CIVIL AIR PATROL
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CIVIL AIR PATROL

ELT/EPIRB SEARCH

This pamphlet is designed to provide guidance to assist CAP search and rescue personnel in accomplishing Emergency Locator Transmitter (ELT), Emergency Position Indicating Radio Beacon (EPIRB), and Personal Locator Beacon (PLB) missions. All suggestions for modification and improvement of the program will be forwarded through the chain of command to National Headquarters Civil Air Patrol/DCS, Operations (DO).

Paragraph Page

Supersedes CAPP 2, December 1973.
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Chapter 1

FEDERAL LAW AND REGULATORY REQUIREMENTS

1-1. General. The Passage of Public Law 90-596, Section 31, by the U.S. Congress on December 29, 1970, amended the Federal Aviation Act of 1958 to require the installation of an emergency locator transmitter (ELT) on most general aviation aircraft. The Federal Aviation Administration (FAA) implemented this new statute by adopting several amendments to the Federal Aviation Regulations (FAR). Many marine vessels already carry emergency position indicating radio beacons (EPIRBs), and new marine regulations will require EPIRBs on most ships in the near future.

1-2. Aircraft Emergency Locator Transmitter (ELT). FAR 91.52 requires, with certain exceptions, all U.S. registered civil aircraft to be equipped with an ELT that meets the applicable Technical Standard Order (TSO) specifications. The FAA has proposed a regulation requiring installation of new units meeting TSO-C91a standards on new aircraft and when replacement of an existing TSO-C91 ELT is. required.

1-3. Marine Emergency Position Indicating Radio Beacon (EPIRB). The U.S. Coast Guard presently requires all fishing vessels, uninspected U.S. commercial vessels that travel more than 3 miles offshore, and (by August 1, 1993) all passenger ships and ships over 300 tons on international voyages to carry an appropriate EPIRB.

1-4. Personal Locator Beacon (PLB). ELTs and EPIRBs presently cannot legally be used in the United States as a personal locator beacon separate from the aviation and marine services for which they are intended.

1-5. Deliberate and Accidental Distress Calls. There are laws against transmitting false distress signals which can be used to cite individuals involved. A "false alarm" may not start out to be malicious or intentional, however once the person responsible for the transmitter has been notified that it is on the air and obviously not in a distress condition, it then becomes a situation of "knowingly transmitting." A person who then refuses to make reasonable efforts to secure the transmitter is in violation of federal law.

a. EPIRBs are covered in 47 CFR Section 80.311. "Authority for distress transmission ...No person shall knowingly transmit, or cause to be transmitted, any false or fraudulent signal of distress or related communications."

b. ELTs are covered in 47 CFR Section 87.187(k). "The frequencies 121.500 MHz and 243.000 MHz are emergency and distress frequencies available for use by survival craft stations, emergency locator transmitters and equipment used for survival purposes. Use of 121.500 MHz and 243.000 MHz shall be limited to transmission of signals and communications for survival purposes..."

Chapter 2

TYPES OF EMERGENCY BEACONS

2-1. General. At present, general aviation aircraft and marine vessels are the principal search and rescue (SAR) concern of the Civil Air Patrol. There are a variety of beacons available to aircraft and vessel operators.

2-2. Aircraft ELT:

a. All aircraft ELTs are required to meet the standards specified in the applicable FAA TSO. ELTs manufactured to the earlier standard, TSO-C91, have a false alarm rate of approximately 97% and have failed to function approximately 75% of the time in aircraft crashes. As a result of this record, an updated standard, TSO-C91a, was approved that corrects many of the deficiencies noted in earlier units and provides improved satellite compatibility. The new ELTs should significantly reduce the number of false alarms, operate more reliably when they should, and provide better satellite position information.

b. All civil aircraft ELTs transmit simultaneously on 121.5 MHz and 243.0 MHz. Transmitter power must be 75 mW after 48 hours at low temperature. Military aircraft only use 243.0 MHz. Some new ELTs also provide voice identification of the aircraft and, if interfaced to a compatible navigation system, position in latitude and longitude 30 seconds prior to activation. The FAA does not presently foresee the need for mandatory installation of 406.025 MHz ELTs on aircraft within the continental United States. Many other countries are requiring ELTs on both 121.5 and 406.025 MHz. The FAA is considering establishment of a TSO specifying the minimum standards for 406 beacons which may be voluntarily carried in addition to the required 121.5/243.0 MHz ELT.

c. Most aircraft ELTs are mounted in the rear of the aircraft aft of the passenger compartment. Typical installations on some general aviation aircraft are:

(1) Cessna single engine. The ELT is usually located on the right side of the rear baggage compartment area just aft of the baggage compartment door. The antenna (flexible whip about 14" long) is typically located on top of the fuselage, on the right side just aft of the rear window.

(2) Cessna multi engine. The ELT is usually located on the left side of the fuselage just forward of the horizontal stabilizer and can be accessed through a small push plate on the side of the fuselage. The antenna is typically located on top of the aft fuselage on the left side along the dorsal 6n.

(3) Piper single and multi engine. The ELT is usually located in the aft fuselage and can be accessed through a small access plate on the right side of the aft fuselage. The antenna is typically located on top of the aft fuselage along the dorsal fin.

(4) Beech single and multi engine. The ELT is usually located in the aft fuselage and can be accessed through a small access plate on the right side of the aft fuselage. The antenna is typically located on top of the aft fuselage on the right side along the dorsal fin.

(5) Jet aircraft, while not required to do so, sometimes carry an ELT. The location of the ELT transmitter and antenna varies, although the transmitter is usually located in the aft tailcone area and the antenna frequently located inside the dorsal fin.

2-3. Marine EPIRB. Two distinctly different types of marine EPIRBs are available. The Coast Guard has taken steps to convert to the newer 406.025 MHz beacons; however, Class A, B, and C units (see below) will still be in use for about 10 more years.

a. "Old" EPIRBs operate on 121.5/243.0 MHz and transmit the familiar sweep tones. These units are designated as follows:

(1) Class A - Activated automatically by floating free of their mounting bracket and turning upright. They also have an additional manual activation switch.

(2) Class B - Activated only by means of manual switch.

(3) Class C - Activated only by means of a manual switch. These units transmit only on marine VHF FM channels 15 and 16 (short beep on channel 16 alternating with a longer homing signal on channel 15). These units are not received by the satellites and do not have the capability of transmitting on 121.5, 243.0 or 406.025 MHz.

b. "406" EPIRBs operate on 406.025 MHz and transmit a digital data burst of 5 watts that carries coded information to the satellite. This data includes the EPIRB's identification code, type of vessel, and owner's name, address, and telephone number. They also have a 25 mW transmitter on 121.5 MHz for terminal homing. They have an upward swept tone (instead of the common downward swept tone) and the swept tone will stop for about 1 second at an interval of approximately every 50 seconds. These units are designated as follows:

(1) Category I - Activated automatically by floating free of their mounting bracket and turning upright. They also have an additional manual activation switch.

(2) Category II - Activated only by means of a manual switch.

(3) Category S - A modified Category 2 type unit. Designed primarily for liferaft installation and are automatically activated when the raft is inflated by using a grenade-style pull pin. They also have an additional manual activation switch.

2-4. Individual PLB. Although ELTs and EPIRBs presently cannot legally be used in the United States as a personal locator beacon separate from the aviation and marine services for which they are intended, there is some unauthorized use of aircraft ELTs and marine EPIRBs as personal locator beacons.

Chapter 3

SIGNAL LOCATION BY AIRBORNE DIRECTION FINDING (HOMING)

3-1. General:

a. Direction Finding (DF) or homing systems are available from several manufacturers. There are two basic types of aircraft DF equipment, those having a built-in receiver on the emergency frequencies as part of the equipment and those requiring connection to one of the aircraft's communications receivers. Most systems operate using the VHF signal (121.5 MHz) while others have an additional capability of operating on the 243.0 MHz signal.

b. Most systems have two external antennas, although one manufacturer adds a third antenna for systems including 243.0 MHz capability. A phasing network or antenna switchbox allows the equipment to display left-right homing on its associated indicator. Antennas MUST be mounted according to the DF manufacturer's specifications, as proper installation is critical to proper DF operation. A manufacturer's antenna and receiver systems must be used together. The antenna system from one manufacturer cannot be used with the receiver from another manufacturer, since the operating characteristics of each manufacturer's system are different.

c. A brief explanation of how the antennas work follows. The two DF antennas establish lobing patterns which alternately switch from left to right. These patterns cross over at the center. If the ELT/EPIRB is located to the right of the aircraft, the right antenna will receive the strongest signal and the DF meter needle will deflect to the right. The pilot turns the aircraft to the right (toward the needle) until the needle centers when the aircraft is heading toward the signal source and both antennas hear the signal at equal strength. An ELT/EPIRB to the left of the aircraft causes the left antenna to receive a stronger signal, deflecting the meter needle to the left and the aircraft is turned left to center the needle (see figures 3-1 and 3-2).

3-2. Conducting the Search. Airborne direction finding (homing) equipment provides a rapid and efficient means of locating the source of an ELT/EPIRB signal.

a. By logically applying the proper procedures, an aircrew can locate the signal source in the minimum time:

(1) Prior to beginning the search, the crew should obtain a thorough briefing on the mission to be flown. Chapter 7, The Electronic Search.

(2) A pre-takeoff ground check of the equipment should be made. Controls of the DF equipment should be set to the manufacturer's recommendations. Start the mission with the DF "up and running," ready to receive a signal. If the unit has an "Alarm" mode, turn it off. Generally, begin an ELT search with the sensitivity control at maximum and in the DF mode of operation.

(3) Electronic searches, as opposed to visual searches, should be started at relatively high altitudes. To minimize the effects of reflections and barriers such as mountains, the best tracking altitude to acquire and work an ELT/EPIRB signal over relatively flat terrain is approximately 3,000 to 4,000 feet above the ground (or water). In mountainous areas, 4,000 to 6,000 feet above the terrain has proven more effective. Aircraft using DF equipment for ELT/EPIRB location should climb to search altitude as soon as possible after takeoff and prior to reaching the probable search area. The DF receiver should be set to 121.5 MHz. A signal alarm circuit, if present, should be turned off. The search should follow as closely as possible the probable flight path of the missing aircraft/vessel until the signal is detected. If the signal is not detected after a full sweep of the probable route, parallel the first search track and repeat the sweep. Track spacings can be roughly determined from the terrain and the signal ranges. In mountainous areas track spacings should be reduced to avoid the possibility of higher terrain blocking the signal if the objective should be located on lower hills, etc. Repeat sweeps can be made at higher altitudes to increase the reception distance and improve "line of sight" characteristics over irregular terrain.

(4) If the equipment being used has the capability to receive 243.0 MHz in addition to 121.5 MHz, the crew should switch to 243.0 MHz every two or three minutes to check for a signal on that frequency. Occasionally an ELT or EPIRB will be heard better or only on 243.0 MHz. When acquiring the ELT signal to track, it will usually build in strength or "fade in" over a period of a minute or two. The pilot should continue flying a stable heading until he has a good signal and/or a positive left or right indication is seen on the DF left/right indicator.

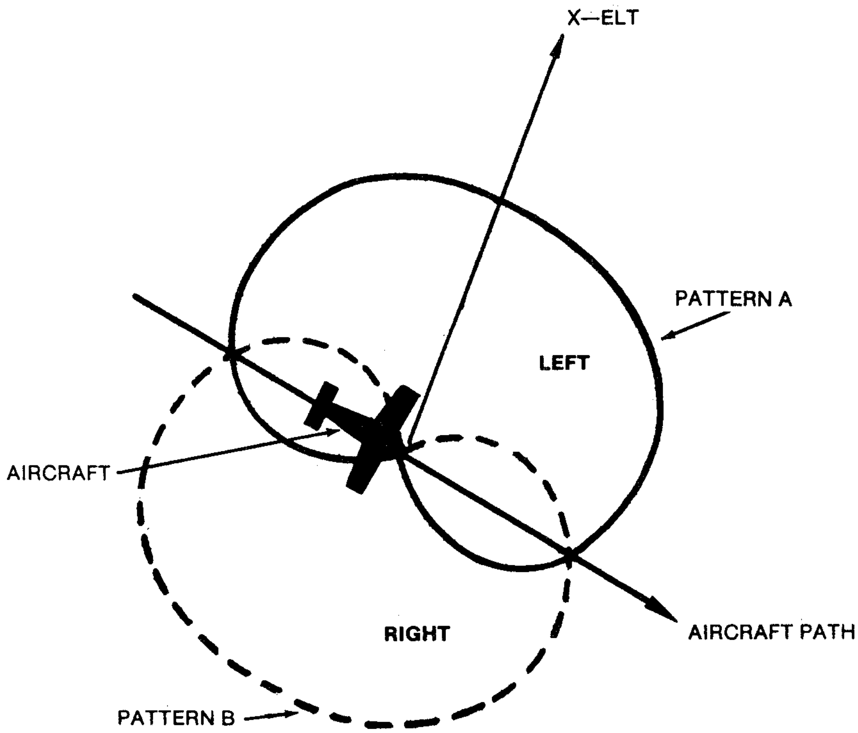
(5) Once receiving a suitable signal, the pilot should then turn in the direction indicated by the DF needle, making a 360-degree shallow banked turn (no more than 30° of bank). The needle of the DF indicator should cross center twice, about 180 degrees apart. If more than two crossings are noted, try a more shallow turn. If there are still more than two crossovers, continue flying in a direction that maintains a good signal and try the 360-degree turn at a new location.

