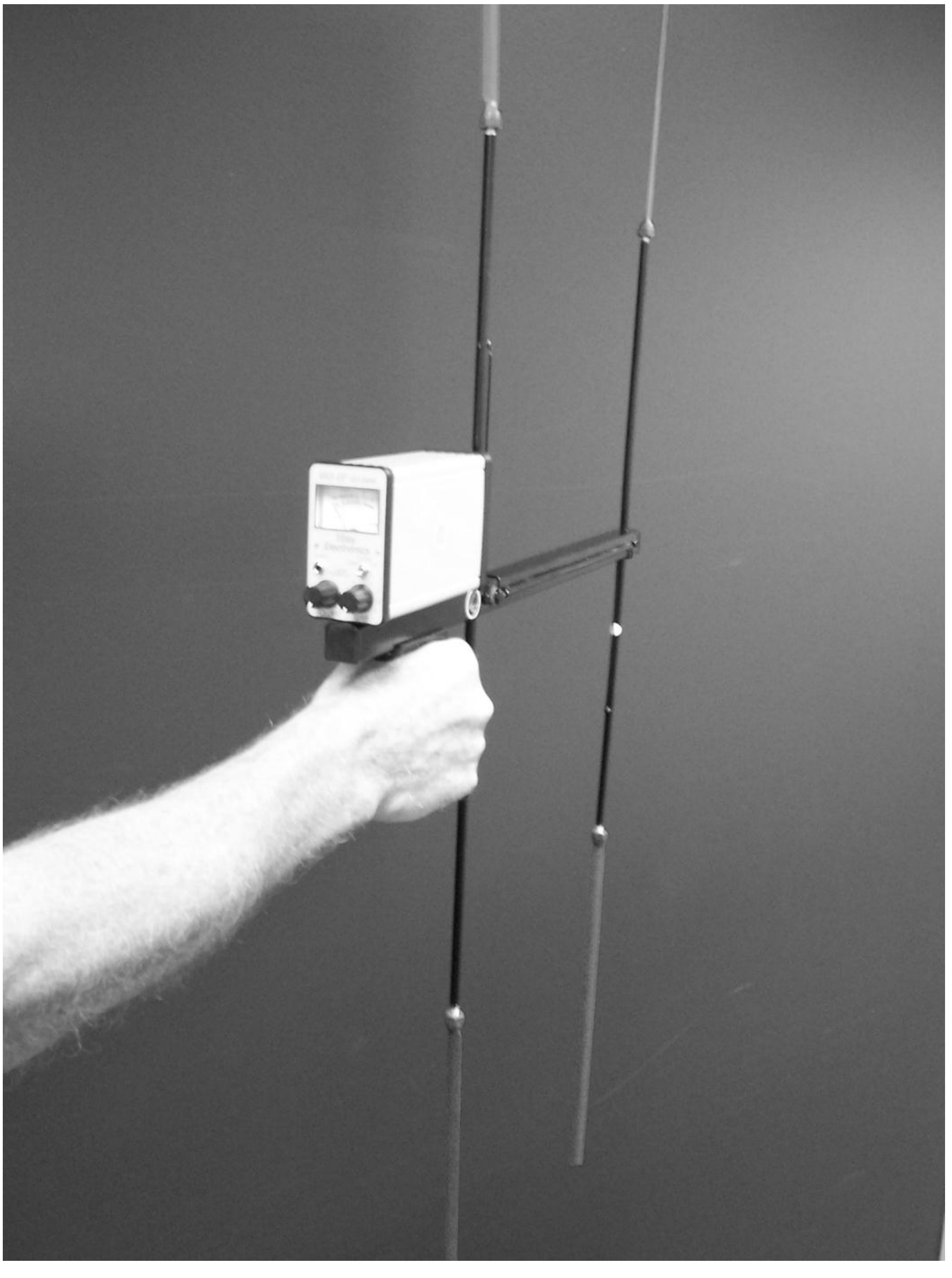
ELECTRONIC BEACON HOMING

RX3 TITLEY



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ELECTRONIC BEACON HOMING

RX3 TITLEY

DISTRESS BEACONS

It is estimated that there are over 600,000 121.5 MHz distress beacons in use worldwide.

Distress beacons, depending on their use, are also known by a number of different names.

