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16. Abstract

The report includes a review of emergency locator transmitter (ELT) problems and efforts to solve these problems, and a survey of the current situation. Statistical data from the National Transportation Safety Board and the Air Force Rescue Coordination Center for 1975 and 1976 is used in this study. Numerous discussions were held with a substantial segment of the ELT and search and rescue community, including those organizations specifically addressing the current ELT problems. Further, an intensive review of the ELT resource literature was completed, including technical papers, general articles, and communications from many of those organizations concerned with the ELT and search and rescue.

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CONTENTS

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

SPECIAL STUDY

Adopted: January 26, 1978

EMERGENCY LOCATOR TRANSMITTERS: AN OVERVIEW

INTRODUCTION

Controversy regarding its effectiveness in search and rescue has engulfed the emergency locator transmitter (ELT) since 1970 when Congress mandated its installation in most general aviation aircraft. The ELT has been plagued with numerous technical and operational problems; often, during an accident, it has failed to activate and thus, failed to provide a distress signal warning of a downed aircraft. It has activated frequently when there is no emergency, thereby requiring the unnecessary expenditure of search and rescue resources. Committees comprised of representatives of governmental agencies, private industry, and special interest groups have been formed to examine various aspects of the ELT problem and of the wider problem of search and rescue. Although these attempts have not produced solutions for all the current problems, they are paving the way for the development of an improved emergency locator system.

A dependable ELT will have a substantial impact on aviation safety. After an aircraft accident, occupant survival may depend upon an ELT which transmits a distress signal. Furthermore, an ELT activation when no accident has occurred could result in an unnecessary airborne search for the source of the errant signal. This might needlessly create the potential for an accident involving the searching aircraft.

For these reasons and because of the current problems created by the ELT, the National Transportation Safety Board has performed this special study, which includes a review of the history of the ELT, of problems which arose from its use, and of efforts to solve these problems. The current situation is discussed and the persistent problems and benefits of the ELT are highlighted. This overview of the ELT also reviews the role of the ELT in the search and rescue mission.

Finally, the Safety Board has made recommendations to encourage and promote the development of a highly reliable, properly functioning ELT. The Safety Board hopes that these recommendations will provide additional support for the necessary work and will impart an added sense of urgency.

The sources of statistical data are the accident files of the National Transportation Safety Board and the quarterly and annual reports of search and rescue activity of the Air Force Rescue Coordination Center.

Sources of qualitative data included: The Air Force Rescue Coordination Center, Scott Air Force Base, Illinois; the Federal Aviation Administration; the Goddard Space Flight Center, of the National Aeronautics and Space Administration; the Office of the Secretary, Systems Development and Technology, Department of Transportation; the Crash Research Institute; the Technical Planning Department of the Aircraft Owners and Pilots Association; manufacturers of ELT's, crash sensors, and aircraft; members of the Radio Technical Commission for Aeronautics; members of the Interagency Committee for Search and Rescue; and the National Association for Search and Rescue, an organization which includes many State search and rescue officials.

Through visits and numerous discussions with these organizations, minutes of meetings, reports,and other documents, the data which forms the foundation of this overview were obtained.

A list of pertinent technical papers, general articles, and communications used in this study is presented in Appendix A.

FIRST-GENERATION ELT'S: HOW THEY WERE DEVELOPED AND USED

ELT's have been used by the U.S. military for over 20 years. They signal the existence of downed aircraft and aid search and rescue teams in locating a crash site. Typically, the ELT unit is self-contained within a plastic or metal alloy case, less than 12 inches long and weighing only a few pounds. A signal is radiated by a single flexible whip antenna, which is attached to the external surface of the aircraft. Many units are equipped with both an external whip antenna and a deployable antenna incorporated into the unit. The ELT unit is attached by a mounting bracket to a rigid structure within the aircraft to facilitate transmission of crash forces to the crash sensor in the main unit.

In 1963, the Federal Aviation Administration (FAA) conducted a study in the Los Angeles, California, and Salt Lake City, Utah,areas to evaluate ELT equipment. On January 9, 1964, the FAA issued Advisory Circular 170-4, which informed the aviation community that the study demonstrated the feasibility of the ELT concept. The Circular also solicited industry comments. On February 28, 1968, an Advanced Notice of Proposed Rulemaking was issued to invite public input toward establishing regulations on crash locator beacons. On March 17, 1969, the FAA issued another notice proposing that a crash locator beacon be required on aircraft operated by air taxis. Concurrently, the FAA issued Advisory Circular 91-19 recommending that aircraft owners install ELT's.

Before the FAA took final rulemaking action, Congress enacted Public Law 91-596, the Occupational Safety and Health Act of 1970. Section 31 of this Act amended Section 601(d) of the Federal Aviation Act of 1958 to require that ELT's be installed on all fixed-wing aircraft manufactured in the U.S. or imported after December 31, 1971, and on all fixed-wing aircraft flown after December 30, 1973. The following aircraft were exempted: Jet powered aircraft, aircraft used in air transportation other than air taxi and charter service, military aircraft, aircraft used solely for training purposes and involving flights of not more than 20 miles, and aircraft used for the aerial application of chemicals.

On March 10, 1971, the FAA issued a Notice of Proposed Rulemaking reflecting the requirements of Public Law 91-596, and in August 1971, the FAA amended the Federal Aviation Regulations (FAR), Parts 25, 29, 37, 91, 121, and 135. These amendments to the FAR's adopted Technical Standard Order (TSO) C91, which specified the minimum performance standards that ELT's must meet in order to be identified with the applicable TSO markings. Further, TSO-C91 required that certain types of ELT's meet standards prescribed in the Radio Technical Committee for Aeronautics (RTCA) Documents DO-145, DO-146, and DO-147 published on November 15, 1970. These standards relate to primary ELT design parameters, including operating frequency, radiated power, operating life, operating temperature, repetition rate, modulation, automatic activation, and battery replacement. The Part 135 revision required that, on extended overwater flights, a survival-type ELT be attached to one of the liferafts.

Amendment 121-93 was issued in July 1972 to require that air carriers be equipped with survival-type ELT's during all extended overwater operations after October 21, 1972. Advisory Circular 20-81 was issued on October 10, 1972, to alert the general aviation community of accidental or unauthorized activation of ELT's and the penalties involved. It also suggested means of controlling or containing the radiated energy on the emergency frequencies during testing. On October 27, 1972, Advisory Circular 00-35 was issued to provide guidelines for licensing, installing, maintaining, and testing ELT's.

Because of unwanted ELT activations, the FAA issued a general notice (GENOT) to its field personnel to emphasize that an aircraft accident or incident must be assumed whenever an ELT signal is heard or reported and that immediate action must be taken to alert rescue forces. Should the signal be found to have been accidentally triggered and the owner or operator could not be readily located, FAA personnel were to take steps to ground the antenna and placard the aircraft. They must then advise the owner/operator that the aircraft may not be operated without first having an FAA inspector check out the ELT installation.

