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REVIEW ARTICLE

Wilderness Communications

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When an emergency situation arises in a remote location, the ability to communicate with outside sources of assistance can prove very valuable. This article reviews the different types of communications technologies available to individuals in remote locations, including satellite telephones, personal locator beacons, satellite messengers, cellular telephones, and the different licensed and non-licensed 2-way radio services available for personal use. It also discusses basic radio communications techniques, emergency communication, requesting ground or air casualty evacuation, and selecting communications devices for different applications.

Key words: wilderness communications, emergency communication, radio communications, satellite communications, casualty evacuation, helicopter evacuation

Introduction

When an emergency situation arises in a remote location, the ability to communicate with outside sources of assistance can prove very useful. Direct communication can be used to obtain medical advice, arrange the evacuation of an ill or injured person, communicate within a party, or permit notification of family members that a delayed party is safe. This article discusses the ever-expanding range of communications technologies available to individuals in remote locations. It also reviews basic radio communications techniques, emergency communication, requesting ground or air casualty evacuation, and selecting communications devices for different applications.

Methods

A review was performed of the wilderness medicine, search and rescue (SAR), emergency medical services (EMS), air medical, wilderness recreation, emergency communications, and amateur radio literature for information related to the use of communications technologies in remote settings, using the PubMed, MD Consult, CINAHL, JSTOR, and Google Scholar databases, and the archives of *QST*, an amateur radio journal that is not indexed in the listed databases. Key words and terms used in the search included: *wilderness communications, remote communications, emergency communication, satellite communications, radio communications, emergency radio, distress signaling, personal locator beacon, search and rescue,* and *helicopter evacuation*. Recent related print references were reviewed, and a web search was conducted for current Federal Communications Commission (FCC) regulations and other pertinent information. The search results were evaluated for usefulness and applicability to the topic, based on the author's experience in SAR, EMS, amateur radio, and helicopter operations.

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Pre-Departure Planning

An important aspect of any trip to a remote location is pre-departure planning, which should include logistical preparation for food, gear, transportation, a review of the capabilities of the group, and an evaluation of the potential risks presented by the environment being visited. These risks may include climate, altitude, terrain, avalanche danger, hazardous plants and animals, endemic diseases, availability of water, and access to roads. Such a risk evaluation assists in tailoring a medical kit to the needs of the trip, and provides guidance in determining the proper course of action should an emergency situation arise.[1]

The planning process should also address communication in the event of an emergency. For mishaps occurring close to a road or a populated area, placing a cellular telephone call or sending a messenger back to the road or

trailhead on foot may be feasible. For progressively more remote locations, decisions need to be made about what types of communication capabilities are desirable, and how much weight, expense, and intrusion into the wilderness experience are acceptable. In general, weight and expense are proportional to the versatility and sophistication of communications technologies. Simpler solutions are usually lighter and less expensive; increasing capabilities or range increase weight and expense.

Another vital component of pre-trip planning is leaving an itinerary with at least 2 reliable individuals who can notify authorities should the party fail to return as planned.[2] This "home team" should know how to contact SAR authorities, what communications equipment the group will be carrying, and the planned methods of contact (radio frequencies, etc).

Radio Frequency Communications Theory

All of the communications technologies discussed in this article are based on radio frequency (RF) signals. Radio frequency waves are a form of electromagnetic radiation, as are light and heat. Radio frequencies are measured in Hertz (Hz), or cycles per second, the number of oscillations every second of the carrier wave. High frequency (HF) radios operate in the 3 to 30 megahertz (MHz) range, very high frequency (VHF) radios in the 30 to 300 MHz range, and ultra high frequency (UHF) radios are in the 300 MHz to 3.0 gigahertz (GHz) range.

