Safety and Airspace Regulation Group

Approval, Operational Serviceability and Readout of Aircraft Flight Recorders

CAP 731

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Chapter 1
Introduction

Aviation legislation in the UK reflects the ICAO Standards and requires that certain categories of aircraft are equipped with crash protected Flight Recorder Systems. In the context of this CAP, Flight Recorder Systems include Flight Data Recorder (FDR), Cockpit Voice Recorder (CVR), Airborne Image Recorder and Data Link Recorder (DLR) systems. These systems are installed primarily to assist investigations into incidents and accidents or, additionally, either by using the FDR or via a secondary quick access recorder, operators can monitor certain operational aspects of their aircraft.

To satisfy the applicable regulations, the installations must comply with the appropriate minimum requirements dependent upon the class of aircraft. Continued serviceability requires compliance with the installer's maintenance instructions as well as validation of the information recorded in-flight. This document provides general advice and guidance to operators of aircraft equipped with Flight Recorders and to the facilities that provide an FDR data readout and CVR / AIR replay services of their respective responsibilities to achieve correlation of this activity.

Where reference is made in this document to 'Part 21' aircraft, such aircraft are required to comply with the requirements of the UK Basic Regulation (EU) 2018/1139 and its associated Implementing Rules, as amended. Where reference is made to 'non-Part 21' aircraft, such aircraft are required to comply with the relevant Articles published in the Air Navigation Order 2016 and British Civil Airworthiness Requirements (BCAR), as amended.

This document has been published to address a number of Safety Recommendations made by the UK Air Accident Investigation Branch (AAIB) that relate to partial/complete un-serviceability of recorders and/or incorrectly installed recorders.

Examples of AAIB Recommendations are detailed below:

97-69

> The aircraft operator shall ensure that the facility conducting the readout is provided with a copy of the data frame layout document applicable to the installation to be addressed.

97-70

> Organisations conducting scheduled mandatory readouts from a Digital Flight Data Recorder (DFDR) have procedures in place to ensure that all information within a data frame layout document is correctly interpreted, used for a scheduled mandatory readout of the relevant recording installation and that any assessment is conducted only on data that has been converted to engineering units. Furthermore, any report

issued by the organisation shall reference both by document number and issue status the data frame layout document against which the readout was performed.

2011-024

It is recommended that the Civil Aviation Authority ensure that UK operators of aircraft equipped with flight data recorders hold and maintain controlled documentation that satisfies the intent of CAP 731 and complies with the requirements of EU-OPS 1.160 (a)(4)(ii).

2011-027

It is recommended that the Federal Aviation Administration, European Aviation Safety Agency and the United Kingdom Civil Aviation Authority should require that, as part of any flight recorder readout procedure mandated by regulation, an assessment is conducted to ensure that the quantity and quality of all data recovered from the FDR is correct for the data rate of the system and the recorder part number concerned.

2022-15

It is recommended that the Civil Aviation Authority ensure that magnetic tape flight data recorders, used in UK airspace, comply with the Civil Aviation Authority Specification No 10, regarding the error rate requirements, by checking the complete recording rather than by undertaking a sample check.

NOTE: Operators are requested to ensure their maintenance programmes include a download and validation of recorded information/data for accuracy and duration, at a frequency specified in the applicable regulations which relate to Flight Recorders and their associated systems.

Chapter 2

Document structure

The following discrete issues are addressed within this document:

1. Simple guidance on the interpretation of the current operational rules.
2. What is required to be established prior to the issuance of the Certificate of Airworthiness (CofA) for individual aircraft.
3. The need to identify scheduled tasks - to ensure the continuing serviceability of the Flight Recorder system whilst the aircraft is in operational service.
4. Who has what responsibility and what should happen when the recorders are download to evaluate recordings to ensure their continued serviceability, in accordance with the applicable regulations.

Chapter 3
Reference material

1. ICAO Annex 6 – Operation of Aircraft (Flight Recorders)
   - Part I, Chapter 6, paragraph 6.3, Appendix 8 and Attachment I
   - Part II, Chapter 6, paragraph 2.4.16, Appendix 2.3 and Attachment 3C
   - Part III, Section II, Chapter 4, paragraph 4.3, Appendix 4 and Attachment F
   - Part III, Section III, Chapter 4, paragraph 4.7, Appendix 4 and Attachment F
2. ICAO Annex 6 – Operation of Aircraft (Flight Recorder Records)
   - Part I, Chapter 11, paragraph 11.6
   - Part II, Chapter 3, paragraph 3.11.3
   - Part III, Section II, Chapter 9, paragraph 9.6
3. Air Navigation Order 2016, Articles 231, 232, 233, 234, 235, 238, and Schedule 6 Scales P, S and SS
4. CAA Specifications 10, 10A, 11 and 18
5. UK Regulation (EU) No 1321/2014, ANNEX I (Part M), ANNEX II (Part 145), ANNEX Vc (Part-CAMO) and ANNEX Vd (Part-CAO), as retained (and amended in UK domestic law) under the European Union (Withdrawal) Act 2018.
6. UK Certification Specifications CS-23, 25, 27 and 29 paragraph 1457 (CVR) and 1459 (FDR)
7. UK Air Operations Regulation (EU) No 965/2012, as retained (and amended in UK domestic law) under the European Union (Withdrawal) Act 2018, CAT.GEN.MPA.195, NCC.GEN.145, SPO.GEN.145
8. CAP553, British Civil Airworthiness Requirements (BCAR), Section A
9. EUROCAE Document ED-112 (and subsequent versions) "Minimum Operational Performance Specification for Crash Protected Airborne Recorder Systems"
10. EUROCAE Document ED-155 (and subsequent versions) “Minimum Operational Performance Specification for Lightweight Flight Recording Systems"
11. CAP 739 Flight Data Monitoring

Chapter 4
List of abbreviations and Definitions

Abbreviations

AAIB	Air Accident Investigation Branch
AFCS	Automatic Flight Control System
AIR	Airborne Image Recorder
AIRS	Airborne Image Recorder System
ANO	Air Navigation Order
ARINC	Aeronautical Radio Inc
BCAR	British Civil Airworthiness Requirements
CAA	Civil Aviation Authority
CAME	Continuing Airworthiness Management Exposition
C of A	Certificate of Airworthiness
CVFDR	Combined Voice Flight Data Recorder
CVR	Cockpit Voice Recorder
DFDAU	Digital Flight Data Acquisition Unit
DFDR	Digital Flight Data Recorder
DFL	Data Frame Layout Document
EASA	European Aviation Safety Agency
ED	EUROCAE Document
EUROCAE	European Organisation for Civil Aviation Equipment
FDM	Flight Data Monitoring
FDR	Flight Data Recorder
HHUMS	Helicopter Health and Usage Monitoring Systems
ICAO	International Civil Aviation Organisation
ICA	instructions for Continuing Airworthiness
JAA	Joint Aviation Authorities

JAR	Joint Aviation Requirements
LLDC	Low Level DC
LRU	Line Replaceable Unit
MCTOM	Maximum Certificated Take-Off Mass
MEL	Minimum Equipment List
MMEL	Master Minimum Equipment List
MOE	Maintenance Organisation Exposition
NPA	Notice of Proposed Amendment
OQAR	Optical Quick Access Recorder
QAR	Quick Access Recorder
STC	Supplemental Type Certification/Certificate
TC	Type Certification/Certificate
Vsn	Version
WPS	Words Per Second

Definitions

Part 145 – Means a UK CAA approved Part 145 organisation.

Chapter 5
Current operational rules

Introduction

The following information provides guidance on the operational requirements relating to the installation of Flight Recorders. They specify when a flight recorder is required to be carried, how long its recording duration shall be and details of the FDR parameters that shall be recorded.

Operators of aircraft types being used for State purposes, such as Police, Customs, Search and Rescue etc. and fitted with Flight Recorders which comply with the requirements of UK Air Operations regulation (EU) No 965/2012 (as amended), may elect to comply with these requirements rather than the requirements for Flight Recorders specified in the Air Navigation Order 2016, for aircraft which are excluded from the UK Basic Regulation. When operators elect to comply with the applicable requirements for Flight Recorders specified in the UK Air Operations regulation, they shall do so in their entirety, and shall include the appropriate procedures in their Continuing Airworthiness Management Exposition and Operations Manual.

At the time of publication, the Air Navigation Order 2016 does not cover the requirements applicable to the carriage of Airborne Image Recorders (AIR) or Data Link Recorders (DLR). If such flight recorders are required to be fitted to non-Part 21 aircraft, this will be mandated through a Safety Directive or Operational Directive. Such Directives will provide details of any requirements for inspection and preservation of records etc. An example of this being Safety Directive SD-2020/001, which mandates the fitment of AIR/AIRS to helicopters conducting State activities involved in the service of a Police authority and those operated under contract with the Maritime and Coastguard Agency (MCA) for the provision of Search and Rescue (SAR).

It should be noted that this information is for guidance purposes only, and that reference should always be made to the appropriate operational rules as these are the definitive source of the requirement.

Non-Part 21 aircraft

Information relating to the carriage of Flight Recorders under the Air Navigation Order 2016 (non-Part 21 aircraft, which includes State aircraft)

- Article 231 — Use of flight recording systems
- Article 232 — Preservation of records of aeroplane flight data recorder

- Article 233 — Preservation of records of helicopter flight data recorder
- Article 234 — Preservation of records of helicopter cockpit voice recorder and flight data recorder
- Schedule 6, Part 1, Paragraph 5, Scale P – CVR / FDR (Aeroplanes)
- Schedule 6, Part 1, Paragraph 5, Scale S – CVR /FDR (Aeroplanes)
- Schedule 6, Part 1, Paragraph 5, Scale SS – CVR / FDR (Helicopters and Gyroplanes)

Part 21 aircraft

Information relating to the carriage of Flight Recorders under UK Air Ops Regulation (EU) No 965/2012 (Part-21 aircraft)

The sections referred to below under Subpart A include the requirements relating to the preservation of recorded data for the investigation of accidents and serious incidents, operational checks of the flight recorders to ensure continued serviceability, documentation requirements, including the documentation necessary to convert raw flight data into flight parameters expressed in engineering units and confidentiality requirements for recorded information (data, voice, and image).

The associated Acceptable Means of Compliance (AMC) and Guidance Material (GM) provide further information on how to comply with the above requirements, including the frequency at which the recordings made by flight recorders need to be inspected / checked for correct operation and quality and accuracy of the recorded information.

The sections below under Subpart D provide details of which aircraft require flight recorder equipment to be fitted, the duration of the recording, what needs to be recorded, the medium on which recordings shall be stored and the operational performance requirements of the system and equipment. Subpart D is further split into sections, one for the requirements specific to Aeroplanes and another for the requirements specific to Helicopters.

For example, under Annex IV, Subpart D, Section 1, CAT.IDE.A.190, aeroplanes with an MCTOM of more than 5700 kg and first issued with an individual CofA on or after 1 June 1990, shall be equipped with a flight data recorder (FDR) that uses a digital method of recording and storing data and for which a method of readily retrieving that data from the storage medium is available. It goes on further to provide details of the parameters that shall be recorded and the duration of the recording.