Airworthiness Directives were issued to three ELT manufacturers to resolve inadvertent activation problems with their products. A fourth Airworthiness Directive was issued to require the inspection of 27,000 units and their replacement or repair as necessary. However, false activations and other malfunctions persisted, many of which required repairs and often the return of the units to the factory. Often, repairs were not made for long periods of time, and, as a result, the FAA received numerous requests for authority to fly without an ELT until it had been repaired. There were also requests that FAA grant exemptions from compliance with the mandatory date of December 30, 1973.

In October 1973, the FAA issued Advisory Circular 00-40 to state that the FAA Administrator was not authorized to grant exemptions from Section 601(d) of the Federal Aviation Act of 1958; only Congress could grant such relief from the mandatory compliance date. On January 2, 1974, Public Law 93-239 further amended Section 601(d) of the Federal Aviation Act of 1958 to extend the compliance date to June 30, 1974. Thus, after June 30, 1974, no nonexempt aircraft could be operated without an ELT or with an inoperative ELT. This was implemented on February 5, 1974, when the FAA issued amendment 91-121.

In April and May 1974, the FAA conducted a Directed Safety Investigation, which substantiated a widely reported problem with ELT's -- breaking away from their mountings during aircraft accidents because of inadequate attachment to the aircraft, severing the antenna lead wires, and malfunctioning.

On July 10, 1974, FAA amendment 91-124 to Part 91 of the FAR's became effective. This adopted the statutory exemptions contained in 601(d) of the Federal Aviation Act of 1958 as amended by Public Law 93-239 and incorporated these exemptions into 91.52(f) of the FAR's. The amendment also adopted minor technical language changes enabling the FAR's to conform with 601(d)(12) of the Federal Aviation Act of 1958. In addition, several new exemptions were added, set forth in 91.52(f)(4), (5), (7), (8), and (9), which permitted aircraft to be used in certain types of flight operations without an ELT. Also, the original exemption 91.52(f)(3) which permitted aircraft engaged in training operations conducted within a 20-mile radius to fly without an ELT, was extended to permit this operation within a 50-mile radius of the airport. A further minor change related to exemption 91.52(f)(6), aerial application of chemicals and other sustances for agricultural purposes. This change allows exemptions during necessary flights to and from the location of the application operation.

In January 1975, the Radio Technical Commission for Aeronautics (RTCA), Special Committee 127 (SC 127), was convened at the request of the FAA to revise the Minimum Performance Standards of RTCA DO-145 and DO-147. The RTCA-SC 127 was especially concerned with the problems of inadvertent activation and nonactivation of ELT's.

To complement the intent of ELT legislation, in 1975 the National Transportation Safety Board required the inclusion of ELT information in its accident reports. At the same time, the Air Force Rescue Coordination Center (AFRCC) at Scott Air Force Base, Illinois, also began recording and publishing data on the ELT as it related to the AFRCC search and rescue coordination mission.

Because of continued reports of ELT malfunction caused by inadequate mountings, battery failures, and the failures of the crash sensor to activate, the Safety Board, on April 15, 1975, issued safety recommendations A-75-41 and 42 to the FAA. The Safety Board recommended that the FAA issue an Airworthiness Directive providing comprehensive design and installation specifications to assure that fixed-type ELT's remain in their mounts. It also recommended that the FAA amend 14 CFR 37.200 to require an easily accessible battery test feature and to provide for activation of the devices under conditions approaching those encountered in actual accidents. In responding to these recommendations, the FAA referred to its Directed Safety Investigation conducted in 1974. The FAA stated that, according to that investigation, about 12 percent of ELT's were inadequately installed. The FAA then stated that the problem had subsequently been corrected and that the current frequency of the incidents did not warrant an Airworthiness Directive. It further stated that the RTCA-SC 127 was studying means of rendering the ELT's more crashworthy. The FAA said that no simple means of testing ELT batteries existed and additional circuitry for battery testing would reduce ELT reliability. It believed that current battery maintenance checks appeared to be acceptable procedures to assure reliable batteries. The FAA pointed out that the RTCA-SC 127 was studying the crash sensor problem with a view to developing more realistic standards and, at the conclusion of such study, appropriate amendments to the FAR's would be proposed.

Because the recurring problems which afflicted the ELT were accompanied by extensive delays in obtaining repairs, legislation was introduced in Congress in September 1975 to amend the Federal Aviation Act of 1958 to permit the temporary operation of certain aircraft without ELT's. This legislation, however, was not enacted.

In 1976, the FAA issued the results of a Directed Safety Investigation conducted in 1975 to examine unwanted ELT activations and failures to activate in accidents. Accident investigators, repair stations, and equipment manufacturers were surveyed. The surveys confirmed that batteries continued to fail because of corrosion, leaks, short circuits, and expiration of shelf life; that crash sensors continued to fail because of improper design, jamming, and corrosion; and that ELT's continued to fail because of improper mounting, location, and short circuits. The surveys also indicated that about 90 percent of the false ELT signals emanated from aircraft parked at airports.

On October 20, 1976, Amendment 91-133 to the FAR's was issued to eliminate certain exceptions to the ELT requirement which, as of

December 30, 1975, were no longer allowable under the law. These exceptions were those aircraft built or imported before December 30, 1971.

As additional problems have developed with specific ELT's, the FAA has continued to issue Airworthiness Directives requiring modification, repair, and periodic inspection or replacement of the units or their components.

THE ELT IN SEARCH AND RESCUE

The National Search and Rescue (SAR) plan designates the U.S. Air Force as the Federal executive agency responsible for coordination of SAR activities within the inland region of the United States. The Aerospace Rescue and Recovery Service (ARRS) operates the AFRCC. Within the maritime region, including Alaska and Hawaii, this function is performed by the U.S. Coast Guard.

The basic responsiblity for SAR rests with the State and local authorities. The State often coordinates with local sheriff departments, fire departments, or police departments who have the actual SAR responsibility in their State. The relationship of the AFRCC with the various State and local authorities is based on legal agreements between the States and the AFRCC, which define the State and local authorities responsible for the SAR function.

Volunteer organizations, including the Civil Air Patrol, are often requested by the State authorities or AFRCC to aid in SAR missions. The coordination of these efforts and Federal SAR assistance requested by local authorities is performed by the AFRCC. There are substantial differences in attitudes, organizations, capabilities, and facilities of the various State and local authorities. The AFRCC depends on the cooperation of State and local authorities to perform its function effectively.

Most ELT reports received by the AFRCC originate from airborne traffic. They are then forwarded to the AFRCC by air route traffic control centers, flight service stations, control towers, approach controls, or fixed-base operators.

Nearly 90 percent of the ELT signals emanate from the vicinity of airports; most of these are false. Many airports have neither receivers to monitor the ELT channels nor direction finding equipment to track the signals. They also lack the personnel needed to search for the source of the signals. The FAA is procuring and providing hand-held direction finding units to its flight service stations; however, the progress is slow.

