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1. Executive summary

New Zealand has traditionally aligned its Civil Aviation Rules (the Rules) for emergency location requirements with the International Civil Aviation Organization’s (ICAO) Standards and Recommended Practices (SARPs), requiring the use of emergency location transmitters (ELTs). The number of ELTs required on an aircraft varies depending on the size of the aircraft and the nature of its operation.

Following the implementation of the requirement for 406MHz ELTs in 2006, issues were raised regarding the reliability of these devices for locating aircraft in an emergency. In 2014 the Civil Aviation Authority of New Zealand (CAA) initiated a review to evaluate New Zealand’s domestic policy on the required equipment for locating aircraft in an emergency.

The review identified that ELTs do not always perform as expected due to limitations of ELT design and installation, maintenance errors and human factors. Recording of ELT performance in accident and incident investigations by the regulator has been inconsistent, but data analysis by the CAA has established that the efficacy ratio of ELTs working as expected is between only 27 and 43 percent of the time.

As part of the review, the CAA consulted with the aviation community on a set of proposed performance objectives for emergency location technologies; an assessment of technologies and how these meet the proposed objectives; and options proposed by the CAA for addressing the problems. Based on the CAA’s analysis and submissions received by the aviation community, the CAA has determined that it will:

1) Revise and amend the ELT Advisory Circular with the aim of making immediate improvements to ELT performance within the scope of the current Rule;
2) Recommend that the Minister of Transport initiate rule development work to draft a performance based rule for emergency location equipage requirements domestically;
3) Adopt a new international standard for ELTs (to replace the current TSO standard), which is due to become available in 2017/18;
4) Develop promotional material to educate the sector on ELT issues and notify them of the regulatory changes;
5) Improve CAA recording of ELT activation in accident reporting.

This multifaceted approach aims to address ELT performance issues in the immediate term whilst establishing an improved regulatory framework for emergency location of aircraft domestically over the long term, including improved standards for emergency location devices.

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2. Introduction

Since 2006, in alignment with International Civil Aviation Organisation (ICAO) recommendations, New Zealand Civil Aviation Rule Part 91 (General Operating and Flight Rules) has required aircraft to have a 406MHz Emergency Location Transmitter (ELT) installed for the purposes of emergency location. The ELT activates when the aircraft is in distress and broadcasts a distinctive signal on designated radio frequencies. This signal is then detected by the international satellite system (COSPAS-SARSAT) to alert search and rescue to an accident and its location.

The number of ELTs required on an aircraft varies depending on the size of the operation. Nearly all aircraft are required to install at least one ELT for emergency location, with larger aircraft operating internationally requiring three ELTs. Aircraft equipped with no more than one seat (for example microlight class one, and gliders) or no more than two seats (if operating no more than 10 nautical miles from an aerodrome) can use a personal locator beacon (PLB) in place of ELT requirements. The different requirements are intended to address the differing safety risks in a way appropriate for the size and operation of the aircraft.

A number of issues have been raised by both industry and CAA staff over the years concerning the reliability of ELTs functioning properly in an accident. A number of participants also requested that the CAA consider allowing the use of Flight Tracking Devices (FTD) as an alternative emergency location device.

In 2010, the CAA completed a study on Missing Aircraft Detection and Location, which confirmed the performance and reliability issues with 406MHz ELTs. In particular, it identified a significant issue with Artex ELT system g-switches. The report also concluded that within New Zealand approved antennas are not crash tolerant and are difficult to install, and the installation requirement of ELTs appears to make the device prone to damage during accidents (particularly in mountainous areas). It also concluded that FTDs were not an acceptable alternative to ELTs as they do not meet certain emergency location objectives. The report recommended a number of actions for the CAA to address the Artex g-switch problems and to work with FTD manufacturers to help their devices become an eligible alternative to ELTs. As an outcome of this report, the CAA has remedied the Artex g-switch issues; however, the other problems and actions identified have not be addressed.

The CAA initiated a review of the domestic policy for emergency location of aircraft in April 2014, to determine the appropriateness of the current device requirements and identify whether interventions are necessary in an effort to improve safety (whilst maintaining alignment with international standards). As part of this review the CAA has to date:

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2 Civil Aviation Rule Part 91.529
• Undertaken further research and analysis to define the problems;
• Consulted with the public on emergency location objectives and an assessment of devices against these objectives;
• Completed data analysis on ELT efficacy (and consulted with a sector working group on this data).

This document establishes the CAA’s policy on domestic emergency location of aircraft as a result of this review.

\[4\] International policy for emergency location of aircraft will remain aligned with ICAO’s international standards

The Civil Aviation Authority of New Zealand
Domestic Policy for the Emergency Location of Aircraft, 2015
4. What are the problems?

The CAA’s review identified two key problems with the status quo of locating a distressed aircraft in New Zealand:

**Problem 1: As a result of design and installation limitations; maintenance errors; and human factors; ELTs perform as expected only an estimated 27 to 43 percent of the time**

Research, accident reports and anecdotal evidence indicates that ELTs do not perform as expected in over half of distressed aircraft incidents, creating barriers to the effective and efficient location of distressed aircraft and its occupants.

These barriers create delays to search and rescue responses, which may result in further harm to occupants of the distressed aircraft (which in some cases, is the difference between life and death) and costs the Government more in search and rescue operations (over $7,500, and may cost up to $25,000 per search).

To determine the scale of this problem, the CAA completed data analysis to establish the likely efficacy ratio of ELTs in aviation accidents (that is, where it activates and transmits). Due to the lack of data available by the CAA on ELT activation (discussed further in the next section), a data set was achieved by comparing all accidents in the CAA database since July 2010 against the Rescue Coordination Centre ‘real distress’ incidents and ELT beacons received during that same period. This data was evaluated by an external working group to help determine a likely efficacy ratio. The analysis indicated that the estimated likelihood of ELTs activating and transmitting in an accident or incident to be approximately 27 to 43 percent over the last four years (refer Appendix 1 for further explanation on this calculation). In comparison, a report completed by the Australian Transport Safety Bureau (ATSB) in May 2013 found that ELTs functioned as intended in about 40 to 60 percent of accidents in Australia in which their activation was expected.

