The Use Of Deployable Flight Recorders in Dual Combi Recorder Installations

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INTRODUCTION

Flight Data Recorders (FDR's), Cockpit Voice Recorders (CVR's) and Emergency Locator Transmitters (ELT's) have been combined into a single deployable unit and used successfully on military aircraft for decades. Their proven survival strategy, of deploying away from the aircraft and hence the crash site**,** allows for quick location and economical recovery of recorder information, particularly in marine incidents, where the floating recorders can readily be retrieved from the surface of the ocean.

Changes in the needs of accident investigators, and in aircraft use, application, performance monitoring, routing, and avionics have resulted in the current initiatives underway to revise aviation recorder standards. The deliberations of EUROCAE Working Group 50 and the discussions of the group preparing the new AEEC standard of ARINC 767 are airing some radically new concepts in flight recorder requirements and configurations. These include the use of a pair of redundant recorders each storing both Cockpit Voice, Flight Data, and requirements for digital communications and video storage.

In this process of reviewing, revising and adding to airborne recorder standards, there is reason to evaluate the use of deployable recorders on civilian aircraft. An opportunity has arisen for the use of a deployable recorder as the alternate recorder in dual redundant recorder installations. This combination of recorder memory media protection schemes would provide the best of both worlds of fixed and deployable survivability strategies.

As the new EUROCAE specifications pass from embryonic concepts to regulation it is important that matching airworthiness standards levied by the FAA, JAA and other authorities continue to include standards for deployables. Definition and regulation of requirements for deployables, such as those included in the performance specifications being drafted by Working Group 50, would allow the option for the use of a fixed and deployable combined recorder installation on civil aircraft.

DEPLOYABLE RECORDERS AND BEACONS

The deployable recorder is an alternative concept to the survivability design of airborne recorder systems, which would include Flight Data Recorder and Cockpit Voice Recorders (CVR/FDR) technologies. The CVR/FDR must survive highly destructive forces over a broad range of accident scenarios. The conventional "fixed" or crash hardened design concept is an ATR type container constructed to withstand

the severest crash scenarios while installed inside the airframe. This construction endures severe impact, fire, and other forces of a crash by enclosing the recorder memory medium in a protective enclosure. These units are installed toward the rear of the aircraft in order to "ride through" an accident.
The deployable design concept has the recording medium housed within an assembly (the beacon) which deploys and falls away from the aircraft thus avoiding the crash environment. One conventional means of accomplishing beacon deployment is to place the recording medium in an aerodynamic lifting body or airfoil which is affixed to the exterior of the airframe. Crash sensors activate a release mechanism which automatically releases the airfoil during an accident, delivering it safely away from the aircraft impact site. This same concept is also used with some classes of Emergency Locator Transmitters, with the primary objective being the rapid identification of an accident site and quick recovery of survivors. A deployable CVR/FDR recorder typically includes an ELT to provide an alert to Search and Rescue authorities of the crash and to allow homing in to the distress signal frequency and thus allowing the finding of the crash site and the recorder. The high location identification precision of 406 MHZ GPS position encoding equipped units allows identification of the beacon position to within a 25 meter accuracy.

The objective is for each type of recorder to achieve maximum survivability of the recorded information. Survivability of the memory storage media ensures that the information is retained and the consequent analysis of this data allows corrective action be taken to prevent accidents recurring and improve the safety of future aircraft operations.

HOW DEPLOYABLES STARTED

In the early 1960's, concerns were raised in Canada on the means available for the location of downed aircraft in the vast and remote parts of its country. A study by the National Research Council of Canada suggested that some form of detachable and automatically activated ELT system would be desirable. A patent was issued for the concept of an airfoil attached to the skin of an aircraft which, when deployed at impact, entered the airstream and attained high lift allowing it to clear the airframe and then tumble to a much less severe impact away from the accident site.

