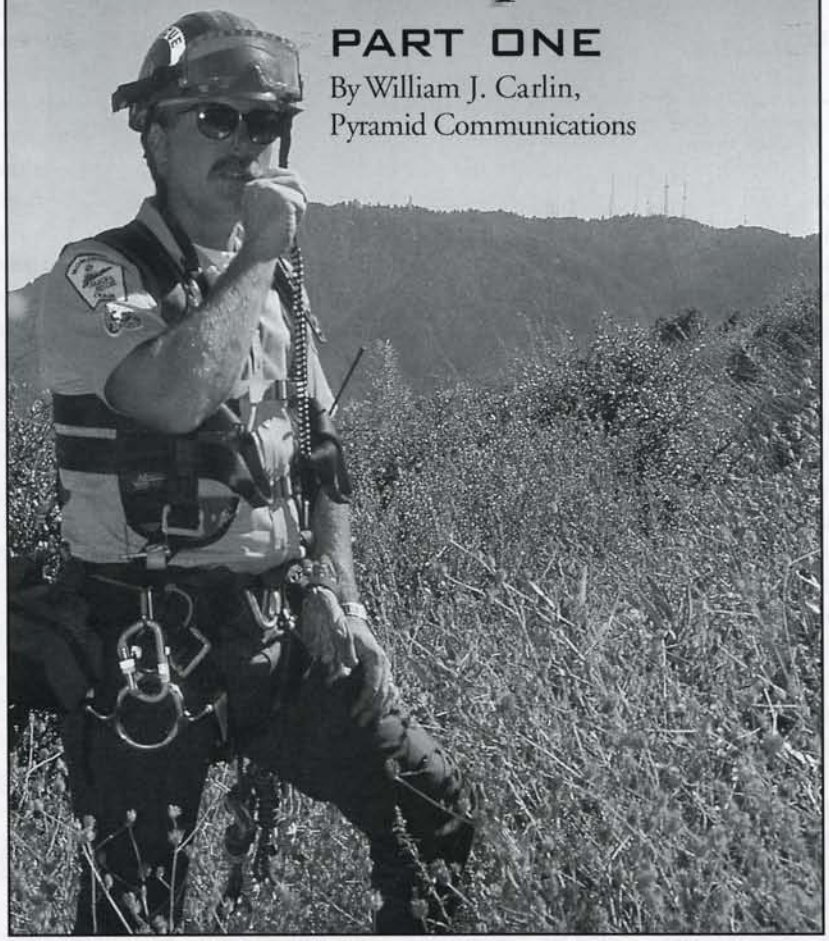
RadioResource™ MAGAZINE

SYSTEM SOLUTIONS FOR MOBILE COMMUNICATIONS—AUGUST 1996

Search & Rescue Teams Gain with Vehicular Repeaters

PART ONE

By William J. Carlin,
Pyramid Communications



When most people think of Southern California, they picture rows of palm trees, sprawling freeways and endless beaches. While all of these can be found in the City of Angels, Los Angeles basin is also surrounded by three separate mountain ranges that make up some of the most rugged wilderness in the country. The mountains are home to numerous hik-

ing trails, bike paths and campgrounds, and are habitats for bears, mountain lions and coyotes.

"The last repeater enabled is always the priority repeater. This is commonly referred to as 'last man out.' "

Every year, the country's busiest search-and-rescue team must pull hundreds of stranded hikers, tourists and campers out of harm's way, including people who have injured themselves rock climbing or in a fall, or perhaps stranded by a sudden snowstorm in the Angeles National Forest. Brush fires are also a constant threat, especially during the dry autumn months. Reliable radio communications in this diverse environment can be challenging at best. Handheld communications inside a canyon or behind several mountain ridges is virtually non-existent. One Southern California agency has adopted a way of improving its handheld communications using vehicular repeaters for search-and-rescue operations.