The impact of this poor performance rate is largely felt by the general aviation sector. This is because larger operators, such as airlines operating domestically and internationally, often have satellite based location tools on board, in addition to one or more ELTs, which tracks the aircraft through flight and can be used to determine the location of the aircraft if it becomes distressed.

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5 For the year 2013/14 RCC estimated there was an average of 1.5 hours per aviation-related search and rescue operation where an ELT was activated. With helicopters being charged at up to $5,000 per hour for a search and rescue operation, an ELT-alerted operation (at 1.5 hours on average) can cost as much as $7,500. It can be reasonably assumed that in aviation-related search and rescue operations where no ELT signal was successfully received for whatever reason, the operation time, and therefore costs, will be significantly higher. RCC estimated that this could be up to $25,000 per search and rescue.

Information gathered and supplied to date identifies engineering and installation issues, maintenance errors and human factors as the key causal factors of poor functionality of ELTs:

**Engineering and installation**

A report completed by the CAA in 2010 titled *Missing Aircraft Detection and Location* identified the following issues affecting the full functionality of ELTs:

- G-switch failure specific to Artex ELT systems, particularly affecting small aircraft and helicopters (note that after identifying this problem, the Artex g-switch problem was fully resolved by the CAA and Artex manufacturer in September 2014);
- Depending on installation, approved 406MHz ELT antennae (as per the TSO C126 minimum performance standard set in the Rule) are not crash tolerant;
- Operators are fitting 406 MHz ELTs systems by replacing the 121.5 MHz ELT system components instead of designing new installations, which is resulting in non-crash tolerant components in some cases;
- The impact of the crash and final placement of the aircraft (e.g. aircraft inverted during crash, or tail boom separation) can affect ELT performance, including severely damaging the antenna, leaving the ELT inoperable and/or unable to transmit a signal;
- In cases where the aircraft rolls or crashes in dense bush, the ELT's signal transmission may be weak, inaccurate, or non-existent due to damage or obstruction.

Similarly, the ATSB report also concluded that ELT performance was, among other maintenance and human factors, impacted by engineering or installation issues:

- Lack of water proofing or fire protection;
- Disconnection of the antenna cable from the unit during impact;
- Damage/removal of the antenna during impact;
- The aircraft coming to rest inverted after impact.

General aviation aircraft and helicopters appear to be particularly affected by ELT damage during a crash, as the antenna is commonly located in a particularly vulnerable part of the aircraft. In these cases there could be a significant delay between the accident occurring and search and rescue services locating the aircraft.

Many of these engineering and installation issues impacting on the performance and reliability of the device are already addressed through the Rules and the related Advisory Circular. Rule Part 91, Appendix A.15, specifies that an ELT must be attached in such a manner that the probability of damage of the ELT is minimized, and sets a number of other technical requirement to ensure it is robust, such as how the ELT and antenna are mounted and the distance between the ELT antenna and other antennae. Advisory Circular 43-11 provides additional guidance to support the technical
requirements of the Rule, including instructions on g-switch alignment; location and mounting of the ELT and the antenna, to avoid traverse separation on impact; antenna cable protection; and other system considerations. However, given the continued concerns raised by the sector about ELT reliability and the estimated efficacy ratio, it may be that the prescriptive Rule and/or guidance in the Advisory Circular on engineering and installation requirements may be ineffective.

Maintenance

The 2010 CAA report also identified that ELTs inadvertently activate when an aircraft is not distressed, or not activate when required. This includes activation in non-emergency situations due to malfunction or mishandling, or accidental activation during maintenance. For example, in 2013/14, ELTs activated 93 times when it was not an emergency (Refer Appendix 1, Table 9). It is understood that most of these false alarms were the result of the pilot activating the ELT by mistake.

By way of comparison, the ATSB identified similar issues – ‘although the overall number of accidents where it was known the ELT was fitted varies significantly each year ... the ratio of not activated to activated ELTs is relatively consistent, with ELTs being known to have activated in about 40 per cent of accidents. However, it should be noted that activation was unknown in 24 per cent of these accidents, and some of these accidents may have involved an ELT activation which ATSB investigators were unaware of.’

Maintenance considerations are also addressed in AC 43-11. It outlines Part 43 requirements and provides guidance on test timing; coding; configuration data; and specifically states that to avoid false alarms tests should be conducted with all avionics equipment powered by the aircraft electrical power generating system operating. Despite this guidance, RCC are still responding to a significant amount of false alarms. The problem with this is that false alarms can deter resources from real distress alerts.

Human factors

The effectiveness of an ELT is also dependent on the pilot activating the ELT when the aircraft first becomes distressed. Activating the ELT early provides search and rescue with an early notification of distress and location – by activating the ELT RCCNZ can monitor the active beacon and will be able commence search planning ahead of an accident. If, in a subsequent crash, the ELT system becomes inoperative, the crash location will still be known reasonably accurately, and so enhance the search and rescue operation.

Anecdotal evidence from RCC and the CAA’s Safety Investigation Unit advise that many pilots are not activating the ELT early, despite the advice in the Advisory Circular and from RCC. This is having an impact on timely search and rescue; however, it is acknowledged that in some cases the pilot is not able to activate the ELT early. There

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have also been instances when pilots have turned the ELT off when still waiting to be located, in order to save battery power. The Advisory Circular recommends not turning the ELT off after a crash, as search and rescue will lose the location beacon.

Related to human factors, is failure of the pilot or operator to correctly register the ELT with RCC. All 406MHZ ELTs and PLBs fitted to a New Zealand registered aircraft must have a New Zealand country code and be registered with RCCNZ. RCC have advised that many aircraft operators are not changing registration information and contact details when aircraft change hands. As a result, RCC do not know who and/or what aircraft they are looking for in real distress or false alarm situations, which is inefficient management of their resources. It is important for the information to be available so that the full benefit of early detection can be taken advantage of.

**Problem 2: Recording of emergency location technology performance by the regulator is inconsistent, leading to difficulties in accurately assessing emergency location device issues**

The ability to more accurately assess, and resolve, ELT reliability issues (such as those described above) is obstructed by a lack of consistent recording of ELT activation or non-activation in CAA accident or incident investigations.