- Emergency Locator Transmitters (ELTs) for aviation use,
- Emergency Position-Indicating Radio Beacons (EPIRBs) for maritime use and
- Personal Locator Beacons (PLBs) for applications which are neither aviation or maritime.

Distress Beacons are simple transmitters, which, when activated; broadcast a swept tone on either 121.5 MHz VHF and/or 243 MHz UHF. They should be Cospas-Sarsat satellite compatible, however, many older beacons may not be.

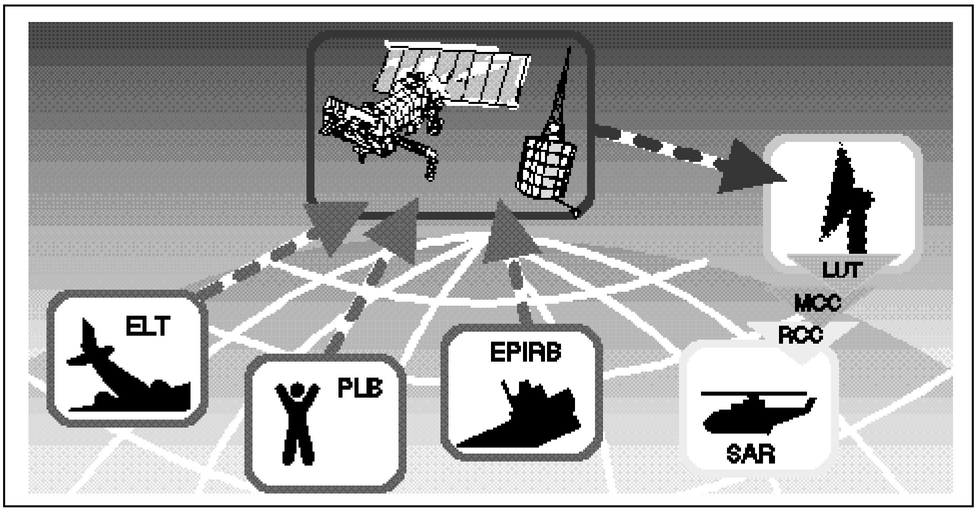


Fig 1 – Distress Beacon Concept

The tones emitted from the various types of distress beacons can vary.

- 121.5 MHz (some older style marine EPIRBs transmit three swept tones followed by an equal period of silence); and/or
- 243 MHz (swept tone); and/or
- 406 MHz (pulse transmission only).

Note: A low power 121.5 MHz homer signal is also transmitted with swept tone characteristics.

121.5 MHz beacons carried aboard aircraft can usually be activated both manually and automatically by shock (using a crash sensor). This latter feature has led to numerous false alerts when a beacon is mounted in an aircraft with insufficient care or when an aircraft makes a "hard landing".

Development of a new generation of distress beacons utilising digital technology transmitting at 406 MHz commenced at the beginning of the Cospas-Sarsat project. The 406 MHz units are designed specifically for satellite detection and Doppler location, and provide the following:

- improved location accuracy and ambiguity resolution;
- increased system capacity (i.e. capability to process a greater number of beacons transmitting simultaneously in field of view of satellite);
- global coverage; and
- unique identification of each beacon.

An important feature of 406 MHz beacons is the addition of a digitally encoded message, which provides such information as the country of beacon registration and the identification of the vessel or aircraft in distress, and optionally, position data from onboard navigation equipment.

An auxiliary transmitter (121.5 MHz transmitter) is usually included in the 406 MHz beacon to enable suitably-equipped SAR units to home on the distress beacon.

Currently more than 220,000 406 MHz distress beacons are in use world-wide.

Satellite processing of distress beacons operating in the 121.5/243 MHz range ceased in February 2009. Users are being encouraged to switch over to 406 MHz beacons.

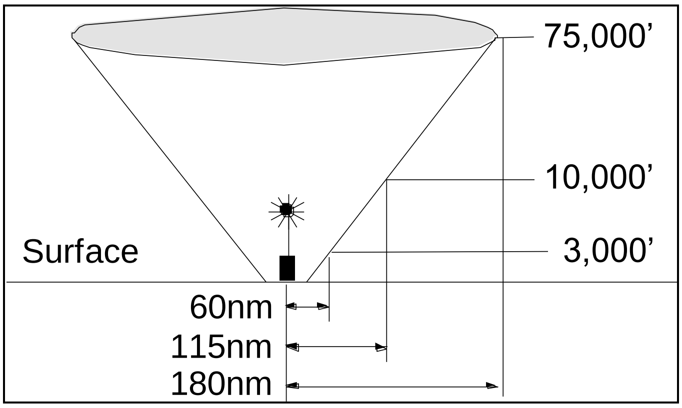
The use of 406 MHz distress beacons will minimise the problems with false alerts being received by rescue coordination centres.

