Safety and Health
Tech Tips

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Emergency Communications for Remote Operations

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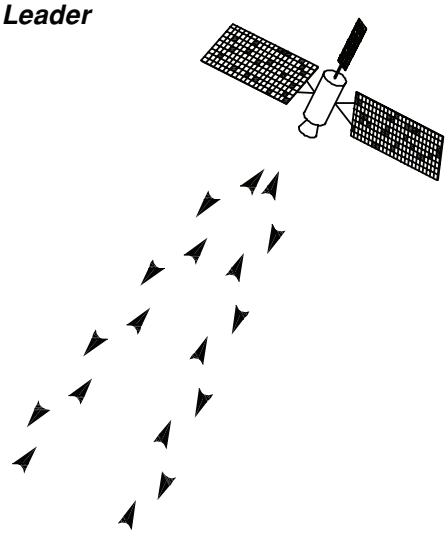
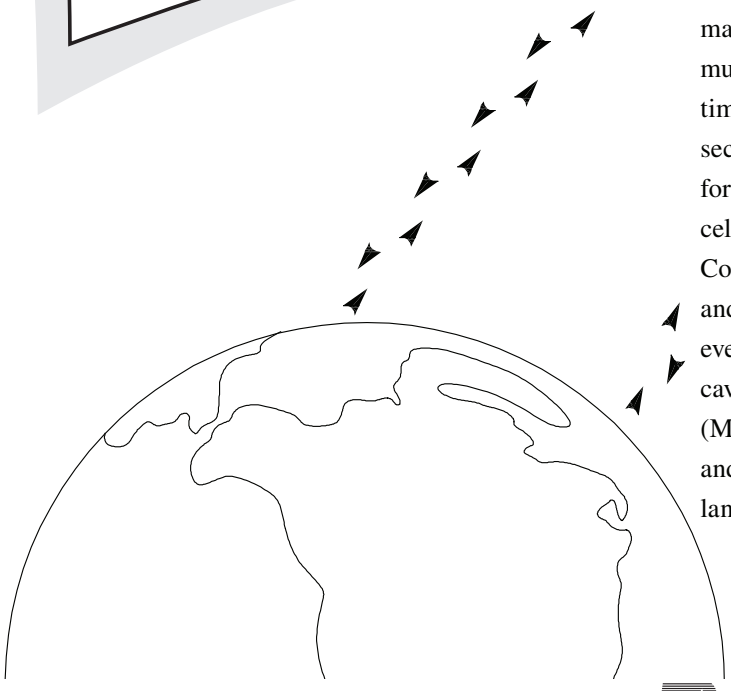
Highlights...

- Forest Service employees working in remote locations need to be able to call for help in an emergency.
- Mountainous terrain can block the Forest Service's standard radio transmissions.
- Satellite phones can provide communications in some areas that aren't reached by radio.
- In the most difficult areas, a combination of remote wireless links with a satellite phone placed at a site with good reception can provide reliable emergency communications.



The safety and well-being of Forest Service personnel is one of the highest priorities of the agency. U.S. Department of Labor Occupational Safety and Health Administration (OSHA) regulations mandate that personnel deployed to remote locations must have emergency communication capabilities at all times. Similarly, the Forest Service Handbook 6709, section 11.21(g), states that personal protective equipment for backcountry travel must include a "two-way radio, cellular phone, or similar personal communication device." Communications in areas outside the range of cell phones and radio repeaters can be provided by satellite systems, but even these systems have some limitations and operational caveats. The Missoula Technology and Development Center (MTDC) surveyed various satellite communication options and tested the effectiveness of one of those options in landscapes typical of national forests.



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The Short Answer

Satellite communication options (figure 1) essentially fall into two types: duplex (two-way communication, such as a telephone) and simplex (one-way communication, such as a pager). A Globalstar, Inc., or an Iridium Satellite LLC satellite phone would allow personnel in the backcountry to call out during emergencies. Globalstar and Iridium have constellations of low-Earth-orbiting satellites (LEOs) for communication links using satellite phones with relatively low power.

Because the satellites orbit just 900 miles above the Earth, they move fairly quickly relative to a fixed location on the surface. A dispersed array of several dozen satellites is needed for continuous coverage. Iridium satellites are deployed to provide coverage near the Earth's polar regions as well as the lower latitudes; Globalstar satellites have poor coverage in northern Alaska and extreme latitudes, but provide good coverage at lower latitudes.

