Simplified Replacement of Older Flight Data Recorders to Meet New Regulations and Data Collecting Needs

Read About

Introduction

For decades, Flight Data Recorders (FDR) have helped accident investigators determine the cause of accidents. Throughout their history, FDRs have changed to meet new regulations that better aid FDR survivability, locatability, and to provide more information to investigators and authorities that can result in changes to aircraft construction or operations.

Operators of aircraft may find they need to upgrade existing FDRs for a variety of reasons including meeting new regulations, obsolescence issues, reducing size, weight, or power (SWaP), or to gather additional data. Whatever the reason, a key concern will be how best to replace the existing FDR as quickly and easily as possible.

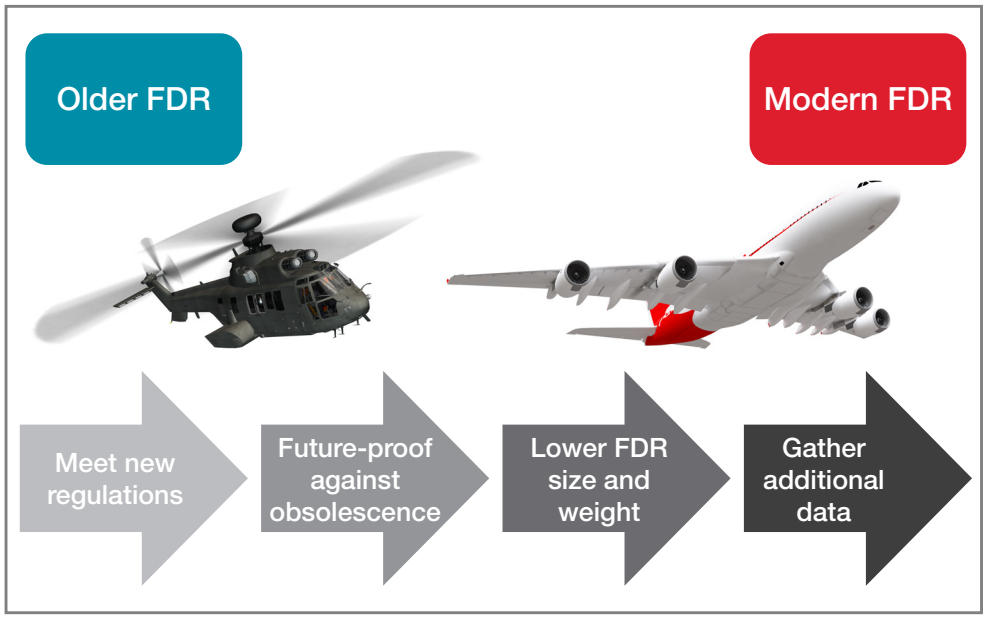

Figure 1: Modern FDRs provide a host of benefits over older models

The procedures that must be followed in order to change one FDR for another depend on the recorders and the needs of the aircraft. This document discusses why one may decide to upgrade FDRs and uses a specific case to discuss the benefits of modern FDRs and the replacement procedures. While this is specific to certain recorders, the principles and steps are similar for any other FDR combination.

Motivations for Upgrading

Aircraft operators often consider upgrading their existing FDRs because they have become obsolete (through lack of support or cost of maintenance), need to meet new regulations, reduce SWaP, or to gather additional data by using a more modern FDR instead of installing a separate recorder.

As an example, Curtiss-Wright's Fortress is a modern FDR that brings a number of benefits including functionality improvements over Curtiss-Wright's older multi-purpose flight recorder (MPFR). These include

+ Equipment approval: Fortress is fully ED-112A certified and has been designed to meet anticipated upcoming requirements (such as GADDS) and is approved to (E)TSO-C123c, C124c, C176a, and C177a with a 90 day Ultrasonic Locator Beacon to TSO-C121b.
+ Mechanical reliability: like the MPFR, Fortress is a solid-state recording unit and therefore has no moving parts, increasing the inherent mechanical serviceability and removing the need for anti-vibration mounting systems and equipment trays. Furthermore, Fortress can be installed in any attitude without a reduction in performance.
+ Crash survivability: Fortress has been tested to, and exceeds the requirements of, ED-112A, which includes new underwater locator beacon (ULB) attachment sheer and tensile tests (6000 lb in each direction).
+ CVR recording capacity: Fortress now extends the audio recording capacity from four channels with 120 minutes duration each to four channels with 25 hour duration each, with one channel allocated to a 6 kHz bandwidth suitable for a cockpit area microphone with input channels suitable for pre-amplified microphones or direct connection.
+ FDR Data Rate: the MPFR is configurable to support ARINC 573/717 data rates of 64 words per second (wps), 128, 192, 256, 512, 1024 and 2048 wps. Fortress has different data rate and interface support depending on the model chosen but, for example, the Fortress 757 records from a single ARINC 717 input over the rates 64 to 4096 wps with automatic data rate detection and real time data monitor output.
+ FDR Interface: MPFR supports a single ARINC 717 FDR data interface. Fortress also supports FDR data reception via ARINC 429 (up to 4 channels) and ARINC 664pt7 with 14 virtual links.
+ FDR recording capacity: the MPFR stores 25 hours at 256 words per second. Fortress stores 25 hours of data at 4096 wps or in excess of 2,500 hours at 256 wps.
+ Rotor tachometer recording: Fortress also provides a dedicated aircraft rotor tachometer input for recording purposes, this input channel supports both the magnetic pick up and rotor tacho generator signal sources, again for a 25 hour record duration.