A number of organisations can be involved in locating a distressed aircraft. Under Rule Part 12 – Accidents, Incidents, and Statistics, the CAA, the Transport Accident Investigation Commission (TAIC) and operators all have some level of responsibility for the investigation of accidents. When conducting investigations, the activation or non-activation of emergency location technologies are not routinely assessed or recorded by the CAA. If the ELT does not activate, the reason for non-activation (for example, broken antenna, damage to the ELT affecting transmission) is also not always recorded. This is because the focus of the investigation is on the cause of the accident, rather than the functionality of emergency location equipment.

This problem is further reinforced by the misalignment between CAA and RCC ELT activation data. For example, the discrepancy between CAA data on ELT activation in accident records and the RCC’s real data on emergency notifications can be as high as 10 out of 17 accidents recorded (refer Appendix 1, Table 10).
5. Addressing the problems

A number of options have been considered to address the domestic emergency location problems that have been identified. The CAA consulted with the public on some of these options in September 2014\(^8\), along with an assessment of different location technologies. Since that time, some further options have been added to ensure all reasonable and practicable options are included in the assessment, and to ensure that the interventions are distinctly defined.

The following intervention options have been considered:

1) **Status quo** – No change to current rules or guidance, ELTs (and PLBs) remain the only acceptable technology for emergency location of aircraft, until ICAO specifies otherwise and the Rule requirements will be reviewed again.

2) **Improve reliability of ELTs** – Engineering, installation, maintenance and human factor issues affecting ELT performance are addressed. This could be achieved by three sub-options:
   - 2a) Recommend Minister of Transport amend rules for ELTs
   - 2b) Amend Advisory Circular for ELTs
   - 2c) Education campaign/promotional material for pilots and operators.

3) **Require an additional tool to assist with emergency location of aircraft** – Recommend that the Minister of Transport amend the rules to require domestic operators to install an additional emergency location tool that provides supplementary location information. In the event the ELT or PLB fails the additional equipment would function as a contingency option, providing information on the aircraft’s location either prior to, or during, distress.

4) **Amend the rules to be performance based, allowing the use of any emergency location technology that meets certain objectives** – Recommend the Minister of Transport amend the Rules to remove references to specific technologies for domestic emergency location of aircraft. The Rules would instead set performance-based objectives which emergency location technologies must satisfy before being approved for use\(^9\).

5) **Make changes to CAA safety investigation reporting to ensure that activation of emergency location technologies information is captured** – Update forms and processes to ensure that CAA Safety Investigators record whether or not the ELT

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\(^9\) Exact wording of any final rule would be determined through the usual rule development process, and would include public consultation on a Notice of Proposed Rule Making (NPRM).
(or another emergency location technology) activated and transmitted before or after impact, and why or why not it worked.

6) **Require more auditing and inspection for ELT installation** – The CAA would conduct more regular and focused audits and inspections of ELT design, and maintenance to ensure that the ELT is installed most suitably for the type of aircraft.

These options were assessed against the following criteria:

- Improves search and rescue operations (the equivalent to maintaining safety/improving safety benefits);
- Does not impose unnecessary regulatory burden and/or cost;
- Can be achieved within the CAA’s resources;
- Is consistent with international standards.

The assessment of options against these criteria, as well as other considerations, is described in the cost and benefits table on the following pages.
Table 1: Intervention options risks and benefits

<table>
<thead>
<tr>
<th>Option</th>
<th>Benefits</th>
<th>Costs/risks</th>
</tr>
</thead>
</table>
| 1 – status quo          | • Remain consistent with ICAO, does not pre-empt future standards they might put in place for emergency location  
                          • Can leverage/utilise other international research/interventions once they have been completed  
                          • No new expense to operators or CAA                                                          | • Problem of low efficacy rate of ELTs remains, this could be a matter of life and death for occupants of those distressed aircraft where the ELT does not function as expected  
                          • Continued unnecessary social cost to NZ                                                  
                          • Continued unnecessary operating costs to RCC (for both real distress and false alarm incidents)  
                          • Does not address reporting problem                                                          |
| 2a – ELT rule change    | • Help to address functionality and performance issues and increase ELT efficacy rate/reliability  | • May develop something not consistent with future international standards  
                          |                                                                                                  | • Would require development of new ELT specification, will be divergence from current TSO and therefore not internationally consistent  
                          |                                                                                                  | • Time to complete rule change– ELT performance not addressed during that wait period  
                          |                                                                                                  | • Will likely require operators to make changes to their ELT installations, resulting in significant cost for operators  
                          |                                                                                                  | • Does not address CAA reporting problems                                                     |
| 2b – Amend AC           | • Help to address functionality and performance issues and increase ELT efficacy rate/reliability  | • Advisory Circular already makes a number of installation and design recommendations to help address performance and reliability issues, amendments may not have significant impact on ELT effectiveness  
                          • Low cost intervention for CAA                                                             | • Further to the above, amendments can only be made within the scope of the current rule and the key problem with the rule with is the currently approved antennas as they are not crash tolerant  
                          • Can be implemented much quicker than rule change                                           | • May require operators to make changes to their ELT installations, resulting in significant cost for operators  
                          |                                                                                                  | • Does not address CAA reporting problems                                                     |
| 2c – Educate and promote| • Operators will better understand ELT engineering and installation challenges and what they can do to lower the risk of the ELT not activating/transmitting  
                          • Education can support other                                                              | • Education on engineering, installation and maintenance ELT issues will not be effective if it contradicts the prescribed rules or acceptable means of compliance in the Advisory Circular  
                          |                                                                                                  | • Education not proportionate to the safety risk ELT performance issues present in its own right – low efficacy rate requires more direct and long term intervention |

The Civil Aviation Authority of New Zealand
Domestic Policy for the Emergency Location of Aircraft, 2015
<table>
<thead>
<tr>
<th>Intervention Options</th>
<th>Does not address reporting problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low to medium cost to the regulator</td>
<td>Cost to operators depends on how they respond to advice given through education campaign (for example, may install additional location tool or may maintain status quo) – cost to operator to engage with education will be low</td>
</tr>
</tbody>
</table>