The relatively high incidence of failure to activate when required combined with the high false alarm rate has created apathy among users, flight service stations, fixed-based operators, and search and rescue organizations. There are numerous reports of delays or refusal of airport personnel to locate and silence ELT's in aircraft parked on their facilities. Some are not aware that the ELT signal they fail to silence can mask an emergency signal from an aircraft downed elsewhere in their area. In densely populated areas, there often is more than one airport from which ELT signals could emanate. The AFRCC Quarterly Report of SAR Activity Related to Aviation for July, August, and September 1976, contained an excerpt from an SAR Mission Summary of such a situation: Two nondistress ELT signals masking a valid distress signal had to be silenced before the accident site could be located by triangulating the weak ELT signal from the downed aircraft.

The cost of locating false ELT signals and implementing search and rescue missions for signals not silenced has been substantial; the AFRCC estimates that this cost exceeds $800,000 a year.

Two significant advances were applied to search and rescue operations during 1976 by the AFRCC which can significantly enhance the effectiveness of the ELT in locating an accident site.

One of these is the ELT/TAP (Track Analysis Program) established in 1976. It utilizes both the ELT and Air Route Traffic Control Center's (ARTCC) computerized radar to determine a last known position (LKP). Once radar contact has been established and the aircraft identified, its position is automatically recorded as the flight progresses. This record may be recalled by the computer and the point at which radar contact was lost can be determined. Thus, the search area is narrowed considerably, the ELT signal can be monitored more easily, and the crash site can be located by triangulating the signal. Because of light conditions, terrain, or weather, it is not always possible to establish visual contact with the downed aircraft, and it is often necessary to use a combination of airborne and ground direction finding equipment to locate the accident site.

The time required to identify an aircraft as missing varies significantly depending on the details known about the flight and the specific location of the crash site. It is possible that an aircraft would not be reported missing until after the ELT's batteries have been exhausted, rendering it valueless in the search and rescue effort. A program employing the filing of flight plans and the use of ELT's and TAP can significantly reduce the search time, which can be critical when either serious injury or a hostile environment exists. The absence of any one of these three position-relating elements can substantially alter the outcome of a search. AFRCC records indicate that the life expectancy of injured survivors decreases as much as 80 percent during the first 24 hours following an accident. The chances of survival of uninjured survivors rapidly diminishes after the first 3 days. Unfortunately flights operating on either IFR or VFR flight plans constitute only 15 percent of general aviation traffic.

TAP is currently available at 15 of the 20 ARTCC's in the continental U.S. This provides coverage of about 70 percent of the continental U.S. now. When all ARTCC have TAP, about 90 percent of the continental U.S. will be covered.

The effectiveness of TAP can be severely limited by mountainous terrain or low altitude, or both, which can block the radar line of sight and prevent the aircraft from appearing on the radarscope.

In addition to TAP, another significant technological advance was applied to SAR operations in 1976. The Air Weather Service Global Weather Central and the National Environmental Satellite Service began providing historical weather data, analysis, and satellite photographs at the known time of a missing aircraft flight. Such information provides an effective tool for predicting areas of high accident probability and thus enables SAR coordinators to reduce the size of the initial search area and decrease the search time.

STATISTICAL DATA

This study contains data from both the NTSB and the AFRCC.

NTSB data on ELT's result from accident investigations. (See Tables 1 through 4.) AFRCC data are based on ELT reports or other incidents of distress, which may or may not involve an accident. Because of these significant differences in the data collection processes, the type of data collected and made available by the two organizations differs significantly. The NTSB data collection process begins after an accident, and the data collected necessarily reflect this fact. Thus, it relates to the activation of the ELT or to the failure mechanism. Failures of the mounting bracket, antenna, crash sensor, and batteries are included in the NTSB data collection.

On the other hand, the AFRCC commences its activity upon the report of an ELT signal or other incidence of distress. It ends its activity upon location of the aircraft if it is able to find it. The data collected thus relate to the proper activation of the ELT on impact or the unwanted activation of the ELT in a nondistress situation. Unfortunately, because its activity ceases upon location of the source of the ELT signal, the AFRCC rarely, if ever, learns of the cause of the improper activation. Because of the differences in data collection and reporting procedures, no direct analytical comparisons between the NTSB and AFRCC data can be made.

TABLE 1

AIRCRAFT DAMAGE BY ELT
(All Operations)

EMERGENCY LOCATOR TRANSMITTER	DESTROYED		SUBSTANTIAL		MINOR		NONE		RECORDS		ACCIDENTS	
	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976
Operated--Used in Locating A/C	57	55	53	40					110	95	110	95
Operated--Not Used	126	177	394	416	1				521	593	520	593
Not Used--Not Armed	41	43	63	57		1			104	101	104	100
Not Used--Separation from Antenna	36	33	9	6					45	39	45	39
Not Used--Battery Malfunction	5	11	13	24					18	35	18	35
Not Used--Other Malfunction	45	49	55	70					100	119	100	119
Not Used--Impact/Fire Damage	125	129	5	7					130	136	130	134
Not Used--Operation Unknown	114	131	225	239	1		1		341	370	336	368
Not Installed	257	295	612	642	6	3	12	8	887	948	879	941
Not Applicable/Insufficient Impact	73	57	996	1,132	8	7	5	10	1,082	1,206	1,066	1,196
Unknown/Not Reported	179	121	565	489	4	4	10	13	758	627	754	622
Other												
Records	1,058	1,101	2,990	3,122	20	15	28	31	4,096	4,269		
Accidents[1/]	1,050	1,086	2,968	3,107	20	15	28	31			4,046	4,221

1/Accidents are occurrences incident to flight resulting in fatal or serious injury or substantial damage. Records are the result of the analysis of an accident. A collision between aircraft is one accident. Each aircraft involved in the collision is analyzed and a record produced for each.

TABLE 2

INJURY INDEX BY ELT
(All Operations)

EMERGENCY LOCATOR TRANSMITTER	FATAL		SERIOUS		MINOR		NONE		RECORDS		ACCIDENTS	
	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976
Operated---Used in Locating A/C	53	43	15	20	13	11	29	21	110	95	110	95
Operated--Not Used	68	98	84	99	115	125	254	271	521	593	520	593
Not Used--Not Armed	32	36	15	15	12	16	45	34	104	101	104	100
Not Used--Separation from Antenna	33	31	5	4	2	3	5	1	45	39	45	39
Not Used--Battery Malfunction	3	10	6	7	3	6	6	12	18	35	18	35
Not Used--Other Malfunction	38	36	9	17	21	14	32	52	100	119	100	119
Not Used--Impact/Fire Damage	111	112	7	13	8	4	4	7	130	136	130	134
Not Used--Operation Unknown	90	98	36	38	44	48	171	186	341	370	336	368
Not Installed	123	165	127	137	150	138	487	508	887	948	879	941
Not Applicable/Insufficient Impact	28	26	56	49	133	123	865	1,008	1,082	1,206	1,066	1,196
Unknown/Not Reported	89	67	63	41	123	80	483	439	758	627	754	622
Other												
Records	668	722	423	440	624	568	2,381	2,539	4,096	4,269		
Accidents1/	656	699	419	438	619	566	2,352	2,518			4,046	4,221

1/Accidents are occurrences incident to flight resulting in fatal or serious injury or substantial damage. Records are the result of the analysis of an accident. A collision between aircraft is one accident. Each aircraft involved in the collision is analyzed and a record produced for each.