For RF communications to occur, there must be a transmitter that takes sound or data, converts it into an RF signal, and transmits it through an antenna. There must also be a receiver that receives the RF signal and converts it back into sound or data. Radios that contain both a transmitter and a receiver are referred to as transceivers. There are 2 important limiting factors that affect RF signals—range and the need for an uninterrupted line-of-sight between transmitter and receiver. Range is dependent on the transmitter's output power, operating frequency, and the size and location of its antenna. Although other factors can affect RF wave propagation, when using the communications technologies discussed in this article, an uninterrupted line-of-sight between transmitter and receiver is required for effective radio communications.[3]

Encoded radio signals allow multiple users to share frequencies. The most common type of encoding is the Continuous Tone-Coded Squelch System (CTCSS). The CTCSS transmits a continuous, subaudible tone along with the regular radio signal. Receivers that have a CTCSS decoder set to that tone are able to receive the transmission, while those without it are not. Some newer 2-way radios have the capability of Digital-Coded Squelch (DCS) encoding that encodes the signal with a continuous stream of digital information.[3]

Communications Technologies

CELLULAR TELEPHONES

Cellular network signals may be present in parts of many remote areas. This can be a valuable resource in an emergency, but is not one that should be relied upon to always be available. Since cellular signals are line-of-sight RF signals, they are more likely to be accessible from high points with a clear view of the surrounding area. Other capabilities found in newer smart phones, such as global positioning system (GPS) and mapping applications, may also be useful in remote locations. Maps should be downloaded to the phone prior to departure, so they will be accessible even if a network signal is absent.

SATELLITE COMMUNICATIONS

Satellite communications technology offers a wide range of applications, including voice, messaging, data, and distress signaling. Direct communication is possible to and from almost any place on the planet. All satellite communications devices must have a clear line-of-sight pathway to the satellite; if the view of the sky is obstructed, the signal may not reach the satellite, or it may be degraded or dropped. When a location with a full view of the sky is not available—such as in a deep canyon or under thick forest cover—a site that offers the least obstructed view should be selected.

Satellite Telephones

Satellite telephones offer direct voice and Short Message Service (SMS) messaging capabilities, and some models also have the capability of 2-way data transfer. In recent years, the size, weight, and cost of satellite telephones have all decreased. Satellite telephones may be purchased or rented, depending on the user's needs. Those considering the purchase or rental of a satellite telephone should thoroughly investigate the different models, coverage areas, and airtime service plans available to determine which option best suits their needs.

Personal Locator Beacons

The Personal Locator Beacon (PLB) is a compact UHF satellite radio transmitter operating on 406.025 MHz. Each PLB transmits a signal encoded with a unique hexadecimal identifier code (hex ID) that is registered to

the specific beacon's owner. Some PLBs also contain an onboard GPS receiver that permits the beacon to transmit its coordinates, resulting in a more rapid and accurate determination of the point-of-origin of the distress signal.[4] There is no fee for beacon registration or service.[5] PLB programs are available in the United States, Canada, most of Europe, Russia, and Australia.[6]

When activated by deploying the antenna and turning on the power, the PLB transmits its hex ID encoded distress signal. The signal is received by one of the Cosmicheskaya Sistema Poiska Avariynyh Sudov (Russian for "*Space System for the Search of Vessels in Distress*")-Search and Rescue Satellite-Aided Tracking (COSPAS-SARSAT) satellites in earth orbit. The satellite identifies the hex ID of the beacon and its position. It then relays this information to a ground station, which, in turn, forwards the message to the Regional Coordination Center (RCC) for the region where the distress signal was detected.[6] The US Air Force RCC located at Tyndall Air Force Base in Florida is responsible for coordinating all inland SAR activities in the United States.[7]

Those considering the purchase of a PLB should investigate the models available. Based on the enhanced accuracy and speed of position-locating offered by GPS-equipped PLBs, the author believes that they are the best choice for all users.

Satellite Messengers

Another device that offers satellite communications for emergency and nonemergency purposes is the SPOT Satellite GPS Messenger (SPOT LLC, Milpitas, CA). The SPOT system utilizes a privately operated network of satellites that are not a part of the COSPAS-SARSAT system. For an annual subscription fee, users are able to send 3 levels of messages: non-emergency "I'm OK" messages, "Help" messages to request assistance without activating outside emergency services, and "911" emergency distress messages. The SPOT Connect is a newer version of the device that, in addition to the functions described above, permits short messages composed on compatible smart phones and GPS devices to be transmitted via the satellite network.[8] Some newer-generation PLBs also provide nonemergency satellite messaging capabilities.

RADIO SERVICES

The FCC designates several different 2-way radio services for personal and emergency use.