Various types of other beacons or markers are used by SAR Units to mark targets once they are located. These beacons operate on a set of different frequencies to distress type beacons and are not satellite compatible.

- SAR Training Beacons operating on 121.4 MHz and 242.8 MHz are used to train SAR operators in distress beacon search techniques.
- SAR Datum Buoys, used to mark targets and confirm drift.
- Life-raft Locator Beacons (LLB) operating on 121.85 MHz and 243.7 MHz and 121.95 MHz and 243.9 MHz are packed with the droppable life raft.

DISTRESS BEACON SIGNAL THEORY

Properties of the Beacon Signal



The pattern of the beacon signal is conical.

The transmitter is of “random quality” and radiates a weak signal on adjacent frequencies. This signal is detectable when the receiver is close to the beacon.

Fig 2 – Properties of the Beacon Signal

Note: The distances shown in Fig 2 are the maximum theoretical values. Actual distances of reception are substantially less e.g. 50–60 nm at 8–10,000 feet (ft).

Beacon Range

The range (in nm) at which a beacon at sea level can be received is equal to 1.2 times the square root of the aircraft height (in feet).

However, this range is significantly affected by the surface over which the signal is travelling, as can be seen in Fig 3 at right.

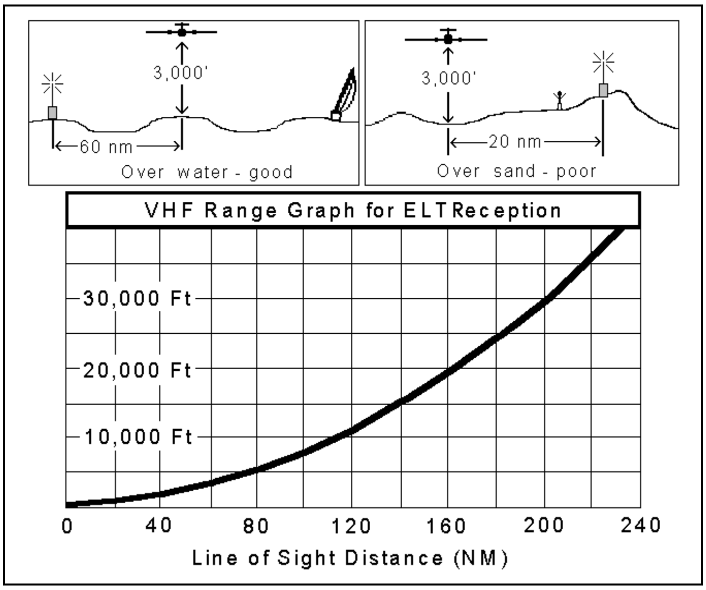


Fig.3 – Distress Beacon Range

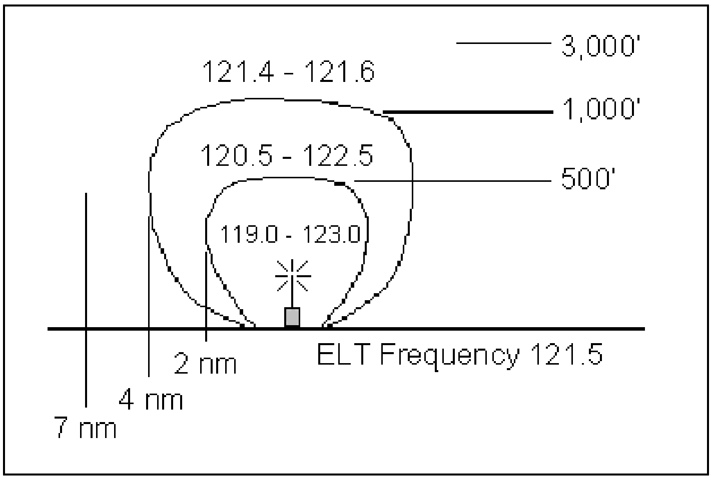


Fig 4 – Reception of Different Frequencies

Because of the frequency arrangement, you may pick up the beacon quicker by detuning one way rather than the other way.

