

الهيئة العامة للطيران المدني  
GENERAL CIVIL AVIATION AUTHORITY



# Air Accident Investigation Sector

## Aviation Safety Study

[SRP/001/2024]

# Effectiveness of Emergency Locator Transmitters (ELT)

Safety Studies are conducted in compliance with the *Air Accident and Incident Investigation Regulation* and conformance with *Annex 13* to the Convention on International Civil Aviation. The final product of a Safety Study is a Research Paper, which may contain safety recommendations addressed to the appropriate organizations. Research Papers are made public on the website.



## EXECUTIVE SUMMARY

The study discusses the effectiveness of the aid that Emergency Locator Transmitters (ELTs) provide for search and rescue (SAR) operations, particularly in remote aviation accident places. It covers accidents that occurred from the beginning of 2010 to the end of 2023.

The study presents a multifaceted evaluation of ELT performance, compliance with International Civil Aviation Organization (ICAO) standards, and the exploration of future detection technologies. This safety study, aimed at bolstering global aviation safety, critically analyzes ELT operational capabilities, signal detection, activation mechanisms.

Key findings indicate variable performance of ELTs in facilitating prompt SAR responses, highlighting instances of successful rescues alongside cases where ELTs had failed to activate or had not been detected in a timely manner. The study scrutinizes the reasons behind ELT non-activation, revealing factors such as impact damage, suboptimal installation, and maintenance lapses. Despite these challenges, conformance with ICAO standards is generally high, though enforcement and compliance monitoring gaps exist.

Advancements in detection technology and the promising integration of Global Aeronautical Distress and Safety System (GADSS), suggest a forward trajectory toward enhanced ELT functionality. However, this potential is contingent upon resolving existing limitations and leveraging new technological solutions.



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## ABBREVIATIONS AND ACRONYMS

<b>AAIS</b>	<b>The</b> Air Accident Investigation Sector of the United Arab Emirates
<b>ADT</b>	Autonomous Distress Tracking
<b>AI</b>	Artificial intelligence
<b>ATS</b>	Air Traffic Service
<b>ATSB</b>	Australian Transport Safety Bureau
<b>AUV</b>	Autonomous Underwater Vehicle
<b>CAR</b>	Civil Aviation Regulations of the United Arab Emirates
<b>CVR</b>	Cockpit Voice Recorder
<b>EASA</b>	European Union Aviation Safety Agency
<b>ELT</b>	Emergency Locator Transmitter
<b>ELT AD</b>	Automatic Deployable ELT
<b>ELT AF</b>	Automatic Fixed ELT
<b>ELT AP</b>	Automatic Portable ELT
<b>ELT-DT</b>	Emergency Locator Transmitter with Autonomous Distress Tracking
<b>ELT S</b>	Survival ELT
<b>FAA</b>	Federal Aviation Administration of the United States
<b>FDR</b>	Flight Data Recorder
<b>GADSS</b>	Global Aeronautical Distress and Safety System
<b>GALILEO</b>	European Global Navigation Satellite System
<b>GCAA</b>	The General Civil Aviation Authority of the United Arab Emirates
<b>GEO</b>	Geostationary
<b>GLONASS</b>	Global Navigation Satellite System
<b>GPS</b>	Global Positioning System
<b>ICAO</b>	International Civil Aviation Organization
<b>LEO</b>	Low-Earth Orbit
<b>LUT</b>	Local User Terminal
<b>MCC</b>	Mission Control Centers
<b>MEOSAR</b>	Medium Earth Orbit for SAR
<b>MHz</b>	Megahertz
<b>NASA</b>	National Aeronautics and Space Administration
<b>NSRC</b>	National Search and Rescue Center
<b>NTSB</b>	National Transportation Safety Board
<b>PLB</b>	Personal Locator Beacons
<b>RCC</b>	Rescue Coordination Centers
<b>RLS</b>	Return Link System
<b>SAR</b>	Search and Rescue
<b>TPL</b>	Towed Pinger Locator
<b>TSO</b>	Technical Standard Order



## CHAPTER 1. INTRODUCTION

### 1.1 What is Aviation Safety Study

The Air Accident Investigation Sector (AAIS) of the United Arab Emirates conducts Aviation Safety Studies in response to identifying adverse safety trends that highlight specific risk factors, warranting a comprehensive assessment for enhancing safety protocols. Such studies may also be undertaken following investigations into similar accidents, incidents, or other occurrences involving the same entity or operation, underscoring their significance in improving aviation safety.

Aviation Safety Studies serve as a pivotal mechanism for the following:

- Analysis of an adverse safety occurrence trend;
- Analysis of identified recurring factors in recent events;
- Analysis of specific risk factors; and
- Reporting on a specific aspect of safety interest.

The AAIS is responsible for conducting the research, analysis, and deriving conclusions within these Safety Studies. The findings from these Studies are instrumental in formulating safety recommendations, which are then directed toward relevant organizations and civil aviation authorities to foster enhanced safety measures.

This Safety Study is initiated in response to observed trends regarding the activation or broadcast function of Emergency Locator Transmitters (ELTs) in alerting the National Search and Rescue Center (NSRC) as the United Arab Emirates agency responsible for initiating search and rescue following accidents, particularly in remote locations.

### 1.2 Problem Definition

A study examining accidents in the United Arab Emirates between 2010 and 2023 revealed that the Emergency Locator Transmitter (ELT) aboard aircraft involved in accidents frequently malfunctioned, failing to activate as intended. Consequently, the National Search and Rescue Center (NSRC) did not receive the necessary distress signals to launch an appropriate search and rescue operation. Although the duration of the search and rescue efforts was not significantly prolonged, the effectiveness of locating the aircraft would have been enhanced had the ELT functioned as intended.

### 1.3 Objectives and Scope of this Safety Study

This Safety Study aims at thoroughly examining the effectiveness of ELTs in facilitating prompt and efficient search and rescue operations following aviation accidents, with emphasis on occurrences in remote places. This analysis will encompass a review of data from 2010 to 2023.