Figure 1: DFIRS Deployable Airfoil For F/A18

Subsequently deployable systems were developed for a wide variety of fixed and rotary wing aircraft types ranging from small general aviation aircraft to large transports. During the 1970's, for example, the U.S. Air Force operated over 3000 aircraft with deployable systems. Similar systems were also developed and fielded for use on helicopters and were later adopted as part of a CAA mandatory requirement on helicopters operating offshore, typically in North Sea oil operations. In parallel with the deployable ELT development, at that time concerns were being expressed about the survivability and recoverability of existing fixed FDR and CVR systems, since many recorders were either totally destroyed or never recovered after an accident. Consequently, the solution of placing the FDR / CVR recording system inside the deployable airfoil unit was adopted. Technology advancements permitted installation of such a capability on high performance fighters such as the F-104, Tornado and F/A-18.Refer to Figure 1. The introduction of new materials and aerodynamic analysis has allowed deployable systems to become smaller, lighter, and less expensive; but of greatest benefit is increased reliability and survivability of the system.

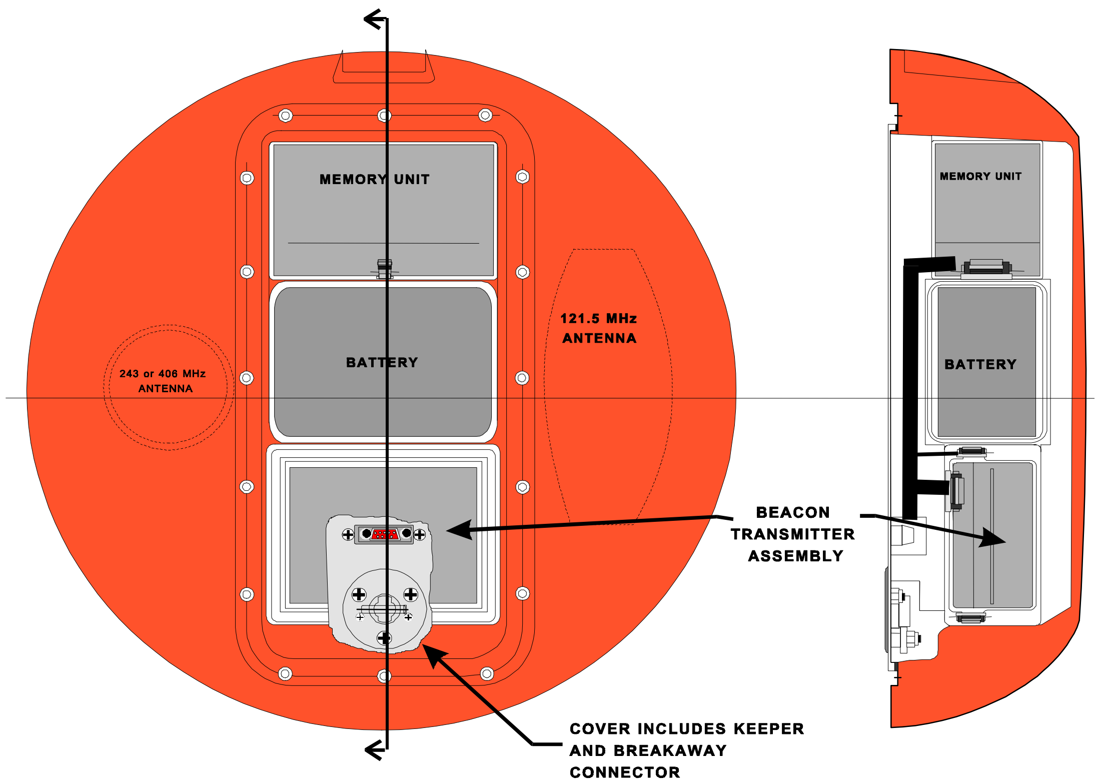


Figure 2: Internal View of Deployable For Use On Helicopters

DEPLOYABLE RECOVERABILITY

The purpose of a combined FDR/CVR/ELT is to provide survivable and recoverable information while at the same time providing immediate notification and location of the accident site for Search and Rescue operations. Location and recovery of a fixed crash hardened system is frequently difficult, time consuming and expensive, particularly in water. Valuable time can be lost when a conventional emergency locator transmitter is either not being carried in the aircraft or fails to operate.

In many deep water accidents, even with an underwater acoustic locator beacon installed, location and recovery is complicated as well as expensive. There are many cases where tremendous effort and resources have been expended over many months to locate aircraft wreckage and recorders. In many instances, nothing was ever recovered.
A deployable CVR/FDR/ELB system addresses and solves all of these concerns. In crash investigations

to date using deployables, in greater than 95% of the cases deployable systems have been recovered in pristine condition or with only superficial damage. In situations such as impact at a high angle of incidence, where the time from initiation of deployment to impact of the airfoil is reduced, the airfoil also includes conventional crash survivability protection means allowing it to be able to withstand high levels of fire and impact. Whatever the scenario, the deployable package is mounted on the exterior of the airframe and actual experience has demonstrated that it remains at the outer edges of the crash site, significantly reducing exposure to the crash environment.

