TECHNOLOGY WHITEPAPER

Utilizing Flexible FDR Architectures to Meet Upcoming Regulations

CURTISS-WRIGHT

DEFENSE SOLUTIONS

Read About

History of Flight Data Recorders

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ED-112A

Introduction

Flight Data Recorders (FDR), also commonly known as “black boxes”, are valuable tools for authorities to help increase flight safety. Since their inception, FDRs have provided information to investigators after a critical event; however, various incidents over the years have highlighted shortcomings in their design. These incidents have helped shape regulations that have improved the survivability of FDRs and the ease of locating them. Technology changes have also enabled new paradigms for data delivery, in particular the relatively recent phenomenon of Wi-Fi availability on aircraft enabling data streaming to ground.

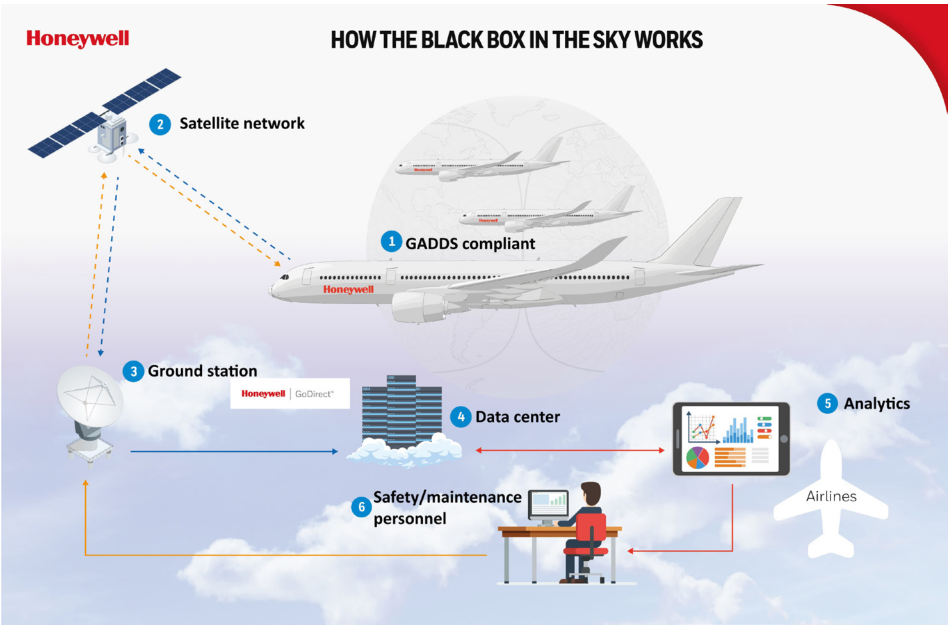

Figure 1: The Honeywell HCR-25 is an example of a next generation FDR system that meets the latest regulations and can stream data to the ground
(Image: Courtesy of Honeywell)

FDRs often need modification to meet a particular aircraft’s interface requirements or to accommodate additional data for other applications. This presents a challenge for FDR manufacturers, as designing an FDR to international standards of crash survivability is a very difficult task. Modifying legacy products to meet new regulatory requirements or individual aircraft needs can be costly and difficult to justify for large OEMs who are more focused on system solutions. This white paper details the requirements for an FDR, how they can be built and how Wi-Fi enabled aircraft can be used to stream FDR data.

History and Evolution of FDRs

The first FDRs came into use in the 1930s for test flights, to preserve data in the event of an incident. More modern recorders emerged during World War II and in the 1950s companies began manufacturing devices that could also record audio. In 1953, Australian Scientist Dr. David Warren conceived the idea for the first black box, developing a prototype in 1958, while investigating a jet-powered commercial aircraft. In 1955, Curtiss-Wright (then Penny & Giles) developed its first FDR, followed by the first aircraft accident recorder based on magnetic recording.

Figure 2: FDRs have evolved over the years from wire-based to solid-state systems

Regulations governing FDRs have been in place for a long time, generally evolving from the need to understand why an incident occurs so that such scenarios could be avoided in the future. The process of developing these regulations began in the 1950s with the Munich air disaster, an incident which took 10 years of investigation to reach any conclusions on, and continues today because of incidents like the Malaysian Airlines MH370 disappearance. Table 1 shows how, over the years, different technical standing orders (TSO) have introduced new regulations to ensure FDRs can cope with certain levels of hazard.