3 – Secondary location tool

- If an ELT fails, which it is estimated to over fifty percent of the time, a secondary location technology may act as a backup option to provide contingency location information
- Little or no change to larger operators who already have other surveillance systems on board
- Significant cost and regulatory burden to smaller operators to install and maintain additional location system
- Limited evidence on whether alternative technologies as a suitable alternative to ELTs, so there is no guarantee that they would be an effective back-up if the ELT failed
- Will require rule change which takes significant time and resources
- Does not address reporting problem

4 – Performance based rule

- Allows new and improved emergency location technologies to easily enter the regulatory system
- Provides a clear evaluation tool for manufacturers
- Supports a more agile/flexible rule so operators can choose what works for them whilst still being compliant with emergency location requirements
- Does not address specific ELT engineering, design and installation problems
- Will require new standards (and/or similar supporting compliance materials/specifications) to be developed to ensure that the change to a performance based rule maintains safety standards, and may not be internationally consistent
- More difficult for CAA auditors, who have to become familiar with broader range of technological requirements (and therefore more costly)
- May be more difficult and costly for search and rescue providers, such as RCC, whose systems may have to be able to accommodate new technology transmissions/signals
- Does not address reporting problem
- Rule changes take time and are resource intensive for the regulator

5 – Improve reporting

- Will allow the CAA to better evaluate the effectiveness of emergency location technologies over time
- Low cost/resource intervention option
- Does not specifically address ELT engineering, design and installation problems and therefore low efficacy rate of ELTs not address

6 – Increase auditing

- May improve design and installation issues
- Additional cost to both the regulator and operators (under the current funding regime)
- Likely impact on efficacy rate of ELTs unknown, but not likely to be significant given limitations of current prescriptive rule
- Does not address reporting problem
International developments

In considering how to address the problem domestically, the CAA will maintain alignment with international standards and practices for international operations. A lot of work is being done by ICAO and other organisations to address aircraft location problems from both a policy and technical perspective. The CAA can observe and utilise this work in parallel to making domestic improvements.

International Civil Aviation Organisation (ICAO)

Following the Malaysia Airlines MH370 disappearance in early 2014, ICAO announced work to review global tracking of airline flights. ICAO established a working group to review the standards for flight tracking (a service available for the surveillance of aircraft by operators) and emergency location (notification to search and rescue when an aircraft has become distressed). This includes:

- A second generation of ELTs, aligned with Cospas-Sarsat developments
- Live data streaming
- Potential to use technologies (such as ADS-B) built into navigation and surveillance systems for emergency location
- Communications in remote airspace
- The development of satellite based flight tracking systems
- Automatic deployable flight data recorders.

In May 2015, ICAO released a State Letter with its proposed amendments to Annex 6 Standards and Recommended Practices (SARPs) for flight tracking. The proposed changes include an amendment to the provisions for ELTs and guidance material for the implementation of the location of an aeroplane in distress. ICAO has since confirmed that Amendment 39 for Part One had been adopted, and will take effect from March 2016 (and be applicable from November 2018).

Technical work by a number of other organisations will feed into ICAO’s updated SARPs for flight tracking and emergency location. In particular, the European Organisation for Civil Aviation Equipment (Eurocae), working with the Radio and Technical Commission for Aeronautics (RTCA), will review and update the minimum standard specifications for 406MHZ ELTs and systems that can be used to detect an in-flight event before an accident. The aim is to have new standards published in 2017, to take effect in November 2018 with the updated ICAO Annex 6 SARP.

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10 The ICAO working group involved participants from ICAO member states and also representatives from the international air transport sector.
11 Note these new minimum standards would replace the current TSO standards specified in the current New Zealand rule for ELTs.
As part of the development of new standards, RTCA is working with the ELT Survivability and Reliability team at the National Aeronautics and Space Administration’s (NASA) Langley Landing and Impact Research Centre, undertaking crash tests to study ELTs at a component level to understand why the systems fail. NASA will soon complete a report on their findings and recommendations, which will inform RTCA’s and Eurocae’s revised specification standards.

**COSPAS-SARSAT**

Cospas-Sarsat is in the process of upgrading its satellite system by placing search-and-rescue receivers (i.e., repeaters or transponders) on new medium altitude earth orbit search and rescue satellites (MEOSAR) to dramatically improve both the speed and location-accuracy for detecting beacons.

The large number of MEOSAR satellites that will be in orbit when the system is fully operational will allow each distress message to be relayed at the same time by several satellites to several ground antennas, improving the likelihood of detection and the accuracy of the location determination than the current satellite arrangement.

Demonstration and evaluation of MEOSAR is planned to end in 2015 and will be followed by the first phase of operational testing by SAR authorities. When enough MEOSAR satellites and commissioned ground stations are available to provide worldwide, real time coverage, the MEOSAR system will be declared at its full operational capability.

Jointly with the Australian Maritime Safety Authority, New Zealand is preparing for MEOSAR improvements by installing MEOSAR local user terminals in the Bay of Plenty. The six antennae will be the ground receiving stations for beacon signals. RCCNZ have advised that these developments will enhance beacon detection capability, which may improve ELT efficacy rates.
6. CAA policy

Summary of issues

Drawing on available data and anecdotal evidence as discussed in this document, the CAA has drawn the following conclusions about the status quo of locating distressed aircraft in New Zealand:

- ELTs often do not work as expected, largely as a result of installation and design issues which render the ELT unable to transmit a beacon in certain accident circumstances – the efficacy rate may be as low as 27 percent;
- The key issue with ELTs design and installation is that the approved antenna (the component part itself, and its placement) is not crash tolerant, and there is no alternative antenna approved;
- It is hard to evaluate the magnitude of the issue, as the CAA does not consistently record information on ELT activation in accidents;
- The poor performance of ELTs, and any intervention to address it, will largely impact the general aviation sector only;
- International regulators/organisations are currently working to address the widely known issues with ELTs, as well as improve flight tracking and other related systems, which should be finalised by 2017 and come into effect in 2018;
- There are other tools available that may be a possible alternative to ELTs;
- Maintaining the status quo is not considered acceptable given poor performance of ELTs;
- Possible interventions consider domestic operations only; international operations will need to remain aligned with international standards.