ACTIVATION

Deployment is typically initiated by a sensor system that is activated by impact or immersion in water. Frangible switches can be located in critical areas of the airframe and provide the deploy command upon deformation as the aircraft begins to crush at impact. A hydrostatic pressure switch will initiate the deployment when the aircraft sinks following a soft ditching when no frangible switches have broken. The sensors provide a signal to the release mechanism so enabling deployment. Under normal operation this mechanism secures the deployable unit to the aircraft. The beacon transmitter is automatically activated upon initiation of the deployment sequence.

DEPLOYMENT

The DRS design involves one of the airfoil attachment points being released by a low energy gas pressure cartridge that permits a small spring to begin moving the airfoil away from its mount. The airfoil then uses the energy imparted by the airstream to continue releasing. This allows deployment in a benign manner during normal operation. Upon automatic release, the deployable airfoil unit assumes its own flight characteristics independent of the aircraft. The airfoil immediately begins to decelerate to an impact level well below that of the impacting airframe. With fixed wing aircraft, depending on attitude and airspeed, the airfoil may fly several hundred feet before landing. For helicopters, it will tumble away and land outside, or on the periphery of the impact site. When in water the airfoil will float indefinitely. In all cases its highly reliable transmitter will broadcast a radio distress signal regardless of where it has come to rest.

DEPLOYABLES	**FIXED-ON BOARD**
Radio beacon locator capability	Underwater pinger only - no locator on land
Ease of recovery on land - survives impact away from wreckage	Requires additional time to remove from wreckage
Ease of recovery on water - airfoil floats	High cost of underwater recovery - if located
Weight advantage - lighter	Weight disadvantage

Table 1: Advantages of Deployable over Fixed On-board Recorders

UPCOMING CHANGES IN FLIGHT RECORDER STANDARDS

The current discussion on changes in desired flight recorder standards opens the forum for alternate applications of the deployable recorder concept. The ICAO meeting in Montreal in November 1998 made a number of recommendations on changes to recorder performance that ICAO would require its member countries to adopt over the next decade. These changes, along with others currently in place, will inevitably require aircraft operators to upgrade or replace their existing flight recorder systems. The following table outlines the nature and timing of the changes being planned

Authority	**Change**	**Planned Implementation Date**
ICAO	Recording of Digital Communications	Jan 1 2005
ICAO	Self contained 10 minute backup power supply for CVR Area channel	under review, 2005 estimated
ICAO	Two Hour CVR's standard for new aircraft	Jan 1 2003
ICAO	Video recording capability	under review
ICAO	Magnetic tape recorders to be phased out	2005
NTSB	Use of dual combi recorders with above features (less video) on new aircraft	Jan 1 2003
NTSB	Retrofit of all aircraft to use of dual combis with above features (less video)	Jan 1 2005
EUROCAE	Preparing replacement of ED 55 and 56A with single new MOPs including video and digital message recording	To be determined, approximately 2005
AEEC	Preparing new standard ARINC 767 for dual combined recorder	To be determined, approximately 2005
FAA	Part 121 revision to DFDR systems, 88 parameters	Aug 19 2002 on new aircraft

Table 2: Upcoming Changes to Standards

In this environment of change, which could result in a potential requirement to upgrade or replace thousands of recorders, the various authorities are reviewing every aspect of FDR and CVR requirements to ensure that the ensuing generation of recorders will better meet the needs of investigators. At the same time they recognise the need for the changes to be affordable to aircraft operators.

One observation that can be made is that due to the nature of the process changes are, by in large, reactive to recent incidents, and it is difficult to put in place requirements for anticipated occurrences, however likely, if there is not the precedence of an actual example incident.

THE DUAL COMBINED RECORDERS CONCEPT

The use of two combined "dual combi" recorders including CVR and FDR capability is being recommended by ICAO for use on new aircraft in the "medium term". Combined recorders are currently built to meet the recorder requirements of large helicopters and it is generally acceptable by airworthiness authorities to use two combined recorders on fixed wing aircraft, where one meets the regulatory requirements for a CVR and the other, for FDR. Figure 3 shows a block diagram of a dual combi installation using a common data acquisition unit and two multi-purpose recorder memory modules.