TABLE 3

TYPE OF WEATHER BY ELT
(All Operations)

EMERGENCY LOCATOR TRANSMITTER	VFR		IFR		BELOW MINIMUMS		UNKNOWN		RECORDS		ACCIDENTS	
	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976
Operated--Used in Locating A/C	70	66	31	27	4	2	5		110	95	110	95
Operated--Not Used	481	551	34	35	5	5	1	2	521	593	520	593
Not Used--Not Armed	87	82	16	16	1	2		1	104	101	104	100
Not Used--Separation from Antenna	22	22	20	11	1	3	2	3	45	39	45	39
Not Used--Battery Malfunction	13	28	3	5	1		1	2	18	35	18	35
Not Used--Other Malfunction	83	95	14	21	2	2	1	1	100	119	100	119
Not Used--Impact/Fire Damage	68	100	52	31	5	3	5	2	130	136	130	134
Not Used--Operation Unknown	300	324	33	38	4	4	4	4	341	370	336	368
Not Installed	849	916	30	25	2	2	6	4	887	948	879	941
Not Applicable/Insufficient Impact	1,039	1,164	31	32	2	5	10	5	1,082	1,206	1,066	1,196
Unknown/Not Required	681	572	41	36	4		32	19	758	627	754	622
Other												
Records	3,693	3,920	305	277	31	28	67	43	4,096	4,269		
Accidents1/	3,645	3,872	304	277	31	28	67	43			4,066	4,221

1/Accidents are occurrences incident to flight resulting in fatal or serious injury or substantial damage. Records are the result of the analysis of an accident. A collision between aircraft is one accident. Each aircraft involved in the collision is analyzed and a record produced for each.

TABLE 4

FIRE AFTER IMPACT BY ELT
(All Operations)

EMERGENCY LOCATOR TRANSMITTER	YES		UNKNOWN		RECORDS		ACCIDENTS	
	1975	1976	1975	1976	1975	1976	1975	1976
Operated--Used in Locating A/C	5	6			5	6	5	6
Operated--Not Used	20	24			20	24	20	24
Not Used--Not Armed	2	7			2	7	2	7
Not Used--Separation from Antenna	11	8			11	8	11	8
Not Used--Battery Malfunction	7	7			7	7	7	7
Not Used--Impact/Fire Damage	84	83			84	83	84	83
Not Used--Operation Unknown	39	36			39	36	38	36
Not Installed	101	108			101	108	101	108
Not Applicable/Insufficient Impact	23	27			23	27	23	27
Unknown/Not Reported	59	40	1		60	40	60	40
Other								
Records	352	347	1		353	347		
Accidents1/	350	345	1				351	345

1/Accidents are occurrences incident to flight resulting in fatal or serious injury or substantial damage. Records are the result of the analysis of an accident. A collision between aircraft is one accident. Each aircraft involved in the collision is analyzed and a record produced for each.

In 1975 and 1976, there were 4,096 and 4,269 accident records, respectively. Of these accident records, 887 in 1975 and 948 records in 1976 revealed that no ELT was installed in the aircraft. The data does not differentiate between aircraft that were legally exempted from the ELT requirement and those that were not. To determine this would require a case by case inspection of 1,835 accident files. Many cases would require a detailed investigation beyond these records. The data do not reveal the effect the installation of an ELT would have had on search and rescue efforts, if, indeed, a search was necessary. These data and the following statistics are summarized in Table 5.

TABLE 5

SURVEY OF ELT PERFORMANCE
(NTSB Data)

	1975		1976	
Total records		4,096		4,269
ELT not installed	887		948	
No data	758		627	
ELT not used/ unknown reason	341		370	
Not applicable/ insufficient impact	1,082		1,206	
Total records with insufficient data	3,068		3,151	
Total records with ELT data		1,028		1,118
ELT not armed		104		101
ELT functioned/ not used		521		593
ELT malfunctioned		293		329
ELT used in locating site		110		95

After eliminating these records where no ELT was installed, there remain 3,209 and 3,321 accident records for 1975 and 1976, respectively. In 1975, 758 accident records contained no ELT data, and in 1976, 627 records contained no data.

Upon eliminating those records which provided no data, there remains 2,451 records in 1975 and 2,694 records in 1976. Within these data, there were 341 records in 1975 and 370 records in 1976 in which an ELT was on board the aircraft but, for unknown reasons, was not used to locate the crash site. Because of the incompleteness of the recorded data, it was not possible to determine whether the ELT activated. The ELT may have functioned for varying periods of time but was not detected or not located before its signal stopped. Further, the data do not reflect accidents in which no search was necessary because the crash site was easily located. Mountains, valleys, trees, foliage, and temperature extremes can seriously limit the transmission effectiveness of an ELT and eliminate its usefulness in locating the accident site, even though it was operating. In addition, accident damage may give the impression of sufficient impact when, in fact, the deceleration forces experienced by the crash sensor were not sufficient to activate the ELT. If the ELT was not examined, or if it was removed or reset, data regarding the performance of the unit were lost. To be of use for accident analysis, the ELT must be examined and tested rigorously immediately after the crash.

Having eliminated this additional group of accident records which provided no knowledge on the functioning of the ELT, 2,110 records remained in 1975 and 2,324 records in 1976. Of these, 1,082 records in 1975 and 1,206 records in 1976 were identified as "not applicable/insufficient impact." These were accidents in which ELT activations were not expected because the type of accident would not involve impact forces sufficient to activate the ELT. Thus, this category is not applicable for inclusion with the remaining records in assessing the effectiveness of the ELT. Typical of this category was structural damage or personal injury caused by ground loops, abrupt maneuvering, turbulence, or ground fires. Problems of interpretation can arise, however, when the crash forces become greater. Without additional test data, assessment of impact forces is highly subjective, especially as the impact force spectrum nears the range of sufficient impact. The severity of impact experienced by the ELT is a function of its location in the aircraft, the method by which it is mounted, and the type of crash sensor used. (Crash sensors range from the commonly used undirectional sensor responding to forces along the longitudinal axis to a 360° omnidirectional sensor responding to forces from any direction.) For example, the longitudinal impact forces in a hard landing might well be insufficient to activate the typical crash sensor which is sensitive to longitudinal accelerations. However, the vertical impact forces could likely be sufficient to activate an omnidirectional crash sensor.