- Annex IV – Commercial Air Transport Operations (Part-CAT)
    - Subpart A, General Requirements, Section 1 – Motor-Powered Aircraft
        - CAT.GEN.MPA.195 - Handling of flight recorder recordings: preservation, production, protection and use.
    - Subpart D, Instruments, data and equipment
        - Section 1 – Aeroplanes
            - CAT.IDE.A.185 (CVR)
            - CAT.IDE.A.190 (FDR)
            - CAT.IDE.A.191 (Lightweight flight recorder)
            - CAT.IDE.A.195 (Data link recorder)
            - CAT.IDE.A.200 (Combined CVR & FDR)
        - Section 2 – Helicopters
            - CAT.IDE.H.185 (CVR)
            - CAT.IDE.H.190 (FDR)
            - CAT.IDE.H.191 (Lightweight flight recorder)
            - CAT.IDE.H.195 (Data link recorder)
            - CAT.IDE.H.200 (Combined CVR & FDR)
- Annex VI – Non-Commercial Air Operations with Complex Motor-Powered Aircraft (Part-NCC)
    - Subpart A, General requirements
        - NCC.GEN.145 - Handling of flight recorder recordings: preservation, production, protection and us.
    - Subpart D, Instruments, data and equipment
        - Section 1 – Aeroplanes
            - NCC.IDE.A.160 (CVR)
            - NCC.IDE.A.165 (FDR)
            - NCC.IDE.A.170 (Data link recording)
            - NCC.IDE.A.175 (Combined CVR & FDR)

- Section 2 – Helicopters
  - NCC.IDE.H.160 (CVR)
  - NCC.IDE.H.165 (FDR)
  - NCC.IDE.H.170 (Data link recording)
  - NCC.IDE.H.175 (Combined CVR & FDR)

- Annex VIII - Specialised Operations (Part-SPO)
  - Subpart A, General requirements
    - SPO.GEN.145 - Handling of flight recorder recordings: preservation, production, protection and us.
  - Subpart D, Instruments, data and equipment
    - Section 1 – Aeroplanes
      - SPO.IDE.A.140 (CVR)
      - SPO.IDE.A.145 (FDR)
      - SPO.IDE.A.146 (Lightweight flight recorder)
      - SPO.IDE.A.150 (Data link recording)
      - SPO.IDE.A.155 (Combined CVR & FDR)
    - Section 2 – Helicopters
      - SPO.IDE.H.140 (CVR)
      - SPO.IDE.H.145 (FDR)
      - SPO.IDE.H.146 (Lightweight flight recorder)
      - SPO.IDE.H.150 (Data link recording)
      - SPO.IDE.H.155 (Combined CVR & FDR)

Chapter 6

Tasks prior to Certificate of Airworthiness issue

The following paragraphs detail the CAA's expectations relating to the replay and validation of CVR, FDR and if applicable, AIR and DLR during the processes related to TC/STC and CofA issue. The order of the paragraphs is intended to reflect the process timeline.

Type Certification and Supplemental Type Certification

At the time of certification, the TC/STC applicant will be expected to demonstrate to the regulatory authority that they have complied with the following:

a) A CVR and FDR, and if applicable, an AIR / DLR, has been installed in accordance with the agreed aircraft certification basis, taking account of the applicable operational requirements.

b) Evidence has been provided that demonstrates the installed flight recorder systems meet the appropriate operational requirements, including accuracy, resolution, range, duration and sampling rates.

c) The flight data recorder system consists of appropriately approved equipment as required by the applicable operational requirements.

d) The information necessary to enable operators of aircraft to conduct a readout of the FDR content is provided. As a minimum this shall include a data frame layout document together with any necessary conversion data to enable translation of the raw flight data into engineering units.

e) The information necessary to enable operators to perform scheduled maintenance tasks that demonstrate continued compliance with the certification requirements is provided. This information is expected to address all parts of the CVR, FDR and if applicable AIR / DLR system, for example, the associated sensors.

f) In order to demonstrate compliance with the initial entry-into-service requirements (e.g. xx.1301) the TC/STC applicant is required to perform the initial flight recorder readout and validation.

NOTE: xx refers to the appropriate Certification Specification requirements e.g. JAR/FAR/EASA/CAA etc. 23, 25, 27, 29 etc.

g) To comply with the requirements of xx.1529, the TC/STC applicant is required to perform an analysis of the required maintenance activities for the FDR. This must be translated into a list of operator maintenance actions that must be provided to the operator. Further guidance on this is provided in EUROCAE Document ED-112.

NOTE: xx refers to the appropriate Certification Specification requirements e.g. JAR/FAR/EASA/CAA etc. 23, 25, 27, 29 etc.

Certificate of Airworthiness (CofA) Issue

At the time of CofA issue an operator/applicant will be expected to provide evidence that, for the individual aircraft to be certificated, the TC/STC holder has met each of the TC/STC requirements specified above.

a) The regulatory authority will expect the operator/applicant to provide a compliance statement that demonstrates the following: A Data Frame Layout Document (DFL) is available for the FDR system.

b) Conversion Data (to enable translation of raw FDR data into engineering units) is available for the FDR system.

c) Procedures are in place to provide the DFL and Conversion Data to an appropriate readout facility.

d) The Aircraft Approved Maintenance Programme (AMP) includes a list of tasks specified by the TC/STC holder to ensure the continued serviceability of the FDR, CVR, AIR, DLR system, as applicable.

e) The FDR Readout from a representative flight, conducted immediately prior to CofA issue, has been evaluated to ensure that the FDR system is functioning correctly.

f) For a used aircraft imported into the UK, an examination of the recorded signal on the CVR and AIR should be carried out by replay of the recording as required by Chapter 12. If this cannot be achieved refer to Note 1 below.

NOTES:

1. Where an operator experiences a delay such that the results of the readout / replay are not available for validation at the time of CofA issue, the responsible CAA Surveyor should be contacted to agree a specified time scale for its completion. This should normally be within 30 days of the date of CofA issue. Failure to provide the information within the agreed timescale may result in the CofA being suspended or revoked.

2. Irrespective of the originating source of the aircraft, the FDR system is required to meet the UK operational rules.

3. A template giving the preferred layout for a Compliance Statement Document is provided in Appendix A to this document.

4. Examples and Descriptions of Data Frame Layout Document and Conversion Data are provided in Appendix B to this document.

5. For CofA issue of used aircraft where the required information can't be obtained from the original design approval holder, the applicant should engage the services of a suitably qualified and approved design organisation to facilitate the function that would have otherwise been provided by the TC/STC holder.

Chapter 7
FDR system serviceability and readout

Introduction

The Air Navigation Order 2016 and the UK Air Operations Regulation (EU) No 965/2012, typically require that operators preserve a record of one representative flight made within the last 12 months. The purpose of this is to ensure that, in the event of an accident/incident, air accident investigators have access to a readout from the flight data recording system that is representative of the actual aircraft condition prior to the accident/incident. It follows that the data originating from the selected representative flight will need to be evaluated to determine that it comprises a valid record. Refer to 'Establishing the Limitations of the Readout'.

Further information and guidance to ensure continued serviceability of FDR systems can be found in EASA SIB 2009-28 (as amended) and ICAO Annex 6, Part I, Appendix 8, ICAO Annex 6, Part II, Appendix 2.3 and ICAO Annex 6, Part III, Appendix 4.

The Flight Data Recorder readout may be carried out either by an organisation holding an appropriate Part 145 C Rating approval with the additional procedures necessary to perform FDR readout, or by an operator that can demonstrate that they have the required equipment and competence to perform this task. This task may be sub-contracted by the operator, details of which will need to be included in their CAME. The approved organisation is also required to have specific procedures detailing how an FDR readout will be performed and controlled (refer to Appendix C).

The aircraft operator/owner is responsible for ensuring the continued serviceability of the FDR system and retaining the relevant records required by the operational requirements. In addition, the validation of recorded data from a representative flight provides evidence of the FDR system performance in a flight dynamic situation that cannot be achieved during ground testing alone. Based on this, the CAA believe that it would be logical and beneficial to use the data required by the applicable operational rules to evaluate the continued serviceability of the FDR system.

NOTES:

1. An operator who conducts their own readout does not need to hold a Part 145 approval, however they will need to conform to the general requirements for a readout facility detailed in Chapter 8 and Appendix C of this CAP; this should be detailed in their CAME. Operators who wish to provide FDR readouts as a service to other operators will need to hold a Part 145 approval with the appropriate C Rating and have additional procedures in their MOE.

2. If a flight data recorder needs to be removed and routed to a Readout Facility to download the required data, the serviceability of the equipment needs to be verified and the equipment released to service by an appropriate Part 145 approved maintenance organisation prior to re-installation in the aircraft.

3. Calibration of the FDR system

   Guidance referred to in ICAO Annex 6, Part I, Appendix 8; Annex 6, Part II, Appendix 2.3; Annex 6, Part III, Appendix 4 and referenced in the EASA SIB 2009-28, has caused some confusion among industry. The word "calibration" is a term that was used for analogue FDR's. Some of the sensors providing data to the recorders could drift out of tolerance and would require re-calibration. Modern aircraft use digital systems to provide data to the FDR, which normally do not require calibration. The Type Certificate holder should be consulted in the event of any doubt.

4. For non-Part 21 aircraft, whilst a record of the serviceability of the FDR though a download and readout must be kept to comply with the ANO on an annual basis, operators of non-Part 21 aircraft equipped with solid-state flight recorders that have a high integrity of serviceability self-monitoring, may submit to their assigned Surveyor a proposal for having their FDR readout carried out and analysed at a frequency of up to every 2 years.

5. For Part-21 aircraft, under the UK Air Operations Regulation the frequency at which the operator is required to perform an inspection of the serviceability of the FDR through a download and readout, is dependent on the type of equipment fitted. The frequency of such inspections varies according to the recording medium, from as often as every 3-months for a magnetic wire-based flight recorders, to up to 2 years, for a solid-state flight recorders.

Detection of FDR recording anomalies may be achieved in one of two ways:

1. Validation of recorded data. To be able to validate the data, the readout facility will require details of the tests carried out or of the representative flight.
2. A combination of scheduled maintenance tasks and validation of recorded data.

Performing/Selecting a Representative Flight

Responsibility

This is the responsibility of the aircraft operator/owner.

Purpose

The purpose of performing a specific FDR test flight or recording the details of a representative commercial flight is to gain an FDR recording of a flight that can be used to assess the functionality of an FDR. This is intended to obviate the need for readout facilities to make a random determination of a representative flight without the supporting information to ensure a good decision.

NOTE: The intent of this activity is to reduce the amount of ground testing that needs to be performed by the aircraft operator/owner and to make best use of the selected representative flight data. In the event that an operator cannot add to flight crew activities in the manner described below, the missing data will need to be provided via a set of ground tests.

General Notes

This activity is not intended to force an operator into performing a specific test flight in order to gain FDR serviceability data. It is intended that an operator will select a flight from a regular service that would stimulate as many FDR parameters as practicable.