The study is designed to evaluate the operational performance of ELT signal detection capabilities, scrutinize adherence to and the adequacy of International Civil Aviation Organization (ICAO) standards pertaining to ELTs, and investigate the mechanisms of ELT activation, including exploring cases where ELTs had failed to activate.

Moreover, the Study intends to identify the underlying reasons for ELT non-activation, project the trajectory of future detection technologies, and assess their potential to enhance ELT functionality. Including insights from ELT-focused reports will enrich the Study with up-to-date research and findings.



By covering these critical areas, the Study generates recommendations for improving ELT reliability and performance, thereby advancing the safety and effectiveness of global aviation search and rescue operations.

#### **1.4 Data Collection Method**

The method for gathering data to evaluate the effectiveness of ELT incorporates a diverse strategy grounded in compliance with standards set by ICAO and the General Civil Aviation Authority (GCAA), an in-depth review of existing research, and selective interviews.

Primary data sources consisted of an extensive examination of the occurrence and previous studies that have delved into aspects of ELT efficiency, their operational metrics, and technological advancements. Interviews were arranged with specialists from the GCAA and Search and Rescue (SAR) team. An analytical review was conducted on specific air accidents that took place in the United Arab Emirates where ELT had or had not activated, along with exploring new technologies and industry news related to ELT.

## CHAPTER 2. ELT CATEGORIZATION AND PRINCIPLES OF OPERATION

### 2.1 General

ELT is a critical safety device installed in aircraft to aid in locating the aircraft and accordingly expedite search and rescue operations. The device is designed to transmit a distress signal that can be detected by SAR operations control center.

### 2.2 ELT Types and Activation Mechanisms

ELTs are categorized into various types based on installation, activation mechanism, and intended use. Here's an expanded overview of the primary types of ELTs<sup>1</sup>:

#### 2.2.1 Automatic Fixed ELT (ELT AF)

The ELT AF is permanently affixed to the aircraft and engineered to activate automatically upon experiencing a significant impact or crash. The installation of the unit protects it from the crash forces and ensures successful distress signal transmission. The automatic activation mechanism relies on a G-switch sensor that detects sudden deceleration. ELT AF also incorporates a manual activation feature, enabling crew members or rescue personnel to activate as required.



Figure 1. Automatic Fixed ELT (ELT AF)

#### 2.2.2 Automatic Portable ELT (ELT AP)

The ELT AP combines the features of automatic activation with the flexibility of being portable. While the unit can be fixed to the aircraft, it is designed to be easily detachable. This allows survivors to take the ELT with them if they evacuate the aircraft, providing a means to signal for help even away from the crash site. Like the ELT AF, the ELT AP is equipped with AN automatic activation mechanism and manual switch, offering versatility in emergencies.

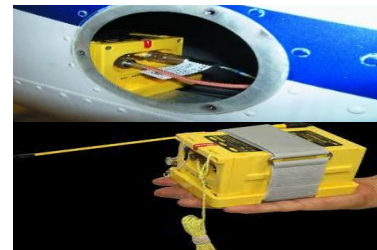


Figure 2. Automatic Portable ELT (ELT AP)

#### 2.2.3 Survival ELT (ELT S)

ELT S is intended to be part of the aircraft's survival equipment and is not permanently attached to the aircraft. Stored within accessible locations, the device is designed for manual activation post-accident, serving as a quick retrieval in an emergency. ELT S is designed for manual activation and is meant to be used after an accident to signal for rescue. The portability and manual operation make the ELT S a critical tool for survival, particularly in situations where the primary ELTs (ELT AF/AP) fail to activate or are inaccessible.



Figure 5. Survival ELT (ELT S)

<sup>1</sup> Federal Aviation Administration. (2022). Advisory Circular AC 91-44A CHG-1. Retrieved from [https://www.faa.gov/documentLibrary/media/Advisory\\_Circular/AC\\_91-44A\\_CHG-1.pdf](https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_91-44A_CHG-1.pdf)

## 2.3 Signal and Operation

### 2.3.1 Signal transmission

ELT transmits distress signals primarily at 406 megahertz (MHz), a frequency monitored globally by the Cospas-Sarsat satellite system<sup>2</sup>. This signal includes digitally encoded information such as the identity of the aircraft and, in many cases, its precise location if the ELT is equipped with GPS capabilities. The 406 MHz frequency allows for more accurate localization and reduces the search area, significantly improving response times. Additionally, some ELTs still transmit a secondary signal at 121.5 MHz, which search and rescue teams can use for "homing" purposes as they approach the site.

### 2.3.2 ELT Operation

The diagram illustrates a satellite-aided SAR operation, a critical component of global emergency response systems.

The process initiates with a distress call emanating from an emergency beacon, which could be triggered by someone in a life-threatening situation, such as an aircraft crash or a lost individual in a remote area (figure 4, (1)). This beacon transmits a signal picked up by dedicated SAR satellites orbiting the Earth (2). These satellites are part of an international satellite system for search and rescue called Cospas-Sarsat, designed to provide accurate and reliable distress alert and location data.

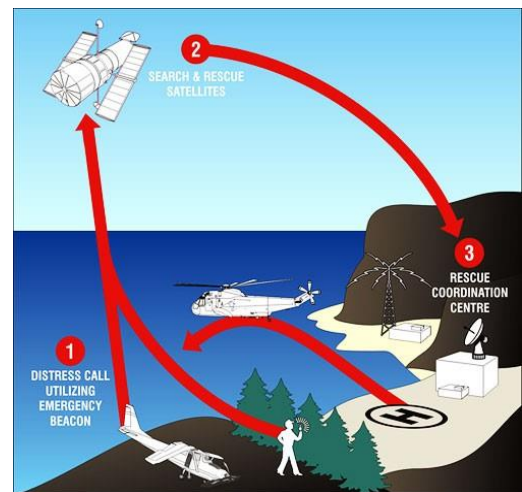


Figure 7. ELT operations diagram

The mission control center, operating with utmost efficiency, swiftly processes this information and immediately relays it to a rescue coordination center (3). This center, a hub of rapid decision-making, is entrusted with organizing the rescue efforts, which encompass assessing the situation, mobilizing SAR teams, and dispatching the necessary resources to the distress location.