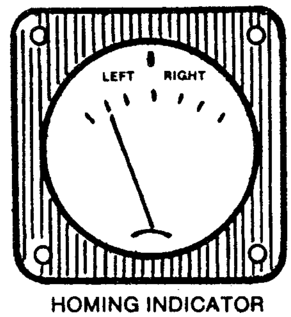
(6) The left/right needle of the DF equipment display will show the direction to turn the aircraft to track the ELT/ EPIRB when deflected from center by a slight turn or yaw of the aircraft. DF equipment that requires use of an aircraft receiver has a gain or sensitivity adjustment that controls the amount of deflection. Equipment with a built-in receiver has a gain or sensitivity control that affects meter movement, but it also adjusts signal strength. Keep the gain or sensitivity control adjusted so the meter doesn't swing wildly from side to side. The needle may wander back and forth around center at 10 to 30 second intervals. Fly in a direction that keeps swings about equal in number left and right; don't try to keep the needle exactly centered.

(7) Some DF equipment has the capability of showing signal strength as well as DF homing. The sensitivity control should be kept adjusted so the signal is weak but audible, the DF needle stays on scale left or right, and the signal strength meter stays on scale. As the strength of the signal increases, the sensitivity is decreased to maintain these parameters.

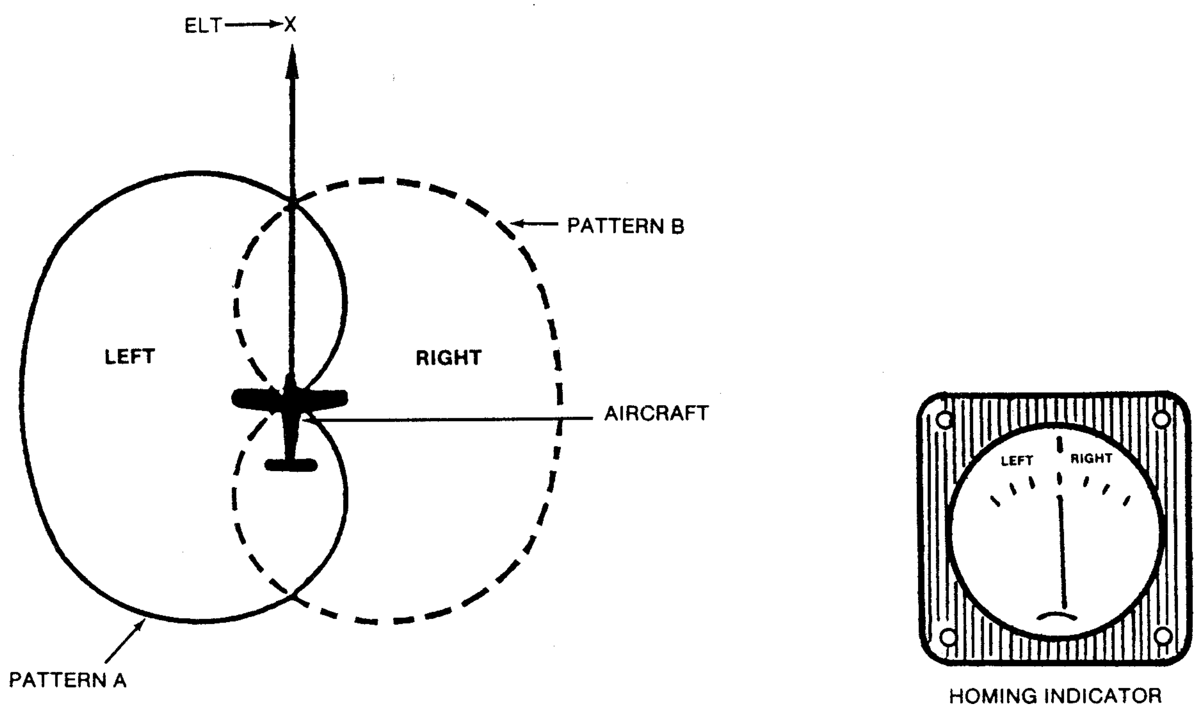
(8) Occasionally, an ELT or EPIRB signal will fade out as a pilot is flying towards it. Continue on the original heading for at least six minutes. The signal should build back up in strength in three or four minutes and be somewhat stronger when it reappears. If there is ever a doubt about the quality of a course, make a shallow 360-degree turn to verify two crossovers about 180 degrees apart.

(9) The signal from an ELT/EPIRB will bounce or reflect off many natural and man-made objects such as mountains, hangars, etc. These reflections are weaker in strength than the direct signal from the ELT. Therefore, the DF will prefer the





ELT TO LEFT OF FLIGHT PATH
Figure 3-1



ELT **IN FRONT OF AIRCRAFT ON FLIGHT PATH**
Figure 3-2

stronger, direct signal over a reflection, if it can hear both signals. The needle may wander a bit more, but the average will be correct. If a barrier, such as a mountain, is blocking the direct signal, the DF will track the reflection until it reaches a location where it can hear the direct signal from the ELT/EPIRB. This phenomena explains apparent changes in direction that occur during some missions.

(10) The absolute signal strength has little bearing on the distance to an ELT or EPIRB. Such things as condition, power output, location of the ELT, and the altitude of the search aircraft, etc., can greatly affect signal strength. A better indication is the rate of change in signal strength. At great distances from the source, a pilot can fly many miles and observe very little increase in signal strength. However, as the source is neared, the strength will increase faster over a given distance.

b. The following common problems may be encountered during electronic searches:

(1) Often an aircrew will be given an assigned area where the ELT/EPIRB signal should be heard. If it can't be acquired, climb 2,000 feet and try the area again. Move the pattern over a mile or two. If no signal is heard, a second climb can be made, but that is about a practical limit. Remember, coordinates given from satellite information indicate a probability the signal will be heard within an area 12 miles wide by 6 miles long. Coordinates from 406.025 MHz EPIRBs are more accurate (about 1 -3 miles).

(2) If the DF readings are confusing, try the 243.0 MHz frequency if available. Sometimes the signal can be tracked better on that frequency.

(3) Working two simultaneous signals can be very difficult. When ELTs or EPIRBs are involved, you can hear the two different sweep rates and use terrain, buildings, etc., to try to isolate one signal so you can get bearings on it. When you have a strong carrier over an ELT or EPIRB signal, you can try using 243.0 MHz if available. You can try using the minimum sensitivity level that will allow hearing the signal and turn the aircraft for maximum signal by ear (don't use the meter). The bearing is not precise, but it may help you continue in the right direction. Do not use the nulls or minimums. They may appear sharp, but there will normally be two or more of them and they can be easily corrupted by the carrier and other nearby objects.

(4) If you have difficulty locating an ELT/EPIRB when you get close to the transmitter, it's probably due to overloading the receiver. If this occurs using equipment incorporating an internal receiver, reduce the sensitivity control to minimum, then slowly increase the sensitivity control until a DF indication is noticed. Any time turning the sensitivity control UP results in a DECREASE of DF needle deflection, overload has been reached. Keep the sensitivity below this point for DF operation.

(5) Sometimes a DF will give more than one "station passage" indication. Try a higher altitude or move laterally several miles as mentioned before. As a last resort and if conditions permit (particularly if moving laterally causes the signal to be weaker), descend. If the ELT/EPIRB can be heard in only one location, the aircraft may be directly over it.

3-3. The Find:

a. Each DF installation will have a slightly different indication of "station passage" or "crossover." However, most give a rapid fluctuation in signal strength and confused DF readings. Yaw the aircraft to see if the course has reversed (meter needle movement will be in the direction of the turn). If it has, continue outbound for a few miles. Turn and make several confirmation passages at different approach angles while having your observers make a visual search for the target. Precise crossing should be avoided to allow observers to see the target area. Most DF equipment is extremely accurate and can pinpoint the target location to within less than one hundred feet from 3,000 to 4,000 above the terrain.

b. The exact location of the target must be pinpointed (paragraph 6-le). It is extremely important that the pilot be able to precisely locate the target so that a rescue helicopter or ground team can reach the survivors.

c. If visual verification of the target cannot be accomplished, gather as much information as possible to assist ground units in confirming the target.

d. Conduct a visual search of the area to determine signs of survivors (messages, distress signals, etc.). Note nearby landmarks and hazards. Survey the area to determine accessibility for ground personnel, helicopter evacuation, etc. Gather as much information as possible.

e. Follow the instructions provided in your pre-flight briefing regarding contacting the search base.

3-4. Summary:

a. DF equipment and antennas must be installed in accordance with the manufacturer's recommendations. Systems are not interchangeable. Any deviation from or modification of these procedures will very likely adversely affect the performance of the equipment.

b. Pilots should know the particular aircraft's DF performance characteristics so he can correctly interpret the information it presents to him. Continual practice and experience are needed to become an efficient ELT/EPIRB search pilot. Critique each mission and learn from it.

c. While a majority of ELT/EPIRB searches will conclude in a non-distress situation, each and every mission must be treated with the urgency of the emergency signal that it is. ELT/EPIRBs do work properly and do save lives! Don't assume an ELT at or near an airport is false - it is not uncommon for a plane to crash on takeoff or approach, especially at night and/or in poor weather.

d. Weather and terrain factors (dense forest, ground fog, air search conducted in or above cloud decks, etc.) may prevent a verification of the target by the aircrew. The pilot should gather as much information as possible and provide the most precise position information possible to the ground units to assist them in locating and verifying the target.

e. The initial briefing should include instructions for the aircrew on the procedures to be followed when the target is located in either distress or non-distress situations.

f. Aircrews should have a means of tracking a signal on an airport, even if it is a small, inexpensive aircraft band radio or FM portable radio.

g. Even though the left-right homing system is more efficient than other methods, wing shadowing should not be overlooked if DF equipment gives unreliable or questionable results. While less efficient and more time consuming than left-right homing, wing shadowing can be successful when DF techniques are unusable. Severe reflections and antenna polarization problems are the most usual causes of such situations. Wing shadowing techniques are covered in Chapter 4.

Chapter 4

SIGNAL LOCATION BY WING SHADOWING AND OTHER METHODS

4-1. General:

a. VHF and UHF signals normally travel by "line of sight." Any physical object between the ELT/EPIRB and receiver's antenna can block or reflect the signal. Objects only a few feet square near the receiving antenna, like a metal airplane wing, can block the signal. Further away, the object must be larger, like a mountain, to be effective. This effect can be used for electronic search by aircraft not equipped with a DF system or as a double check in those few situations where the DF gives confusing or unreliable results. Location by wing shadowing is less accurate and slower than use of a DF, but all pilots should be familiar with the techniques and procedures applicable to this method.

b. Two things are required to do wing shadowing. First, the receiving antenna (VHF communication antenna) must be mounted so that the wing can be placed between it and the ELT/EPIRB using a steep bank turn. Second, the radio must be operated so that the drop in strength of the signal caused by the wing shadow can be heard or seen.

4-2. Antennas and Receivers:

a. The top location near the wing trailing edge common to Cessna and other high wing airplanes usually works quite well. A top mount near the cabin on a low wing airplane normally works acceptably, but a location further aft may make getting a good shadow difficult. Wingtip and rudder mounted antennas are usually useless. In any case, a flight test with a known transmitter is necessary so that each pilot knows the shadow pattern of the particular airplane being used.

b. On airplanes where the antenna locations are not suitable for wing shadowing, a special antenna for shadowing could be installed with a switch to use it during search, although the cost of such an installation often equals or exceeds the cost of installing DF equipment. Moving existing communications antennas to create better shadowing techniques is not recommended and should not be attempted. The location of these antennas is part of the approved design of the airplane and resulted from FAA certification tests to determine their suitability. If modification of an aircraft is considered, installation of DF equipment will almost always be more economically feasible and result in a much more useful search aircraft.

c. Wing shadows will cause a drop in signal strength but will usually not make the signal disappear altogether (null). Designers of communication radios work hard on automatic volume controls (AVC) so that changes in strength are not audible to the pilot. To do wing shadowing, the AVC must be circumvented. When the signal is weak and noisy, the change of signal to noise caused by the shadow is easy to hear. As the signal grows stronger, the squelch can help. Set the squelch so the signal is just audible while in level flight. The squelch should close (no signal) when the source is shadowed in the subsequent turn. If more than one closure occurs, open the squelch some more and try again.

d. As the source is approached, it may not be possible to use squelch. In this case, tune the radio frequency away from 121.5 MHz (or the practice frequency), either up or down, until the squelch or the ear can again detect changes in strength. ELT/ EPIRBs "bleed over" into adjacent channels more than signals like an ATIS that might be used for practice, so the method works better for actual ELT/EPIRBs. Some communications radios with non-adjusting automatic squelch may not open the squelch for an ELT **or** EPIRB at any range. To use these radios, hold the squelch open manually and adjust tuning so that shadows can be detected by ear.

e. DF equipment incorporating their own receivers give meter indications of signal strength, making the above routines unnecessary. An auxiliary strength meter can be attached to many communications receivers by a radio shop, but, as with antennas, the cost of a one time modification and certification may approach that of a DF set. In any case, only aircraft with some type of strength meter can locate "carrier only" signals that make no sound using wing shadowing.

4-3. Determining Direction. Direction is determined by making a steep (approximately 45 degree bank) 360-degree turn. At some point in the turn, the wing will come between the ELT/ EPIRB and the receiving antenna, producing a shadow and drop in signal strength. In clear weather, note a landmark in the direction of the wing doing the shadowing. In poor visibility or for plotting, note the magnetic heading shown on the directional gyro during the shadow and add or subtract 90 degrees depending on turn direction and aircraft configuration to get a direction vector.