The appropriate selection of a representative flight and recorded flight details can greatly increase the FDR serviceability information that can be established during FDR readout validation. The flight should endeavour to function discretes that can be operated safely.

NOTE: This does not necessarily require the performance of a specific FDR test flight.

If the information provided by the representative flight is sufficient to establish parameter functionality and reasonableness it may be possible to gain FDR serviceability credit for the parameters concerned.

NOTE: The actual assessment of this will depend upon how much information about the flight is provided to the readout facility. See Chapter 8, paragraph 2.2 for more details on this.

Details of a representative flight which must include a take-off, climb, cruise, descent, approach to landing and landing, together with general details of the flight profile, could be expanded to include:

- Pre-departure checks;
- Flight duration;
- Altitude reached;
- Flight control settings;
- Power settings;
- Flight deck indications;
- Autopilot engagement status

NOTE: Autopilot engagement status is taken to be autopilot operating modes, auto throttle and AFCS system engagement status and operating modes.

- Test warnings (such as GPWS, Stall and TCAS) etc. The operator should ensure the following:
  a) An appropriate pro-forma is produced to ensure that flight crew perform and record the necessary tasks during the ‘representative flight’. This should be provided together with FDR data when requesting a download and validation;

b) Pre-departure checks that have been selected, as part of the representative flight, are being recorded on the FDR.

NOTE: The level of information gained will depend on when the FDR is powered up and the operator should ensure that the selected information is being recorded;

c) Aircraft warnings (e.g. engine fire) are included in the FDR content;

d) The FDR download contains, at a minimum, all the mandatory FDR parameters. The list of mandatory FDRs parameters can be found in the relevant operational rule.

Providing FDR Data, Representative Flight Details, Data Frame Layout (DFL) and Conversion Data

Responsibility

This is the responsibility of the aircraft operator/owner.

Purpose

The purpose of providing the FDR data and the appropriate supporting data to the readout facility is to enable the generation of the most accurate possible readout of the FDR's content to ensure continued serviceability.

General Notes

The accuracy and assessment of an FDR readout is dependent on the provision of a DFL and associated conversion data. This, in conjunction with details of a representative flight, should enable a meaningful assessment of all/most of the mandatory parameters of the FDR system functionality to be carried out.

Establishing Limitations of the Readout

Responsibility

The responsibility of assessing the supporting information provided with the FDR data and determining how much information can be provided about the FDR system lies with the Part 145 organisation or operator performing the readout.

Purpose

This task should be performed prior to the readout and its purpose is to establish a clear understanding of the limitations that the readout assessment is able to provide. An initial assessment can be done by looking at the documentation. After the replay is attempted, it is possible that the documentation may be found to be incorrect. If this is the case, further work on the replay validation should be postponed until correct documentation can be obtained.

General Notes

Several readout facilities have commented that their 'customers' have erroneously assumed that the presentation/delivery of a readout report implies that the overall FDR system is serviceable, even when the content of the report is incomplete or implies that there may be faults within the system.

This misunderstanding has resulted in FDR system faults remaining unresolved. Appropriate validation of the initial data provided, together with a clear statement of the limitations of the readout report will help to minimise the chance of such dormant faults remaining undetected.

The following guidelines may assist in establishing a better understanding between the replay organisation and its customers:

1. A replay organisation should have sufficient information about the aircraft and its modification status to enable them to make an accurate replay;
2. Unless the replay organisation has sufficient information to determine the representative flight details for the recording, no attempt should be made to determine whether or not parameters are functioning correctly;
3. If any parameters are 'no shows' or have unusual characteristics this should be noted on the report. The replay organisation should not attempt to extrapolate additional information regarding the functionality of parameters (i.e. they should not attempt to derive information that is not directly available from the data obtained from the flight data recorder). The operator or recipient of the report has responsibility for investigating any reported anomalies. That said, if a replay organisation has sufficient experience to suggest possible meanings for the data, they can provide additional commentary to support the validation report as long as the report makes it clear that the final responsibility lies with the operator;
4. The operator should ensure that an assessment is conducted to confirm that the quantity and quality of all data recovered from the FDR is correct for the data rate of the system and the recorder part number concerned.
5. At intervals not exceeding 12 months, magnetic tape-based FDRs, should be checked throughout the complete recording and not just sample checks. It has been observed that certain parts of the magnetic tape may suffer from recording losses due to aging.

Establishing Revision and Applicability of DFLs and Conversion Data

Responsibility

It is the responsibility of the operator to provide, along with their work request, the details of the appropriate DFL and conversion data provided as part of the TC/STC and CofA processes – see Chapter 6, paragraphs 1 and 2 together with their current revision status.

Purpose

The purpose of defining the revision status and applicability of Data Frame Layouts (DFLs) and Conversion data prior to replaying a recorder is to ensure that the appropriate and up-to-date information is used during the replay process.

General Notes

None.

Replaying the FDR Recorded Data

Responsibility

This is the responsibility of the organisation performing the readout.

Purpose

The purpose of replaying the FDR is to generate a report on the FDR's content for subsequent review and validation.

General Notes

The organisation responsible for performing the readout will ensure that it is carried out using the appropriate approved decoding data and equipment recommended for the process (see also Chapter 8, paragraph 2.3).

In the event that more technologically advanced equipment becomes available, the means of complying with this should be justified as being equivalent and suitable and should involve the approval of the relevant equipment/aircraft manufacturer.

Reporting the FDR Readout Results

Responsibility

This is the responsibility of the replay organisation responsible for performing the readout.

Purpose

The purpose of generating a readout report is to provide the customer with documented evidence of the content of their recorder, together with any anomalies the replay organisation has identified.

General Notes

There is no pre-defined layout or format for FDR readout reports, but the following information should be provided as a minimum:

1. Unique Document Identifier for the Readout Report;
2. Aircraft Registration;
3. Aircraft Serial Number;
4. FDR Part Number;
5. FDR Serial Number;
6. Data Acquisition Unit Details;
7. Date of Replay;
8. Issue/Vsn and Reference of Data Frame Layout Document;
9. Issue/Vsn and Reference of Other Associated Documents (e.g. Information to Convert to Engineering Units);
10. Supplier of DFL and Associated Information;
11. Parameters Replayed;
12. 'No Shows';
13. Noted Anomalies;
14. Compliance with General FDR Requirements, e.g. Sampling Rates;
15. How to Interpret Report (i.e. 'This report is solely documenting the outcome of the replay. The operator is responsible for the assessment of these results and determination that the FDR system is functioning correctly');
16. Download Validation Equipment used – part number/vsn no. etc.

Assessment of the FDR Readout Results

Responsibility

This is the responsibility of the aircraft operator/owner.

Purpose

The purpose of this assessment is to determine the actual serviceability of the FDR system and to assist in the scheduling of any necessary maintenance work.

General Notes

The aircraft operator/owner must carefully analyse the FDR readout to establish whether it contains any anomalies. If anomalies are found, the aircraft operator/owner must investigate them to determine their cause.

Where an operator is to contract this task this should be detailed in the CAME and a contract established with the delegated organisation. The operator, however, remains responsible for ensuring this task is carried out.

A more detailed explanation is given in Appendix C.

Where the readout includes data of a representative flight a check for the reasonableness of recorded data against the representative flight profile should be carried out.

Anomalies may relate to any of the following:

1. Mandatory Parameters;
2. FDM Parameters;
3. Non-Mandatory Parameters.

Where an operator is running an approved FDM programme, the supporting documentation should be updated to include the FDM parameters.

NOTE: This is only intended to ensure that the FDM parameters can be accurately analysed, it is not to be confused with the requirements for the FDR mandatory parameter list.

If an anomaly relates to one or more mandatory parameters the necessary rectification work must be performed within the time period specified by the relevant MEL or operational rule. In addition, the aircraft operator/owner should organise for a further replay immediately the rectification work is complete. Alternatively, if the defect can be positively identified and rectification established via ground testing, then no further download is required.

Where an MEL allowance is required, the MEL rectification interval starts when the FDR parameter(s) defects are identified.

In the scope of this document, the MEL allowances refer only to unserviceable FDRs or FDR parameters. If the equipment that parameters are derived from is faulty, that equipment is subject to its own MEL restrictions.

All proposed FDR maintenance programme tasks, particularly related to mandatory parameters, require approval by the CAA unless this has been approved through an ‘AMP Indirect Approval’ procedure in the organisations CAME.

NOTE: Whilst it is not intended to exceed the FDM guidance provided in CAP 739 in terms of parameter maintenance, the CAA considers that it would be beneficial for operators to ensure that parameters used by their FDM programmes remain serviceable.

Retention and Control of FDR Readout Results

Responsibility

This is the responsibility of the FDR readout facility and the aircraft operator/owner.

1. The operator/owner is required to retain the record of a representative flight conducted during the previous twelve months.
2. The readout facility is required to retain readout records/test reports in a manner and for a period acceptable to the CAA. For Part 145 approved organisations the records shall be retained in accordance with the requirements of 145.A.55.

Purpose

The purpose of this is to ensure that both the aircraft operator/owner AND the replay house can accurately determine the currently recorded status of the FDR system.

General Notes

The record(s) must be retained in a safe manner and correctly identified to the aircraft and the flight to which it pertains.

Chapter 8

General requirements for a readout/replay facility

Introduction

Applicants seeking Part 145 approval for FDR / DLR Readouts or CVR / AIR replays will need to take the following information into consideration for approval to be granted and specified in the Maintenance Organisation Exposition (MOE). These include:

1. Procedures specific to the readout of the FDR / CVR / AIR / DLR;
2. Provision and control of associated readout support documentation;
3. Staff Training and Competence;
4. Procedures specific to the certification of FDR / DLR / CVR / AIR readouts (refer to Chapter 9).

NOTES:

1. An operator which has contracted this task must detail in their CAME who carries out the readout and how they control and audit them.
2. Where the term readout is used, this also includes CVR and AIR replays.

Required Procedures

Procedures for Support Documentation

These procedures should cover the provision and configuration control of the documents and the means used to correlate specific documents to specific aircraft and flight recorders.

The same procedures should be applied to any other supporting data necessary for an FDR readout. As a minimum, the documents covered by these procedures should include the following:

1. Data Frame Layout Documents;
2. Engineering Conversion Documents.

Procedures for Assessing Aircraft/Flight Information

All readout facilities should have procedures in place to assist when assessing the level of aircraft/flight information provided by the customer to determine whether it is possible to provide an accurate and useable readout.

The procedures should cover:

1. checks for the existence of basic information;
2. checks for assessing the information provided relating to the sample flight, to determine what data can or cannot be gathered on individual parameters (i.e. if flight altitude data is not provided the altitude parameter cannot be validated);
3. the way in which this data should be assessed to make a determination of the possible FDR readout report detail (i.e. is there sufficient information to validate the accuracy of the parameters or is it only possible to determine 'shows' and 'no-shows'?);
4. the generation of the 'Report Limitations' section of the FDR report;
5. the formal agreement of those limitations with the operator/aircraft owner.