<sup>2</sup> The Cospas-Sarsat system is an international satellite-based search and rescue (SAR) initiative. It utilizes a constellation of low-earth orbit (LEO) and geostationary (GEO) satellites to detect and locate the signals transmitted by ELTs. Upon capturing a distress signal, satellites relay this information to ground stations, known as Local User Terminals (LUT), which process the data to determine the location of the distress. This information is then forwarded to Mission Control Centers (MCCs) and ultimately to the appropriate Rescue Coordination Centers (RCCs), which orchestrate the search and rescue efforts



## CHAPTER 3. INTERNATIONAL STANDARDS AND NATIONAL REGULATORY REQUIREMENTS FOR ELT

### 3.1 International Standards Set by ICAO

ELT Standards are covered in various Annexes, each focusing on aviation safety, operations, and communications aspects. Following is a summary of the Annexes related to ELTs and how they pertain to their use, requirements, and regulatory framework:

#### 3.1.1 Annex 6 – Operation of Aircraft

Annex 6 pertains to aircraft operation and includes specific Standards concerning the ELT. The details in Annex 6 cover requirements for the types of ELT that must be carried on board different categories of aircraft, including commercial and general aviation, as well as the operational guidelines that must be followed to ensure their effectiveness in an emergency.

Key Standards covered in Annex 6 include:

- **Types of required ELT.** Types of ELT that aircraft shall be equipped with, such as automatic ELT AF, ELT AP, and ELT S. The requirements may vary based on the type of operation and the aircraft.
- **Installation and maintenance.** Installation, maintenance, and periodic testing of ELT to ensure they are operational when needed.
- **Activation requirements.** How ELTs should be activated in the event of an emergency, including automatic activation upon impact or manual activation by the crew or passengers.
- **Operational.** Operation of ELTs, including testing protocols to prevent false alerts and ensure the integrity of the distress signal system.
- **International coordination:** The requirement for ELTs to operate on frequencies that are internationally recognized for search and rescue, facilitating a coordinated response in case of an emergency.

#### 3.1.2 Annex 10 – Aeronautical Telecommunications

Annex 10 encompasses the Standards for aviation communication systems and navigation. Within Annex 10, specific volumes are dedicated to different aspects of aeronautical telecommunications, including the specifications of the ELTs. Essential information about ELTs in Annex 10 typically includes:

- **Technical Specifications.** Detailed technical requirements for ELTs, including frequency bands, signal strength, modulation characteristics, and encoding of distress signals.
- **Operational frequencies.** Operational frequencies for ELTs, typically including the 406 MHz frequency band for digital distress signals, which is monitored globally by the Cospas-Sarsat satellite system.
- **Compatibility and interoperability.** ELTs shall be compatible with international search and rescue systems, ensuring that the global distress signal monitoring network can detect ELTs made by different manufacturers.



- **Testing and certification.** Testing and certification of ELTs to ensure they meet ICAO Standards for performance and reliability.
- **Maintenance and inspection.** Recommendations for the regular maintenance and inspection of ELTs to ensure they remain in good working order.

### 3.1.3 Annex 12 – Search and Rescue

This Annex is dedicated to the provisions concerning the preparation for and execution of SAR operations to ensure a timely and efficient response to aircraft in distress. While Annex 12 itself primarily focuses on the framework, organization, and execution of search and rescue operations globally, it inherently involves the use of ELTs as part of the overall SAR system. However, Annex 12 does not delve into the technical specifications of ELTs; instead, it outlines how SAR operations should be conducted and how ELT signals are integral to these operations.

Critical considerations regarding ELTs within the framework of Annex 12 are delineated as follows:

- **SAR alerting.** The role of ELTs in alerting SAR authorities to an aircraft in distress.
- **Coordination with satellite systems.** The importance of ELTs in the Cospas-Sarsat satellite system for detecting and locating distress signals.
- **SAR planning and execution.** Guidance on how SAR operations should plan for and respond to activations of ELTs, including the procedures for locating the source of the signal and conducting rescue operations.
- **International cooperation.** The necessity of international cooperation in SAR efforts, especially when ELT signals indicate an aircraft has crashed in remote or international waters.
- **Testing and false alerts.** Managing ELT testing and minimizing false alerts to ensure that SAR resources are used efficiently and only deployed in genuine emergencies.

## 3.2 Civil Aviation Regulations of the United Arab Emirates

The *Civil Aviation Regulations (CARs)* of the United Arab Emirates promulgated by the GCAA govern the ELT requirements in alignment with the international standards set by the ICAO. Essential provisions include:

### 3.2.1 CAR Part IV – Aircraft Operations

The *Aircraft Operations* regulation sets forth stringent requirements for the installation and operations of the ELT to enhance aviation safety. Main provisions include:

- **ELT requirements.** Specifies mandatory ELT equipment for aircraft tailored to their operational profile and mission objectives.
- **Installation standards.** Define installation protocols to ensure ELT survivability and effective signal transmission.
- **Maintenance and testing.** Outline periodic inspections, battery checks, and signal strength assessments to maintain ELT reliability.
- **Operational procedures.** Detail procedures for manual ELT activation and mandates crew training on ELT use.



- **Recordkeeping.** Requires accurate documentation of ELT maintenance and testing activities.

### 3.2.2 CAR Part V – Airworthiness

This regulation delineates comprehensive standards to uphold the airworthiness of aircraft. This section specifically includes directives for emergency equipment, such as ELTs, ensuring their operational readiness at all times. Key provisions include:

- **ELT equipment standards.** Specifies the types and specifications of ELTs required for different aircraft, ensuring compatibility with global search and rescue systems.
- **Installation.** Proper installation requirements to enhance the ELT's survivability and effectiveness in transmitting distress signals.
- **Maintenance protocols.** Mandates regular maintenance schedules for ELTs, including routine checks and servicing to prevent failures.
- **Inspection.** Outlines detailed inspection requirements to assess ELT functionality, battery life, and signal strength, ensuring they meet safety standards.
- **Testing.** Periodic testing of ELTs is required to verify their operational status and readiness to activate in emergencies.
- **Recordkeeping.** Enforces accurate documentation of ELT maintenance, inspection, and testing activities, facilitating accountability and regulatory compliance.
- **Crew training.** Stipulates flight and ground crew training on ELT operations, including activation procedures and troubleshooting, enhancing emergency response capabilities.