4-4. Conducting the Search:

a. Aircraft using the wing shadow technique for ELT/ EPIRB location should climb to search altitude as soon as possible after takeoff and prior to reaching the probable search area. The VHF receiver should be set to 121.5 MHz with the squelch fully off. The search should follow as closely as possible the probable flight path of the missing aircraft/vessel until the signal is detected. If the signal is not detected after a full sweep of the probable route, parallel the first search track and repeat the sweep. Track spacings can be roughly determined from the terrain and the signal ranges. In mountainous areas track spacings should be reduced to avoid the possibility of higher terrain blocking the signal if the objective should be located on lower hills, etc. Repeat sweeps can be made at higher altitudes to increase the reception distance and improve "line of sight" over irregular terrain.

b. Once the ELT/EPIRB signal has been detected, the search aircraft should continue on course until the signal is fully audible. If the signal is lost while continuing on the initial course, return to the estimated point where the signal was heard. From this point, fly a criss-cross pattern until the signal is again detected. If this pattern does not produce a signal, increase altitude 1,000 to 2,000 feet and try again.

c. As soon as the signal is positively detected, accomplish a steep bank 360-degree turn to establish an initial direction estimate. With a weak signal, the shadow may be quite broad. If a usable direction is obtained and nothing prevents it (assigned search areas, control zones, weather, terrain, etc.), turn and fly in the indicated direction. Repeat the turn for direction at 3 to 5 minute intervals until either no direction is indicated with a strong signal or the direction changes to back the way you came. Either will indicate that you are in the vicinity of the signal source. Keep a record of your position and the bearings determined at each turn.

d.. It is quite common for the signal to fade as you fly toward an ELT/EPIRB due to reflections from the ground, even in flat terrain. If a good direction vector is once obtained, maintaining that heading for up to 10 minutes will allow you to pass through the fade. When flying toward such a fading signal, each new maximum should be higher than the preceding one.

e. As the aircraft comes close to the source, a point will be reached where, during the turn, antennas on top of the aircraft will always be in shadow and those on the bottom will never be shadowed. Up to a point, bank angle can be increased to recover direction information. The amount of bank required to produce a usable shadow can be a rough indicator of distance. If a 60 degree bank produces no direction, descend to the minimum altitude safety will permit and try again. The lower the altitude, the closer the aircraft can be to the source before direction is lost (figure 4-3). Do not descend below the minimum legal and safe altitude, and do not use bank angles greater than 60 degrees.

f. If sufficient location accuracy cannot be obtained at minimum usable altitude, fly beyond or outside the suspect area and take additional bearings (additional vectors in figures 4-1 and 4-2). Two other shadows can be useful here. Top mounted antennas will be shadowed when the aircraft, in level flight, passes over the ELT/EPIRB. Because antenna rods receive poorly off the ends, bottom mounted antennas will lose the signal when directly over the source. While not strictly a shadow, the effect is the same. In any case, the shadow may not be straight down. If varies from aircraft to aircraft and the importance of a thorough knowledge of the particular aircraft being used cannot be overemphasized.

g. Figures 4-1 and 4-2 also illustrate a simple triangulation plot which can give an estimate of the position of the ELT/ EPIRB without actually flying to it. Plots can be made in the aircraft or on the ground using reports from one or more aircraft. In order to be successful, the aircraft must accurately know their own positions as well as the direction vectors. Such plots can be very useful when control zones or weather make a direct, homing flight difficult or dangerous. Because direction accuracy with wing shadowing is seldom better than 15 degrees, such location plots are subject to much larger errors than if a DF was used.

h. The exact location of the target must be pinpointed as precisely as possible (paragraph 6-le). It is extremely important that the pilot be able to precisely locate the target so that a rescue helicopter or ground team can reach the survivors.

i. If visual verification of the target cannot be accomplished, gather as much information as possible to assist ground units in confirming the target.

j. Conduct a visual search of the area to determine signs of survivors (messages, distress signals, etc.). Note nearby landmarks and hazards. Survey the area to determine accessibility for ground personnel, helicopter evacuation, etc. Gather as much information as possible.

k. Follow the instructions provided in your pre-flight briefing regarding contacting the search base.

4-5. Multiple Aircraft Parallel Track Search. When the line of search is conducted with two or more aircraft, the most experienced crew should be placed near the center of the track and designated on-scene commander. Mission coordinators must exercise extreme care when selecting pilots to fly electronic search missions using more than one aircraft along the same parallel track route. Communications between the aircraft should be checked out prior to reaching the search area and must be maintained throughout the search activity. Communications between search aircraft can be accomplished using CAP VHF FM radio or 123.1 MHz (122.9 MHz on practice missions). Aircraft that do not have the capability to monitor the communications frequency at the same time as they conduct the search should not be used for multiple aircraft search. Safe horizontal and vertical separation must be maintained at all times (see figure 4-4). The same basic procedures used with a single aircraft are employed, with the direction vectors obtained by each aircraft plotted on a situation map to locate the target.

4-6. Other Methods:

a. Occasionally a situation will occur, usually in mountainous terrain, where neither DF equipment or wing shadowing will give useful direction vectors. If weather permits, the search can be continued by descending into the valleys, one by one, and making note where the signal can and cannot be heard. This method takes advantage of shadows caused by mountains to determine where the signal must be, and requires precise position information from the aircraft. The areas where the signal can be heard are plotted on a chart and evaluated to determine possible locations for the target. It is possible for a signal to scatter over a ridge like light at sunset, but strength will be much weaker with a mountain in the way. Search by terrain shadowing is tedious and potentially dangerous, but has worked when all other means failed.

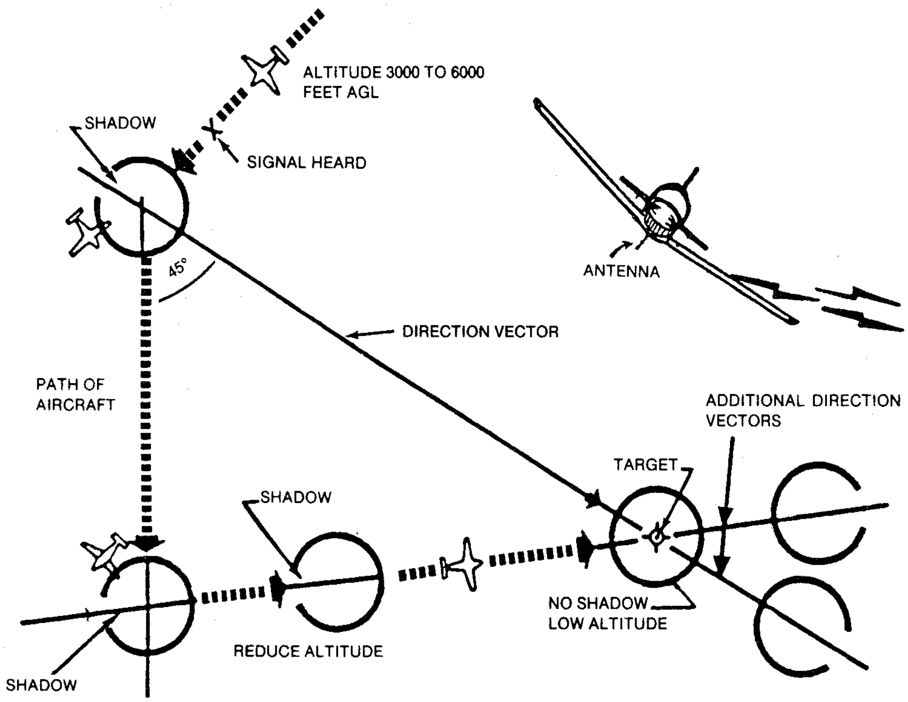
b. In the early days of electronic search, considerable attention was given to various aural methods of ELT/EPIRB location based upon the strongest signals being received near the signal source and fading out uniformly with distance in all directions. Various patterns were used based on the assumption that the signal was strongest halfway between signal fade in and fade out. These methods were very time consuming, subject to considerable errors, and not very reliable. Since ELT/EPIRBs rarely transmit evenly in all directions, aural techniques of ELT/EPIRB location are not currently depended upon by any reputable search organization.

4-7. Summary.

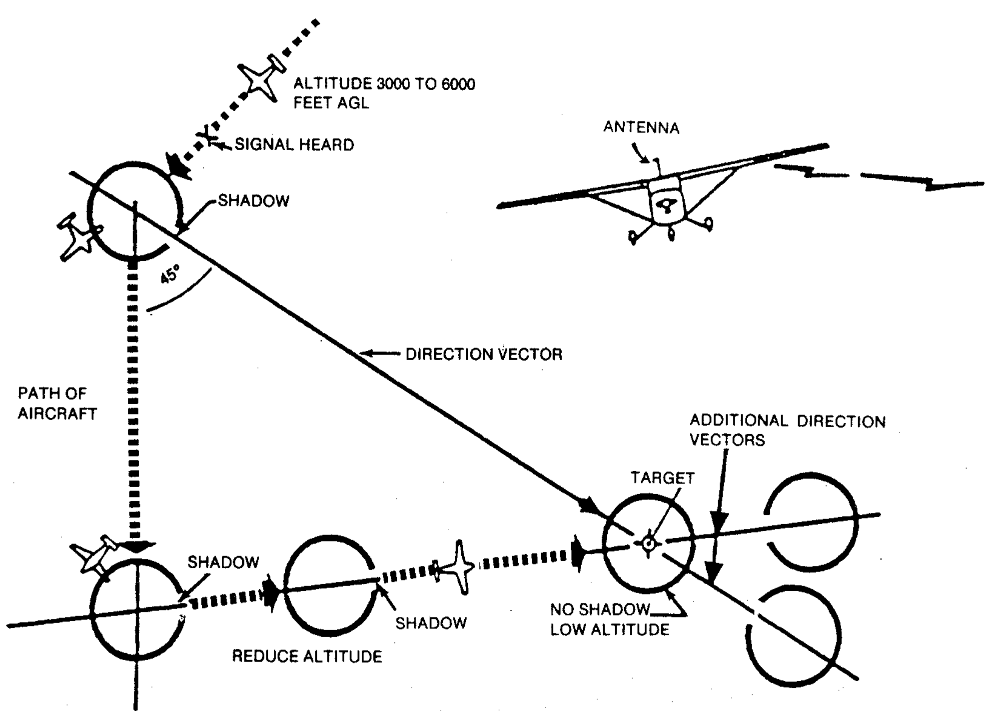
a. The pilot should have a thorough knowledge of the shadow characteristics of the particular aircraft being used so he can correctly interpret the information presented to him. Continual practice and experience are necessary to become an efficient ELT/EPIRB search pilot. Critique each mission and learn from it.

b. While a majority of ELT/EPIRB searches will conclude in a non-distress situation, each and every mission must be treated with the urgency of the emergency signal that it is. ELT/EPIRBs do work properly and do save lives! Don't assume an ELT at or near an airport is false - it is not uncommon for a plane to crash on takeoff or approach, especially at night and/or in poor weather.

c. As with DF equipped search operations, weather and terrain factors (dense forest, ground fog, air search conducted in or above cloud decks, etc.) may prevent a verification of the target by the aircrew. The pilot should gather as much information as possible and provide the most precise position information possible to the ground units to assist them in locating and verifying the target.



LOW WING PATTERN
Figure 4-1



HIGH WING PATTERN
Figure 4-2

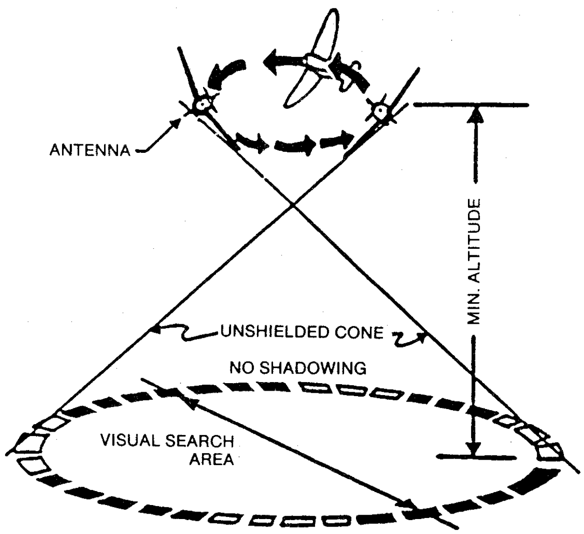
d. The initial briefing should include instructions for the aircrew on the procedures to be followed when the target is located in either distress or non-distress situations.

e. Aircrews should have a means of tracking a signal on an airport, even if it is a small, inexpensive aircraft band radio or FM portable radio.

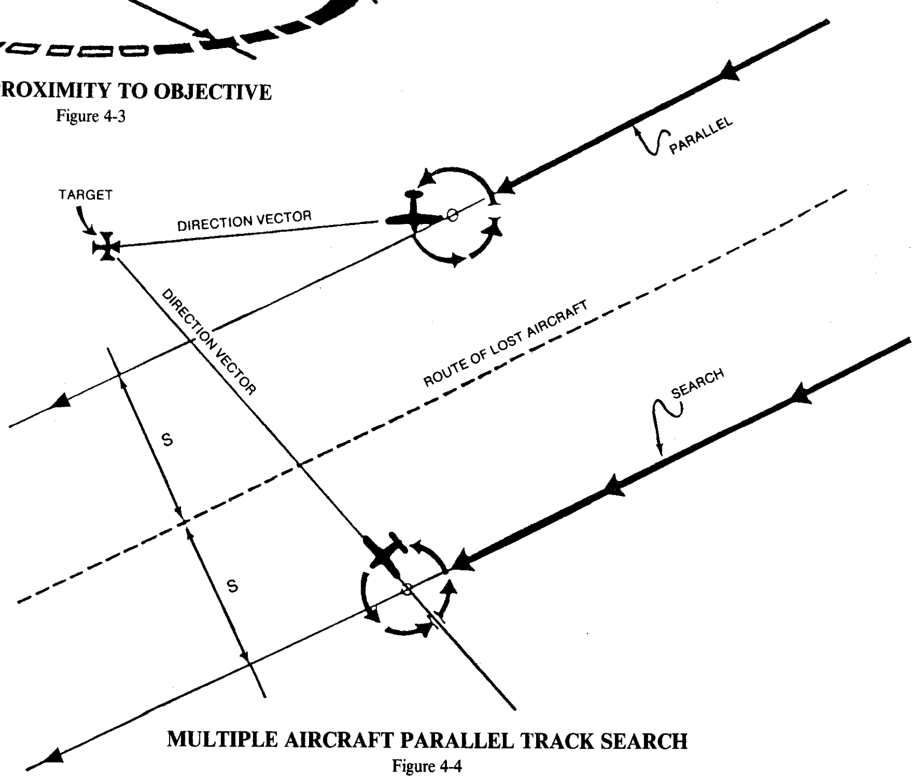
£ Even though wing shadowing is not as efficient as the left-right homing system, it should not be overlooked if DF equipment gives unreliable or questionable results or is not available. While less efficient and more time consuming than left-right homing, wing shadowing can be successful when DF techniques are unusable. Severe reflections and antenna polarization problems are the most usual causes of such situations.

g. Use of multiple aircraft along a parallel track search pattern can be beneficial when DF equipped aircraft are not available, however careful consideration must be given to the abilities of the pilots involved, local terrain, and other factors affecting such search operations.

h. Aural methods of tracking ELT/EPIRBs have not proven reliable or efficient, and are not currently depended upon.



