Emergency locator transmitters

Chapter 7

The detection and location of an aircraft crash is vitally important to the search and rescue (SAR) teams and to potential survivors. Studies show that while the initial survivors of an aircraft crash have less than a 10% chance of survival if rescue is delayed beyond two days, the survival rate is increased to over 60% if the rescue can be accomplished within eight hours. For this reason, emergency locator transmitters (ELT) are required for most general aviation aircraft. ELT are designed to emit signals on the VHF and UHF bands thereby helping search crews locate aircraft and facilitating the timely rescue of survivors. This chapter provides a general introduction to the types and operating principles of ELT fitted to modern passenger aircraft.

7.1 Types of ELT

Several different types of ELT are in current use. These include the older (and simpler) units that produce a modulated RF carrier on one or both of the two spot VHF frequencies used for distress beacons (121.5 MHz and its second harmonic 243.0 MHz). Note that the former frequency is specified for civil aviation use whilst the latter is sometimes referred to as the military aviation distress frequency. Simultaneous transmission on the two frequencies (121.5 MHz and 243.0 MHz) is easily possible and only requires a frequency doubler and dual-band output stage.

Simple VHF ELT devices generate an RF carrier that is modulated by a distinctive siren-like sound. This sweeps downwards at a repetition rate of typically between 2 and 4 Hz. This signal can be readily detected by Sarsat and Cospas satellites (see later), or by any aircraft monitoring 121.5 MHz or 243.0 MHz.

More modern ELT operate on a spot UHF frequency (460.025 MHz). These devices are much more sophisticated and also operate at a significantly higher power (5 W instead of the 150 mW commonly used at VHF). Unlike the simple amplitude modulation used with their VHF counterparts, 460 MHz ELT transmit digitally encoded data which incorporates a code that is unique to the aircraft that carries them.

Provided they have been properly maintained, most ELT are capable of continuous operation for up to 50 hours. It is important to note that ELT performance (and, in particular, the operational range and period for which the signal is maintained) may become seriously impaired when the batteries are out of date. For this reason, routine maintenance checks are essential and any ELT which contains outdated batteries should be considered unserviceable.

The different types of ELT are summarised in Table 7.1. These are distinguished by application and by the means of activation. Modern passenger aircraft may carry several different types of ELT. Figure 7.1 shows a typical example of the Type-W (water activated) survival ELT carried on a modern transport aircraft.

Most ELT in general aviation aircraft are of the automatic type. Fixed automatic units contain a crash activation sensor, or G-switch, which is designed to detect the deceleration characteristics of a crash and automatically activate the transmitter.

With current Sarsat and Cospas satellites now in orbit, ELT signals will usually be detected, within 90 minutes, and the appropriate search and rescue (SAR) agencies alerted. Military aircrew monitor 121.5 MHz or 243.0 MHz and they will also notify ATS or SAR agencies of any ELT transmissions they hear.

It is worth noting that the detection ranges for Type-W and Type-S ELT can be improved if the ELT is placed upright, with the antenna vertical, on the highest nearby point with any accessible metal surface acting as a ground plane. Doubling the height will increase the range by about 40%.
### Types of ELT

<table>
<thead>
<tr>
<th>Type</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A or AD</td>
<td>Automatic ejectable or automatic deployable</td>
<td>This type of ELT automatically ejects from the aircraft and is set in operation by inertia sensors when the aircraft is subjected to a crash deceleration force acting through the aircraft’s flight axis. This type is expensive and is seldom used in general aviation.</td>
</tr>
<tr>
<td>F or AF</td>
<td>Fixed (non-ejectable) or automatic fixed</td>
<td>This type of ELT is fixed to the aircraft and is automatically set in operation by an inertia switch when the aircraft is subjected to crash deceleration forces acting in the aircraft’s flight axis. The transmitter can be manually activated or deactivated and in some cases may be remotely controlled from the cockpit. Provision may also be made for recharging the ELT’s batteries from the aircraft’s electrical supply. Most general aviation aircraft use this ELT type, which must have the function switch placed to the ARM position for the unit to function automatically in a crash (see Figure 7.5).</td>
</tr>
<tr>
<td>AP</td>
<td>Automatic portable</td>
<td>This type of ELT is similar to Type-F or AF except that the antenna is integral to the unit for portable operation.</td>
</tr>
<tr>
<td>P</td>
<td>Personnel activated</td>
<td>This type of ELT has no fixed mounting and does not transmit automatically. Instead, a switch must be manually operated in order to activate or deactivate the ELT’s transmitter.</td>
</tr>
<tr>
<td>W or S</td>
<td>Water activated or Survival</td>
<td>This type of ELT transmits automatically when immersed in water (see Figure 7.1). It is waterproof, floats and operates on the surface of the water. It has no fixed mounting and should be tethered to survivors or life rafts by means of the supplied cord.</td>
</tr>
</tbody>
</table>

### 7.2 Maintenance and testing of ELT

ELT should be regularly inspected in accordance with the manufacturer’s recommendations. The ELT should be checked to ensure that it is secure, free of external corrosion, and that antenna connections are secure. It is also important to ensure that the ELT batteries have not reached their expiry date (refer to external label) and that only approved battery types are fitted.