Because of the conical shape, we can make an initial homing.

By de-tuning to the adjacent frequencies, we can make a final homing.

DISTRESS BEACON DIRECTION FINDERS

Most simple electronic homers fitted to aircraft utilise a combination of an aural signal and visual signal right-left direction indicator. A left-right indicator is a simple non-automatic DF system that essentially is a biquadrant indicator that requires physical rotation of the DF antenna. The bearing display indicator can tell the operator only that the target transmitter is either to the right or left of the aircraft's track. With a certain level of operator skill, patience, persistence, and luck, the operator can eventually home in on the transmitter.

The direction finder is usually linked to the aircraft's VHF Com 2. This will give the ability to home to any signal in the normal aviation VHF band.

When in active operation, the signal direction indicator works in a similar manner to the Course Direction Indicator (CDI) on a VOR. There is also a sensitivity control, which is set near maximum with a weak signal but must be turned down as the signal becomes stronger.

GROUND DF

The ELT Location Problem

There are three parts to this problem:

1. Get to a point where the ELT signal can be heard.
2. Establish a direction to the target or a target location
3. Get to the target.

Execution of these steps will vary radically from incident to incident. On an airport, it may be as simple as walking out of a door, taking a single DF bearing and walking to the offending aircraft.

There are three characteristics of an ELT signal that must be understood in order to locate the signal transmitter:

1. Unimpeded radio signals travel in a straight line,
2. Conductive objects reflect and/or block the signal and
3. Signals get stronger near the source regardless of the direction of approach. In addition, the rate of change in signal strength will be faster as you get closer.

Once a signal is heard and confirmed, to determine direction to the beacon, turn initially towards the strongest signal indication. The strength meter will not point you directly at the signal; rather it will give you a rough direction to head. The direction will be in a 30 – 45 degree arc.

Reflectors and Barriers
Conductive objects that reflect and/or block ELT signals include man made objects such as buildings and natural ones like mountains, smooth wet snowfields and grasslands. These objects are called 'reflectors' because they cause the ELT's signal to bounce off, much like a mirror reflects images.

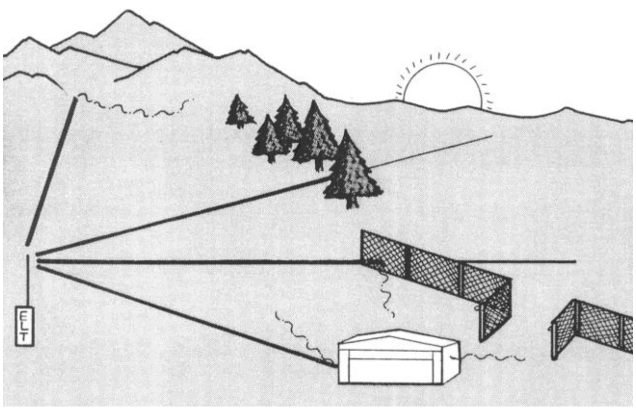


Fig 6 – Reflectors and Barriers

These objects can affect the receiver's ability to hear and obtain directional information on the ELT's signal. Reflections have less power; therefore if the DF can hear the direct (stronger) signal, it will prefer it to the weaker reflective one.

For an ELT search, this usually means going for higher ground or conducting an air search. This will both get away from nearby reflectors and possibly improve the chance of getting a clear view of the source over the obstructions. Exceptions occur in air operations where the signal is blocked from going upward or is too weak to be heard 10,000 feet away.

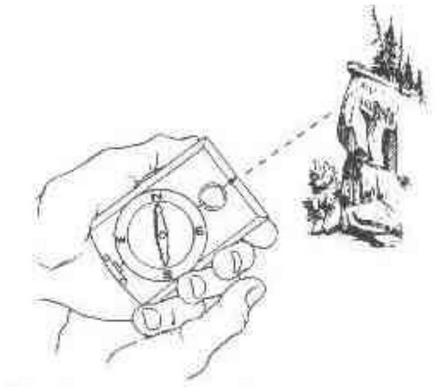


Fig.7 – Using a Compas to Take a DF Bearing

TRIANGULATION METHOD

To accuratly plot the location of an ELT, some knowledge of the operation of a compass and magnetic variation will be usefull. Triangulation can be used to indicate the general location of the signal, this can be followed up with a more precise Direction Find (DF) in the triangulated area. The triangulation method can be used to DF a signal anywhere where there is an unobstructed view, i.e. from high ground. Roofs of buildings also count as high ground.