Procedures for the Use of Replay Equipment

All replay facilities should have procedures in place detailing the required means of operating the replay equipment.

The procedures should cover:

1. how to establish that the correct replay equipment is being used;
2. how to connect the replay equipment;
3. how to operate the replay equipment;
4. how to detect replay equipment failures.

Procedures for Revision Control and Storage of Replay Documents

All replay facilities should have procedures in place covering the revision control of all FDR replay documents, including regulatory, technical and background documents.

The procedures should cover:

1. a list of all documents to be configured;
2. a list of the different types of media being used (e.g. CD, Magnetic Tape, Solid-State etc.);
3. the method of configuration control being used;
4. the means used to store them (including any environmental considerations);
5. the location of all configured documents;
6. the means of accessing those documents;
7. the backup procedures;

8. the procedures for off-site duplicates (to avoid fire/flood damage);
9. full software and hardware descriptions and control of past versions etc;
10. security and control of access to FDR data.

Procedures for Staff Training

All replay facilities should have procedures in place to address the issue of staff training.

The procedures should cover:

a) the basic knowledge required to replay FDRs. As a minimum this should include:
   (i) understanding of FDR hardware design, maintenance and replay;
   (ii) assessing the accuracy/currency of the associated DFLs etc;
   (iii) assessing the aircraft information provided;
   (iv) software design;
b) the interpretation of:
   (i) the ANO;
   (ii) the UK Air Operations regulation (UK Reg (EU) No 965/2012)
   (iii) ED112 & ED155 (as applicable);
   (iv) CAA Specifications, Spec 10, 10A, 11 and 18 (as applicable);
c) using the necessary tools;
d) interpreting the output of those tools;
e) drafting replay reports;
f) the required update training (e.g. new recorders);
g) the means of staff training;
h) the method of keeping and updating staff training records.

Control of Tools and Equipment

All replay facilities should have procedures in place to address the issues related to control of the tools and equipment used for replaying flight data recorders.

The procedures should cover:

a) the considerations related to determining the need for new tools/equipment;
b) the issues to consider when buying new tools/equipment;

c) assessing proposed updates for current tools/equipment;

d) maintaining/calibrating any tools used for replaying flight data recorders;

e) the processes for backing up any necessary files.

Control of DFLs

Sources of DFLs

It is the responsibility of the operator/owner to provide or confirm the appropriate issue and revision status of the DFL and conversion data.

Determining Status of DFLs

Before using a DFL for FDR replay purposes, a replay organisation must ensure that they have the most up-to-date issue of the DFL for the aircraft in question.

The issues to consider include:

1. the currency of the proposed DFL;
2. the applicability of the DFL for the aircraft in question.

Document Control of DFLs and Other Related Records

All replay facilities should have a set of document control processes for the DFLs (and any other related documents) they hold.

The processes should include:

1. Configuration Control. These should include:
    a) controls for access to the documents (to ensure they do not get lost);
    b) version control (to ensure that all relevant versions are held in known locations) and means to enable the relevant versions to be determined;
    c) controls for internal document updates (i.e. what update was made, who made the update and when);
    d) control of the deletion/removal of documents to ensure they are not deleted/removed before the end of their useful life;

Means of Storage. These should include:

  a) the media the data is stored on (e.g. paper, CD-ROM, memory device etc.);
  b) the necessary protection for that data (e.g. fire, water and EM proof stores etc.);
  c) any off-site duplicates in case of fire, flood, theft or structural damage;

Control of Customer Records. These should include:

a) a list of what records are stored for each customer;

b) the details of where those records are stored.

Staff Competence

All replay facilities are expected to have a sufficient number of staff with the appropriate levels of experience to perform flight data recorder replays with an acceptable level of accuracy.

Additional Requirements for CVR/AIR Replay Facility

For CVR/AIR replay, a quiet secure area should be provided, to both ensure privacy and to enable recording quality to be assessed.

When inspecting flight recorder audio recordings to ensure flight recorder serviceability, the operator shall protect the privacy of those audio recordings and make sure that they are not disclosed or used for purposes other than for ensuring flight recorder serviceability.

When images of the flight crew compartment that are recorded by a flight recorder are inspected for ensuring the serviceability of the flight recorder, those images shall not be disclosed or used for purposes other than for ensuring flight recorder serviceability. If body parts of crew members are likely to be visible on the images, the operator shall ensure the privacy of those images.

For both CVR and AIR replays, the readout facility should ensure they have appropriate procedures in place related to the handling of such recordings.

Chapter 9

Release certification of readouts

The type of release certification required for the readout will depend on the purpose for which the readout is being used.

1. If the purpose of the readout is to confirm the correction operation of the Flight Recorder under the Air Navigation Order or UK Air Operations Regulation, this is not classified as maintenance and therefore the issue of a CAA Form 1 is not appropriate. However, it is expected that the integrity of the data is validated prior to being placed on record.
2. If the purpose of the readout is to confirm the correct presence of a discrete, the accuracy of a sensor, or comply with a maintenance programme requirement to verify that parameters are being accurately recorded, the issue of a CAA Form 1 may be appropriate. However, this will depend on the information supplied to the readout facility that allows them to determine the accuracy of the downloaded data (refer to Chapter 7).
3. If the readout facility is not provided with sufficient information by the operator or their assigned maintenance organisation to enable them to determine the accuracy of the recorded data, they cannot issue a CAA Form 1.
4. If the readout facility is provided with sufficient information by the operator or their assigned maintenance organisation and the accuracy of the recorded data is confirmed to be within the specified tolerances, the issue of a CAA Form 1 is appropriate. In this case the wording on the CAA Form 1 should be as follows:

    Box 11: annotated *"Inspected"*

    Box 12: *"Certified that the flight data transcription has been carried out in accordance with the requirements of the Civil Aviation Authority relating to the supply of flight data information. Data held by this organisation, and in accordance with UK Part 145.A.45(b), has been used to prepare the FDR readout and is referenced as xxxxxxx (insert applicable data references, DFL etc.)".*

NOTE 1: Work orders from operators must clearly specify the purpose of the readout and what certification is required, taking into consideration paragraphs 1 and 2 above.

NOTE 2: Due to the number of parameters recorded by modern DFDR systems, certification on a CAA Form 1 only relates to the serviceability of parameters classified as mandatory by the relevant operational rule.

NOTE 3: For CAA Form 1 box numbers refer to UK Regulation (EU) No 1321/2014, as amended.

Chapter 10
General guidance on FDM

General

The United Kingdom Civil Aviation Authority’s Flight Operations Policy Department and Strategic Safety and Analysis have developed and published CAP 739 'Flight Data Monitoring A Guide to Good Practice'.

For further information on this subject please refer to CAP 739.

Chapter 11
Timescales

Non-Part 21 aircraft

Under the ANO 2016, Article 232, (as amended) operators are required to preserve a record of one representative flight made within the last 12 months. Following this flight, validation of the recorded data should be carried out to ensure that the data corresponds with the representative flight profile.

Part 21 aircraft

Under the UK Air Operations Regulation (EU) No 965/2012, operators are required to conduct operational checks and evaluations of the recordings to ensure the continued serviceability of the flight recorders which are required to be carried under the Regulation.

The frequency of the operational checks and evaluation will typically be annually, however, depending on the type of storage medium used in the flight recorder, it can up to 2-years.

General

Where a validation has taken place and evidence has shown certain parameters to be faulty, these are required to be addressed within the timeframe given in the approved Minimum Equipment List.

Chapter 12

Cockpit Voice Recorder (CVR) (including combined CVR and FDR) and Airborne Image Recorder (AIR) maintenance and continued airworthiness

This Chapter deals with the ongoing maintenance and continued airworthiness requirements for Cockpit Voice Recorders and Airborne Image Recorders.

The European Organisation for Civil Aviation Equipment (EUROCAE) has developed ED-112A, the most recent industry standard for FDR, CVR, AIR and DLR. In addition, ICAO has also published information in Annex 6 that provides guidance in order to detect dormant failures in both Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR) systems. Annex 6, Part I, Appendix 8 relates to international commercial air transport – aeroplanes; Annex 6, Part II, Appendix 2.3 relates to international general aviation – aeroplanes; and Annex 6, Part III, Appendix 4 relates to international operations – helicopters.

EASA Safety Information Bulletin (SIB) 2009-28 (as amended) was published to highlight to owners and operators the minimum maintenance recommendations for both CVR and FDR systems.

CAA recommendations for CVRs

Unless otherwise specified in the UK Reg (EU) No 965/2012 (the Air Operations Regulation), in addition to a daily operational check (pre-flight and/or post-flight) to confirm the recorder serviceability using a TEST function on the controller (if available), the CAA recommends the following for continued airworthiness of Cockpit Voice Recorders, which should be included in the aircraft maintenance programme.

1 At intervals not exceeding 6 months

a) In the first instance the Type Certificate (TC) or Supplemental Type Certificate (STC) Holder’s Recommendations should be followed. If these recommendations are not as comprehensive as detailed in paragraph b) that paragraph should be carried out as a minimum.

b) In the absence of specific instructions from the TC/STC holder, inspect the installation. Whenever the following functions are available, confirm by means of the CVR controller monitor jack, proper recording on each audio channel from area microphone(s), receiver audio, sidetone, interphone, public address (if recorded) and boom microphone (including 'hot mike' function, i.e. interphone OFF). Confirm proper function of the inhibit logic for the bulk erase.

2 At CofA issue and for Tape Based CVRs, at intervals not exceeding 12 months and Solid State CVRs at intervals not exceeding 24 months

An examination of the recorded signal on the CVR should be carried out by re-play of the CVR recording. While installed in the aircraft, the CVR should record test signals from each aircraft source and from relevant external sources to ensure that all required signals meet intelligibility standards; and where practicable, during the annual examination, a sample of in-flight recordings of the CVR should be examined for evidence that the intelligibility of the signal is acceptable.

Further guidance can be found in CAA specification 11.

3 System sensors

Any ditching sensor (E.G. Float Switch), crash sensor or underwater locator beacon should be checked / function tested to confirm correct operation, at intervals recommended by the vendor(s), or 24 months whichever is less, and in accordance with the applicable vendor requirements. If practical, such tests may be performed in-situ.

4 General

Operators should review all their Approved Aircraft Maintenance Programmes for compliance with the above recommendations. If changes are needed these should be submitted to the CAA for review and approval, or if applicable, approved under the CAMO ‘AMP indirect approval’ procedures.

5 Example Replay and Analysis

The replay centre should establish that recordings of adequate quality have been made on all channels for the test conditions stated below. In addition to subjective listening tests, proper signal recording level should be confirmed.

The recording should be played back in an area where the privacy and confidentiality of the recorded voices may be assured. This may require a separate room depending on the size of the organisation performing the task.