Finally, of the remaining 1,028 records in 1975, 631 ELT's, or 61 percent, operated successfully with 110, or 11 percent, used in locating the accident site. In 1976, of the remaining 1,118 records, 688, or 62 percent, operated and 95, or 8 percent, were used to locate the accident site.

In 1975, 104 of the 1,028, or 10 percent, were not armed, and in 1976, 101 of the 1,118, or 9 percent, were not armed. Therefore, they were not capable of being automatically triggered to broadcast a distress signal. The data do not reflect why the ELT's were not armed before flight.

The remaining segment of the accident records -- 293, or 29 percent, of the 1,028 in 1975, and 329, or 29 percent of the 1,118 in 1976 -- represents units that malfunctioned. This segment can be divided into four categories:

(1) <u>Separation from antenna</u> -- 45 recorded cases in 1975 and 39 in 1976. Separation was most commonly caused by impact damage because the antenna was mounted externally and, therefore, subject to full decelerative loads during impact and breakup. Without the antenna, the ELT is virtually incapable of transmitting a signal. Searchers would have to be within a short distance of the unit to be able to receive the signal.

(2) <u>Battery malfunction</u> -- 18 records in 1975 and 35 records in 1976. Problems include insufficient shelf life, inadequate operating power and endurance (especially at very low temperatures), corrosion, and in the case of lithium sulfur dioxide batteries, the off-gassing of noxious, eye-irritating, and incapacitating gasses which can result in fires.

(3) <u>Other malfunctions</u> -- 100 records in 1975 and 119 records in 1976. This category represents only those incidents in which the ELT failed to activate properly. Occurrences in which the ELT emitted undesired signals are not included in NTSB data. Malfunctions of the former type include internal circuitry failures caused by short circuits or corrosion and improperly functioning crash sensors. Also included are internal component failures not associated with or induced by impact, fire, mounting, or battery problems. Another problem recorded in this category is the impairment or attenuation of the ELT signal because of the unfavorable position of the ELT antenna of a downed aircraft. The antenna, although intact and still attached to the aircraft, may be shielded by steep terrain, foliage, snow, or by the wreckage itself. The signal range is thereby limited. The accuracy of this segment of the data can be affected by accidents in which the impact angle or magnitude is outside the design parameters of the crash sensor. This type of accident might result in the recording of an ELT malfunction when, in fact, the ELT might be capable of properly responding, but not to the particular crash sequence.

(4) ELT malfunction caused by impact or fire damage -- 130 records in 1975 and 136 records in 1976. In this category impact damage was distinguished from "antenna separation" or "other malfunction." The inability of the ELT to function was solely caused by impact damage to the electro/mechanical system. Nonsurvivable accidents resulting from catastrophic fire or destruction, and accidents in which the occupants survived the crash, but the ELT did not, were also included in this category.

An ELT's ability to withstand impact forces and function thereafter depends on its location in the aircraft and the method used to mount it there. Faulty mountings that permit the ELT to separate from the aircraft and subject the unit to secondary impact damage are also included in this category.

Fire which destroys or substantially damages the aircraft will probably disable the ELT as well. Fire also can be caused by ELT's. NTSB data reflect several cases in which the antenna cable of one model of ELT loosened from its attachment, dropped onto the aircraft battery solenoid, and contacted the aircraft skin. The resulting short circuit caused a fire. Vibration was a likely cause of this attachment failure.

AFRCC data provide a perspective of the ELT's impact on the overall SAR program. These data result from reported incidents of distress which may or may not involve an accident. The data do not contain followup information providing breakdowns into causes of malfunctions. Further, AFRCC data do not represent the total of all aviation incidents during the period covered in this study. Reporting procedures during this period did not insure that all data reported to other agencies, principally the FAA, would be reported to the AFRCC. The FAA has since modified its reporting procedure; it now provides the AFRCC with data including incidents which would not have previously been reported directly.

The data presented in this study lacks some analogous characteristics, because AFRCC data collected in 1975 and 1976 differed substantially in format and to some extent in content mainly because of the desire to select data reflecting changing problem areas.

The following tabulation was formulated from data provided by the AFRCC:

	1975[1/]	1976[1/]
ELT signals reported to the AFRC:	6,603	5,672
ELT signals located and silenced	2,100	1,889
ELT signals terminated before source was located	4,503	3,783

	1975[1]	1976[1]
AFRCC mission initiated for ELT signals alone	241	344
Crash sites located with the aid of an ELT	8	- [2]
ELT signals activated by crashes or forced landings	20	58
Incidents of aircraft distress or potential distress not ELT initiated	2,696	2,603
Search missions initiated for aircraft distresses	284	265
Crash sites located with aid of ELT	37	38[3]
Aircraft crashes readily located and rescue resolved locally	133	90[3]
ELT aided in locating site	6	4[3]
Total from all sources in which the ELT was instrumental in locating aircraft crash sites	51	42[3]

In 1975, 6,603 ELT incidents were reported to the AFRCC and 2,100 were located and silenced. During 1976, 5,672 ELT incidents were reported and 1,889 were located and silenced. These signals resulted in 241 SAR missions being flown for ELT signals alone in 1975 and 344 such missions in 1976. The overall result for these missions was the location of 8 crash sites in 1975 and an undetermined number of sites in 1976. There is no further breakdown available on the 4,503 signals in 1975 and the 3,783 signals in 1976 which terminated before the source was located. Although the number of ELT reports decreased about 15 percent between 1975 and 1976, most reports still appeared to be false alarms.

There were also 2,696 non-ELT incidents related to aviation in 1975 and 2,603 non-ELT incidents in 1976. Typical of non-ELT incidents is overdue aircraft or reported sightings of downed aircraft. The AFRCC

1/ During this year all ELT involvement in aircraft related activity was not necessarily reported to AFRCC.

2/ Included in 38 crash sites located in 1976 with the aid of ELT in searches initiated for aircraft distress.

3/ Estimated -- AFRCC.

initiated 284 missions for missing, overdue, or reportedly downed aircraft in 1975 and 265 such missions in 1976. In 1975, 39 crash sites were located with the aid of an ELT and the AFRCC estimates 38 crash sites were located with the aid of an ELT in 1976.

In 1976, the first year in which the TAP program was used, 104 SAR missions were flown without the aid of ELT/TAP and 52 missions were flown with ELT/TAP. The following tabulation of data provided by the AFRCC illustrates the value of the ELT and TAP in reducing the resources and time expended in search and rescue.

	Average No. of aircraft used	Average No. of sorties	Average No. of hours per mission
SAR w/o ELT/TAP	31	63	125.5
SAR with ELT/TAP	11	22	38.3

CURRENT PROBLEMS AND THE NEED FOR A SECOND GENERATION ELT

The RTCA-SC 127, which was convened in 1975, has continued its work to develop Minimum Performance Standards for the second generation ELT. The committee was bound in the scope of its task by the Terms of Reference defined by the RTCA (RTCA Paper No. 99-74/SC 127-1). These required Special Committee 127 to review and update the existing Minimum Performance Standards of RTCA DO-145 and-147 and to prepare Minimum Performance Standards for additional parameters not considered in DO-145 and DO-147. These additional parameters included: Battery test points external to ELT case, cockpit control of ELT's and alerting of ELT activation, battery standards, antenna standards, crystal crashworthiness, ELT crashworthiness, considerations of radio frequency radiation, and digital encoding transmitters. In addition, the Terms of Reference suggested that the Committee prepare a separate report on Minimum Performance Standards for the automatic portable, the automatic fixed, and the deployable, and a separate report for the personnel-type ELT.