CAA’s approach

The most acute problem to address as timely as possible is the poor efficacy rate of ELTs. The ability for ELTs to assist in emergency location is dependent on the reliability of the device activating when required, and when ELTs perform as intended they provide sufficient information for aircraft emergency location. Actions need to be taken by the regulator to improve their performance or to improve the regulatory framework for emergency location of aircraft so that alternative devices can be used.

Research indicates that the TSO approved antenna in the current rule is the key component affecting ELT reliability, as it is not crash tolerant. Making changes to the antenna specifications will likely have the biggest impact on ELT effectiveness. However, making this type of improvement will have constraints, dependencies and costs – it will require rule change (which takes time), a new standard for ELTs to developed (or wait for revised international standard to become available), and have cost implications for operators, who may have to change the design/installation of their emergency location devices.
In considering these challenges, and the assessment of costs and benefits of each option, the CAA has determined a multifaceted and staged approach to address the problem of emergency location of aircraft in New Zealand. This includes the following interventions:

1) Revise and amend the ELT Advisory Circular with the aim of making immediate improvements to ELT performance within the scope of the current Rule;
2) Recommend that the Minister of Transport initiate rule development work to draft a performance based rule for emergency location of aircraft;
3) Adopt a new international standard for ELTs (to replace the current TSO standard), which is due to become available in 2017/18;
4) Develop promotional material to educate the sector on ELT issues and notify them of the regulatory changes;
5) Improve CAA recording of ELT activation in accident reporting.

The purpose of this approach is to feasibly address ELT reliability within the scope of the current rule, to make short term improvements, whilst avoiding significant regulatory burden and cost for operators. It also initiates work to make medium-long term improvements to both ELT systems and the regulatory framework for emergency location device requirements.

The process of this staged approach is illustrated in the diagram below (Figure 1), with further explanation on the rational and implementation of each step provided in the following sections.
Figure 1: CAA intervention process

1. Initiate work to change to performance/objective based rules.
2. Update Advisory Circulars to improve ELT effectiveness within the scope of the current rule.
3. Require CAA Safety Investigators to record ELT activation and conditions in accident reporting.
4. Produce promotional material to notify sector of ELT challenges, what changes they can make to improve ELT efficacy in the interim, and the CAA’s future rule development to address issues long term.

- CAA adopts objectives for performance based rules.
- NPRM consultation on proposed performance/objective based rule.
- Adopt revised international standard for ELTs (to replace TSO in current rule).
- Performance/objective based rule for emergency location of aircraft introduced.
- Advise alternative location tool manufacturers of technology objectives.
- Develop NZ standard for alternative location tool (e.g. FTD).
- Performance based rule for emergency location of aircraft effective.
- Develop NZ standards for alternative location tools as they meet objectives (ongoing).
**Work to improve ELT performance**

Addressing ELT performance will be three-fold:

1) Conduct a review of the Advisory Circular for ELTs and make amendments to improve design, engineering, maintenance and human factor causes within the scope of the current rule. AC 43-11 was last revised in 2008;

2) The CAA will adopt a revised international specification standard for ELTs when it becomes available. As discussed in this paper, the current minimum specification standard for ELTs required under Rule Part 91.529 (TSO C126) does not provide for ELT antennas that are sufficiently crash tolerant. A new international standard for ELTs is currently being produced, and should become available in 2017/18;

3) The CAA will also produce promotional material to inform and educate participants on the problems identified with ELTs, what actions can be taken to address the problems until a new standard is available (such as ensuring the pilot activates the ELT at the first signs of distress), and advising on the CAA’s approach to make longer term improvements. CAA Safety Advisors and auditors will also engage with participants on the issues whilst out in the field.

**Performance based rules for emergency location of aircraft**

The current technology specific rule for emergency location requirements limits the ability for alternative devices to be considered for integration into the regulatory system, including devices that may be better performing and more reliable than the status quo.

The CAA will recommend that the Minister of Transport initiate rule development to amend the Rules for the domestic emergency location of aircraft to be performance-based (international operations will be required to meet international standards).

The CAA considers that section 28(5) of the Civil Aviation Act 1990 provides the provision for performance based rules to be drafted. Objectives will be used as the baseline criteria that technologies will be required to meet in order to be installed in an aircraft as an emergency location tool. The new rule will be supported by an Advisory Circular and/or a specification standard.

Over time, it is expected that domestic operators (mainly general aviation/recreational participants) will have increased options when choosing an emergency location technology that suits their operation’s needs. For manufacturers, the objectives will provide clear criteria that new or expanding location technologies are expected to meet in order to be approved for use as an emergency location tool. This approach will provide greater flexibility for the Rules to more quickly account for new and rapidly advancing technology.

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12 Any proposed changes to the Rules are subject to public consultation via a Notice of Proposed Rule Making (NPRM). Final changes to the Rules are subject to decision by the Minister of Transport.
Establishing objectives for emergency location technology

In New Zealand, there are a number of organisations that have roles and responsibilities for locating distressed aircraft, including the New Zealand Search and Rescue Council (NZSAR), the New Zealand Rescue Coordination Centre (RCC), the New Zealand Police, and Land Search and Rescue. These organisations, including the CAA, operate under a framework that outlines clear objectives for how SAR services will be managed effectively and efficiently in New Zealand, based on international obligations (such as ICAO Annex 12).

The CAA’s role in aircraft emergency location is to set the equipage requirements and, along with the Transport Accident Investigation Commission (TAIC), investigate any aircraft accidents and incidents. To date, the CAA has not set clear objectives for aircraft equipage that supports emergency location domestically. In line with the international search and rescue system, the CAA has worked to the goal of enabling the location of a downed or distressed aircraft and its occupants as soon as possible.

