Enhancements and Alternatives Proposed for Emergency Homing Devices

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Abstract- This paper deals with the problems faced by the current designs of aircraft-based emergency homing devices like ELTs (Emergency Locator Beacons) and ULBs (Underwater Locator Beacons). Particularly, it deals with issues like low battery life of the transmitters and remaining in a deactivated state even after a crash. Many alternative methods are proposed which can make the homing beacons more efficient.

Index Terms- Black box, Electronic Locator Transmitter, Search and Rescue, Underwater Locator Beacon

I. Introduction

There have been 1114 commercial airplane accidents since 2008 [1,2]. When an aircraft crashes, specialized hardware, namely a black box, is responsible for protecting the flight data recorder (FDR) and cockpit voice recorder (CVR), which is used to collect information about flight instruments and pilot's interaction just before the crash. This information is crucial to ascertain the cause of the crash and improve safety in aviation. According to EUROCAE, the black box is made to withstand extremely high pressures of over 3400 g and temperatures of about 1000 deg C [3]. In addition, the black box also has integrated ULB (Underwater Locator Beacon) for SAR (Search and Rescue) operation, which are of acoustic pinger type and have varying amounts of range depending on weather conditions (2-5 km). Also, they usually transmit over the 8.8 or 37.5±1 kHz band and have an underwater transmission depth of 6096m. [4,5,6] Additionally, they have a life of about 30/90 days, after which the signal begins to degrade and the output decreases as a result [6].

To transmit such emergency signals when crash happens in land area, ELT (Emergency Locator Transmitter) is used. The International Civil Aviation Organization (ICAO) defines an ELT as equipment which broadcasts distinctive signals on designated frequencies and, depending on the application, may be automatically activated by impact or be manually activated [b]. ELTs are radio beacons carried on most aircraft so that in the event of an accident in a remote location the aircraft wreckage and its occupants can be located quickly by search and rescue (SAR) operations. Finding the aircraft wreckage quickly not only increases the chance of survival of the occupants but also reduces the risk to pilots of SAR aircraft who commonly need to operate in marginal weather conditions and over mountainous terrain.

Over the years, there have been various cases of failure of ELT/ULB, two of which are Air France flight AF447 on June 1, 2009. It took 2 years and $41 million dollars to recover the black boxes, because its location could not be pinpointed due to the low pinging frequency of one in 10 minutes. Another famous incident occurred on March 8, 2014, where Malaysia Airlines flight MH370 veered off course and reportedly crashed somewhere in the ocean. In this case, no pings were heard and the search was stopped after 5 years which was conducted by 26 countries and approximate cost of search operations was $200 million dollars [7].

For this paper, we will focus on ELTs, as they have a much shorter life as compared to ULBs. However, the core technology used remains the same, and thus all ideas discussed in this paper will also be applicable to ULBs unless stated otherwise.

ELTs are of many different types, based on their application, some of which are-

Automatic fixed ELT (ELT/AF): An automatically activated ELT which is permanently attached to an aircraft.

Automatic portable ELT (ELT/AP): An automatically activated ELT which is rigidly attached to an aircraft but readily removable from the aircraft.

Automatic deployable ELT (ELT/AD): An ELT which is rigidly attached to an aircraft and which is automatically deployed and activated by impact, and, in some cases, also by hydrostatic sensors. Manual deployment capability is also provided.

Survival ELT (ELT/S): An ELT which is removable from an aircraft, stowed so as to facilitate its ready use in an emergency, and manually activated by survivors [8].

II. Background and History

Before 1970, whenever a plane met with an accident in a remote area, it was very difficult to locate the plane and provide rescue operations to the survivors. Sometimes it took many days to find the location of the accident and quite a few times the plane was never found. Because of this problem, a need was felt to develop a mechanism so that the plane can be located at the earliest in the event of an accident. For this it was decided to install a radio beacon called ELT (Emergency Locator Transmitter) in the plane such that in the event of an accident this ELT should get activated and should start emitting the radio beacon and by using this beacon the site of the accident can be quickly searched out and rescue operation can be performed at the earliest. The basic purpose of this system is to help rescuers to find survivors within the so-called "golden period" (the first 24 hours following an accident) during which the majority of survivors can usually be saved.

In 1970, the USA mandated to install Emergency Locator Transmitter (ELT) in all general aviation airplanes by December 30, 1973. These ELTs were operating at 121.5 MHz frequency, the designated international distress frequency. These ELTs were manufactured to the specifications of a Federal Aviation Administration (FAA) technical standard order (TSO-91) [9].

ELTs were originally intended for use on the 121.5 MHz frequency to alert air traffic control and other aircraft monitoring the frequency.