The satellite phone (figure 2) is about the size of first-generation cell phones and can be used by anyone familiar with a cell phone. If the user has good visibility of the sky and is not trying to communicate from a deep drainage or through heavy forest canopy, the call will probably go through. However, a person traveling alone may not be able to reach such an area to call for help. Some users of satellite phones complain that calls of any significant length are dropped when satellites pass out of coverage. The important safety feature of duplex communication is that employees know whether they have made contact.

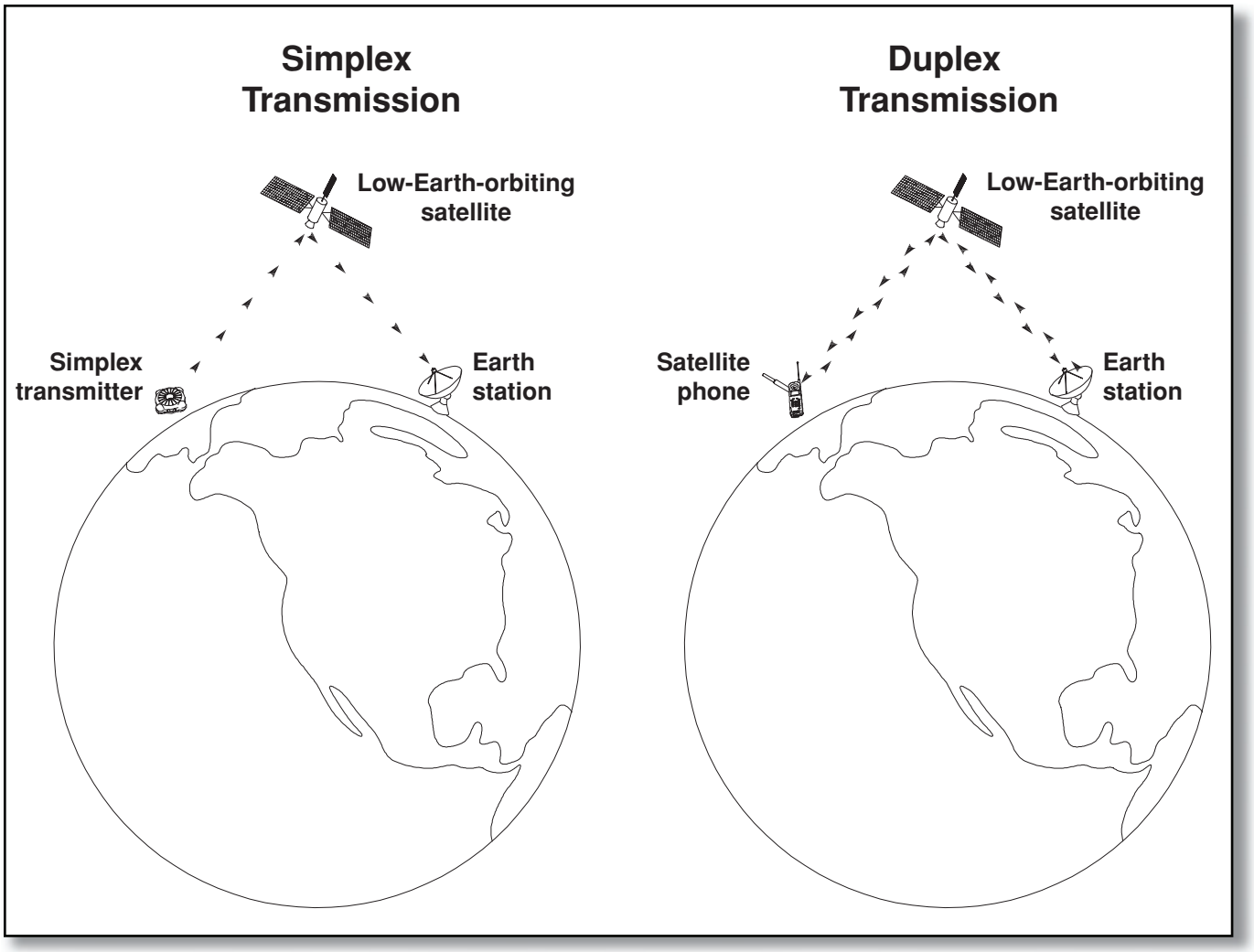


Figure 1—Each type (simplex and duplex) of satellite communication has advantages and disadvantages.

Figure 2—A satellite phone provides duplex (two-way) communication.