Air testing normally involved first listening on the beacon’s output frequency (e.g. 121.5 MHz), checking first that the ELT is not transmitting before activating the unit and then checking the radiated signal. Simple air tests between an aircraft and a ground station (or between two aircraft) can sometimes be sufficient to ensure that an ELT is functional; however, it is important to follow manufacturer’s instructions when testing an ELT. Two-station air testing (in conjunction with a nearby ground station) is usually preferred because, due to the proximity of the transmitting and receiving antennae, a test carried out with the aircraft’s own VHF receiver may not reveal a fault condition in which the ELT’s RF output has become reduced.

To avoid unnecessary SAR missions, all accidental ELT activations should be reported to the appropriate authorities (e.g. the nearest rescue coordination centre) giving the location of the transmitter, and the time and duration of the accidental transmission. Promptly notifying the appropriate authorities of an accidental ELT transmission can be instrumental in preventing the launch of a search aircraft. Any testing of an ELT must be conducted only during the first five minutes of any UTC hour and restricted in duration to not more than five seconds.
Emergency locator transmitters

Figure 7.1 Type-W ELT with attachment cord secured by water-soluble tape (the antenna has been removed)

Figure 7.2 Interior view of the ELT shown in Figure 7.1. Note how the battery occupies approximately 50% of the internal volume

Figure 7.3 ELT transmitter and modulator printed circuit board (the crystal oscillator is located on the right with the dual-frequency output stages on the left)

Figure 7.4 ELT test switch and test light (the antenna base connector is in the centre of the unit)

7.3 ELT mounting requirements

In order to safeguard the equipment and to ensure that it is available for operation should the need arise, various considerations should be observed when placing and mounting an ELT and its associated antenna system in an aircraft. The following requirements apply to Type-F, AF, AP ELT installations in fixed wing aircraft and rotorcraft:

1. When installed in a fixed wing aircraft, ELT should be mounted with its sensitive axis pointing in the direction of flight
2. When installed in a rotorcraft ELT should be mounted with its sensitive axis pointing
Parameter Specification

Operating frequencies

121.5 MHz, 243 MHz and 406.025 MHz

Frequency tolerance

±0.005% (121.5 MHz and 243 MHz); ±2 kHz (406.025 MHz)

RF output power

250 mW typical (121.5 MHz and 243 MHz); 5 W ±2 dB (406.025 MHz)

Pulse duration

10 ms

Activation

G-switch

Power source

Internal lithium battery

Battery life

5 years (including effects of monthly operational checks)

Beacon operating life

50 hours

Digital message repetition period (406.025 MHz only)

Every 50 s

Modulation

AM (121.5 MHz and 243 MHz); phase modulation (406.025 MHz)

Housing material

Aluminium alloy

Aircraft communications and navigation systems

approximately 45° downward from the normal forward direction of flight

3. ELT should be installed to withstand ultimate inertia forces of 10 g upward, 22.5 g downward, 45 g forward and 7.5 g sideways

4. The location chosen for the ELT should be sufficiently free from vibration to prevent involuntary activation of the transmitter

5. ELT should be located and mounted so as to minimise the probability of damage to the transmitter and antenna by fire or crushing as a result of a crash impact

6. ELT should be accessible for manual activation and deactivation. If it is equipped with an antenna for portable operation, the ELT should be easily detachable from inside the aircraft

7. The external surface of the aircraft should be marked to indicate the location of the ELT

8. Where an ELT has provision for remote operation it is important to ensure that appropriate notices are displayed.

The antenna used by a fixed type of ELT should conform to the following:

1. ELT should not use the antenna of another avionics system

2. ELT antenna should be mounted as far away as possible from other very high frequency (VHF) antennas

3. The distance between the transmitter and antenna should be in accordance with the ELT manufacturer’s installation instructions or other approved data

4. The position of the antenna should be such as to ensure essentially omnidirectional radiation characteristics when the aircraft is in its normal ground or water attitude

5. The antenna should be mounted as far aft as possible

6. ELT antenna should not foul or make contact with any other antennas in flight.

The following considerations apply to Type-W and Type-S ELT:

1. ELT should be installed as specified for Type-F but with a means of quick release, and located as near to an exit as practicable without being an obstruction or hazard to aircraft occupants
2. Where the appropriate regulations require the carriage of a single ELT of Type-W or Type-S, the ELT should be readily accessible to passengers and crew.