In 1982, a satellite-based monitoring system named COSPAS-SARSAT was implemented, to provide a better way to detect these distress signals. This satellite-based monitoring system was monitoring the distress signals at 121.5 MHz, 243 MHz, and 406 MHz radio frequencies. However, such a satellite-based monitoring system was receiving a high number of false signals at 121.5 MHz and 243 MHz frequencies. It was found that such false alert signals were mainly from old ELTs. In 2009, the international COSPAS-SARSAT satellite system discontinued satellite-based monitoring of the 121.5/243 MHz frequencies, in part because of a high number of false signals attributed with these frequencies. Satellite monitoring today utilizes the 406 MHz frequency only [10,11].

In USA Federal Aviation Administration (FAA) Issues Technical Standard Orders (TSO) which states a minimum performance standard for specified materials, parts, and appliances used on civil aircraft. Generally, these standards are followed by many countries.

- In 1985, a new TSO-C91A for ELT was issued, this was operating at 121.5 MHz frequency [9].
- In 1992, TSO C126 for ELT was issued, this was operating at 406 MHz frequency [12].
- In 2008, TSO C126a for ELT was issued, this was operating at 406 MHz frequency [13].
- In 2012, TSO C126b for ELT was issued, this was operating at 406 MHz frequency [14].

However, the International Civil Aviation Organization (ICAO) requires that ELTs carried in airplanes shall operate on both 121.5 MHz and 406 MHz Though satellite system no longer identifies 121.5 MHz signal, it is useful for homing. [15,16]

Operation of an ELT:

Ideally, it is required that in the event of an accident, the ELT should get activated and should start emitting the radio beacons at 406 MHz frequency signal and 121.5 MHz frequency signals periodically up to next 24 Hrs. or 48 Hrs. **For this, ELTs get triggered due to high g-force typical of airplane crash or temperature, whichever goes above the threshold first.**

The 406 MHz signal will be detected by the satellite network and its location can be estimated by satellite system using doppler triangulation or by GPS trilateration [10]. This location estimate will be provided to the Search and Rescue operation team and hence the survivors can be saved at the earliest (within golden hours).

Similarly, 121.5 MHz signal can be received by local ATC or nearby local observation center. This can help the Search and Rescue operations without satellite network.

Why the accident site cannot be located earliest despite having ELT:

The main reason for this is that **at about 40% of time ELT does not get activated** [17]. Hence no signal on 406 MHz frequency or 121.5 MHz frequency are available to be detected. Also, in some cases, the ELT gets damaged in the accidents mainly due to fire or due to the force of impact.

Issues with the present form of ELTs:

Airframe mounted ELTs are designed to automatically activate following an impact typical of a collision. However, the effectiveness of airframe ELTs in aviation accidents has been questioned by accident investigation agencies and by the aviation community. A government organization, Australian Transport Safety Bureau (ATSB) has done the research investigation to identify the safety concerns regarding the operation of ELTs and presented data on the effectiveness of ELTs activating following an accident. In this research investigation, the ATSB identified safety concerns regarding the operation of ELTs and presents data on the effectiveness of ELTs activating following an accident.

ATSB found that ELTs function as intended in only about 40 to 60 percent of accidents in which their activation was expected.

Therefore, the main issue with the present form of ELTs is that in the majority of cases it doesn't get activated. In some cases, the ELT gets damaged in the accident.

Accidents and Incidents where ELT is not damaged but does not get activated [18]:

- AN 32, Indian Air Force, Jun 2019, Arunachal Pradesh, India, ELT did not get activated in the crash.
- Cessna 182P Skylane June 2012, Maryvale Station (near Cunnamulla), Queensland, the fixed fuselage mounted ELT did not activate during the impact.
- B190, Blue River BC Canada, 2012 - The impact forces had not been enough for the ELT to be activated.
- Piper PA-30 Twin Comanche, May 2001, Archerfield Airport, Queensland, the ELT did not activate as a result of the initial impact.

- Mooney M20J from Jandakot to Laverton, Western Australia, 1998 - ELT was not activated despite high G-force of the accident.

Accidents and Incidents where ELT was damaged [18]:

- S76, vicinity Moosonee ON Canada, 2013 - The wreckage, which was near to the departure airport, was not located for over 5 hours after the ELT failed to function. The ELT failure was attributed to the tail boom-sited external antenna being severed.
- E190, en route, Bwabwata National Park Namibia, 2013 - No distress calls were made and no signal was transmitted from the ELT after the crash. This was found to be due to a break in the coaxial cable which linked the unit to the external antenna.
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- MD83, en route, near Gossi Mali, 2014 - No signal was received from the ELT and it was found damaged at the crash site.
- C130J, en-route, northern Sweden 2012 - The ELT did not transmit and was found to have sustained major damage at impact.

III. Enhancements and ALTERNATIVES PROPOSED

Despite many different ways to mount the ELT, the failure of the ELTs to get activated in the event of accidents remains the main reason for ELT not being useful and not being able to provide the Search and Rescue operations within time to the survivors.