Table 1 presents a summary of the technical differences between the Fortress and MPFR. It can be seen that there are several benefits to upgrading to a modern FDR, although whether to make this decision will, at least in part, depend on how simple it is to make this change. Note: to support Fortress, the PGS replay software has been upgraded and release 5.7.1 or later, will be required.

How to Upgrade an FDR

An operator will likely want to replace the existing FDR as quickly and easily as possible to minimize aircraft downtime and minimize costs. The issues an operator will typically encounter replacing an FDR include

+ Physical differences between FDRs that may result in new mounting holes, brackets, etc.
+ Connector differences that requires cable looms to be reassembled
+ Software changes and the associated training required
+ New wiring and associated installation of any additional data acquisition hardware

The procedures that must be followed in order to change one FDR for another depend on the recorders and the needs of the aircraft. What follows is a detailed overview of how an MPFR can be replaced with a Fortress FDR, both from Curtiss-Wright. While this is specific to these recorders, the principles and steps are similar for any other FDR combination. While the example aircraft is a helicopter, similar procedures can be followed for fixed wing aircraft.

Table 1

MPFR	FORTRESS
FDR	
Single ARINC 717 input	Single ARINC 717 input
64, 128, 256, 512 and 1,024 wps programmed	64, 128, 256, 512, 1,024, 2,048 and 4,096 wps auto rate detect
25 hours @ 512 wps	+25 hours @ 4,096 wps, +1,400 hours @ 512 wps
	Up to 4 ARINC 429 inputs @ 100 kHz, 25 hours all data received
	Dual channel ARINC 664pt7 with 14 configured virtual links
	Pin strap to select FDR data interface source
	Direct tri-axial accelerometer recording
CVR	
4 channels (analogue), 2 hours min	4 channels (analogue), 25 hours min
3 crew (150 Hz – 3.5 kHz each)	3 crew (2 x 150 Hz – 10 kHz, 1 x 150 Hz – 3.5 kHz)
1 area mic (150 Hz – 6 kHz)	1 area mic (150 Hz – 6 kHz)
Remote, pre-amplified input	Remote, pre-amplified mic input Direct area mic connection (via pin selection)
Rotor tach input	Rotor tach input
DLR (Data Link Recorder)	
Not supported	1 x ARINC 429, Williamsburg 3 protocol
	Low or high speed
	25 hours record duration
Airborne Image Recorder	
Not supported	Single Ethernet channel with image monitor
	Dedicated 100BaseT Ethernet input
	1.6MB/s max data thoughput
	2 hours record duration
Memory Capacity – 364MB max	**Memory Capacity – 64MB max**
FDR 2 x 96 MB	FDR 2 x 8 GB
CVR 2 x 96 MB	CVR/DLR 2 x 8 GB
	AIR 2 x 16 GB
BITE Status Output	
FDR & CVR Fault Output discretes	FDR, CVR, DLR & AIR Fault Output discretes
	ARINC 429 OMS Status Output message
Download – 100 BaseT Ethernet	Download – 1000Mb BaseT Ethernet
Approvals;	
TSO-C123b Cockpit Voice Recorder	TSO-C123c Cockpit Voice Recorder
TSO-C124b Flight Data Recorder	TSO-C124c Flight Data Recorder
	TSO-C176a Data Link Recorder
	TSO-C177a Airborne Image Recorder
TSO-C121b 90 day ULB	TSO-C121b 90 day ULB
Eurocae ED-112	Eurocae ED-112A
Weight: 3.2 kg	Weight: 3.8 kg
	Recorder Independent Power Supply (RIPS) Status I/F Support
	Expansion slot supporting additional IO options