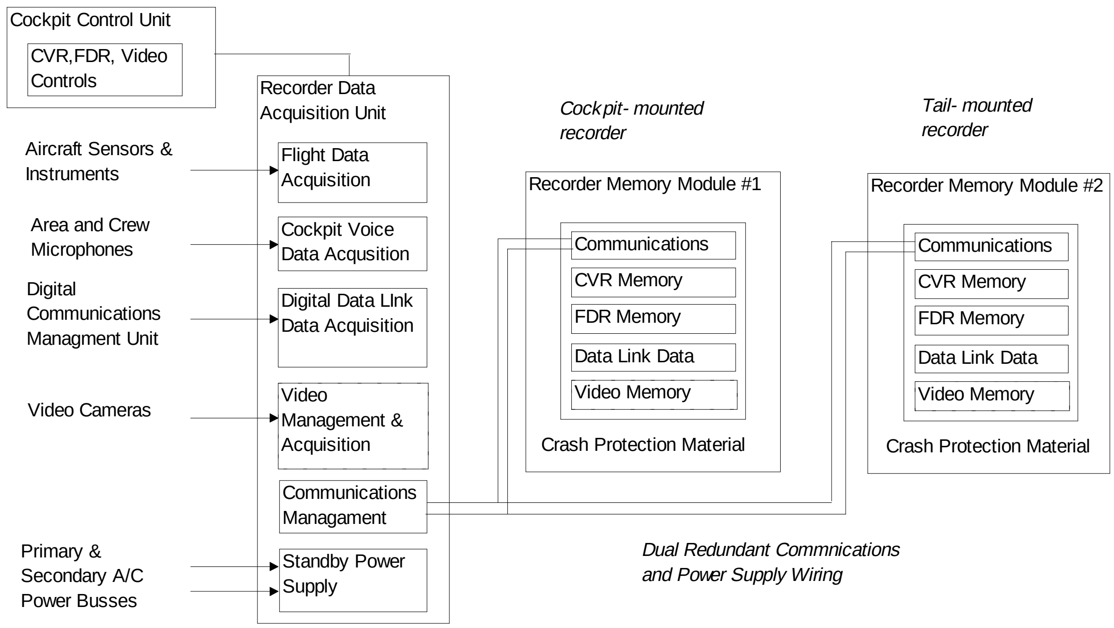


Figure 3: Dual Combined Recorder Block Diagram

EUROCAE WORKING GROUP 50

EUROCAE Working Group 50 is in the course of preparing a new standard to align the requirements of ED-55 with ED 56A. ED-55 is the Minimum Operational Performance Specification for Flight Data Recorders, which is the foundation document for both European and north American Flight Data Recorders. This new document will also replace ED-56A, the Minimum Operational Performance Specification for Cockpit Voice Recorders.

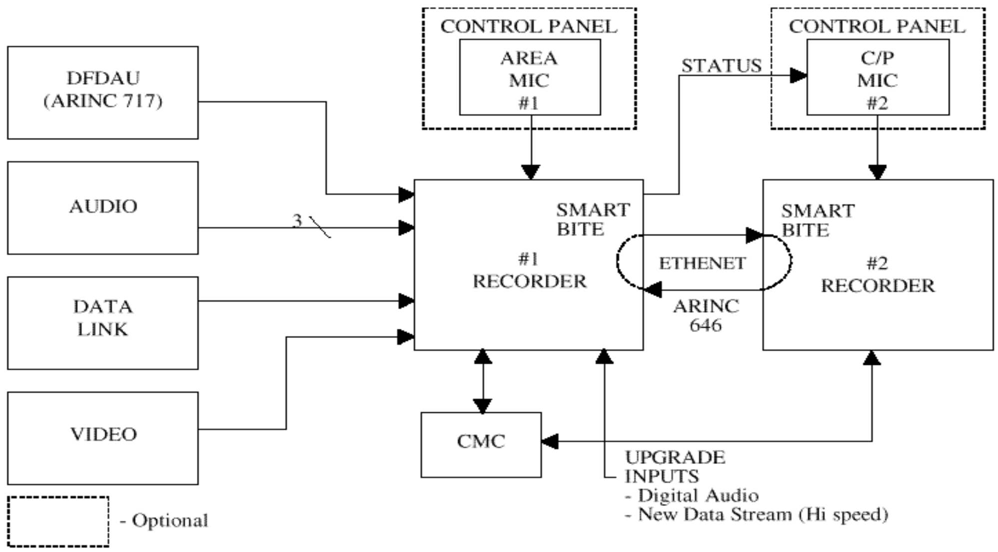
The new document will integrate the two requirements and will add the requirements for cockpit video recording and recording of digital message communications to and from the aircraft. The document will include a section defining the environmental and survivability requirements for the memory medium, which will apply regardless of what type of data is stored in it. It will also include requirements for deployable recorder performance.