Hence below mentioned additional enhancements are suggested to increase the ELT effectiveness and locate the accident site, even if ELT was not activated on accident.

These enhancements are suggested keeping in view the requirements of civilian as well as defense planes. Kindly note that these enhancements suggested below are also applicable for Underwater Locator Beacons (ULBs) unless stated otherwise.

1. It should be possible to activate ELT remotely using Radio Frequency signals (RF) so that even if the ELT is not activated in the event of an accident it can be activated via radio frequency signals before the search operations begin. For this ELT should be provided with the ability to listen passively at a designated frequency or frequencies. When an ELT receives the activation signal for its own ID, at that particular designated frequency, it should get activated and start emitting the emergency beacon signals at 406 MHz frequency (and 121.5 MHz frequency).

2. It should be possible to send these activation signals via any of the below-mentioned methods:

2.1 Local ATC signals.

2.2 RF signals from the Search and Rescue team during SAR operation.

2.3 Satellite return link of the system like COSPAS-SARSAT. This is useful when the area where the accident happened is not known at all or the probable area is too big for the signals mentioned in the options 2.1 and 2.2 above.

3. However, in respect of the planes whose operations are critical in nature like defense planes, remote activation of ELT via radio frequency signals as mentioned above may become a security issue. If someone wants to know the location of that plane, then it may activate the ELT of that plane by sending the activation signals to that ELT. Once the ELT starts emitting the radio beacon, the location of the plane can be easily detected even though the plane is operating normally. Hence ELT should be activated only on receipt of authenticated secure signals. It should be possible that such authenticated secure signal can be sent via any of the ways mentioned in point 2 above.

4. It should be required that one authenticated secure signal can be used only once. It should not be possible to re-use the same authenticated secure signal. This is required in view of the fact that these authenticated secure signals are sent via radio frequency, which can be easily captured off the air. If the restriction of using one authenticated secure signal only once is not imposed then it will be possible for the other entities to use such off the air captured signal to activate the ELT and locate the plane

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5. It should be possible to activate ELT in any of the below mentioned ways

5.1 ELT can be activated such that ELT will keep on emitting the radio beacon for 24 to 48 Hrs. This is the normal way in which ELT is supposed to be activated in the event of an accident.

5.2 ELT can be activated such that ELT will emit one or two or some predefined number of beacons only. This mode will be useful when the search and rescue team will be activating the ELT during its search operation and such activation signals are sent from the device onboard with the search and rescue team. This will provide the efficient use of the battery in the case of accident and also, we can have the scope for more powerful beacons. This will also provide a longer battery life. Also, more power would also mean that the range of the transmitter will increase.

However, it should be possible that ELT can be activated in any of the modes via any of the link mentioned in 2 above.

6. It should be explored whether ELT cab is integrated with the Blackbox such that it will suffer minimum physical damage.

7. In view of point 6 above, it should be explored whether some part of the Blackbox can be used as an antenna of the ELT, as in

many cases the antenna is known to break and unable to transmit any signal.

8. In addition to the above-mentioned enhancements, further to increase the probability of locating the plane in the event of an accident, it is suggested that the flight control monitoring all the parameters which include, but are not yet limited to airspeed, altitude, pitch, yaw, roll, GPWS (Ground Proximity Warning System) along with excessive flight inputs to predict crashing probability (for example when more than 2 of the parameters are showing negative prognosis) and transmit a distress signal while it is happening before crash. It allows the system to use aircraft antennas which are much more powerful. The ELT can be configured such that, if the signal from any of these devices (which are placed at different locations inside the plane) is not received continuously, indicating a situation of an emergency/accident or if the parameters indicating the emergency situation are received by the ELT from such devices, ELT should get activated. The main advantage of this arrangement is that; in most of the accident cases, ELT will get activated even before the airplane touch the ground/water in the event of an accident, thus before any damage can occur to antennas.

8.1 The above method would also allow us to send more detailed information to satellites, and multiple pings can also show the flight path.

8.2 The above method will also allow for more detailed information to be sent in real time, especially now when a plane can be permanently connected to satellites such as SpaceX's Starlink, which will have worldwide coverage in coming years.

8.3 In the above method, a switchable "stealth mode" can be added to defense aircraft as they can encounter highly variable parameters during testing/ exercises/ war. This would enable the plane to temporarily disconnected from commercial satellites, and thus cannot be tracked.

9. In the future, if there is a return of supersonic commercial passenger jet flight, the forces produced in an accident would become too high to be sustained by the black box. The specifications needed by the black box would not be practical. In this scenario, the above method mentioned in 8 would be the only viable solution.