Although the Terms of Reference allowed some latitude in the parameters that could be considered, the Committee took a limited view of their area of purview. As a result, the recently drafted Minimum Performance Standards concern primary ELT components and generally do not relate to the ELT as a system. Thus, some of the more persistent and significant systems problems were not addressed by SC 127 and, therefore, were not the subject of standards recommended in the revised Minimum Performance Standards.

ELT Mounting

One such ELT system problem which the Committee decided was outside its purview is the inadequate or improper mounting of a fixed-type ELT unit. (This position is clearly stated in a letter from the Chairman of RTCA-SC 127 to the Secretariat of the RTCA, dated 27 October 1977, RTCA Paper No. 194-77/SC 127-40). Improper mounting can result in the ELT breaking free from its mounting system on impact and severing its attachment with the coaxial cable leading to the antenna. Also, if the mounting system is too flexible, the system can absorb a significant portion of the impact energy and the crash sensor might not experience sufficient deceleration energy to activate the unit.

Also placement of the ELT in the aircraft has not been adequately examined. If the ELT is mounted too far forward, its chances of survival on impact decrease. The unit might well experience deceleration forces on impact too severe for it to function properly. The farther aft the unit is placed, the higher the probability of its survival in a crash if the attachment point withstands the crash forces. However, in typical nose-first impacts the forward portion of the aircraft absorbs much of the energy of impact, and if the ELT is mounted too far aft, the ELT may not experience sufficient decelerative forces to activate the crash sensor. The best location for mounting will necessarily differ from one model aircraft to another, because structural variations result in different energy absorption when subjected to similar impacts.

There are no standards that specify the type or location of attachment except for the requirement of the RTCA-SC 127 revised Minimum Performance Standard that the ELT shall have a means of attachment so that the ELT will withstand inertial forces of 100g downward, backward, and sideward (2 directions), and 100g forward and upward without breaking loose from the mounts damaging the equipment and causing the ELT to fail to activate. ELT's are attached in numerous locations from the forward part of the cabin to the rear of the tail cone by a variety of mounting methods. NASA has performed, and is continuing to perform, light aircraft crash tests to examine the crash forces experienced at various locations within the aircraft (RTCA Paper No. 132-77/SC 127-33). However, the mounting problems remains unsolved.

Antenna Mounting

Another problem not addressed completely by the proposed RTCA-SC 127 revised Minimum Performance Standards is the failure during a crash of the externally mounted antenna system. This is especially true when the system is subjected to the large deceleration forces of a high speed crash. Even more commonly, the antenna is sheared off as the the aircraft descends through trees or other obstructions or by ground obstacles upon impact. Further, if the antenna is covered by the wreckage or other debris, the signal is attenuated significantly. Mounting multiple antennae on the aircraft, perhaps one on the top and one on the bottom, has been suggested as a possible solution. This solution would be more costly because of the additional antenna, additional mounting, and wiring. Extra circuitry would also be required to enable the ELT signal to radiate only on one antenna, so the power of the radiated signal would not be reduced if both antennae survive.

The ELT and antenna survival problems have resulted in the design and production of some sophisticated ELT's. One design, which is claimed by it's manufacturers to have solved the problem, relies on a series of crash sensors in the nose and lower portions of the aircraft to initiate a spring triggered release of the entire unit on impact. The antenna is a flat plate design incorporated into the outer shell of the unit. Ground impact is kept to a minimum by the airfoil shape which allows the unit to tumble toward the ground at less than normal gravitational acceleration. The system is similar in some respects to one of the ELT devices used by the U.S. Air Force.

As in the case of the ELT, there are no standards that specify the attachment of an external antenna to an aircraft. The only requirement is that of the RTCA-SC 127 revised Minimum Performance Standards which require the ELT to be connected to the externally mounted antenna by a suitable RF cable using interlocking connectors. This problem remains unsolved and unaddressed.

Crash Sensor

The crash sensor was a subject of standards in the revised Minimum Performance Standards of RTCA-SC 127. This component, which senses the impact and activates the ELT when the design level is reached, has apparently caused numerous false alarms and has failed to activate when it should have activated.

Many ELT experts have concluded that the original crash sensor design is, in effect, a vibration sensor; that is, it is extremely sensitive to and will activate when subjected to high frequency vibrations. Such vibrations can be transmitted through the airframe when an aircraft experiences external forces, such as those experienced during hard landings, cabin door slamming, turbulence and strong surface winds. All have been reported to cause unwanted activation of the current ELT's. The standards proposed in the RTCA-SC 127 revised Minimum Performance Standards result from a study performed by the Crash Research Institute of Tempe, Arizona, (RTCA Paper No. 130-77/SC 127-32). The new design requirements of this component specified in the proposed Minimum Performance Standards are similar to a recently produced crash sensor. The manufacturer claims that this new crash sensor has virtually eliminated both the numerous false activations and the failures to activate common to the old crash sensor.

The Crash Research Institute estimates that the current crash sensor will not respond to the deceleration forces in 80 percent of the survivable crashes, although it is highly sensitive to vibrations. The CRI also estimates that the proposed standards of the revised Minimum Performance Standards should result in a crash sensor that will activate in 70 percent to 80 percent of these crashes, with a small false alarm rate. However, crash sensor testing has yet to be done, which leaves doubt as to whether the new design standards will, in fact, solve these persistent problems.

Some model ELT's have had crash sensors which failed to operate because the sensor jams, short circuits, or becomes corroded. Field testing of prototype second generation ELT's will be necessary to determine if these problems have been solved by the redesign of the units.

Battery

Still other problems involve the battery. The revised Minimum Performance Standards require that the battery operate at a low temperature of only -20°C (or -4°F). It was pointed out in RTCA Paper No. 179-77/SC 127-38 that the search and rescue requirement is for a battery that will operate for 100 hours at -40°C. The low temperature standard of -20°C is not sufficient to insure operation of the ELT during winter in many areas of the United States, particularly in rugged mountainous terrain, where rapid location of the accident site and rescue is a requisite for survival. Numerous solutions to this problem have been suggested, such as the use of an insulated enclosure to contain the battery or the use of a small heating element to keep the battery warm. A quick disconnect system which enables the battery to be removed when the aircraft is not in use could help to prevent cold soaking of the battery while not in use. Several ELT manufacturers have used the lithium sulfur dioxide battery ($LiSO_2$), which has long operating life (50-100 hours) at low temperature (-40°C) as well as a long shelf life (up to 5 years).