Other Options

Several simplex satellite links provide alternatives to duplex satellite phones. Most of the simplex options (figure 3) provide the caller's location and other data with each broadcast. The shortcoming of simplex transmitters is that the user has no immediate confirmation that the broadcast was received. Anyone using simplex devices must be aware of the conditions that limit all satellite communication—although supplementary hardware can reduce those limitations.

Personal Locator Beacons (PLBs)

One solution for summoning help in an emergency is the personal locator beacon. This simplex device broadcasts on two frequencies: one frequency alerts a satellite network that there is an emergency condition; the second provides a homing beacon that satellites can trace. The alarm and coordinate information are transmitted to a national coordination center that initiates emergency response. This type of device is marketed to boaters, aircraft pilots, and backcountry hikers.

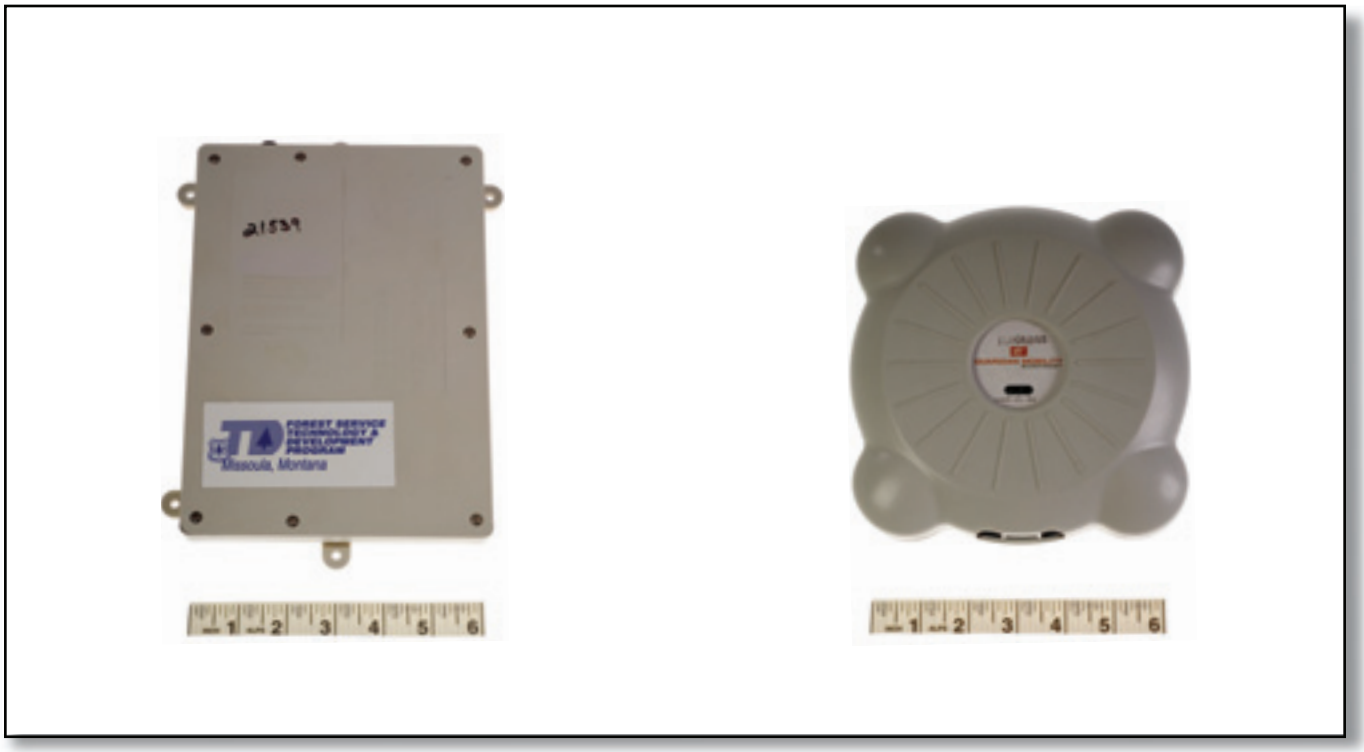


Figure 3—The Axonn AXTracker (left) and Guardian Mobility Tracer (right) transmitters provide simplex (one-way) communication. Newer models are smaller than these units that we tested.

Transmitters cost about $500 and must be registered with a national registry.

These beacons were not investigated by MTDC because we could find no way to conduct test transmissions without summoning a rescue team. Although there may be a way to coordinate such testing with the monitoring agency, we were unable to do so during this study.