10. The alternate method consists of a smaller independent beacon which can be ejected just before the aircraft touches the ground. It will have the same working as explained in 8, and its time of ejection will primarily depend on the altimeter, once it is verified that crash is imminent. Can also have a parachute to have a safer landing. It can also have buoyancy (not by additional hardware like floats, but inherently due to its shape and build).

11. In commercial passenger jets, any person should not be able to fiddle with or turn off safety systems like ACARS (aircraft communications addressing and reporting system), which is used to track planes via satellites. To ensure this, it can be integrated with the black box so that it becomes physically inaccessible to any person on board. It is theorized that the captain of MH370 turned off ACARS, and that is the main reason anyone has failed to relocate the plane even 5 years after it went missing.

IV. CONCLUSION

Providing above mentioned enhancements in the ELT and ULB can significantly increase their activation rate for the planes in case of an accident and thereby significantly increasing the chances of the rescue of the survivors. Above mentioned enhancements will not pose any security risk to the civil aviation planes as well as defense planes. There is no downside of the above enhancements mentioned, except marginal additional cost. Hence these enhancements should be considered by the manufacturers as an additional feature of their product till the time authorities make it a mandatory requirement.

REFERENCES

[1] Icao.int. (2019). *Accident Statistics*. [online] Available at: https://www.icao.int/safety/iStars/Pages/Accident-Statistics.aspx [Accessed 4 Jul. 2019].

[2] Baaa-acro.com. (2019). *Death Rate per Year*. [online] Available at: https://www.baaa-acro.com/statistics/death-rate-per-year [Accessed 4 Jul. 2019].

[3] Minimum Operational Performance Specification For Crash Protected Airborne Recorder Systems. (2019). EUROCAE ED 112, Revision A, September 2013. Saint-Denis: EUROCAE…..1’

[4] FAA (2015). *TSO 121b*. Washington, DC: FAA, DOT, pp.12698-12699.

[5] Minimum Performance Standard for Low Frequency Underwater Locating Devices (Acoustic) (Self-Powered). (2015). 2nd ed. [ebook] Troy, Michigan: SAE. Available at: https://www.sae.org/standards/content/as6254a/ [Accessed 4 Jul. 2019].

[6] Minimum Performance Standard for Underwater Locating Devices (Acoustic) (Self-Powered). (2011). 2nd ed. [ebook] Troy, Michigan: SAE. Available at: https://www.sae.org/standards/content/as8045a/ [Accessed 4 Jul. 2019].

[7] Inside GNSS. (2018). *The Cospas-Sarsat MEOSAR System Solution to Support ICAO GADSS*. [online] Available at: https://insidegnss.com/the-cospas-sarsat-meosar-system/ [Accessed 4 Jul. 2019].

[8] Draft Regulation Respecting the Carriage of Emergency Locator Transmitters (ELT). (2007). In: *Conference on Search and Rescue*. [online] ICAO. Available at: https://www.icao.int/Meetings/AMC/MA/2007/SARafrica/sarconf_wp10_en.pdf [Accessed 4 Jul. 2019].

[9] Proposed Technical Standard Order (TSO)-C91a. (1885). [FAA Notice] US Federal Register, Washington DC.

[10] Foster, E. (n.d.). *NOAA - Search and Rescue Satellite Aided Tracking - History of the program*. [online] Sarsat.noaa.gov. Available at: https://www.sarsat.noaa.gov/background.html [Accessed 4 Jul. 2019].......d

[11] Comparison of 406 MHz and 121.5 MHz Distress Beacons. (n.d.). NOAA-SARSAT, p.1.

[12] Proposed Technical Standard Order (TSO)-C126. (1992). [FAA Notice] US Federal Register, Washington DC.

[13] Proposed Technical Standard Order (TSO)-C126a. (2008). [FAA Notice] US Federal Register, Washington DC.

[14] Proposed Technical Standard Order (TSO)-C126b. (2012). [FAA Notice] US Federal Register, Washington DC.

[15] Draft Regulation Respecting the Carriage of Emergency Locator Transmitters (ELT). (2007). In: *Conference on Search and Rescue*. [online] ICAO. Available at: https://www.icao.int/Meetings/AMC/MA/2007/SARafrica/sarconf_wp10_en.pdf [Accessed 4 Jul. 2019].

[16] Honeywell International Inc. "Honeywell RESCU 406® AFN, Automatic Fixed Navigation Emergency Locator Transmitter." Dec. 2006, www.skybrary.aero/bookshelf/books/2401.pdf.

[17] Australian Transportation Safety Bureau (2013). *A review of the effectiveness of emergency locator transmitters in aviation accidents*. Canberra, Australia: ATSB, p.8.

[18] Skybrary.aero. (2019). *Emergency Locator Transmitter (ELT) - SKYbrary Aviation Safety*. [online] Available at: https://www.skybrary.aero/index.php/Emergency_Locator_Transmitter_(ELT) [Accessed 4 Jul. 2019].

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