### 3.2.3 CAR Part VIII, Subpart 8 – Search and Rescue Service Regulations

This regulation specifies the management and use of ELTs in SAR operations within the United Arab Emirates. Key aspects include:

- **ELT Registration and Maintenance.** SAR service providers must maintain an updated register of all 406 MHz ELTs, which ensures that SAR team can access accurate ELT data promptly during emergencies, enabling quick and efficient response.
- **Accessibility of ELT Information.** ELT data must be accessible to Rescue Coordination Center (RCC) staff and other authorized SAR parties. That facilitates effective coordination and swift location pinpointing during SAR operations.
- **Operational Integration of ELT Data.** The regulations underscore the necessity for RCCs and SAR entities to integrate ELT data into SAR missions seamlessly. This integration is a critical pillar in supporting SAR readiness and effectiveness, as it leverages precise location data to enhance response times and overall success in rescue efforts.

These regulations highlight the critical role of ELTs in SAR operations, emphasizing meticulous management, ready accessibility, and strategic use of ELT data to optimize SAR efficiency and effectiveness in the UAE.



## CHAPTER 4. ELT STUDIES AND SOURCES

Academic and professional investigations into ELTs span a comprehensive array of subjects, including the technological progression in signal transmission capabilities, enhancements in geographic positioning accuracy, and the resilience of these devices under adverse environmental conditions.

Furthermore, research scrutinizes the integration of ELTs with the international satellite-based search and rescue initiative, Cospas-Sarsat, assessing its efficacy in diminishing rescue operation response times and augmenting survival probabilities. These studies also examine the regulatory standards governing ELT deployment, optimal use strategies, and performance efficiency across diverse and challenging terrains. Such scholarly inquiries contribute to the advancement of ELT technology and underscore the global commitment to refining emergency response mechanisms and safeguarding lives in critical scenarios.

### 4.1 Australian Transport Safety Bureau (ATSB) Reports

The ATSB's investigation into the performance of ELTs during aviation accidents between 1993 and 2012 disclosed a notable activation rate of approximately 40 to 60% in scenarios involving high g-force impacts. The study pinpointed several factors compromising ELT efficacy, including improper installation, depleted batteries, inadequate waterproofing or fire protection, and physical damage upon impact. Recommendations were made to adopt GPS-enabled ELTs for enhanced locational precision, strategic aft placement of ELTs within aircraft, and the carriage of Personal Locator Beacons (PLBs) to augment search and rescue efforts effectively.

Additionally, the study observed that in majority of cases, the presence of ELTs and their compliance with Technical Standard Orders (TSO) was indeterminate, suggesting variability in ELT models and a potential for improved performance in newer iterations. The report also documented instances where ELTs failed to activate following severe impacts, attributing these failures to various causes such as installation errors, antenna disconnections, and damage from environmental factors, thereby underscoring the critical importance of ELTs and PLBs in lifesaving search and rescue operations<sup>3</sup>.

### 4.2 Defense Research and Development Canada

Defence Research and Development Canada researched the effectiveness of ELTs in aviation mishaps during the period 2003 to 2008. Like the ATSB's observations, this study also noted a need for more comprehensive ELT performance data in accident reports, with only 13% of the 1,301 examined cases providing sufficient details for evaluating ELT efficacy. The study found that ELTs activated successfully in 74% of the accidents, with 64% occurring automatically. However, it also highlighted a high false alarm rate of 90%. Recommendations for enhancing ELT effectiveness focused on several key areas: increasing the durability of ELTs against crash impacts; ensuring ELTs can withstand fire; improving the resilience of the coaxial cable connecting

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<sup>3</sup> A review of the effectiveness of emergency locator transmitters in aviation accidents. (2013, May 13). Retrieved from Australian Transport Safety Bureau: <https://www.atsb.gov.au/publications/2012/ar-2012-128>



to the external antenna; enhancing antenna durability; ensuring ELT functionality after submersion in water; and boosting educational initiatives to mitigate issues related to human factors<sup>4</sup>.

#### **4.3 National Transportation Safety Board (NTSB) Special Study Cooperated with the National Aeronautics and Space Administration (NASA)**

To enhance data collection on ELT performance, the NTSB collaborated with NASA to enhance ELTs' effectiveness by exploring their historical performances and conducting new testing.

The NTSB updated its aviation accident reporting form to include specific fields detailing the make, model, and TSO of ELTs involved in accidents. This update aimed to capture detailed information on ELT performance and document any noted or suspected reasons for failure. From a database of 469 aviation accidents and incidents from 2009 to 2014, 62 cases (13%) involved newer-generation ELTs in incidents that resulted in injuries or fatalities.

The primary challenge in finding more cases for detailed study was the need for ELT information in most accident reports, a situation anticipated to improve with the introduction of the new reporting form as per ICAO standards<sup>5</sup>. Additionally, the prevalence of older ELT models in service further limited the number of relevant cases<sup>6</sup>.

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<sup>4</sup> Defense Research and Development Canada. (2009, September). Retrieved from <https://cradpdf.drddc-rddc.gc.ca/PDFS/unc90/p532159.pdf>

<sup>5</sup> ICAO Standards comprise: Annex 6 on aircraft operations for commercial and general aviation, Annex 10 on aeronautical telecommunications for air traffic management, and Annex 12 on global and regional search and rescue operations.

<sup>6</sup> Stimson, C. M. (2017, 28 March). Emergency Locator Transmitter Survivability and Reliability Study. Retrieved from <https://ntrs.nasa.gov/citations/20170002586>



## CHAPTER 5. REVIEW OF AIR ACCIDENTS THAT OCCURRED IN THE UNITED ARAB EMIRATES WITH ASSUMED ELT ACTIVATION

Examination of the United Arab Emirates air accident investigation data and reports from the beginning of 2010 to the end of 2024 indicates that in 5 out of 7 accidents, the SAR operations center did not receive distress ELT transmissions.