3. Where the appropriate regulations require the carriage of a second Type-W or Type-S ELT, that ELT should be either located near a life raft pack, or attached to a life raft in such a way that it will be available or retrievable when the raft is inflated.

4. An ELT fitted with a lithium or magnesium battery must not be packed inside a life raft in an aircraft.

### 7.4 Typical ELT

Figures 7.1 to 7.4 show the external and internal construction of a basic Type-W ELT. The unit is hermetically sealed at each end in order to prevent the ingress of water. The procedure for disassembling the ELT usually involves withdrawing the unit from one end of the cylindrical enclosure. When reassembling an ELT care must be taken to reinstate the hermetic seals at each end of the enclosure.

The specification for a modern Type-AF ELT is shown in Table 7.2. This unit provides outputs on all three ELT beacon frequencies; 121.5 MHz, 243 MHz, and 406.025 MHz. The ELT uses amplitude modulation (AM) on the two VHF frequencies (121.5 MHz and 243 MHz) and phase modulation (PM) on the UHF frequency (406.025 MHz). The AM modulating signal consists of an audio tone that sweeps downwards from 1.5 kHz to 500 Hz with three sweeps every second. The modulation depth is greater than 85%.

The block schematic diagram for a simple Type-W ELT is shown in Figure 7.6. The supply is connected by means of a water switch (not shown in Figure 7.6). The unit shown in Figure 7.6 only provides outputs at VHF (121.5 MHz and 243 MHz). These two frequencies are harmonically related which makes it possible to generate the 243 MHz signal using a frequency doubler stage.

### Test your understanding 7.2

1. State THREE requirements that must be observed when an ELT is mounted in an aircraft.

2. Describe two methods of activating an ELT.

3. What precautions must be taken when an ELT is tested?

![Figure 7.6 Block schematic diagram for a Type-W ELT](image)
7.5 Cospas–Sarsat satellites

Cospas–Sarsat is a satellite system designed to supply alert and location information to assist search and rescue operations. The Russian Cospas stands for ‘space system for the search of vessels in distress’ whilst Sarsat stands for ‘search and rescue satellite-aided tracking’.

The system uses satellites and ground stations to detect and locate signals from ELT operating at frequencies of 121.5 MHz, 243 MHz and/or 406 MHz. The system provides worldwide support to organizations responsible for air, sea or ground SAR operations.

The basic configuration of the Cospas–Sarsat system features:

- ELT that transmit VHF and/or UHF signals in case of emergency
- Instruments on board geostationary and low-orbiting satellites detecting signals transmitted by the ELT
- Local user terminals (LUT), which receive and process signals transmitted via the satellite downlink to generate distress alerts
- Mission control centres (MCC) which receive alerts from LUTs and send them to a Rescue coordination centre (RCC)
- Search and rescue (SAR) units.

There are two Cospas–Sarsat systems. One operates at 121.5 MHz (VHF) whilst the other operates at 406 MHz (UHF). The Cospas–Sarsat 121.5 MHz system uses low earth orbit (LEO) polar-orbiting satellites together with associated ground receiving stations. The basic system is shown in Figure 7.7.

The signals produced by ELT beacons are received and relayed by Cospas–Sarsat LEO-SAR satellites to Cospas–Sarsat LUTs that process the signals to determine the location of the ELT. The computed position of the ELT transmitter is relayed via an MCC to the appropriate RCC or search and rescue point of contact (SPOC).

The Cospas–Sarsat system uses Doppler location techniques (using the relative motion between the satellite and the distress beacon) to accurately locate the ELT. The carrier frequency transmitted by the ELT is reasonably stable during the period of mutual beacon-satellite visibility. Doppler performance is enhanced due to the low-altitude near-polar orbit used by the Cospas–Sarsat satellites. However, despite this it is important to note that the location accuracy of the 121.5 MHz system is not as good as the accuracy that can be achieved with the 406 MHz system. The low altitude orbit also makes it possible for the system to operate with very low uplink power levels.

![Figure 7.7 The Cospas–Sarsat system in operation](image-url)
A near polar orbit could provide full global coverage but 121.5 MHz can only be produced if the uplink signals from the ELT are actually received by an LUT. This constraint of the 121.5 MHz system limits the useful coverage to a geographic area of about 3,000 km radius around each LUT. In this region, the satellite can ‘see’ both the ELT and the LUT.