Table 1: Summary of technical differences between Fortress and MPFR

Installation and Test Duration

Upgrading an FDR requires installing and testing the device, as well as confirming its performance on an aircraft. With an available power supply, FDR replacement requires the following approximate time on a test aircraft:

+ Evaluation = 0 hours
+ Strip down = < 1 hours
+ Replacement = < 1 hours
+ Rebuild = < 1 hours
+ Re-identification = 0 hours
+ Testing = 2 hours
  - Total time = < 5 hours

Strip Down

+ Once access to the MPFR has been gained, remove the recorder and its equipment tray from the aircraft then disconnect it from the equipment tray/mounting points.
+ Remove the MPFR connector from the aircraft loom.

Replacement

+ Mount the Fortress in the desired location. The simplest location is where the MPFR was; Fortress uses the identical mounting lugs on the same pitch as MPFR and therefore does not require additional mounting points to be created. Alternatively, choose another suitable location (e.g. on the tail boom equipment shelf).
+ Attach the aircraft loom to the Fortress. Because Fortress was designed to be backwards compatible with the MPFR, there is no need to alter the aircraft loom's connector. The exception to this rule is if additional functions supported by Fortress are being implemented, for example from an Ethernet camera or DataLink recording. These cables can be wired into Fortress's auxiliary connector as appropriate.
+ Mount the two off relay bases and two off relays in a suitable location in close proximity to the FDR. Wire as dictated by their installation guide.
+ Within the cockpit center console, terminate the loom as appropriate.
+ Mount any extra data sources, such as a cockpit area microphone, camera, or sensors as recommended by the relevant ARINC characteristic.
+ Connect any extra microphones to the control unit microphone input connections or direct to the Fortress as required - the location of the area microphone and control unit may necessitate the extension of the microphone flying lead.
+ If implementing the Airborne Image Recorder function, install the Cockpit Area Camera in a suitable location to capture the required cockpit image. Note the camera positioning can be verified through connection to the Fortress MTI and selecting the image monitor output.
+ Connect the camera to the Fortress secondary connector.
+ Fit the control unit connector to the rear of the Cockpit Control Unit and reinsert within the cockpit center console.

Rebuild

+ Replace any access panels that were removed.

Test and Certification

Following a successful Fortress installation, the ground and flight test procedures commence, outlining an acceptable method of confirming installation integrity, system checkout, and operational performance. The test results are documented using an installation checklist and are submitted to the Local Installation Approval Authority for approval.

Ground/Flight Test

NOTE: Fortress will preserve a minimum of 25 hours of recorded information compared to the 30 minutes of recorded information (for CVR area microphone at high quality, 120 minutes for all channels combined) of the MPFR. Thus the need to design a test program not exceeding 30 minutes of recording time with a ground check not exceeding 15 minutes that was necessary for the MPFR is not relevant for Fortress. There should be more than sufficient recording time available to preserve the important sections of the test flight i.e. take-off, landing, and other significant "events".

Ground Test

This check is required to confirm the recording integrity of the complete system as installed. The following procedure is derived from the process outlined in ED-112A and is applicable to CVRs and FDRs.

Should an image recorder function also require evaluation, the recording shall be checked to confirm that the required input sources are connected to the AIR system, and that image quality is acceptable and by ensuring that the resolution available is sufficient to meet the specified resolution requirements. For combined recorders with AIR function, image recordings may be verified by correlating data values against announcements made by the flight crew.

+ 1. Close Cockpit Voice and Flight Data Recorder (CVFDR) circuit breaker.
+ 2. Announce "CVFDR on, start of CVFDR ground test." Note time: _____
+ 3. Use pilot headset and announce your name, crew station, date, and the Aircraft Registration. State the position being spoken from, and the distance from the area microphone, also state the position of the area microphone. Check each NAV aid (i.e. ADF, VOR, ILS, DME) for proper IDENT and indication. Check each COMM system (i.e. VHF, HF, V/UHF).
+ 4. Use a co-pilot headset and announce your name, crew station, date, and the Aircraft Registration. State the position being spoken from and the distance from the area microphone, also state the position of the area microphone. Check each NAV aid (i.e. ADF, VOR, ILS, DME) for proper IDENT and indication. Check each COMM system (i.e. VHF, HF, V/UHF).
+ 5. Use a hand microphone and test Cabin PA System stating your name, station, date, and the Aircraft Registration.
+ 6. Make a test transmission using the Cabin PA system from each pilot station stating your name, station, date, and the Aircraft Registration.
+ 7. From each pilot station, with ICS off and without keying Radio, Deselect ALL radios, ICS volume at lowest setting, and announce "Live Mic" test and the location. (i.e. "Live Mic test from pilot position")
+ 8. Test all aural warnings identifying each one. If no aural warnings are installed, announce: "No aural warnings."
+ 9. Announce "End of ground test." Open CVFDR CB and note time: _____