A minumum of two bearings can be used for triangulation. The more bearings taken – the more accurate the ELT position.

You must be receiving a clear signal:

Position yourself on high ground

- Centre up DF unit on the signal,
- Take the magnetic bearing (shoot an azimuth),
- Correct for magnetic variation,
- Plot your bearings (draw a line) on map.

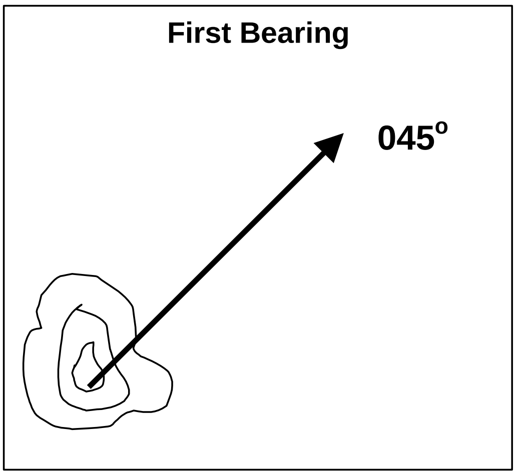


Fig 8 – Taking a First Bearing

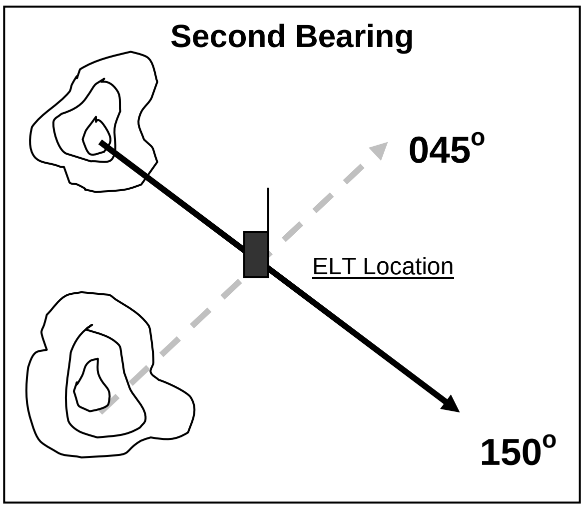


Fig 9 – Taking a Second Bearing

Move to another location (high ground)

- Centre up DF unit on the signal,
- Take the magnetic bearing (shoot an azimuth),
- Correct for magnetic variation,
- Plot your bearings (draw a second line) on map

The ELT should be located where the lines cross!

(NOTE: The eyeball method can also be used, although it is less acurate).

The positions where the bearings are taken from should be plotted on a map or rough sketch. In the event that the signal is lost, a return to a bearing site will confirm if the signal has ceased transmitting.

Note: Compasses are affected by iron ore deposits throughout the earth, causing them to not point at the true north, but rather magnetic north. This variation is known, and maps will show the corrections to be made in the form of the magnetic variation. In Australia it varies from 11^{o} E to $4\ ^{o}$ W. This variation will be displayed on a map.

To apply the magnetic variation, carry out the following:

From Compass to Map - Add degree variation for East and subtract degree variation for West.

From Map to Compass - Subtract degree variation for East and add degree variation for West.

Obstructions to the Beacon Signal

If moving to higher ground isn't possible or doesn't work, a methodical search will probably be required to find a place where the source can be seen clearly. In most cases, clear view is distinguished by a positive direction that does not change much as the observer moves.

The effects of obstructions in the path between the beacon and the DF set can be roughly grouped according to their location:

- Obstructions near the transmitter,
- Obstructions near the receiver, or
- Obstructions at intermediate range.

Obstructions near the transmitter (ELT) affect the signal distribution or directivity of the source like the reflector of a flashlight. They affect both the ability to hear a signal at a distance and the intensity of reflections. Both obstructions near the receiver and at intermediate range will block or reflect the ELT signal but those near the receiver (DF equipment) are more visible, more severe, and are easier to avoid.