In addition to the 7 cases mentioned above, there were 14 accidents and serious incidents where the force of impact could have triggered the ELT. However, 4 of the aircraft involved in these occurrences were not equipped with ELT. In the remaining 10 cases, the ELT did not trigger for unknown reasons. The investigation reports for these 14 cases did not provide information about ELT. Appendix A to this Study illustrates all the cases.

The non-activation of ELTs in various accidents underscores complex challenges within aviation safety protocols and equipment reliability.

In one scenario (AIFN/0015/2012), the ELT, despite being capable of transmitting on designated emergency frequencies, failed to activate, suggesting potential system malfunctions or the absence of specific conditions required for activation.

Another case (AIFN/0004/2017) highlighted a situation where the aircraft's descent rate did not reach the threshold to trigger the ELT's G-sensor. In addition, the crew did not manually activate the switch of ELT AD as one of the deployment and activation options.

In a military context (AIFN/0013/2018), details regarding ELT non-activation were not provided, implying that operational protocols or classified considerations may influence the deployment of safety mechanisms.

There was an accident (AIFN0007/2019) where the ELT was rendered inoperative due to destruction by impact forces, indicating a vulnerability in the device's design to withstand extreme conditions.

Lastly, in one accident the aircraft (AIFN/0011/2023) was unequipped with an ELT, pointing to regulatory non-compliance or gaps in safety equipment oversight<sup>7</sup>.

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<sup>7</sup> *Air Accident Investigation Reports*. (n.d.). Retrieved from the General Civil Aviation Authority "E-Publications": <https://www.gcaa.gov.ae/en/departments/airaccidentinvestigation/invigation-reports>



## CHAPTER 6. ADVANCEMENTS IN ELT TECHNOLOGY

### 6.1 ICAO Working Paper

During the Thirteenth Air Navigation Conference, held in October 2018, working paper 212 was presented, highlighting the integral role of ELT in augmenting SAR operations via the implementation of the Global Aeronautical Distress and Safety System (GADSS). The paper meticulously addressed several pivotal areas:

- **ELT performance and case studies.** It showed cases where ELT activation played a critical role in pinpointing accident locations, underscoring ELTs' design purpose to locate survivors accurately through satellite-based and ground-homing techniques. This accuracy is emphasized as being crucial, particularly in mountainous terrains where locating survivors within a 6 NM (nautical miles) radius may prove inadequate.
- **Advancements in SAR technologies.** The document introduced the Medium Earth Orbit for SAR (MEOSAR) system, leveraging new satellites from GPS, GLONASS, and GALILEO constellations to boost ELT detection capabilities significantly. This enhancement in timely and precise alert generation and advancements in ELT design for more significant impact survivability and integrated antennas represents a notable leap in SAR operational efficiency.
- **Amendments to Annex 6.** Reflecting on the insights gleaned from notable accidents such as AF447 and MH370, the paper discussed recent modifications to Annex 6. These changes strive to ensure more accurate aircraft localization in distress situations, particularly over challenging terrains. It also advocates for a further examination of Annex 6 to incorporate performance-based ELT standards that guarantee more precise localization of debris and survivors, thereby improving SAR operation outcomes.
- **Recommendations for advanced ELT standards.** The working paper calls upon ICAO to reassess aircraft equipment standards. The goal is to ensure that aircraft are fitted with durable, automatic mechanisms capable of accurately determining the end-of-flight location, thereby optimizing the efficacy of SAR responses in the aftermath of accidents, especially in rugged terrains<sup>8</sup>.

GADSS outlined in working paper 212 was a pivotal initiative by ICAO to revolutionize the tracking, localization, and assistance capabilities for distressed aircraft worldwide, prompted by critical incidents such as Air France 447 and Malaysia Airlines 370, where existing air navigation systems struggled to swiftly identify and locate distressed aircraft, GADSS endeavors to rectify these limitations by streamlining search and rescue operations and expediting flight data retrieval for accident investigations. With its core objectives focused on timely detection of distress, efficient initiation of search and rescue actions, and provision of accurate aircraft location data post-flight, GADSS operates seamlessly across all flight phases and conditions. The system's architecture centers on three essential functions: Aircraft Tracking, Autonomous Distress Tracking (ADT), and Post-Flight Localization and Recovery, each serving distinct yet interdependent roles in ensuring enhanced safety and swift response to aviation emergencies. Emphasizing a collaborative

<sup>8</sup> ICAO Working Paper 212: Implementing search and rescue (SAR) processes . (2018, October 19). Retrieved from ICAO: [https://www.icao.int/Meetings/anconf13/Documents/WP/wp\\_212\\_en.pdf](https://www.icao.int/Meetings/anconf13/Documents/WP/wp_212_en.pdf)

approach between Air Traffic Services (ATS), aircraft operators, and Rescue Coordination Centres (RCC), GADSS embodies a comprehensive framework designed to bolster global aviation safety and resilience<sup>9</sup>.

The field of ELT has seen significant technological advancements aimed at enhancing aviation safety and compliance with new global safety regulations such as following:

### 6.1.1 Automatic Deployable ELT (ELT AD)

ELT AD is designed for automatic activation and ejection from the aircraft in the event of a crash. Equipped with sensors to detect crash conditions, the unit autonomously deploys and begins transmitting a distress signal at 406 MHz to the Cospas-Sarsat satellite system. ELT AD features both automatic and manual activation options, guaranteeing signal transmission when manual intervention is impossible. This technology marks a significant advancement in aviation safety, offering a critical mechanism for swift emergency response<sup>10</sup>.