CLOSE PROXIMITY TO OBJECTIVE
Figure 4-3



MULTIPLE AIRCRAFT PARALLEL TRACK SEARCH
Figure 4-4

Chapter 5

GROUND ELT LOCATION

5-1. General. Ground ELT location has some similarity to airborne location and some equipment can be used in both services. For instance, wing shadowing in an airplane becomes body shadowing on the ground. Ground location has more obstacles (both literally and figuratively) to overcome. Fortunately, the flexibility inherent in ground location provides more options to overcome these obstacles. In both cases, ELTs are located by determining the direction of signal travel (DF) and by sensing the increase of signal strength nearer to the ELT. The ELT may be located by plotting a series of direction measurements on a map (triangulation), by following a measured direction to the source (homing) or by observing strength while driving or walking in a controlled pattern (build and fade). Good search technique takes account of both direction and strength changes. A single search often employs all three location techniques, using each where it is most effecient.

a. There are three types of DF units in common use for ground ELT location:

(1) Left/right systems, as in airborne DF, use an electrically switched antenna system. This method determines which side of the antenna is receiving the stronger signal and indicates direction with a left/right steering meter. These DFs must use the antenna designed for them. The L-Tronics "Little L-Per" is the most common unit of this type. Left/right DFs are more accurate than signal strength DFs.

(2) A second DF system uses a directional antenna. As the antenna is rotated, peak signal strength is indicated when the antenna is pointed at the ELT. The Clue Finders "Omega 1" is the most common signal strength DF unit. Receivers that use body shadowing to give directivity to a simple whip antenna also fall into this class. The Dorne & Margolin "B Line" is of this type as are portable radios and scanners used with body shadowing.

(3) The third type of DF is an interferometer. It uses an existing left/right or signal strength DF unit and adds an additional antenna and length of coaxial cable. When properly used, the antennas wind up separated on a line at a right angle to the direction to the ELT. The interferometer is the most accurate type of DF but requires two people and extra time and space to use.

b. Most left/right DFs can be switched to become signal strength DFs and both left/right and signal strength DFs can be used with short whip antennas as sniffers or with body shadowing as described in the section on the find. Except for this, DF sets should NEVER be used with antennas not designed for them. The following is a brief description of the basics of operating the DF sets. It is not complete. Read the instruction manuals for your particular unit or contact its manufacturer for more complete, specific information.

c. Left/Right DF Units:

(1) Set the unit to DF mode. Turn the sensitivity control from minimum toward maximum until the signal is heard and the meter needle moves away from center. Turn the antenna left and right about 90 degrees. Set the sensitivity control so the maximum needle deflection from center is about half scale. If INCREASING sensitivity ever causes the needle to GO BACK toward the center while the antenna is held still, REDUCE the sensitivity setting. This setup procedure gives best accuracy in ALL circumstances and should be carefully followed.

(2) Turn the DF through a full circle while observing the left/right meter. The needle will usually wander about but should cross through center only twice, about 180 degrees apart. If the needle doesn't move or if it bangs against the stops, reset the sensitivity as described above. If the needle stays on one side, check the equipment or try another DF unit. If the needle crosses the center more than two times, try another location or see the following sections on site selection and multiple signals.

(3) If the needle centers twice in a full circle indicating that the site is good, turn the antenna in the direction indicated by the needle until the needle centers. You are now facing the direction toward the ELT. If the needle is centered when you start, or if you wonder if you are facing the right way, turn the antenna either way until the needle moves and then turn in the indicated direction. If you were facing the right way, this will result in a return to your former direction.

(4) While watching the needle during rotation, also listen to the signal. The switching action of the antenna causes a buzz or hum to be heard along with the swept ELT tone. This buzz should be softest when the needle centers. A buzz in all directions, particularly if the needle is erratic, usually indicates electrical interference. Try a different site. Nearby transmitters can also cause noises and needle jumping. Wait until the transmission stops then continue to DF.

d. Signal Strength Units:

(1) The techniques for using signal strength to determine direction are the same for units which rely on this mode only, as well as left/right units which can be switched from left/right (DF) to signal strength (Receive). Start with the sensitivity or range switch set to bring the needle on scale. Slowly rotate the antenna 360 degrees, watching for maximum needle deflection. If the needle hits the upper (right hand) stop during the turn, reduce the sensitivity or change the range switch to bring it back on scale. Make a full turn after adjusting the sensitivity. Do not readjust if the signal is lost or the needle hits the low (left) stop during the turn. Note only the signal maximum. If the maximum is very broad, more than 60 degrees, adjust the sensitivity until the needle is less than half scale and try again. If the signal strength DF has an insensitive meter or no meter, turn back and forth around the maximum signal direction while slowly tightening the squelch. An adjustment should be found where the squelch breaks (makes sound) for 20 degrees or so on each side of the proper direction. This helps to define the peak.

(2) The ELT will be in the direction the antenna is pointing at maximum signal. The proper direction is marked on most DF antennas. The antenna will also show one or more nulls or dips in signal strength. Nulls are sharper than the maximum but are not reliable direction indicators. Do not use them. When moving into an area of increasing signal strength, reduce the sensitivity to give a half scale indication or change the range switch any time the needle goes to maximum.

e. Body shadowing:

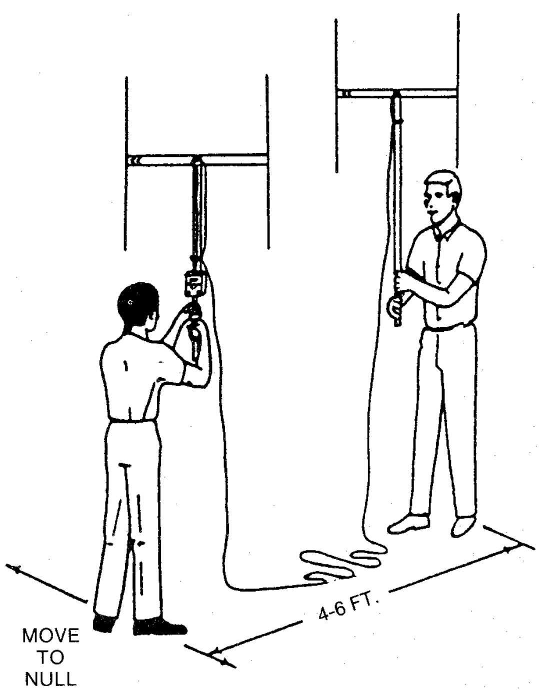
(1) The human body partly blocks ELT signals. The received signal strength will drop when the body is placed between the receiver and the ELT. Put a whip antenna on the DF set. It need not be for the right frequency. A "rubber duck"

borrowed from a handie talkie works fine. Stand with the receiver about 6 inches away from the body at waist level and with the antenna straight up. This makes the meters on many units hard to see so the procedure is done with sound. Turn the volume up high and turn down the sensitivity until the ELT is barely audible. If there is not enough sensitivity range to make the signal weak, turn to 121.6 and try again. Turn in a full circle. The ELT will be weakest when it is directly behind you.

(2) When using a scanner or radio without a sensitivity control, turn up the volume to near maximum and tune up or down away from 121.5 until the signal is weak. This defeats the automatic volume control in the radio and makes it possible to hear small changes in strength. Turn and listen for the minimum as above. If the radio has a squelch, this can also be used to sense changes in strength. Adjust the squelch while turning until it closes (goes quiet) for a small angle. The ELT is behind you when the squelch closes. When working close to an ELT, tuning away from 121.5 may also be needed to give the squelch enough range to close. Body shadowing is usually used close to the ELT but can be used at any distance where the ELT can be heard. At short range, even inexpensive FM radios can be used with body shadowing. Tune around 100 MHz.

£ Interferometers:

(1) First, get an initial bearing to the ELT using left/right or signal strength DF as described above. Then connect the second antenna and cable to form an inteferometer. Put the DF in the signal strength mode and use the same sensitivity or meter range setting as for initial bearings. Start with the two operators facing each other about five feet apart on a line at a right angle to the approximate ELT direction. Both antennas should point at the ELT as shown in figure 5-1. While one operator stands still, the other moves toward and away from the ELT (left and right like the arrows in the picture) to find a signal strength minimum or null. It is usually easier for the operator with the radio to do the moving because he can see the meter and hear the null easily, but the other way works, too. When the null is found, mark this spot on the ground and move away (backwards) another five feet. Repeat the toward and away motion to find a new null and put down another mark. Repeat this procedure every five feet until coming to the end of the cable or the available space. Do not try to skip steps in this procedure or make the null measurements further apart. It is possible to get on the wrong phase front if you do, producing a BIG error.



Initial null location, vertical polarization.
Used by permission. Copyright 1983 by L-Tronics
Figure 5-1

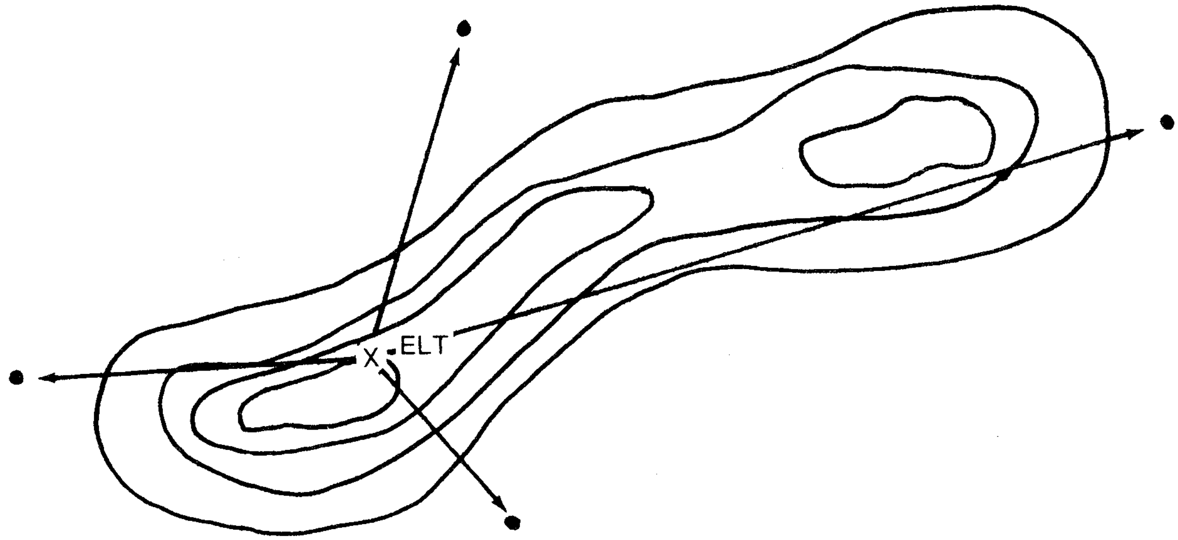
(2) If many reflections are present, the marks will not line up. The best straight line fit to the marks will be at a right angle to the direction to the ELT. If reflections are not severe, sighting between the two antennas at maximum separation can be used, saving the time of ground marking.

5-2. Conducting the Search. Safety is the number one concern of any search and should never be sacrificed for speed in getting to the target. However, every distress beacon search should be considered to be an emergency and response made accordingly. A systematic approach to ELT location is required to achieve a safe but rapid response and it ultimately saves time.

a. Acquiring the signal can be the most difficult part of the search. Though SARSAT provides coordinates of the approximate signal location, these can sometimes be very far off. SARSAT coordinates represent a 50% probability that the ELT is within an elliptical area 7 miles north/south and 14 miles east/west. Aircraft can provide a better signal location but they are not always available. Having a preplan for ground DF missions can greatly aid initial signal acquisition. Personnel with monitoring and especially DF capability should be called, not necessarily to respond, but to listen for a signal and provide a bearing from home if possible. Even without actual DF bearings, this can provide valuable information. For instance, a number of widely scattered stations all receiving a signal is an indication of a signal up high, either airborne or on elevated terrain (fig. 5-2). Good DF sites, including those which can indicate if a signal is coming from high probability areas such as marinas and airports, should be pre-determined.

(1) Prior to departure, ground DF teams should plot all known SARSAT hits, PIREPs (pilot reports), and any ground reports on appropriate maps. These plots are used to determine approximate target location and potential DF sites. The team should also know the signal characteristics, 121.5, 243, or both; sweep or carrier only etc.

(2) Once dispatched, all teams need to monitor the ELT/EPIRB frequencies while mobile. If multiple teams are used, they should be in contact with each other or a base by radio to make a coordinated search. The DF should be connected to the vehicle electrical system to conserve battery power for use outside the vehicle. An outside DF antenna will permit both reception and DF in motion. A simple whip antenna cut to 121.5 MHz will allow best reception only, (although no DF) but a CAP VHF antenna or FM radio antenna will work and an inside whip is better than nothing. Mobile monitoring saves time because the team does not have to stop to see if the signal can be heard and the signal may be heard prior to reaching the plotted signal areas or DF sites. One caution: vehicle noise may obscure a weak signal. If the ELT is not heard in the expected area, stop and listen with the DF set away from the vehicle.