However, the lithium sulfur dioxide battery is subject to venting of the noxious and highly corrosive sulfur dioxide (SO_2) which can cause temporary vision difficulties or other debilitation when introduced into the cockpit without sufficient ventilation. The venting can be so rapid and violent that it approximates an explosion and can result in a fire. Two such occurrences have been recently reported to the FAA. These two problems have led most ELT manufacturers to utilize other types of batteries (usually the alkaline battery) and accept reduced performance rather than the potential risks. Recently, the Canadian Ministry of Transportation prohibited the use of all lithium-type batteries for ELT's. The FAA is currently drafting an Airworthiness Directive which might require the replacement of all nonhermetically sealed $LiSO_2$ batteries, and many hermetically sealed $LiSO_2$ batteries. This will probably be required within 30 aircraft operating hours of service or within 90 days from date of issuance.

Since some ELT's can only be operated by lithium batteries, a significant hardship will result for some not exempt from the ELT requirement. In addition, low-temperature operation will be aggravated by the prohibition of lithium batteries. ELT manufacturers are currently attempting to solve these problems. Several lithium batteries, including the lithium thionyl chloride and the lithium monofluoride battery are claimed to hold some promise for eliminating the venting and explosion hazards of the lithium sulfur dioxide battery. The lithium thionyl chloride battery has been tested by one ELT manufacturer, and none of the problems associated with the lithium sulfur dioxide battery has apparently been evident. The AD being drafted by the FAA will probably include a testing procedure, which will allow the use of some lithium batteries in ELT units, if they meet the test requirements.

Corrosion is another leading cause of battery malfunction. Undetected corrosion can be partially attributed to infrequent inspection. Since batteries are not always readily accessible, inspection is difficult. Batteries should be easily accessible for routine check and the FAR's should specifically require inspection of the battery during the annual or 100-hour maintenance inspection, or both.

Still another problem is failure to replace the battery at the required time. Easy accessibility and required inspection should help to alleviate this problem.

ELT Arming and Display

Often, pilots fail to arm the ELT during the preflight check, either inadvertently or because they have become disenchanted or complacent because of the repeated malfunctions. Inclusion of arming as a specific step in the manufacturer's preflight check list would remind the pilot to take this action before takeoff. This could also serve as a reminder to the pilot to check the remaining shelf life of the batttery.

The inclusion of the remote control and the remote warning light in the cockpit, as proposed in the RTCA-SC 127 revised Minimum Performance Standards, will enable the pilot to easily arm the ELT. One glance at this control switch would enable the pilot to determine if the ELT is set to "OFF," "MANUAL ON," or "ARMED" for automatic activation. The problems associated with false alarms should also be alleviated by the remote control and remote warning light. The warning light would alert the pilot to the inadvertent operation of his ELT, and he could then easily silence the malfunctioning ELT with the cockpit control.

Signal Reradiation

Two additional problems encountered are the triggering of the ELT by other radio signals and the reradiation of FM broadcast signals. The revised Minimum Performance Standards specify tests which must be applied to assure that this will not happen with the second generation unit.

These persistent problems can have a negative effect on the national search and rescue program. Much effort has been put into the development of the revised Minimum Performance Standards, and it is reasonable to expect that components will be satisfactorily produced in accordance with these new specifications. However, many systems problems that were not addressed remain unanswered. The Safety Board believes that the lack of system engineering and prototype field testing might well result in a second-generation ELT which will not adequately correct the currently unsatisfactory performance of the ELT's.

Signal Monitoring and Location

Many accidents occur in remote, rugged and mountainous terrain, often accompanied by severe climatic conditions. In this terrain, signals are sometimes not picked up by ground receivers because of line of sight limitations, and thus difficulty in monitoring and locating signals is created. Often, severe weather conditions delay air search jeopardizing injured or even uninjured survivors. To examine this problem the ad hoc working group on the satellite for search and rescue was formed in November 1975 by agreement of the Interagency Committee on Search and Rescue (ICSAR). ICSAR consists of representatives from the U.S. Departments of Commerce, Defense, and Transportation, the Federal Communications Commission, and the National Aeronautics and Space Administration. The working group was established to review the current situation and problems of aircraft and marine distress and alerting (DAL); examine advance space and nonspace techniques for improving the situation; design and estimate costs of research and development for an operational satellite system for monitoring distress signals.

In October 1976, the results of the ad hoc working group were reported. The report recommended the demonstration of a low-orbiting SAR satellite system for monitoring and locating existing ELT and emergency position indicating radio beacons (EPIRB). It also recommended the development of an advanced distress ELT/EPIRB that would radiate at 406 MHz, the internationally accepted frequency reserved for the use and development of low power (not to exceed 5 watts) ELT/EPIRB systems using space techniques.

The revised Minimum Performance Standards proposed by the RTCA require the second generation transmitter to operate simultaneously on 121.5 MHz and 243.0 MHz, the frequencies currently used for ELT's. The 406 MHz frequency is reserved for the satellite and no satellite currently exists to monitor this frequency. Coordination between RTCA-SC 127 and the ICSAR Working Group on Emergency Locator Transmitters is directed at assuring compatibility between the second-generation ELT and the satellite development program. The satellite monitor will receive on 121.5 MHz and 406 MHz. Ultimately, a third-generation ELT which will operate on 406 MHz will evolve into the system.

The ICSAR Working Group on ELT's reported on its work to the ICSAR Chairman in September 1977. The committee reviewed the report and requested that the working group prepare a draft letter to the FAA with certain recommendations. This draft has been prepared. It proposes four recommendations aimed at alleviating the current false alarm problem and preventing future ones. The group proposes that the FAA give high priority to changing Part 43, Appendix D, to require 100-hour or annual ELT inspections, or both; that higher priority be given to the proposed procurement of hand-held direction finding units for flight service stations; that consideration be given to obtaining a change in laws governing expenditures from the Aviation Trust Fund to permit its use for the purchase of the second generation ELT and the exchange of these for existing ELT's without charge; and that a research and development program be established to test the new standards being developed by the RTCA for the second-generation ELT's.

Another study of search and rescue, including the ELT/EPIRB and the satellite monitoring system for SAR, has been undertaken by a staff level task force of the Office of the Secretary, U.S. Department of Transportation. The task force has been examining the feasibility of the ICSAR recommended satellite approach with both the current ELT and the proposed 406 MHz system. It has assessed the problems associated with this approach and alternate approaches. A draft of this report should be available in the near future. It is expected to contain recommendations to enhance the prospects that the second-generation ELT will solve the current ELT problems and recommendations regarding the proposed satellite program and the third-generation ELT to broadcast on 406 MHz.

In early November 1977, Section 601(d) of the Federal Aviation Act of 1958 was amended to enable the Administrator, FAA, to issue regulations which permit, subject to limitations and conditions prescribed in the regulations, the operation of any aircraft equipped with an ELT when the transmitter has been removed from the aircraft for inspection, repair, modification, or replacement. This amendment clearly reflects the persistence of the malfunctions of the current ELT and the need for an improved second-generation system.