Figure 8. Automatic Deployable ELT (ELT AD)

### 6.1.2 Distress Triggered ELT (ELT DT)

ELT DT is a specialized category of ELTs that activates based on specific distress signals or conditions within the aircraft, making it highly effective for emergency response and aviation safety. Unlike traditional ELTs that activate through manual intervention or impact detection, the ELT DT is designed to recognize predefined distress scenarios, such as significant altitude changes, unusual accelerations, or other parameters indicative of emergencies through the aircraft's monitoring systems<sup>11</sup>.



Figure 10. Distress Triggered ELT (ELT DT)

## 6.2 Manufacturers Adaptations of the New Technology

### 6.2.1 Boeing and ARTEX ELT 5000 (DT)

The collaboration between Boeing and ACR Electronics has led to the development of the ARTEX ELT 5000 (DT), a device that meets GADSS standards. This ELT can autonomously transmit an aircraft's position in real-time during distress, using a 406 MHz signal for global coverage. The device enhances inflight tracking in response to ICAO Standards following significant air incidents. It includes features for crash survivability and supports advancements in beacon technology, aiming to improve SAR operations by providing more accurate location data.

<sup>9</sup> Global Aeronautical Distress and Safety System (GADSS). (2019, Sept 25). Retrieved from Skybrary: <https://skybrary.aero/articles/global-aeronautical-distress-and-safety-system-gadss>

<sup>10</sup> Shah, V. K., Patel, H. J., & Jani, U. N. (2017). Economical automatic deployable emergency locator transmitter system. *ResearchGate*. [https://www.researchgate.net/publication/321983792\\_Economical\\_automatic\\_deployable\\_emergency\\_locator\\_transmitter\\_system](https://www.researchgate.net/publication/321983792_Economical_automatic_deployable_emergency_locator_transmitter_system)

<sup>11</sup> International Civil Aviation Organization. (2019). Presentation 1.4 from SAR Workshop. ICAO. <https://www.icao.int/MID/Documents/2019/SAR%20Wksp/PPT%201.4.pdf>



This technology is set to be implemented across Boeing's commercial aircraft fleet to comply with safety regulations by January 2023<sup>12</sup>.

### 6.2.2 Orolia's New-Generation ELT

Airbus has chosen Orolia to supply its all-new ELTs for all its airplane programs. This follows an earlier recommendation under GADSS, where new aircraft delivered from January 2023 are mandated to report their location anywhere in the world autonomously. This technology aims to enable better tracking of aircraft worldwide following incidents like the MH370 and AF447 accidents. It has a mode of operation at when distress conditions are detected, GADSS will automatically activate and turn on its transmitter. It is to be fitted on all Airbus commercial aircraft programs, including A220, A320 family, A330, and A350. The first units of Ultima-DT<sup>13</sup> from Orolia were planned for delivery to Airbus in 2022 for their installation in the final assembly line. Having this installation would ensure that the aircraft delivered fully comply with the requirements of Autonomous Distress Tracking as mandated by EASA and FAA safety regulations that came in January 2023<sup>14</sup>.

As of the current date, Airbus has equipped its new generation of aircraft, including the A220, A320 family, A330, and A350, with the newly developed Emergency Locator Transmitter with Autonomous Distress Tracking (ELT-DT). This system, which received EASA certification, allows real-time tracking of aircraft in distress by transmitting their location and other vital parameters to satellite networks every minute. This enhances targeted search and rescue operations and meets the International Civil Aviation Organisation's mandate for new commercial aircraft to have ADT capabilities by 2025<sup>15</sup>.

### 6.2.3 Safran Electronics & Defense Beacons

Safran has developed emergency locator transmitters that fulfil aviation safety regulations. The ULTIMA-S respects the latest FAA and EASA standards for non-rechargeable lithium batteries and can optionally be delivered with a distress signal acknowledgment feature to the Galileo satellite constellation's Return Link System (RLS)<sup>16</sup>.

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<sup>12</sup> *Boeing Selects Artex Distress Tracking Emergency Locator Transmitter for GADSS Compliance On Commercial Aircraft.* (2021, March 30). Retrieved from ARTEX: <https://www.acrartex.com/news/boeing-selects-artex-distress-tracking-emergency-locator-transmitter/>

<sup>13</sup> Ultima-DT is a fixed Emergency Locator Transmitter – Distress Tracking type, designed to meet the ICAO GADSS ADT requirement which will be applicable in January 2023. Adaptable to any commercial aircraft, its trigger-in-flight capability detects imminent distress situations and automatically sends a secure 406 MHz distress signal including the accurate aircraft position

<sup>14</sup> *Orolia's Distress Tracking Emergency Locator Transmitter Selected by Airbus for GADSS Compliance.* (2020, December 9). Retrieved from Aviationpros: <https://www.aviationpros.com/engines-components/aircraft-airframe-accessories/avionics/press-release/21165947/orolia-orolias-distress-tracking-emergency-locator-transmitter-selected-by-airbus-for-gadss-compliance>

<sup>15</sup> Airbus, "Safety Innovation #12: Aircraft Autonomous Distress Tracking," Airbus, February 2024, <https://www.airbus.com/en/newsroom/stories/2024-02-safety-innovation-12-aircraft-autonomous-distress-tracking>

<sup>16</sup> *Repair Centers in the United States and Singapore.* (2023, October 17). Retrieved from Safran: <https://www.safran-group.com/news/integra-and-ultima-aeronautical-emergency-location-transmitters-elt-two-new-authorized-repair-2023-10-17>



## CHAPTER 7. CURRENT STATE OF ELT TECHNOLOGY IN THE UNITED ARAB EMIRATES

### 7.1 Registering and Annual Testing of ELTs

The GCAA has implemented a crucial initiative incorporated in Information Bulletin (IB) 2023-10, released on 16 November 2023. The IB outlines guidance and program for registration and annual testing of ELTs. This program is a collaborative effort between the GCAA and the National Search and Rescue Center (NSRC) aiming at enhancing aviation safety across the United Arab Emirates by ensuring that all ELTs on UAE-registered aircraft are registered in the NSRC and their data accurately maintained.