Widely scattered sites that can receive a signal indicate an elevated target.
Figure 5-2

(3) The best DF sites are those above the surrounding terrain, vegetation, buildings, traffic, etc. Elevated areas are preferred because the DF is above some, if not all, of the obstructions between it and the transmitter. Since the beacon is transmitting in all directions, the signal is going up as well as out, so getting above the signal takes advantage of the clearer signal in this direction. The site should be large enough to use the DF equipment freely, keeping in mind that an area for an interferometer needs to be at least twice as large as an area for just the basic DF unit. If mobile, there also needs to be room to pull the vehicles safely off the road. The site should be clear of obstructions, though an elevated location with some obstructions is generally preferred over a lower, but clearer site. Obstructions include trees, thick vegetation, large rocks, buildings, vehicles, planes, boats, etc. These may both block or reflect some or all of the signal. There is no set distance the DF should be kept from these objects but an area 20 or 30 feet in all directions should be satisfactory for a basic DF unit. Low brush and isolated objects like a tree or pole should not be a problem. More distance should be kept from larger objects like buildings and the sides of hills. When DFing in areas of many buildings, rows of hangars, in canyons and valleys or other locations where the clear areas are relatively long with large or dense obstructions on either side, DF down the middle, between the obstructions.

(4) Though obstacles are generally a problem because of their blocking effects on the signal, these can also be used to an advantage. For instance, a signal which is received at the mouth of one canyon or valley, but not in another, indicates the source is in the one canyon or valley. Objects large enough to cause blocking can also cause signal reflection or bounce. For the most part, this cannot be intentionally taken advantage, of like blocking (fig. 5-3). It can help in some cases where it causes a signal to go around an obstacle by bouncing off another. In general though, signal bounce causes more problems than it helps because it creates multiple signals.

(5) The area should also be clear of electrical objects such as transformers, generators, and outdoor lighting. Power and phone lines should also be avoided and at the least should not be directly overhead. Signals tend to align with overhead lines (as well as metal fences). Electrical devices can cause a hum on the DF and faulty direction indications, possibly masking real signal indications. Vehicle ignitions and power accessories such as power windows can also give false indications.

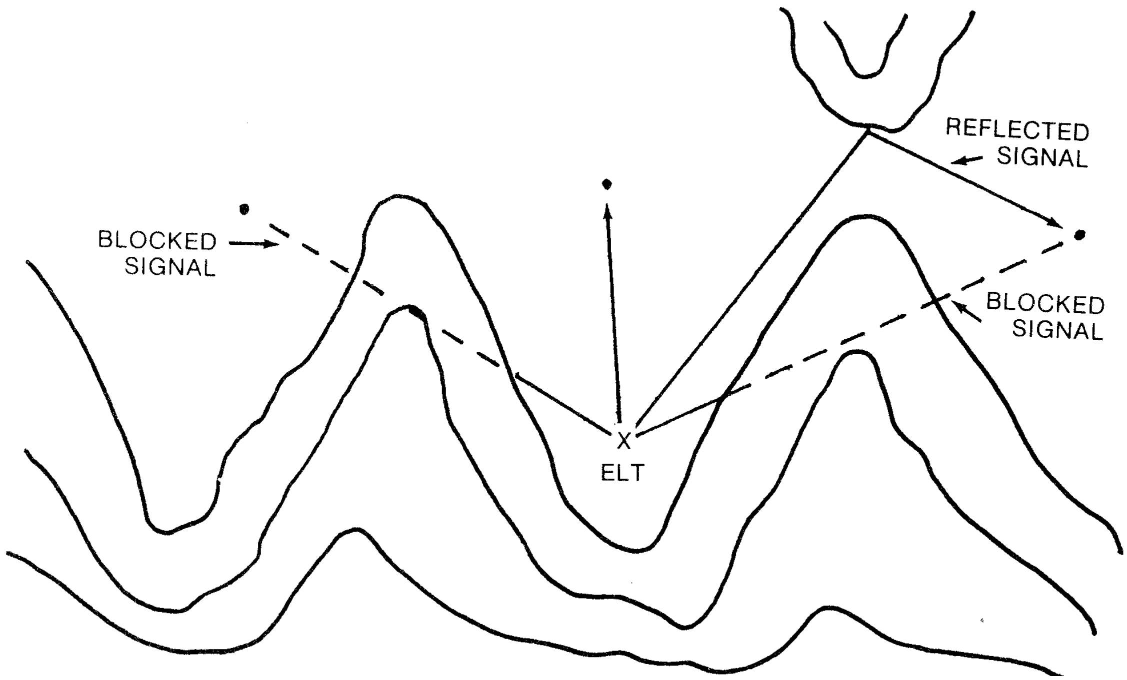
(6) Signals in forested areas tend to align with the roads. Intersections in these areas are good DF sites since they are clear and the intersecting roads help to minimize signal alignment. Eventually DFing will have to be done off the roads so areas as large as possible and with less dense vegetation should be selected.

(7) Bridges make good DF sites because they tend to be above the surrounding terrain. Simple span bridges are best, avoid truss, suspension and other bridges with a lot of overhead metal as this tends to give false indications. Bridges should be used only if the search vehicles can be safely parked off the bridge and there is pedestrian access across the bridge. Compass readings taken from bridges are often unreliable because of their steel content. When the DF bearing is obtained, sight on a distant landmark and take a compass bearing on the landmark when off the bridge.

(8) People can also affect the signal, so when taking the DF reading, other team members should stay either several feet behind the DF or at least 15 feet away. If the member with the unit turns, the group should also move to stay behind the DF.

(9) There is no set distance the DF should be kept from objects due to many factors, the most likely being the lack of choice in location. To minimize the time involved in site selection on an actual search, pre-planning should include identification of good DF sites and checking them out on practice missions.

b. Site suitability. Assuming that the signal can be received, the selected site may still not be suitable for DFing. Connect a DF antenna matching the frequency to be tracked. A signal can be heard on 121.5 using the 243 MHz antenna and vice versa, and the DF needle will move, **BUT THE READINGS ARE NOT ACCURATE.** Switch off or disconnect any interferometer antenna and cable. Hold the unit vertical, turn it on and take a direction reading. If more than two needle crossings about 180 degrees apart are found on a left/right DF or if more than one peak is found with a signal strength DF, try the following: First, move as far away as possible from any nearby objects, especially electrical or metal ones and repeat the DF procedure.



Obstacles such as buildings and ridges can block and reflect the signal, causing both DF problems and advantages.
Figure 5-3

Move about 10 feet and repeat the same procedure. If the multiple indication problem persists, move about 10 feet roughly perpendicular to the first movement. If this still doesn't provide a good indication, check for polarization or multiple signals as described below. Take the bearing again with horizontal polarization if that is indicated or try to separate the multiple signals. Except for resolving multiple signals, the interferometer will not be usable if a rough DF cannot be obtained using left/right or signal strength. If none of the above works, move to a completely new spot.

(1) Measuring other parameters. Once a site is selected, several things besides the direction to the signal should be determined, such as sweep type or carrier only, motion, and polarization. These should be measured upon first hearing the signal and again when a good solid signal is being received. Since they don't usually change during a search, they need not be checked at each site. Take the following measurements:

(a) Motion. This is very important because determining that a target is moving will affect the whole progress of a search, often halting it altogether. When determining direction using left/right DF, turn the antenna to center the needle and hold it steady for 30 to 45 seconds while watching the needle. If the needle swings slowly back and forth, it is a positive indication that the source is moving or, sometimes, that something very near the source is moving. Airborne ELTs usually produce a slow, smooth variation with a period of 10 to 45 seconds depending on range, speed, and altitude. An ELT in a moving car or with cars moving nearby will give a choppy, irregular variation. Signal strength DFs will usually show a smooth or choppy strength variation, respectively, but this is not dependable. A **free-floating** EPIRB is a special case, important for rescue. Its signal will often fade at a 7-15 second rate due to **waves, but it will NOT show** a direction change using left/right DF.

(b) Sweep and modulation. FCC rules permit a wide variance in sweep rates and sweep pitch limits. All airborne and all old style (non-406 MHz) EPIRBs have a downward sweep. The 121.5 MHz signal from the new 406 MHz EPIRBs sweeps upward and stops about every 50 seconds for about 1 second. Damaged or corroded ELTs may have a fluttery, irregular sweep or no sweep at all (carrier only signal). A few ELTs have synthesized voice position announcements. Other background voices can indicate a stuck microphone or a communications station a hundred miles away. Because ELT sweep and pitch are not uniform, it is usually easy to tell if more than one ELT is present by listening. Use signal strength (receive) mode so the DF switching buzz doesn't confuse the sound. The sweep rate of most ELTs shows as the batteries run down, but some don't and a few speed up. This happens over many hours, so it is an interesting phenomenon but is not very useful.

(c) Polarization. The antenna on the transmitter being tracked may not be vertical due to a crash or because it fell over in storage. This is particularly true of EPIRBs. In most cases, the ELT can still be tracked with the antenna vertical but using a horizontal mode, if available, will make location easier. Refer to the instruction manuals for the particular DF unit for horizontal operation. To determine polarization, set the DF for signal strength (receive) mode and turn the antenna for maximum signal. Tilt the antenna over from vertical to horizontal while watching the meter. When horizontal, the antenna should still be pointing at the ELT. If the signal is much stronger with the antenna horizontal and if a sharp null is found with the antenna nearly vertical, change to horizontal mode if possible and then take bearings.

(d) Carrier only signals and noise. Damaged ELTs and radios with their microphones stuck may put out signals with no sound. Accidental signals from computers or other equipment may make a variety of strange noises. They will give the same meter **indications and** may be **tracked using the** same procedures described here for ELTs. **Only the sound is different.** DF units are capable of tracking both ELTs too weak to be heard and broadband noise sources like an arcing power line. To tell the difference, determine **direction on 121.5 MHz.** Then change to the practice frequency, usually 121.6 MHz, and take the bearing again. If the two bearings agree, you are tracking noise. If not, you are tracking a weak ELT, carrier or other narrow band signal.

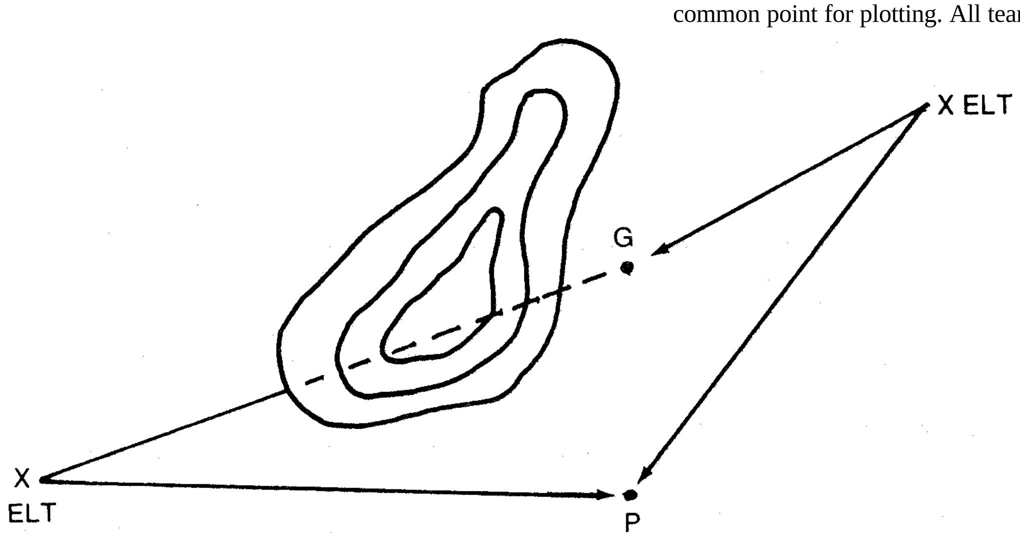
(e) Multiple signals. Reflected signals from a single ELT that arrive at the DF over different paths will cause variation or swinging of the apparent direction. These can be overcome by averaging, the interferometer or careful site selection. Reflections from one source are not really a problem in that they will be tracked to the same source, it just may be by a longer route. Listening, using signal strength (receive) mode, is the best way to determine if two separate signals from different transmitters are being received. The DF will point to the stronger signal so if the signals are quite different in strength, the stronger one can be located. If the strengths are nearly equal, averaging or moving a short distance will NOT help. This is why it is important to discover if two signals are there. Move to a completely new site trying to put obstacles in the way of one of the signals as shown in figure 5-4. Keep track of the sites where multiple signals are heard, and once one signal has been secured, return to one of these sites to start tracking the other signal. If two ELT sweeps sound distinctly different, separate bearings to each can be determined using the interferometer. Determine the null at each point in the procedure by listening rather than using the meter, being careful to always null the same sweep. Repeat, nulling on the other sweep. This is a tedious and time consuming process but can be better than driving around at random.

(2) Once it has been determined that the site is usable, 'a compass should be used to record the bearing, even if it is not going to be plotted for triangulation. Bearings and locations should be kept in a written log along with an estimate of bearing quality. The speakers and meters in DF units and other radios can cause compass error. Attaching or holding a compass to the mast at the manufacturer's mounting point is the most convenient **and avoids math errors.** Bearings taken by a second person sighting between the uprights of a left/right DF are subject to large error, particularly at night. If a second person is used with a DF in the left/right mode, sight along the crossbar, lining up the two sets of antenna rods. Add or subtract 90 degrees depending on which side the compass holding is standing.