To assess the serviceability of the CVR system the TC/STC holder’s data should be used, however, the following checks and functional tests are given as an example:

a) All voice communications transmitted from or received by the aircraft communications equipment;

b) All conversation on the flight deck;

c) Voice communications of flight crew-members on the flight deck, using the aircraft’s interphone system;

d) Voice or audio signals identifying navigation aids introduced into the aircraft audio system;

e) Audio signals from alerting or warning devices on the flight deck, both fully integrated with the aircraft audio system and non-integrated;

f) General flight deck sounds, monitor the Cockpit Area Microphone to ensure that it satisfactorily picks up all cockpit sounds.

CAA recommendations for AIRs

Unless otherwise specified in the UK Reg (EU) No 965/2012 (the Air Operations Regulation), in addition to a daily operational check (pre-flight and/or post-flight) to confirm the recorder serviceability using a TEST function on the controller (if available), the CAA recommends the following for continued airworthiness of Airborne Image Recorders;

1 At intervals not exceeding 6 months

a) In the first instance the Type Certificate (TC) or Supplemental Type Certificate (STC) Holder's Recommendations should be followed. If these recommendations are not as comprehensive as detailed in paragraph b) that paragraph should be carried out as a minimum.

b) In the absence of specific instructions from the TC/STC holder, carry out a functional check of the AIR system, confirm proper function of the inhibit logic for the bulk erase and inspect the installation of the recorder and associated cameras.

2 At CofA issue and at intervals not exceeding 12 months

Carry out a replay to evaluate the quality of the in-flight recording. If the recorder and system has shown a high level of integrity, the frequency of the replay and evaluation can be extended to an interval not exceeding 24 months, subject to CAA approval.

3 System sensors

Any ditching sensor (E.G. Float Switch), crash sensor or underwater locator beacon should be checked / function tested to confirm correct operation, at intervals recommended by the vendor(s), or 24 months whichever is less, and in accordance with the applicable vendor requirements. If practical, such tests may be performed in-situ.

4 General

Operators should review all their Approved Aircraft Maintenance Programmes for compliance with the above recommendations. If changes are needed these should be submitted to the CAA for review and approval, or if applicable, approved under the CAMO 'AMP indirect approval' procedures.

Operators Responsibilities

Where an operator undertakes to carry out validation of their own CVR/AIR Replays this should be detailed in the company CAME. This replay will be undertaken by competent staff and will be documented.

A procedure should be established, acceptable to the CAA, which enables the operator to demonstrate that a replay has been carried out, which should highlight any deficiencies and the associated remedial actions.

The operator may sub-contract this task to an unapproved organisation and detail this in the CAME. However, this task will still form part of the operator's Continuing Airworthiness Management Organisation approval (CAMO).

The Civil Aviation Authority recognises that in certain cases an aircraft operator may lack sufficient resources to undertake a replay. In these cases, the replay, as detailed in the subject procedure, may be contracted to a third party by the operator. In these circumstances the operator will need to provide evidence of the following:

- The Part 145 organisation has the capability to replay CVR/AIR in their approved procedures.
- The Part 145 CVR/AIR replay report should include an assessment in accordance with these procedures.

The report should identify the aircraft and flight concerned and should confirm that all input channels were identified for the various test conditions. Details of any other observations made from the recording should be included. For CVR in helicopters, correlation between rotor speed announcements by the crew and recorded rotor speed data should be established and recorded. In all cases, the position of the CVR area microphone in the particular aircraft should be stated in the report.

Preservation of Recording

Under certain conditions the recorder may continue to run and record while electrical power is provided to the recorder. Evidence from the AAIB confirms that even if the Flight Crew has isolated electrical power to the recorder, subsequent maintenance or other activity may have re-instated the power supply resulting in the loss of the recording.

Regulations at the date of publication, requiring the preservation of recordings are as follows:

ICAO Annex 6 Part I, 11.6 requires that "An operator shall ensure, to the extent possible, in the event an aeroplane becomes involved in an accident or incident, the preservation of all related flight recorder records and, if necessary, the associated *flight recorders, and their retention in safe custody pending their disposition as determined in accordance with annex 13."*

UK Regulation (EU) No 965/2012 (Part-CAT, Part-NCC, Part-SPO, as referenced in Chapter 5 of this document) requires that:

Following an accident, a serious incident or an occurrence identified by the investigating authority, the operator of an aircraft shall preserve the original recorded data of the flight recorders for a period of 60 days or until otherwise directed by the investigating authority.

Operators and CAMOs should ensure that robust procedures are in place and prescribed in the relevant Operations Manual and Expositions to ensure that CVR/FDR/AIR/DLR recordings that may assist in the investigation of an accident or incident are appropriately preserved. This should include raising awareness of Flight Crew and Maintenance staff to minimise the possibility of loss of any recorded data from any flight recorder.

When appropriate, the relevant circuit breakers should be pulled and collared / tagged, and an entry made in the aircraft technical log to make clear to any airline personnel that an investigation is progressing. Furthermore, confirmation from the investigating authority/operator is required to be obtained before systems are reactivated and power is restored.

Operators who contract their maintenance activities or ground handling to a third party should ensure that the contracted organisation is made aware of all their relevant procedures.

APPENDIX A
Flight data recorder compliance document

Table 1

Aircraft Type:	Registration:
FDR Make and Model:	CAA Approval ref:
Installed in accordance with: *	A/C Maintenance Programme ref: #
Data Frame Document ref:	Revision:
Conversion Data Document ref:	Revision:
Date of readout:	Test report ref:

The flight data recorder installation in this aircraft has been installed in accordance with the current requirements for the type. An assessment of the test report and a check against the flight profile has been carried out to verify correct operation.

Signed: Operator: Date:

* ANO 2016 Schedule 6, Part 1; UK Regulation (EU) No 965/2012, Part-CAT, Subpart D; Part-NCC, Subpart D; Part-SPO, Subpart D; CAA Spec 10/10A and 18; and EUROCAE Doc ED-112A and ED-155, as applicable.

EUROCAE Doc ED-112A paragraph 2.16 and Annex 4; CAA Spec 10A; FDR maintenance requirements included in the aircraft Maintenance Schedule.

APPENDIX B

Example FDR replay support documents

Introduction to Data Frames

A Flight Data Acquisition Unit (FDAU) takes the aircraft inputs and condenses the data into a multiplexed digital data stream for recording onto the Digital Flight Data Recorder (DFDR).

When the data is extracted, the process has to be reversed and the raw binary data has to be converted back into engineering units.

This decoding process has two phases. The first is to know which data bits correspond to which variable parameters as defined by the dataframe layout and the second is to know the scaling factor that will convert the binary value for a given parameter back to the original engineering value. The dataframe definition defines the bit map and scaling laws that allow conversion between raw binary and engineering units.

The number of bits that a parameter occupies determines the number of states that a given parameter can have. Thus, a parameter stored in 12 bits can have 4,096 possible states (range of 0 to 4,095 counts, see Table 2). The resolution is the range of the parameter, divided by the number of possible states and is hence the bit weighting of the least significant bit used. Note that the recorded range is always larger than the range encountered in service in order to accommodate the actual and out of range inputs. Some ranges will be signed, such as roll angle or outside air temperature. Some ranges will be positive only, such as airspeed or magnetic heading.

A parameter's sample rate is the number of recordings made by the DFDR within a given period of time, usually per second. Some parameters, such as vertical acceleration, are recorded several times a second, while others, such as date, are recorded at a very slow rate, e.g. once per 16 seconds. Each parameter's minimum sample rate in the DFDR is determined by the regulations, and should be distinguished from the rate at which the parameter is refreshed on the DFDAU input bus. Thus, whilst the gross weight may be refreshed every 20 milliseconds at the DFDAU 429 input port, it will only be recorded every 64 seconds on the DFDR. It is important that the Databus refresh rate is consistent with the required data capture rate.

What is a Data Frame?

The previous section introduced the notion of a data frame that contains bit mapping and scaling information. The FDR system data frame will normally comprise of multiples of 64_D words recorded every second, e.g. 64, 128, 256, 512 or 1,024 words per second. This number is used due to the original encoding of the word number counter using three bit octal counters and 64_D being equivalent to the maximum available using the two least significant bits of this counter = 77_O. For the purposes of this section, a data rate of 64 wps is used, and at 12 bits/word, this corresponds to a bit rate of 768 bits/sec.

Data Frame Structure

An FDR data frame occupies a 4 second interval, within which are four 1 second subframes, called subframes 1, 2, 3 and 4. These subframes appear in sequential order, over and over again in the data as the subframe pattern repeats for each new data frame.

The ARINC Characteristic 573 (Mark 2 Aircraft Integrated Data System) data frame concept developed at the point when tape damage due to crash loads was a concern. ARINC defined a set of synchronisation words (sync words), one for each subframe, that would be located into the first word of each subframe. This sync pattern was clarified in ARINC Characteristic 717 (Digital Flight Data Acquisition Unit), removing the ambiguity in ARINC 573 concerning the direction that the bit pattern should be read.

In good flight data, once the sync word for subframe 1 has been found, moving 64 words further into the data will find the sync word for subframe 2, and so on until subframe 1 is reached in the next frame. A block of data that has all the right sync words in all the right places is synchronised. Any unsynchronised data should be treated with caution.

Once the sync word pattern has been restored, the data integrity in terms of data location should also have been restored.

Most data frames contain a frame counter to help track possible gaps in the data. This frame counter is usually a full word (12 bits) and can have 4,096 possible states (0 to 4095) which the data frame steps through, until the frame counter gets to 4,095 and the process begins again. This counter is generated by the DFDAU.

However, the readout software may put a frame number on each sequential group of four subframes. Thus, if there are 20,000 frames in a block of data, the frame number will run from 1 to 20,000, in order. This frame number applied to the data by the readout software is not contained within the data itself and does not repeat as part of a cycle.

Other than the sync words and a possible frame counter, all other words in the data frame can be filled with any combination of numeric parameters and discretes. Each subframe is defined separately, so that different subframes can record quite different data, if so desired.

Each four second 64 wps data frame can generate 252 12-bit words (256 available, minus the 4 sync words), or 3,024 bits that are available to record data. The number of parameters that can be stored depends on the range and resolution of each parameter (number of bits) and the sample rate (how often a parameter is recorded) required. For DFDR data frames, range, resolution and sample rates are set by the regulations for all mandatory parameters.

Resolution is the smallest change in a parameter value that can be recorded. This depends on the number of bits allocated to that parameter, and the value range that the DFDR can accommodate.

For example, oil temperature may vary from 0°C to 300°C. To be sure to cover the operational range, the recorded range is 0° to 400° C.

If oil temperature is stored in a 12-bit word with 4,096 possible states, then the resolution is:

Resolution = range/range of recorded digital word

400°C range/4,095 bits = 0.09768°C/bit

In some cases, the regulations may require a resolution that a single 12-bit word cannot provide. In this case, it will probably be necessary to store such a parameter in two data frame words, with a fine and coarse component. Examples of parameters that may require more than 12 bits to meet the range and resolution requirements are altitude, latitude and longitude.