By establishing a detailed process for verifying ELT functionalities, including the integrity of the distress signal and the battery's expiry date, the initiative provides a centralized platform for operators to assess compliance quickly. Offered free of charge until 1 March 2024, this initiative aims to significantly boost the efficiency of search and rescue operations, marking an advancement in the nation's aviation safety protocols without impacting aircraft operational continuity<sup>17</sup>.

### 7.2 Boost Aviation Safety Nationwide

The NSRC, the GCAA, and Bayanat<sup>18</sup> have unveiled a ground-breaking ELT project, setting a new benchmark in aviation safety and artificial intelligence (AI) in the United Arab Emirates. This innovative smart technology streamlines the ELT testing process from days to minutes, eliminating the need to remove the device for testing and allowing continuous flight operations. This initiative, the first globally, enhances distress call system testing efficiency from the device to ground receivers, ensuring rapid and secure communication.

The process of receiving test signals is governed through the electronic cloud to provide the highest standards of cybersecurity and facilitate passing information to the relevant authorities. The system also offers additional services to airlines through which the devices in the aircraft fleet are inventoried and monitored, and the due dates for tests and essential data for device registration are determined, which helps improve the performance of asset management for airlines. It also reduces human error resulting from paperwork through automatic electronic reports sent to the concerned authorities. The new process will raise the percentage of registered devices for distress calls in the country by international standards. Bayanat and Yahsat<sup>19</sup> will continue to operate independently until shareholders' and regulatory approvals are received and the merger is effective, which is expected to take place in mid-2024.

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<sup>17</sup> Information Bulletin 2023-10: Registering and Annual Testing of Emergency Locator Transmitters (ELT) - Issue 01." Issued on November 16th, 2023, by the National Search and Rescue Center (NSRC), as per Federal Decree-Law No. (4) of 2013. This bulletin addresses the need for registration and annual testing of all ELTs installed on UAE-registered aircraft to ensure the accuracy of the information in the registration database and the integrity of the ELT distress signals. Available at <https://www.gcaa.gov.ae/en/epublication/view-file?file=JdhdOMdDRM1mgxyBxdB95FcObUH0/41lt3fxHypV2jU=>

<sup>18</sup> Bayanat is a public joint stock company in the United Arab Emirates known for its focus on AI and data analytics. The company specializes in geospatial and data intelligence, offering solutions that cater to various sectors including environmental, logistics, energy, and public safety.

<sup>19</sup> Yahsat (Al Yah Satellite Communications Company) is a satellite communications company based in Abu Dhabi, United Arab Emirates. Founded in 2007, it is a subsidiary of Mubadala Development Company. Yahsat provides multipurpose satellite solutions (government and commercial) for broadband, broadcast, military, and communications use across the Middle East, Africa, Europe, and Central and South West Asia.



## CHAPTER 8. CONCLUSIONS

8.1 The ongoing development of ELT technology represents a critical endeavor toward enhancing accident emergency response. However, this innovative journey is marked by the understanding that the refinement and validation of new systems necessitate a substantial period of rigorous testing. Typically, a five-year timeline is essential to comprehensively assess these advancements' effectiveness and reliability. This period allows for extensive evaluations under various conditions, ensuring that the ELT systems meet the required safety standards and integrate seamlessly with existing protocols.

8.2 The review of ELT activation after air accidents that took place during the period from 2010 to 2023 revealed that out of seven accidents where ELT should have activated, the ELT had not activated in five accidents. The causes of non-activation varied between technical malfunctions, physical destruction, or ELT device uninstallation. Notably, the non-activation instances point towards potential areas for improvement in system design, crew training, and regulatory compliance. Furthermore, in the additional 14 cases categorized as "potentially triggered," the ambiguity in the reports regarding whether the ELTs actually activated further complicates the assessment of ELT effectiveness. These cases, combined with the accidents where the aircraft either lacked ELTs or were not mandated to have them at the time, underscore a broader issue in both the implementation and monitoring of these potentially life-saving devices. The data underscores the necessity for ongoing enhancements in ELT technology to ensure robust performance even under extreme conditions and the importance of comprehensive equipment standards and procedures that adapt to evolving aviation safety needs. Ultimately, this safety study highlights the critical role of ELTs in search and rescue operations.



## CHAPTER 9. RECOMMENDATIONS

The Air Accident Investigation Sector (AAIS) of the United Arab Emirates recommends that:

### 9.1 Operators/owners of aircraft registered in the United Arab Emirates

#### SSR 06/2024

Ensure that each aircraft is equipped with an Emergency Locator Transmitter (ELT) that complies with the design, manufacture, installation, and continuing airworthiness requirements outlined in CAR Part IV – *Aircraft Operations*, and Part V – *Airworthiness*, of the *Civil Aviation Regulations*. The ELT shall be registered with the National Search and Rescue Center (NSRC).

#### SSR 07/2024

Enhance their emergency response system by incorporating policies and operational procedures related to ELT airworthiness and operational standards, and regularly assess the system's effectiveness through arrangement for regular tests in collaboration in conjunction with the General Civil Aviation Authority (GCAA) and the NSRC.

### 9.2 The General Civil Aviation Authority of the United Arab Emirates

#### SSR 08/2024

Conduct an assessment, in conjunction with operators/owners of aircraft registered in the United Arab Emirates, for the possibility of upgrading the installed ELTs with GPS functionality to enhance the precision of emergency location tracking.

### 9.3 The Air Accident Investigation Sector of the United Arab Emirates

#### SSR09/2024

Seeks annual updates on the status and advancements of ELT installments of all aircraft registered in the United Arab Emirates to ensure continuous compliance with the *Civil Aviation Regulations*.