(3) When using left/right or signal strength DFs without an interferometer, a more accurate bearing can be obtained by taking the average of a series of bearings. This method can also help determine the usability of a questionable DF site. Obtain an initial bearing, then move perpendicular to the approximate direction to the signal and every five feet or so, take another bearing until about 50 feet from the initial point. If any of the bearings differ by more than +/- 45 degrees, the bearings and site should not be used. If the bearings are within this, then average them. This average is the assumed bearing to the ELT. If any of the bearings differ from the average by more than 20 degrees, then this average should be considered marginal.

c. Plotting. Plotting is not always required. In many cases a car with DF antennas can be quickly driven to the offending airport ramp or pier without ever taking a formal bearing. If bearings are taken, they should be plotted as an aid to picking the next site and a route to it. A log should also be kept. In areas with easy access, extensive plotting for triangulation is a waste of time. In the back country, however, multiple plotted bearings can play a major role in efficiently positioning rescue forces. This section addresses the back country situation.

(1) Once a bearing and signal characteristics have been determined, the next step is to plot the DF site and bearing as accurately as possible on a suitable map of the area. Accuracy is emphasized because signals can be DFed from long distances and only slight errors in taking bearings and plotting them can lead to large errors in signal location. These errors can be magnified considerably if magnetic declination is not used properly when plotting (see Table 5-1). One way to avoid this is to place a grid of magnetic north reference lines on maps to be used for search before the search begins. If more than one DF team is working, bearings and locations can be sent by radio to a common point for plotting. All teams should use the same maps



Using blocking to assist in DFing multiple ELTs, by moving from P to G.
Figure 5-4

and report magnetic bearings. DF sites must be chosen so that their location can be accurately reported. Some teams use portable Loran as an aid to finding the location of their DF sites. Sites should be surveyed to discover any discrepancies in Loran readings.

DISTANCE FROM DF TO SOURCE

Bearing Error	1 mile	5 miles	12 miles
2°	184 ft	922 ft	0.4 mile
5°	460 ft	0.4 mile	1.0 mile
12°	1106 ft	1.0 mile	2.5 miles

Example: If the DF bearing is off by 12 degrees and the signal source is approximately 5 miles away, the actual source will be about 1 mile from where it plots on the map.

DISTANCE FROM DF TO SOURCE

Declination	1 mile	5 miles	12 miles
5°	1382 ft	1.3 miles	3.1 miles
10°	0.4 mile	2.2 miles	5.2 miles
15°	0.6 mile	3.1 miles	7.3 miles

Errors are due to using declination wrong when converting between magnetic and true bearings. Assumes a 5 degree bearing error.

Example: For a bearing that is off by 5 degrees and when plotting, the declination of 10 degrees is added instead of subtracted from the compass reading, the actual source, if about 12 miles away, will be 5.2 miles from where it plots on the map.

Distance Errors Between Actual and Plotted Signal Location

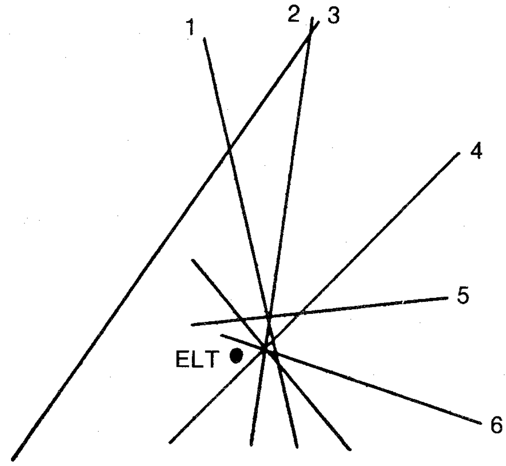
Table 5-1

(2) A minimum of two bearings are required to establish the ELT location. Once the DF locations are plotted on the map, a line representing the bearing to the signal is drawn. Where the lines cross is the theoretical location of the ELT. This is called triangulation. How close the intersection comes to the actual location depends on the accuracy of the bearings, the accuracy of DF site location, and signal characteristics.

(3) The next step is determining the next DF site. The objective is to move closer to the signal if possible and to pick a position that is not on a direct line between the current position and the ELT. Try to get bearings with large crossing angles so that small DF bearing errors do not result in large location errors. Ultimately enough bearings could be taken to surround the ELT location. When plotted on a map, a cluster of crossings between the various bearing lines will appear which defines the most probable ELT location (figure 5-5). It is normal to get some errors. As the number of plotted bearings accumulates, those in error will become apparent like bearing 2 in the figure.

(4) Plotting for triangulation or to determine the next DF site is carried on until it becomes quicker to home in on the suspect area than it is to make further bearing plots. If, during the search, the signal is lost, the plot record or bearing log will allow a return to a site where the signal was heard previously to see if the signal has really gone off the air.

d. Homing on the ELT. The DF should be on, at least periodically, when moving from site to site whether driving or walking. Glance at the meter often and listen but do not allow "meter fascination" to compromise safety. Stop to take careful bearings. Bearings change and signal strength increases more rapidly as the ELT is approached. Readjust sensitivity to prevent overload. When changes are rapid, stops should be close together. In general, walking readings should be no more than a hundred yards apart.



Each succeeding DF bearing should move closer to the source and a position so that the source is finally surrounded, forming a rough spiral. Figure 5-5

(1) When mobile, the DF should be connected to an external vehicle antenna. If vehicle DF antennas are not installed, hand held antennas can be extended from windows, roofs or truck beds to give direction as well as signal strength changes for location while driving at slow speeds on airport ramps or other unobstructed areas.

(2) Left/right DF antennas can be installed on the vehicle to provide fore/aft DF, right/left DF, or both. Vehicle homing using the preferred fore/aft antennas is different than hand operation. The DF unit is operated in the left/right (1317) mode. The needle will swing left if the signal is in front of the vehicle and right if it is behind. Reflections from nearby objects will cause the needle to flutter about while in motion. Use the predominant indication; that is, if the needle is to the left most of the time, go forward. Because motion averages reflections, indications in motion are actually more accurate than steady readings while stopped.

(3) To home on an ELT, turn the vehicle until the needle swings left (forward) and pick a road that goes approximately in that direction. Continue to drive in that direction until the needle swings back and forth spending about equal time to the left and right. Find a cross road and turn till the needle again indicates (mostly) forward. Periodically adjust the sensitivity to keep the needle on scale most of the time. On winding roads, a compass is used to determine the heading which makes the needle go to the left (forward) most of the time. When this is no longer the general direction the road is going, find a side road that does. Continue this process until the roads permit no further advance, then walk. If possible, circle the suspect area in the vehicle before walking to verify that the ELT is inside. Finding an ELT in a house after walking all the way across a major airport is embarrassing.

e. Location by build and fade. A single, non-directional whip antenna on a vehicle or a hand held radio can be used to locate an ELT by changes in signal strength, often called the "build and fade" location method. It works because signals become generally stronger near the ELT. In flat, open areas, the strength will increase 4 times (6 dB) each time the distance is cut in half. This means the change is much faster near the ELT. Going from 10 miles from the ELT to 5 miles will make the same CHANGE in strength as going from 100 feet to 50 feet. The rate of change of strength can give a rough estimate of distance. Location by build and fade is inefficient when far from the ELT. Close in, particularly inside buildings, hangars or marinas where DF is confusing, it may be the quickest method. When properly equipped, both DF and signal strength data should be taken. Each method can reinforce confidence in the other. Other characteristics of the signal, such as sweep rate, do not change with distance. If the DF emits strange squeals and groans, it indicates that the sensitivity control or range switch is improperly set.

(1) In a vehicle, to locate a signal by build and fade, select signal strength mode, set sensitivity to put the needle on scale, pick a likely direction and drive. Buildings, trees and wires near the road will cause the strength to flutter about. Look for the longer trend, up or down. If the signal builds up, keep going. If it fades out, turn around. If it fades out both ways, pick a road at right angles to the first and repeat the procedure. Far from an ELT, it may take many miles to produce a positive build or fade. Closer in, a block or two might do it and on an airport ramp, the length of 2 or 3 planes can be enough. Turn down the sensitivity to give a half scale reading each time the needle reaches maximum. Don't turn it up again if the signal fades out or if you do, carefully mark the knob position so you can return to it. This allows you to accurately "remember" the strongest signal over 20 or 30 minutes of searching.

(2) The build and fade procedure is the same while walking, only over a smaller area. In buildings and hangars, it is particularly important to "remember" maximum signal levels to compare readings taken in different rooms or areas many minutes apart.

(3) Changes in strength when driving or walking by buildings or hills can also be used to determine signal direction. In Fig 5-6, ELT A would increase in strength at G and decrease

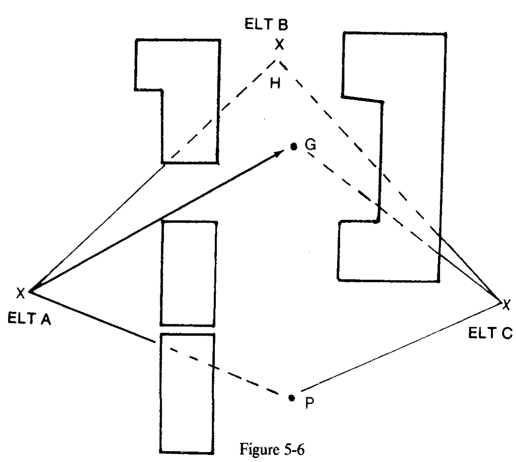


Figure 5-6

again at H. ELT C would decrease going to G and stay down at H. ELT B would get stronger at G and stronger still at H. The same effect occurs on a large scale if the buildings in the figure are replaced by hills. For example, if a signal can be heard at the mouth of one canyon and not at the mouths of its neighbors, it is likely somewhere in that canyon.

(4) Target distance when far away can only really be estimated by triangulation. Attempts to use absolute signal strength as a measure of distance in the real world are subject to errors of up to 100 to 1. As noted above, the best indication that the target is near while homing is that signal strength increases faster and faster.

5-3. The Find:

a. Locating the ELT:

(1) In reasonably open areas, the DF antennas, either left/right or signal strength, can be used right up until the ELT antenna and DF antennas touch. If the area gets crowded with more reflections, as in a boat marina, turn the left/right DF antennas fore and aft as described for mobile DF above (arrows forward). Then a predominantly left needle means forward and a mostly right needle means aft. Walk along a line of airplanes or along a pier until the needle changes from fore to aft. Then turn at right angles (piers permitting) so the needle again faces left and proceed until a single boat or plane is isolated.

(2) If the target is a communications radio rather than an ELT, the antenna may be high up a mast and the DF will fail when underneath. The best method here is to back off a few hundred feet and do a short range triangulation. Bearing intersections will have to be estimated by reference to landmarks rather than plotted on a map but the same principles apply and the proper mast or tower can usually be identified. This kind of "outside the problem area" short range triangulation is also useful to pick a starting point in a marina or in a cluster of T hangers.

(3) Once it is felt the source has been pinpointed, walk completely around it, using the DF to verify that the signal is coming from this target. Repeat this circle further away if possible. If this is indeed the source, then the DF will still point back towards the target but the signal will be weaker. Surrounding the signal is an absolute must if the actual source is not apparent, as when the signal is coming from a building.

(4) If a complete walk-around a building cannot be accomplished or is inconclusive, get as legally and safely close as possible and place the DF near doors, windows, vents, or other openings to the inside. If the source is inside, the signal should be stronger at these locations. This "sniffer" operation usually works better if a whip or rubber duck antenna is used instead of the DF antenna. Do not try to do it without any antenna or by holding something in the antenna jack because small changes of hand position will affect the apparent strength more than its position near the building.

(5) After completing the walk-around of an airplane on a ramp, the location can be verified by holding the DF within an inch or two of each antenna on the aircraft and turning down the sensitivity until the signal is weak. Turn to 121.6 if the sensitivity control runs out of range on 121.5. Then pull the DF away. If it was near an active ELT antenna, the signal will be lost in about 2 feet. This test also can be made with most CAP VHF transceivers. This test may not work if the ELT is a portable type not connected to an outside antenna. "Sniff' around the windows as was done for a building above.

(6) Walk-around of boats in a marina should also be performed but at least one side of the boat will not be accessible. A DF bearing should be taken from other docks to complete the walk-around on these sides. The water and rigging act as good reflectors, so pinpointing a boat is more difficult than an aircraft. The fore/aft mode described above is often very good at positively selecting between two candidate boats when held between them. Don't forget that many EPIRBs also have flashing lights visible at night.

(7) Inside buildings, hangars and ships, DF is difficult or impossible. Body shadowing may help some and should be tried but the best procedure is usually to put a whip antenna on the DF and, using the sensitivity control as a "memory" for the peak signal encountered, make an orderly patrol through the areas until the trail of successively higher peaks leads to the offending ELT. Again, the DF can be used as a "sniffer" around cabinets and lockers in suspect areas like it was around windows on the outside of a building.

b. Securing the signal:

(1) On distress DF missions, looking for and tending to survivors takes priority over securing the ELT. Leaving it on initially may also help other personnel to locate the site. Once the crash scene is under control, move only what is necessary to locate and secure the ELT. Do not move it or take it for safekeeping, but note its location and the position of the on/off switch before it was turned off. Pass this information along to other rescue and investigation personnel to minimize the chances of it being turned on accidentally later.