The development of a performance based rule for equipage requirements will need to be based on clearly prescribed objectives or criteria. The CAA considers that devices used for aircraft emergency location should support the goal of enabling the location of a downed or distressed aircraft and its occupants as soon as possible. They should operate effectively in high impact accidents in order to pin-point the location of an aircraft accident site. Finding aircraft wreckage quickly may not only increase the chance of survival of the occupants, it also reduces the risk to search and rescue personnel and costs to Government.

The CAA proposes seven specific objectives for New Zealand emergency location tools to underpin the proposed performance based rule. They are based on the objectives ICAO adopted when developing its ELT requirements. The objectives are:

- Aircraft emergency location technologies must:
  - Activate and broadcast a signal to search and rescue (SAR) service providers when the aircraft becomes distressed
  - Provide the aircraft’s location as accurately as possible, to a five kilometre radius or better
  - Alert SAR service providers within five minutes
  - Alert SAR service providers with no human intervention
  - Provide global coverage
  - Broadcast the distress position for no less than 24 hours after onset of distress.

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- Aircraft emergency location technologies must meet a minimum specification standard approved by the Director of Civil Aviation.

Once adopted, any system intended for the detection and location of missing aircraft would need to meet these objectives to be approved technologies under the performance based rule. As previously noted, they will be supported by approved standards/acceptable means of compliance.

Five available location technologies or methodologies – ELTs, FTDs, Automatic Dependent Surveillance-Broadcast, PLBs and flight plans – were assessed against the above objectives, and it was determined that ELTs were the only device to meet all seven objectives (if the device performs as intended).

In September 2014, the CAA consulted with the sector on the objectives. The CAA will be seeking further comment on these objectives as part of the Notice of Proposed Rulemaking (NPRM) consultation, once the proposed rule development is agreed to by the Minister of Transport. There are three key points in particular the CAA wishes to obtain further views on to inform the final objectives:

1. **Alert SAR service providers with no human intervention** – SAR service providers are significantly impacted by these objectives. RCC may be required to monitor and respond to a broader range of notification devices under the performance based rule. Currently, RCC receive notifications from ELTs directly by 406MHZ beacon and respond accordingly to determine whether it is a real distress call or false alarm. RCC also receive notifications from some flight trackers, such as Spider Tracks, however unlike ELTs, when an alert is triggered, this is verified as a real distress call by an independent organisation before RCC are notified to initiate SAR. RCC have indicated that this type of system is preferred, so long as the verification organisation is legitimate, as it filters out false alarms which free up RCC resources for real distress alerts. Further work and consultation is required to establish whether ‘no human intervention’ should be removed from the objectives, or whether an exception or requirement could be added to the objective.

2. **Provide global coverage** – The CAA would like to further explore whether this objective should specify that the signal should be broadcast on 406MHZ Cospas-Sarsat. This is because RCC have informed that other location devices available on the market utilise commercial satellites rather than global satellites. Unlike the Cospas-Sarsat global satellite, which constantly re-routes messages to ensure that an alert is received, flight trackers generally use commercial satellites for US and European markets which do not always have good coverage of New Zealand and cannot re-route signals to other satellites to ensure a notification is received. Further consultation is required in order to consider the impacts of this.

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14 Consultation on the Emergency Location of Aircraft, 12 September 2014.  
3. **Provide the aircraft’s location as accurately as possible, to a five kilometer radius or better** – Five kilometers is the current minimum specification for location accuracy in the TSO for ELTs, however it is understood that all ELTs can achieve a three kilometer radius location accuracy. The CAA wants to seek further information to confirm whether the objective should be 3km or 5km.

**Improve the recording of the activation of technologies in accident and incident investigations**

The CAA will also require its accident investigation unit to record information about the activation of emergency location technologies (ELTs and otherwise). This information will allow the regulator to determine if technologies are meeting the specified objectives, in order to evaluate the effectiveness of the new policy over time and make changes where appropriate.

**Risks and impacts of CAA policy**

The CAA acknowledges that a shift to a performance based rule for emergency location could risk New Zealand implementing a domestic system that, over time, becomes increasingly different from that implemented internationally. Implementation of this policy is not intended to restrict international operators from meeting their international requirements. The CAA will continue to monitor international emergency location requirements and recommend any appropriate changes to the Minister. Until ICAO changes are implemented, international operators will still be required to use ELTs as their primary emergency location technology.

The release of this information and the proposals will have an impact on all relevant stakeholders including general aviation participants and passengers, SAR service providers, and ELT and other location device manufacturers. Our approach to introduce performance based rules to allow alternative tools into the regulatory system may affect the commercial market of location tools – FTD and other location device manufacturers will use the CAA’s estimated ELT efficacy data to sell FTD’s as a better alternative to ELTs, and in the long term ELT manufacturers may lose their proportion of the commercial market. The CAA considers that a performance based rule, with its clear objectives/criteria, will ensure a level playing field in the market.

Additionally, general aviation participants and passengers may be dissatisfied or concerned with the CAA’s regulatory system for emergency location, as it currently mandates a device that has poor performance. This is why the CAA is proposing a staged and multifaceted approach which over the medium to long term will introduce improved standards for ELTs and the opportunity for participants to use alternative technologies. However, there is a risk that the CAA may receive an influx of exemptions to Rule Part 91.529 in the short term (until the new performance based rule comes into effect), on the basis of the poor ELT efficacy. As per the CAA’s current exemption
process, these will be assessed on a case-by-case basis and considered in the context of the problems identified within this review.

The promotional material that will be developed will also help to mitigate these risks more generally, by ensuring that suitable key messages are provided to stakeholders.
7. Conclusion

Our review of New Zealand’s domestic policy for emergency location of aircraft identified ongoing issues with the reliability of ELTs and an opportunity to provide clear emergency location device objectives within a more responsive Rule for emergency location requirements. The review also identified problems resulting from inconsistent recording of ELT performance in accident and incident investigations.

Consequently, the CAA has established a set of objectives for the devices used domestically for aircraft emergency location. These are designed to provide clear criteria to measure the performance of technologies against and assess their effectiveness in aircraft emergency location. The CAA will recommend to the Minister of Transport that these objectives be integrated into the regulatory system as performance-based rules, replacing the prescriptive requirements for emergency location technologies required for domestic operations. Over time, the CAA expects this will provide increased technology options for emergency location of aircraft, particularly for general aviation/recreational participants.