The document will also reflect the recommendations of ICAO and FAA in terms of enhanced record times, additional power supplies, and enhanced FDR parameter sets.

THE AIRLINES ELECTRONIC ENGINEERING COMMITTEE DFDR PROJECT PAPER 767

The Airlines Electronic Engineering Committee Digital Flight Data Recorder (DFDR) subcommittee is now working on Project Paper 767, for a Digital Data and Voice Recorder (DDVR). They are now preparing their second draft of this standard, first released in March, 1998. The AEEC have considered it timely to prepare an entirely new standard for Flight Data Recorders, and for the first time in decades are proposing a radically new architecture that is not an enhancement of previous standards and largely reverse compatible to existing installations. Although the AEEC does not set standards for recorder performance or survivability their specification of recorder architecture and interfaces profoundly influences the industry.

The draft ARINC 767 architecture includes two data storage modules where primarily CVR and FDR data is stored, but potentially also video and data linking information. Figure 3 shows one concept proposed by the sub-committee for the ARINC 767 recorder architecture.



Proposed Data and Voice Recorder Architecture

Figure 4: Draft ARINC 767 Recorder Architecture

INTEGRATED DEPLOYABLE AND FIXED COMBINED RECORDER SYSTEMS

It is planned that dual combined recorder systems will achieve enhanced survivability by locating one recorder in the cockpit area and the other towards the rear of the aircraft. The rational for this being based on observations at crash sites where it has been rarely seen that both sections of the aircraft receive the brunt of a crash impact.

The integrated deployable and fixed recorder concept would have the tail recorder provided with the ability to deploy from the aircraft under certain ejection criteria, the primary one being the immersion of the recorder in water below a certain depth. This release capability would facilitate the prompt recovery of the recorder in the event of an over water crash event. The standards for the fixed and deployable components of the system should be compatible to optimize the probability of recovery of recorder information from one of the two systems under any conceivable crash scenario**.**