The sample rate needed for a given parameter can vary widely. For example, "month" changes rarely during a flight, and can be recorded with a long interval. Vertical acceleration (Nz) is typically recorded at eight times per second to capture the parameter with sufficient precision. A parameter stored in the same word in each subframe has a sample rate of once per second. Nz requires eight words per data frame, and these must be spread evenly through the 64 available words, for a sample rate of once every 0.125 seconds and a total of 32 total words in the four second data frame.

As data frames developed, designers found that they had more parameters to record than there were words to store them. To increase the possibilities available the superframe was defined. In this concept, the same word in the frame has a 16 count cycle where different parameters may be stored. When the 16th step is reached, the next word goes back to the first step and starts over again. If superframes are used, a superframe counter also has to be stored. The superframe counter determines the recording position within the 16 step sequence.

Starting with the assumption that a data frame has been defined with a superframe word only in subframe 1, the following would be true:

If a parameter is recorded in only one of the 16 slots, the refresh rate will be (subframe 1 every 4 seconds) x (16 states per superframe cycle) = a 64 second sample rate. If the same superframe word is placed in all four subframes, the refresh rate becomes 16 seconds. Obviously, a superframe is only used for those parameters which change slowly. Typical superframe parameters may include gross weight, day/ month/year, and flight number.

Some parameters, such as airspeed, are numeric. That is, they have a numeric value, such as 325 knots. Other parameters, called discretes, are a coded way to describe the aircraft configuration or system configuration.

A discrete is a parameter that can have only two defined states. A discrete will have a value of one or zero, such as gear up/down or master caution ON/OFF.

However, a number of discretes may be used together to represent a combination of values and require tables to define the recorded bit patterns. In this way, n discretes can provide 2^n combinations. For example, four discretes could be combined to represent sixteen autopilot modes.

NOTE: This coding normally takes place within the aircraft system LRUs, e.g. autopilot, and is not normally a function performed by the FDR system LRU (FDAU), that purely sample and store the input data within a serial dataframe for recording on the FDR. However, this coding process must be determined to permit accurate re-conversion of the recorded data into engineering terms.

Data Conversions

The range and resolution with which the data word can store numeric values depends on the number of bits that the data frame assigns to that parameter. If a parameter occupies all 12 bits, there can be 4,096 different values covering the range of the engineering parameter. Table 2 shows the number of states possible for different numbers of bits. The resolution of the storage process is one bit divided by the total number of possible states. Thus, a 12-bit word has a resolution of 1/4,095 of the full range of the engineering parameter being represented.

Shown below, the data word has a maximum range of 8,190 with a resolution of 2.

Table 1 Powers of 2 (Bit Resolution)

Number of Bit	12 MSB	11	10	9	8	7	6	5	4	3	2	1 LSB
Bit Weighting	4,096	2,048	1,024	512	256	128	64	32	16	8	4	2

NOTE: MSB=Most Significant Bit LSB=Least Significant Bit

There are two basic kinds of data to be stored; data from an analogue source (synchro, AC or DC voltage ratio, variable resistance, potentiometer, High Level DC, Low Level DC or Very Low Level DC) or a digital source such as an ARINC 429 bus. The conversion to and from the 12-bit word value is different for the two kinds of data.

To describe the process of converting digital data into the FDR system data format, let us assume an altitude value is being sent to the FDR system 12-bit word on an ARINC 429 bus input. Let the altitude range between 0 and 65,535 ft, where 65,536 is the number of possible states for an input that occupies 16 bits. Thus, the parameter range is from 0 to 65,535 with a resolution of 1 ft. To be recorded within one FDR system data word, this needs to be mapped into a 12-bit parameter with 4,096 different states. Therefore, for an altitude value of 10,000 ft:

Digital counts, 12 bits = 4,095 * (10,000 ft data/65,536 full range)
= 625 counts (decimal), or 1,161 counts (octal)

Resolution, 12 bits = 65,536 ft full range/4095 counts full range in 12 bits)
=16 ft

=The equivalent of 4 bits resolution when 16 bits map into 12
=16 ft/count x 4,096 counts possible = 65,536 (0 to 65,535 ft)

Once the resolution is established, this can be used to recalculate the actual count value using the actual range achievable with the 12 recorded bits, i.e. maximum range is not 65,536 but is 65,520 due to the 16 foot recorded resolution.

Therefore:

Digital counts, 12 bits = 4,095 * (10,000 ft data/65,520 full range)
= 625 counts (decimal), or 1,161 counts (octal).

For the next example, assume a signed altitude (plus and minus values possible) is being stored. Thus, in the 16-bit word, one bit is the sign, which leaves 15 bits (32,768 possible states) plus the sign bit to give an overall range of 65,536 states split evenly over the +/- 32,767 ft range. In order to accommodate the +/- range in the recorded data word, the input value is converted into an offset binary value such that a zero input equates to half range recorded counts. This offset is then subtracted during the data re-conversion process, using a "c" in a y = mx+c format.

To calculate the digital counts for a one foot accuracy (+/- 32,767 ft):

Digital counts, 12 bits = 4,095 * (10,000 ft - (-32,768 ft at 0 counts))/65,536 ft
= 4,095 * 42,768/65,536
= 2,672 decimal or 5,160 octal counts
where 2,048 counts decimal is approximately zero altitude.

Resolution = (+32,736 to - 32,736 range)/4,096 states in 12 bits
= 16 ft

Once the resolution is established, this can be used to recalculate the actual count value using the actual range achievable with the 12 recorded bits, i.e. maximum range is not 65,536 but is 65,520 due to the 16 ft recorded resolution.

Therefore:

Digital counts, 12 bits = 4,095 * (10,000 ft - (-32,752 ft at 0 counts))/65,520 ft
= 4,095 * 42,752/65,520
= 2,672 decimal or 5,160 octal counts.

Analogue data works somewhat differently, with one exception. Synchro inputs can be treated like digital data, where the full range of 0 to 360° (inclusive) can be encoded directly into the full range of a data word such that a full range count of 4,095 = 359.9° and 4,096 counts = 360° = 0 counts = 0°, because it is possible to cross over zero degrees and continue, like a compass reading.

In order to convert into engineering units, it is then necessary to apply the signal source LRU's data conversion factor as a part of, or after, this conversion process.

Other analogue source data will use a count to input range specified for each input, normally in accordance with ARINC 573. For example, a Low Level DC (LLDC) input will be accepted with an input range of 0 to 5Vdc with 0V being recorded as 0 counts and 5V as 4,095 counts (assuming a 12 bit word).

Thus, any conversion from the recorded data will identify the input voltage that then must be reconverted to raw source (engineering unit) data using the signal source LRU's data.

For example:

Normal Acceleration (Nz) is recorded as a 12-bit word with 4,096 states. The total range of the input is –3.375g to +6.0g, giving an input range of 9.375g. As this is a bipolar input (+ and – ranges), the data is handled as an offset bipolar word with a -3.375g offset.

Therefore, for a Nz of 2.0g;

Digital counts, 12 bits	= 4,095 x (2g + 3.375g)/9.375g = 2,348 decimal or 4,454 octal counts
Resolution, 12 bits	= total input range (gravities)/total range (counts) = 9.375g/4,096 (0 to 4,095 counts used)
	= 0.002289 g/bit.

NOTE: In this case, a value of "4,096" is used in the calculation because the input range is –3.375 to +6.0g and thus 0 counts = -3.375g, an actual value and is thus considered as an "inclusive" range.

If the range had been 0 to 6.0g, 0 counts would equate to 0g with no offset, so any value would have been equated using the value 4,095 as this is considered an "exclusive" range.

NOTE: The following data in this Appendix are examples of, and extracts from, typical FDR replay support documents. They are for illustrative purposes only.

Example

Table 2 Data Frame Format – Analogue Frame

WD	PARAMETER	WD	PARAMETER	WD	PARAMETER	WD	PARAMETER	WD	PARAMETER	WD	PARAMETER	WD	PARAMETER	WD	PARAMETER
00 1	SYNCH WORDS	10 9	MAGNETIC HEADING	20 17	AFCS DISCRETES WORD A	30 25	AFCS WORD B AFCS WORD C AFCS WORD B AFCS WORD C	40 33	LAT DEV #1 LAT DEV #2 LAT DEV #1 LAT DEV #2	50 41	DRIFT ANGLE WIND SPEED LAT/LONG HSP WIND ANGLE	60 49	WARNING DISCRETES	70 57	ILS FREQ 1&2 SUPERFRAME 1 LONGIT LSP SUPERFRAME 2
01 2	BRAKES LH GR BRAKES RH GR BRAKES LH YE BRAKES RH YE	11 10	COMPUTED AIRSPEED	21 18	PITCH TRIM POS'N	31 26	RAD ALT #1 RAD ALT #2 RAD ALT #1 RAD ALT #2	41 34	VERT DEV #1 VERT DEV #2 VERT DEV #1 VERT DEV #2	51 42	GROUND SPEED	61 50	TCAS RESOLUTION ADVISORY	71 58	PRESSURE ALTITUDE FINE
02 3	ANGLE OF ATTACK	12 11	LH ROLL SPOILER	22 19	PR ALT CRS TE FLAP REAL TIME TE FLAP	32 27	AIRBRAKE POS'N	42 35	ANGLE OF ATTACK	52 43	RH ROLL SPOILER	62 51	FRAME COUNT ST AIR TEMP LATITUDE LSP ST AIR TEMP	72 59	AIRBRAKE POS'N
03 4	NORMAL ACCELERATION	13 12	NORMAL ACCELERATION	23 20	NORMAL ACCELERATION	33 28	NORMAL ACCELERATION	43 36	NORMAL ACCELERATION	53 44	NORMAL ACCELERATION	63 52	NORMAL ACCELERATION	73 60	NORMAL ACCELERATION
04 5	LONGITUDINAL ACCELERATION	14 13	PITCH ATTITUDE	24 21	LONGITUDINAL ACCELERATION	34 29	PITCH ATTITUDE	44 37	LONGITUDINAL ACCELERATION	54 45	PITCH ATTITUDE	64 53	LONGITUDINAL ACCELERATION	74 61	PITCH ATTITUDE
05 6	LATERAL ACCELERATION	15 14	ROLL ATTITUDE	25 22	LATERAL ACCELERATION	35 30	RUDDER POS'N	45 38	LATERAL ACCELERATION	55 46	ROLL ATTITUDE	65 54	LATERAL ACCELERATION	75 62	RUDDER POS'N
06 7	LH ELEVATOR POS'N	16 15	LH AILERON POS'N	26 23	RH ELEVATOR POS'N	36 31	RH AILERON POS'N	46 39	LH ELEVATOR POS'N	56 47	LH AILERON POS'N	66 55	RH ELEVATOR POS'N	76 63	RH AILERON POS'N
07 8	PLA ENG #1 PLA ENG #4	17 16	N1 ENGINE #1	27 24	THRUST TARGET ENG VIB #2&3 THRUST TARGET ENG VIB #1&4	37 32	N1 ENGINE #2	47 40	PLA ENG #2 PLA ENG #3	57 48	N1 ENGINE #3	67 56	ENGINE WARNING DISCRETES	77 64	N1 ENGINE #4

Table 3 Data Frame Format - Discrete Frame

(This table will need to be re-drawn if changes need to be made)