Simplex Globalstar Transmitters

Several companies (primarily in the trucking and asset tracking industries) have developed simplex transmitters for the Globalstar network. These transmitters send global positioning system (GPS) data with other information during broadcasts. MTDC evaluated Globalstar transmitters manufactured by Axonn, LLC of Louisiana and GMC Guardian Mobility Corp. of Ontario, Canada. Both transmitters include a GPS receiver and broadcast GPS coordinates along with an elementary data payload during each transmission. These simplex transmitters repeat their broadcasts several times during a 10- to 12-minute period, increasing the chance of catching a passing satellite on the Globalstar satellite network.

Using one or more of the simplex Globalstar transmitters requires signing up with a Globalstar service provider. Globalstar does not deal directly with customers for simplex services; those users pay value-added resellers who combine Web-based services with paging or phone messaging options triggered by the transmissions.

In evaluating Globalstar simplex performance, MTDC obtained the services of Worldtrac, LLC, for the Guardian Mobility Tracer transmitters and Orbit One Communications, Inc., for the Axonn AXTracker transmitters. Each company provided a Web site that listed transmitter broadcast times and GPS coordinates. We used the Web logs to determine the reliability and accuracy of the transmitters in a variety of landscapes and at different locations.

Because the Globalstar satellite constellation does not cover polar regions, we had some concerns regarding the orientation of the transmitters. If a transmitter operating in northern regions was tilted to the north, would it have a lower probability of being detected by the satellite network? We performed tests (figure 4) at 12 sites in California, Oregon, Idaho, and Montana with 2 transmitters from each manufacturer. During one set of tests, the transmitters were flat. During a second set of tests they were oriented to the north.

Figure 4—Axonn AXTracker (left) and Guardian Mobility Tracer (right) transmitters were mounted on a stand that was tilted 45 degrees north during some of the tests. In northern regions, transmitters tilted to the north would be more likely to have difficulty making satellite transmissions.

We also selected several sites that were at the foot of cliffs (figure 5) or steep slopes that blocked the view of the sky, particularly to the south. At most sites, a Globalstar satellite phone was on hand to provide a relative signal strength reading from the satellites in service.

The redundant transmissions of the simplex transmitters proved to be a good feature because the display on the phone frequently indicated that it was "looking for service." Some of the sites were selected because they lacked coverage from the Forest Service's VHF (very high frequency, between 30 and 300 megahertz) repeater network.

Transmissions were successful 100 percent of the time from 4 of the 12 test sites. Even so, 8 of the 57 transmissions from these 4 sites took longer than 2 minutes to register on the receiving end; the longest delay was 12 minutes.

Of the remaining eight test sites, four sites had success rates of 90 percent or higher. Three of these four sites had moderate visibility of the sky but no VHF radio repeater coverage because of their location in deep drainages. None had cellular phone coverage. At two of the four sites, the majority of transmissions took longer than 2 minutes to register. Delays of 5 to 9 minutes were common.

Only 1 transmission out of 24 was successful at the most difficult of the remaining four sites. This site in the Sierra National Forest has presented a long-term challenge for a telemetry project with the Pacific Southwest Research Station in Fresno. The tree canopy is fairly dense and the west-facing drainage has steep slopes on both sides. The remaining three sites had heavy canopy and/or adjacent cliffs. About 60 to 80 percent of transmissions were successful. Transmissions took less than a minute to 18 minutes to register.

Besides examining the successful connection rates and delays of the simplex transmitters in different settings, we also examined the accuracy of the GPS coordinates registered on successful transmissions.

At the test sites north of California, a 1-second error in the longitude reading of a location represents about 72 feet; at the California sites, the same error represents 82 feet. A 1-degree error in latitude would represent an error of about 102 feet.

At sites with high connection percentages, logged coordinates tended to be within 1 to 2 seconds of longitude, or within 200 feet. At sites with lower connection rates, coordinates varied by as much as 12 seconds in longitude, or nearly a quarter of a mile.

The reliability and accuracy of the simplex transmitters depend on the terrain where they are used. Because simplex transmitters do not provide feedback, users need to understand the possibility that their transmissions might not have been received. Even from areas where the duplex Globalstar phone indicated that it couldn't establish a satellite connection, some simplex transmissions were successful.

Figure 5—Despite the cliff, communication was relatively successful at this site in the Indian Creek drainage, Siuslaw National Forest, OR.

Optimizing Transmitter Locations

During field testing of simplex Globalstar transmitters, reliable communication was established from locations with a good view of open sky. While Forest Service employees may not be working in such areas, an optimal location may be nearby.