A vehicular repeater extends handheld communications by connecting to an existing high-power mobile radio and repeating conversations in both directions. When the mobile radio is receiving, the vehicular repeater will transmit the mobile receive audio to the handheld on a simplex frequency different from the mobile radio. When the handheld transmits to the vehicular repeater, the repeater will key the mobile radio and transmit its receive audio to the base, effectively giving the handheld the same range as the mobile radio.

This technique allows rescuers like Rick Homan, who works for what is said to be North America's busiest search-and-rescue unit, to carry a minimum amount of radio equipment when scaling steep inclines or working with an injured person.

In single-vehicle applications, this technique works quite well, even with multiple handheld operators working off the same vehicular repeater. During a rescue operation, one vehicle can be parked at a central location, usually on high ground where all handheld traffic can reach it. The vehicular repeater operates on simplex frequencies, most often in a different frequency band than the mobile.

Any radio traffic received by the mobile will be rebroadcast by the vehicular repeater to all of the handhelds on site. Any handheld that transmits will be received by the vehicular repeater and rebroadcast by the mobile to the base or main repeater. As long as the handhelds remain within range of the vehicular repeater (typically up to one or two miles from the vehicle), they maintain reliable communications with the base even if they are up to 50 to 60 miles away.

However, if more than one mobile equipped with a vehicular repeater arrives at the scene, some method of preventing radio collisions must be implemented (if one handheld keys up, both vehicular repeaters may respond by keying both mobile radios). Some vehicular repeaters have on-board logic to prevent this situation by establishing one mobile-repeater pair as the priority vehicle that handles all radio traffic.

All other mobile repeaters will be on, but at non-priority status and will not repeat in either direction. If the priority repeater leaves the scene (or is shut off), the other non-priority repeaters will sense the lack of a priority repeater during base-to-handheld or handheld-to-base transmissions, and one and only one repeater will take over as the new priority. This multi-vehicle format involves a fair amount of logic, and some vehicular repeaters employ microprocessors to handle all of the various situations that must be processed by the repeater logic.

Multi-Vehicle Format

When the vehicular repeater is first enabled, it transmits a short-tone burst; the tone has two functions. It alerts the handheld operators that the repeater has been enabled, and it is a signal to other vehicular repeaters. When the first unit arrives and is enabled, it transmits its tone burst and assumes priority status. Another repeater arrives and does the same; the first repeater decodes the tone burst from the second, assumes a non-priority status and increments an internal counter that indicates its position in the non-priority hierarchy. As each repeater arriving on the scene is enabled, all other repeaters previously enabled increment their counters, each with a unique count in the non-priority status. The last repeater enabled is always the priority repeater. This is commonly referred to as "last man out."

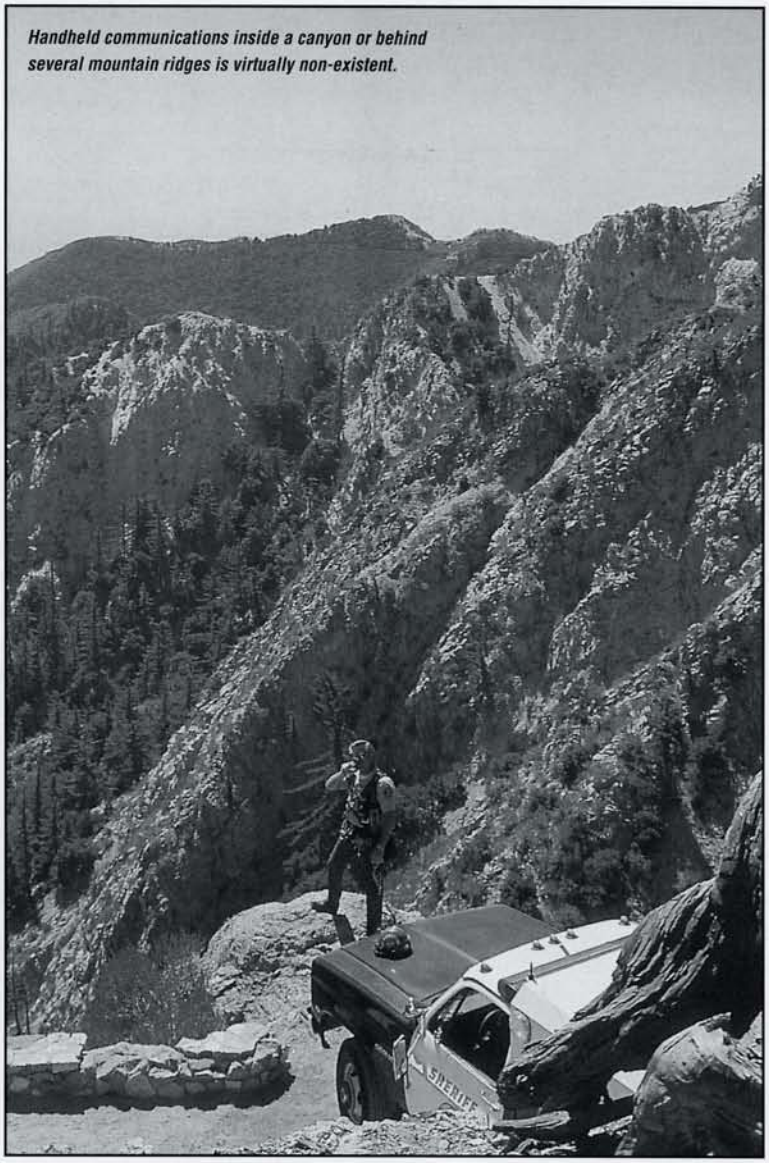
"During a rescue operation, the handheld operator may need to speak with several agencies."

