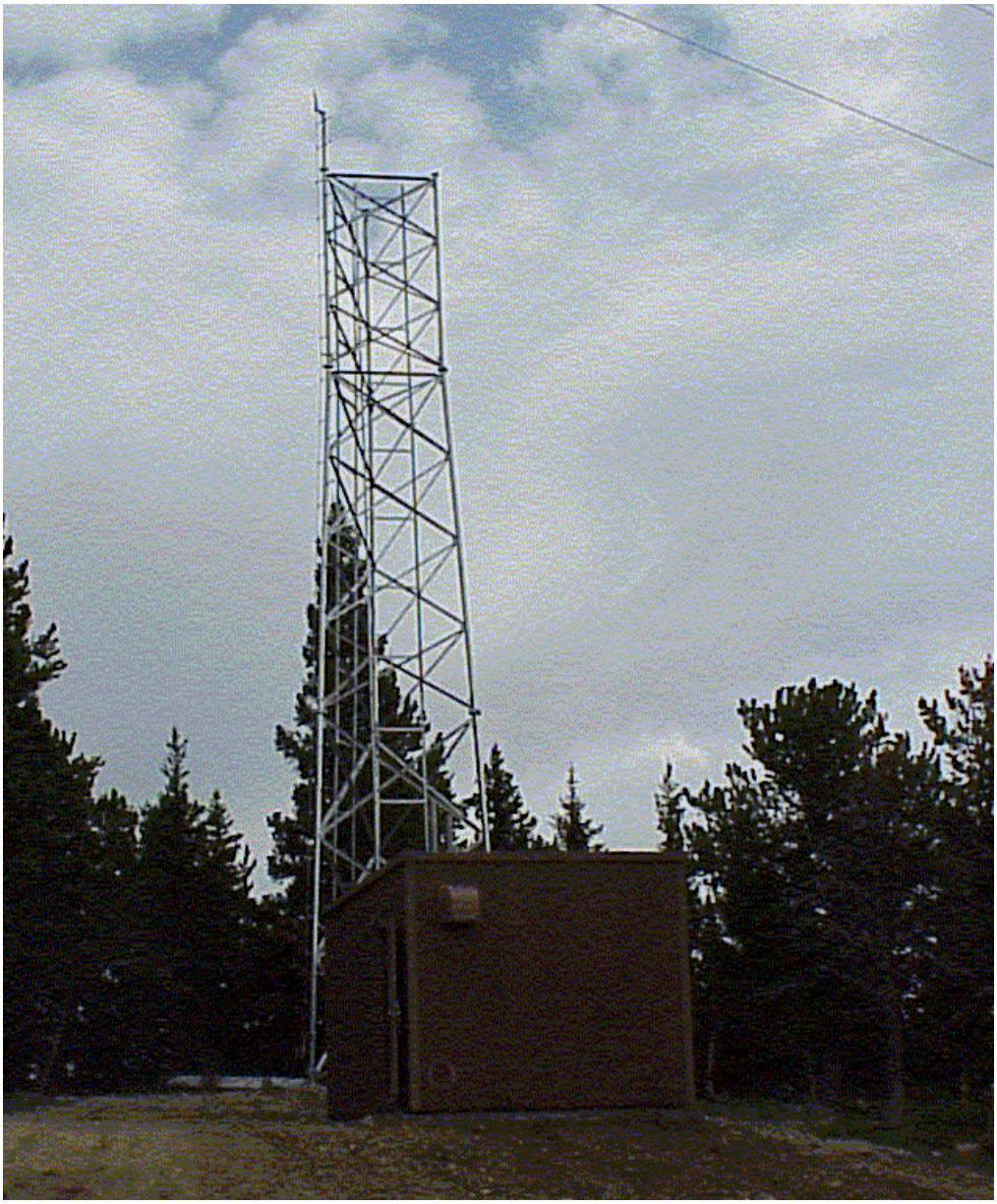
Final acceptance of the site involved a step-by-step comparison of the installed shelter and tower against the approved drawings. Deficiencies were identified and resolved. These deficiencies included—

- Fire extinguishers were not installed
- Tower climbing harness was missing
- External GFI outlet was not installed
- External light fixture was not installed
- Backup generator connector was not installed
- Site Ground System not was installed
- Shelter Ground System was not installed correctly
- Main power was not connected.

5. PHOTOGRAPHS

5.1 Tower

The tower is a self-supported structure standing 52 feet tall. Step bolts for climbing are installed on one of the three legs of the tower. A safety-climbing device is installed on the same leg. It can be seen in the photograph extending slightly above the main tower. An additional 48-foot section can be added to the tower to bring the total height to 100 feet.