WD	BITS		WD	BITS		WD	BITS		WD	BITS		WD	BITS		WD	BITS		WD	BITS		WD	BITS	
	2	1		2	1		2	1		2	1		2	1		2	1		2	1		2	1
00 1			10 9		MAG HDG VALID	20 17			30 25			40 33	HF KEY #2	HF KEY #1	50 41		DA VAL WS VAL LL VAL WA VAL	60 49			70 57		
01 2	SP SH MARKER SP SH MARKER	GR LP MARKER GR LP MARKER	11 10		CAS VALID	21 18	SPARE SHUNT	GPWS MODE 1-5	31 26			41 34	LAT DEV VALID	VERT DEV VALID	51 42		GND SPEED VALID	61 50			71 58		PRESS ALT VALID
02 3		ANGLE OF ATTACK VALID	12 11	CABIN HIGH ALT	SMOKE WARN	22 19			32 27	YELL SPOIL DEP	GRN SPOIL DEP	42 35		ANGLE OF ATTACK VALID	52 43	SPARE MARKER	EVENT	62 51	HYD G HYD G	HYD Y HYD Y	72 59	YELL SPOIL DEP	GRN SPOIL DEP
03 4			13 12			23 20			33 28			43 36			53 44			63 52			73 60		
04 5	SQUAT SWITCH RIGHT	SQUAT SWITCH LEFT	14 13		PITCH ATT VALID	24 21	SQUAT SWITCH RIGHT	SQUAT SWITCH LEFT	34 29		PITCH ATT VALID	44 37	SQUAT SWITCH RIGHT	SQUAT SWITCH LEFT	54 45		PITCH ATT VALID	64 53	SQUAT SWITCH RIGHT	SQUAT SWITCH LEFT	74 61		PITCH ATT VALID
05 6	VHF KEY #3	SQUAT SWITCH NOSE	15 14		ROLL ATT VALID	25 22	VHF KEY #3	SQUAT SWITCH NOSE	35 30	CONFIG WARN	APU FIRE WARN	45 38	VHF KEY #3	SQUAT SWITCH NOSE	55 46		ROLL ATT VALID	65 54	VHF KEY #3	SQUAT SWITCH NOSE	75 62	CONFIG WARN	APU FIRE WARN
06 7	MIDDLE MARKER	STICK SHAKE	16 15	OUTER MARKER	AIRWAY MARKER	26 23	VHF KEY #2	VHF KEY #1	36 31	GEAR DOWN LOCK	STICK PUSH	46 39	MIDDLE MARKER	STICK SHAKE	56 47	OUTER MARKER	AIRWAY MARKER	66 55	VHF KEY #2	VHF KEY #1	76 63	GEAR DOWN LOCK	STICK PUSH
07 8			17 16		N1 #1 VALID	27 24			37 32	RAD ALT VALID	N1 #2 VALID	47 40			57 48		NI #3 VALID	67 56			77 64	RAD ALT NORMAL SOURCE	N1 #4 VALID

Table 4 Data Frame format - Discrete Words and Superframes

BIT	AFCS WORD A SIGNAL	AFCS WORD B SIGNAL	AFCS WORD C SIGNAL
12 (MSB)	A/T ENG STATUS – 1	LAT ENG MODE – 1	A/T ENG MODE – 1
11	A/T ENG STATUS – 2	LAT ENG MODE – 2	A/T ENG MODE – 2
10	AP FD STATUS – 1	LAT ENG MODE – 3	A/T ENG MODE – 3
9	AP FD STATUS – 2	LAT ENG MODE – 4	A/T ENG MODE – 4
8	FLAP TRIM ENGAGE	VERT ENG MODE – 1	A/T ENG MODE – 5
7	AUTO TRIM ENGAGE	VERT ENG MODE – 2	THRUST AUTO ON
6	ELEC TRIM ENGAGE	VERT ENG MODE – 3	N1 COMPENSATE
5	YAW DAMPER ENGAGED #1	VERT ENG MODE – 4	SPARE
4	YAW DAMPER ENGAGED #2	DFGC #1 ACTIVE	DFGC #1 ACTIVE
3	APPROACH STATUS – 1	DFGC #2 ACTIVE	DFGC #2 ACTIVE
2	APPROACH STATUS – 2	ILS STATUS – 1	PA STATUS – 1
1 (LSB)	APPROACH STATUS – 3	ILS STATUS – 2	PA STATUS – 2

BIT	WARNING DISCRETES ENGINE TYPE	WARNING DISCRETES ENGINE SIGNAL	WARNING DISCRETES TYPE	WARNING DISCRETES SIGNAL	CONVERSION WARNING OUT OF LIMIT PARAMETER
12 (MSB)	LATCH SE	MASTER WARNING	SHUNT	LOW OIL PRESSURE #1	LH/RH ELEVATOR
11	SHUNT	WINDSHEAR WARNING	SHUNT	LOW OIL PRESSURE #2	LH/RH AILERON
10	SHUNT	FADEC #1 OFF	SHUNT	LOW OIL PRESSURE #3	TE FLAP
9	SHUNT	FADEC #2 OFF	SHUNT	LOW OIL PRESSURE #4	AIRBRAKE
8	SHUNT	FADEC #3 OFF	SERIES	PYLON OVERHEAT #1	LH/RH ROLL SPOILER
7	SHUNT	FADEC #4 OFF	SERIES	PYLON OVERHEAT #2	PITCH TRIM
6	SHUNT	FADEC #1 FAULT	SERIES	PYLON OVERHEAT #3	RUDDER
5	SHUNT	FADEC #2 FAULT	SERIES	PYLON OVERHEAT #4	LONGIT ACC’N
4	SHUNT	FADEC #3 FAULT	SERIES	ENGINE FIRE #1	LATERAL ACC’N
3	SHUNT	FADEC #4 FAULT	SERIES	ENGINE FIRE #2	NORMAL ACC’N
2	SERIES	DFGC #1 MASTER	SERIES	ENGINE FIRE #3	BRAKES LH
1 (LSB)	SERIES	DFGC #2 MASTER	SERIES	ENGINE FIRE #4	BRAKES RH

	SUPERFRAME 1	SUPERFRAME 2	ILS 1 & 2 FREQUENCY
FRAME	PARAMETER	PARAMETER	PARAMETER
0	SELECTED MACH	SELECTED VERT SPEED	ILS #1 FREQUENCY
1	SELECTED ALTITUDE	SELECTED SPEED	ILS #2 FREQUENCY
2	SELECTED HEADING	SELECTED COURSE	ILS #1 FREQUENCY
3	CALIBRATION WORD	DAY/MONTH	ILS #2 FREQUENCY
4	SELECTED MACH	SELECTED VERT SPEED	ILS #1 FREQUENCY
5	SELECTED ALTITUDE	SELECTED SPEED	ILS #2 FREQUENCY
6	SELECTED HEADING	SELECTED COURSE	ILS #1 FREQUENCY
7	CALIBRATION WORD	CONVERSION WARNING	ILS #2 FREQUENCY

Parameter: Pressure Altitude (Fine)

Table 5 Source Definition

<table>
<tr><th rowspan="2">Signal Source/Type</th><th rowspan="2">Code Representation</th><th rowspan="2">Bits (Bit 0 = LSB)</th><th rowspan="2">Min Update Rate (times/sec)</th><th colspan="2">SDI</th></tr>
<tr><th>BITS 10</th><th>9</th></tr>
<tr><td>A.D.C. 1
ARINC 429 DATABUS
LABEL 203</td><td>BNR</td><td>28 to 11</td><td>62.5 ms
(16/sec)</td><td>0</td><td>1</td></tr>
<tr><th>Resolution/LSB Value</th><th colspan="2">Range</th><th colspan="3">Accuracy</th></tr>
<tr><td>1 ft</td><td colspan="2">Operating - -1,000 to +50,000 ft
Output - -2,000 to +50,000 ft</td><td colspan="3">Defined in Ops Manual</td></tr>
</table>

Table 6 Recording Definition

FDR Word No(s)	**Superframe No.**	**Bits (Bits 1=LSB)**	**Sampling INT (Sec)**
Octal: 071	N/A	12 to 2 (Bit 1 – Validity)	1
Decimal: 58 SF 1			
Resolution/LSB Value	**Range**	**Conversion Accuracy**	**Overall RSS Accuracy**
2 ft	-1,024 to 64,512 ft	-	Defined in Ops Manual

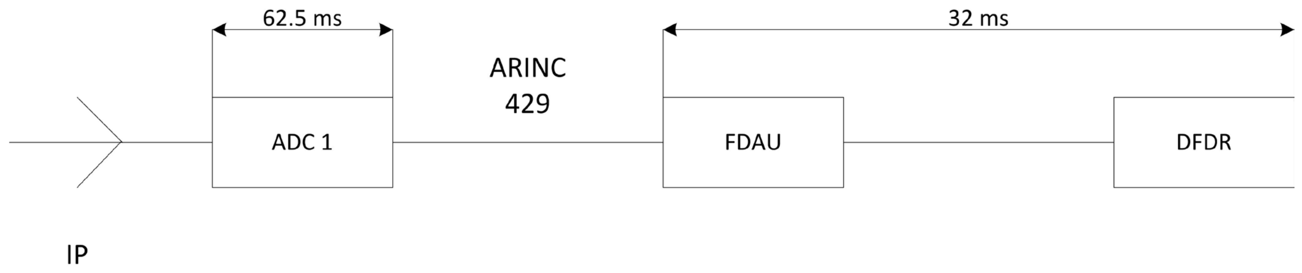

Figure 1 Transport Delay(s)

Algorithm

Defined in Ops Manual

Sign Convention Sign Bit 29 - 0 - Positive

(Digital Source) - 1 - Negative

Parameter: Pressure Altitude (Coarse)

Table 7 Source Definition

Signal Source/Type	Code Representation	Bits (Bit 0 = LSB)	Min Update Rate (times/sec)	SDI BITS 10	SDI BITS 9
A.D.C. 1 ARINC 429 DATABUS LABEL 203	BNR	28 to 11	62.5 ms (16/sec)	0	1
Resolution/LSB Value	**Range**		**Accuracy**		
1 ft	Operating - -1,000 to +50,000 ft Output - -2,000 to +50,000 ft		Defined in Ops Manual		

Table 8 Recording Definition

FDR Word No(s)	Superframe No.	Bits (Bits 1=LSB)	Sampling INT (Sec)
Octal: 022 **Decimal:** 19 SF 1	N/A	12 to 8	4
Resolution/LSB Value	**Range**	**Conversion Accuracy**	**Overall RSS Accuracy**
2,048 ft	-1,024 to 64,512 ft	-	Defined in Ops Manual

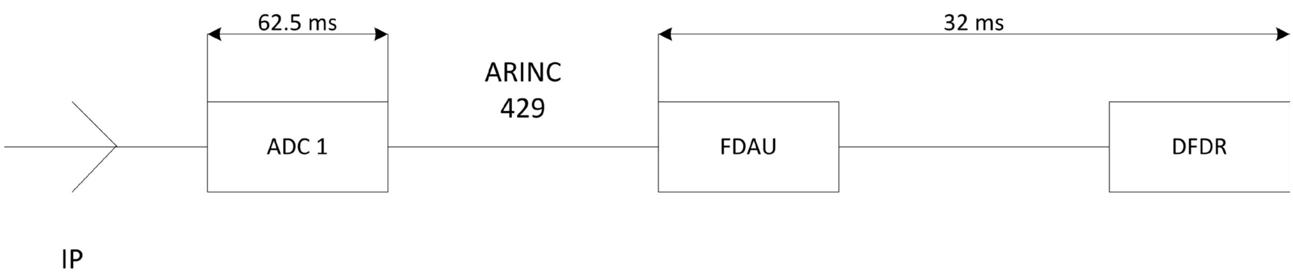

Figure 2 Transport Delay(s)

Algorithm

Defined in Ops Manual

Sign Convention Sign Bit 29 - 0 - Positive

(Digital Source) - 1 - Negative

Algorithms and Parameters Details (cont)

Pressure Altitude

Pressure altitude is determined from coarse and fine components (words 022 and 071) with an offset of –1,024 ft.