Final Location of the ELT

The final location of the signal can be the most difficult part of the whole process. If the source of the signal is apparent, then no problem. Quite often the source of the signal is either shielded or not immediately obvious. The DF unit will tell you when you are close because the sensitivity of the unit will be right down. If you have passed by the source, the signal strength will drop right off. This process is called Station Passage.

Station Passage

Station Passage refers to the point when the DF passes over (or close by) the ELT. The indications are similar for both airborne and ground DF, it will be indicated by a signal fade and a swing on the Strength Meter.

To confirm suspected ELT location, go past the point of signal fade and turn 180^o and move over the same area again. To be sure go over the same area, only this time come in 90^o to the original track.

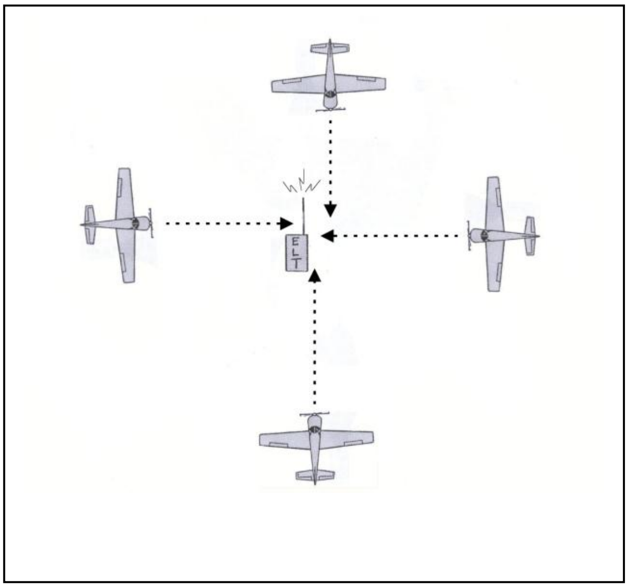


Fig 5 - Station Pasage

Once a source has been pinpointed on the ground, walk completely around it, using the DF to varify that the signal is coming from this target. Repeat this circle further away if possible. If this is indead the scource of the signal, 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 scource is not apparent, as when the signal appears to be coming from inside a building.

If a complete walkaround of a building cannot be acomplished 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 scource is inside, the signal should be stronger at these locations.

Inside buildings, hangars and ships, DF is difficult or near impossible. Body shadowing may help and should be tried. An orderly search of the building should be undertaken until the offending signal is located.

Securing the Signal

Looking for and tendering to survivors takes priority over securing an ELT. Leaving it on initially may also help other personnel 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 safe keeping, 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 minimise the chances of it being turned on accidently later.

It is important to remember that you do not have the authority to enter any aircraft, boat, vehicle or building, whether locked or not, or board boats to secure an ELT or EPIRB.

For signals coming from boats and aircraft, marina or airport operators/security or local Police should be contacted for assistance. Even these personnel will not be able to enter the boat or aircraft, but may be able to assist in locating the owner. In all cases contact the Rescue Coordination Centre (RCC) in Canberra and inform them of your findings.

If the signal is coming from a building that is closed, try to find an emergency, alarm company or security company phone number on the building, these are usually located near a door. Local Police may also be able to assist with owner contact details.

For safety reasons, Police assistance should be called when the signal is detected coming from a house. Ground search team members will most likely have to talk to the occupants as it is unlikely that the Police officers will have a knowledge of beacon DF procedures.

Once the beacon has been located and the signal has been shut off, confirm no other signal is being transmitted and contact the RCC.

With a small amount of practice, trained personnel should be able to track an ELT signal to it's source, be it on an airfield, in a marina or located within a built up area.

What Information Do You Need To Pass To The RCC?

- Make of ELT/EPIRB
- Model and Model #
- Manufacturer
- Location Description
- Approximate location (Latitude & Longitude)
- Owner (if known)
- Aircraft Registration or Boat Name and/or Number
- Time Found and Time Shut-off
- Switch Position on ELT or EPIRB when found:
- ON, OFF, or ARM
- Manufacture date
- Battery expiration date
- Information which could indicate reason for accidental or justified activation of ELT or EPIRB