(2) Civil Air Patrol personnel do not have authority to enter any plane, boat, vehicle, or building, whether locked or not, or board boats to secure an ELT or EPIRB**.** For signals coming from boats and planes, marina or airport operators, security, fixed base personnel, Coast Guard, harbor patrol or other local law enforcement should be contacted for assistance. Don't expect these people to enter the boat or plane, but they may be able to assist in locating the owner. If along delay is expected, the signal from an ELT may be sharply reduced and taken out of the satellite system by wrapping the antenna in aluminum foil as shown in figure 5-7. Similar wrapping can be

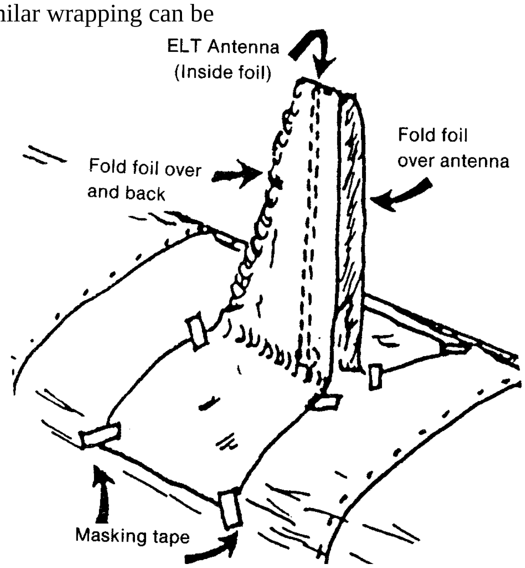


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Figure 5-7

applied around the antennas of external EPIRBs. It does not hurt the ELT or EPIRB**.** To be effective, the foil must be unbroken and has to have flaps taped to the body of the EPIRB or the fuselage skin. Be sure to leave a notice of this action for the pilot or captain.

(3) If the signal is coming from a business or building that is closed, try to find an emergency, alarm company, or security company phone number on the building, usually near a door. The local law enforcement agency may have an emergency number if one cannot be found otherwise. For safety reasons, law enforcement assistance should be called when the signal is coming from a house. Ground team members will have to talk to the occupants as it is unlikely the officers will have knowledge of DFing, ELTs or EPIRBs.

(4) Both owners and law enforcement may be reluctant to help or cooperate. Most cities and counties, as well as the Federal government, have laws against the intentional transmission of a false distress call. Find out what the local and state laws are by number in your area. After the owner is notified, refusal to cooperate has been interpreted as "willful transmission." Discussing this with owners calmly and gently usually gets the ELT shut off quickly. Stick with the shutdown effort until it is off or a positive plan for turning it off is in place. Don't just assume "someone" will take care of it and walk away.

(5) Once the signal has been secured, on both distress and non-distress missions, reconnect the DF antenna, set sensitivity to maximum and check both 121.5 and 243.0 MHz for other signals.

5-4. Summary:

a. DF Safety. Ground DF is no more or less hazardous than other ground search except that the preoccupation with the DF unit causes searchers to be less aware of their surroundings. When walking, do not watch the meter continuously. Glance about to remain aware of your surroundings. Listen but don't concentrate so hard on listening that other sounds, noises and voices are missed. There should be at least two people in every DF equipped vehicle, one to drive, one to work the DF. The driver should not try to watch the meter or listen intently to the signal. On airport ramps watch and listen for moving aircraft, and watch for wings, tails, tie down chocks, and chains. Also watch that runways are not entered or crossed. Docks and piers can be slippery, lines and ropes on them may be difficult to see. When stopping the search vehicle to take bearings, do not stop on freeways, expressways, interstates, etc., exit and DF from side streets. Do not stop on bridges either, park safely nearby and walk to the DF spot. Wherever the vehicle is stopped, make sure it is completely off the roadway. After the vehicle is safely out of the way, don't walk out into traffic lanes to DF. Before raising the antenna, watch for wires, branches, overhangs, ceilings, and other overhead objects.

b. General DF Tips. Become familiar with your DF equipment and other equipment you will have access to in your unit. Practice with it at every opportunity so the procedures outlined above, which may sound complex, become easy and natural. Know how to determine if the batteries need replacing. Carry spare batteries and any tools necessary to replace them. Also carry foil and tape, pilot notices, and a few small tools so you can help an owner secure a broken ELT.

(1) Monitor when mobile and take fixed DF readings from the clearest, highest spots available. Unless the antenna needs to be horizontal to track a signal, keep the antenna

vertical and the individual elements aligned properly. Check 121.6 and the other frequency not being DFed, either 121.5 or 243.0, on a regular basis. This will provide indications that the source is getting closer as well as help determine if a carrier only signal is present. The possibility of carrier only signals should always be considered. Always take enough DF readings to surround the source and once it is secured, verify there are no other signals present.

(2) The most important thing to remember is that only the DF can receive the signal and locate it. Complete trust must be placed in the DF and its indications. Hunches, feelings and comments from others should not be followed unless these agree with the DF indications or there is positive knowledge that the equipment is faulty. Confidence in one's own ability to use the equipment and familiarity with it are the keys in developing this trust. Confidence can only be developed through practice and experience on actual missions.

Chapter 6

ELECTRONIC SEARCH TRAINING

6-1. General. Successful electronic search operations depend primarily upon complete and thorough advance planning and training for their success. Loss of time, confusion, and wasted efforts can be largely eliminated by the care taken in mission planning, organization, and execution. The same advanced preparations used to train aircrews and ground teams in electronic search techniques will serve to prepare and organize search personnel for actual SAR missions. The training of CAP personnel for electronic search will, in many aspects, be no different than the training required for visual search operations. However, there are some aspects that will require more indepth consideration to assure aircrews and ground teams can handle the more demanding requirements of electronic search. Some of the facets of search that will require study and additional training/planning are:

a. Timeliness of Response. Each and every mission must be treated with the urgency of the emergency signal that it is. Alert procedures for an electronic search must differ from the visual search somewhat as the time factor is usually significantly compressed. A timely and expeditious launch of an electronic search is imperative.

(1) CAP aircraft with independent DF equipment should monitor 121.5 MHz continuously whenever the aircraft is airborne.

(2) Alert procedures for practice missions and tests should simulate as closely as possible an actual mission. In order to achieve the desired training, the speed of a training alert may have to be sacrificed in order to brief or instruct the crews in the search techniques best suited for their equipment, aircraft, and abilities; however, this serves to improve actual mission capability. No crew should depart on any sortie with any doubt as to their task, the methods and procedures to be employed, or actions to be accomplished upon completion of the sortie. Every crew member should clearly understand the limitations of the aircraft being used, the conditions of the search area, and the weather to be expected during the search. The briefing should be educational and informative, stressing safety as well as performance.

b. Mission Data. Data on the missing aircraft or vessel (SAR objective) needed to provide initial search direction should be quickly and carefully evaluated. Knowledge of the flight plan, position reports, weather, sighting reports, satellite "hits," radar fixes, nature of terrain (or sea), etc., will provide information needed to establish the probable area of the SAR incident and save precious search time. Advance coordination with all agencies involved to assure this information is immediately available should be accomplished.

c. Weather Limitations. Weather may impose limitations on aircrew and aircraft capabilities. If CAP forces are unable to safely perform an electronic search due to existing weather conditions, the mission coordinator should advise the Rescue Coordination Center. The mission coordinator should not unnecessarily commit CAP forces to a "high-risk" mission beyond their capabilities and limitations. The Rescue Coordination Center is cognizant of CAP limitations, and has other qualified, better equipped, SAR forces that can be called upon (military, Coast Guard, etc.) when needed.

d. Duties and Performance of Aircrews and Ground Teams. Electronic search, especially under marginal conditions, requires a high degree of aircrew/ground team skill, proficiency, and coordination. High standards must be imposed and strictly adhered to. Regularly scheduled training sessions are imperative, and must be conducted to assure search crews achieve and retain the highest possible level of proficiency.

e. Accuracy in Map Reading and Navigation:

(1) Search crews must have knowledge of their precise position at all times during an electronic search or they will be of little value. A signal received or lost, a vector established, and a target or survivor located all require precise location on maps and the ability to rapidly relay the location information to the mission headquarters. Accurate information and expeditious relay will speed rescue teams to the scene.

(2) Every search crew member should become intimately familiar with the Sectional Aeronautical Charts for their local area as well as surrounding areas with a high SAR incident rate where they could reasonably expect to be utilized. Crews should be familiar with the location of all navigation aids in the vicinity. Knowledge of the standardized grid system and precise position location by geographical reference (latitude/longitude) is imperative. Aircrews must be proficient in establishing position by reference to bearings from various navigational aids (VORTAC, ADF, etc.).

(3) The exact location of the target must be pinpointed. It is extremely important that the pilot or ground team leader be able to precisely locate the target so that a rescue helicopter or ground rescue team can reach the survivors. Crews should routinely practice determining precise position location to maintain their proficiency. Accurate position location should be emphasized in all SAR training and checkouts leading to SAR qualification. Position location can be determined in a variety of ways, including:

(a) Loran C position coordinates. The accuracy of Loran equipment is dependent upon a number of factors, including signal quality and station geometry. In general, Loran C position coordinates will be accurate to within approximately .5 mile, however in many areas the error can be significantly greater. Loran C position data should always be verified by other means.

(b) Bearing and distance from VORTAC navigation aids. VOR bearing accuracy is dependent primarily upon the accuracy of the VOR receiver in the aircraft, and could differ by as much as 8 degrees between two receivers. DME distance information is generally accurate to within. l mile, and a cross reference between two or more DME stations is an excellent position reference.

(c) GPS (global positioning system) position coordinates. The accuracy of GPS position data is typically within approximately 300 feet. Provided adequate satellite coverage is available, GPS provides an excellent position reference.

(d) A transponder location by air traffic control. The accuracy of air traffic radar data is generally within.2 mile, and can be a useful position reference. Normally, ATC will give position in terms of bearing and distance from a VORTAC or airway fix.

(e) Placement on a map based upon terrain features and pilotage techniques. The accuracy of position determined by reference to terrain features is dependent upon the skill of the pilot and observers as well as the prominence of available features. Depending upon the area and available features, position accuracy can be pinpoint or approximate.

(f) Deadreckoning calculations accounting for wind drift, ground speed, etc. Normally, deadreckoning is the least accurate means of position determination.

f. Aircraft/Vehicle Selection. Aircraft and vehicles selected for electronic search missions should be chosen based upon the installed equipment and crew qualifications.

(1) Aircraft should, if possible, have direction finding equipment and be equipped for night and instrument flight in accordance with the applicable FARs. Mission pilots holding instrument ratings should be available.

(2) Ground vehicles should be suitable for the terrain in the search area, and should have direction finding equipment as well as normal ground team equipment.

g. Communications. All search resources should be equipped with adequate communications capability to properly and reliably communicate with the mission headquarters and other search teams. Aircraft and vehicles should have CAP VHF FM capability (repeater and simplex). Aircraft should have a minimum of two VHF aircraft receivers. Use of search teams with inadequate communications equipment not only has been proven to be inconvenient, but in many cases detrimental to the mission.

6-2. Classroom Training. Classroom training should be conducted to ensure search personnel have a thorough and complete understanding of electronic search procedures and techniques. Each training session should concentrate on specific aspects or problems in electronic search, however, training in the fundamentals of visual search, ground operations, and other associated concentrated area coverage techniques should not be neglected. A suggested list of topics for electronic search training is as follows:

a. Precision use and interpretation of maps and charts.

b. Position locating techniques and procedures (visual, Loran, VOR/DME, etc).

c. Electronic search techniques (search patterns, direction finding, wing shadow).

d. Communications (air-to-air and air-to-ground).

e. Alert response procedures.

f. Visual search of small areas, seeking small, partially obscure targets.

g. Electronic search resources.

h. ELT/EPIRB signal characteristics.

i. Regulations and laws concerning ELT/EPIRBs.

j. Search team coordination.

6-3. Field Training. Thorough and realistic field training exercises are necessary in order to maintain proficient and efficient search capability. Exercises should be planned to simulate as closely as possible actual mission conditions, however additional time should be spent to ensure all search personnel thoroughly understand their assignments. Aircrews and ground teams should be allowed adequate time to "work" the ELT/EPIRB signal and improve their proficiency. When training new pilots and ground team members, specific emphasis should be placed on learning to use direction finding equipment with precision, speed, and accuracy.

a. Training ELT Location Planning:

(1) In setting up an ELT/EPIRB exercise, first consideration should be given to selecting the location for the target. As these exercises can be multi-faceted training operations, the site selected should provide for adequate ground search as well as the aerial search activities. Locations should be well away from control zones and areas of high-density traffic, in terrain that will simulate an actual mission, and at a location that will not interfere with ground operations.

(2) Selected sites should be surveyed well in advance to check the terrain and to obtain permission of landowners for the operation planned. Personnel delegated to select practice ELT/**EPIRB** sites should keep the information confidential to assure a valid training exercise.

(3) Initial training for new search crews should utilize a target that can be easily identified, using bright colored parachute or cloth panels to mark the target site. As crews progress in proficiency, smaller and partially concealed targets should be used to enhance and refine search techniques.

(4) The FSS responsible for the area in which the training target is located should be advised of the operation, including the times during which the training ELT will be operating and its location.

b. ELT Training Beacon. ELT training operations require the use of an FCC accepted electronic beacon as the signal source. Practice beacons must simulate actual beacon operation as closely as possible without interference with voice communications, radiating spurious harmonics, or initiating a general alert for a fictitious downed aircraft. The standard training frequency used by CAP is 121.6 MHz (the standard emergency frequencies of 121.5 and 243.0 MHz may not be used for training stations). Modified ELTs for training purposes can be purchased from the CAP Supply Depot. Field modification of standard ELTs for training purposes is not recommended, and FCC approval of units so modified may not be obtainable. A station license for the ELT training station must be obtained prior to use. The applicable procedures for obtaining this license are contained in CAPM 100-1.

c. Qualified mission pilots and ground team leaders/ members with extensive electronic search experience should be used as instructors for new personnel.

d. Frequent training exercises are imperative in order for search personnel to maintain proficiency in electronic search techniques.