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## APPENDIX A. ACCIDENTS AND SERIOUS INCIDENTS THAT HAVE TRIGGERED OR COULD HAVE TRIGGERED THE ELT

**Table 1.** Air accidents data that required ELT activation from 2010 to 2023

N°	Case number (AIFN)	Date of the occurrence	Aircraft type & registration	Manufacture year	Brief Description of the occurrence	Activated Yes/ No	Remarks
1	001/2010	2 Feb. 2010	Diamond DA-42 A6-FTZ	2002	The aircraft improperly landed without its gear fully extended, causing the fuselage, tail skid, and propellers to contact the runway.	No	Potential for triggering, but did not trigger due to unknown reasons
2	003/2010	19 Mar. 2010	Aeroprakt A-22 A6-XAP	1999	An aircraft crashed shortly after takeoff from the runway due to a stall during a go-around manoeuvre, resulting in serious injuries to the pilot and passenger and the destruction of the aircraft.	No	Potential for triggering (if equipped with ELT)
3	013/2010	3 Sept. 2010	Boeing 747-44AF N571UP	2007	The cargo plane crashed due to a fire caused by improperly packaged lithium batteries.	No	Potential for triggering, but did not trigger due to unknown reasons
4	015/2010	13 Oct. 2010	Aeroprakt A-22 A6-XYZ	1999	A newly assembled aircraft experienced engine problems and potential stalling, leading to an emergency landing in a nearby field where it broke its landing gears and stopped abruptly.	No	Potential for triggering (if equipped with ELT)
5	002/2011	27 Feb. 2011	McKinnon G-21G N221AG	1944	An aircraft crashed shortly after takeoff during a test flight, as it entered a steep left turn at low altitude, resulting in a fatal crash.	No	Potential for triggering, but did not trigger due to unknown reasons
6	015/2012	4 Sept. 2012	Agusta-Bell 206-3B A6-FTB	1984	A helicopter was irreparably damaged during a practice autorotation at Al Ain International Airport, resulting in hard landing and significant structural damage.	No	The ELT satellite interface with the UAE Mission Control Center (AEMCC) Cospas-Sarsat system is functioning for civil ELT transmission on the following frequencies 406.025 MHz $\pm$ 2 kHz, 121.5 MHz $\pm$ 6 kHz or 243.0 MHz $\pm$ 12 kHz.



7	001/2013	2 Jan. 2013	Bell Helicopter- Textron 206-3B A6-FTI	1983	A student pilot's hover attempt caused the aircraft to yaw and roll right, leading to rotor blade ground contact.	No	Potential for triggering, but did not trigger due to unknown reasons
8	002/2014	22 Jan. 2014	Airbus EC-130B4 A6-DYR	2005	A helicopter crashed during a repositioning flight from the Palm Atlantis hotel heliport to Dubai International Airport, causing severe damage and incapacitating the pilot and Helicopter Landing Officer.	Yes	
9	014/2014	11 Aug. 2014	Cessna 172S A6-FAA	1999	During a training flight, a Cessna 172S encountered a simulated engine failure that led to a heavy landing and detachment of the right main landing gear.	No	Potential for triggering, but did not trigger due to unknown reasons
10	020/2014	5 Dec. 2014	AgustaWestland AW109SP A6-FLP	2011	A helicopter for a VIP flight from Emirates Palace Hotel to Al Marmum Farm, crashed due to an over-torque during an overweight takeoff.	Yes	
11	013/2015	9 Dec. 2015	AUTOGYRO GMBH A6-GY0	N/A	A gyrocopter crashed into the sea at Palm Jumeirah following a high-speed manoeuvre.	No	Potential for triggering (if equipped with ELT)
12	004/2016	19 Mar. 2016	Boeing B737- 8KN A6-FDN	2010	An aircraft crashed during its second go-around due to improper aircraft configuration and pilot errors.	No	Potential for triggering, but did not trigger due to unknown reasons
13	008/2016	3 Aug. 2016	Boeing 777-31H A6-EMW	2003	The aircraft initiated a go-around in response to wind shear and a tailwind, but a brief touchdown prevented the manoeuvre's success, it collided with the runway, resulting in the destruction of the aircraft.	No	Potential for triggering, but did not trigger due to unknown reasons



14	012/2016	4 Oct. 2016	Aeroprakt A-22 A6-XGG	1999	In response to changing weather, the pilot diverted to Marjan Island for landing. Despite a smooth touchdown, a ditch encountered during deceleration required preparedness for impact.	No	Potential for triggering (if equipped with ELT)
15	004/2017	29 Apr. 2017	AgustaWestland AW139 A6-AWN	2009	A helicopter encountered a gearbox overheating issue and ditched near Mubarras Island after a high oil temperature warning.	No	Due to a low rate of descent that didn't trigger the Atomically Deployable Emergency Locator Transmitter (ELT AD) G-sensor. Additionally, the crew did not manually activate the switch, leaving only the water-activated switch to initiate the ELT (AD).
16	013/2018	29 Dec. 2018	AgustaWestland AW139 UAE352	N/A	A UAE Armed Forces helicopter crashed during a mission at Jebel Jais, Ras Al Khaimah, after its tail rotor hit a zipline cable.	No	Military aircraft
17	007/2019	16 May 2019	Diamond DA62 G-MDME	2017	An aircraft crashed at Dubai International Airport due to insufficient spacing and inadequate turbulence from an Airbus A350.	No	ELT had been destroyed by the impact forces
18	005/2021	26 Mar. 2021	Grob G109B, G- OSOX	N/A	A Grob G109B Aircraft experienced an engine failure during the landing approach at Skydive Dubai airfield. The pilot attempted to land on an asphalt road, but the right-wing touched the road, causing a fracture.	No	Potential for triggering, but did not trigger due to unknown reasons
19	008/2022	31 Aug. 2022	Cessna 208B Grand Caravan N208JM	N/A	During descent, the pilot deviated from the flightpath, causing the aircraft to crash near the runway.	No	Potential for triggering, but did not trigger due to unknown reasons
20	011/2023	7 Sept. 2023	Bell B212 A6-ALD	1976	After multiple landing exercises, a helicopter crashed	No	Not equipped



					during a training flight to ARAS Driller Rig. The incident occurred 600 meters northwest of the rig, and a distress call was initiated shortly after.	
21	014/2023	5 Oct. 2023	EFTA Cirrus SR022	N/A	A trainee pilot flying solo noticed fumes shortly after takeoff and decided to land immediately. During landing, the pilot made multiple hard touchdowns, resulting in aircraft damage.	No  Potential for triggering, but did not trigger due to unknown reasons