Figure 7.8 shows the polar orbit of a single satellite. The path (or ‘orbital plane’) of the satellite remains fixed, while the earth rotates underneath. At most, it takes only one half rotation of the earth (i.e. 12 hours) for any location to pass under the orbital plane. With a second satellite, having an orbital plane at right angles to the first, only one quarter of a rotation is required, or six hours maximum. Similarly, as more satellites orbit the earth in different planes, the waiting time is further reduced.

The complete Cospas–Sarsat system uses four satellites as shown in Figure 7.9. The system provides a typical waiting time of less than one hour at mid-latitudes. However, users of the 121.5 MHz system have to wait for a satellite pass which provides for a minimum of four minutes, simultaneous visibility of an ELT and an LUT. This additional constraint may increase the waiting time to several hours if the transmitting beacon is at the edge of the LUT coverage area. The Doppler location provides two positions for each beacon: the true position and its mirror image relative to the satellite ground track. In the case of 121.5 MHz beacons, a second pass is usually required to resolve the ambiguity.

Sarsat satellites are also equipped with 243 MHz repeaters which allow the detection and location of 243 MHz distress beacons. The operation of the 243 MHz system is identical to the 121.5 MHz system except for the smaller number of satellites available.

The Cospas–Sarsat 406 MHz System is much more sophisticated and involves both orbiting and geostationary satellites. The use of 406 MHz beacons with digitally encoded data allows unique beacon identification.

In order to provide positive aircraft identification, it is essential that 406 MHz ELT are registered in a recognised ELT database.
accessible to search and rescue authorities. The information held in the database includes data on the ELT, its owner, and the aircraft on which the ELT is mounted. This information can be invaluable in a search and rescue (SAR) operation.

The unique coding of a UHF ELT is imbedded in the final stage of manufacture using aircraft data supplied by the owner or operator. The ELT data is then registered with the relevant national authorities. Once this has been done, the data is entered into a database available for interrogation by SAR agencies worldwide.

### 7.6 Multiple choice questions

1. ELT transmissions use:
   - (a) Morse code and high-power RF at HF
   - (b) pulses of acoustic waves at 37.5 kHz
   - (c) low-power RF at VHF or UHF.

2. A Type-P ELT derives its power from:
   - (a) aircraft batteries
   - (b) internal batteries
   - (c) a small hand-operated generator.

3. Transmission from an ELT is usually initially detected by:
   - (a) low-flying aircraft
   - (b) one or more ground stations
   - (c) a satellite.

4. The operational state of an ELT is tested using:
   - (a) a test switch and indicator lamp
   - (b) immersion in a water tank for a short period
   - (c) checking battery voltage and charging current.

5. A Type-W ELT needs checking. What is the first stage in the procedure?
   - (a) Inspect and perform a load test on the battery
   - (b) Open the outer case and inspect the hermetic seal
   - (c) Read the label on the ELT in order to determine the unit’s expiry date.

6. If bubbles appear when an ELT is immersed in a tank of water, which one of the following statements is correct?
   - (a) This is normal and can be ignored
   - (b) This condition indicates that the internal battery is overheating and producing gas
   - (c) The unit should be returned to the manufacturer.

7. The air testing of an ELT can be carried out:
   - (a) at any place or time
   - (b) only after notifying the relevant authorities
   - (c) only at set times using recommended procedures.

8. On which frequencies do ELT operate?
   - (a) 125 MHz and 250 MHz
   - (b) 122.5 MHz and 406.5 MHz
   - (c) 121.5 MHz and 406.025 MHz

9. A Type-W ELT is activated by:
   - (a) a member of the crew
   - (b) immersion in water
   - (c) a high G-force caused by deceleration.

10. The location accuracy of a satellite-based beacon locator system is:
    - (a) better on 121.5 MHz than on 406 MHz
    - (b) better on 406 MHz than on 121.5 MHz
    - (c) the same on 121.5 MHz as on 406 MHz.

11. An ELT fitted with a lithium battery is:
    - (a) safe for packing in a life raft
    - (b) unsafe for packing in a life raft
    - (c) not suitable for use with a Type-F ELT.

12. A Type-W or Type-S ELT will work better when the antenna is:
    - (a) held upright
    - (b) slanted downwards slightly
    - (c) carefully aligned with the horizontal.

13. The satellites used by the Cospas–Sarsat 121.5 MHz system are:
    - (a) in high earth orbit
    - (b) in low earth orbit
    - (c) geostationary.