NOTE: If you can't get certain information, don't worry, the RCC understands

TITLEY RX3- EPIRB TRACKING UNIT

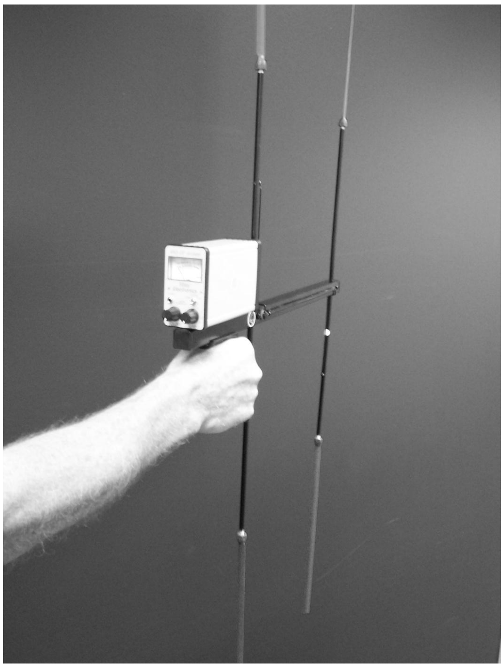


Fig 10 - Titley RX3 EPIRB Tracking Unit

Some aircraft operating in the Australian Maritime Safety Authority's Search and Rescue Unit program are allready fitted with a fixed homer. As these homers cannot be removed from the aircraft for ground DF, the Titley RX3 EPIRB Tracking Unit is provided.

The RX3 unit is also provided to non aviation units such as Water Police, Volunteer Coast Guard units and Airport Safety Officers.

The RX3 unit consists of a reciever/antenna combination. The antenna provides the desired directional properties and the reciever provides the means of hearing and interpreting the signals from an activated EPIRB.

The audio signals from the reciever, which are used by the operator to indicate the direction to the EPIRB, are heard from the internally mounted weatherproof speaker as well as optional lightweight headphones.

To assist in the direction finding ability of the system, there is a signal strength meter located on the front pannel.

The RX3 unit is powered by a single 9 volt battery, located inside the reciever. The battery is accessable by undoing the two (2) knurled screws on the rear cover.

Fig 11 - Rescue/Test Frequency Switch

Rescue and Test Frequency
The unit can be used in the operational role (Rescue Frequency) on 121.5 MHz and in the training role (Test Frequency) on 121.4 MHz.

To switch between the Rescue Frequency and Test Frequency, the rear cover of the reciever must be removed and the switch positioned as required.

An audible tone and red LED on the front pannel indicates if the unit is in the Test Frequency position.

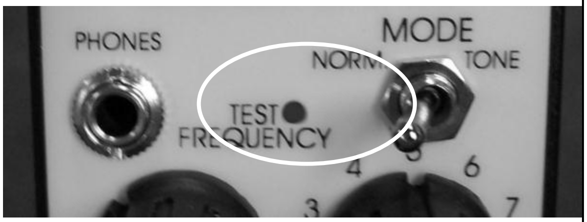


Fig 12 - Test Frequency Indicator

Fig 13 - Mode Switch

To Test the Reciever

- turn the **GAIN** control fully clockwise,
- place the **MODE** switch to **NORM** and
- turn the receiver ON by rotating the **VOLUME** control fully clockwise position.

A loud hissing noise should be heard from the built in speaker, which should diminish as the **GAIN** control is turned anti-clockwise.

With the **MODE** switch in the **TONE** position, a slow ticking noise should be heard. The stronger the signal the higher the pitch of the tone.

With the **MODE** switch in the **NORM** position, the actual audio modulated signals transmitted by the EPIRB should be heard. The louder the signal heard, the stronger the signal.

Operational Mode

- Turn the unit on by turning the **VOLUME** control clockwise,
- Set **GAIN** control initially to fully clockwise
- Upon hearing a signal, adjust the sensitivity slowly by rotating the **GAIN** control anti-clockwise from the maximum **GAIN** setting until the maximum reading on the signal strength meter is approximately 0 µV. (this will ensure the receiver is not overloaded)
- As the signal strength increases adjust the sensitivity counter clockwise with the **GAIN** control.

Training Mode

When using the RX3 - EPIRB Tracking Unit in the 121.4 MHz training mode, the **TEST FREQUENCY** indicator on the front pannel will flash red once per second and two (2) short beeps will be heard every four (4) seconds. The unit will still act normally.