In the near term, ELTs are expected to remain the sole technology approved for emergency location, as they currently best meet the objectives. The CAA will take immediate action to address ELT performance issues that are feasible within the scope of the current rule, by updating the Advisory Circular and developing promotional material.

The CAA will also improve its recording of the activation of emergency location technologies in accident and incident investigations. This will provide information on the effectiveness of the devices, and the effectiveness of the CAAs policy to improve the emergency location of aircraft in New Zealand.
8. Appendix One

The data presented below aims to establish the efficacy rate of emergency location transmitters (ELT) in aviation accidents.

This data is approximate only; it is important to reiterate that a lack of consistent ELT occurrence recording and reporting in CAA safety investigations results in incomplete data.

All data are derived from occurrences taking place within the timeframe of July 2010 – June 2014:

1. A dataset from RCC NZ with records of each ‘real distress’ incident, meaning that search and rescue work was required and/or an accident had occurred (termed ‘crash’ in the RCC dataset); and

2. A CAA occurrence dataset of all accidents in the CAA database for the period.

Summary of RCC data:

RCC record a total of 46 beacon activations where there was ‘real distress’ for the time period July 2010 – June 2014. There were 4 incidents where the RCC was notified by a PLB (3 in microlights and 1 in a glider). There were 6 further incidents where the RCC was notified of a ‘real distress’ incident but there was no COSPAS SARSAT signal received at any stage in the search and rescue sequence. 2 notifications were removed from the dataset because these did not involve New Zealand-registered civil aviation aircraft; 2 were removed because they were not accidents (i.e. no damage to aircraft or harm to people).

The 56 remaining ‘real distress’ incidents are presented in the table below by financial year:

<table>
<thead>
<tr>
<th>Financial year</th>
<th>ELT beacon activations received by RCCNZ</th>
<th>RCCNZ notified but no ELT activation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010/11</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>2011/12</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>2012/13</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>2013/14</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>46</strong></td>
<td><strong>10</strong></td>
</tr>
</tbody>
</table>

30 of the ELT beacon notifications have been for aeroplanes:

<table>
<thead>
<tr>
<th>Aeroplanes</th>
<th>Financial year</th>
<th>Beacon activations received by RCCNZ</th>
<th>RCCNZ notified but no ELT activation</th>
</tr>
</thead>
</table>

The Civil Aviation Authority of New Zealand
Domestic Policy for the Emergency Location of Aircraft, 2015
13 of the ELT beacon notifications have been for helicopters:

*Table 3: Helicopter ‘real distress’ incidents recorded by RCCNZ*

<table>
<thead>
<tr>
<th>Financial year</th>
<th>Beacon activations received by RCCNZ</th>
<th>RCCNZ notified but no ELT activation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010/11</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2011/12</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2012/13</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>2013/14</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>13</strong></td>
<td><strong>1</strong></td>
</tr>
</tbody>
</table>

3 of the ELT beacon notifications have been for gliders and microlights:

*Table 4: Glider and microlight ‘real distress’ incidents recording by RCCNZ*

<table>
<thead>
<tr>
<th>Financial year</th>
<th>PLB activated</th>
<th>Beacon activations received by RCCNZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010/11</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2011/12</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2012/13</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2013/14</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>4</strong></td>
<td><strong>3</strong></td>
</tr>
</tbody>
</table>

**CAA accident data:**

There are some accident scenarios where the ELT cannot be expected to function. An ELT will generally not transmit underwater, so all accidents where the aircraft impacts water and is completely submerged are excluded. Post-crash fires are also likely to destroy ELTs, so accidents involving these are excluded. Only helicopters and aeroplanes can be reliably expected to have ELTs installed so only accidents involve these aircraft are included. Finally, there are some accidents where the impact forces involved would never be expected to trigger and ELT. Examples are collisions between aircraft and ground vehicles, and helicopter wire strikes where the situation is recovered and a normal landing is made. Minor damage accidents like these are also excluded. The purpose of this refinement process is to establish a dataset of accidents where it is reasonable to expect that the ELT should function in line with its purpose. The efficacy rates for helicopters and aeroplanes are presented below:
Table 5: Aeroplane efficacy rate

<table>
<thead>
<tr>
<th>Financial year</th>
<th>Aeroplane accidents</th>
<th>Beacon activations received by RCCNZ</th>
<th>ELT % efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010/11</td>
<td>27</td>
<td>5</td>
<td>19%</td>
</tr>
<tr>
<td>2011/12</td>
<td>22</td>
<td>10</td>
<td>45%</td>
</tr>
<tr>
<td>2012/13</td>
<td>34</td>
<td>6</td>
<td>18%</td>
</tr>
<tr>
<td>2013/14</td>
<td>25</td>
<td>9</td>
<td>36%</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>108</strong></td>
<td><strong>30</strong></td>
<td><strong>28%</strong></td>
</tr>
</tbody>
</table>

Table 6: Helicopter efficacy rate

<table>
<thead>
<tr>
<th>Financial year</th>
<th>Helicopter accidents</th>
<th>Beacon activations received by RCCNZ</th>
<th>ELT % efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010/11</td>
<td>13</td>
<td>2</td>
<td>15%</td>
</tr>
<tr>
<td>2011/12</td>
<td>12</td>
<td>3</td>
<td>25%</td>
</tr>
<tr>
<td>2012/13</td>
<td>19</td>
<td>5</td>
<td>26%</td>
</tr>
<tr>
<td>2013/14</td>
<td>10</td>
<td>3</td>
<td>30%</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>54</strong></td>
<td><strong>13</strong></td>
<td><strong>24%</strong></td>
</tr>
</tbody>
</table>

Based on this information, an average efficacy rate of 27% for ELTs (both aeroplanes and helicopters) has been determined.

Consultation on the data:

The CAA acknowledges that there is a level of arbitrariness to its analysis, given the limited data available and the subjectivity of determining whether or not an ELT would activate an transmit in certain accident circumstances. For this reason, the CAA sought independent review of the data from an external working group.