The Family Radio Service

The Family Radio Service (FRS) has 14 UHF channels, the first 7 of which are shared with the General Mobile Radio Service (GMRS), and 38 different CTCSS tones. The FRS band may be used for personal or business communication, and no operator's license is required.[9] FRS radios have an output power of 100 to 500 mW, and a range of one half to 1 mile. They are inexpensive and widely available, making them a good choice for youth groups, small group outings, and other short-range applications. Since FRS radios are so widely used, most frequencies can become busy in areas with many users. Channel 1 is the commonly used FRS emergency channel, although there is no FCC-designated emergency frequency.[10]

The General Mobile Radio Service

The GMRS consists of 15 UHF channels: the first 7 are shared with the FRS, while the last 8 are for GMRS use only. An FCC license is required and covers communication between the license holder and members of the licensee's immediate family.[11] Consumer handheld GMRS radios offer a maximum output of 5 watts and, while many manufacturers advertise ranges of 20 to 36 miles, a range of up to 5 miles line-of-sight is a more reasonable expectation. The commonly recognized GMRS emergency frequency is 462.675 MHz (channel 20).[10] Many FRS/GMRS radios also have National Oceanographic and Atmospheric Administration (NOAA) weather radio receivers.

The Citizens Band

Citizens band (CB) radios operate on 40 designated HF channels with a maximum transmit power of 4 watts. Handheld CB radios typically have a range of 1 to 5 miles. No FCC license is required to operate a CB station. The CB is still the most common communication method between commercial truck drivers, which means there is a large pool of potential receiving stations if a distress call needs to be placed. Channel 9 is the FCC-designated emergency channel, and channel 19 is the designated national calling channel.[12]

The Amateur Radio Service

Amateur radio is perhaps the most versatile option among those covered here, but requires that each operator be individually licensed. Amateur radio operators, also known as "hams," are licensed by examination at several different levels, with increasing privileges for

higher levels of licensure. Ham operators may utilize a wide range of frequency bands and may operate handheld, mobile, base, and satellite radios.

A good ham radio choice for wilderness travelers is a compact 5-watt handheld transceiver that covers the 2 m (140 MHz) VHF and 70 cm (440 MHz) UHF amateur bands. Models using lithium-ion batteries are typically much smaller and lighter than those using other battery technologies. Other desirable features include a waterproof case, a wide-band receiver that permits monitoring frequencies outside the amateur bands, a NOAA weather radio receiver, a keypad to permit field programming, CTCSS/DCS encoding and decoding, variable output power, and the capability of memory programming. The standard short "rubber duck" antenna supplied with most handheld ham radios does not deliver the best performance; replacing it with a longer whip antenna will improve signal strength and range.[10]

Many amateur radio clubs and individual hams operate radio repeaters. A repeater is a specialized transceiver located on a high point like a mountaintop, building, or tower that receives a radio signal on the *input* frequency and retransmits it at a higher power level on the *output* frequency.[3] The use of repeaters can dramatically increase signal range, and can bypass obstructions such as mountains, hills, canyons, or buildings. The Amateur Radio Relay League (ARRL) publishes a repeater directory that is updated annually,[13] and many amateur radio clubs list local repeaters on their websites. Investigating repeaters that might provide coverage to the intended route of travel is a worthwhile part of pre-trip planning.

The ARRL Wilderness Protocol is a suggested practice for amateur radio operators who are in remote areas outside of repeater range. It is based on the monitoring of specific frequencies at specific times. The primary frequency is 146.520 MHz (the national ham 2 m emergency and calling frequency), with alternate frequencies in different bands at 52.525, 223.500, 446.000 and 1294.500 MHz. The Wilderness Protocol recommends that amateur operators in remote locations monitor the primary frequency—and the alternate frequencies, if possible—for 5 minutes every 3 hours starting at 7:00 AM (7:00–7:05 AM, 10:00–10:05 AM, etc). Individuals or parties who need assistance can then conserve battery power by attempting to make contact at these times.[14]

International Considerations

If international travel is involved, it is important to obtain the appropriate authorizations from the government of the country(s) being visited for the use of radios, satellite phones, or PLBs. The United States has reciprocal agreements with many other countries that allow US amateur radio license holders to operate while traveling abroad.[3] Laws governing amateur radio and other radio services vary from country-to-country and each operator is responsible for knowing the laws in the intended destination.