CONCLUSIONS

The first-generation ELT has been plagued with numerous problems. NTSB and AFRCC data have revealed that many of these are technical and engineering problems and have resulted from inadequate design, testing, and installation. Operational and maintenance problems also exist.

Existing statistical data provide some insight into these problems; however, improvement is needed in data collection, recording, and interpretation. Data that are not readily useful must be replaced by data that will provide greater insight into current ELT problems. Accident investigators must adhere strictly to collecting and recording procedures, which must be accompanied by consistent and accurate interpretation of the data for storage in the computer system.

A well designed, installed, and properly functioning ELT can be an extemely effective tool as part of a search and rescue effort especially when used in conjunction with TAP and a flight plan to complete the system. Most problems associated with ELT's are recognized and many have been and are being addressed by responsible organizations. Nevertheless, questions remain regarding the successful outcome of the second-generation ELT.

Attachment of the ELT unit, including the type of mounting system and the location within the aircraft, remains a significant problem. Current tests performed by the National Aeronautics and Space Administration to determine deceleration forces experienced at various locations within an aircraft, must be supplemented by additional tests, if necessary, and the proper location for attaching ELT's in aircraft determined. Furthermore, additional testing is necessary to determine the type of mounting system required.

Adequate design and specifications for a crashworthy antenna also remain to be established. Success in this area will do much to prevent future antenna separations.

Numerous problems related to battery performance persist. The revised Minimum Performance Standards have specified inadequate operating life and low operating temperature for the requirements of search and rescue, due in part to current technical limitations of nonlithium-type batteries and the hazards associated with the lithium sulfur dioxide battery. Other lithium-type batteries currently being developed by various manufacturers must be considered; technical alternatives must be examined. A safe, economical, and technically feasible solution to this problem must be found.

Battery problems associated with corrosion, short circuits, or operation beyond shelf life must also be addressed. Much can be accomplished through the mandatory inspection of the battery during the annual or 100-hour maintenance checks, or both. Easy access to the battery unit would enable pilots to readily inspect their batteries during preflight checks.

Similarly, the recurrent ELT failures caused by corrosion, short circuits, and coaxial cable disconnection must be reduced. Again, the mandatory inspection of the ELT during the annual or 100-hour maintenance checks, or both, would help. Providing ready access to the ELT unit so that it could be inspected visually would further reduce these problems.

Numerous ELT's have failed to activate during an accident because they were not armed before takeoff. The installation of an ELT cockpit control and warning light, as provided for in the revised Minimum Performance Standards, should reduce significantly this problem. The ability to monitor the ELT in flight should also reduce the number of false signals that come to the attention of search and rescue and yet remain unknown to the pilot.

Unfortunately, new aircraft are continuing to be sold without provision for the control and warning light. These cockpit aids should be provided as soon as possible.

Many failures to arm automatic ELT's during preflight preparation could also be eliminated if aircraft manfacturers would add an "ELT ARMED" check to the preflight and "ELT OFF" to the shutdown check lists when so provided with the aircraft. Perhaps the mandatory inclusion of such check lists in new aircraft would yield the best results.

The existing crash sensor fails to respond to the majority of crash forces actually experienced in accidents. Instead the sensor responds to vibrations and other nondistress forces. The Minimum Performance Standards for the second-generation ELT are currently being formulated by the RTCA. Many of the problems of current ELT's exist partly because component research and development and system field testing of the standards were not a part of the initial development of commercial ELT's for general aviation. The development of a redesigned crash sensor has theoretically solved this problem. Until the component is tested, however, solution of the problem will remain in doubt. Furthermore, ELT prototypes which incorporate this redesigned sensor must be field tested. Without such testing even if the component operates as designed, there is no assurance that the system problem will have been solved. The time to deal with these problems is during the preproduction testing phase, not after thousands of ELT's have been manufactured and installed in aircraft.

Advances in the technological capabilities of search and rescue have significantly enhanced the value of satisfactory ELT capability. The ability to rapidly determine last known position and predict areas of high probability of adverse weather conditions have complemented the ELT in the search and rescue mission.

To further this process of improving the overall SAR system, a highly reliable, properly functioning ELT is required. It is the intent of the following recommendations to provide impetus and a sense of urgency to the effort currently underway to produce such an ELT.

RECOMMENDATIONS

Based on the results of this study, the National Transportation Safety Board recommended that the Federal Aviation Administration:

"Establish the location(s) and method of mounting an automatic fixed-type ELT in an aircraft so that they will properly operate consistent with the RTCS-SC 127 revised Minimum Performance Standards; include this in the Technical Standard Order which will incorporate the RTCS-SC 127 revised Minimum Performance Standards on ELT's. (Class III - Longer Term Action) (A-78-5)

"Establish the location(s) and method of mounting a fixed-type antenna(ae) externally to an aircraft so that the ELT will properly operate consistent with the RTCS-SC 127 revised Minimum Performance Standards; include this in the Technical Standard Order which will incorporate the RTCA-SC 127 revised Minimum Performance Standards on ELT's. (Class III - Longer Term Action) (A-78-6)

"Study existing and proposed batteries or undertake research to provide a battery or battery system that will provide useful operation of the ELT for at least 50 hours at -40°C and require its use within the second-generation ELT's. (Class III - Longer Term Action) (A-78-7)

"Include a provision in the Technical Standard Order which will incorporate the RTCA-SC 127 revised Minimum Performance Standards on ELT's requiring that the ELT and battery be readily accessible for visual inspection. (Class III - Longer Term Action) (A-78-8)

"Amend 14 CFR 43, Appendix D, to include a separate, specific line item in either the annual or 100-hour maintenance inspection, or both, to require a visual check of the ELT system, including the ELT, battery, antenna or antennae, cockpit control and warning light for indications of problems, including corrosion and improper connections and an operational check of the system. (Class III - Longer Term Action) (A-78-9)

"Require engineering development and testing of all components which are the subject of standards in the RTCS-SC 127 revised Minimum Performance Standards for ELT's, including the crash sensor, to insure that these components perform as specified. (Class III - Longer Term Action) (A-78-10)

"Field test preproduction ELT prototypes supplied by manufacturers to insure that these second-generation ELT's will perform satisfactorily under field conditions and will also meet RTCS-SC 127 Minimum Performance Standards. (Class III - Longer Term Action) (A-78-11)

"Request general aviation aircraft manufacturers that provide preflight check lists with their aircraft, to include in their check lists, the statement "ELT ARMED" in the preflight section and "ELT OFF" in the shutdown and parking section. (Class III - Longer Term Action) (A-78-12)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ KAY BAILEY
Acting Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ JAMES B. KING
Member

January 26, 1978

APPENDIX A

TECHNICAL PAPERS, COMMUNICATIONS, AND GENERAL ARTICLES

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