A total of four of 11 working group members, made up of aviation industry, government and SAR related organisations, responded to the data consultation.

Three respondents provided responses in the yes/no column of the data spreadsheet. One respondent provided high level observations in text only.

There were 212 accidents to determine whether or not the ELT would activate and transmit.

Of those 212, the CAA considered that an ELT would be expected to activate and transmit in 163 cases. The CAA determined an ELT would not have been expected to activate and transmit in the remaining 50 accidents, where post-crash fire or destruction of the ELT would have been likely, or if the accident forces were only minor.

In comparison, three respondents submitted the following:
Table 7: Responses on whether ELT would activate and transmit

<table>
<thead>
<tr>
<th>Respondent</th>
<th>Yes, ELT would transmit</th>
<th>No, ELT would not transmit</th>
<th>Unsure/no answer provided/yes or no but with exceptions or assumptions</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>47</td>
<td>110</td>
<td>55</td>
<td>212</td>
</tr>
<tr>
<td>B</td>
<td>42</td>
<td>134</td>
<td>36</td>
<td>212</td>
</tr>
<tr>
<td>C</td>
<td>68</td>
<td>144</td>
<td>0</td>
<td>212</td>
</tr>
</tbody>
</table>

This demonstrates that the proportion of accidents where the three respondents considered an ELT would activate and transmit was similar; however this proportion was contrary to CAA analysis. In other words, the proportion of accidents that the CAA considered the ELT would activate and transmit was similar to the proportion accidents that the respondents considered wouldn’t activate and transmit.

There were 54 of the 212 accidents where the CAA and all three respondents agreed that the ELT would or would not activate and transmit. In 77 of the 212 accidents, there was some agreement between the CAA analysis and one or two respondents, and in the remaining 81 accidents there was no agreement between the CAA and the respondents (for example, the CAA considered that in a certain accident scenario an ELT would be expected to activate and transmit, but all three respondents said it would not).

Two of the four respondents reflected that their ability to provide a response was limited, as there was not enough detail provided in the accident notification report to determine whether the ELT should have activated and transmitted, such as how hard the aircraft impacted. One respondent said “it can be assumed that if an aircraft is out of control it will impact hard and if it’s a controlled forced landing it won’t - but there are a large number of accidents in between that we can only guess at their severity”. This respondent advised that weighting should not be placed on the responses received through this consultation, given this limitation of the data and therefore the subjectivity of the responses. The CAA acknowledges these limitations.

Further to this, another respondent clarified their approach to undertaking their analysis: “I have tried to use a simple set of rules to make the decisions as it is very difficult to really understand the full circumstances of each accident or incident. I considered things like the potential for injury or actual injury and the likely need for RCC action for example. There are so many landing incidents that damage aircraft but do not require RCC response. I have also made the assumption that if the spreadsheet had TRUE [for ELT beacon], that the activation was not caused by other factors, in other words the system functioned normally.”

The respondent’s information can be used to calculate an efficacy rate for ELTs based on the accident dataset. In 97 of the accidents, at least one of the respondents indicated that the ELT would be expected to activate and transmit. In 42 of these, the ELT did. This produces an efficacy rate of 43%. The raw figures are provided in the table below:
Table 8: Comparison of actual ELT performance with working group responses

<table>
<thead>
<tr>
<th>Did ELT actually activate and transmit?</th>
<th>Working group’s judgements on ELT activation and transmission in accident scenarios</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All said “No, did not activate and transmit”</td>
<td>All said “Yes, did activate and transmit”</td>
</tr>
<tr>
<td>ELT activated and transmitted</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>ELT did not activate and transmit</td>
<td>114</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>115</td>
<td>20</td>
</tr>
</tbody>
</table>

In comparison to this, the CAA determined an efficacy rate for ELTs to be 27% on average over the last four years. Acknowledging the data limitations in both CAA and working group analysis, an efficacy range of between 27% and 43% can be established.

**Other comments:**

The fourth respondent (Respondent D) who provided overall observations, noted that the expectation for a passenger would be that there is quite a low threshold for ELT activation (i.e. if a helicopter rolled it should activate, or severe turbulence could be a good precursor to an accident) and was surprised by the RCC data on the number of accidents where an ELT beacon had not been received. The respondent also reflected on the robustness of the beacon – “If a crash isn’t serious enough, it won’t activate; and if it is too serious, it won’t transmit. I would prefer extending the ‘activate and transmit’ window from both ends”. One respondent noted helicopters in slow roll overs will not activate and transmit an ELT message.

**False alarm data:**

Below details the number of ELT activated in non-emergency situations as compared to emergency situations. Activations in non-emergency situations were reported as being caused by malfunction, mishandling/inadvertent activation, or malicious activation.

Table 9: Emergency versus non-emergency activations

<table>
<thead>
<tr>
<th></th>
<th>2013/14</th>
<th>2012/13</th>
<th>2011/12</th>
<th>2010/11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency situation</td>
<td>17</td>
<td>15</td>
<td>17</td>
<td>11</td>
</tr>
<tr>
<td>Non-emergency situation</td>
<td>93</td>
<td>88</td>
<td>97</td>
<td>110</td>
</tr>
<tr>
<td>Total activations</td>
<td>110</td>
<td>103</td>
<td>114</td>
<td>121</td>
</tr>
</tbody>
</table>
**Differences between CAA and RCC data:**

The below table illustrates the difference in real emergency notifications to RCC compared to CAA records of ELT activations in accidents.

*Table 10: RCC data versus CAA data*

<table>
<thead>
<tr>
<th></th>
<th>2013/14</th>
<th>2012/13</th>
<th>2011/12</th>
<th>2010/11</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCC ELT-activated distress situations</td>
<td>17</td>
<td>15</td>
<td>17</td>
<td>11</td>
</tr>
<tr>
<td>CAA ELT activations noted</td>
<td>7</td>
<td>6</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Discrepancy</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>

The discrepancy is due to the CAA not consistently recording whether the ELT had activated in an accident. The CAA was able to manage this discrepancy to establish the effectiveness of ELTs by matching the RCC ELT activation records with CAA accidents figures (as outlined throughout Appendix 1).