Back to Basics

All of the communications technologies discussed so far share a common trait: they are electronic devices that operate on some form of battery power. Therefore, they are all subject to failure. Every wilderness traveler should carry basic, low-tech signaling devices and be proficient in their use. The 3 primary signaling devices everyone should carry are a whistle, a signal mirror, and a reliable method of starting a fire (to produce light and smoke).[2,4] Other simple visual devices such as a strobe light or a brightly colored tarp are also good options.

Radio Communications Techniques

There are a few simple practices that can make a big difference in the effectiveness of radio communications. Handheld radios should be held away from the body with the radio and antenna in a vertical position. If the antenna is in contact with the operator's body, the RF signal strength will be reduced. Holding the radio and its antenna as high as possible will increase the line-of-sight range. The antennas on both transceivers in a radio link need to be in the same plane, or polarization. For VHF/UHF mobile radios, handheld radios, and repeaters, the polarization is always vertical. Having the antennas in different polarities can result in up to a 100-fold loss of signal strength.[15]

To transmit a message, hold the radio 2 to 3 inches from the face and listen for several seconds to ensure the frequency is available. Press and hold the push-to-talk button for 1 second before speaking—this prevents the first word or two of the message from being dropped. Speak slowly and clearly in a normal pitch, using normal vocabulary. Avoid the use of law enforcement "10-codes" and CB radio jargon. It is often a good idea for the receiving station to repeat radio messages back to the sending station to ensure that the message was correctly understood, particularly if the signal is weak or garbled. One should assume that all radio transmissions are being monitored and that anything said on the radio is being said in public.[16]

Emergency Communication

The goal of all wilderness travelers should be self-sufficiency. Having the capability to call for help from a

remote location carries with it the responsibility to do so only if it is truly necessary. If an illness or injury occurs, every effort should be made to manage the situation using the resources of the group. Placing an emergency call by cellular or satellite phone, activating a PLB, or making a radio distress call should be reserved for situations that exceed the capabilities of the party. Search and rescue missions are frequently performed because someone used a cell phone or PLB to place a distress call in a situation that did not warrant it.[17] Search and rescue authorities assume that all distress calls are genuine and respond accordingly. It is also important that one bear in mind that, even though the capability to communicate exists, there is no guarantee of establishing direct communication, or of immediate rescue.

Emergency Communication Techniques

In an emergency situation, all available methods of communication should be utilized. It is advisable to program local SAR and emergency numbers into cellular and satellite phones before departure. Dialing "911" on a cellular or satellite telephone from a remote spot may not direct the call to the appropriate emergency call center for the caller's location. Activating a PLB or satellite messenger will notify SAR or public safety authorities of the location of the party, but not the nature of the emergency. Foot messengers can be sent to the trailhead, the nearest road, a pass, or another point where help, a cell phone signal, or a radio repeater may be available. If a team is going to be sent by ground to a road, or to a location with cellular phone or radio coverage, a detailed written note should be sent with them. This note should include the patient's location, condition, and what type of rescue is indicated (ground evacuation, helicopter, etc). For safety reasons, those leaving a party to go for help should not travel alone, unless there is no other option.

Radio communication should be attempted to any station that may be able to hear the distress message. The radio message should include the nature of the emergency, the location of the party, and what type of assistance is required. When immediate assistance is required, the radio message should be prefaced by repeating the term "Mayday" 3 times, followed by the information listed above. A "Mayday" call indicates a significant emergency and should only be placed under circumstances of life-threatening illness or injury, or of serious or imminent danger.[18]

Attempting to communicate directly with public safety agencies (law enforcement, fire service, EMS, or SAR) using public safety frequencies should be considered only as a last resort. Public safety frequencies are assigned for the exclusive use of the public safety radio license holder. Many amateur radio transceivers may be modified to permit transmitting and receiving across an extended frequency range, including the public safety bands. For some radios, this is a software modification; for others, it requires desoldering a jumper on the radio's main board (physical modification such as this may void the manufacturer's warranty). The FCC does not specifically state that it is illegal to possess a modified amateur radio transceiver, but using one to transmit on frequencies outside the amateur bands is prohibited.[10]