Several products are designed so that Globalstar transceivers can be placed at optimal locations, providing users with short-range wireless links to the transmitters. Worldtrac has a wireless mesh network called the "Man Down/Lone Worker Mote System" that links multiple users to a common transmitter that could be mounted on a vehicle parked nearby. This system uses a simplex transmitter, but the vehicle (or a suitcase with the hardware and a battery) can be placed where the probability of successful transmissions is close to 100 percent. The common transmitter and communication link costs about $1,000 while the individual motes (remote transmitters) cost about $150 each.

Premier GPS Inc. of Calgary, Alberta, offers Safety-Star, a more expensive duplex version of the Worldtrac mote system that uses a duplex Globalstar modem. Users carry a pocket-sized transceiver (called a fob) with an indicator that displays whether the transmission was received and acknowledged. The satellite transceiver is mounted on a vehicle or stowed in a rugged suitcase at a site with optimal coverage. The Safety-Star base unit with the fob interface costs about $4,100 and the duplex fobs cost around $700 each. The fobs have motion sensors that can trigger "man down" alerts.

Conclusions

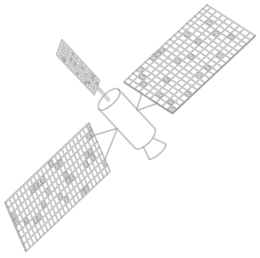
In some locations, no form of wireless communication can be expected to establish a communication link reliably. However, transmissions from other areas nearby are likely to be successful. While the satellite transmitters and modems may be a bit too large to carry in a backpack, the motes or fobs that activate them from a distance are quite compact.

Most VHF FM radios used by the Forest Service can generate the dual-tone multifrequency tones used by TouchTone phones. The VHF FM radios could be used to activate satellite transmitters that have a VHF/tone decoder interface.

The initial costs are similar for simplex and duplex satellite communication devices. U.S. General Services Administration (GSA) pricing on the Globalstar GSP–1600 phone with a few accessories is about $650. Pricing of an AXTracker or a Guardian Mobility Tracer costs about $600 from value-added resellers.

Monthly service charges differ greatly between the two modes of satellite communication. GSA pricing for voice service starts at about $45 per month for 75 minutes of service. Alarm notification to cell phones and pagers from simplex devices costs about $20 per month. A small activation fee is usually required when registering a device with the satellite carrier. Forest Service employees need technical approval before procuring satellite communication services.

Supervisors who are considering simplex satellite transmitters for backcountry alarm transmissions need to decide the level of reliability required. Simplex satellite transmitters cost less to purchase, and have lower service charges and longer battery life than the Globalstar satellite phone. The simplex satellite transmissions include location information along with alarm or status conditions. Some simplex transmitters also can be programmed to broadcast at specified intervals so that the user's travel route can be mapped. In some cases, the simplex transmitters were successful when the Globalstar satellite phone couldn't find coverage. Despite the appeal of a satellite phone, the simplex transmitters offer several advantages in certain situations.