If the non-priority repeater leaves or is disabled and a condition to repeat ex-

ists, the other vehicular repeaters will sense the repeat condition and will monitor the channel for the priority repeater. If they do not see transmissions from the priority repeater within a predetermined time, they all will start decrementing their internal counters until one of them reaches priority status (count=0). Since they all have unique counts based on when they were enabled, only one repeater will reach priority status and begin repeating. The other repeaters will see the new priority repeater transmitting and cease counting down, preserving the non-priority hierarchy.

When the priority repeater is transmitting base to handheld, it will periodically cease transmissions to check for handheld or other repeater activity on the channel. If it detects handheld transmissions (carrier and proper tone), it will switch to handheld-to-base repeat mode and key the mobile so the handheld is given priority in a conversation. This allows the operator to respond during hang-time from the main mobile repeater. If the vehicular repeater detects another vehicular repeater (carrier with no tone), it will cease transmissions, increment its counter and assume non-priority status. This is a self-clearing mechanism built into the repeaters to prevent radio collisions in case another priority repeater arrives already enabled from a different scene.

When the vehicular repeater is receiving a transmission from the handheld, it keys the mobile radio to rebroadcast the message to the base. Since the mobile radio is in transmit, any personnel still in the vehicle will not be able to hear the handheld-to-base conversation, only the reply from the base. Similarly, if the person in the vehicle keys the mobile to talk with the base, the handhelds will not hear that side of the conversation since they are on a different frequency. The vehicular repeaters used in LA County have a local speaker output that allows the person to monitor the handheld side of the conversation and will repeat the local mic audio from the mobile over the vehicular repeater link to the handheld. In this way, both parties will hear both sides of the conversation.



Handheld communications inside a canyon or behind several mountain ridges is virtually non-existent.

During a rescue operation, the handheld operator may need to speak with several agencies, especially during a brush fire involving many fire companies, police and sheriffs departments, and ambulance operators. Since the handheld repeater link operates on simplex frequencies and usually on a different band than the mobile radio, the user will need some way to change channels on the mobile without having to return to the vehicle.

The Southern California rescue operations have the capability to remotely change mobile channels by using a DTMF pad installed on the handheld radios. By entering "*" plus a two-digit channel number from the handheld keypad, any number of mobile channels can be remotely selected (up to 99). The vehicular repeater will also announce the selected channel number over-the-air in a synthesized voice, confirming operation to the user who changed the channel and alerting all other users on the link that the mobile channel has changed.