5.2 Main Power

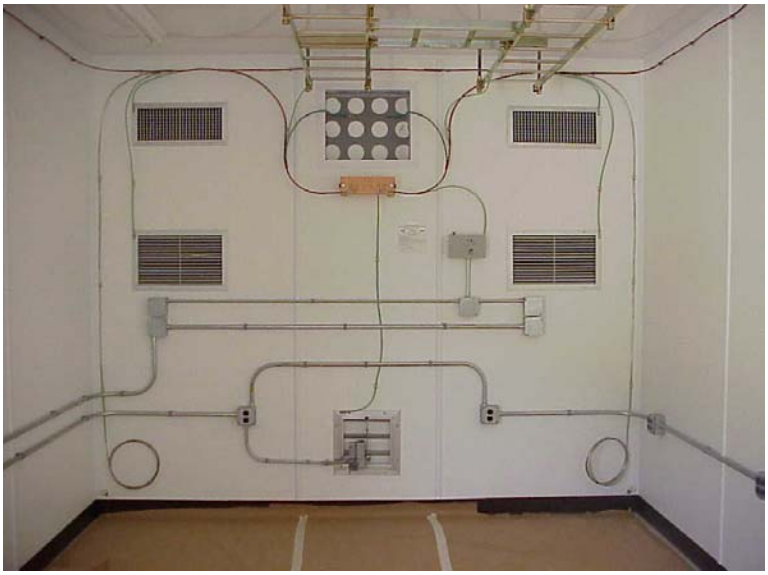
Commercial power is delivered to the shelter via underground cables routed from the electrical pole shown in the right side of the top picture. A meter is installed adjacent to the door of the shelter. Two load centers are provided: a 200A single phase 40-position unit and a 100A single-phase 20-position unit. In addition, a 200A manual transfer switch, lightning arrestor, 20A the exterior GFI duplex receptacle and 200A 4-pin generator plug were provided. Inside the shelter, nine 120VAC duplex receptacles are provided.

5.3 Back-up Battery Power

Six 12V batteries in conjunction with two SCR125100 battery chargers provide backup power. These batteries are designed to provide 30.4 A of power, at 12VDC, for 72 hours. This backup system is located at the end of the shelter near the door, as shown in the picture below.

5.4 Heating, Ventilation, and Air Conditioning (HVAC)

HVAC is provided by two 24,000 BTU wall-mounted air conditioners with 4 kW heat strips. These units are installed at the shelter end closest to the tower, on either side of the 12-port waveguide entry. A 12-inch motorized intake louver, with filter, is installed at the base of the shelter between the two HVAC units.



6. CONCLUSIONS AND OBSERVATIONS

The project saw the successful consolidation of the radio equipment from multiple public safety agencies into a single shelter and tower. Rollout of additional projects throughout Montana is anticipated, but none are currently funded.

The PSWN Program made the following observations during the course of the pilot project:

1. It is very important to maintain the continuity of a single point of contact (POC) for the duration of the job whenever possible. By maintaining consistent POCs during the project, there is less likelihood of confusion about requirements and design issues. A single POC with the contractor performing the installation is of particular importance. Confusion regarding where holes should be dug, what trees can be removed, how grounding should be installed, etc. can arise when more than one source is providing direction.

2. Site geography must be considered for scheduling and planning purposes. Heavy equipment movement must be timed to coincide with dry weather, but sufficient schedule margin must be given to accommodate natural occurrences associated with dry weather such as wildland fires. Further, if the site is located in northern latitudes, sufficient schedule margin must be planned for installations that will extend through winter months (i.e., during periods of site inaccessibility due to heavy snow pack).

3. A process for documenting key design decisions should be used to ensure traceability of requirements. This process should include, at a minimum, a description of the decision made, what trade-offs were considered, why the decision was made, and who was involved.

4. A configuration control process should be used to ensure that all parties involved in the consolidation are aware of what the design baseline is, and what changes are being made.

5. The geotechnical survey should be completed for multiple locations at the site, and the results should be given to the tower and shelter installer prior to issuing the purchase order. In this way, the installer will be better able to estimate and quote the job. In addition, the survey should include resistivity tests to aid in the grounding system design.

6. All constraints that might be present at the site should be identified and discussed early on in the project and made part of the request for proposals for the installer. These constraints might include tree removal restrictions, required road improvements, water control, access restrictions, etc.

7. The HVAC system requirements should be carefully considered relative to the weather conditions and elevation of the site. Severe weather conditions related to ice and snow or extreme heat should be considered.

8. The grounding system should be designed and documented carefully, using the geotechnical survey resistivity data.

9. The IPT should conduct a site survey at the beginning of the project, at the time of the geotechnical survey, and during any excavation, to ensure compliance with requirements.

10. An acceptance test checklist should be developed to ensure compliance with all requirements.