The class of an aircraft defines whether or not it must have an FDR and if so, what FDR functionally is required. Table 2 outlines which operating regulations an aircraft is subject to. For example, a transatlantic airliner is a Part 23 craft subject to Part 125 regulations, as it is a commuter craft that exceeds 6,000 lb in weight and has more than 20 passenger seats. This means it currently requires a 25-hour FDR and a two-hour Cockpit Voice Recorder (CVR), although this will change in line with the upcoming 2021 EASA minimum 25-hour cockpit voice recording mandate.

TABLE 1:	Regulations						
TSO / HAZARD	C51	C84	C51A	C123/C124	C123a/C124a	C123b/C124b	C123C/C124C
Effectivity Date	1958	1964	1966	1992	1996	2010	2015
MOPS	TSO-C51	TSO-C84	TSO-C51a	ED-55 / ED-56	→	ED-112	ED-112A
Impact Shock	100g	→	1,00g, 5ms	3,400g, 6.5ms	→	→	→
ULB Sheer & Tensile Strength	X	X	X	X	X	X	6000lb in each direction, 1 min
Penetration Resistance	X	X	500lb, 10ft, 1/4" Spike	→	→	→	→
Static Crush	X	X	5,000lb, 5 min / face	→	→	→	→
Fire Resistance	1100°C, 30 min 50% coverage	→	→	1100°C, 30 min, 50% coverage, 50,000 BTU/Hr/ft^2	→	→	→
Heat Resistance	X	X	X	X	10 hrs @ 260°C	→	→
Deep Sea Pressure	X	X	X	20,000ft, 24 hrs	→	→	→
Salt Water Corrosion	48 hrs	36 hrs	30 days	9ft, 30 days	→	→	→
Corrosive Fluids	X	X	Specified fluids, 24 hrs	→	→	→	→

Table 1: Regulations have changed over the years since the introduction of C51 in 1958

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TABLE 2: Operating Regulation

Airworthiness Standards Part				PART 91	PART 121	PART 125	PART 129	PART 133	PART 135
				General Operating and Flight Rules, all craft except Ultralight	Operating Requirements: Domestic, Flag, and Supplemental	Certification + Operations: 20+ seats or, TOW >2730kg	Foreign Air Carriers + Ops. Of U.S. Reg. Craft Engaged in Common Carriage	Rotorcraft External-Load Operations	Operating Requirements: Commuter and On Demand Operations
	23	Normal, Utility, Acrobatic and Commuter (NUA) Airplanes	(NUA): < 9 seats, TOW < 5700kg	> 6 passenger seats = 2h CVR	Turbine engine craft 2h CVR; > 25,000ft 25h FDR	NA	As part 121, 125 or 135	NA	> 6 seats = 2h CVR
			Commuter: < 19 seats, TOW < 8600kg	As above; > 10 seats = 25h FDR		> 6,000lb, 25h FDR; 2h CVR			> 10 seats = FDR > 6 seats = 2h CVR
	25	Transport Category Airplanes	Not classified NUA						
	27	Normal Category Rotorcraft	< 9 passanger seats, TOW < 3180kg	> 6 seats = 2h CVR	NA	NA	FDR and CVR regulations match Part 135	NA	> 6 seats = 2h CVR
	29	Transport Category Rotorcraft	Category A: > 10 seats, TOW > 9090kg	> 10 seats, 25h FDR > 6 seats = 2h CVR					> 10 seats, 25h FDR > 6 seats = 2h CVR
			Category B: > 9 seats, TOW > 9090kg	> 6 seats = 2h CVR					> 6 seats = 2h CVR

Table 2: Different aircraft need to meet certain regulations depending on the category of aircraft and how it is used

Improving Safety Today

When Malaysian Airlines MH370 disappeared in 2014, only a few years after the loss of Air France AF447, various agencies made recommendations into the International Civil Aviation Organization (ICAO). The ICAO then called on a working group from the International Air Transport Association (IATA) to put a study paper together. The fact that details of MH370's disappearance are still unknown, coupled with the recovery of AF447's FDR having taken nearly two years following its crash in 2009, revealed significant weaknesses in aircraft safety and post-event analysis.