When paramedics are on-scene and out of their vehicle, they may have difficulty transmitting back to their base or to the hospital using only a handheld radio. This is especially true when they are inside buildings or are responding to an incident in the surrounding mountains.

The vehicular repeater allows them to maintain contact with their base or with the doctors at the emergency room to relay patient information or receive orders for medication.

In Los Angeles and Orange counties, the paramedics call in on a "hailing" channel to obtain a base hospital frequency assignment. Once the channel has been assigned, the paramedic changes the mobile channel using the DTMF keypad on the handheld. The paramedics may also send EKG telemetry information through the vehicular repeater using a handheld equipped with an EKG modulator. The modulator translates the EKG signals into tones that will pass through a normal 25 kHz radio channel and can be decoded for display back at the emergency room.

Agency Use

Many of the county agencies have switched to 800 MHz trunking for their communications systems. While this generally improves channel usage and gives them adequate coverage in the city, they can experience difficulty when using handhelds inside steel buildings or in the mountains surrounding Los Angeles.

One county agency's situation involves the supply of water. Most of the water supply for Los Angeles is piped in from other locations around the state via the aqueduct system and is stored in reservoirs located in the mountains.

The water department cannot reliably communicate with handhelds from many of the dam sites located deep within the canyons north of the city. A vehicular repeater connected to their high-power trunking mobile radio allows them to stay in contact using a low-power UHF handheld.

There are several obstacles to overcome when connecting a vehicular repeater to a trunking mobile. The vehicular repeater must be able to monitor the trunking radio transmitter in order to determine when a voice channel has been successfully acquired; otherwise part of the transmission may be cut off. Since users cannot see or hear the trunking mobile, they must be advised when the radio has acquired a voice channel, when the system is busy, or if the call attempt fails. The microprocessor in the vehicular repeater can detect these situations and generate the proper call progress tones to the handheld user.

"There are several obstacles to overcome when connecting a vehicular repeater to a trunking mobile."

When handheld users wish to call the base or another vehicle, they key their portable briefly, then release. The vehicular repeater will then attempt to acquire a voice channel by keying the trunking radio while monitoring the mobile transmitter B+ line. If it does not sense the mobile transmitting at all (system is busy), it will unkey the mobile and send a busy tone to the handheld. The repeater will then retry automatically every five seconds until successful, or time out (30 seconds). If unsuccessful, the repeater will transmit error tones to the handheld to alert the user that the call attempt has failed.

When the repeater senses that the mobile is transmitting, it continues to monitor the on-air sense line to ensure that the mobile is not merely handshaking or retrying. When it detects that the transmitter has remained on the air uninterrupted for more than 300 msec, it has successfully acquired a voice channel and will send a go-ahead blip to the handheld while continuing to hold the mobile PTT line active.

The handheld user must then respond within two seconds and their transmission will be repeated as normal. If they do not key up within the two-second period, the repeater will unkey the mobile and send error tones to the handheld to indicate call failure. In order to ensure that the handheld operator hears the queuing tones, the repeater will wait until the handheld has unkeyed before sending any call progress tones. This system of positive channel acquisition works much better than the long PTT delay used by some vehicular repeaters.

Southern California has had its share of natural disasters in the recent past. Los Angeles has experienced earthquakes, floods and brush fires in addition to the "routine" rescue operations that occur in the city and surrounding mountain areas. The country's busiest search-and-rescue operation relies heavily on its communications capabilities to save lives and property. Vehicular repeaters play a vital role in those capabilities by providing wide-area coverage from low-power handhelds in a hostile terrain. Other public safety operations may find vehicular repeaters to be a valuable enhancement to their communications strategies. ***RR***

Part 2 of this series will focus on how a county agency overcame the problem of interagency communications in Southern California during the riots of 1992, the fires and floods in 1993 and the Northridge earthquake in 1994.

William J. Carlin is president of Pyramid Communications, a manufacturer of vehicular repeaters and data transmission equipment. Carlin has been an engineer in the land mobile and telecommunications industry for 15 years, and has worked for Southwest Bell, Standard Communications and Yaesu.