6-4. Summary:

a. ELT/EPIRB search has become the most common search operation conducted by CAP. All mission pilots, observers and ground teams should be proficient in locating ELT/EPIRBs. They should feel confident of rapidly locating a survivor. This confidence cannot come from a single find, but is built on practice and repetition. Search personnel have found that continuous practice and training is necessary to retain their proficiency.

b. The feeling of accomplishment can be far greater on practice ELT/EPIRB operations than on practice visual searches. The search crews are more occupied and more crews can achieve a feeling of success in the participation. Finds can be made in far less time and crews will be encouraged by practice missions and their success.

c. The most important part of an ELT/EPIRB exercise can frequently be the post mission evaluation of the results. Every crew should report techniques used, problems, hints, failures, suggestions, etc. A short meeting immediately following a training is most effective in assessing the results.

d. Records of aircraft, aircrew, and ground team capability and availability should be maintained in an "up-to-date" status to accurately provide mission coordinators an assessment of search capability. Alert procedures for electronic search missions may differ from those used on visual searches. Timeliness is essential. Every ELT/EPIRB mission must be treated as distress until proven otherwise.

Chapter 7

THE ELECTRONIC SEARCH

7-1. General. While a majority of **ELT/EPIRB searches** will conclude in a non-distress situation, each and every mission must be treated with the urgency of the emergency signal that it is. ELT/EPIRBs do work properly and do save lives! Alert procedures for an electronic search must differ from the visual search somewhat as the time factor is usually significantly compressed. ELT/EPIRB batteries, regardless of quality, do not have an extended life. Missing pilots who fail to file a flight plan or take other precautionary measures may not be missed and/or alert notification issued until much of the battery life has been depleted, even further reducing the time available for an electronic search. Thus a timely and expeditious launch of an electronic search is imperative.

7-2. Procedures:

a. Each CAP wing should establish an immediate alert capability of mission coordinators, aircrews, aircraft, and ground teams trained for electronic search techniques. Qualified crews capable of search under marginal VFR or IFR conditions should be identified and a 24-hour alert system with a rapid response capability implemented. Aircraft equipped with direction finding equipment for electronic search (both member owned and corporate) should be identified and readily available in the areas of the highest SAR incident rates. Ideally, an aircraft with direction finding equipment for electronic search should be within a range of less than one hour of any given area within a respective wing.

b. Have available to each potential mission coordinator an up-to-date list of all personnel and resources and their qualifications.

c. The first consideration on an electronic search should be the use of a DF-equipped aircraft. The electronic search should be launched as soon as possible, typically within one hour of notification, and as soon as adequate information is available. By utilizing a well-established alert and response procedure to dispatch aircraft in areas of highest probability, timely "finds" of downed aircraft or missing vessels can be made. Prior to dispatching aircraft on an electronic search, determine the following:

(1) Availability and readiness of qualified search crew and aircraft.

(2) Basic information on the downed aircraft/missing vessel (identification, intended route, position reports, sightings, radar reports, etc.). Don't delay launching the initial aircraft while pursuing detailed information, just get the basics at first.

(3) Weather along the proposed route or search area. Give consideration to capability of the aircraft and crews under existing and forecast conditions. Night and/or IFR searches must have trained and current instrument rated pilots and adequately equipped search aircraft.

(4) Assemble and brief the aircrew (by telephone if appropriate) using all available information. Knowledge of an approximate or assumed route may be enough to quickly locate the objective.

(5) Brief the crew on the actions to be taken when the signal is heard, the find is made, etc. Get the search aircraft airborne!

d. Continue to gather additional information and proceed with the mission.

e. Search crews must communicate at once with the mission headquarters when the signal is received, as bearing vectors are determined, and when the objective is located. All findings should be reported accurately and quickly to the mission headquarters.

£ Search aircraft should not leave the area until relieved or recalled by the mission coordinator. The search aircraft may be needed to direct ground teams into the area and serve as a communications relay. Countless hours may be wasted if the objective location is improperly defined or lost when the search aircraft leaves the scene. Search aircraft should not land at the scene unless directed to do so by the mission coordinator and then only if the pilot determines that a suitable landing area exists. Off airport landings are restricted to helicopters only. Only in the event all means of communication have failed or an airborne emergency should the scene be abandoned. Prior to leaving, ensure the location has been accurately and correctly determined.

7-3. Common Difficulties. Simple errors can easily result in mission failure or an excessive expenditure of time and resources. Some of the common errors that can easily occur are as follows:

a. Lack of or failure to use adequate maps of the search area. Plotting of direction vectors, leads, etc. is difficult without adequate maps. Search crews can erroneously report their position when using inadequate or out of date charts.

b. Failure to maintain the altitude necessary for detection of the signal. Search aircraft must follow the applicable electronic search procedures.

c. Failure of air and ground search crews to accurately navigate and/or determine the position of the target. Navigation/position determination errors (read chart wrong, fail to read bearings "from" a VORTAC, identify the wrong navigation aid, etc.) are probably the single most common difficulty in electronic search operations. Inaccurate navigation leads to inaccurate plotting of information and can send the search in the wrong direction.

d. Improper installation of DF equipment on aircraft. Proper installation and operation of DF equipment should be verified after installation. Equipment that doesn't work when needed is worse than useless, it can hinder the search effort.

e. Failure of search crews to be familiar with their assigned search area. Local familiarity is important when tracking an elusive signal.

f. Failure of search crews to follow proper electronic search procedures as outlined in Chapters 3 and 4.

g. Aircraft/vehicles have inoperative equipment, fail to fuel, etc. Professional crews ensure they are ready for the mission and their equipment is functioning properly.

h. Failure to start the search promptly, especially during inclement weather that may reduce ELT/EPIRB battery life.

7-4. Summary. At present, ELTs and EPIRBs provide the best potential for rapidly locating survivors in aircraft and vessel distress situations. It is imperative that CAP personnel responding to these missions treat them as the emergency situation they are intended to be until it is positively confirmed to be a non-distress situation. Even with the non-distress signal, it must be located and silenced as soon as possible to avoid interference with actual distress signals that may be covered by the non-distress signal. Timeliness is imperative! Remember, it could be you on the other end someday.

ELT/EPIRB SIGNAL RANGE

While manufacturers claims will vary, the table below provides the approximate ranges over level terrain that a 250 mW signal can be clearly heard:

Altitude Above Ground Level (ft)	Distance in Nautical Miles (nm)
1,500	18
2,000	21
3,000	30
4,000	35
6,000	40
8,000	65
10,000	80

This table was derived from a series of field tests. Several factors play a significant role in limiting the distance at which emergency beacons can be detected. Some of these factors are as follows:

a. ELT/EPIRB Power Output. Rated and/or remaining power output of the ELT/EPIRB will affect reception range.

b. Battery Life. Rated battery life will affect the reception range. Batteries in the ELT of a downed aircraft may be at or beyond the recommended life. Different battery types can further affect the reception range under varying climatic conditions.

c. Receiver Capability. Receiver sensitivity plays a significant role in the detection distance limit. The more sensitive the equipment, the better the reception distance. (Improper sensitivity or squelch control adjustments will also affect a given receiver's sensitivity.)

d. Aircraft Antenna and Transmission Line Configuration. Experiments have demonstrated that two identical receivers can produce markedly different reception distances under identical test conditions. Thus, it can be concluded that the configuration of the aircraft (low wing, high wing, dihedral, fuselage, and empennage design, etc.) plays a significant role in signal detection limits. For the optimum utilization of SAR resources, a good knowledge of the capability of each individual aircraft is necessary.

e. Altitude. In general the reception distance vs altitude parameter has been displayed as more or less a parabolic shape in which reception distance increased with the square root of the altitude. The average general aviation aircraft for the most part will not match the reception claims made by most ELT/ EPIRB manufacturers. Tests have indicated that optimum search altitude envelope occurs around 3,000 - 4,000 feet above the terrain with reception distances varying from 30 to 50 nm. In many cases, tests at higher altitudes indicate no significant increase in reception distance. Experimentation with individual aircraft and equipment will have to be conducted.

f. Aircraft Attitude. The search aircraft's bearing angle to the signal source plays a significant role in signal detection. Slight changes in bank angle can significantly modify received signal detection. Banking a search aircraft on its longitudinal axis can yield a marked reception improvement when the bearing angle to the signal source is 45 to 135 degrees from the aircraft heading. Changes in pitch (i.e., climb or descent) may change signal reception characteristics.

g. Atmospheric Conditions. Differing conditions (above or below cloud decks, temperature inversions, etc.) may affect signal detection in varying degrees.

h. Terrain Contours. Terrain and its associated foliage will distort or modify signals. Shadowing occurs when the beacon is blocked out by terrain. However, this can be used to advantage if the beacon is located in a canyon, because the signal will appear to stop if a search is initiated in the wrong canyon at a lower altitude. False targeting occurs when the signal is bounced off terrain features causing search aircraft to get a strong but false signal. There is no foolproof way to recognize a false target, but it will not become stronger and more localized at lower search altitudes.

i. Signal Polarization. ELT/EPIRBs provide optimum signals when their antenna is in a vertical position. Experience indicates that the beacon signal as received by the search aircraft is generally depolarized from the vertical due to reflected components reradiated from the aircraft. Furthermore, in many cases a downed aircraft ELT antenna will produce signal polarizations other than vertical due to a non-vertical (horizontal) orientation of the antenna resulting from the crash. An antenna in a horizontal position may cause drastic reductions in signal strength reception. Tests conducted by CAP National Headquarters revealed a 25 percent reduction in signal ranges at 8,000 feet AGL when the antenna is placed horizontal. Even with the ELT antenna horizontal, direction finding functions normally once a clearly audible signal is established.

SARSAT

Those of you in the ELT/EPIRB location field have undoubtedly been given information received from the satellite system. A number of you have asked for some additional information on what this is and how it relates to SAR folks. We want to thank the people at NASA and at Scott Air Force Base for their help in putting this very elementary explanation together. The project is co-sponsored by the United States, Canada, France, and the Soviet Union. Other countries assist in the program. It combines the US system called SARSAT (Search and Rescue Satellite-Aided Tracking) and a similar Soviet system called COSPAS (Cosmicheskaya Sistyema Poiska Avariynych Sudov, a Russian acronym for Space System for Search of Vessels in Distress). The US system monitors the three emergency frequencies of 121.5, 243.0, and 406.025 MHz, while the Russians hear 121.5 and 406.025. The satellite program was developed by NASA. In 1984, after the system was operational, NASA turned over leadership to NOAH, which is responsible for operational US civilian satellites. NASA continues in research and development, particularly in the area of second-generation ELTs. The first question that has probably already jumped into mind is: How can an ELT be heard by a satellite over five hundred miles in space while I sometimes can't hear one when I'm five miles away? Radio waves at any frequency radiate in all directions - including upward into space. You already know that mountains, trees, and buildings can get in the way of the radio signal on the ground, but it travels unimpeded into space. An airliner at 30,000 feet or so can hear an ELT for about 200 miles, or when it is in a direct line of sight of it. The satellite, at its altitude, can see a much larger area. That's not to say that if the ELT is damaged or its antenna is stuffed down a gopher hole that the satellite would hear it any better than you would - it just has a better chance. The satellites are in near-polar orbits, moving in roughly north-south direction. They continuously monitor the ELT frequencies, retransmitting everything they hear to ground stations, called Local User Terminals, or LUTs. Complete coverage of the US inland and coastal regions, including Alaska and much of Canada, is provided by LUTs located in Kodiak, AK; Pt. Reyes, CA; Scott AFB, IL; and Ottawa, Ontario. Goddard Space Flight Center in Maryland also has a LUT, but is not permanently on-line. The ground stations relay their input to the Mission Control Center at NASA in Suitland, MD. Signals on 406.025 MHz can be stored by the satellite if it is not in view of a LUT. When a LUT is available, it sends the information down to be processed by the MCC. The method used by the satellite system to indicate the likely position of the ELT on the ground is called a Doppler process. Very simply stated, it uses the relative motion between the spacecraft and the ELT to determine location, based on the ratio at which the frequency of the received signal changes, with the fastest rate of change measured when the satellite passed abeam the ELT. The information received by the LUTs from the satellite is fed into a computer at the MCC. Each signal heard by the satellite is plotted and displayed on a computer screen on a dot plot showing frequency versus time. The computer processing can get a fairly accurate reading of the north-south or latitude position of the ELT. By using newly developed software, the computer processes the longitude information to select a merge position, which is a statistical area of highest probability of the ELT's longitudinal location. The MCC collects and edits the information and forwards the data to the Rescue Coordination Center at Scott AFB, which is responsible for initiating and coordinating all inland search and rescue. If the data appears to be a maritime situation, they are given to the appropriate US Coast Guard District RCC. A search is rarely launched on the first satellite hit unless there is a known problem, such as an overdue aircraft or MAYDAY call that closely matches a hit. The next time a satellite passes over, which could be from 10 to 15 minutes to as much as six or seven hours later, the data between the two satellites are compared, using the computer to match up the location of a hit to a specific ELT. Each ELT has slightly different characteristics, such as frequency stability and modulation format, allowing the systems operators to compare signatures like they would with a voiceprint or fingerprint. With the second set of data, the controllers can usually give coordinates where the ELT is likely to be, with approximately a 50% probability that it will be in an elliptical area about six miles in latitude and 12 miles in longitude. The longer the ELT operates and the more satellite hits received on it, the greater the accuracy of plotted location can become. With the second pass and hit on an ELT, the RCC opens an incident, usually contacting the FAA Air Traffic Control Centers to solicit airborne monitoring of the frequency. Since the computer can't always distinguish between an ELT and another type of signal, such as a carrier, verification is attempted. Some notable causes of carrier interference on the emergency frequencies have been large computer installations, such as the New York Stock Exchange and Disneyland rides, and cable TV and powerlines. For those of you in the SAR field, this program means that the satellites are now able to hear an ELT very soon after it is activated, not depending on ground monitoring or pilot reports. This, in turn, will mean more timely alerting of SAR forces and faster response time to put the first available resources into a high probability area at a time when the likelihood of survivors is greatest.