This group assigned to investigate the issue, dubbed the Air Tracking Task Force, returned a report that resulted in the ICAO releasing recommendations for a Global Aeronautical Distress Safety System (GADSS). A key aim of this system is to maintain an up-to-date record of an aircraft's progress. In case of a crash, forced landing or ditching, the system would provide the location of survivors, the aircraft and recoverable flight data. This mandate includes a performance metric that, for certain classes of aircraft, means a tracking system must be installed.

This tracking system has two modes: routine and abnormal tracking. The routine mode sends reports on a periodic basis (<15 minutes), whereas the abnormal tracking sends reports to an emergency response group if certain conditions are encountered, such as a high bank angle in the cruise or other abnormal flight patterns. The details of how this system is implemented aren't mandated but, overseas at least, it's likely that communication will require the use of satellites. This could be relatively simple to implement, given the growing adoption of Wi-Fi availability on aircraft in response to consumer demand. It could become standard to have every aircraft streaming all the data that would go to an FDR to an operations center.

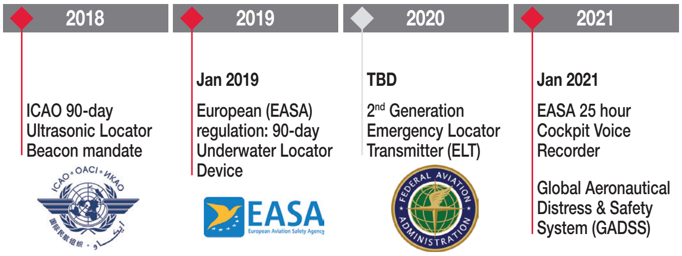

Figure 3: In the next few years, the regulations being introduced are aimed at more rapidly and reliably locating aircraft and their FDRs

There is another route to achieving this second recommendation: using a deployable recorder that can be launched from the aircraft in the event of significant disruption. Such a recorder needs to be fitted with a so-called second generation beacon that transmits at frequencies that can be picked up by Cospas-Sarsat satellites. This will alert first responders to the fact an incident has occurred, thus enabling them to quickly get to a location where survivors can be rescued. However, there are concerns that deployable recorders will have a high false launch rate. Given the number of aircraft trips, even a low failure rate could result in several false launches a year. Each false launch would carry a high risk of injury or damage given, an FDR by design is a compact, relatively heavy and strong object.

In the future, an always-on data streaming capability could be commonplace. This would provide accident investigators with immediate access to data that identifies the location of an incident and allows them to assess what occurred, dramatically reducing the time it takes to locate the aircraft. It also benefits aircraft owners, operators and manufacturers with options to help decrease aircraft downtime through better predictive maintenance. Such ideas have been floated before, but costly satellite access has limited the desirability of this option. As more and more aircraft connect to satellites to offer Wi-Fi services to customers, data streaming may too become commonplace.

Meeting Regulations and Modern Aircraft Needs

FDR design has not changed significantly over the last 15 years, with the exception of the memory technology inside the box. Manufacturers are still using the same sort of materials, and all FDRs on the market are similar in high-level design. Solid-state memory is encased in thermal protection, which is contained within a mechanically resistant case. The challenge in manufacturing FDRs lies in making sure everything is designed in the right proportion to survive various rigorous tests (some of which are outlined in Table 3), while providing a competitive product. It is also worth pointing out that not all FDRs have to be made to meet standards such as ED-112A; for example, various military applications don’t necessarily look to meet commercial standards.

EUROCAE ED-112A Environmental Tests	
Fire intensity	High: 1100° C for 60 minutes Low: 260° C for 10 hours
Impact shock	3,400 G for 6.5 ms
Penetration resistance	500 lb from 10 ft ¼ inch contact point
Static crush	5,000 lb for 5 mins per axis
Shear/Tensile strength	6,000 lb for 1 minute each axis 1
Fluid immersion	Immersion in aircraft fluids for 24 hr
Water immersion	30-day sea water
Hydrostatic pressure	Equivalent to depth of 20,000 ft

Table 3: Some environmental tests an FDR must pass to meet EUROCAE ED-112A

An FDR must be designed to work reliably for a long period of time in an aerospace environment, possibly up to 20 years. Such long-term reliably calls for the unit to withstand long-term exposure to environmental factors such as temperature changes, vibrations and shocks. Software is also a consideration, as it too must be proven reliable. Failures during this reliability phase also require complete reliability re-testing once fixes have been made.