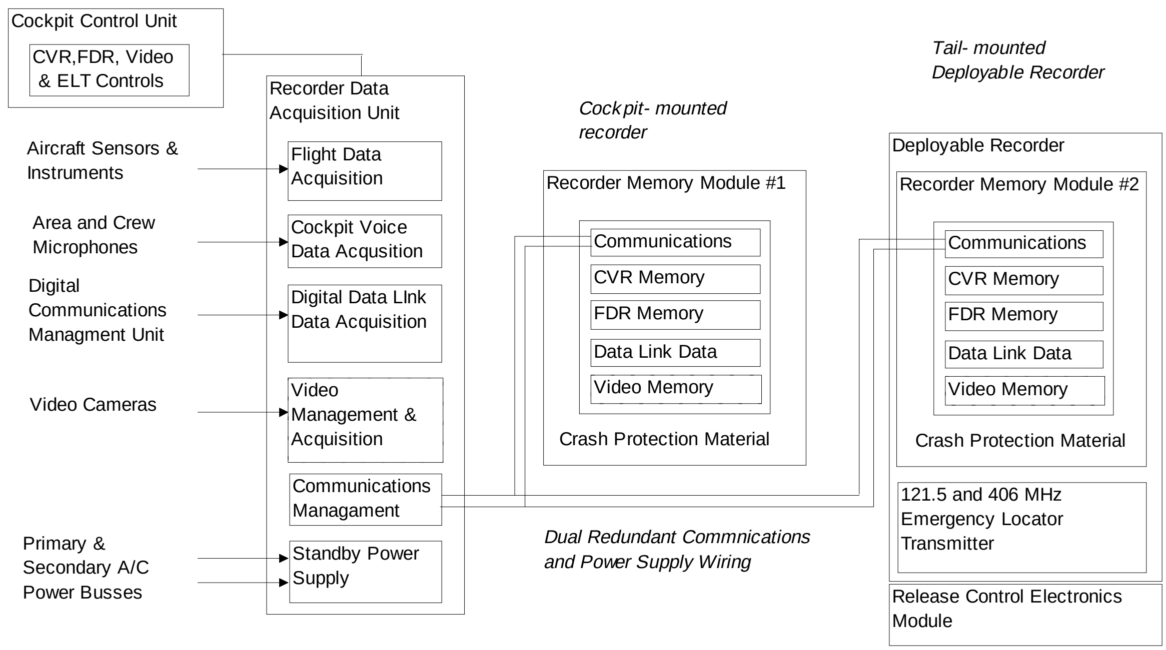


Figure 5: Integrated Deployable and Fixed Airborne Recorder System

NEW REASONS FOR DEPLOYABLE APPLICATIONS

The following provides examples of why the use of deployable recorders need to be considered in light of new developments in air travel and accident investigation.

THE NEED FOR PROMPT ACCESS TO RECORDER DATA

A number of recent major air tragedies in North America have resulted in the loss of aircraft in ocean or swamps, and recorder recovery has taken from days to months:

Incident	Nature of crash
ValuJet Flight 592	Swamp impact
TWA flight 800	Midair explosion over the ocean
Swissair flight 111	High speed impact with ocean
Air india	Midair explosion over the ocean
Korean Airlines	Shot down into ocean
Dominican Republic	Impact into ocean

Table 3: Recent Ocean Incident Recorder Recovery Times

The slow recovery of recorder information, in some instances, has resulted in a lot of pressure being placed on authorities while awaiting recorder retrieval. In turn demand for corrective measures has arisen, some typical concerns being:

What if the event had been a terrorist incident?

> The nature of terrorism is that it tends to be repeated, and is vital that any possibility of its occurrence be confirmed promptly and appropriate measures be taken. For some time after the TWA event there was intense speculation as to its cause. The prompt recovery of recorder data, which would have been more likely with a deployable in a maritime incident, could have made a significant difference to the investigation. Had the cause of the accident really been terrorism prompt recovery of the recorder could have confirmed this and allowed authorities to take preventative measures.

If it takes several days to recover a recorder, is there a possibility of one being utterly lost?

> One can imagine cases such as a midair breakup over deep ocean where the exact location of the aircraft is difficult to track and ensuing debris is dispersed over a wide expanse of ocean several miles deep. Recovery of recorders could be quite difficult, especially if the bottom was muddy. If the search extended beyond the 30 day lifetime of the ultrasonic locator beacon the the recorders might never be found. There comes a point where sifting the mud of several square miles of deep ocean floor is simply impossible. Other similar scenarios can be imagined, where a floating recorder with a built in locator beacon is much preferable to a lost one.

INCREASED AIR TRAFFIC INCIDENTS AND INVESTIGATION COSTS

A major aircraft manufacturer predicts that air accidents will reach the rate of one a week in the near future simply as an extrapolation of increases in air traffic. Although it is also the goal of airworthiness authorities to proportionally improve statistical air safety, it will remain to be seen if this is achieved.

These additional incidents will put a higher work load on air accident investigation authorities. Already, due to limited budgets, investigators regularly choose not to investigate some minor events. To date it is rare that compromises are been made between full investigation and none at all. However the ready access of a floating recorder may allow the adoption of a compromise policy where, in the case of certain types of well understood accident, the recorder is recovered but the wreckage is not. The availability of a floating recorder may then save the authority , and in turn taxpayers, the multi million dollar bill for recovering equipment off the ocean floor.

This latter approach is currently favoured by some military authorities, where in the case of a fighter aircraft pilot ejecting from his aircraft for known reasons, the ready availability of the recorder data can provide a formal record of an incident and economically provide closure to it.