Flight Test

+ 1. Close CVFDR CB and announce “CVFDR on, start of flight test.” note time: _____
+ 2. Start one engine and record the normal cockpit conversations for one minute.
  - a. Note: Call out RPM at 50%, 80% and 100%.
+ 3. Continue with second engine start and again identify Nr or any significant events/sounds.
+ 4. Each crew member should identify themselves using the intercom system and note that he is listening on his headset at a comfortable listening level. All crewmembers should then make an announcement without using the intercom. These tests should be repeated with the flight deck windows open.
+ 5. Call out N1%, T5 and Torque for each engine before take-off, Perform a normal take-off sequence. Normal crew conversations should be recorded during this time.
+ 6. Before raising gear, announce “Raising landing Gear”. Announce “CVFDR off.” Open CVFDR CB and note time: _____
+ 7. Establish cruise, Close CVFDR CB, announce “CVFDR on, start of cruise test.” note time: _____
+ 8. At cruise perform a test transmission on each communications radio and the cabin PA system from each pilot position (state which) plus Nr.
+ 9. Select an ADF or VOR signal and identify these signals and which crew position has them selected.
+ 10. Call out N1%, T5 and Torque for each engine
+ 11. Announce “CVFDR off,” Open CVFDR CB and note time: _____
+ 12. Prepare to Hover (have gear up).
+ 13. Close CVFDR CB announce “CVRFDR on” and note time _____
+ 14. Announce “Hover test.” Announce “Lowering Landing Gear.”
+ 15. Announce “Hovering” once a hover is achieved and perform a hover for approximately one minute and record normal conversation.
+ 16. Announce “End of Hover Test.”
+ 17. Wait one minute, Open CVFDR Circuit Breaker and note time: _____
+ 18. Achieve safe altitude and air speed to perform an Auto-Rotation descent with power recovery.
+ 19. Close CVFDR CB, announce “CVFDR on” and note time: _____
+ 20. Announce “Auto-Rotation Test”, air speed and altitude. Perform an Auto Rotation with power recovery.
+ 21. Achieve Hover and announce “Hover.” Remain at hover for approximately 20 seconds.
+ 22. Open CVFDR Circuit Breaker and note time: _____
+ 23. As you approach for a landing,
  - a. Close CVFDR Circuit Breaker and note time: _____
+ 24. Perform normal landing and shutdown.
+ 25. Before power is shut off, but all other shut downs complete (i.e. Rotor has stopped), announce “End of CVFDR Test” and note time: _____
+ 26. Following shut-down, record the reporting/ evaluation data referenced below.
+ 27. Send the downloaded CVFDR data & audio (include a copy of this test) for audio quality and intelligibility evaluation and FDR graphical trace and tabular format to the Local Installation Approval Authority.
+ 28. Forward the completed Function Test to the Local Installation Approval Authority for their approval files.

Reporting and Evaluation

Record the information identified below and forward along with the downloaded audio information to the Local Installation Approval Authority:

Aircraft registration/serial number:	
Location:	
CVR system installation drawing:	
Date of CVR system installation:	
Installation by:	
License no:	
CVR serial number:	
Control unit serial number:	
Impact switch serial number:	

Post Installation Ground Check

Checked by:	
License no:	
Date:	
Location:	

Flight Check

Pilot:	
License no:	
Copilot:	
License no:	
Checked by:	
License no:	
Date:	
Location:	
Functional check:	
EMI/RFI check:	

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Conclusions

Aircraft operators may wish to upgrade their FDR for a number of reasons including meeting new regulations, overcoming obsolescence challenges, or adding new capability to the aircraft but are challenged with minimizing aircraft downtime. This paper has shown that replacing an FDR can be quick and easy and is greatly facilitated by the backwards compatibility of the Fortress with the MPFR. Although it will take longer if new mounting points or fixtures are required, and aircraft looms may need alteration to support additional functions now included within Fortress, it is still be possible to upgrade an existing FDR relatively swiftly.

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- History and Future of Flight Data Recorder Regulations

Curtiss-Wright Case Studies

- Replacing an Obsolete Custom Flight Data Recorder with an Off-the-Shelf Solution

Curtiss-Wright Videos

- The History of Flight Data Recorders