Federal Communications Commission Part 97 rules governing amateur radio also state that, "No provision of these rules prevents the use by an amateur station of any means of radio communication at its disposal to provide essential communication needs in connection with the immediate safety of human life and immediate protection of property when normal communications systems are not available (§97.403)."[19] This may be interpreted to mean that in an emergency situation, when no other method of communication is available, an amateur radio operator may make an emergency transmission on a public safety frequency to request assistance. While this use is legal under FCC rules, amateur radio operators have been prosecuted by local law enforcement agencies under local or state laws for such use.[10]

Casualty Evacuation

When circumstances arise that may require the evacuation of an ill or injured person, the entire situation needs to be critically evaluated. The severity of the illness or injury, the capability of the patient to self-evacuate or evacuate with assistance, and the distances, weather, and terrain involved should all be considered. If a litter or helicopter evacuation is indicated, that information should be communicated to local SAR or public safety authorities by whatever means are available. This message should include as much detail as possible about the situation and the patient's needs. Search and Rescue resources take time to muster and, even if the location is known, it may take a significant amount of time for SAR personnel to locate and access the individual or party in distress. The party must be prepared to manage the situation until additional resources arrive.[20]

Helicopter Evacuation

The decision to request a helicopter evacuation should not be taken lightly. When making this decision, one must carefully evaluate the risks versus the benefits. The primary factor to be considered in all helicopter operations is safety. Helicopter operations in remote or moun-

tainous terrain are inherently risky. When other hazards exist, such as darkness or inclement weather, these risks are multiplied. These conditions can also delay or prevent a helicopter from reaching a remote spot.

If the patient has a life-threatening or time-critical illness or injury, is in an exposed or dangerous location that cannot be easily accessed by ground, or if ground evacuation is not feasible, requesting helicopter evacuation is indicated.[21-23] In situations where these circumstances do not exist, ground evacuation may be more appropriate. The reader is encouraged to consult the *Wilderness Medical Society Practice Guidelines for Wilderness Emergency Care* for a more detailed discussion of the factors to consider when deciding on the appropriate mode of patient evacuation.[23] Helicopter transport is also very costly, and the patient may be charged for the service. Many air medical programs offer memberships that may reduce this expense, should the service be needed.

For helicopter evacuations, communication must be established with the aircraft as early as possible using radio or visual signals. Public safety, SAR, and EMS aircraft are typically equipped with aviation and local/regional public safety radios, and many also have onboard satellite telephones. Some aircraft may be able to access the 2 m amateur radio band, but most are not able to communicate on FRS/GMRS or CB frequencies.[24] Military aircraft may or may not have the capability of radio communication on public safety or amateur frequencies.

If radio communication cannot be established, simple visual signals such as mirror flashes, smoke, or brightly colored objects should be used to attract the attention of the helicopter crew and guide the aircraft to your location. Visual signals should be in sets of 3, the internationally recognized distress signal.[4] Once the helicopter crew has established visual contact, the usual practice is to circle the scene to size-up the landing site. Additional information may be communicated using the standard ground-to-air signals depicted in Figure. These signals can be formed by stamping out lines in snow or sand, using strips of colored material, or by piling up branches, debris, or rocks.[25] The goal when creating visual ground-to-air signals is to create as much contrast with the background surface as possible. The pilot may elect to not land or attempt a hoist rescue until clear communication can be established.

The most important safety rules for operating around helicopters are to remain 100 feet or more away from the landing zone, and never approach the aircraft unless specifically directed to do so by the pilot or a member of the flight crew—or accompanied by the pilot or a member of the flight crew.[22,24] The details of helicopter operations and landing zone management are beyond the scope of this article. The reader is encouraged to refer to references 20 to 24 and to seek hands-on orientation to helicopter operations from local public safety, SAR, or EMS aircraft programs.