IMPORTANT

FOLLOWING ANY TRAINING, THE RX3- EPIRB TRACKING UNIT MUST BE SET BACK TO 'RESCUE FREQUENCY'

Hostile Environments

The RX3 unit can be used in reasonably hostile environments. However, some deterioration due to corrosion etc would be expected with continious exposure to rain/marine environments. To prolong the life of the unit, carry out the following:

- Try to protect the unit with minimal exposure to the environment,
- Cover the receiver with plastic or similar material if operating in rain or sea spray,
- Wipe down the antenna and receiver after use and
- Do not leave the unit in the sun or in a vehicle for prolonged periods.

Maintenance

The RX3 - EPIRB Tracking Unit should be stored in its protective bag in a cool, dry preferably low humidity environment.

The flexible antenna extensions should be checked for damage prior to use. If a damaged extension is found, contact SAR Resources and Training at AMSA on 1800 813 855 to arrange an immediate replacement.

DISTRESS BEACON HOMING ON THE GROUND USING A PORTABLE AVIATION BAND MULTI CHANNEL AM VHF RADIO

- **Tune the radio to 121.5 MHz**

If a beacon is heard, proceed as follows:

- Detune the radio to 121.45 or 121.55 MHz
- If a beacon signal is still being heard, you are within approximately 100 metres of the beacon.
- Look for a likely source of the signal and move towards the area likely to be producing the signal. If you progressively detune the radio away from 121.5 MHz (eg. 121.4, 121.35 MHz and even further) and continue to receive the signal you are getting closer to the beacon.
- When you are within one (1) metre of the beacon, the beacon signal will break through on all frequencies. If possible remove the antennae from your portable VHF radio. If the signal can still be heard, you are extremely close to the beacon. **Look for the source**.

DISTRESS BEACON HOMING ON THE GROUND USING A HAND HELD FM OR AM RADIO RECEIVER

An FM radio tuned to 99.5 MHz will pick up a beacon signal at a range of approximately one (1) kilometre.

An AM radio will pick up a beacon signal on any frequency at less than three metres and can be used to check individual aircraft.

Note: There is the possibility that a beacon radiating from inside a closed hangar or storage container may be shielded altogether from a receiver outside the hangar.

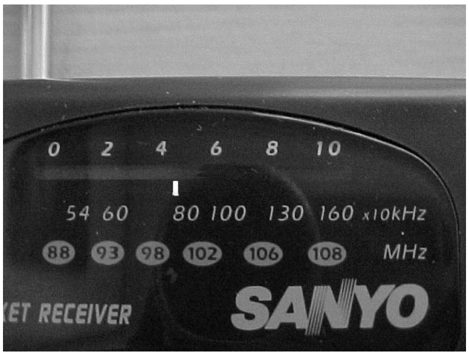


Fig 14 – 99.5 MHZ on a Portable FM Radio

Blocking or Shielding of the Beacon Signal

You are some distance from the beacon and need to isolate it to a smaller area.

- Use a building or hangar as a shield. If the signal is lost, the building is between you and the beacon. Use another building to verify the direction.
- You can also use your own body as a shield. Hold the radio against your chest. Your body will block out the signal. This is called a "NULL". The signal should be weakest when your back is to the beacon.
- This works when you trying to figure out a particular aircraft on a flight line, it will probably not identify a particular hangar.

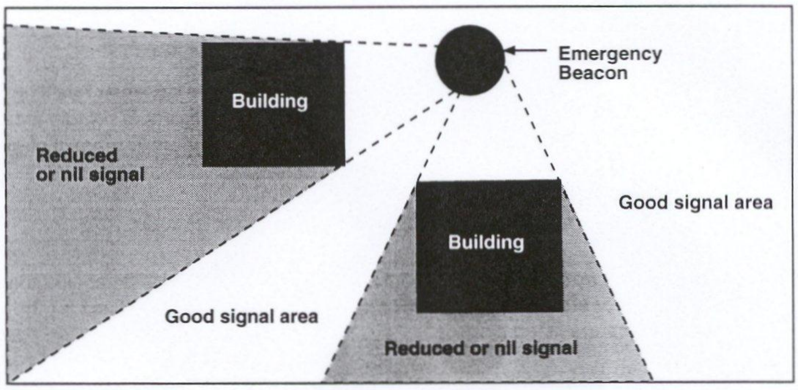


Fig 15 – Distress Beacon Signal Blocked by Building