Even deeply experienced manufacturers will likely find problems with their designs during testing and will need to adjust and retest several times during the evolution of a product. This process is very costly, and is why meeting new regulations or making FDR alterations to meet specific aircraft needs can be difficult to achieve. Because of the challenges associated with creating or altering an FDR that meets stringent international standards, it is best achieved by specialized companies rather than OEMs or Tier 1 solution providers, whose competencies generally lie more at the system level.

Creating a Cloud in the Sky

Honeywell and Curtiss-Wright have long been pioneers and innovators in crash protected recording, providing FDRs to the industry for over 60 years. Curtiss-Wright's latest FDR development is called Fortress. Fortress was designed to be as compact and lightweight as possible while meeting current and anticipated regulations (such as a 25 hour CVR), as is optimized for rapid reconfiguration to accommodate different interface and data acquisition requirements.

Figure 4: At the core of the Fortress is the Fortress crash protected memory module (CPMM)

Honeywell has been working to provide aircraft owners, operators and manufacturers with new voice and flight data recording options to help decrease aircraft downtime through better predictive maintenance and, in the unlikely event of an emergency, help with the subsequent investigation. To support this mission, Honeywell sought a modern FDR that would fit its needs and meet upcoming regulations, such as the 2021 European Aviation Safety Agency minimum 25-hour cockpit voice recording mandate.

Working together, Honeywell and Curtiss-Wright have developed the next generation of recorders that leverage their extensive hardware and software expertise to meet the EASA 25-hour CVR requirement and the recommendations for GADSS. Providing operators with real-time data streaming and cloud-upload capabilities enabled by Honeywell's Connected Aircraft software, these innovative recorders will serve as a "Black Boxes in the Sky". Owners, operators and manufacturers will have the option to access the data at all times, resulting in the potential for better maintenance predictability and operational insight through data analytics. In addition, in the event of an emergency, the data on board will be quickly accessible to investigators – meeting the needs of the upcoming GADSS recommendations.

Along with added connectivity, these next-generation recorders provide an easy upgrade path that reduces installation time and lowers costs due to their design as form-fit replacements for Honeywell's HFR-5 series cockpit voice and flight data recorders. Curtiss-Wright recently certified its 25-hour CVR/FDR Fortress recorder that is used as the foundation for the new Honeywell Connected Recorder-25 or HCR-25. This means it meets the January 2021 mandated requirements now so no further changes are required closer to that date.

As part of the development of the new recorders, Honeywell will offer the product in several variants, including as a standalone CVR, as a standalone FDR, or as a combined voice and flight data recorder.

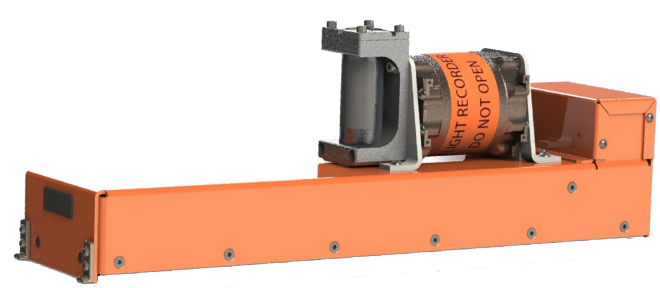

Figure 5: Honeywell's HCR-25 contains Curtiss-Wright's latest FDR technology to provide a 'black box in the sky'

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Conclusions

FDRs have helped improve aviation safety standards since their introduction in the 1950s, providing vital information on thousands of variables including fuel levels, altitude, engine performance, temperature, direction and speed. This ensures that, in the event of an accident, investigators can use the data to learn more about the chain of events leading up to it.

FDRs evolve over time to meet new regulatory mandates and to exploit new technologies. Recent incidents have highlighted the need for better methods to locate and retrieve information in the aftermath of an accident to extract this vital information (outlined in the GADSS recommendations).

Honeywell and Curtiss-Wright have teamed up to meet these challenges, leveraging over a hundred years of combined expertise in the FDR market to design an entirely new way for airlines to monitor and analyze flight data. By combining the most advanced FDR technology on the market with an advanced connectivity solution, Curtiss-Wright and Honeywell are providing operators to 24/7 access to critical aircraft data. This unprecedented level of availability enables improved maintenance and operational insight through data analytics, and proactively supports upcoming regulations, such as GADSS and 25-hour CVR time.

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