Resources

Orbit One Communications, Inc.
Bozeman, MT
Web site: *http://www.orbit-one.com*

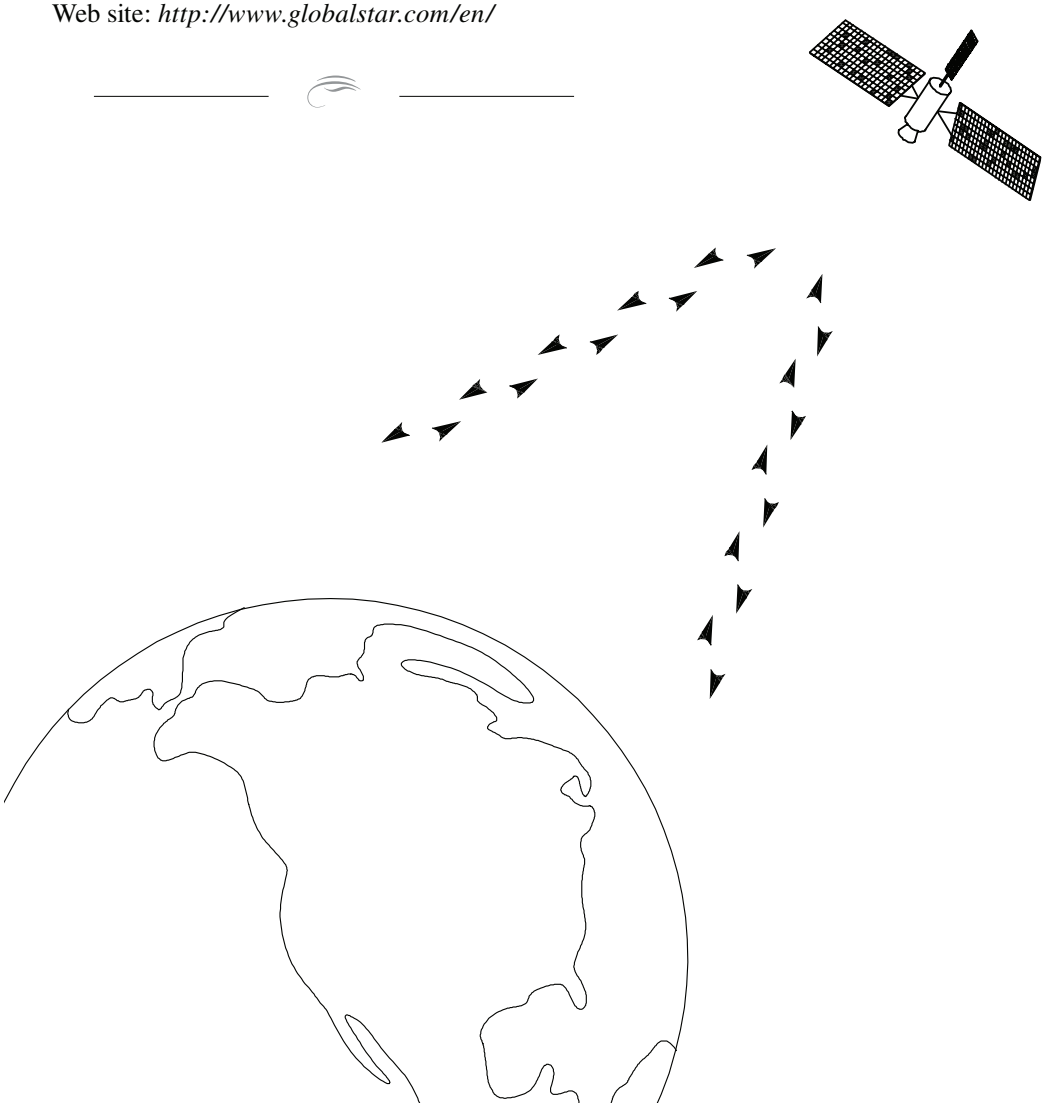
Worldtrac, LLC
St. George, UT
Web site: *http://www.usatrac.com*

Premier GPS, Inc.
Calgary, AB
Web site: *http://www.premier-gps.com/products/*

Globalstar, Inc.
Los Angeles, CA
Web site: *http://www.globalstar.com/en/*

About the Author

Ted Etter joined MTDC in 2002 to work on electronics projects. He has spent more than 25 years working in the areas of electronic instrumentation and display technology. He received a bachelor's degree in mathematics from the University of Oregon in 1992 and a master's degree in teacher's education from Eastern Oregon State University in 1993. Before coming to MTDC, he taught courses in programming, digital circuits, data communications, radiofrequency communications, robotics, microprocessors, and operating systems at the University of Montana–College of Technology.



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The Forest Service Handbook and the U.S. Department of Labor Occupational Safety and Health Administration's regulations require that employees working at remote locations have personal communication capabilities at all times. Providing emergency communications in remote mountainous terrain is difficult. The Missoula Technology and Development Center tested satellite communication options for effectiveness at remote, mountainous Forest Service work sites in California, Oregon, Idaho, and Montana. Although transmissions could be established from most of the test sites, transmissions from some of the sites took several minutes or longer to become established and at one site only 1 of 24 attempted transmissions was successful. In such areas, it may be possible to use commercially available packages combining a satellite transmitter that is located for good coverage with companion pocket-sized devices that connect to it using a wireless network. Although satellite phones offer the assurance of a standard phone conversation, some satellite transmitters that simply send location and an alarm status may be smaller, lighter, and more likely to establish communication.

Keywords: Axon, LLC; AXTracker; backcountry; Bendix-King radios; Globalstar, Inc.; safety at work; satellite radios; wilderness

Additional single copies of this document may be ordered from:

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Forest Service and Bureau of Land Management employees can search a more complete collection of MTDC's documents, videos, and CDs on their internal computer networks at:

http://fsweb.mtdc.wo.fs.fed.us/search/