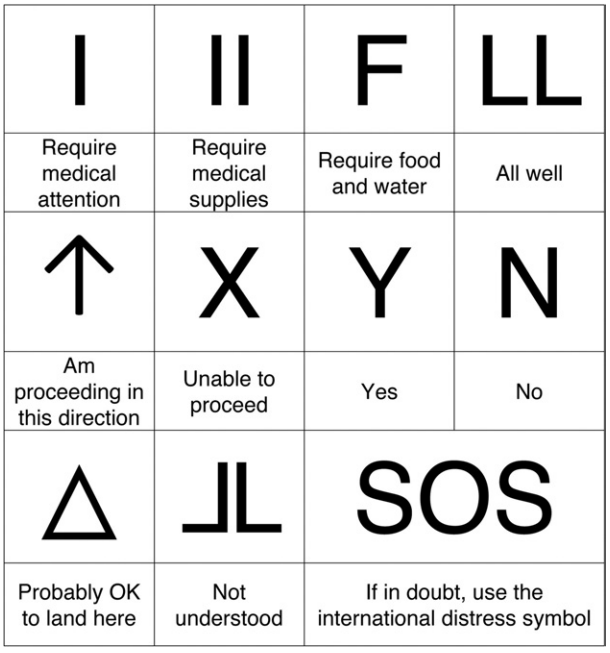

Figure. Ground-to-air signals.[25]
(Adapted from: United States Army. *Field Manual No. 21-60, Visual Signals.* Washington, DC: Department of the Army; 1987:5.)

Selecting Communications Devices

The selection of which communications devices one should carry is individual and depends on the nature of the outing. The GPS-equipped PLB is the primary tool that all wilderness travelers should consider. A PLB is a lightweight and relatively inexpensive device that will not intrude on the wilderness experience unless it is needed, in which case it may literally be a lifesaver. Table lists recommended communications devices for a range of wilderness travel applications. New technology and new devices are constantly becoming available, and each individual or group should carefully investigate the specific devices being considered to determine which is the best choice for their particular needs. It is important to become familiar with the operation of whatever communications devices are selected before leaving for the backcountry.

Conclusions

Skier Bill Briggs once said, "If there's no risk, there's no adventure."[26] Those who are drawn to wilderness med-

Table. Selecting communications devices

Application	*Recommended communications devices*	*Other communications devices to consider*	*Comments*
Individuals			
Solo travel	• PLB (with GPS)	• FRS/GMRS radio • Satellite messenger	• GMRS radios require FCC license
Remote location or extended trip	• PLB (with GPS) • Satellite Phone	• Amateur radio • Satellite messenger	• Amateur radios require FCC license
Groups			
Small group outings	• PLB (with GPS)	• FRS/GMRS radios • Satellite messenger	• GMRS radios require FCC license
Large group outings	• PLB (with GPS) • FRS/GMRS radios	• Satellite messenger • Satellite Phone	• Consider redundant PLBs • GMRS radios require FCC license
Scouting, youth, or outdoor education groups	• PLB (with GPS) • Satellite Phone • FRS/GMRS radios	• Satellite messenger	• GMRS radios require FCC license • Consider redundant PLBs and radios if small groups will separate from main party
Very remote location or extended trip	• PLB (with GPS) • Satellite Phone	• FRS/GMRS radios • Amateur radio • Satellite messenger	• Amateur or GMRS radios require FCC license
Foreign Travel	• PLB (with GPS) • Satellite Phone	• Satellite messenger • Amateur radio	• May need to obtain authorization for use in destination country • Consider redundant systems and units

icine—and to the places and circumstances where it is practiced—are, by definition, drawn to adventure and its accompanying risks. Whether it is a backpacking trip, an international mountaineering expedition, or a disaster response, risk cannot be avoided (nor would we wish it to be). What needs to be done in these circumstances is to understand, accept, and manage the risks involved. The tools available for managing risk include thorough predeparture planning, critically evaluating the situation when problems arise, making sound decisions, and having a plan in place for communicating with sources of outside aid, should their assistance be required.

Wilderness travelers today have a wide range of communications technology options available to them. These devices must be used responsibly when requesting assistance. Even though one possesses the ability to communicate, there is no guarantee of establishing direct communication, or of immediate rescue. A belief that one can readily call for help and be rescued should not lead to taking imprudent risks that would be considered unacceptable if the ability to call for help were not present. Anything that is dependent on technology or batteries can fail. Terrain, weather conditions, and distance can all delay or prevent rescuers from reaching an individual or party in distress. When traveling to the wilderness or to other remote locations, each individual must accept responsibility for themselves and for all the possible outcomes of their adventures.

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