FDR BIT No	12	11	10	9	8	7	6	5	4	3	2	1
	|	|	|	|	|	|	|	|	|	|	|	|
Data Source (Fine)	2,048	1,024	512	256	128	64	32	16	8	4	2	V
	|	|	|	|	|							
Data Source (Coarse)	32,768	16,384	8,192	4,096	2,048							

Therefore altitude is found by adding the value of the 4 most significant bits of the coarse word (022) to the fine word (071) and correcting for the offset.

NOTE: Bit 1 of the fine word (071) is the validity bit and therefore always set to 1 for valid data.

Example – 10,000 ft.

	12				8							
	|				|							
Coarse FDR count (022) = 8,192 (5 bit) =	0	0	1	0	X							
Fine FDR count (071) = 2,832 (12 bit) =	1	0	1	1	0	0	0	1	0	0	0	1
	|				|							
	12				1							

Therefore alt. (ft) = 8,192 + 2,832 – 1,024 = 10,000 ft.

Parameter: Computer Airspeed

Table 9 Source Definition

Signal Source/Type	Code Representation	Bits (Bit 0 = LSB)	Min Update Rate (times/sec)	SDI BITS 10	9
A.D.C. 1 ARINC 429 DATABUS LABEL 206	BNR	28 to 15	62.5 ms (16/sec)	0	1
Resolution/LSB Value	**Range**		**Accuracy**		
0.0625 kt	Operating - 30 to 450 kt Output - 0.0 to 500 kt		60kt - +/- 4 kt 100kt - +/- 2 kt 200kt - +/- 1 kt 450kt - +/- 1 kt		

Table 10 Recording Definition

FDR Word No(s)	Superframe No.	Bits (Bits 1=LSB)	Sampling INT (Sec)
Octal: 011 **Decimal:** 10 SF 1	N/A	12 to 2 (Bit 1 - Validity)	1
Resolution/LSB Value	**Range**	**Conversion Accuracy**	**Overall RSS Accuracy**
0.5 kt	0 to 1,024 kt	-	± 7% @ 60 kt ± 2% @ 100 kt ± 0.5% @ 200 kt ± 0.2% @ 450 kt

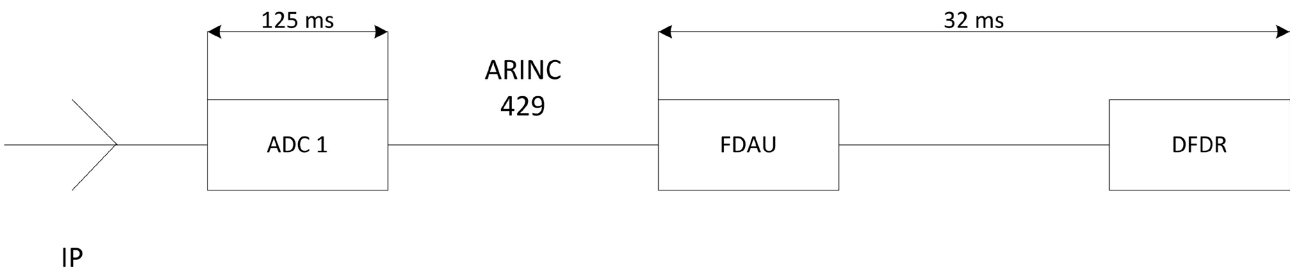

Figure 3 Transport Delay(s)

Algorithm

FDR Range 0 to 2,048 digital counts where:

Airspeed (kt) = 0.5 x (FDR digital count [11 BIT Res])

e.g. 30 = 15 kt; 450 = 225 kt

													LSB Value
												LSB	- Validity BIT
	12	11	10	9	8	7	6	5	4	3	2	1	- Recorded Data
	|	|	|	|	|	|	|	|	|	|	|	|	
29	28	27	26	25	24	23	22	21	20	19	18	17	- ARINC DATA

Sign Convention Sign Bit 29 - 0 - Positive

(Digital Source) - 1 - Negative

Parameter: Magnetic Heading

Table 11 Source Definition

<table>
<tr><th rowspan="2">Signal Source/Type</th><th rowspan="2">Code Representation</th><th rowspan="2">Bits
(Bit 0 = LSB)</th><th rowspan="2">Min Update Rate
(times/sec)</th><th colspan="2">SDI</th></tr>
<tr><th colspan="2">BITS
10 9</th></tr>
<tr><td>I.R.U. 1
ARINC 429 DATABUS
LABEL 320</td><td>BNR</td><td>28 to 13</td><td>400 ms
2.5/sec</td><td>0</td><td>1</td></tr>
<tr><th>Resolution/LSB Value</th><th colspan="2">Range</th><th colspan="3">Accuracy</th></tr>
<tr><td>0.0055°</td><td colspan="2">± 180°</td><td colspan="3">AT +/- 50° Lat – 2°
50 to 79° N Lat – 3°
50 to 60° S Lat – 3°
Above 79° N Lat – 8°</td></tr>
</table>

Table 12 Recording Definition

FDR Word No(s)	Superframe No.	Bits (Bits 1=LSB)	Sampling INT (Sec)
Octal: 010 **Decimal:** 9 SF 1	N/A	12 to 2 (Bit 1 - Validity)	1
Resolution/LSB Value	**Range**	**Conversion Accuracy**	**Overall RSS Accuracy**
0.18°	0° to 360° (± 180°)	-	As Above

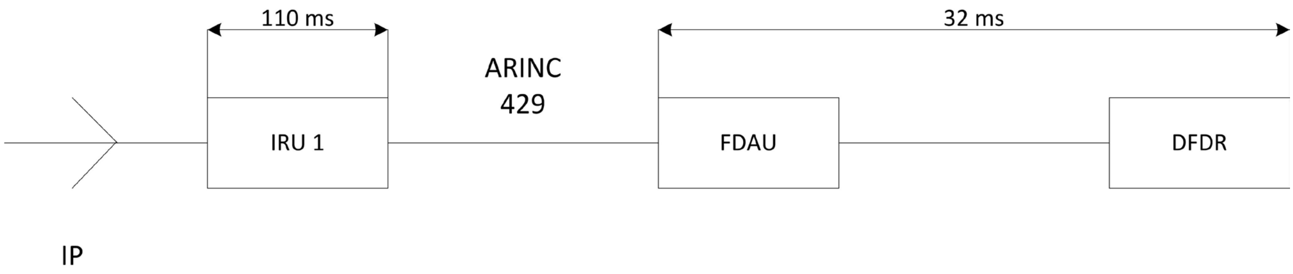

Figure 4 Transport Delay(s)

Algorithm

Heading Degree = 0.1758 x FDR Count (11 bit) - 180

										LSB Value	LSB	- Validity BIT
12	11	10	9	8	7	6	5	4	3	2	1	- Recorded Data
|	|	|	|	|	|	|	|	|	|	|	|	
29	28	27	26	25	24	23	22	21	20		V	- ARINC DATA

NOTE: The above bit patterns for recorded and ARINC Data are nominal only.

Sign Convention Sign Bit 29 - 0 - Positive (0° to 180°) (Digital Source)

- 1 - Negative (180° to 360°)

Parameter: Normal Acceleration

Table 13 Source Definition

Signal Source/Type	Code Representation	Bits (Bit 0 = LSB)	Min Update Rate (times/sec)	SDI BITS 10 9
Tri-Axial Accelorometer Magnatek or Sundstrand	N/A	N/A	N/A	N/A
Resolution/LSB Value	Range		Accuracy	
Infinite	-3.375g to +6.0g		± 0.75% FSO	

Table 14Recording Definition

FDR Word No(s)	Superframe No.	Bits (Bits 1=LSB)	Sampling INT (Sec)
Octal: 003 Decimal: 4 SF 1	N/A	12 to 1	0.125
Resolution/LSB Value	Range	Conversion Accuracy	Overall RSS Accuracy
0.00229g	-3.375g to +6.0g	±0.25%	±0.79%

Transport Delay(s)

FDAU/DFDR Conversion Delay Only = 32ms

Algorithm

FDR range 0 to 4,096 digital counts where:

Acceleration (g) = (2.289 x 10-3 x (FDR Digital count (12Bit))) – 3.375

Scale	**Range**	**Output**
Up	+6g	5000mV
Down	-3g	200mV

Sign Convention

(Digital Source) N/A

APPENDIX C

Guidance on FDR validation

Where an operator undertakes to carry out validation of their own FDR readouts this will be detailed in the company CAME. This validation will be undertaken by competent staff, using the appropriate equipment and procedures, and will be documented.

The procedure should be established, acceptable to the CAA, which enables the operator to demonstrate that a timely validation has been carried out, which should highlight any deficiencies and the associated remedial actions. The procedure should also detail how system performance is assessed, and how that performance is included as part of the ongoing reliability system for each aircraft type.

The operator may sub-contract this task to an unapproved organisation and detail this in the CAME. However, this task will still form part of the operator's Continuing Airworthiness Management Organisation approval.

The Civil Aviation Authority recognises that in certain cases an aircraft operator may lack sufficient resources and/or competence to undertake FDR readout validation. In these cases, the validation, as detailed in the subject procedure, may be contracted to a third party by the operator. In these circumstances the operator will need to provide evidence of the following:

- The Part 145 organisation has the validation of FDR readouts in their approved procedures.
- The Part 145 FDR Readout Facility report should include an assessment in accordance with these procedures.

A copy of the test report and converted data from the representative flight should be provided to the operator together with a CAA Form 1, where appropriate. Refer to Chapter 9.

NOTE: The level of information provided will be dependent on the level of flight/aircraft information originally supplied.

In conclusion, there are three possible ways to comply with this requirement:

1. FDR readout and validation by the operator.
2. FDR readout and validation by an organisation under a sub-contract arrangement with the operator under the operator's CAMO Approval.
3. FDR readout and validation by a suitably approved Part 145 organisation contracted by the operator.