FREE FLIGHT

The concept of Free Flight, where aircraft no longer adhere to prescribed routes but choose the most direct or economical route between two points, probably to be introduced in the middle of the next decade, will result in increased air traffic over the poles and other inhospitable areas of the globe where finding the location of an air incident may be much more difficult. There will be an equally significant need for ensuring the timely identification of the crash location to enable the provision of speedy medical aid to help survivors.
The nature of a deployable recorder is that it includes a built in Emergency Locator Transmitter which has,

due to the higher crash survivability requirements of the recorder, much better protection than normal and consequently is better assured to operate in adverse conditions.

As previously mentioned, the survival record of non-deployable emergency locator transmitters is disappointing. NASA and NTSB data shows an overall effectiveness of only 20%-25% for these systems, largely due to damage during crashes. Fixed emergency locator transmitters can suffer significant transmitter attenuation (up to 20 dB), and antenna pattern nulls due to unpredictable crash debris. In contrast, the deployed beacon airfoil containing the emergency locator transmitter travels away from the immediate crash site, providing better homing and more reliable signal for SARSAT and SAR reception. Accordingly, with accidents occurring in more severe environments there is greater reason to both increase the ease of obtaining the accident information, but more importantly provide better assurance of rescue to the survivors through the deployable ELT. Air Accident Investegators have the mandate to investigate crashes, but airworthiness authorities have the larger mandate to ensure the best package of safety measures is provided to the public.

SETTING THE STANDARD FOR THE FIXED AND DEPLOYABLE COMBINED RECORDER SYSTEM

The inclusion of requirements for deployables in the WG 50 MOPS sets a standard that needs to be reviewed by international airworthiness authorities, particularly with the respect to deployable use on large helicopters and dual combi fixed wing applications. Understanding the implications of these standards, and obtaining international agreement on them, will ease the way towards their formal incorporation in airworthiness regulations.

It is likely that a deployable recorder used in a dual combi installation would need to meet the full functional and environmental requirements of a fixed recorder. However some deployable specific issues need to be addressed in any regulation, reflecting the nature of the system as a combined CVR, FDR and ELT, such as:

- -The need for additional ELT endurance in a combined system
- -The replacement of the ULB function with that of the ELB
- -The conditions for release of the deployable
- -The need for the deployable to capture the last milliseconds of flight
- -Deployable crash survivability requirements

Until recently, international Minimum Operational Performance Standards (MOPS) and Type Standard Orders (TSO’s) included specific requirement for deployable recorders. Unfortunately the recent update of TSOC124 to 124a dropped its applicability to deployables by including the requirements of ED 56A, which again excluded deployables. The following table summarizes the applicability to deployables of recent regulation:

Organization	Standard	Addresses	Applicability to Deployables
FAA	TSO C91a	121.5/243 ELT’s	Included
	TSO C123	CVR	Included
	TSO C123a	CVR	Not Addressed
	TSO C124	FDR	Included
	TSO C124a	FDR	Included (intent requires confirmation)
	TSO C126	121.5/406 ELT’s	Included
EUROCAE	ED 55	FDR	Included
	ED 56	CVR	Included
	ED56A	CVR	Specifically not addressed
	ED 62	121.5/243/406 ELT’s	Included
	WG 50	FDR/CVR	Included
RTCA	DO-183	121.5/243 ELT’s	Included
	DO-204	121.5/406 ELT’s	Included
TCA	SCA 96-03	CVR, FDR, ELT	Included

Table 4: Applicability of Current Recorder Standards to Deployable Systems

CONCLUSION

The deployable recorder is a proven flight safety system. The adoption of a dual combined recorder system as the standard for commercial transport aircraft provides for a wider application for deployable recorders as the alternate recorder in these combined systems. This combination of technologies if correctly adopted could provide unsurpassed survivability of recorder information along with prompt access to it.

The draft MOPS to be produced by WG 50 does include the requirements for deployable recorder systems, and for reasons of improved recorder recovery and passenger safety it is important that international parties such as the NTSB, FAA and CAA review these requirements, and include provision for deployables in upcoming FAA TSO’s and European JARs.

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BIOGRAPHY

Rob Austin is the Senior Systems Engineer at DRS Technologies Canada, and was instrumental in the development of an integrated deployable combined CVR/FDR/ELT system for use on civil helicopters and military fixed wing aircraft. He has worked closely with Transport Canada airworthiness (TCA), the UK Civil Aviation Authority (CAA), the UK Air Accident Investigation Branch (AAIB), and the Canadian Transportation Safety Board (TSB) in the development and implementation of deployable recorder standards.